4. Climate and Hydrology

Many aspects of the physical setting of Butte County play a role in the hydrologic cycle within the County. Topography within the County significantly impacts precipitation patterns. Temperature variations influence whether precipitation falls as rain or snow, which in turn impacts the timing of surface water runoff. Temperature and other factors also influence the evaporative demand of the atmosphere and corresponding irrigation requirements for crops. Both surface water and extracted groundwater are used to meet the water demands. System components impacting water resources in the County described in this section include climate, surface water hydrology, and groundwater hydrology.

4.1 Climate

Butte County has a Mediterranean climate with cool, wet winters and hot, dry summers. Unlike many locations in California, rainfall and winter snowpack in the Sierra Nevada provide significant surface water flows and groundwater recharge as water drains through the County.

Climate variation within the County occurs primarily due to changes in elevation. Precipitation is least on the valley floor and greatest in the Foothill Inventory Unit (IU) and Mountain IU areas as elevation increases. Conversely, temperatures are warmest on the valley floor and coolest in the mountains. Similarly, reference evapotranspiration (ETo), a measure of evaporative demand, is greatest on the valley floor and least in the mountains. This variability in climate is discussed in greater detail in the following sections.

4.1.1 Precipitation

Average annual precipitation generally increases from west to east across Butte County, associated with increasing elevation. Moisture-laden weather patterns from the Pacific Ocean travel west to east across California and Butte County during the winter months. Air cools as it moves east and it is lifted over the Sierra Nevada through the process of orographic cooling. This process results in condensation of moisture and precipitation. Precipitation from orographic cooling is evidenced by the spatial distribution of average annual rainfall for Butte County from 1981 to 2010 shown in Figure 4.1[1].

Precipitation is strongly seasonal, occurring generally between October and March or April, with about two thirds of the total annual precipitation generally occurring between November and February. Average monthly precipitation totals for valley floor IUs (Vina, West Butte, East Butte, and North Yuba), the Foothill IU, the Mountain IU, and the County as a whole for the

[1] Source: PRISM Climate Group, Oregon State University (prism.oregonstate.edu).

period 1981-2010 are shown in Figure 4.2. Water year[2] annual precipitation totals for 1981 to 2015 for the Chico University Farm and Paradise weather stations[3] are shown in Figure 4.3.

Inter-annual precipitation varies widely. For Chico University Farm, water year precipitation between 1981 and 2015 averaged 27.0 inches but varied between 13.2 inches in 2007 and 48.0 inches in 1998. For Paradise, water year precipitation between 1981 and 2015 averaged 55.8 inches but varied between 34.8 inches in 2014 and 102.3 inches in 1995.

4.1.2 Temperature

Converse to precipitation, average temperature decreases from west to east across Butte County, associated with increasing elevation. The spatial distribution of average annual temperature within Butte County from 1981 to 2010 is shown in Figure 4.4[4].

Monthly County-wide average temperature varies from approximately 45 F in January and December to 77 F in July based on PRISM estimates for the 1981 to 2010 period. Average monthly temperature is similar among valley floor IUs and decreases slightly for the Foothill IU (Figure 4.5). Temperatures are least for the Mountain IU.

Although there is substantial seasonal variability in temperature, there is not a large difference between the valley floor and mountain areas. For example, the difference in annual average air temperature between the valley floor IUs and the Mountain IU is only 6 F.

4.1.3 Reference Evapotranspiration

Similar to temperature, reference evapotranspiration (ETo) decreases from west to east across Butte County, associated with increasing elevation. The spatial distribution of annual ETo within Butte County for 2014 is shown in Figure 4.6[5]. ETo is relatively similar on the valley floor.

Monthly average ETo for the California Irrigation Management Information System (CIMIS) weather station at Durham (Station 12) varied from 1.2 inches in December to 7.3 inches in July for the 1981 to 2015 period (Figure 4.7). About three quarters of annual ETo generally occurs between April and September. Annual ETo tends to be greatest in warm, dry years and least in cool, wet years. For Durham, water year ETo between 1981 and 2015 averaged 50.1 inches but varied between 43.4 inches in 1998 and 54.1 inches in 2007 (Figure 4.8).

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[2] A water year refers to the period from October to September each year, with the beginning month of October selected based on the typical beginning of the winter rainy season. For example, the 2000 water year includes the period from October 1999 to September 2000.
[3] Source: National Climatic Data Center (NCDC) stations 041715 and 046685 (www.ncdc.noaa.gov).
[4] Source: PRISM Climate Group, Oregon State University (prism.oregonstate.edu).
[5] Source: California Irrigation Management Information System (cimis.water.ca.gov). Derived from SpatialCIMIS ETo raster data. Long-term average raster data are not currently available, though the spatial distribution of relative ETo is expected to be similar across years.

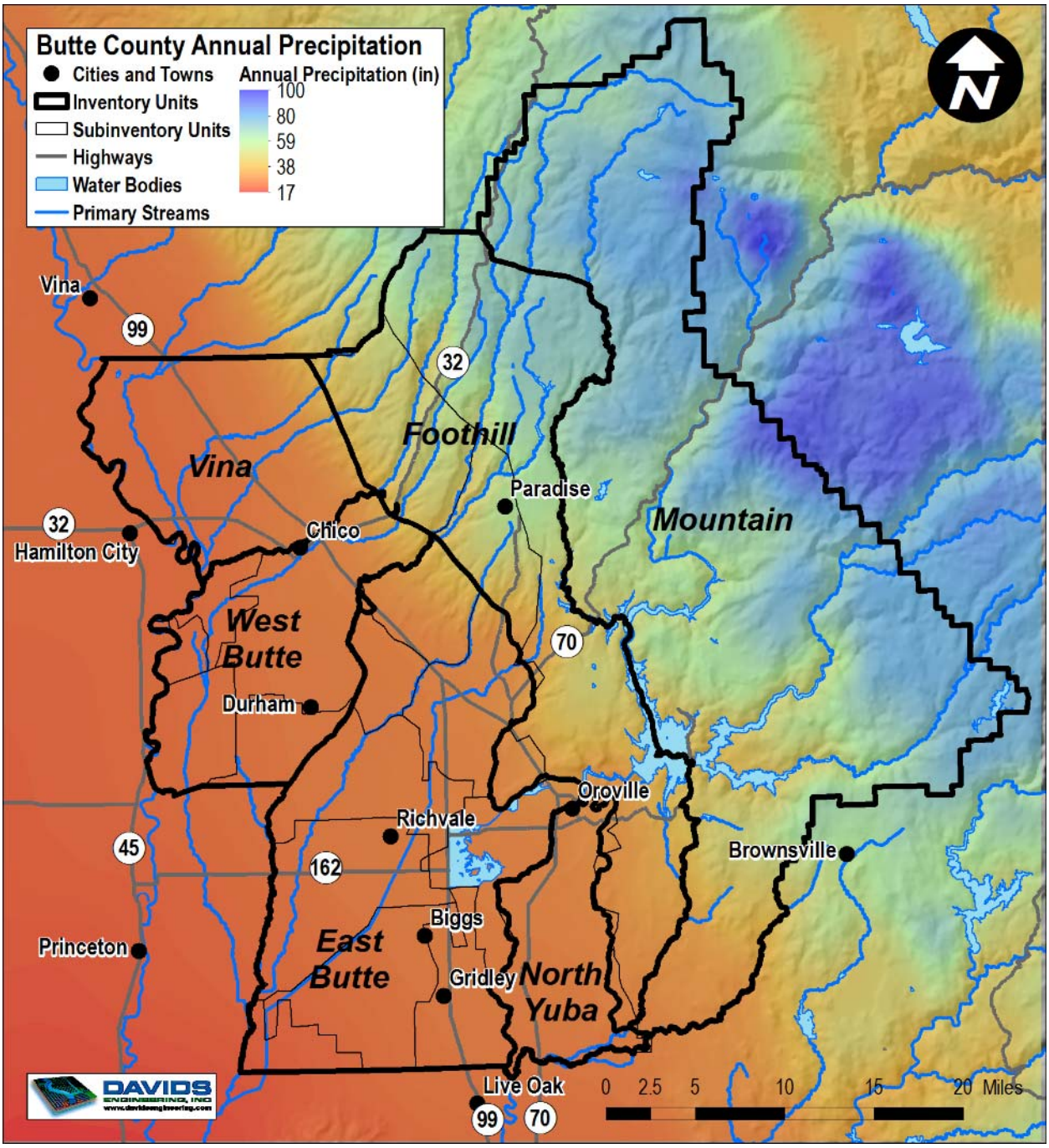

Figure 4.1. Butte County Average Annual Precipitation, 1981-2010 (Source: PRISM Climate Group).

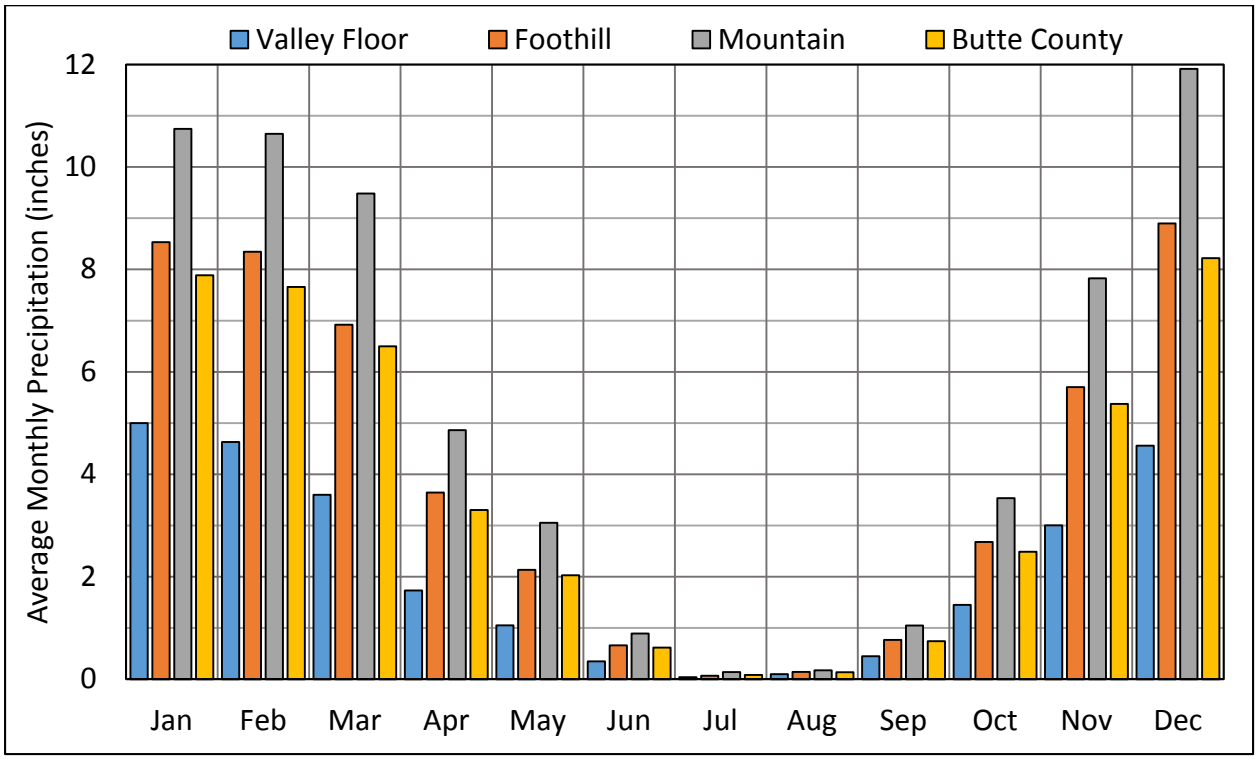

Figure 4.2. Average Monthly Precipitation for Valley-Floor, Foothill, and Mountain Inventory Units and Butte County, 1981-2010 (Source: PRISM Climate Group).

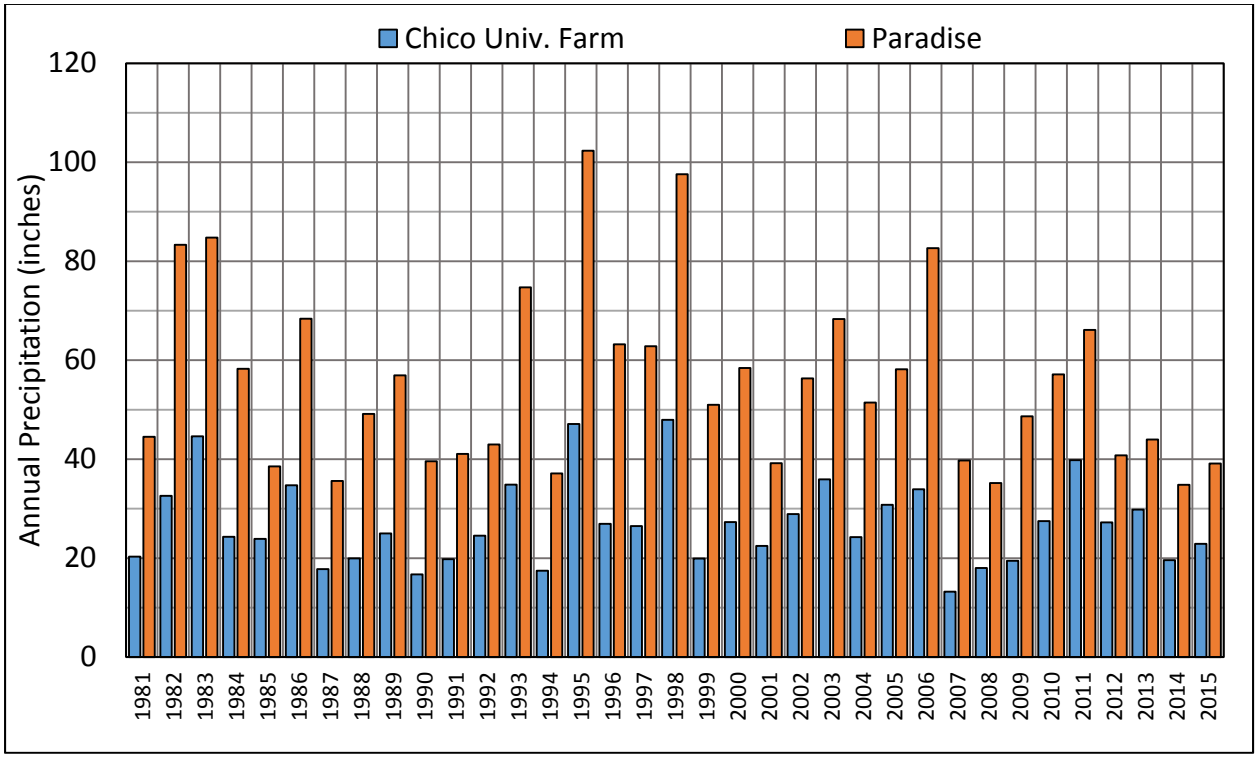

Figure 4.3. Water Year Precipitation for Chico University Farm (NCDC 041715) and Paradise (NCDC 046685), 1981-2015.

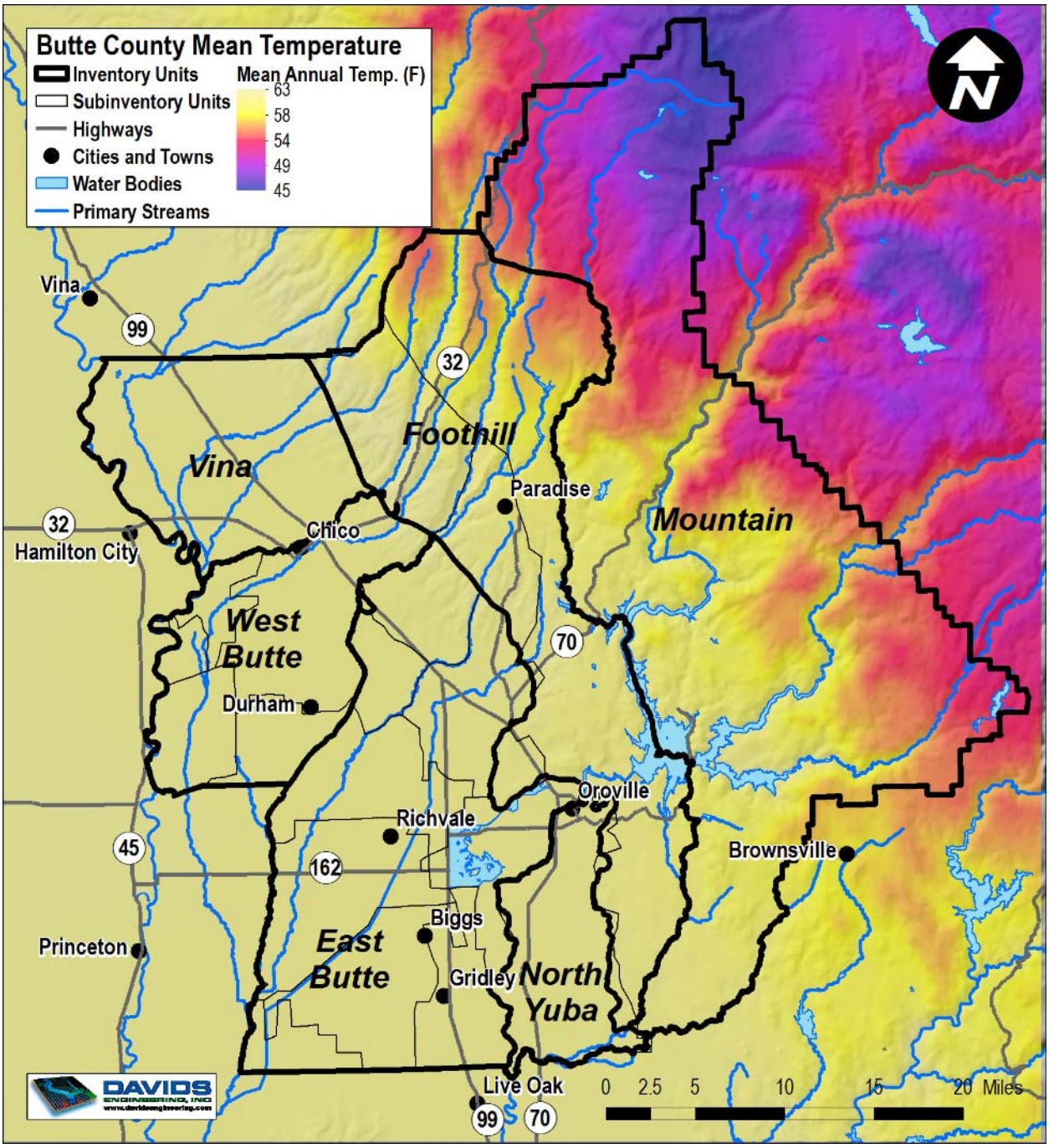

Figure 4.4. Butte County Average Annual Temperature, 1981-2010 (Source: PRISM Climate Group).

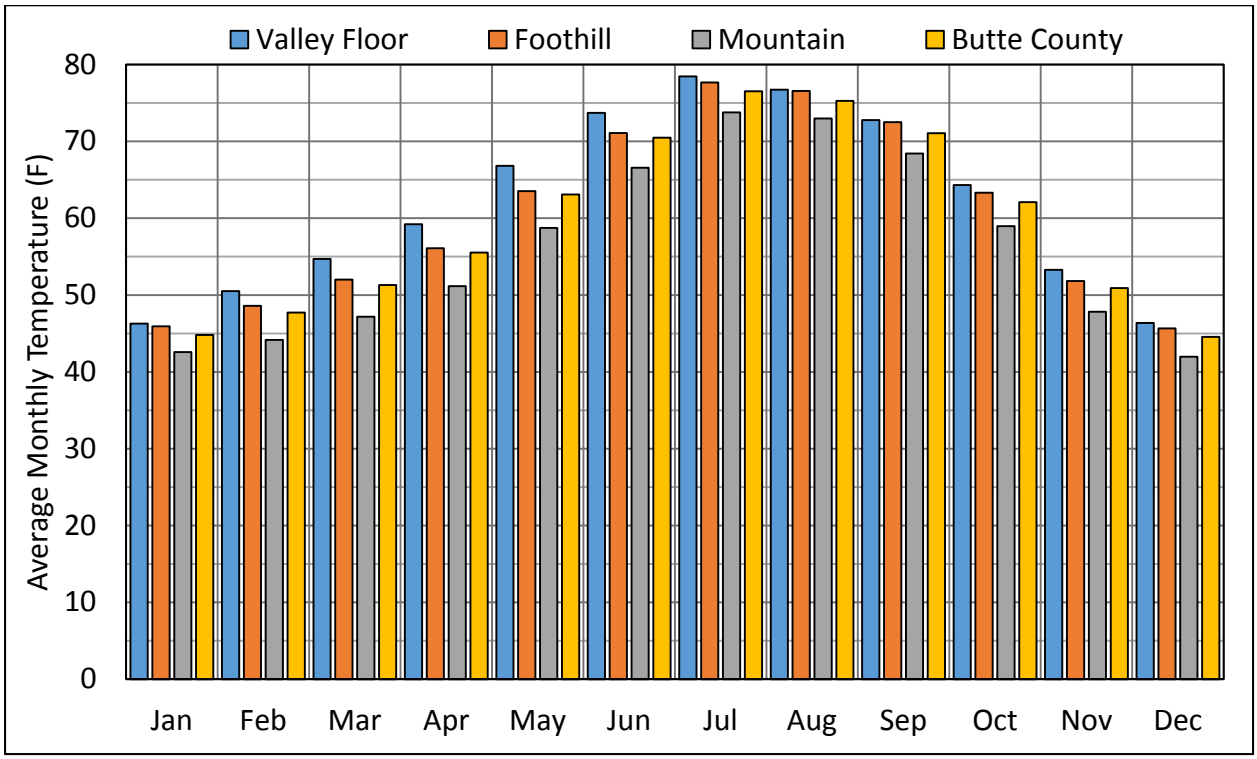

Figure 4.5. Average Monthly Temperature for Valley-Floor, Foothill, and Mountain Inventory Units and Butte County, 1981-2010 (Source: PRISM Climate Group).

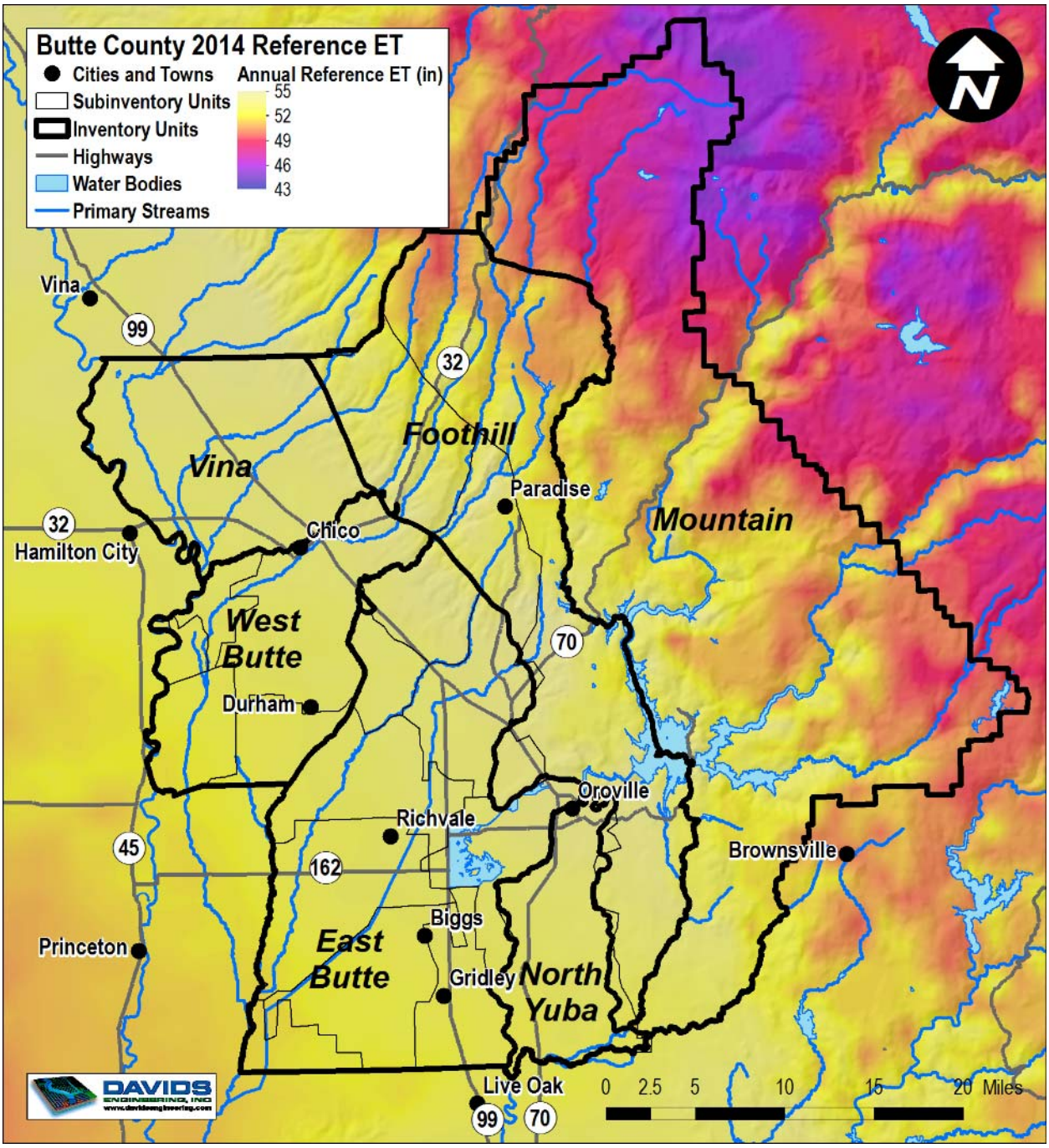

Figure 4.6. Butte County Annual Reference Evapotranspiration, 2014 (Source: CIMIS).

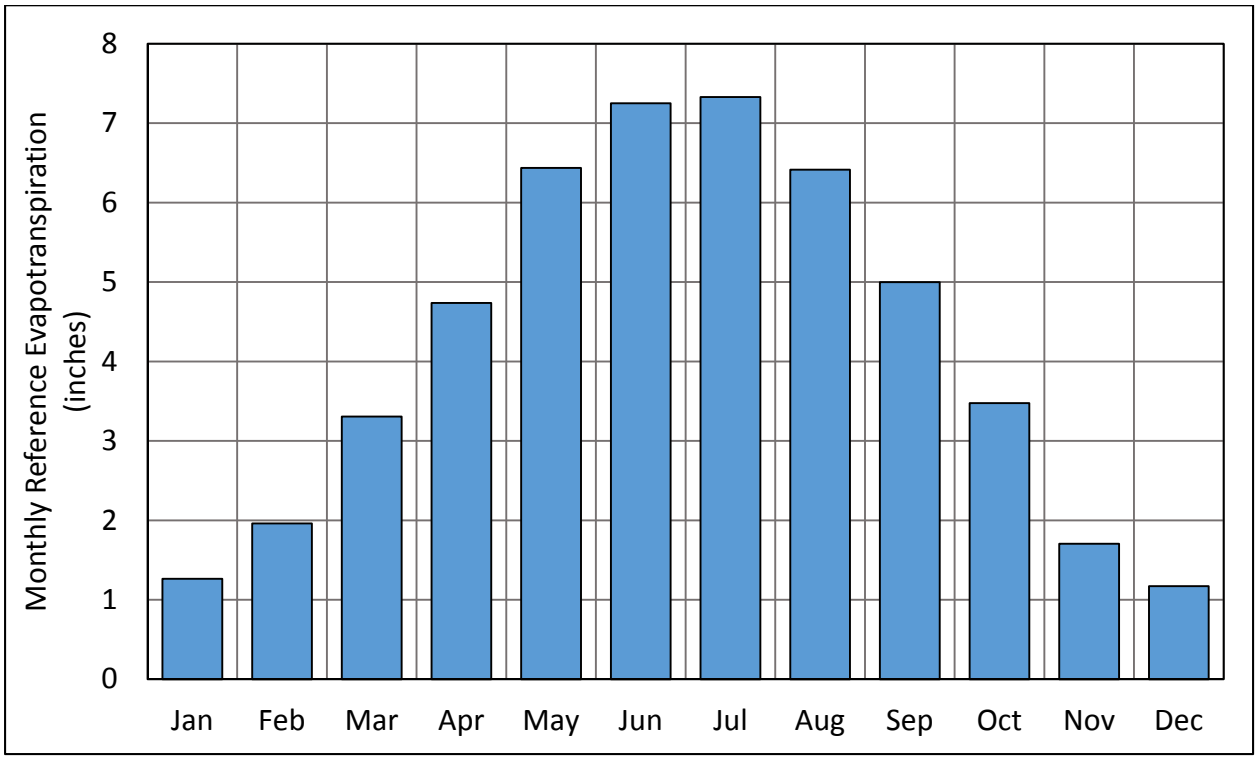

Figure 4.7. Average Monthly Reference Evapotranspiration for Durham CIMIS (Station 12), 1981-2015.

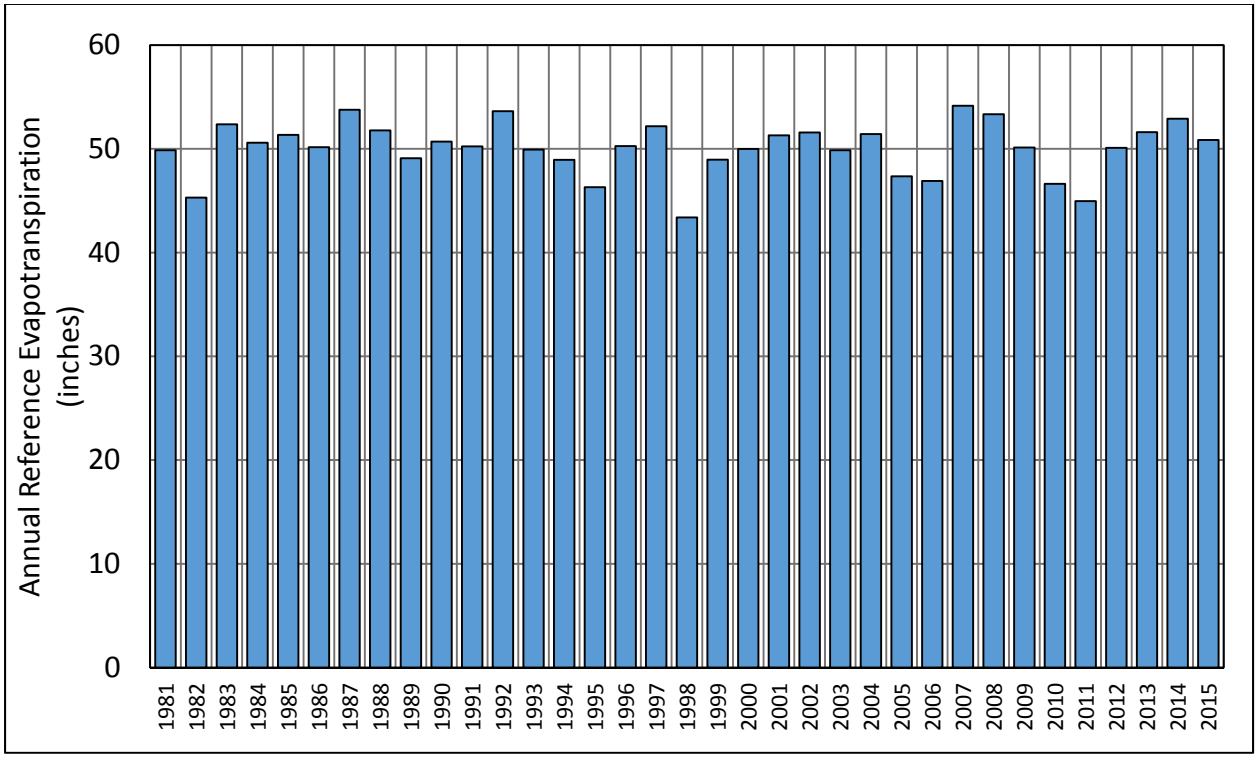

Figure 4.8. Water Year Reference Evapotranspiration for Durham CIMIS (Station 12), 1981-2015.

4.2 Surface Water Hydrology

This section provides an overview of the surface water hydrology of Butte County, including discussion of surface water sources and channels, other measured flows, surface water storage, and diversions.

4.2.1 Overview

Surface water hydrology of the Sacramento Valley and Butte County is characterized by large variability in inter-annual precipitation and runoff resulting in both drought and flooding, sometimes in the same year. In contrast, relative differences in seasonal runoff are more predictable, with rainfall runoff occurring during the winter or snowfall forming snowpack in higher elevations that runs off as it melts in the spring and early summer.

A key indicator of seasonal variability in inter-annual hydrology is the Sacramento Valley Water Year Index (WYI), which is used to classify individual water years as Wet (W), Above Normal (AN), Below Normal (BN), Dry (D), or Critical (C) with respect to surface water runoff in the Sacramento River Basin. Key rivers contributing to runoff from the basin are the Sacramento River itself, the Feather River, the Yuba River, and the American River. The WYI for each year is weighted 70 percent based on unimpaired runoff from the Basin for the current year and 30 percent based on unimpaired runoff from the prior year (expressed in millions of acre-feet (maf)). Unimpaired runoff represents the amount of runoff that would occur in the basin absent any diversions, storage, or inter-basin imports and exports.

The Sacramento Valley WYI for the 45-year period from 1971 to 2015 is shown in Figure 4.9, along with corresponding water year type classifications. During this period, the WYI ranged from 3.1 maf in 1977 to 15.3 maf in 1983[6], representing a five-fold difference occurring only 6 years apart. The average WYI over this period is 7.9 maf. Historical and recent drought periods are evident in the figure. Of note is that only one above normal or wet year has occurred since 2007, and only four above normal or wet years have occurred since 2001.

[6] These years also represent the historical minimum and maximum WYIs for the 115-year period of record from 1901 to 2015.

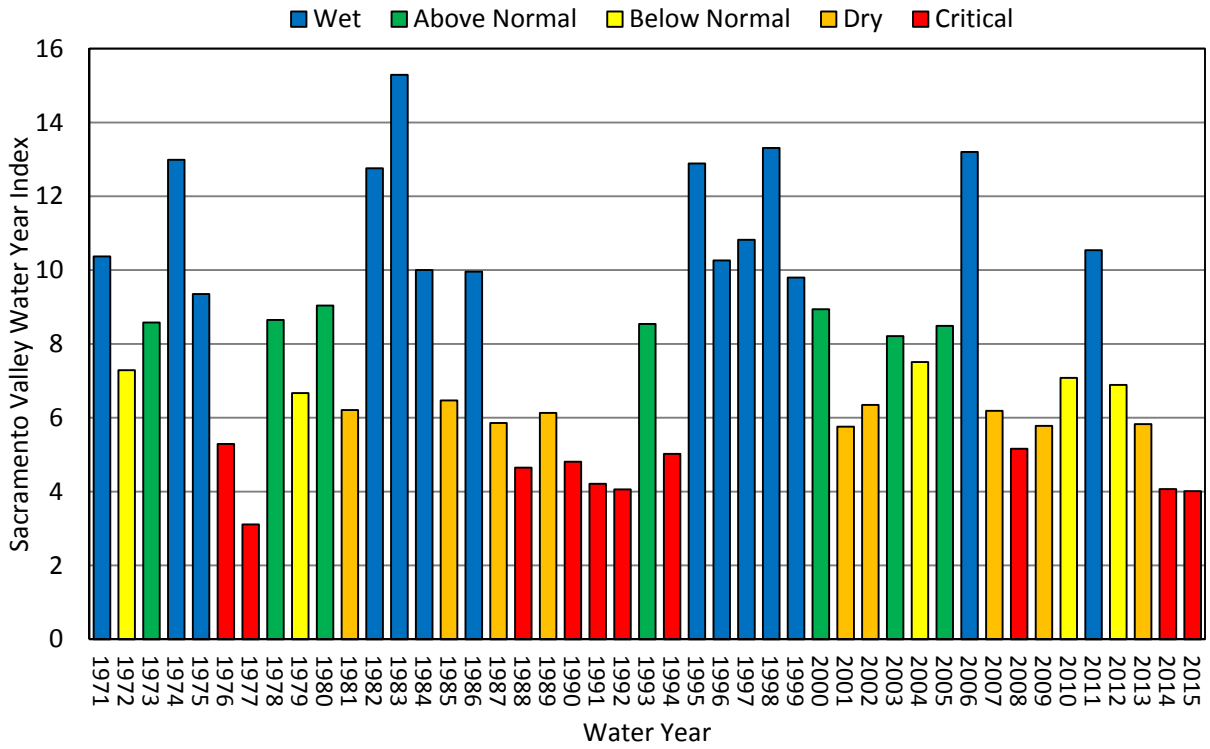

Figure 4.9. Sacramento Valley Water Year Index.

4.2.2 Surface Water Sources and Channels

Figure 4.10 shows the principal entry points to Butte County for surface water and the major channels, natural and modified, by which it flows through the County. The principal waterways originating outside the County are:

- The Sacramento River
- The Feather River. The North, Middle and South Forks originate outside the County and, together with the West Branch, supply water to Lake Oroville with a portion of flow routed through the Thermalito Forebay and Afterbay facilities to generate hydropower and deliver irrigation water supply, with the remaining water returning to the Feather River.
- Big Chico Creek
- Butte Creek
- Pine Creek

Runoff and groundwater flows within the County contribute to the flows in the above waterways and also to those arising within the County. These waterways represent the major streams and water supply and drainage features in the County and include:

- Natural Waterways
    - The West Branch of the Feather River. The West Branch joins the forks originating outside the County and supplies water to Lake Oroville and then to

Thermalito Forebay and Afterbay. Diversions are additionally made by PG&E to Butte Creek, as described below.
    - Little Chico Creek
    - Rock Creek
    - Dry Creek
    - Little Dry Creek
    - Clear Creek
    - Angel Slough
    - Wyandotte Creek
    - Honcut Creek
- Supply Canals
    - Western Main Canal
    - Western Lateral 374
    - Richvale Main Canal
    - Sutter Butte Canal
    - Minderman Canal
    - Biggs-West Gridley Main Canal
- Flood Control Channels
    - Cherokee Canal
    - Lindo Channel (Sandy Gulch)
    - Sycamore Bypass Channel

Water is distributed from Thermalito Afterbay to canals serving multiple users including Western Canal Water District and the Joint Districts. The Joint Districts include Richvale Irrigation District, Biggs-West Gridley Water District, Butte Water District[7], and Sutter Extension Water District[8].

Water from the West Branch of the Feather River is diverted to the Toadtown Canal for power generation and cold water for fish by PG&E. The Butte Canal carries Toadtown Canal and Butte Creek water to the De Sabla power plant forebay. Hydropower is also generated at several other locations. Operations at all of these sites affect the timing of water releases. At Oroville-Thermalito, Toadtown, and De Sabla-Centerville, water for power generation is transferred from the Feather River watershed to the Butte Creek watershed.

[7] A portion of Butte Water District's service area falls within Sutter County.
[8] All of Sutter Extension Water District's service area falls within Sutter County.

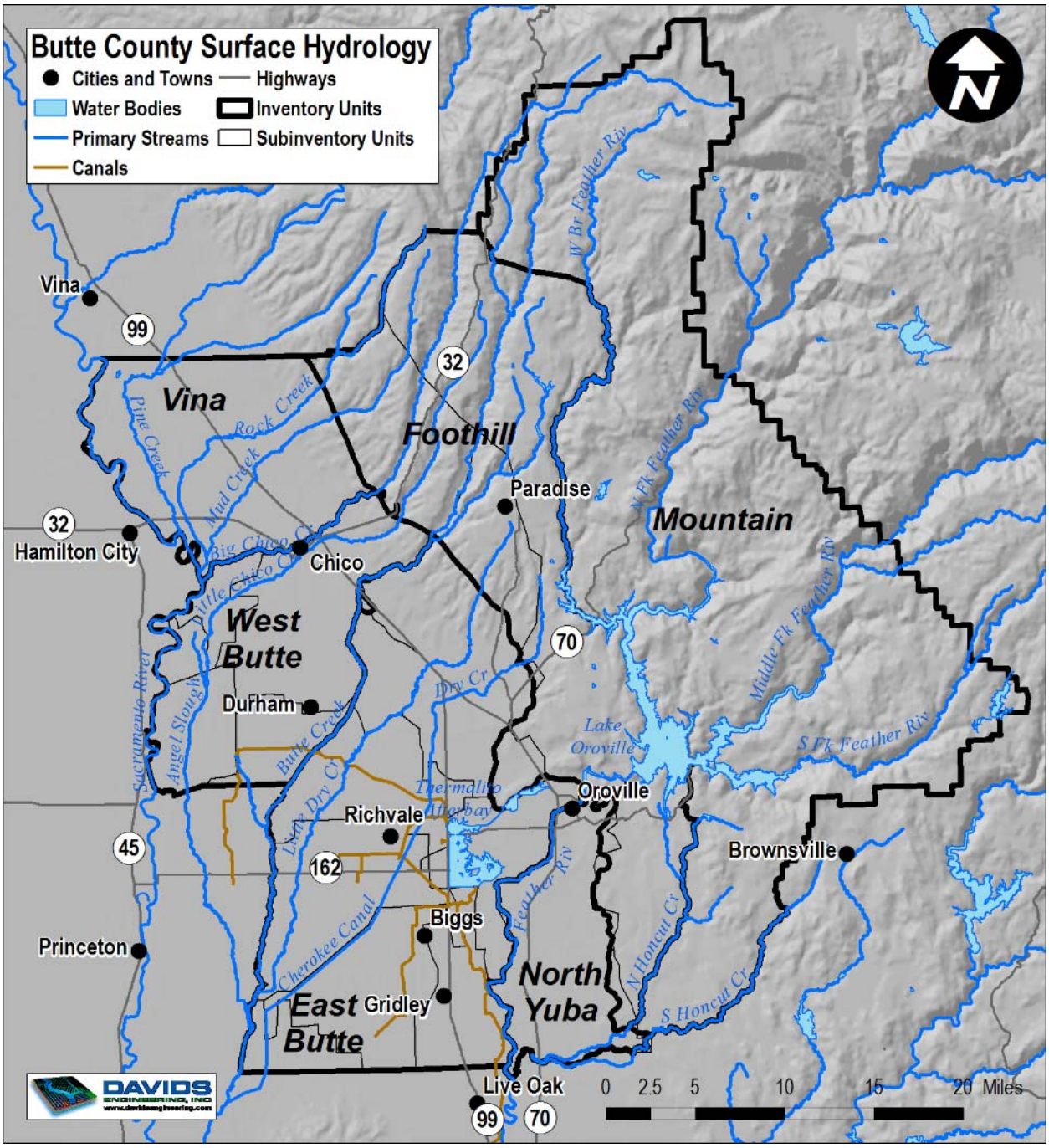

Figure 4.10. Butte County Surface Hydrology.

Historical flows for several surface water channels in Butte County have been estimated as part of the WI&A update and to update datasets for the BBGM. Flows correspond to locations where stream gages currently exist or were historically present, or locations where surface channels enter the valley floor alluvium. Flows summarized below include the following:

- Sacramento River at Vina Bridge[9]
- Feather River at Oroville Full Natural (Unimpaired) Flow[10]
- Butte Creek near Chico[11]
- Big Chico Creek near Chico[12]

As indicated in Figure 4.11, average monthly flows for the Sacramento River are greatest between January and March, reflecting runoff from precipitation on the valley floor, planned reservoir releases, and reservoir spillage in some years. Flows are sustained through July or August and even into November as water is released from storage in Lake Shasta. In contrast, unimpaired Feather River flows and flows from Butte Creek and Big Chico Creek are greatest between approximately February and May as a result of runoff from snowmelt. These flows decrease greatly between May and July once the snow has melted.

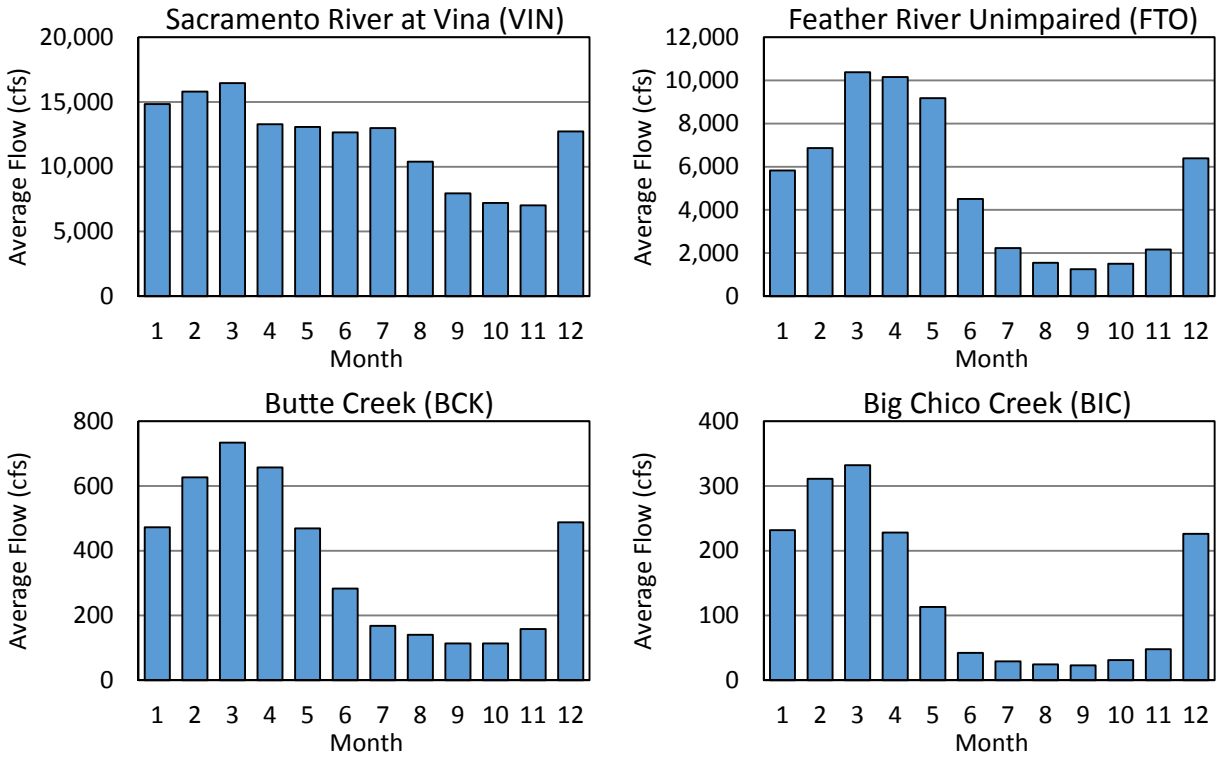

Figure 4.11. Average Monthly Flow by Surface Water Channel, 2000-2014.

Annual runoff varies greatly among streams and from year to year (Figure 4.12). During the 2000 to 2014 period, maximum annual runoff occurred in 2006 for all four streams reported herein, and minimum annual runoff occurred during 2014.

[9] Source: California Data Exchange Center (CDEC) station VIN (cdec.water.ca.gov).
[10] Source: CDEC station FTO (cdec.water.ca.gov).
[11] Source: CDEC station BCK (cdec.water.ca.gov).
[12] Source: CDEC station BIC (cdec.water.ca.gov).

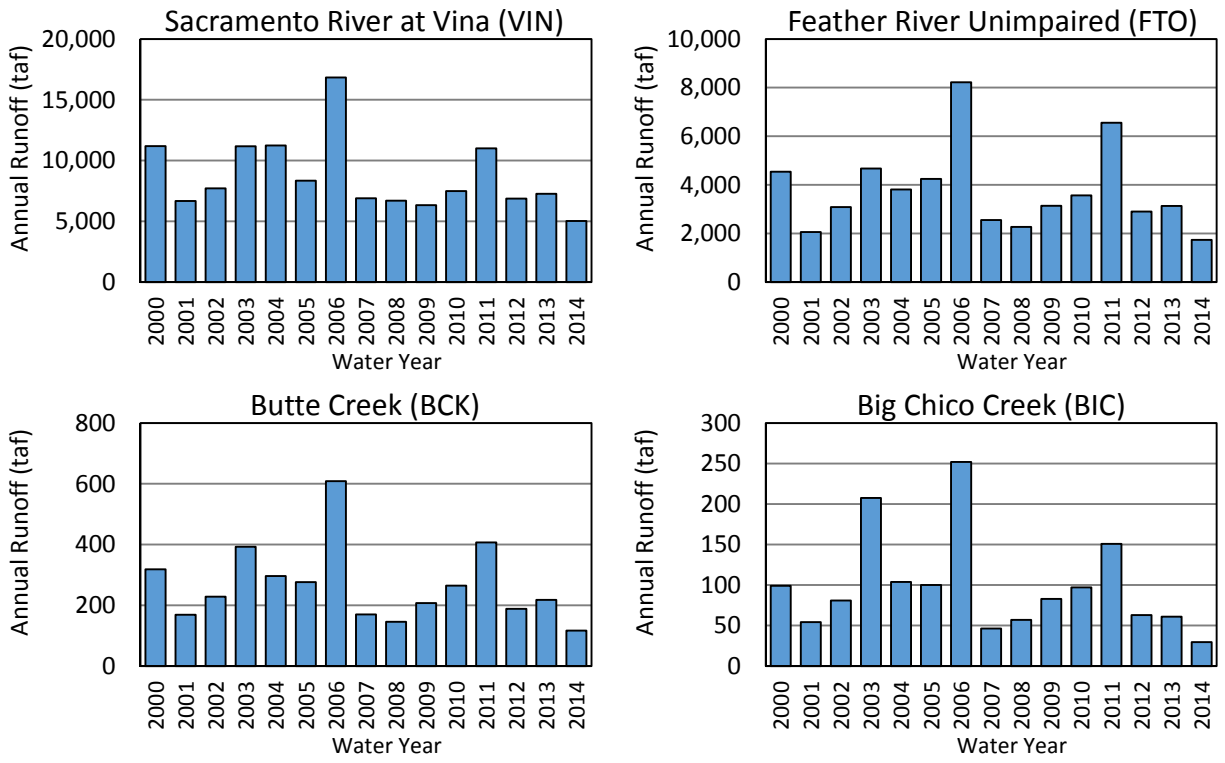

Figure 4.12. Annual Runoff by Surface Water Channel, 2000-2014.

4.2.3 Other Measured Flows

Other measured flows in Butte County include numerous historical and existing stream gages. Data for these gages are available through the California Data Exchange Center (CDEC), from the U.S. Geological Survey (USGS), and through the DWR Water Data Library (WDL). In many cases, data for a particular gage is available from more than one source. For example, several USGS gages are also reported through CDEC. In addition to these public data sources, local water suppliers maintain additional flow monitoring sites to track diversions and flows within canal systems to support system operations. Due to the passage of Senate Bill 88 (SB88), additional real time monitoring of diversions will be conducted in coming years, including the availability of diversion information for large diversions being made publicly available by 2020.

A list of past and current locations in Butte County providing surface water flow and/or storage information is provided in Appendix B. The sites listed include those identified as being located in Butte County by CDEC and USGS. The list includes 34 CDEC sites and 89 USGS sites.

4.2.4 Surface Water Storage

Numerous water storage reservoirs exist within the County. DWR Bulletin 17 provides information on 24 dams in Butte County that fall under the jurisdiction of DWR's Division of Dam Safety (DWR, Bulletin 17, 2000). Table 4.1 lists dams within Butte County under the jurisdiction of the Division of Dam Safety, including information on the dam name, owner, year completed, stream dammed and storage capacity.

Table 4.1. Butte County Dams under Jurisdiction of the Division of Dam Safety.

Reservoir Name	Owner	Year Completed	Stream Impounded	Storage Capacity (acre-feet)
Al Chaffin	George Chaffin	1957	Cottonwood Creek Tributary	450
California Park	California Park Homeowners Association	1986	Dead Horse Slough	335
Cannon Ranch	Spring Valley Minerals	1870	Oregon Gulch Tributary	176
Concow	Thermalito Table Mountain Irrigation District	1925	Concow Creek	8,600
Desabla Forebay	Pacific Gas and Electric Company	1903	Middle Butte Creek	280
Feather River Hatchery	Department of Water Resources	1964	Feather River	580
Forbestown Division	South Feather Water and Power Agency	1962	South Fork Feather River	358
Grizzly Creek	Mr. & Mrs. Ronald T. Dreisbach	1964	Grizzly Creek	76
Kunkle	Pacific Gas and Electric Company	1907	West Branch Feather River Tributary	253
Lake Madrone	Lake Madrone Water District	1931	Berry Creek	200
Lake Wyandotte	South Feather Water and Power Agency	1924	North Honcut Creek	1,300
Lost Creek	South Feather Water and Power Agency	1924	Lost Creek	5,680
Magalia	Paradise Irrigation District	1918	Little Butte Creek	2,900[13]
Miners Ranch	South Feather Water and Power Agency	1962	North Honcut Creek Tributary	912
Oroville	Department of Water Resources	1968	Feather River	3,537,577
Paradise	Paradise Irrigation District	1957	Little Butte Creek	11,500
Philbrook	Pacific Gas and Electric Company	1926	Philbrook Creek	5,180
Poe	Pacific Gas and Electric Company	1959	North Fork Feather River	1,150
Ponderosa Division	South Feather Water and Power Agency	1962	South Fork Feather River	4,750
Round Valley	Pacific Gas and Electric Company	1877	West Branch Feather River	1,147
Sly Creek	South Feather Water and Power Agency	1961	Lost Creek	65,050
Thermalito Afterbay	Department of Water Resources	1967	Feather River Tributary	57,041
Thermalito Division	Department of Water Resources	1967	Feather River	13,328
Thermalito Forebay	Department of Water Resources	1967	Cottonwood Creek Tributary	11,768

[13] Storage capacity of 2,900 af based on DWR Bulletin 17. According to Paradise Irrigation District, actual storage is currently limited to 800 af.

4.2.5 Irrigation Water Source

Areas with access to surface water for irrigation include the southern portion of the West Butte IU and the majority of the East Butte IU. Other areas with surface water supplies also exist within the County as shown in Figure 4.13. The figure shows the water source for irrigation based on DWR's 2011 land and water use survey for Butte County. In addition to areas with access to surface water for irrigation, areas reliant on groundwater or a mix of groundwater and surface water are also shown.

4.2.6 Diversions

Surface water diversions to meet demands for irrigated agriculture, wetlands, and developed lands are summarized in this section. Primary surface streams providing water supplies in Butte County include the Feather River and Butte Creek. Water is also diverted from the Sacramento River and other, minor sources[14]. The vast majority of these diversions occur within the valley floor IUs, although Paradise Irrigation District also diverts water for domestic and M&I use within its service area. Recent historical diversions are summarized for the County as a whole and for each valley floor IU.

Diversions are subject to limitations based on diversion agreement terms (e.g. settlement contracts between DWR and Western Canal Water District and the Joint Districts) and regulatory actions of the State Water Resources Control Board (SWRCB). SWRCB regulatory actions to curtail diversions may apply to senior pre-1914 and riparian water rights in periods of drought.

Butte County

Estimated annual diversions for water years 2000 to 2014 are presented in Figure 4.14. Total surface water diversions during this period ranged from 742,600 af to 906,800 af with an average of 827,900 af. Feather River diversions ranged from 629,900 af to 778,600 af during this period with an average of 696,600 af. Butte Creek diversions ranged from 24,400 af to 71,600 af with an average of 54,700 af. Sacramento River diversions ranged from 2,400 af to 18,300 af with an average of 8,400 af. Other diversions ranged from 49,400 af to 58,800 af with an average of 54,600 af.

The primary destination of diverted surface water in Butte County is irrigation deliveries; however, some water is lost through conveyance to seepage, spillage, and evaporation. Estimated annual deliveries and conveyance losses between 2000 and 2014 are presented in Figure 4.15. Deliveries ranged from 635,300 af to 777,100 af with an average of 709,200 af. Losses to seepage, spillage, and evaporation averaged 55,200 af, 58,800 af, and 4,700 af, respectively.

[14] Other sources include miscellaneous riparian diversions and surface water supplies. These include diversions from the Feather River watershed other than the Feather River Settlement Contractors (e.g., South Feather Water and Power) and the Cherokee Canal.

Annual diversions were substantially less in 2015 than during the 2000-2014 period due to curtailments of Feather River, Butte Creek, and Sacramento River supplies. Estimated diversions during 2015, considered provisional at the time of preparation of this report, are included in Appendix D.

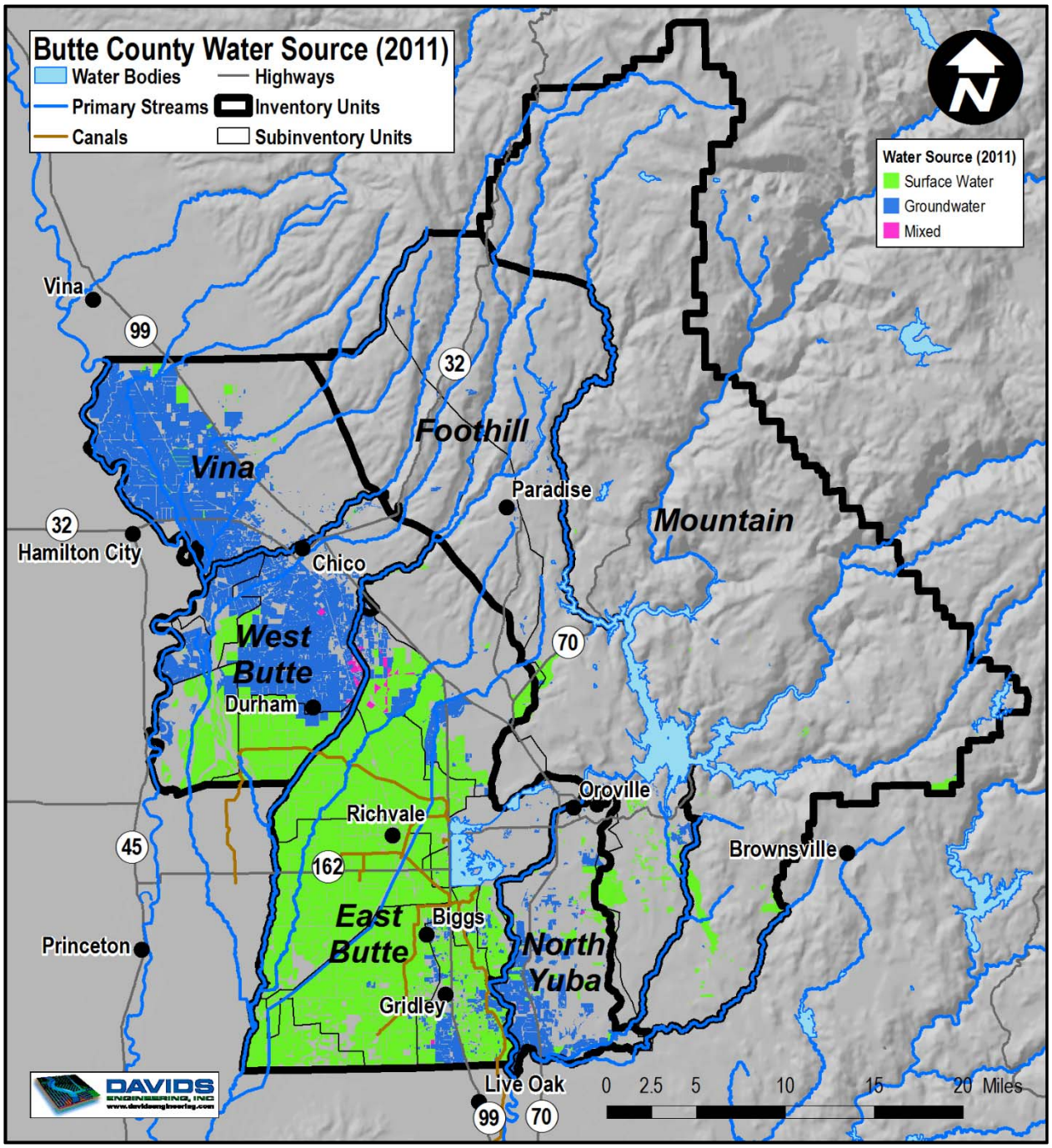

Figure 4.13. Butte County Irrigation Water Source, 2011 (Source: DWR).

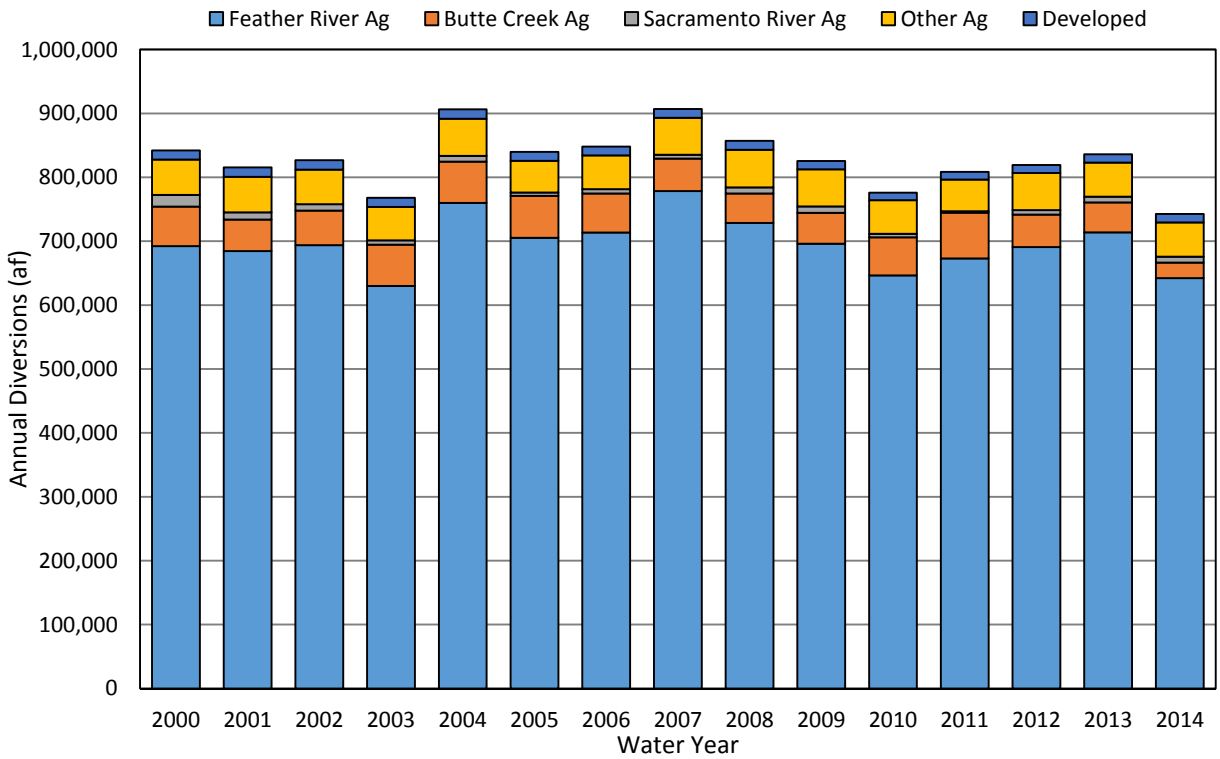

Figure 4.14. Butte County Estimated Surface Water Diversions by Source, 2000-2014.

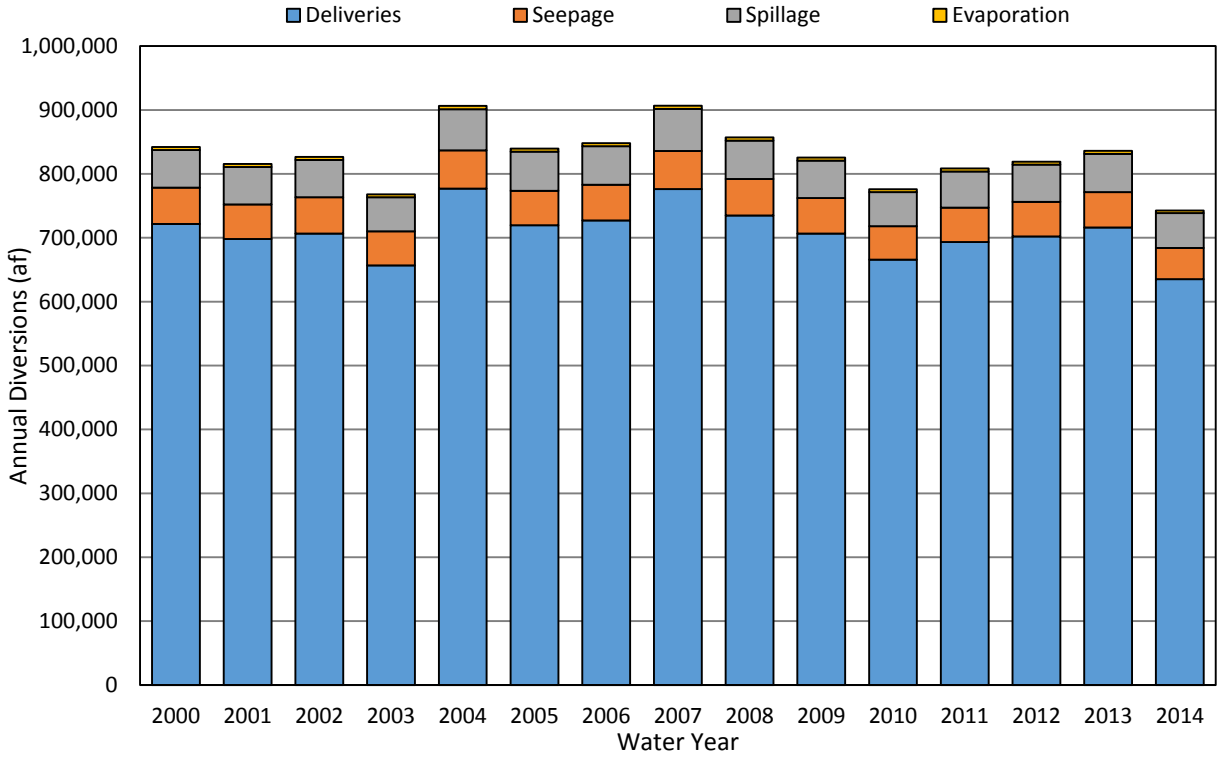

Figure 4.15. Butte County Estimated Surface Water Deliveries and Conveyance Losses, 2000-2014.

Vina Inventory Unit

Surface water diversions to meet demands within the Vina IU are limited to minor riparian diversions for irrigation. There are no surface water diversions for domestic or municipal and industrial (M&I) use in Vina. Estimated annual diversions for water years 2000 to 2014 from the Sacramento River are presented in Figure 4.16. Total surface water diversions during this period ranged from 9,400 af to 12,400 af with an average of 11,000 af.

The primary destination of diverted surface water in the Vina IU is irrigation deliveries; however, some water is lost through conveyance to seepage, spillage, and evaporation. Estimated annual deliveries and conveyance losses between 2000 and 2014 are presented in Figure 4.17. Deliveries ranged from 6,700 af to 8,900 af with an average of 7,900 af. Losses to seepage, spillage, and evaporation averaged 2,000 af, 800 af, and 300 af, respectively.

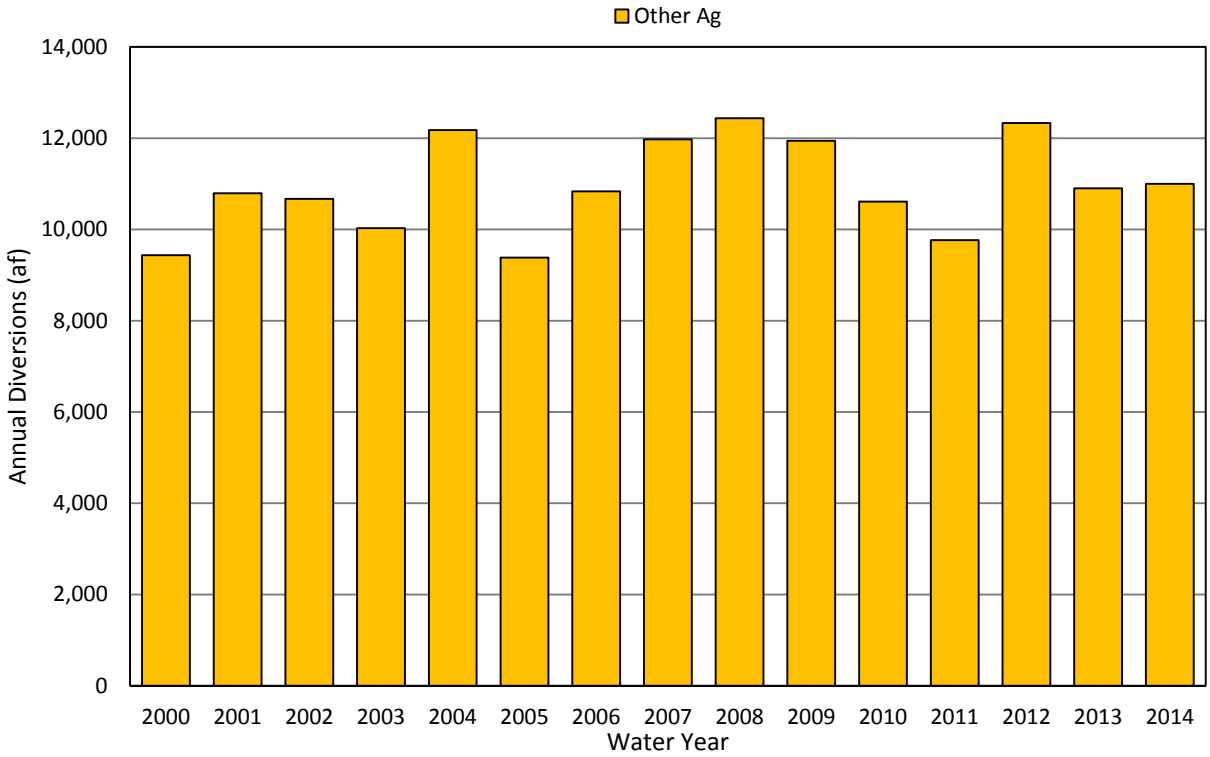

Figure 4.16. Vina Inventory Unit Estimated Surface Water Diversions by Source, 2000-2014.

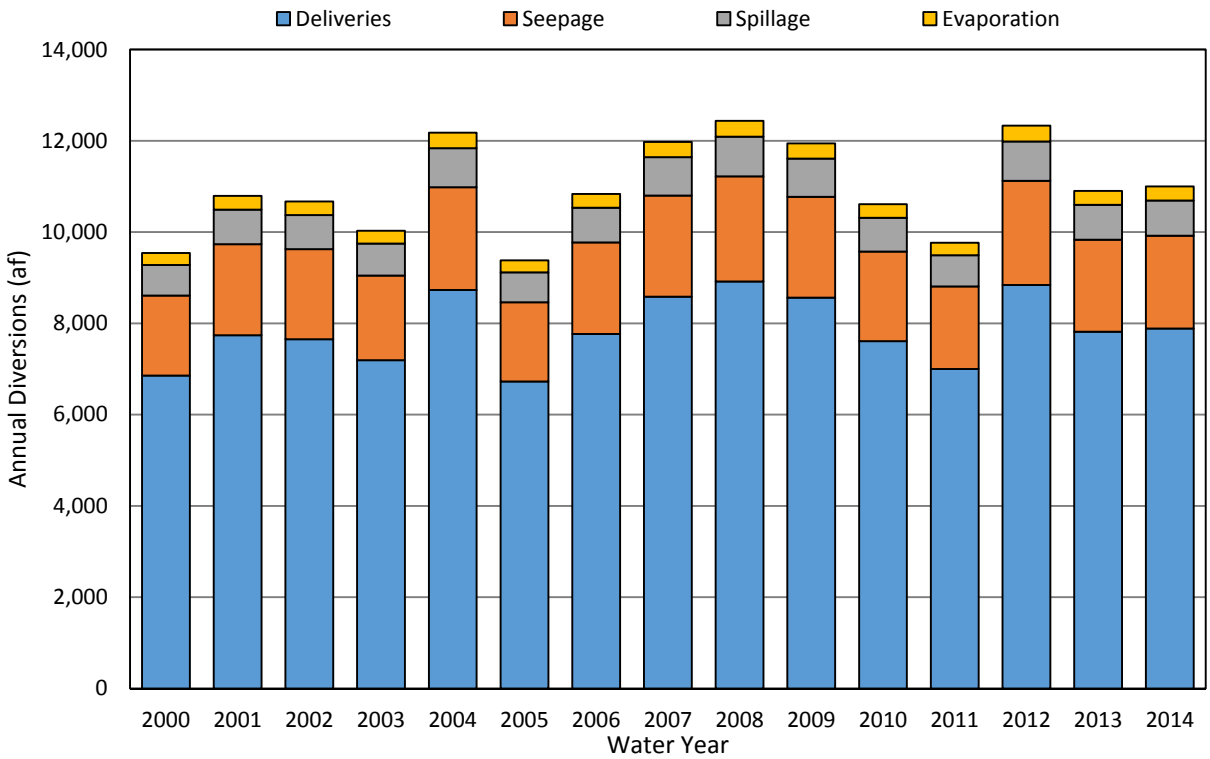

Figure 4.17. Vina Inventory Unit Estimated Surface Water Deliveries and Conveyance Losses, 2000-2014.

West Butte Inventory Unit

Surface water diversions to meet demands within the West Butte IU include diversions from the Feather River by Western Canal Water District; from Butte Creek by Dayton Mutual Water Company, Durham Mutual Water Company, Llano Seco Rancho, and M&T Chico Ranch; and from the Sacramento River by Llano Seco Rancho, M&T Chico Ranch, and riparian diverters in the Angel Slough SIU. M&T also has water rights to a small amount of water from Little Chico Creek. There are no surface water diversions for domestic or municipal and industrial (M&I) use in West Butte.

Estimated annual diversions for water years 2000 to 2014 are presented in Figure 4.18. Total surface water diversions during this period ranged from 92,500 af to 124,800 af with an average of 108,400 af. Feather River diversions ranged from 54,900 af to 70,700 af during this period with an average of 65,300 af. Butte Creek diversions ranged from 16,400 af to 41,800 af with an average of 34,700 af. Sacramento River diversions ranged from 2,400 af to 18,200 af with an average of 8,400 af.

The primary destination of diverted surface water in the West Butte IU is irrigation deliveries; however, some water is lost through conveyance to seepage, spillage, and evaporation. Estimated annual deliveries and conveyance losses between 2000 and 2014 are presented in Figure 4.19. Deliveries ranged from 81,000 af to 101,300 af with an average of 94,400 af.

Losses to seepage, spillage, and evaporation averaged 8,300 af, 4,800 af, and 900 af, respectively.

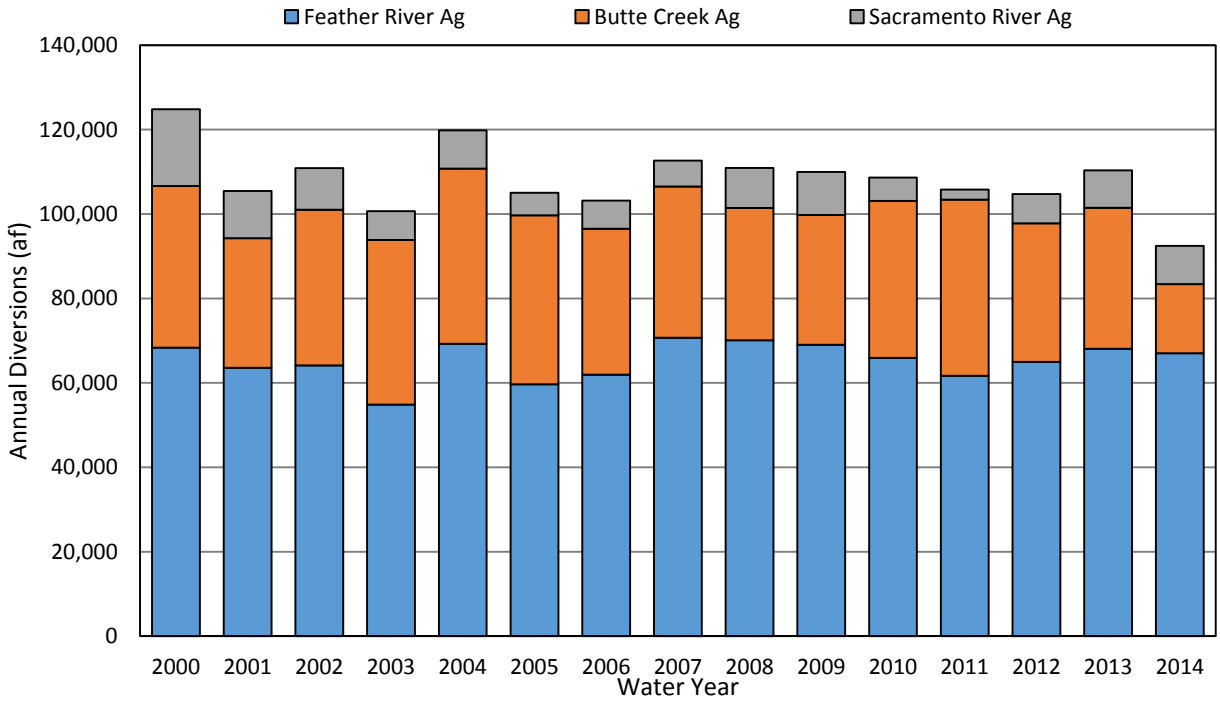

Figure 4.18. West Butte Inventory Unit Estimated Surface Water Diversions by Source, 2000-2014.

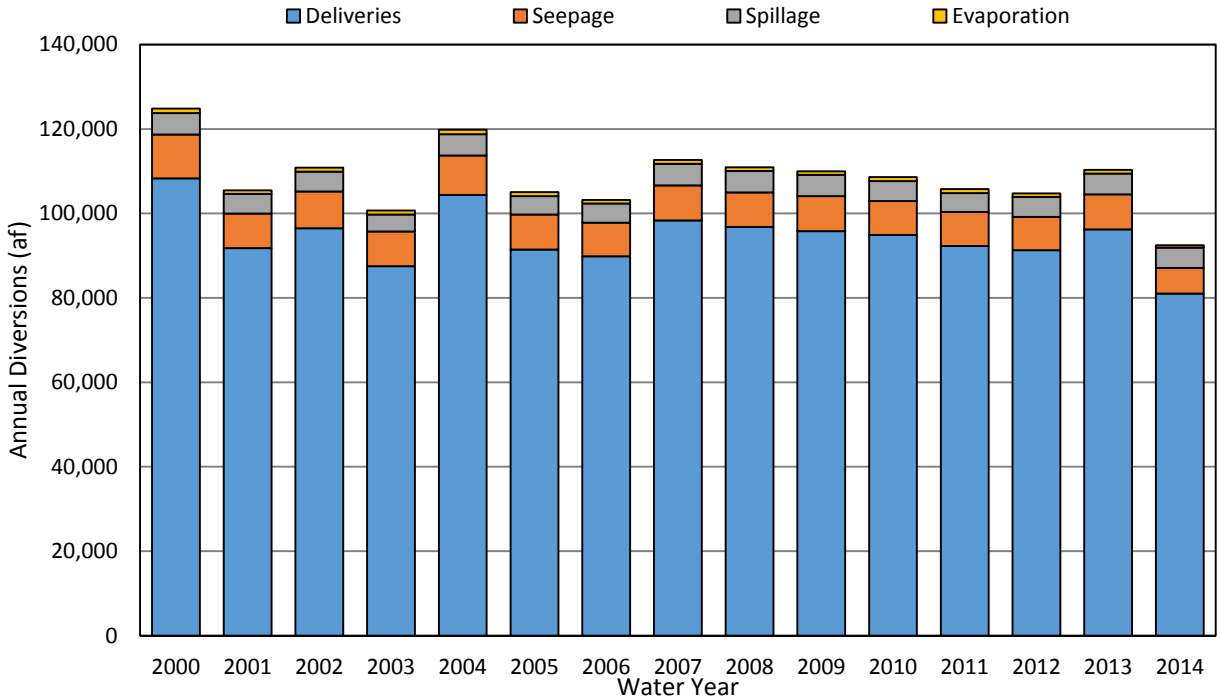

Figure 4.19. West Butte Inventory Unit Estimated Surface Water Deliveries and Conveyance Losses, 2000-2014.

East Butte Inventory Unit

Surface water diversions to meet demands within the East Butte IU include diversions from the Feather River by Western Canal Water District, Richvale Irrigation District, Biggs-West Gridley Water District, and Butte Water District; from Butte Creek by Durham Mutual Water Company, Rancho Esquon, and Western Canal Water District; and other diversions in the Cherokee, Thermalito, and Butte Sink subinventory units. In addition to diversions for irrigation and wetlands, these other diversions include water diverted by Thermalito Water and Sewer District for domestic and M&I use.

Estimated annual diversions for water years 2000 to 2014 are presented in Figure 4.20. Total surface water diversions during this period ranged from 617,000 af to 758,500 af with an average of 686,200 af. Feather River diversions ranged from 575,100 af to 707,900 af during this period with an average of 631,300 af. Butte Creek diversions ranged from 8,000 af to 29,800 af with an average of 20,000 af. Other diversions ranged from 30,100 af to 35,500 af with an average of 32,700 af.

The primary destination of diverted surface water in the East Butte IU is irrigation deliveries; however, some water is lost through conveyance to seepage, spillage, and evaporation. Estimated annual deliveries and conveyance losses between 2000 and 2014 are presented in Figure 4.21. Deliveries ranged from 527,300 af to 649,100 af with an average of 587,700 af. Losses to seepage, spillage, and evaporation averaged 42,800 af, 52,500 af, and 3,200 af, respectively.

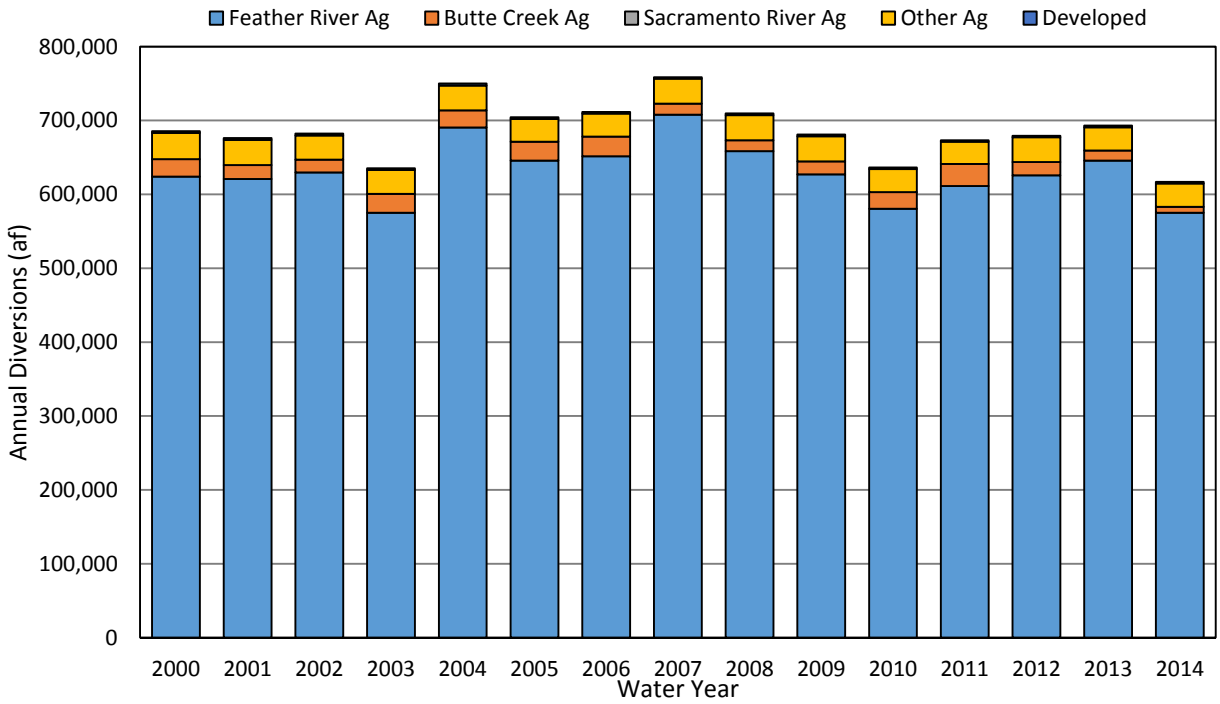

Figure 4.20. East Butte Inventory Unit Estimated Surface Water Diversions by Source, 2000-2014.

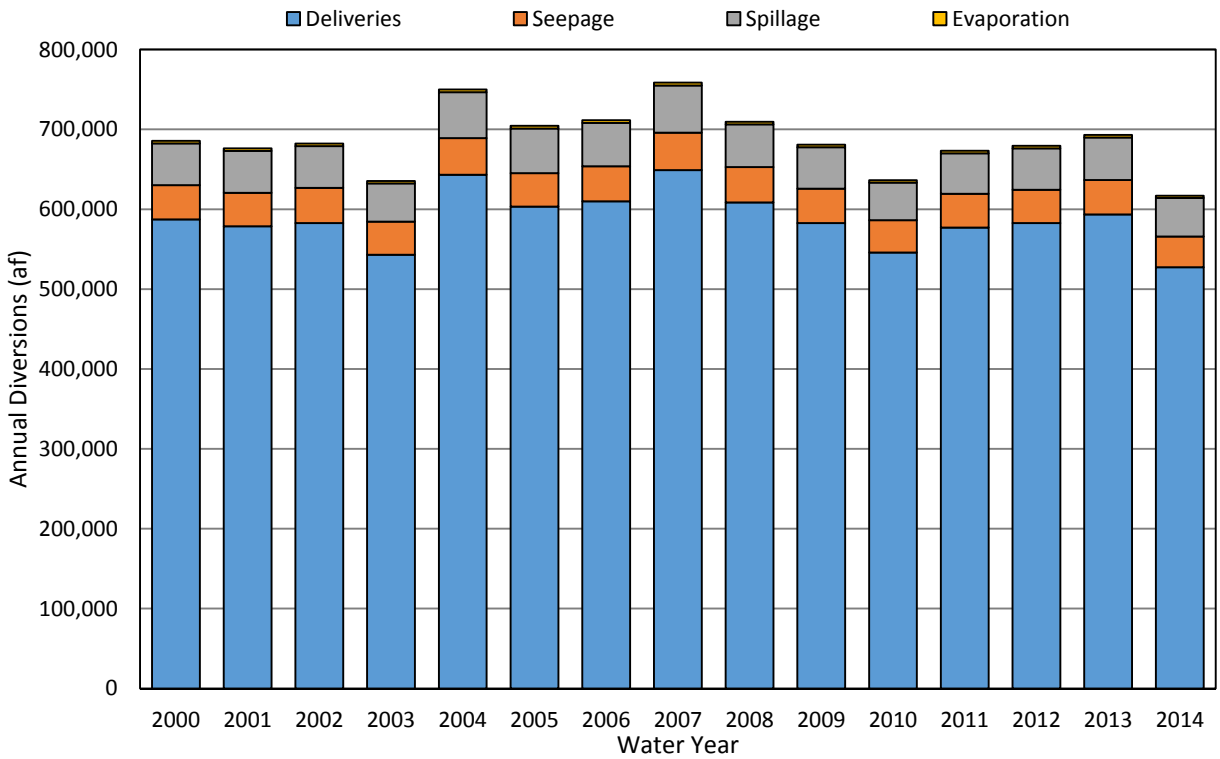

Figure 4.21. East Butte Inventory Unit Estimated Surface Water Deliveries and Conveyance Losses, 2000-2014.

North Yuba Inventory Unit

Surface water diversions to meet demands within the North Yuba IU include diversions by South Feather Water and Power Agency and CalWater Oroville. Diversions by South Feather are for irrigation and domestic and M&I use, while diversions by CalWater are exclusively for domestic and M&I use. Estimated annual diversions for water years 2000 to 2014 are presented in Figure 4.22. Total surface water diversions during this period ranged from 13,300 af to 16,200 af with an average of 14,900 af.

The primary destination of diverted surface water in the North Yuba IU is irrigation deliveries; however, some water is lost through conveyance to seepage, spillage, and evaporation. Estimated annual deliveries and conveyance losses between 2000 and 2014 are presented in Figure 4.23. Deliveries ranged from 10,600 af to 12,700 af with an average of 11,700 af. Losses to seepage, spillage, and evaporation averaged 2,000 af, 800 af, and 300 af, respectively.

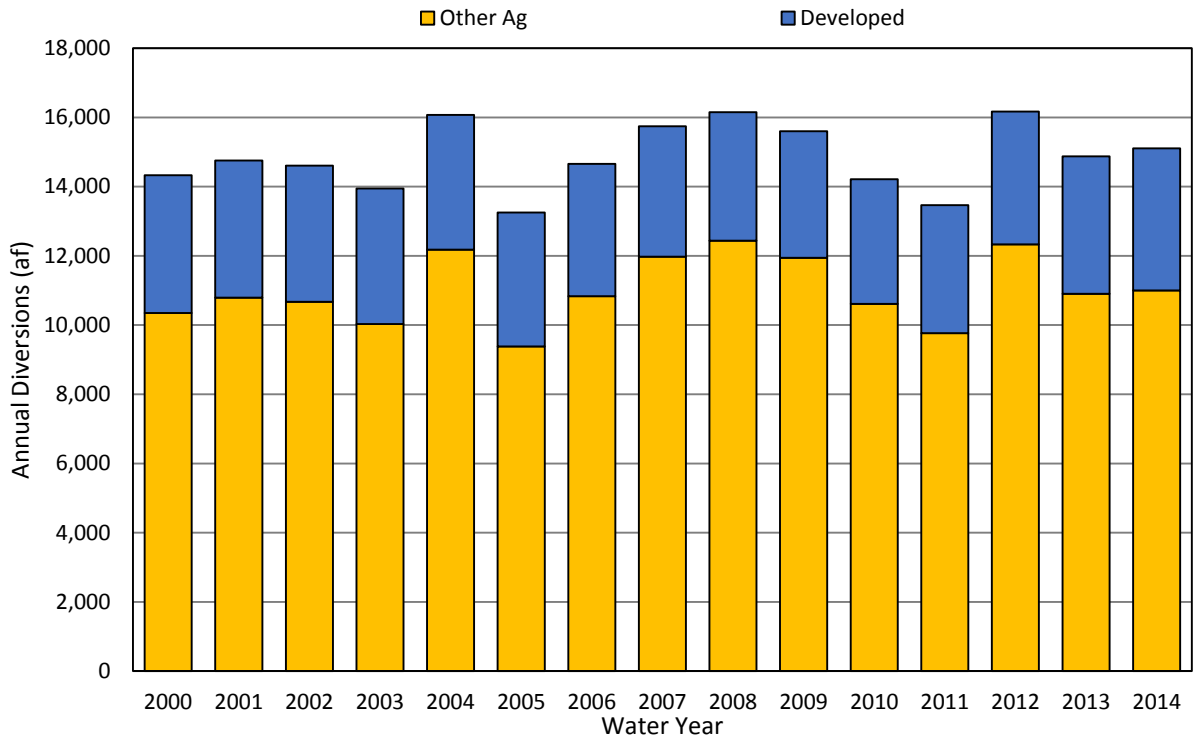

Figure 4.22. North Yuba Inventory Unit Estimated Surface Water Diversions by Source, 2000-2014.

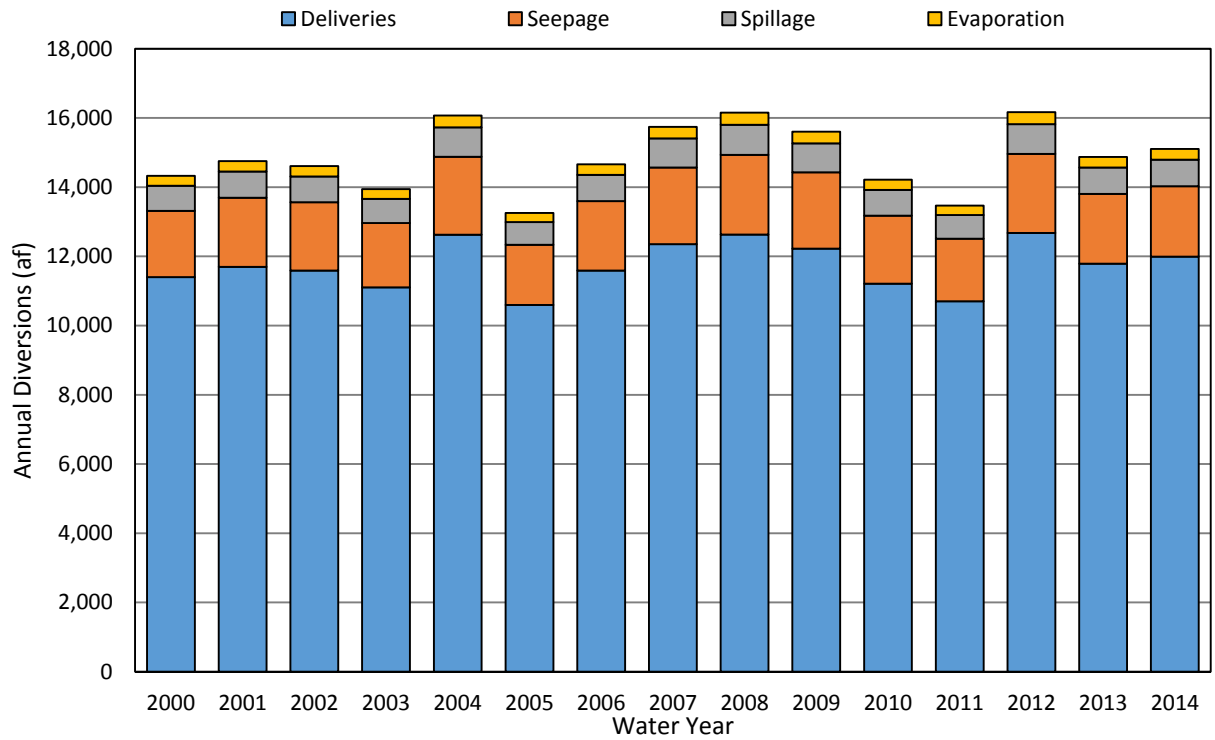

Figure 4.23. North Yuba Inventory Unit Estimated Surface Water Deliveries and Conveyance Losses, 2000-2014.

4.3 Groundwater Hydrology

This section provides a brief background on the hydrogeology of the County and the differences between the Valley and Foothill and Mountain aquifer systems. It then describes the groundwater conditions in the Butte County portions of Sacramento Valley groundwater subbasins (Vina, West Butte, East Butte and North Yuba inventory units) based on available groundwater level monitoring data and estimates of groundwater pumping. Finally, the distribution and number of wells in each inventory unit is provided and discussed.

Current groundwater level conditions are documented each year in the Annual Groundwater Status Report, available on the Department's webpage (www.buttecounty.net/waterresourceconservation/GroundwaterStatusReports).

4.3.1 Hydrogeology

Other reports have detailed the hydrogeology of the Sacramento Valley and the formations making up the aquifer systems in Butte County. These reports by the Department of Water Resources include the *Geology of the Northern Sacramento Valley, 2014 (DWR 2014)*, the *Butte County Groundwater Inventory Analysis, 2005 (DWR 2005)*, and the Butte County *Lower Tuscan Aquifer Monitoring, Recharge, and Data Management Project final report, 2013 (Brown and Caldwell 2013)*. Included below is a brief overview of the local hydrogeology.

Butte County hydrogeology is generally characterized by two different types of groundwater systems. In the Foothill and Mountain inventory units (IUs), fractured rock aquifers provide variable amounts of water primarily to domestic wells. In fractured rock, water fills the space between cracks and fractures in the rock and therefore the degree of fracturing and the extent to which those fractures are connected highly influences potential well production. Conditions are highly variable, and water levels or production of a well in one location does not necessarily provide information on what conditions may be in another well, even if it is nearby. Therefore, groundwater level monitoring is not conducted in the fractured rock areas of the county.

In the Foothill region, groundwater occurs in the fractures and joints of the Tuscan Formation volcanic mudflows, as well as in the weathered horizons between buried mudflows. Lesser amounts of groundwater are found in the Modesto Formation, which is a localized source of groundwater and supplies moderate amounts of water to shallow wells. The Tuscan Formation is also found in the Mountain Region but it is tightly cemented and consolidated and supplies only limited amounts of water. Where groundwater does occur, it is limited to the fractures and joints within the volcanic mudflows and breccias (DWR 2005).

Wells in fractured rock in the Foothill and Mountain regions are at greatest risk of producing less water or "going dry" from year to year and especially during drought and dry periods. During the drought period beginning in 2012, the County received a number of reports of wells in the Cohasset, Forest Ranch, and other foothill areas having problems or no longer supplying water for domestic use. Wells that historically experienced water supply reliability problems in the fall from year to year, began having problems earlier in the year in the spring or summer.

The majority of Butte County's groundwater resources come from the Sacramento Valley Region where spaces between gravel, sand, and clay particles of various formations store and transmit water in the aquifer systems. Principal hydrogeologic units of the Sacramento Valley groundwater basin consist of Pliocene sedimentary deposits, such as the Tuscan, Laguna, and Tehama formations, and Quaternary terrace deposits, such as the Riverbank and Modesto formations. Aquifer systems composed of Tuscan, Laguna, and Tehama formations are the source of water for deep irrigation and municipal wells, while the Riverbank and Modesto formations yield water to the shallower domestic wells (DWR 2005).

A notable feature within West and East Butte inventory units is the Butte Basin. This area lies south of Chico and west of the Feather River. Characterized by an expansive, flat topography, the Butte Basin was, prior to flood control on the Feather and Sacramento rivers, an area of extensive seasonal flooding. This slow-moving floodwater deposited the fine clay that now provides the rich agricultural soil used primarily for rice production (DWR 2005). In this area, groundwater mounds up on the north side of the Sutter Buttes before it flows westward around the Buttes and between the buried Colusa dome and southward (DWR, 2014).

The 2014 and 2005 DWR reports (DWR 2014 and DWR 2005) provide more details on Sacramento Valley geology and individual geologic formations and structure. DWR has developed geologic cross sections of the region which are included in the 2014 DWR report along with maps of surficial geology. Other research by Dr. Todd Greene at California State University, Chico is exploring and mapping the hydrostratigraphy of the Lower Tuscan and Tehama Aquifer (Greene and Hoover 2014). Better understanding the hydrogeology, aquifer dynamics, and recharge paths of the aquifer systems in Butte County and the Northern Sacramento Valley region is an area of active research by Butte County, DWR, and others.

4.3.2 Valley Floor Groundwater Conditions

This section describes the general directions of groundwater flow in the County and trends in groundwater levels and groundwater pumping in each inventory unit. The purpose of this section is to provide an overview of groundwater conditions to provide context for the water budgets provided in Section 5.

Groundwater levels are monitored through a cooperative agreement between DWR and Butte County and provide the basis for the groundwater contour map, change in groundwater level map, and hydrographs from specific wells included in this section.

Groundwater Movement

The overall pattern of groundwater movement in Butte County during spring is southwesterly toward the Sacramento River. The direction of groundwater movement is illustrated in Figure 4.24 by a series of small arrows perpendicular to the groundwater elevation contours. These contours are created from water level measurements collected from wells during the spring of 2012. Water level measurements are filtered based on well construction information (when

available) and are intended to approximate groundwater elevations in the unconfined to uppermost semi-confined portions of the aquifer.

Locally, the movement of groundwater varies. Isolated areas of groundwater depression are located in the City of Chico resulting from year-round pumping of groundwater for municipal use. South of Chico in the vicinity of Durham, where agricultural pumping is greatest, a cone of depression has formed causing water to move toward that area. South of there, the southwesterly pattern of movement resumes with a generally uniform gradient through the southwestern portion of the county where surface water is mainly used for irrigation and groundwater levels tend to be stable. Another small depression is located in the southeast portion of the basin.

An interesting flow pattern is also present in the southwestern corner of the East Butte Inventory Unit. The valley sediments deformed by the intrusion of the Sutter Buttes and the buried Colusa Dome, west of the Sutter Buttes, partially control groundwater flow in this area. The Sutter Buttes block the general north-to-south trend of groundwater migration, forcing groundwater to the surface. The upward movement results in a shallow groundwater table, shallow gradient (indicated by contours that are farther apart), and the formation of wetlands along the west side of the Sutter Buttes.

Direction of movement can vary from year to year. During drought years when groundwater use increases, areas of groundwater depression can be exacerbated.

Groundwater Level Change

Groundwater level change maps produced by DWR Northern Region Office (NRO) provide a snapshot of how groundwater conditions have changed over time. Figure 4.25 shows the difference between measured water levels in the spring of 2004 and the spring of 2015 for the main pumping zone of the aquifer system, wells 100-450 feet deep. This maps shows the areas of greatest decline to be in the Vina and West Butte inventory units, where groundwater demand to meet urban and agricultural demands is greatest. In contrast, it highlights the relatively stable groundwater conditions in the southern portion of the County mostly corresponding to surface water irrigated agriculture.

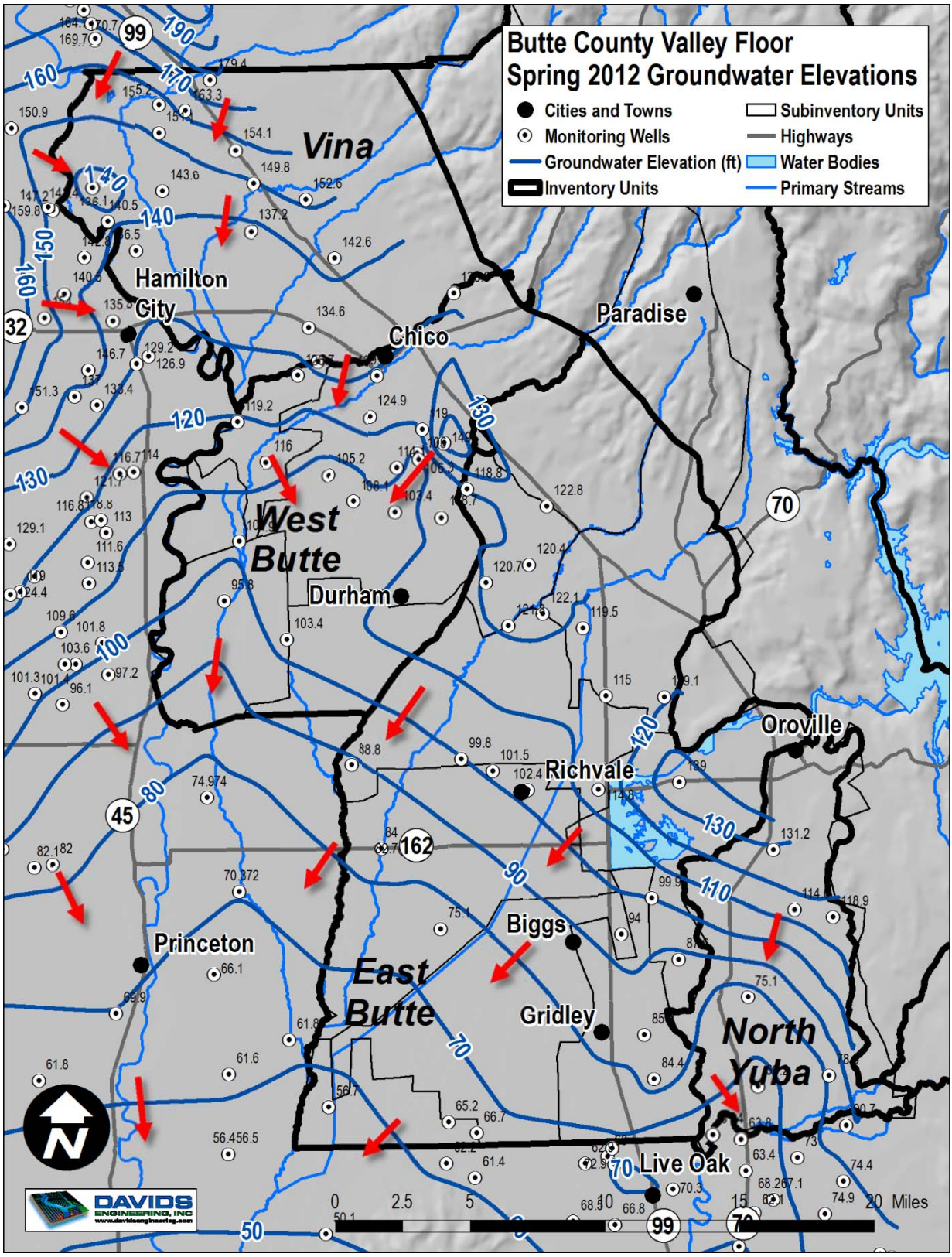

Figure 4.24. Spring 2012 Groundwater Elevations, with Flow Direction Indicated by Red Arrows (Source: DWR Groundwater Information Center).

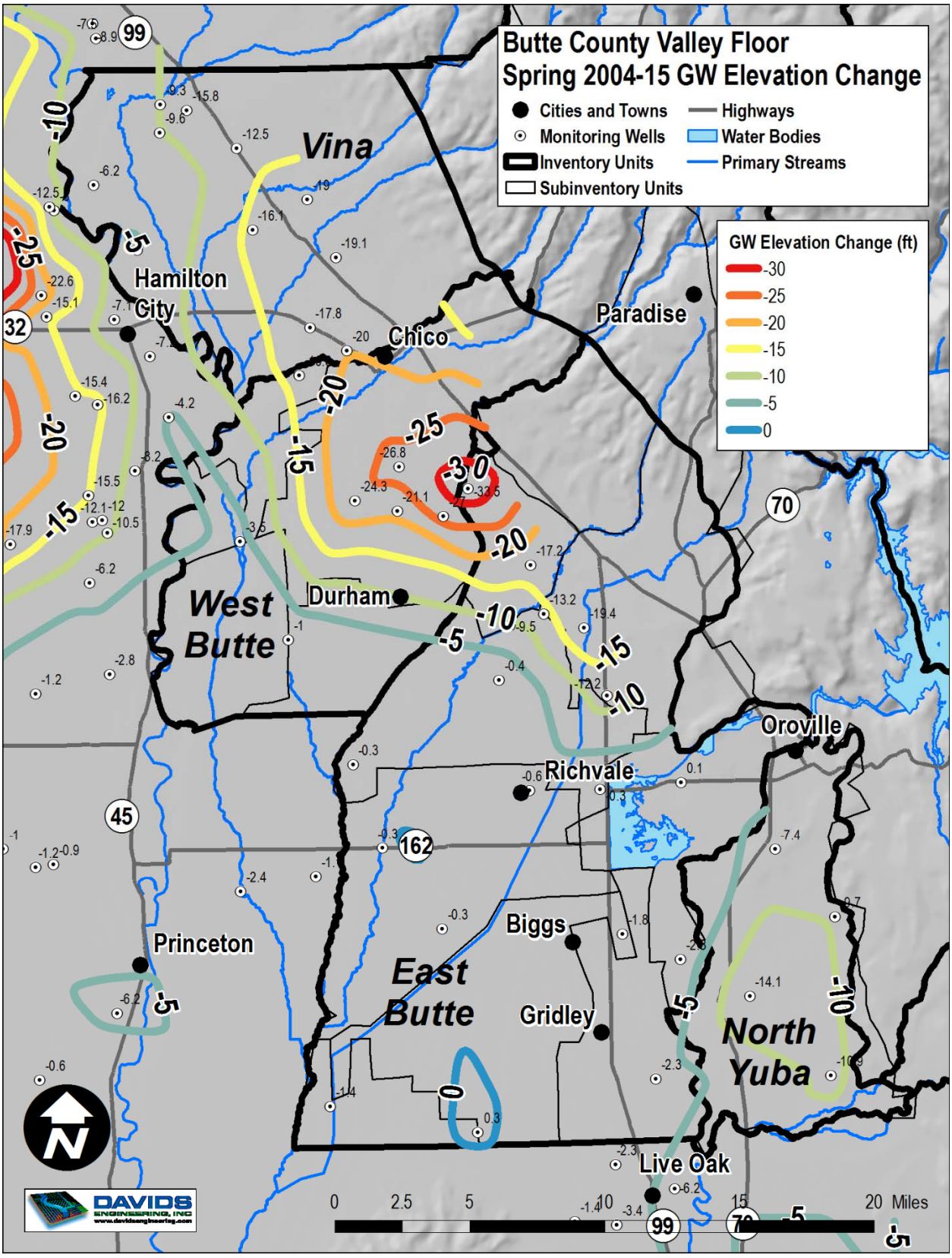

Figure 4.25. Groundwater Elevation Change, Spring 2004 to 2015 for Wells 100-450 feet Deep.

Groundwater Levels

Within the Butte County portion of the Sacramento Valley groundwater basin, groundwater level monitoring is conducted by a cooperative effort between Butte County and DWR NRO. Water levels are monitored in a network of approximately 140 wells in March, July, August, and October. The number of wells and type are summarized for these wells in Table 4.2, and the well locations are shown in Figure 4.26. A list of individual monitoring wells is provided in Appendix B.

Due to recent drought conditions, water levels were measured monthly from March through October in 2014, 2015, and 2016. A number of these wells are multi-completion dedicated monitoring wells and the rest are agricultural or domestic wells. These data provides information on groundwater storage conditions and water level trends dating back to the late 1940s in some cases and are available online from the state's Water Data Library (http://www.water.ca.gov/waterdatalibrary/). In addition, California Water Service Chico and Oroville districts provide spring and fall groundwater level data for a selection of their wells for inclusion in annual County reporting (see Appendix G of the County's Groundwater Status Report).

Groundwater level conditions are described in each Inventory Unit in the following sections.

Table 4.2. Number of Butte County Monitoring Wells by Inventory Unit and Well Type.

	Monitoring Well Count					
Inventory Unit	**Irrigation**	**Observation**	**Residential**	**Stockwatering**	**Other**	**Total**
Vina	9	15	6	0	0	30
West Butte	20	17	4	1	0	42
East Butte	14	30	12	0	4	60
North Yuba	5	0	2	0	1	8
Totals	48	62	24	1	5	140

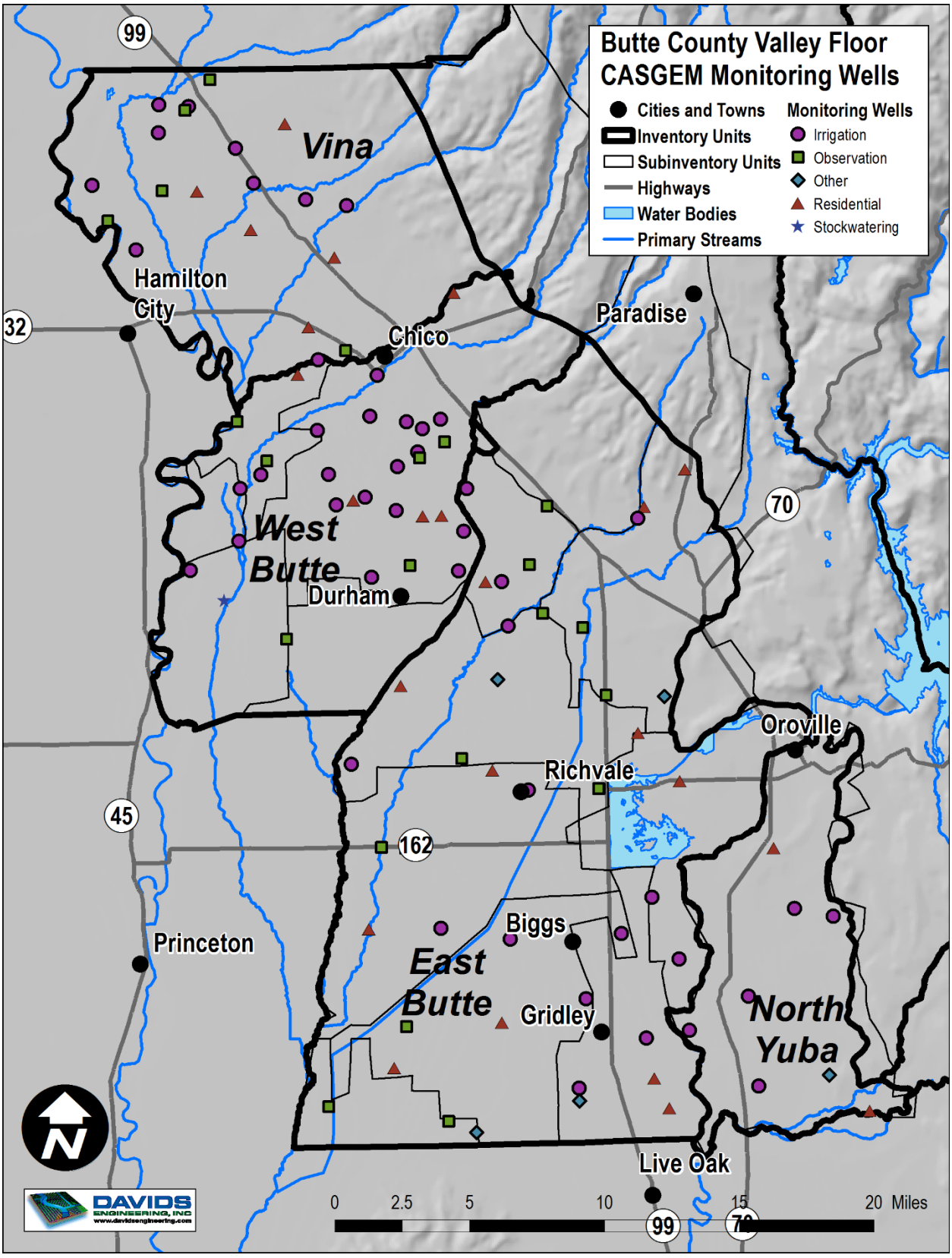

Figure 4.26. Butte County Monitoring Wells.

Vina Inventory Unit

The Vina Subbasin (5-21.57) covers about 75,000 acres in the northern portion of Butte County in the Sacramento Valley Groundwater Basin. It is bordered by Tehama County to the north, Big Chico Creek to the south, the Sacramento River to the west, and the foothills to the east. The Vina aquifer system includes stream channel and alluvial fan deposits, and deposits of the Modesto and Tuscan formations.

The Vina inventory unit has a network of about 30 monitoring wells. A number of these wells are multi-completion dedicated monitoring wells and the rest are agricultural or household wells. This data provides information on groundwater storage conditions and water level trends dating back to the late 1950s in some cases. In addition, the CalWater Service area covers a portion of the inventory unit and Cal Water-Chico provides spring and fall groundwater level data for seven of their wells for inclusion in annual County reporting.

Groundwater serves as the sole source of agricultural irrigation water for the vast majority of the Vina inventory unit, as shown in the map of irrigation water source from DWR land use surveys (Figure 4.13). Groundwater levels have been declining on the order of 1-2 feet per year for the past 10 years, with the exception of a couple of wet years that occurred during that time (namely 2006 and 2011). This has resulted in declines in groundwater levels in the primary pumping zone (100-450 feet below ground surface) of up to 15-20 feet (Figure 4.25). Declines are greatest in the Chico area and toward the eastern side of the inventory unit. A significant portion of these water level declines has occurred over the past four years of severe drought, about 7-16 feet. Groundwater levels are closer to the ground surface in the western part of the inventory unit near the Sacramento River.

A number of monitoring wells with long periods of record are reaching new historical lows. These wells tend to be shallow (<200 feet) domestic wells, however irrigation wells have reportedly experienced reduced pressure, production, or water supply reliability problems in recent years as well. Figure 4.27 shows groundwater levels from a shallow domestic well near the center of the inventory unit, 23N01W36P001M. The hydrograph shows trends in groundwater levels since 1959 with declines during previous drought periods and recently declining spring levels on the order of 16 feet from 2004 to 2015.

Hydrographs for all BMO wells in the Vina inventory unit can be viewed in the BMO reports for Vina and the Chico Urban Area found in Appendix G of the Groundwater Status Report.

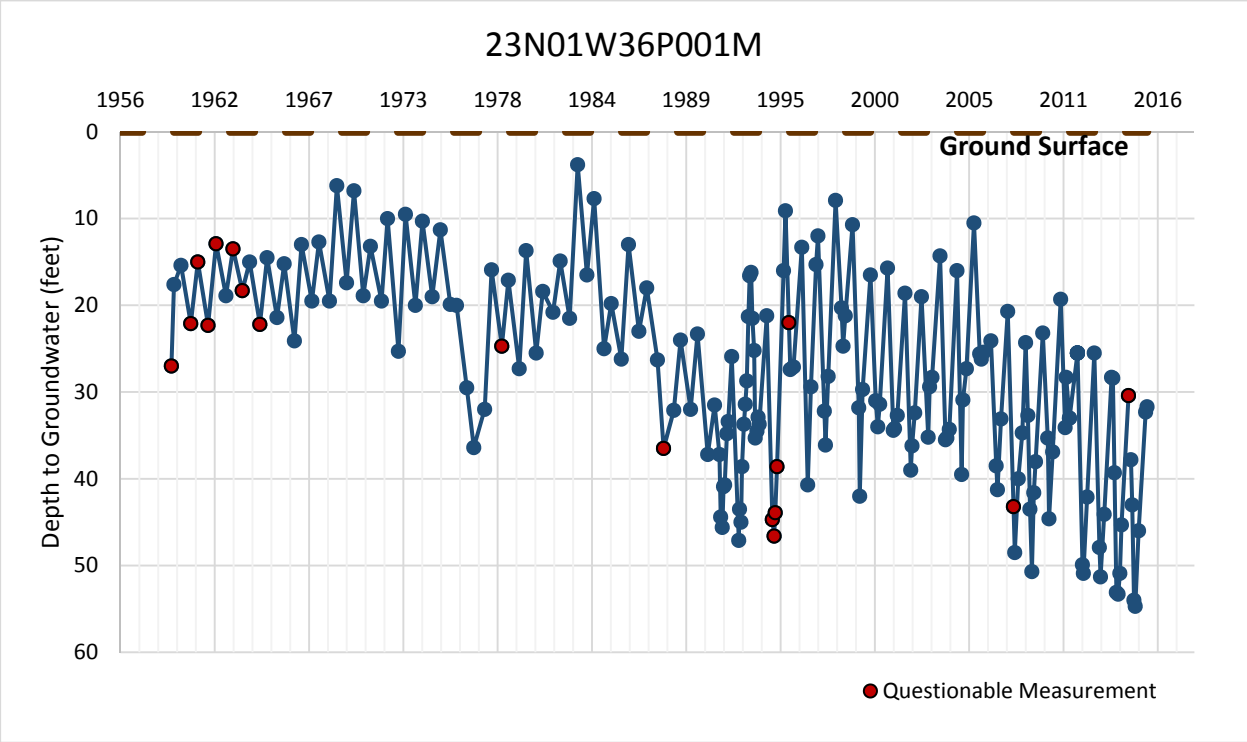

Figure 4.27. Monitoring Well 23N01W36P001M Hydrograph.

West Butte Inventory Unit

The West Butte Subbasin (5-21.58) covers about 86,500 acres in the north-central portion of Butte County in the Sacramento Valley Groundwater Basin. It is bordered by Big Chico Creek to the north, Butte Creek to the south, the Sacramento River to the west and the foothills to the east. The West Butte aquifer system includes stream channel deposits, basin deposits, Sutter Buttes alluvium, and deposits of the Modesto, Riverbank, Tuscan and Tehama formations (DWR 2005).

The West Butte inventory unit has 42 wells monitored by the County and DWR. In addition, Cal Water-Chico is partially located in the northern portion of the inventory unit and also provides groundwater level data for seven of their production wells.

In groundwater dependent areas of this inventory unit, groundwater levels have larger variations within an irrigation season and between years than in surface water irrigated areas where groundwater levels are relatively stable. Groundwater serves as the sole source of agricultural irrigation water for a large area of the West Butte inventory unit, as shown in the map of irrigation water source from DWR land use surveys (Figure 4.13). The greatest groundwater level declines in the County have occurred in the Durham area south of Chico. Groundwater levels declined on the order of a couple of feet per year for the past 10 years, except in a couple of wet years that occurred during this time (namely 2006 and 2011). This has resulted in declines in groundwater levels in the primary pumping zone (100-450 feet below

ground surface) of up to 33.5 feet from 2004 to 2015 (Figure 4.25). A significant portion of these water level declines occurred over the past four years of severe drought, about 8-15 feet.

A number of monitoring wells with long periods of record are reaching new historical lows. These wells tend to be shallow (<200 feet) domestic or irrigation wells. Wells in this inventory unit have reportedly experienced reduced pressure, production and water supply reliability problems in recent years. This results in lowering pumps within the well, construction of new wells, or deepening existing wells. Figure 4.28 shows groundwater levels from a shallow domestic well near the center of the groundwater dependent area, 21N01E27D001M. The hydrograph shows trends in groundwater levels since 1946 with declines during previous drought periods, recovery during extended wet periods, and recently declining spring levels on the order of 24 feet from 2004 to 2015. Shallow domestic wells surrounded by groundwater dependent irrigated agriculture are especially vulnerable to going dry as water levels drop during the irrigation season.

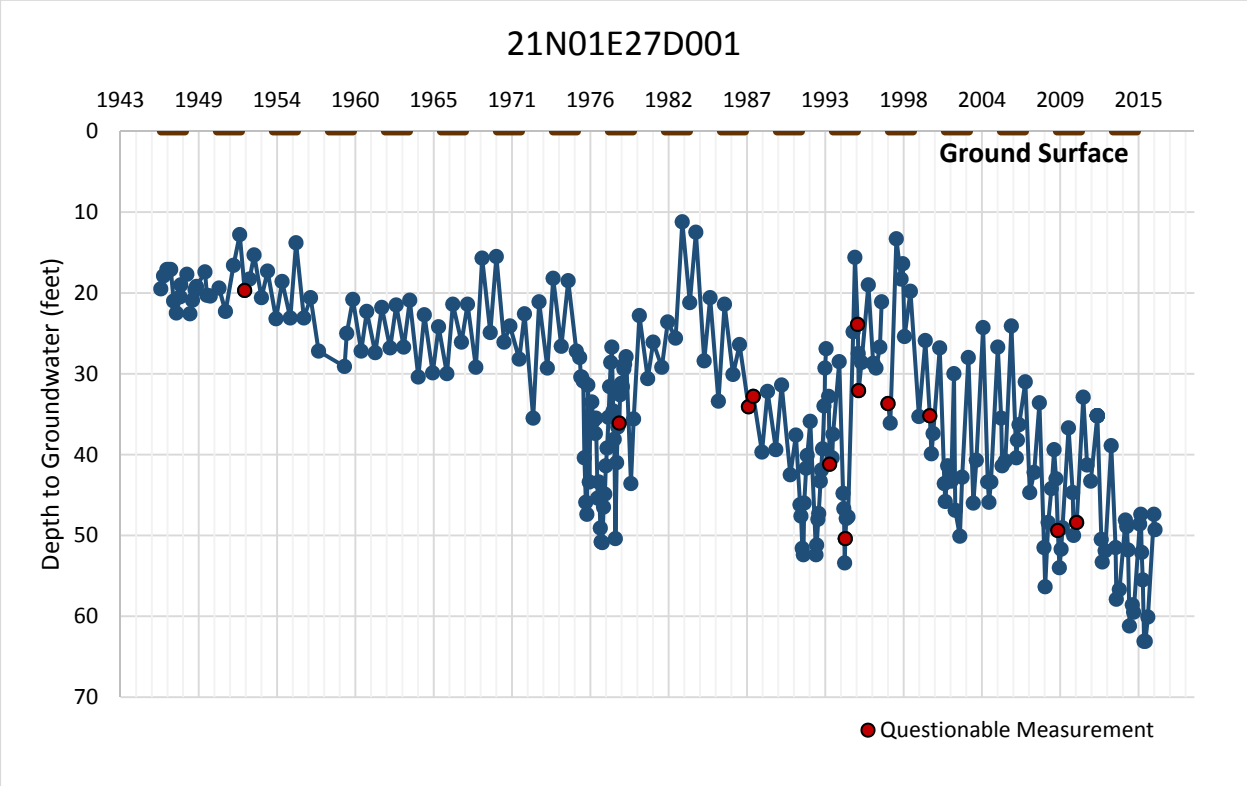

Figure 4.28. Monitoring Well 21N01E27D001M Hydrograph.

Adjacent to these groundwater dependent agricultural areas (i.e. Durham-Dayton) are surface water irrigated lands primarily growing rice (i.e. Western Canal). With rare use of groundwater, these areas have more stable groundwater level conditions and shallower groundwater. Spring levels have remained relatively the same from 2004 to 2015 in the primary pumping zone (100-450 foot deep wells), with declines on the order of only 0.3 to 1.5 feet (Figure 4.25). Figure 4.29 shows groundwater levels in a dedicated multi-completion monitoring well,

20N01E18L003M, on 7 Mile Lane that shows conditions in the shallow portion of the aquifer system (screening interval 100-110 feet). Water levels are within eight feet of the ground surface and vary only a few feet within the year and very little from year to year. In recent years, orchards have replaced rice acreage on the margins of these surface water irrigated areas. Often, a water source change from surface water to groundwater is associated with this land use change. Groundwater levels have begun to respond with greater seasonal variation and moderate declines from one year to the next in recent years in these areas.

Hydrographs for all BMO wells in the West Butte inventory unit can be viewed in the BMO reports for the Chico Urban Area, Durham Dayton, M&T, Angel Slough, Llano Seco, and Western Canal subregions found in Appendix G of the Groundwater Status Report.

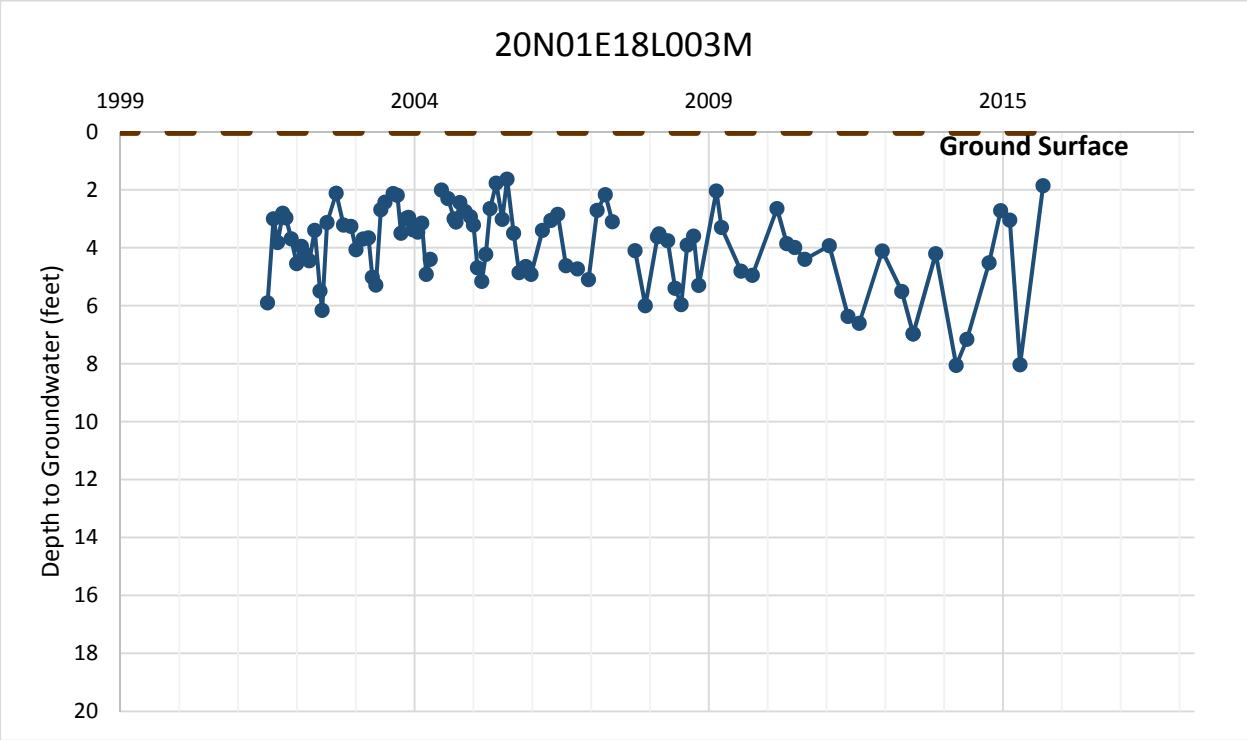

Figure 4.29. Monitoring Well 20N01E18L003M Hydrograph.

East Butte Inventory Unit

The East Butte Subbasin (5-21.59) covers about 188,700 acres in the south-central valley portion of Butte County in the Sacramento Valley Groundwater Basin. It is bordered by Butte Creek to the north and west, the Butte County line to the south, foothills to the northeast, and the Feather River to the southeast. The East Butte aquifer system includes stream channel deposits, basin deposits, Sutter Buttes alluvium, and deposits of the Modesto, Riverbank, Tuscan and Laguna formations.

Groundwater levels are monitored in a network of over 60 wells in the East Butte inventory unit. This data provides information on groundwater storage conditions and water level trends

dating back to the 1940s in some cases. In the groundwater dependent areas in the northeast portion of the East Butte inventory unit (Figure 4.13), groundwater levels have declined on the order of 1-2 feet per year for the past 10 years, with the exception of a couple of wet years that occurred during that time (namely 2006 and 2011). This has resulted in declines in groundwater levels in the primary pumping zone (100-450 feet below ground surface) of up to 15-20 feet in the East Butte inventory unit and up to 30-35 feet in the adjacent West Butte inventory unit since 2004 (Figure 4.25). A significant portion of these water level declines has occurred over the past four years of severe drought, about 7-14 feet.

Figure 4.30 shows groundwater levels from a dedicated monitoring well, 20N02E24C001M, in the Cherokee Strip area of the East Butte inventory unit. This area is groundwater dependent and primarily produces orchard crops. The hydrograph shows trends in groundwater levels since 2000 with declining spring levels on the order of 19 feet from 2004 to 2015.

Adjacent to these groundwater dependent agricultural areas are surface water irrigated lands primarily growing rice. With rare use of groundwater, these areas have stable groundwater level conditions. Depth to water is shallow (typically less than 5-10 feet) and spring 2015 groundwater levels are within three feet of their 2004 spring levels (Figure 4.25). Figure 4.31 shows a hydrograph for monitoring well 18N02E16F001M located near the center of the inventory unit in the Biggs-West Gridley irrigation district. Groundwater levels in this shallow irrigation well vary only a couple of feet within the year and are generally within 10 feet of the ground surface. Although groundwater is rarely pumped for irrigation in most of the water district areas, groundwater serves as an important water supply buffer in times of drought as experienced in 2015 when the surface water districts within the County received water supply cutbacks for the first time in 23 years.

Areas with long term declining groundwater levels in Butte County are areas solely dependent on groundwater for irrigation. In Butte Water District, located within the southeastern portion of the East Butte inventory unit, growers in recent years have shifted to wells for water supply when they shift from annual crops to orchard crops or from flood irrigation to pressurized systems. This shift to groundwater increases demand on the basin and reduces recharge from applied surface water. This land and water source shift has also occurred on the margins of Western Canal Water District. Although water levels within the Butte Water District area have not declined drastically yet, should the area slowly shift to groundwater dependence, it will likely develop cones of depression like other areas of the county that are solely dependent on groundwater. Maintaining use of surface water for irrigation in portions of the inventory unit where it is available and delivery infrastructure already exists is an important step in achieving sustainable groundwater management as required by the Sustainable Groundwater Management Act.

Hydrographs for all BMO wells in the East Butte inventory unit can be viewed in the BMO reports for the Pentz, Esquon, Cherokee, Western Canal, Thermalito, Richvale, Biggs-West

Gridley, Butte Sink, and Butte subregions found in Appendix G of the Groundwater Status Report.

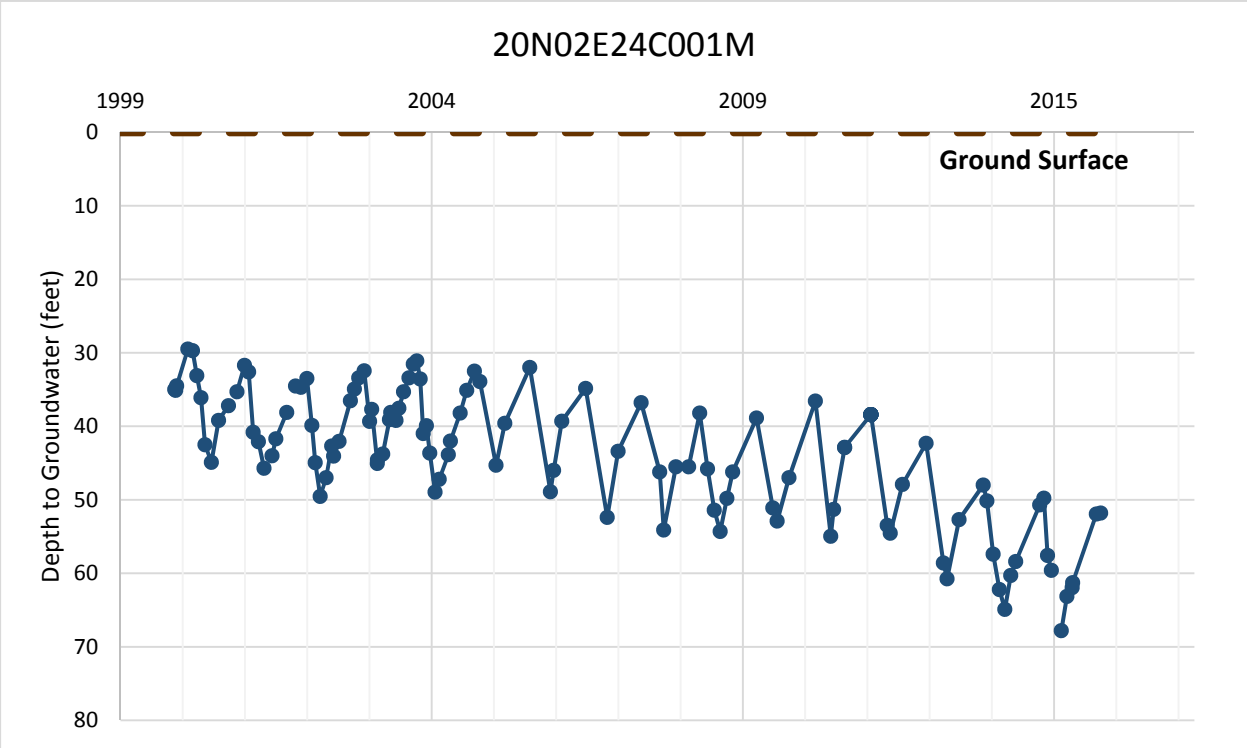

Figure 4.30. Monitoring Well 20N02E24C001M Hydrograph.

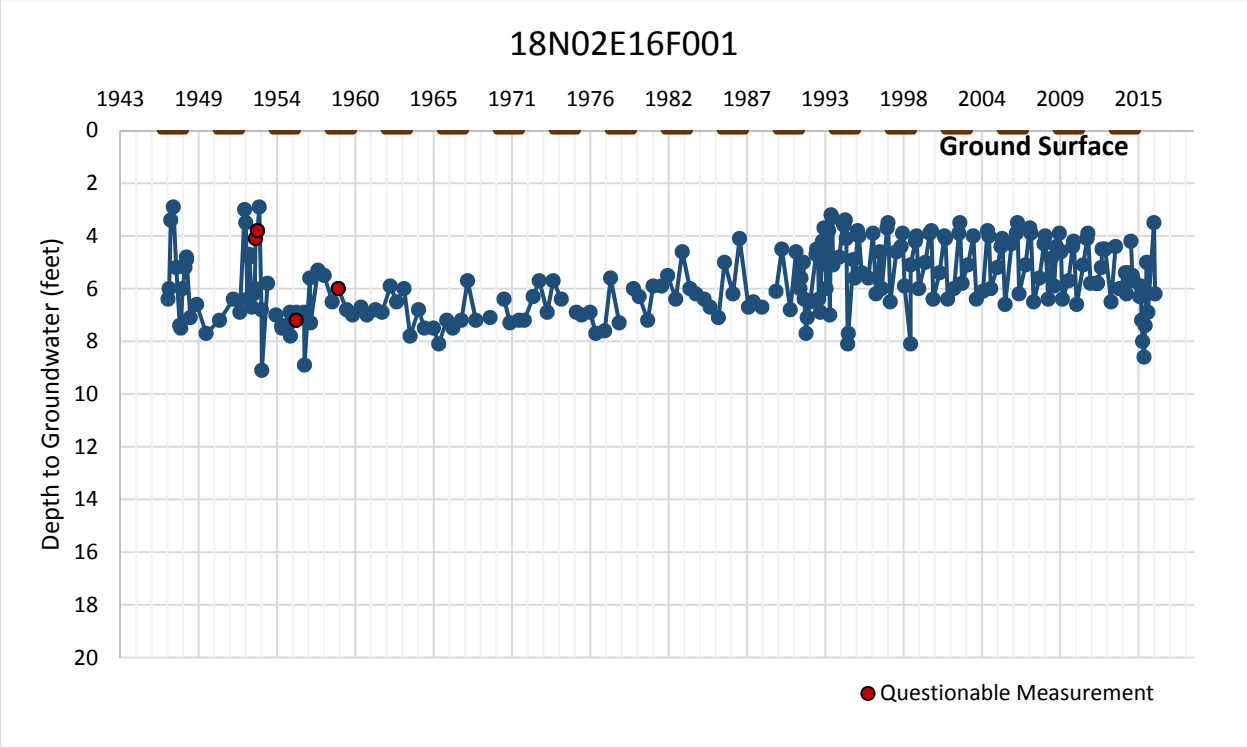

Figure 4.31. Monitoring Well 18N02E16F001M Hydrograph.

North Yuba Inventory Unit

The North Yuba Subbasin (5-21.60) covers about 47,500 acres in the southeastern portion of Butte County in the Sacramento Valley Groundwater Basin. It is bordered by the Feather River to the north and west, Yuba County to the south, and foothills to the east. The North Yuba aquifer system includes recent valley sedimentary deposits, floodplain and alluvium deposits, and deposits of the Victor, Laguna, and Mehrten formations. The primary source of agricultural water in the North Yuba Inventory Unit is groundwater. Groundwater is also used as a municipal water source for portions of Oroville.

Groundwater levels are monitored in a network of about 8 wells in the North Yuba inventory unit. These wells are agricultural or domestic wells. This data provides information on groundwater storage conditions and water level trends dating back to the late 1940s in some cases. In addition, CalWater - Oroville provides spring and fall groundwater level data for three of their wells for inclusion in annual County reporting.

In groundwater dependent areas, groundwater levels have larger variations within an irrigation season and between years than in surface water irrigated areas where groundwater levels are relatively stable. Along the Feather River, surface water generally provides water for irrigation. Further east, groundwater serves as the sole source of agricultural irrigation water for a large area of the North Yuba inventory unit, as shown in the map of irrigation water source from DWR land use surveys (Figure 4.13). The limited network of monitoring wells show that water levels are relatively stable in some places, are affected by Feather River flows near the river, and have experienced declines during dry and critical years in other places. Groundwater levels in the four wells monitoring the main pumping zone (100-450 feet below ground surface) in this inventory unit fell 7 to 14 feet from 2004 to 2015 (Figure 4.25). A significant portion of these water level declines occurred over the past four years of severe drought, about 5-8 feet.

Figure 4.32 shows groundwater levels from an irrigation well of intermediate depth (200-600 feet) near the county border on the east side of the inventory unit, 17N04E09N002M. The hydrograph shows trends in groundwater levels since 2001 with slight declines during previous drought years and declining spring levels on the order of 10 feet from 2004 to 2015.

Hydrographs for all BMO wells in the North Yuba inventory unit can be viewed in the BMO report for the North Yuba subregion found in Appendix G of the Groundwater Status Report.

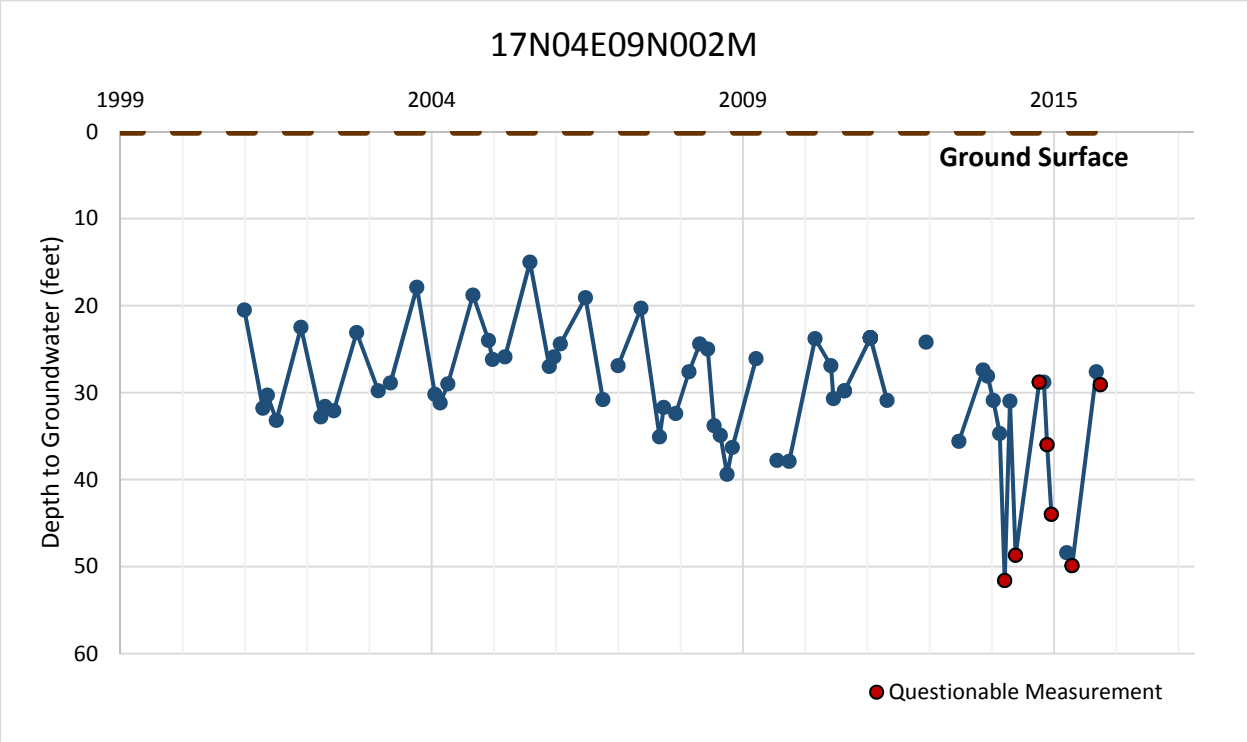

Figure 4.32. Monitoring Well 17N04E09N002M Hydrograph.

4.3.3 Groundwater Pumping

Groundwater provides a source of supply to meet irrigation, domestic, M&I, environmental, and stockwater demands. Estimated pumping within the valley floor IUs for water years 2000 to 2014 is presented in Figure 4.33. In the figure, symbols for each year are color-coded based on the Sacramento Valley Water Year Index (WYI), a key indicator of seasonal variability in inter-annual hydrology. The WYI is used to classify individual water years as Wet (W), Above Normal (AN), Below Normal (BN), Dry (D), or Critical (C) with respect to surface water runoff in the Sacramento River Basin. Total estimated groundwater pumping during this period ranged from 316 thousand acre-feet (taf) in the wet year of 2011 to 489 taf in the critically dry year of 2008. Average pumping during this period is estimated to be 411 taf annually.

As indicated in the figure, pumping varies substantially from year to year and is highly correlated to the WYI, with increased pumping in dry and critical years to meet increased irrigation demands and decreased pumping in wet and above normal years. Although linear regression suggests some increase in pumping over time, the correlation between pumping and time is weak ($R^2 = 0.05$), and the apparent increase between 2011 and 2014 is likely due to drought.

Pumping in the County increases substantially in years during which Feather River supplies in the East Butte and West Butte IUs are curtailed. For example, in the curtailment year of 2015, it is estimated that groundwater pumping in the Feather River Settlement Contractor service areas within Butte County increased by approximately 130 taf in response to curtailment of

approximately 50 percent of surface water supplies (Davids Engineering 2016, included as Appendix D).

Table 4.3 summarizes estimated average annual groundwater pumping for the four IUs and the Valley Floor portion of Butte County as a whole by water demand type: irrigated agriculture and wetlands, Municipal/Industrial (M&I), and rural residential.

Table 4.3. Average Annual Groundwater Pumping (taf), 2000-2014.

Inventory Unit	Irrigated Agriculture and Wetlands	M&I	Rural Residential	Total
Vina	88.3	19.6	0.8	108.7
West Butte	115.8	8.9	1.2	125.9
East Butte	119.5	2.9	2.1	124.5
North Yuba	50.7	0.1	0.8	51.5
Valley Floor	374.3	31.4	4.8	410.6

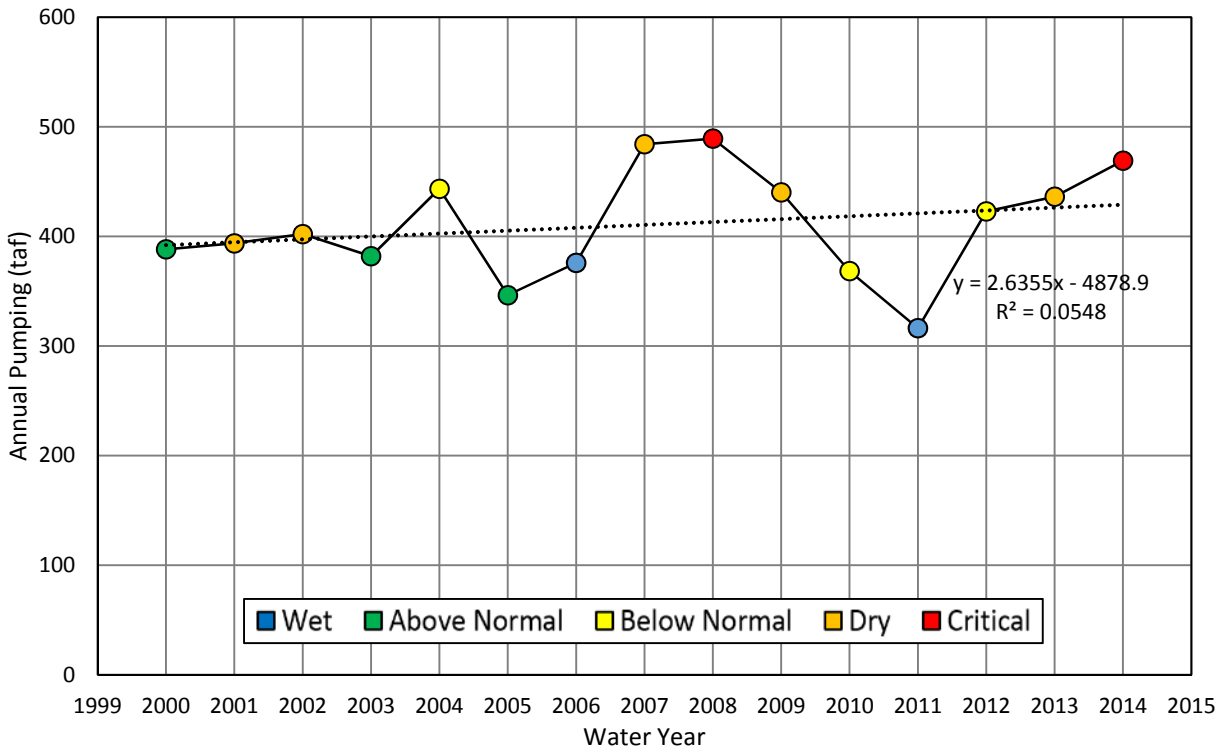

Figure 4.33. Butte County Valley Floor Estimated Groundwater Pumping and Water Year Type, 2000-2014.

Vina Inventory Unit

In the Vina IU, the majority of demands are met using groundwater. Vina includes irrigated agriculture, wetlands, portions of the Chico urban area, and rural residential land use dependent on private domestic wells for indoor and outdoor water use. Estimated pumping within the Vina IU for water years 2000 to 2014 is presented in Figure 4.34. Total estimated groundwater pumping during this period ranged from 82 thousand acre-feet (taf) in the wet year of 2011 to 128 taf in the critically dry year of 2008. Average pumping during this period is estimated to be 109 taf annually. The linear regression suggests no significant trend in pumping over time (correlation between pumping and time is weak, $R^2 = 0.0002$), and the apparent increase between 2011 and 2014 is likely due to drought. Variations in pumping appear to be mainly driven by variability in annual precipitation.

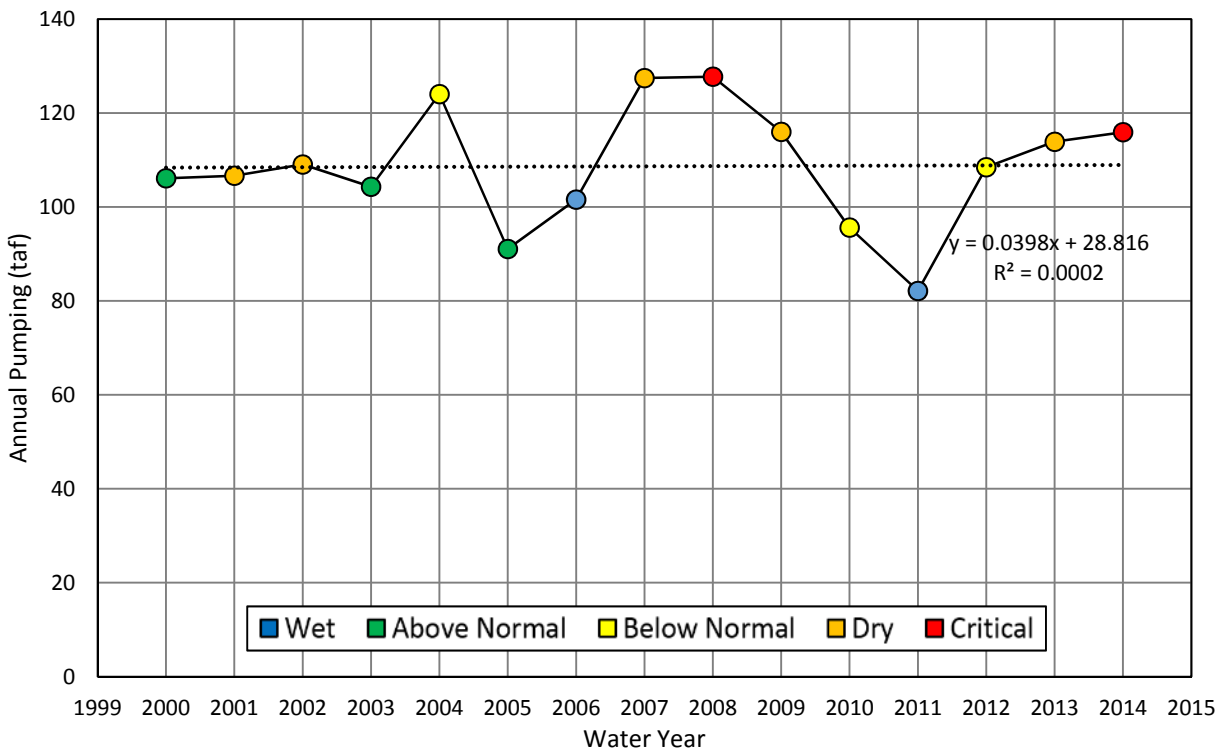

Figure 4.34. Vina Inventory Estimated Groundwater Pumping and Water Year Type, 2000-2014.

West Butte Inventory Unit

In the West Butte IU, the majority of demands are met using groundwater. West Butte includes irrigated agriculture and wetlands, portions of the Chico urban area, Durham, and rural residential land use dependent on private domestic wells for indoor and outdoor water use. Estimated pumping within the West Butte IU for water years 2000 to 2014 is presented in Figure 4.35. Total estimated groundwater pumping during this period ranged from 88 thousand

acre-feet (taf) in the wet year of 2011 to 156 taf in the dry year of 2007. Average pumping during this period is estimated to be 126 taf annually. Although linear regression suggests some increase in pumping over time, the correlation between pumping and time is weak (R^2 = 0.01), and the apparent increase between 2011 and 2014 is likely due to drought. Variations in pumping appear to be mainly driven by variability in annual precipitation.

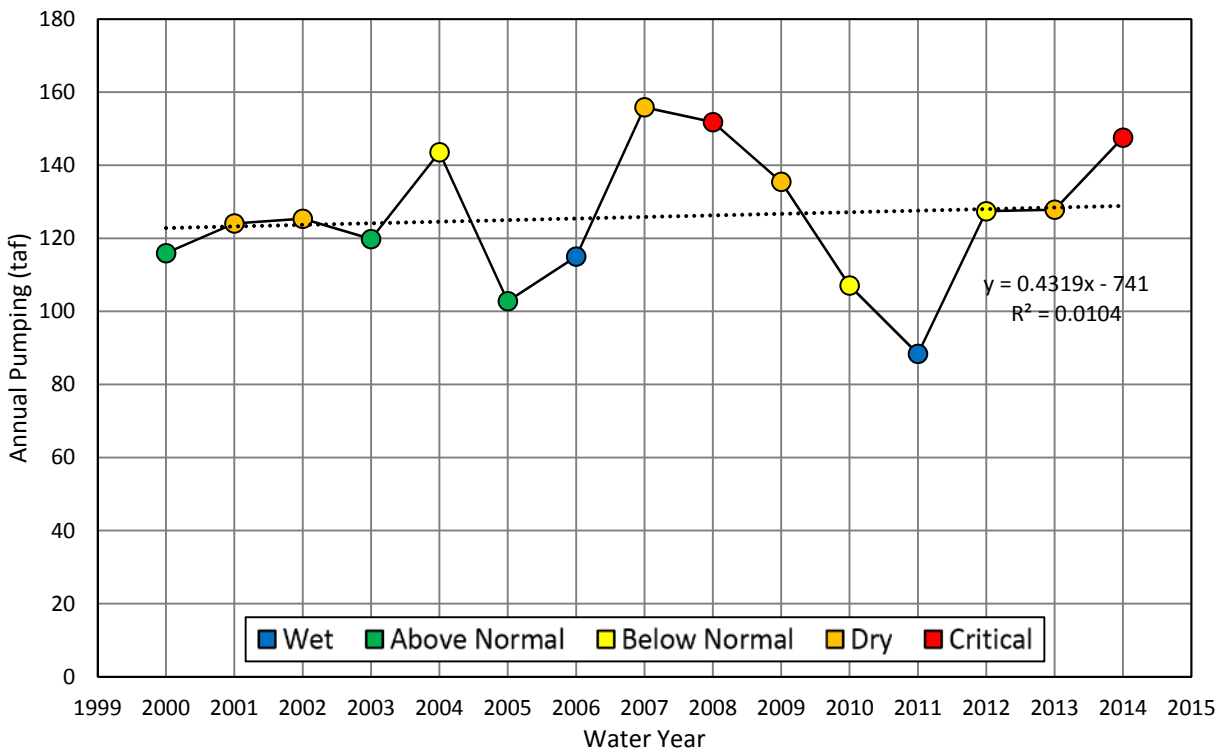

Figure 4.35. West Butte Inventory Estimated Groundwater Pumping and Water Year Type, 2000-2014.

East Butte Inventory Unit

In the East Butte IU, the majority of demands are met using surface water with groundwater mainly serving orchard irrigation needs and providing a source of drought water supply during cutback years to the Feather River Settlement Contractors (as in 2015). East Butte includes irrigated agriculture and wetlands, the Oroville, Gridley and Biggs urban areas and rural residential land use dependent on private domestic wells for indoor and outdoor water use. Estimated pumping within the East Butte IU for water years 2000 to 2014 is presented in Figure 4.36. Total estimated groundwater pumping during this period ranged from 105 thousand acre-feet (taf) in the wet year of 2011 to 152 taf in the critically dry year of 2014. Average pumping during this period is estimated to be 124 taf annually. Linear regression suggests some increase in pumping over time, with a moderate correlation between pumping and time (R^2 = 0.38). The apparent increase between 2011 and 2014 is likely primarily due to drought.

Variations in pumping appear to be mainly driven by variability in annual precipitation, although additional examination of other potential factors such as changes in crops grown, overall irrigated acreage, or conversion from surface water to groundwater may be other factors.

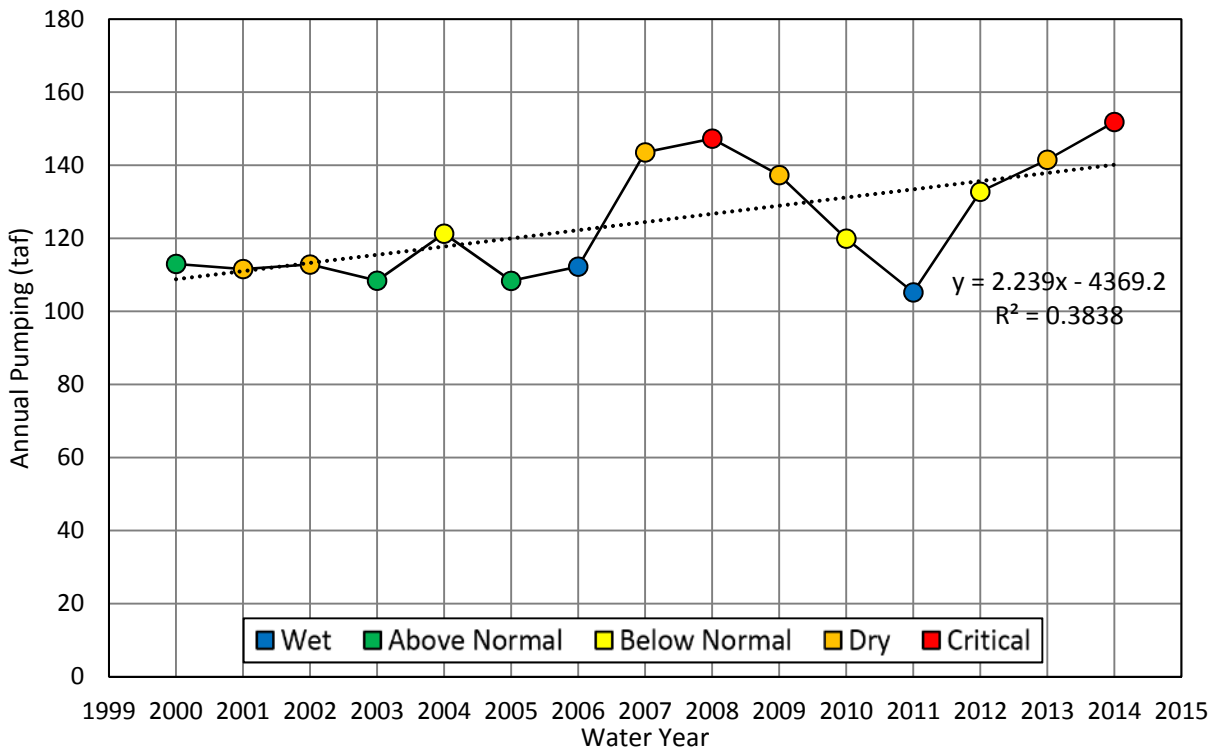

Figure 4.36. East Butte Inventory Estimated Groundwater Pumping and Water Year Type, 2000-2014.

North Yuba Inventory Unit

In the North Yuba IU, the majority of demands are met by groundwater. North Yuba includes irrigated agriculture and wetlands, and rural residential land use dependent on private domestic wells for indoor and outdoor water use. Estimated pumping within this IU for water years 2000 to 2014 is presented in Figure 4.37. Total estimated groundwater pumping during this period ranged from 41 thousand acre-feet (taf) in the wet year of 2011 to 62 taf in the critically dry year of 2008. Average pumping during this period is estimated to be 52 taf annually. Although linear regression suggests some decrease in pumping over time, the correlation between pumping and time is weak ($R^2 = 0.004$). Variations in pumping appear to be largely influenced by variability in annual precipitation.

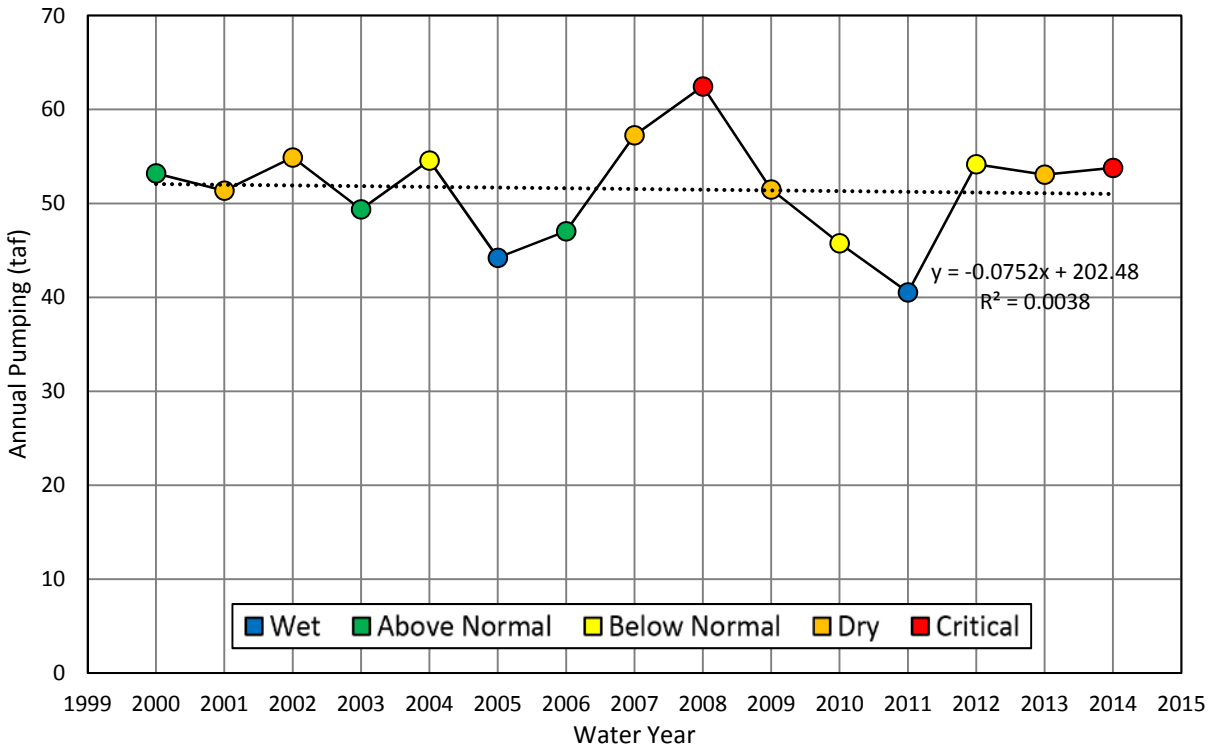

Figure 4.37. North Yuba Inventory Estimated Groundwater Pumping and Water Year Type, 2000-2014.

4.3.4 Groundwater Development

Well Counts, Distribution, and Development over Time

Based on well completion reports on file with DWR NRO describing wells constructed between 1900 and August 2015, there are over 17,000 wells in Butte County. The wells are classified by type as domestic, irrigation, municipal and industrial (M&I), monitoring, and other. Figure 4.38 indicates the densities of domestic, irrigation, M&I, and monitoring wells within the County. Table 4.5 summarizes the number of wells by type, inventory unit, and subinventory unit within the County.

Domestic wells are widely distributed through most portions of the County, including the Foothill Inventory Unit and the southern portion of the Mountain Inventory Unit. Irrigation wells are distributed across the valley floor inventory units, with the greatest concentrations in the Vina and West Butte inventory units, corresponding to areas of reliance on groundwater for irrigation. M&I and dedicated monitoring wells are most concentrated in populated areas such as the cities of Chico and Oroville.

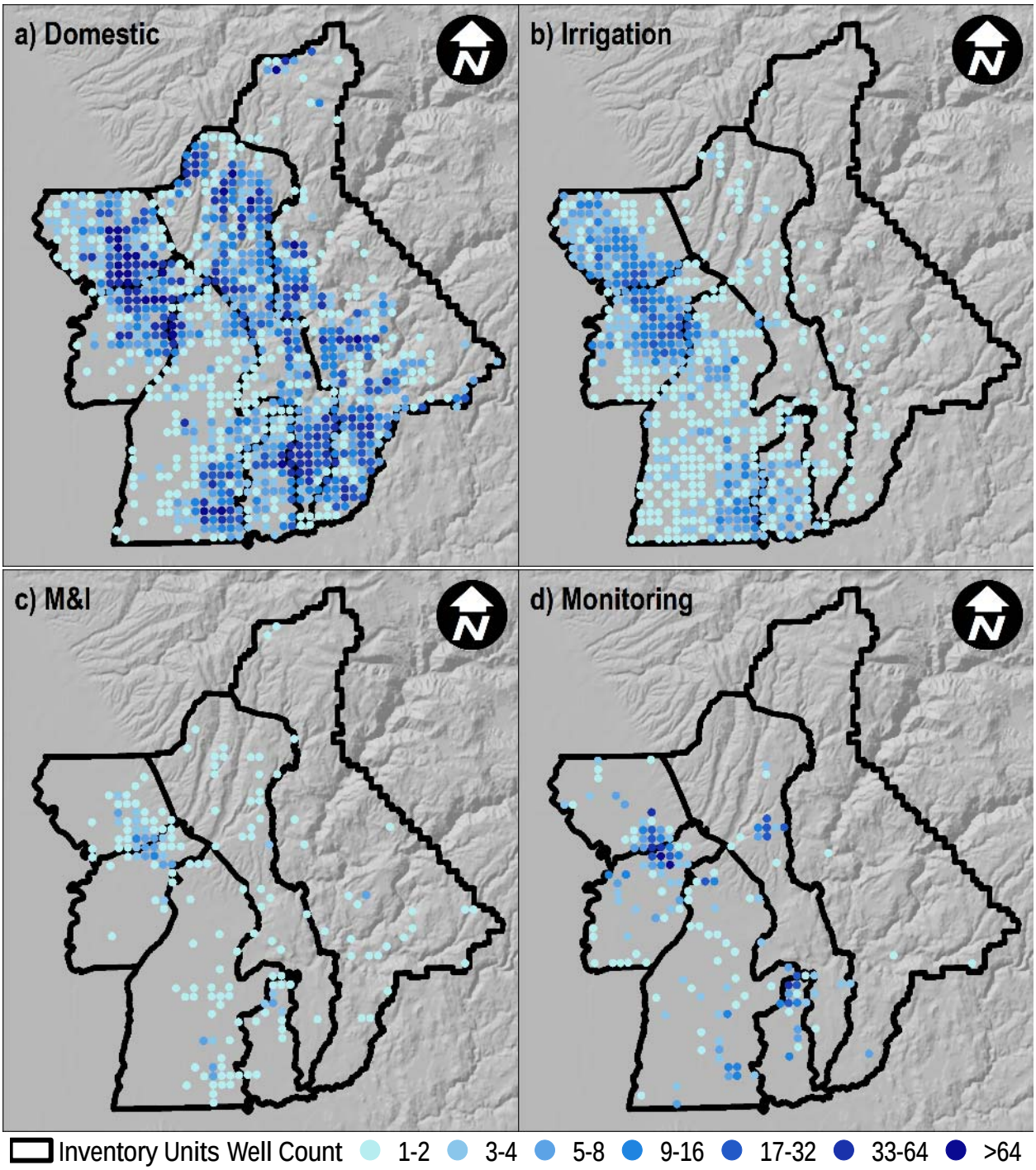

Figure 4.38. Distribution of Wells in Butte County by Type.

Table 4.4 and Figure 4.38 were prepared based on information in the Well Completion Report database on file at DWR. The accuracy of the well-location information varies according to the source of the particular data. Although most locations are correct to within one-half mile, some well completion report data may be in error by up to several miles.

Based on well completion data from DWR for the period 2000 to 2014, well construction has varied over time (Figure 4.39). Domestic well construction increased from 2000 to 2004 and then declined until 2013, when construction increased from approximately 70 to 150 wells per year (average of 164 wells per year between 2000 and 2014). Irrigation well construction has been relatively steady over time, averaging approximately 15 wells per year, with increases to 30 or more wells per year in 2007 and 2014, potentially due to drought or long term water level declines in some areas. M&I well construction varied between 1 and 5 wells per year (average of 3 wells per year) during the 2000 to 2014 period, with monitoring well construction varying over time but averaging 32 wells per year.

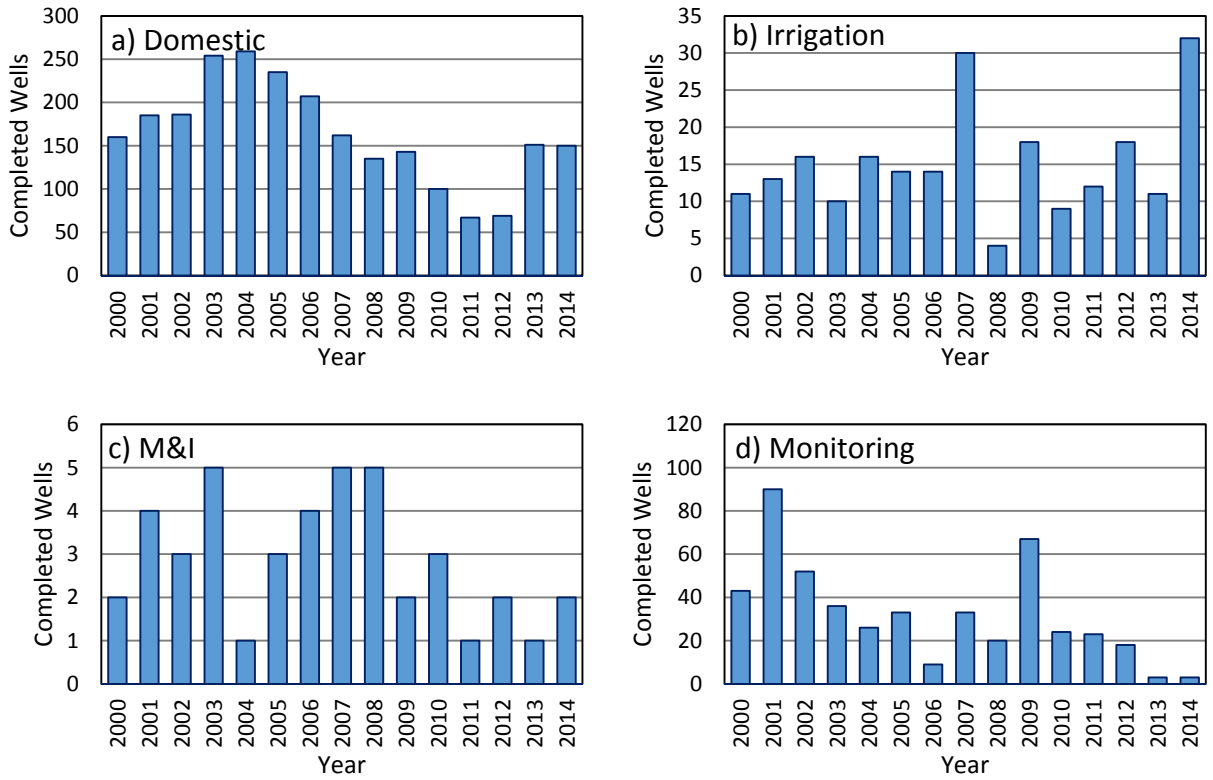

Figure 4.39. Butte County Annual Well Construction.

Well Depths

Well depth and well use data were collected from Well Completion Reports filed with DWR. A total of approximately 15,000 well records having depth data were evaluated and classified into three well-type categories: domestic, irrigation, and M&I. The minimum, maximum, and average well depths listed by well type and by inventory unit and subinventory unit are presented in Table 4.5.

Table 4.4. Number of Wells by Inventory Unit and Subinventory Unit.

Inventory Unit	Subinventory Unit	Well Count					
		Domestic	Irrigation	M&I	Monitoring	Other	Total
East Butte	Biggs-West Gridley	208	93	8	21	24	354
	Butte	693	211	30	48	49	1,031
	Butte Sink	3	14	0	6	2	25
	Cherokee	110	79	4	8	17	218
	Esquon	339	122	4	10	36	511
	Pentz	81	23	3	38	11	156
	Richvale	96	88	4	13	15	216
	Thermalito	223	82	17	48	113	483
	Western Canal	46	84	4	10	13	157
	Total	1,799	796	74	202	280	3,151
Foothill	Cohasset	269	4	3	0	7	283
	Ridge	426	19	3	42	29	519
	Other	2,742	63	31	88	96	3,020
	Total	3,437	86	37	130	132	3,822
Mountain	Mountain	2,885	33	30	12	62	3,022
North Yuba	North Yuba	587	189	25	143	93	1,037
Vina	Vina	2,297	651	83	211	266	3,508
West Butte	Angel Slough	9	44	0	0	2	55
	Durham/Dayton	1,404	608	68	390	262	2,732
	Llano Seco	1	17	0	6	8	32
	M&T	29	54	1	30	15	129
	Western Canal	28	28	1	6	3	66
	Total	1,471	751	70	432	290	3,014
County Total		12,476	2,506	319	1,130	1,123	17,554

Table 4.5. Well Depths by Inventory Unit and Subinventory Unit.

		Well Completion Depth (Feet)														
		Irrigation					Domestic					Municipal and Industrial				
Inventory Unit	Subinventory Unit	Count	Min.	Max.	Mean	Median	Count	Min.	Max.	Mean	Median	Count	Min.	Max.	Mean	Median
East Butte	Biggs-West Gridley	93	60	750	243	203	208	32	323	99	91	8	55	381	163	115
	Butte	211	35	983	165	140	693	19	399	86	80	30	35	430	199	200
	Butte Sink	14	193	616	391	400	3	110	200	140	110	0	NA	NA	NA	NA
	Cherokee	79	84	871	426	468	110	26	630	178	153	4	110	475	286	279
	Esquon	122	62	883	376	334	339	25	320	131	121	4	93	460	266	255
	Pentz	23	93	535	300	275	81	43	705	201	155	3	97	735	479	605
	Richvale	88	80	692	289	260	96	40	310	113	105	4	137	180	164	169
	Thermalito	82	36	463	185	148	223	30	700	120	100	17	55	275	128	104
	Western Canal	84	109	880	511	540	46	50	500	157	133	4	87	215	166	181
	Total	796	35	983	292	274	1,799	19	705	114	102	74	35	735	195	190
Foothill	Cohasset	4	117	600	439	520	269	25	960	314	215	3	300	857	617	695
	Ridge	19	69	875	228	126	426	18	1,030	345	265	3	132	600	334	270
	Other	63	30	875	291	200	2,742	19	1,060	266	200	31	37	930	447	430
	Total	86	30	875	284	199	3,437	18	1,060	279	209	37	37	930	452	439
Mountain	Mountain	33	45	600	291	300	2,885	11	1,010	240	200	30	100	970	279	240
North Yuba	North Yuba	189	28	656	294	278	587	25	990	140	120	25	64	600	195	185
Vina	Vina	651	40	1,050	327	248	2,297	14	940	149	140	83	33	830	454	525
West Butte	Angel Slough	44	60	367	211	213	9	35	125	88	100	0	NA	NA	NA	NA
	Durham/Dayton	608	60	750	356	337	1,404	15	800	146	130	68	36	924	396	399
	Llano Seco	17	175	905	411	390	1	56	56	56	56	0	NA	NA	NA	NA
	M&T	54	52	920	444	460	29	54	640	161	140	1	710	710	710	710
	Western Canal	28	109	880	516	555	28	67	540	165	100	1	420	420	420	420
	Total	751	52	920	361	347	1,471	15	800	147	129	70	36	924	401	404
County Total		2,506	28	1,050	320	270	12,476	11	1,060	200	146	319	33	970	345	275