Glenn County Preliminary Water Budget

Prepared for the County of Glenn

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DAVIDS ENGINEERING, INC

WEST YOST ASSOCIATES

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The hydrologic cycle describes the movement of water between the Earth's surface (land surface and surface water system), the atmosphere, and the groundwater system, including considerations of flow timing and amount and storage. Several physical processes occur within the system, including evaporation, transpiration, condensation, precipitation, infiltration, runoff, streamflow, etc. A water budget provides a quantitative accounting method to assess the total volume of groundwater and surface water entering and leaving the basin over time, along with the change in the volume of water stored.

In principle, a water budget is a simple concept that provides the accounting framework to measure and evaluate all inflows and outflows from all parts of the hydrologic cycle – atmospheric, land surface, surface water, and groundwater systems. In practice, it is difficult to accurately measure and account for all components of the water budget for a given area. Some water budget components may be estimated independent of the water budget, while others may be calculated based on the fundamental principle that the difference between basin inflows and outflows is balanced by a change in the volume of water in storage.

This study presents a preliminary historical water budget for the portions of the Colusa, Corning, and West Butte subbasins overlying Glenn County and has been prepared as part of Proposition 1 Stressed Basins grant from the California Department of Water Resources (DWR) to support preparation of Groundwater Sustainability Plans (GSPs) for these basins as required by the Sustainable Groundwater Management Act of 2014 (SGMA) and associated GSP Regulations (Regulations). Results are presented according to the Regulations to describe the hydrologic systems within the Study Area and include estimates of uncertainty in water budget components. A preliminary estimate of the sustainable yield of the basins within Glenn County is provided.

Following the presentation of the water budget, recommendations for future activities to ultimately result in the development of water budgets for inclusion in GSPs by January 2022 are provided.

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The Study area is defined as the portions of the Colusa (5-21.52), Corning (5-21.51), and West Butte (5-21.58) subbasins in Glenn County as defined by DWR Bulletin 118 and updated in 2016 (Figure 2.1) (DWR 2003). The Colusa Subbasin represents approximately 305,000 acres in Glenn County on the Sacramento Valley floor, with the Corning and West Butte subbasins each representing approximately 45,000 acres (90,000 acres total). For purposes of analysis, the valley floor area was divided into 19 subareas (Figure 2.1). For each subarea, the water budget for the surface system was developed uniquely based on information describing land use, available surface water supplies, and other factors to facilitate estimation of groundwater pumping. Water budget subareas are listed in Table 2.1.

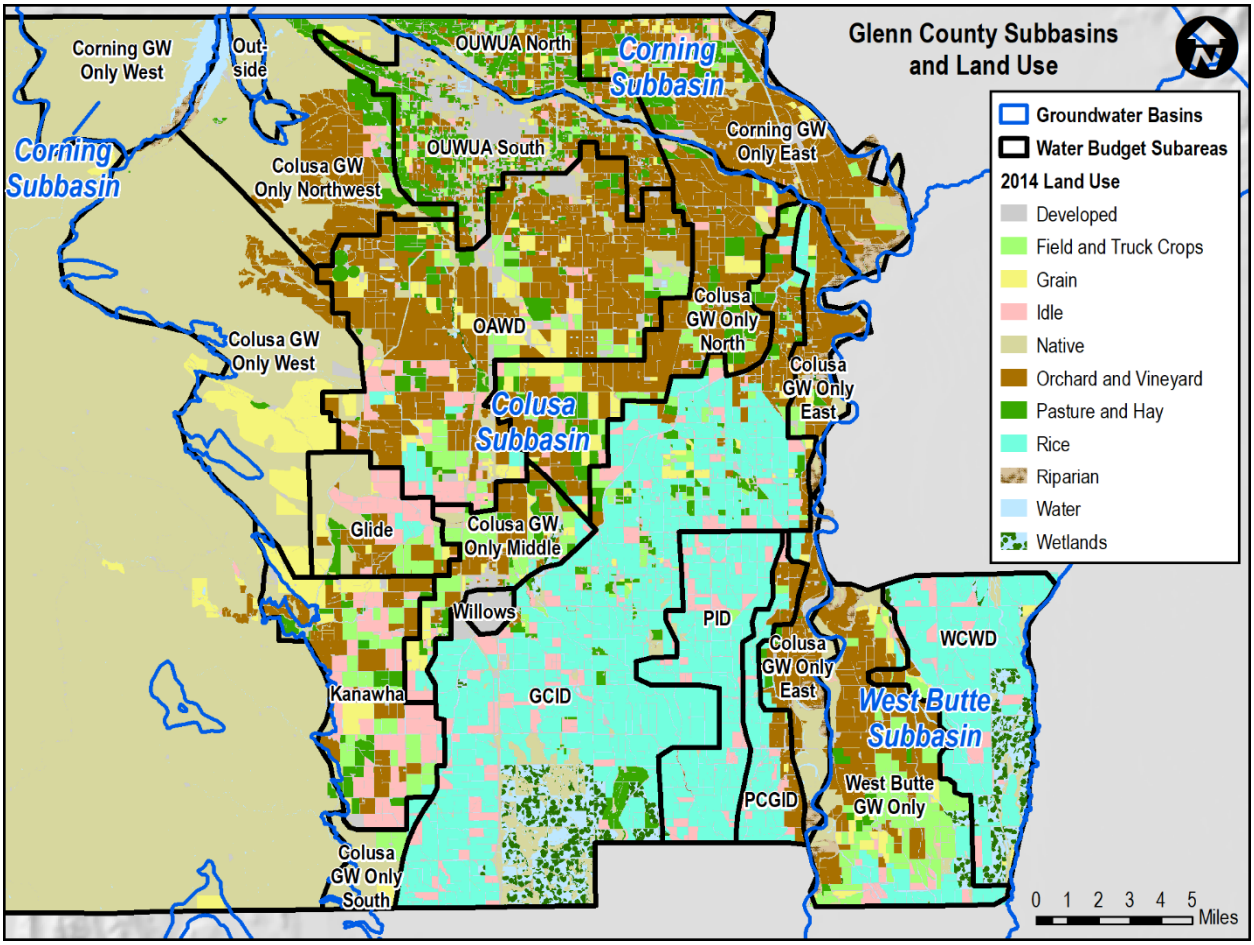

Figure 2.1. Study Area.

As indicated in Figure 2.1, much of the study area consists of irrigated agriculture, with primary crops including rice and orchards. Land use is discussed in greater detail for each subbasin in Chapters 5 through 7.

Table 2.1. Glenn County Water Budget Subareas.

Subbasin	Name	Acres
Colusa	Colusa GW Only East	14,692
	Colusa GW Only North	23,208
	Colusa GW Only Northwest	23,219
	Colusa GW Only South	3,938
	Colusa GW Only Middle	10,100
	Colusa GW Only West	40,277
	GCID	75,064
	Glide	9,458
	Kanawha	18,722
	OAWD	49,064
	OUWUA South	18,774
	PCGID	7,244
	PID	15,188
	Willows	1,235
	SUBTOTAL	**310,182**
Corning	Corning GW Only East	23,072
	Corning GW Only West	13,953
	OUWUA North	8,622
	SUBTOTAL	**45,647**
West Butte	WCWD	19,860
	West Butte GW Only	24,442
	SUBTOTAL	**44,302**
	TOTAL	**400,131**

3.1 GENERAL WATER BUDGET ACCOUNTING STRUCTURE AND COMPONENTS

For accounting purposes, the water budget is divided primarily into the land surface and stream system (surface water system) and the groundwater system. For the land surface and stream system, the water budget is further divided into the land surface system, consisting of irrigated and non-irrigated lands, and the stream system, consisting of natural waterways, canals, and drains. Finally, the land surface system is divided into water use sectors including agricultural, urban and industrial, managed wetlands, and native lands. Each of these systems are referred to as *accounting centers*. Flows between accounting centers and storage within each accounting center represent water budget *components*.

A conceptual representation of the water budget accounting centers and components is provided in Figure 3.1. Required components for each accounting center are listed in Table 3.1, along with the corresponding section of the GSP Regulations. Note that precipitation is not explicitly listed as a required water budget component, though it is needed to provide complete accounting of basin inflows and outflows.

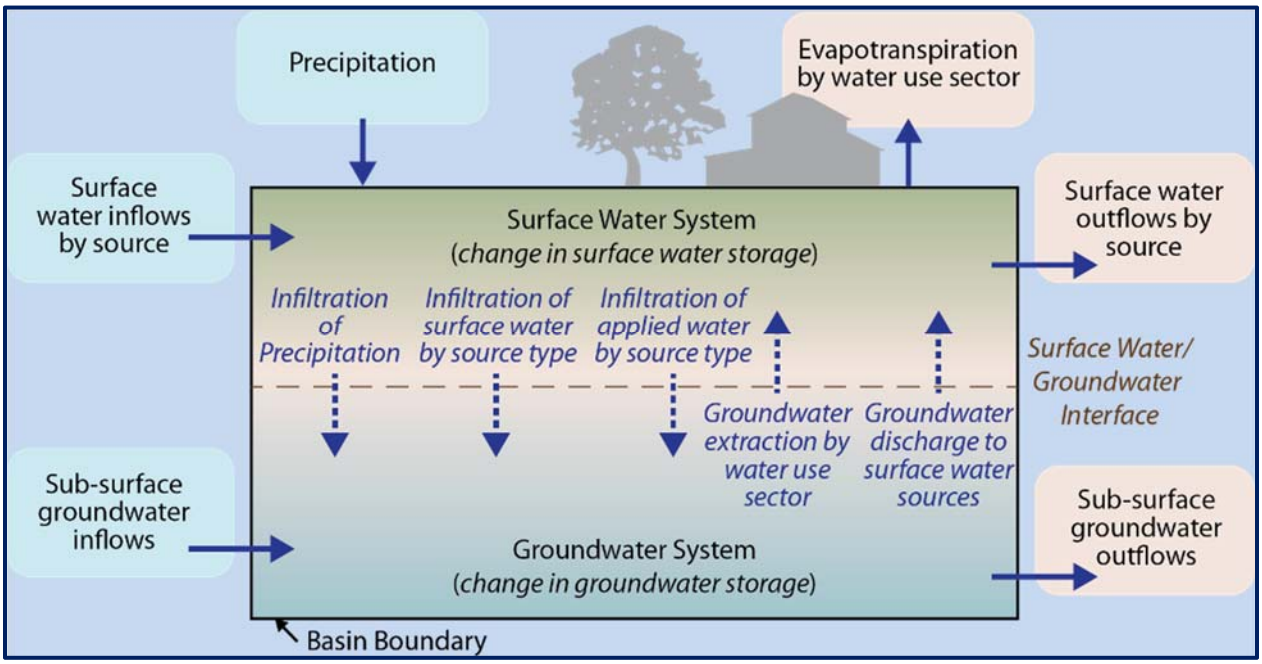

Figure 3.1. Water Budget Accounting Structure (Source: DWR 2016).

Table 3.1. Water Budget Components by Accounting Center and Associated GSP Regulations.

Accounting Center	Water Budget Component	GSP Regulation Section
Basin	Surface Water Inflow[1] (+)	§354.18(b)(1)
	Precipitation (+)	Implied
	Subsurface Groundwater Inflow (+)	§354.18(b)(2)
	Evapotranspiration[2] (-)	§354.18(b)(3)
	Surface Water Outflow[1] (-)	§354.18(b)(1)
	Subsurface Groundwater Outflow (-)	§354.18(b)(3)
	Change in Storage	§354.18(b)(4)
Surface Water System	Surface Water Inflow[1] (+)	§354.18(b)(1)
	Precipitation (+)	Implied
	Groundwater Extraction (+)	§354.18(b)(3)
	Groundwater Discharge (+)	§354.18(b)(3)
	Evapotranspiration[2] (-)	§354.18(b)(3)
	Surface Water Outflow[1] (-)	§354.18(b)(1)
	Applied Water Infiltration[3,4] (-)	§354.18(b)(2)
	Surface Water Infiltration[5] (-)	§354.18(b)(2)
	Precipitation Infiltration[4] (-)	§354.18(b)(2)
	Change in Storage[6]	§354.18(a)
Groundwater System	Subsurface Groundwater Inflow (+)	§354.18(b)(2)
	Applied Water Infiltration[3,4] (+)	§354.18(b)(2)
	Surface Water Infiltration[5] (+)	§354.18(b)(2)
	Precipitation Infiltration[4] (+)	§354.18(b)(2)
	Subsurface Groundwater Outflow (-)	§354.18(b)(3)
	Groundwater Extraction (-)	§354.18(b)(3)
	Groundwater Discharge (-)	§354.18(b)(3)
	Change in Storage	§354.18(b)(4)

1. By water source type.
2. By water use sector.
3. Includes applied surface water, groundwater, recycled water, and reused water.
4. Synonymous with deep percolation.
5. Lakes, streams, canals, drains, and springs.
6. Includes surface water streams and root zone (not groundwater system). May be assumed zero in many cases.

3.2 DETAILED WATER BUDGET ACCOUNTING CENTERS AND COMPONENTS

To estimate the water budget components required by the Regulations, the water budget accounting center for the surface water system is further subdivided into detailed accounting centers representing irrigation canals, drains, rivers and streams, and the land surface itself.

Additionally, detailed water budget components are defined for each detailed accounting center. The addition of these detailed water budget accounting centers and components facilitates the development of water budgets based on the best available data and science by facilitating the incorporation of information from agricultural water management plans (AWMPs), urban water management plans (UWMPs) and other sources.

Water budget components for each detailed accounting center within the surface water system are described in Tables 3.2 through 3.5.

Table 3.2. Canal System Water Budget Components.

Detailed Accounting Center	Detailed Component	Category	Description
Canal System	Diversions	Inflow	Diversions from river and stream system, including lakes and reservoirs in some cases.
	Reuse	Inflow	Water supplier reuse of spillage and runoff from drain system.
	Evaporation	Outflow	Direct evaporation from canal water surface.
	Seepage	Outflow	Seepage from canals to groundwater system.
	Spillage	Outflow	Spillage resulting from canal operations to drain system.
	Deliveries	Outflow	Deliveries from canal system to customers.

Table 3.3. Drain System Water Budget Components.

Detailed Accounting Center	Detailed Component	Category	Description
Drain System	Spillage	Inflow	Spillage resulting from canal operations to drain system.
	Runoff of Applied Water	Inflow	Direct runoff of applied irrigation water. Includes tailwater and pond drainage for ponded crops.
	Runoff of Precipitation	Inflow	Direct runoff of precipitation.
	Evaporation	Outflow	Direct evaporation from drain water surface.
	Seepage	Outflow	Seepage from drains to groundwater system.
	Reuse	Outflow	Water supplier and private reuse of spillage and runoff from drain system.
	Surface Outflows	Outflow	Surface outflows at lower boundary of water budget area.

Table 3.4. River and Stream System Water Budget Components.

Detailed Accounting Center	Detailed Component	Category	Description
River and Stream System	Surface Inflows	Inflow	Surface inflows at upper boundary of water budget area and runoff of precipitation from adjacent lands.
	Evaporation	Outflow	Direct evaporation from river and stream water surface.
	Seepage	Outflow	Seepage from rivers and streams to groundwater system (net of groundwater discharge).
	Surface Outflows	Outflow	Surface outflows at lower boundary of water budget area.

Table 3.5. Land Surface System Water Budget Components.

Detailed Accounting Center	Detailed Component	Category	Description
Land Surface System	Deliveries	Inflow	Deliveries from canal system to customers.
	Groundwater Extraction	Inflow	Groundwater pumping to meet water demands.
	Precipitation	Inflow	Direct precipitation on the land surface.
	Reuse	Inflow	Private reuse of spillage and runoff from drain system.
	ET of Applied Water	Outflow	Consumptive use of applied irrigation water. In wetlands and riparian areas, may represent shallow groundwater uptake.
	ET of Precipitation	Outflow	Consumptive use of infiltrated precipitation.
	Runoff of Applied Water	Outflow	Direct runoff of applied irrigation water. Includes tailwater and pond drainage for ponded crops.
	Runoff of Precipitation	Outflow	Direct runoff of precipitation.
	Percolation of Applied Water	Outflow	Percolation of applied water below the root zone.
	Percolation of Precipitation	Outflow	Percolation of precipitation below the root zone.
	Change in Storage	Storage	Change in storage of applied water within the root zone.

3.3 WATER BUDGET ANALYSIS PERIOD

For the preliminary water budgets developed as part of this study, an analysis period of October 1999 to September 2015 was selected. This 16-year period would likely be expanded as part of GSP preparation to support the development of current, historical, and projected water budgets. Water budget calculations were performed on a monthly time step, but for reporting purposes, are summarized by water year. A water year is defined as the period from October 1 to September 30. For example, the 2000 water year represents the period from October 1, 1999 to September 30, 2000.

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4.1 ESTIMATION OF WATER BUDGET COMPONENTS

This section provides a summary of the methodologies and information sources used to estimate each water budget component.

4.1.1 Canal System

The canal system represents open irrigation canals and supplier irrigation pipelines within the study area. By subbasin, primary irrigation distribution systems in Glenn County include the following:

- Colusa Subbasin
  - Glenn-Colusa Irrigation District (GCID) – Main and lateral canals
  - Provident Irrigation District (PID) and Princeton-Codora-Glenn Irrigation District (PCGID) – Main and lateral canals
  - Orland Unit Water Users Association (OUWUA) – Canal system south of Stony Creek
  - Orland Artois Water District (OAWD) – Pipeline distribution system from Tehama-Colusa Canal (TCC)
  - Glide Water District (GWD) – Pipeline distribution system from TCC
  - Kanawha Water District (KWD) – Pipeline distribution system from TCC
- Corning Subbasin
  - OUWUA – Canal system north of Stony Creek
  - GCID – Main canal
- West Butte Subbasin
  - Western Canal Water District (WCWD) – Canal system west of Butte Creek

Detailed canal system water budget components are summarized in Table 4.1, along with a description of the estimation technique and information sources for each.

Table 4.1. Canal System Water Budget Components and Estimation Techniques.

Detailed Component	Category	Estimation Technique	Information Sources
Diversions	Inflow	Estimated from historical reported diversions.	AWMPs, USBR delivery records
Reuse	Inflow	Estimated from supplier information, where available.	AWMPs
Evaporation	Outflow	Estimated from reference ET, evaporation coefficient, and estimated water surface area.	AWMPs, Colusa CIMIS Station
Seepage	Outflow	Estimated from wetted area and estimated seepage coefficient by soil type.	AWMPs, NRCS soil survey
Spillage	Outflow	Estimated from supplier information, where available.	AWMPs
Deliveries	Outflow	Estimated through water balance (sum of canal system inflows - sum of other canal system outflows. Verified based on supplier information.	AWMPs

4.1.2 Drain System

Drains and sloughs are generally present throughout irrigated areas in Glenn County, with the greatest concentration present in rice growing areas in the Colusa and West Butte subbasins. Drains collect canal spillage, runoff of precipitation from adjacent lands, and runoff of applied water. Water entering drains may then leave the system as evaporation, seepage, reuse by water suppliers or private landowners, or surface runoff such as through the Colusa Basin Drain. In many cases, water is delivered to drains by water suppliers to serve downstream users or support habitat. In rice growing areas, seepage may be negative, as shallow groundwater enters the drains as an accretion, or discharge from the groundwater system.

Detailed drain system water budget components are summarized in Table 4.2, along with a description of the estimation technique and information sources for each.

Table 4.2. Drain System Water Budget Components and Estimation Techniques.

Detailed Component	Category	Estimation Technique	Information Sources
Spillage	Inflow	Estimated from supplier information, where available.	AWMPs
Runoff of Applied Water	Inflow	Estimated based on simulation of irrigation processes by crop, considering irrigation methods, practices, and technologies over time.	AWMPs, DWR irrigation method surveys, IWFM Demand Calculator (IDC)
Runoff of Precipitation	Inflow	Estimated based on daily simulation of rainfall runoff using curve number analysis.	PRISM precipitation data, NRCS curve numbers, IDC
Evaporation	Outflow	Estimated from reference ET, evaporation coefficient, and estimated water surface area.	Colusa CIMIS Station, National Hydrography Dataset (NHD)
Seepage	Outflow	Estimated from wetted area and estimated seepage coefficient by soil type.	AWMPs, NRCS soil survey, NHD
Reuse	Outflow	Estimated from supplier and farm water use information, where available.	AWMPs
Surface Outflows	Outflow	Estimated through water balance (sum of drain system inflows - sum of other drain system outflows. Verified based on stream gage information, where available.	Colusa Basin Drain flows at Highway 20, prorated based on Glenn County drainage area relative to total upstream drainage area

4.1.3 River and Stream System

For purposes of the preliminary water budgets presented herein, rivers and streams represent primarily ephemeral streams within each subbasin. Perennial waterways flowing along basin boundaries (e.g. the Sacramento River, Stony Creek, and Butte Creek) were not explicitly included in the water budgets for each subbasin. Rather, net discharges from the groundwater system (groundwater accretions) to these streams are estimated through closure of the groundwater system budget. It is anticipated that more explicit representation of adjacent perennial streams will be included as part of GSP development using an appropriate integrated hydrologic model or other approach.

Detailed river and stream system water budget components are summarized in Table 4.3, along with a description of the estimation technique and information sources for each.

Table 4.3. River and Stream System Water Budget Components and Estimation Techniques.

Detailed Component	Category	Estimation Technique	Information Sources
Surface Inflows	Inflow	Estimated based on daily simulation of rainfall runoff using curve number analysis.	PRISM precipitation data, NRCS curve numbers, IDC
Evaporation	Outflow	Estimated from reference ET, evaporation coefficient, and estimated water surface area.	Colusa CIMIS Station, NHD
Seepage	Outflow	Estimated from wetted area and estimated seepage coefficient by soil type for ephemeral streams. Net seepage for boundary waterways (e.g. Stony Creek and Sacramento River) estimated as closure term for groundwater system budget.	NRCS soil survey, NHD, groundwater system water budget closure
Groundwater Discharge	Outflow	Estimated through groundwater system water balance (sum of inflows – sum of other outflows – change in storage).	Overall water budget closure term
Surface Outflows	Outflow	Estimated through water balance (sum of river and stream system inflows - sum of other river and stream system outflows.	Calibrated to result in limited runoff in driest years

4.1.4 Land Surface System

The portions of the Colusa, Corning, and West Butte subbasins in Glenn County are dominated by irrigated agriculture, with an average acreage of 252,000 acres in recent years (63%). Other land uses include native lands (95,000 acres or 24%), developed lands (29,000 acres or 7%), and managed wetlands and open water (23,000 acres or 6%). Land use is described in greater detail for each subbasin in Chapters 5 through 7. Land surface processes, including recharge from applied irrigation water and precipitation and groundwater extraction represent primary exchanges between the surface water system and the groundwater system.

Detailed land surface system water budget components are summarized in Table 4.4, along with a description of the estimation technique and information sources for each.

Table 4.4. Land Surface System Water Budget Components and Estimation Techniques.

Detailed Component	Category	Estimation Technique	Information Sources
Deliveries	Inflow	Estimated through water balance (sum of canal system inflows - sum of other canal system outflows). Verified based on supplier information.	AWMPs
Groundwater Extraction	Inflow	For agricultural lands, estimated through water balance (sum of land surface outflows + change in storage - sum of other land surface inflows). For urban lands, estimated based on population and per-capita water use.	Calculated independently for each subarea and compared to available information from AWMPs, UWMPs, etc.
Precipitation	Inflow	Estimated from observed precipitation (weather stations, PRISM, etc.)	PRISM precipitation data
Reuse	Inflow	Estimated from farm water use information, where available.	AWMPs
ET of Applied Water	Outflow	Estimated from land use, reference ET, crop coefficient information, daily simulation of irrigation and precipitation processes.	DWR and ag commissioner land use, Colusa CIMIS, satellite-based crop coefficients, IDC
ET of Precipitation	Outflow	Estimated from land use, reference ET, crop coefficient information, daily simulation of irrigation and precipitation processes.	DWR and ag commissioner land use, Colusa CIMIS, satellite-based crop coefficients, IDC
Runoff of Applied Water	Outflow	Estimated based on simulation of irrigation processes by crop, considering irrigation methods, practices, and technologies over time.	AWMPs, DWR irrigation method surveys, IDC
Runoff of Precipitation	Outflow	Estimated based on daily simulation of rainfall runoff using curve number analysis.	PRISM precipitation data, NRCS curve numbers, IDC
Percolation of Applied Water	Outflow	Estimated based on daily simulation of root zone applied water moisture content and saturated and unsaturated flow.	AWMPs, NRCS soil survey, IDC

Detailed Component	Category	Estimation Technique	Information Sources
Percolation of Precipitation	Outflow	Estimated based on daily simulation of root zone precipitation moisture content and saturated and unsaturated flow.	AWMPs, NRCS soil survey, IDC
Change in Storage	Storage	Estimated based on daily simulation of root zone applied water moisture content and saturated and unsaturated flow.	AWMPs, NRCS soil survey, IDC

4.1.5 Groundwater System

Most inflows to and outflows from the groundwater system have been estimated as part of the detailed water budgets prepared for the surface water system. Additional components of the groundwater system water budget have been estimated from independent sources or via water budget closure, as summarized in Table 4.5.

Table 4.5. Groundwater System Water Budget Components and Estimation Techniques.

Detailed Component	Category	Estimation Technique	Information Sources
Seepage	Inflow	Sum of seepage estimated for canal, drain, and river and stream systems.	AWMPs, NRCS soil survey, NHD
Percolation of Applied Water	Inflow	Estimated based on daily simulation of root zone applied water moisture content and saturated and unsaturated flow.	AWMPs, NRCS soil survey, IDC
Percolation of Precipitation	Inflow	Estimated based on daily simulation of root zone precipitation moisture content and saturated and unsaturated flow.	AWMPs, NRCS soil survey, IDC
Subsurface Inflows	Inflow	Integrated hydrologic model.	C2VSim fine grid version R374 Beta
Groundwater Extraction	Outflow	For agricultural lands, estimated through water balance (sum of land surface outflows + change in storage - sum of other land surface inflows). For urban lands, estimated based on population and per-capita water use.	Calculated independently for each subarea and compared to available information from AWMPs, UWMPs, etc.

Detailed Component	Category	Estimation Technique	Information Sources
Subsurface Outflows	Outflow	Integrated hydrologic model.	C2VSim fine grid version R374 Beta
Groundwater Discharge	Outflow	Estimated through groundwater system water balance (sum of inflows – sum of other outflows – change in storage).	Overall water budget closure term
Change in Storage	Storage	Estimated from specific yield and groundwater level changes.	Specific yield from Central Valley Hydrologic Model (CVHM); water level changes from DWR Groundwater Information Center (GIC)

4.2 CHARACTERIZATION OF WATER BUDGET COMPONENTS BY HYDROLOGIC YEAR TYPE

Surface water hydrology of the Sacramento Valley and Glenn 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 4.1, 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, 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.

To support evaluation of differences in water budget components related to variable hydrology, the water year type associated with each year is shown along with the annual water budget results reported in Chapters 5, 6, and 7 of this report for the Colusa, Corning, and West Butte subbasins, respectively. Additionally, average annual volumes associated with each water year type are reported. Finally, preliminary estimates of sustainable yield presented in Chapter 8 are calculated based on the relative probability of each water year type occurring based on long-term hydrology.

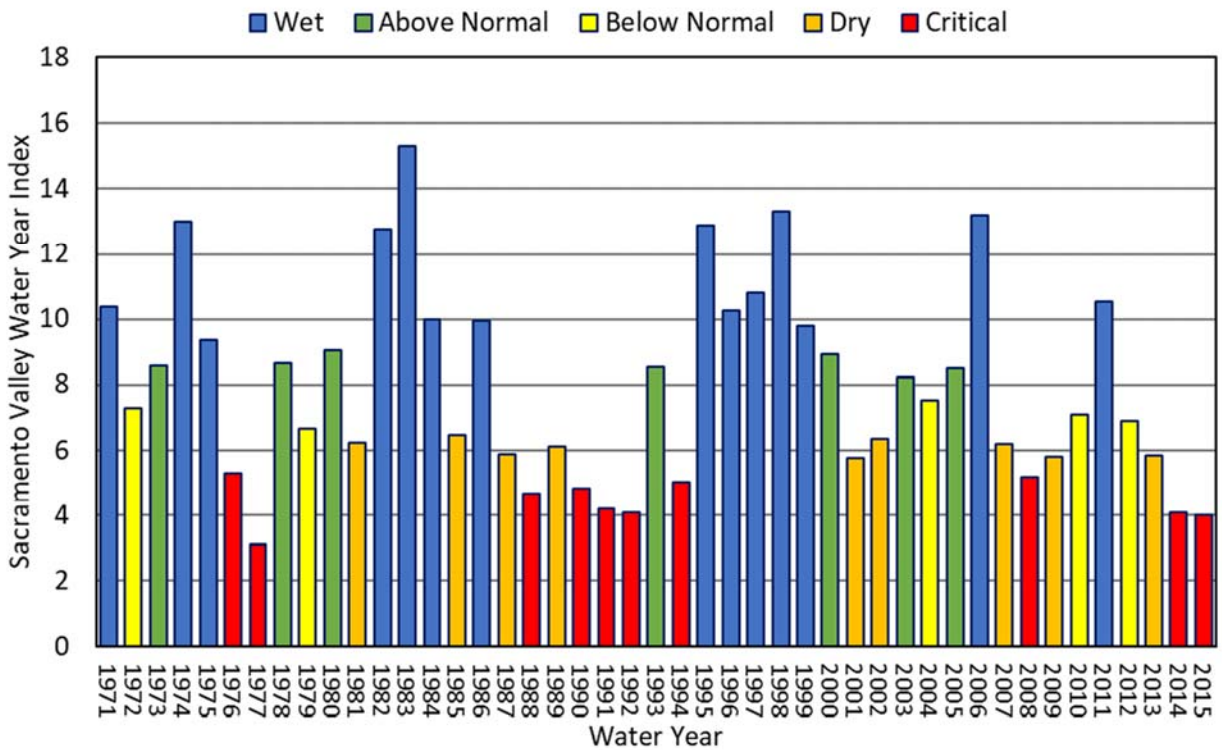

Figure 4.1. Sacramento Valley Water Year Index, 1971-2015.

4.3 UNCERTAINTIES IN WATER BUDGET COMPONENTS

Uncertainties associated with each water budget component have been estimated as described by Clemmens and Burt (1997) as follows:

1. The uncertainty in each independently estimated water budget component is estimated as a percentage representing approximately a 95% confidence interval. These uncertainties are estimated based on professional judgement.
2. Assuming random, normally-distributed error, the standard deviation is estimated as the confidence interval divided by 2 for each independently estimated component.
3. The variance is estimated for each component as the square of the standard deviation for each independently estimated component.
4. The variance in the closure term is estimated as the sum of variances for each independently estimated component.
5. The standard deviation in the closure term is estimated as the square root of the sum of variances.

6. The 95% confidence interval in the closure term is estimated as twice the estimated standard deviation.

Estimated uncertainties associated with the land surface system applied water budget for the Colusa Subbasin portion of Glenn County are shown in Table 4.6. In the table, the average annual volume based on the 2000-2015 analysis period is provided in thousands of acre-feet (taf), along with an estimate of the uncertainty expressed as a percent. Inflows are shown as positive values, while outflows and change in storage are shown as negative values. As a result, a positive value for change in storage actually reflects a decrease in storage. The closure term is shown in **bold**. As shown, the relative uncertainties in deliveries, reuse, evapotranspiration (ET) of applied water, runoff of applied water, percolation of applied water, and change in storage are 5%, 30%, 10%, 25%, 25%, and 50%, respectively. Following the procedure described above, this results in an estimated uncertainty in groundwater extraction of approximately 44%.

Estimated uncertainties in the water budget for the groundwater system are shown in Table 4.7. Estimated uncertainties in independently estimated components of the water budget result in an estimated uncertainty in groundwater discharge of 69%.

Estimated uncertainties in the water budget for the basin are shown in Table 4.8. Estimated uncertainties in independently estimated components of the water budget result in an estimated uncertainty in surface outflows of 24%.

Estimated uncertainties for the portion of the Colusa Subbasin in Glenn County are provided for illustrative purposes. It is anticipated that these uncertainties are similar for the water budgets for the Corning Subbasin and West Butte Subbasin portions of Glenn County and for the Colusa Subbasin portion of Colusa County. It is recommended that similar uncertainty analyses be conducted for the Colusa, Corning, and West Butte subbasins as a whole as part of GSP development. These uncertainties provide a basis for evaluating confidence in water budget results and help to identify data gaps or data reliability issues that may be addressed during GSP preparation and implementation.

Table 4.6. Estimated Uncertainty for Colusa Subbasin Land Surface System Applied Water Budget Components.

Water Budget Component	Colusa Subbasin Annual Volume (taf)	Estimated Uncertainty (%)
Deliveries	638	5%
Groundwater Extraction	**230**	**41%**
Reuse	33	30%
ET of Applied Water	-527	10%
Runoff of Applied Water	-182	25%
Percolation of Applied Water	-206	25%
Change in Storage	14	50%

Table 4.7. Estimated Uncertainty for Colusa Subbasin Groundwater System Water Budget Components.

Water Budget Component	Colusa Subbasin Annual Volume (taf)	Estimated Uncertainty (%)
Subsurface Inflow	40	35%
Infil. of Precipitation	65	10%
Infil. of Surface Water	111	25%
Infil. of Applied Water	206	25%
Subsurface Outflow	-54	35%
Groundwater Extraction	-230	41%
Groundwater Discharge	**-165**	**69%**
Change in Storage	26	50%

Table 4.8. Estimated Uncertainty for Colusa Subbasin Basin Boundary Water Budget Components.

Water Budget Component	Colusa Subbasin Annual Volume (taf)	Estimated Uncertainty (%)
Precipitation	501	10%
Surface Inflows	687	5%
Subsurface Inflows	40	35%
Evapotranspiration	-772	10%
Surface Outflows	**-429**	**24%**
Subsurface Outflows	-54	35%
Change in Storage	26	50%

5.1 LAND USE

While the water budget analysis was performed for water years 2000-2015, land use has been summarized for the period from 1990-2015 to provide a broader context of historical land (and water) use in the County. General land use estimates for 1990-2015 corresponding to water use sectors (as defined by the GSP Regulations) are summarized in Figure 5.1 and Table 5.1 for the Colusa Subbasin within Glenn County. The "Developed" land use category includes urban and industrial lands. These water use sectors have not been described individually due to very few industrial lands existing in the Subbasin.

As indicated, agricultural lands have remained relatively steady since 1990, at approximately 197,000 acres, on average. Native vegetation has decreased from over 80,000 acres in the early 1990's to less than 70,000 acres after 2010. Developed lands have increased from around 16,000 acres in the early 1990s to over 25,000 acres in recent years. This is due in part to changes in DWR's delineation of developed lands in land use surveys over time. Similarly, water acreage is shown to have nearly doubled between 1990 and 2015, which is likely due to changes in DWR's delineation of water bodies over time.

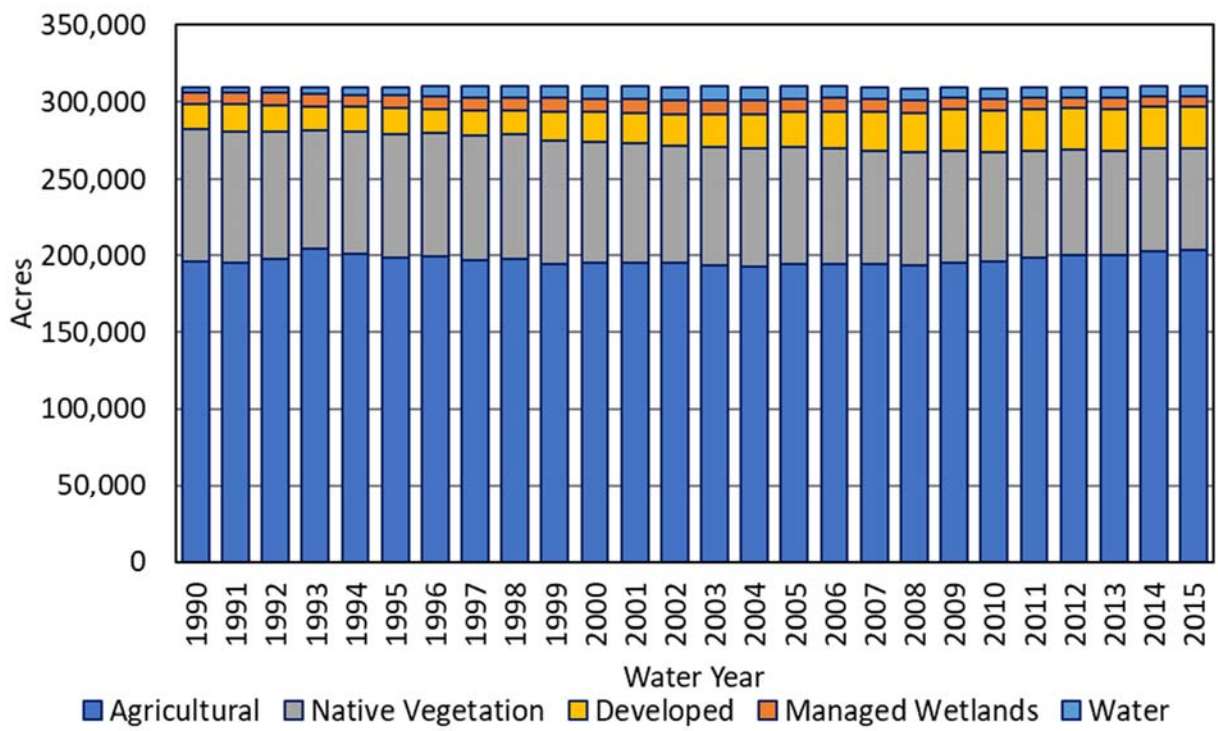

Figure 5.1. Colusa Subbasin General Land Uses.

Table 5.1. Colusa Subbasin General Land Uses (Acres).

Year	Agricultural	Managed Wetlands	Native Vegetation	Developed	Water
1990	196,430	7,288	86,080	16,214	3,400
1991	195,453	7,581	86,048	17,045	3,651
1992	198,038	7,866	82,815	17,045	3,900
1993	204,415	8,122	77,736	15,039	4,168
1994	200,695	8,191	80,409	15,518	4,847
1995	198,689	8,260	80,732	16,612	5,527
1996	199,214	8,330	80,803	15,419	6,206
1997	196,881	8,400	81,376	16,515	6,887
1998	197,675	8,472	81,764	14,772	7,568
1999	194,289	8,672	81,405	18,105	7,780
2000	195,279	8,873	79,257	18,766	7,991
2001	195,229	9,074	78,219	19,428	8,203
2002	195,414	9,275	76,620	20,014	8,414
2003	193,133	9,476	78,084	20,742	8,627
2004	192,591	9,194	77,270	21,739	8,324
2005	190,614	8,912	76,320	22,734	8,021
2006	190,880	8,629	75,450	23,729	7,718
2007	194,008	8,347	74,588	24,730	7,416
2008	193,666	8,065	73,759	25,729	7,113
2009	195,378	7,783	72,821	26,727	6,811
2010	196,315	7,555	71,550	26,781	6,774
2011	198,439	7,328	69,895	26,837	6,738
2012	199,925	7,101	69,121	26,895	6,702
2013	199,835	6,873	68,747	26,952	6,665
2014	202,287	6,645	67,683	27,008	6,629
2015	203,221	6,457	67,054	27,028	6,601
Average	196,846	8,107	76,754	21,082	6,642

Agricultural land uses are further detailed in Figure 5.2 and Table 5.2. Rice acreage has remained relatively steady over time, with decreases in 2014 and 2015 resulting from curtailment of surface water supplies. Orchard acreage more than tripled between the early 1990s and recent years, with corresponding decreases in pasture and alfalfa, grain crops, and other field and annual crops.

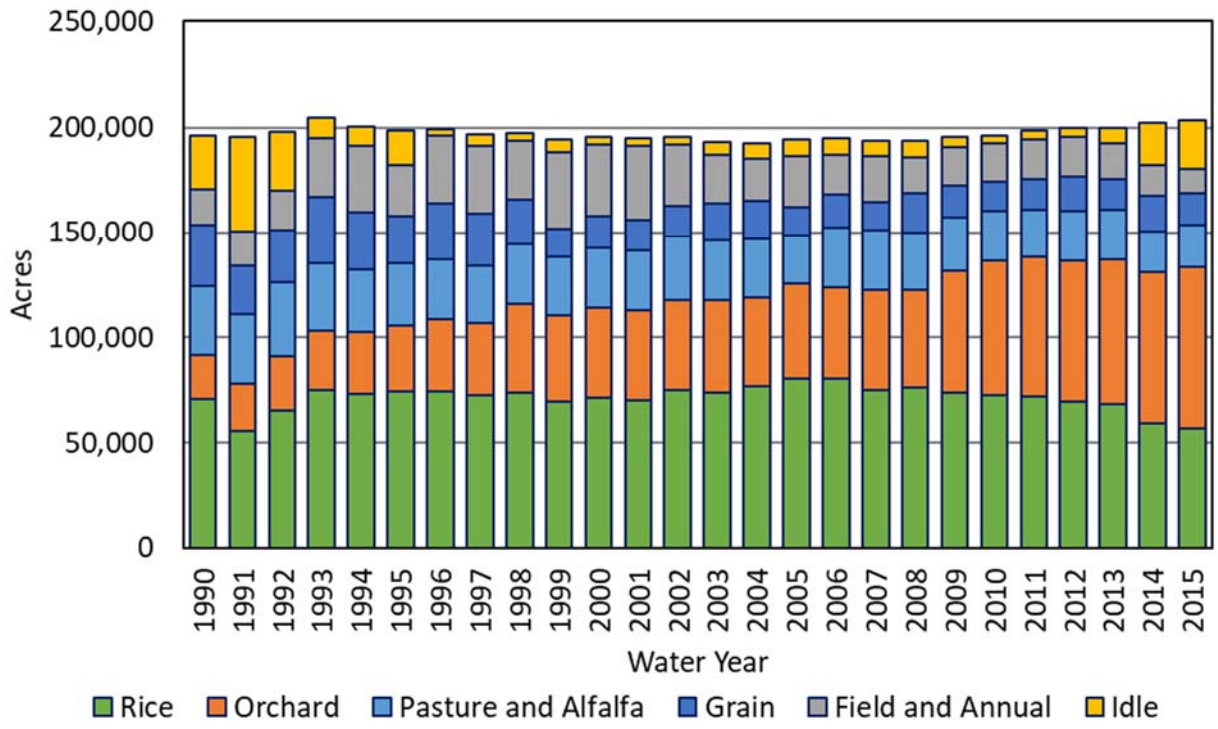

Figure 5.2. Colusa Subbasin Agricultural Land Uses.

Table 5.2. Colusa Subbasin Agricultural Land Uses (Acres).

Year	Field and Annual	Grain	Idle	Orchard	Pasture and Alfalfa	Rice
1990	16,940	29,412	25,639	20,795	32,742	70,902
1991	16,281	23,047	45,178	22,338	32,760	55,848
1992	18,741	24,726	28,292	25,911	35,060	65,308
1993	28,093	31,873	9,327	28,305	31,756	75,062
1994	32,108	26,913	9,188	28,678	30,166	73,643
1995	24,536	22,181	16,491	31,261	29,802	74,419
1996	32,059	26,689	3,153	34,039	28,512	74,762
1997	32,509	24,850	5,410	33,570	27,509	73,034
1998	28,268	20,906	3,756	42,158	28,572	74,016
1999	36,763	13,442	5,960	41,001	27,566	69,559
2000	33,721	15,072	3,583	42,510	28,821	71,571
2001	35,279	15,043	3,638	42,407	28,496	70,367
2002	28,910	14,989	3,685	43,047	29,832	74,953
2003	23,187	17,403	6,002	44,113	28,510	73,917
2004	19,922	17,867	7,597	42,199	28,253	76,753
2005	23,754	13,185	7,684	44,441	22,623	78,928
2006	18,534	15,169	7,553	42,420	27,999	79,205
2007	21,841	13,456	7,708	47,391	28,392	75,221
2008	17,546	18,591	7,579	46,671	27,167	76,111
2009	17,903	15,198	4,783	58,005	25,734	73,754
2010	18,244	13,656	4,045	63,811	23,573	72,987
2011	18,833	14,645	4,141	66,310	22,520	71,991
2012	18,848	16,415	4,196	66,802	23,950	69,713
2013	16,892	14,937	7,373	68,881	23,217	68,535
2014	14,457	17,070	20,198	71,739	19,661	59,160
2015	11,551	15,030	22,901	76,622	20,249	56,868
Average	23,297	18,914	10,579	45,209	27,440	71,407

5.2 BOUNDARY BUDGET

This section presents the basin boundary water budget for the Colusa Subbasin in Glenn County.

5.2.1 Inflows

5.2.1.1 Surface Water Inflow by Water Source Type

Surface water inflows include surface water flowing into the basin across the basin boundary. Per the Regulations, surface inflows must be reported by water source type. According to the Regulations:

> *"Water source type" represents the source from which water is derived to meet the applied beneficial uses, including groundwater, recycled water, reused water, and surface water sources identified as Central Valley Project, the State Water Project, the Colorado River Project, local supplies, and local imported supplies.*

Additionally, runoff of precipitation from upgradient areas adjacent to the basin represents a potential source of surface water inflow.

Primary surface water inflows to the Colusa Subbasin in Glenn County include diversions from the Sacramento River by Sacramento River Settlement Contractors (SRSC), diversions from the Sacramento River by Tehama-Colusa Canal (TCC) contractors, and diversions from Stony Creek by the Orland Unit Water Users Association (OUWUA).

5.2.1.1.1 Local Imported Supplies

For purposes of this preliminary water budget, SRSC diversions by Glenn-Colusa Irrigation District (GCID), Princeton-Codora-Glenn Irrigation District (PCGID), and Provident Irrigation District (PID) have been classified as local imported supplies, although under diversion agreements with the U.S. Bureau of Reclamation (USBR), these diversions include a combination of "Base" (local) and "Project" (Central Valley Project or CVP) supplies, with the majority of diversions being based on senior, local water rights. Additionally, estimated diversions for these preliminary water budgets represent "net" diversions for use in Glenn County and do not include diversions that occur in Glenn County but pass through to Colusa County for GCID, PCGID, or PID, whose service areas include portions of both Glenn and Colusa counties.

The OUWUA diverts water from Stony Creek made available via one of USBRs earliest water supply projects, which predates the CVP. As a result, these supplies are considered local imported supplies for purposes of this preliminary water budget.

Additional riparian and other small diversions likely occur but have not been included as part of this preliminary effort. It is anticipated that additional diversions will be addressed as part of subsequent phases of GSP development.

5.2.1.1.2 CVP Supplies

TCC contractors in the Glenn County portion of the Colusa Subbasin include Glide Water District (GWD), Kanawha Water District (KWD), and Orland Artois Water District (OAWD). For purposes of the preliminary water budgets presented herein, these supplies are classified as CVP supplies.

5.2.1.1.3 Recycling and Reuse

For purposes of this analysis, recycled water, as locally defined, represents recovery and reuse of drainwater by surface water suppliers. Reuse refers to reuse by individual growers. Although substantial recycling and reuse occurs within the study area, recycled or reused water generated outside of the basin does not flow into the basin in significant quantities; therefore neither recycling nor reuse are included as part of the estimation of boundary surface water inflows.

5.2.1.1.4 Groundwater

Groundwater pumped outside of the study area does not flow into the study area through surface water conveyances; therefore, groundwater is not included as part of the estimation of boundary surface water inflows.

5.2.1.1.5 Other Surface Inflows

Colorado River Project supplies are not applicable to the study area.

There are no State Water Project (SWP) contractors within the study area.

Some precipitation runoff enters the study area as runoff from small watersheds along the western boundary of the subbasin. For the preliminary water budgets presented herein, it is assumed that these inflows are relatively small and pass through the County following relatively large storm events. It is anticipated that these surface inflows will be quantified as part of GSP development.

5.2.1.1.6 Summary of Surface Inflows

Surface water inflows by water year type are summarized in Figure 5.3 and Table 5.3. During the study period, local imported supplies were limited to 75 percent in 2014 and 2015, and TCC supplies were less than 100 percent in 2001, 2008, 2009, 2014, and 2015 (60%, 40%, 40%, 0%, and 0%, respectively) . Total surface water inflows ranged from approximately 400 taf in 2015 to 800 taf in 2004.

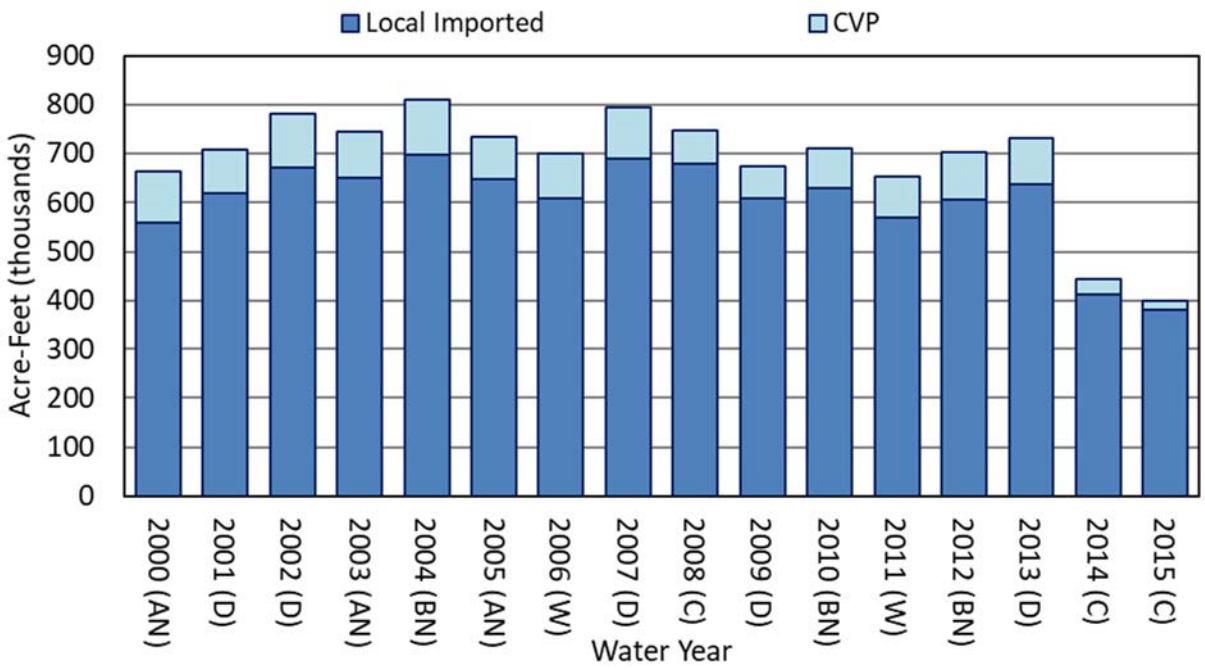

Figure 5.3. Colusa Subbasin Surface Water Inflows by Water Source Type.

Table 5.3. Colusa Subbasin Surface Water Inflows by Water Source Type (Acre-Feet).

Water Year	Local Imported	CVP	Total
2000 (AN)	559,049	103,929	662,978
2001 (D)	619,876	89,171	709,047
2002 (D)	671,912	110,050	781,962
2003 (AN)	651,520	92,463	743,983
2004 (BN)	697,492	111,830	809,322
2005 (AN)	647,094	85,946	733,040
2006 (W)	608,946	91,925	700,871
2007 (D)	689,009	105,356	794,365
2008 (C)	679,576	68,080	747,656
2009 (D)	608,689	64,030	672,719
2010 (BN)	629,087	80,494	709,581
2011 (W)	569,828	82,841	652,669
2012 (BN)	606,253	96,299	702,552
2013 (D)	636,530	95,186	731,716
2014 (C)	413,450	31,633	445,083
2015 (C)	380,845	19,619	400,464
Average	604,322	83,053	687,375
W	589,387	87,383	676,770
AN	619,221	94,113	713,334
BN	644,277	96,208	740,485
D	645,203	92,759	737,962
C	491,290	39,777	531,068

5.2.1.2 Precipitation

Precipitation estimates for the Glenn County portion of the Colusa Subbasin are provided in Figure 5.4 and Table 5.4. Precipitation estimates are reported by water use sector. According to the Regulations:

> *"Water use sector" refers to categories of water demand based on the general land uses to which the water is applied, including urban, industrial, agricultural, managed wetlands, managed recharge, and native vegetation.*

For Glenn County, minimal industrial water use is present, and industrial uses have been combined with urban uses for this study. Additionally, there is no known managed recharge occurring within the County.

Precipitation is highly variable in the study area, ranging from approximately 230 taf in 2007 to 800 taf in 2005.

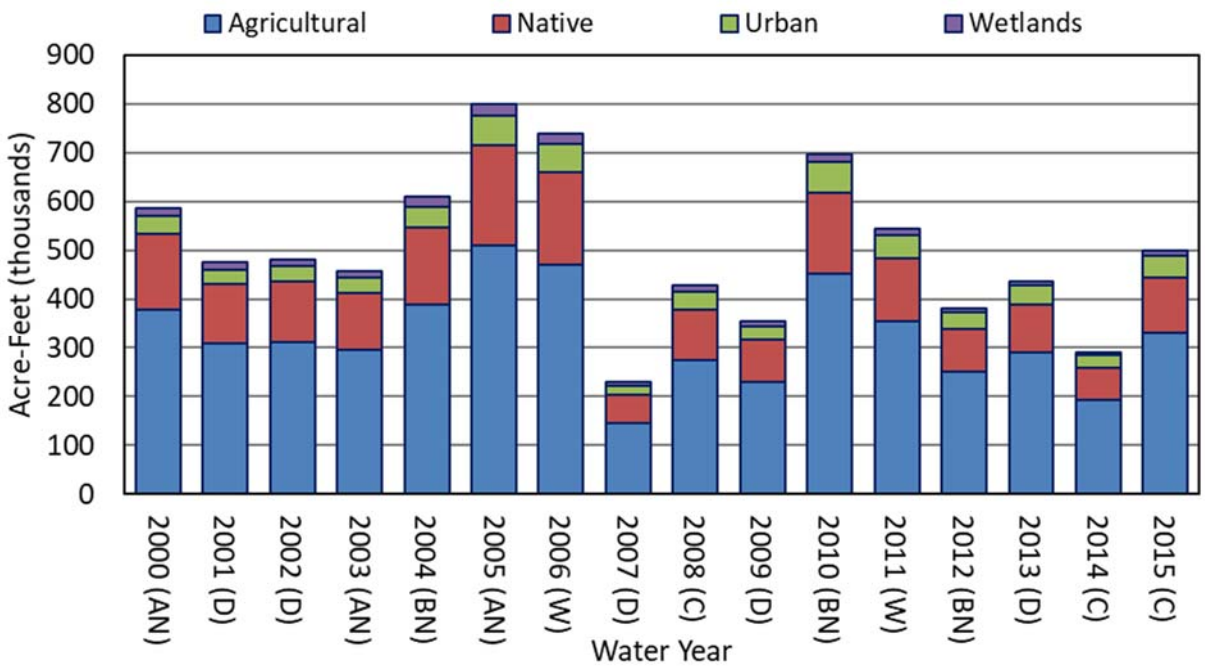

Figure 5.4. Colusa Subbasin Precipitation by Water Use Sector.

Table 5.4. Colusa Subbasin Precipitation by Water Use Sector (Acre-Feet).

Water Year	Agricultural	Native	Urban	Wetlands	Total
2000 (AN)	378,817	155,096	36,431	17,248	587,592
2001 (D)	307,186	123,767	30,527	14,282	475,762
2002 (D)	311,739	124,583	31,369	14,618	482,309
2003 (AN)	294,233	118,167	31,235	14,334	457,969
2004 (BN)	389,656	157,289	42,923	18,915	608,783
2005 (AN)	509,909	204,690	59,572	24,090	798,261
2006 (W)	471,468	187,560	57,787	21,626	738,441
2007 (D)	146,875	57,214	18,547	6,463	229,099
2008 (C)	275,147	105,085	36,311	11,539	428,082
2009 (D)	228,881	85,993	31,035	9,263	355,172
2010 (BN)	452,442	165,910	61,815	17,571	697,738
2011 (W)	356,322	127,352	48,401	13,391	545,466
2012 (BN)	251,402	87,524	33,913	9,050	381,889
2013 (D)	289,076	99,919	38,950	10,191	438,136
2014 (C)	193,529	64,900	25,878	6,375	290,682
2015 (C)	332,910	111,132	44,458	10,858	499,358
Average	324,350	123,511	39,322	13,738	500,921
W	413,895	157,456	53,094	17,509	641,954
AN	394,320	159,318	42,413	18,557	614,607
BN	364,500	136,908	46,217	15,179	562,803
D	256,751	98,295	30,086	10,963	396,096
C	267,195	93,706	35,549	9,591	406,041

5.2.1.3 Subsurface Groundwater Inflow

Subsurface groundwater inflow was estimated based on DWR's C2VSim fine grid application of the Integrated Water Flow Model (IWFM), version R374 Beta. The fine grid beta version is equivalent to the coarse grid R374 public release version of the application, but includes a more detailed element grid to allow for improved definition of zones to extract groundwater budget results along county and subbasin boundaries. C2VSim results for water years 2000 to 2009 were available as model outputs; estimates for 2010 to 2015 were interpolated based on changes in annual subsurface inflows over time.

Subsurface inflow estimates for the Glenn County portion of the Colusa Subbasin are provided in Figure 5.5 and Table 5.5. C2VSim suggests that subsurface inflow has increased over time, from around 38 taf in 2000 to 43 taf in 2015; however, groundwater inflow is small compared to surface water inflows.

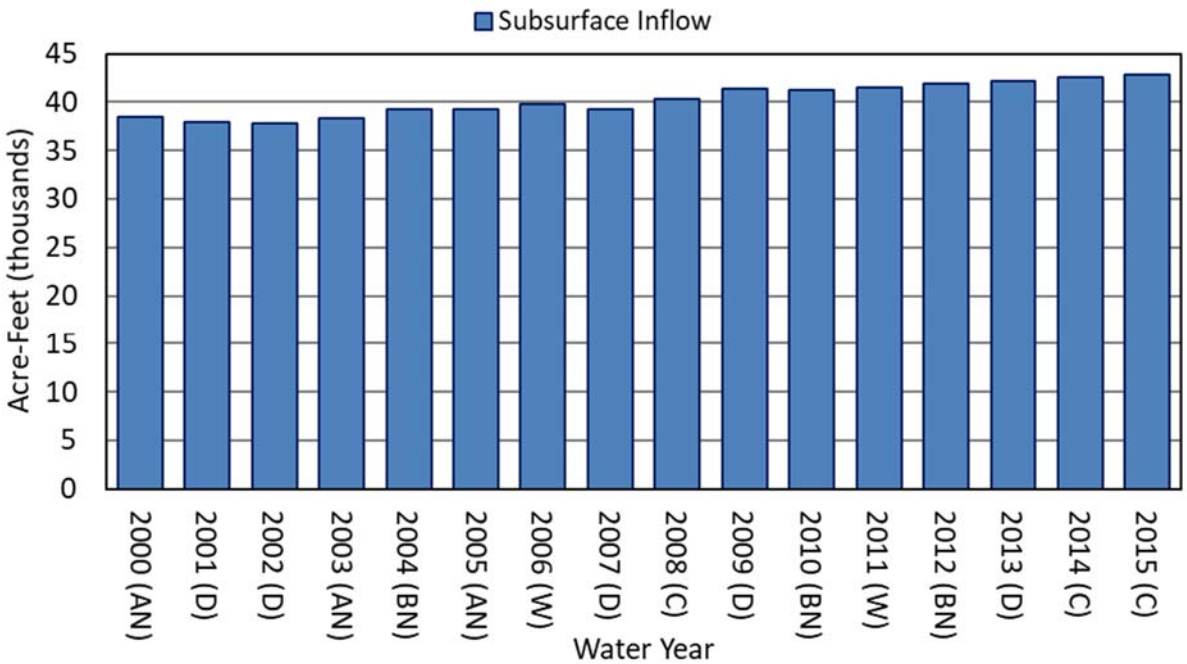

Figure 5.5. Colusa Subbasin Subsurface Inflows.

Table 5.5. Colusa Subbasin Subsurface Inflows (Acre-Feet).

Water Year	Subsurface Inflow
2000 (AN)	38,430
2001 (D)	37,975
2002 (D)	37,802
2003 (AN)	38,333
2004 (BN)	39,204
2005 (AN)	39,258
2006 (W)	39,733
2007 (D)	39,211
2008 (C)	40,361
2009 (D)	41,381
2010 (BN)	41,169
2011 (W)	41,502
2012 (BN)	41,835
2013 (D)	42,169
2014 (C)	42,502
2015 (C)	42,835
Average	40,231
W	40,617
AN	38,674
BN	40,736
D	39,708
C	41,899

5.2.2 Outflows

5.2.2.1 Evapotranspiration by Water Use Sector

Evapotranspiration (ET) by water use sector is reported in Figures 5.6 to 5.8 and Tables 5.6 to 5.8. First, total ET is reported, followed by ET from applied water and ET from precipitation. "Urban" lands include urban, industrial, and rural residential lands. Other than cities of Willows and Orland and the community of Artois, these lands are primarily rural residential.

In addition to ET from land surfaces, estimates of evaporation from canals, drains, lakes, and streams are included. ET of applied water for native lands represents estimated ET of groundwater by riparian vegetation.

ET was least in 2014, at approximately 715 taf, and greatest in 2012, at approximately 800 taf. Agricultural ET tends to increase in drier years, while native ET decreases. Total ET has remained relatively steady over time.

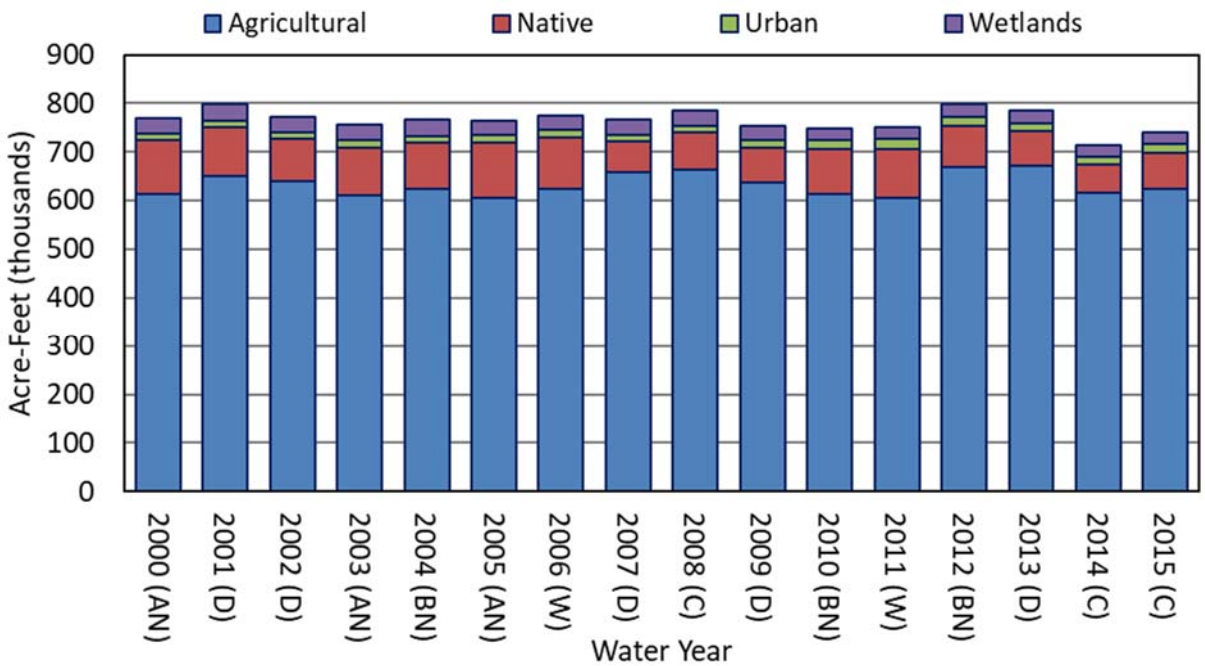

Figure 5.6. Colusa Subbasin Evapotranspiration by Water Use Sector.

Table 5.6. Colusa Subbasin Evapotranspiration by Water Use Sector (Acre-Feet).

Water Year	Agricultural	Native	Urban	Wetlands	Total
2000 (AN)	614,042	109,952	14,486	30,969	769,449
2001 (D)	649,463	101,410	13,801	32,715	797,389
2002 (D)	640,224	87,452	12,135	33,085	772,896
2003 (AN)	611,189	97,552	14,943	31,451	755,135
2004 (BN)	624,283	95,802	13,227	33,208	766,520
2005 (AN)	605,608	112,218	17,756	29,566	765,148
2006 (W)	623,381	105,727	16,044	29,360	774,512
2007 (D)	657,055	64,150	14,286	31,142	766,633
2008 (C)	662,988	76,403	14,613	30,775	784,779
2009 (D)	637,623	70,971	15,931	27,707	752,232
2010 (BN)	612,767	92,040	18,591	24,588	747,986
2011 (W)	606,797	99,638	19,964	23,658	750,057
2012 (BN)	667,980	85,745	19,106	25,459	798,290
2013 (D)	670,352	72,518	16,356	25,833	785,059
2014 (C)	615,241	58,376	15,816	25,473	714,906
2015 (C)	623,525	75,268	17,708	23,727	740,228
Average	632,657	87,826	15,923	28,670	765,076
W	615,089	102,683	18,004	26,509	762,285
AN	610,280	106,574	15,728	30,662	763,244
BN	635,010	91,196	16,975	27,752	770,932
D	650,943	79,300	14,502	30,096	774,842
C	633,918	70,016	16,046	26,658	746,638

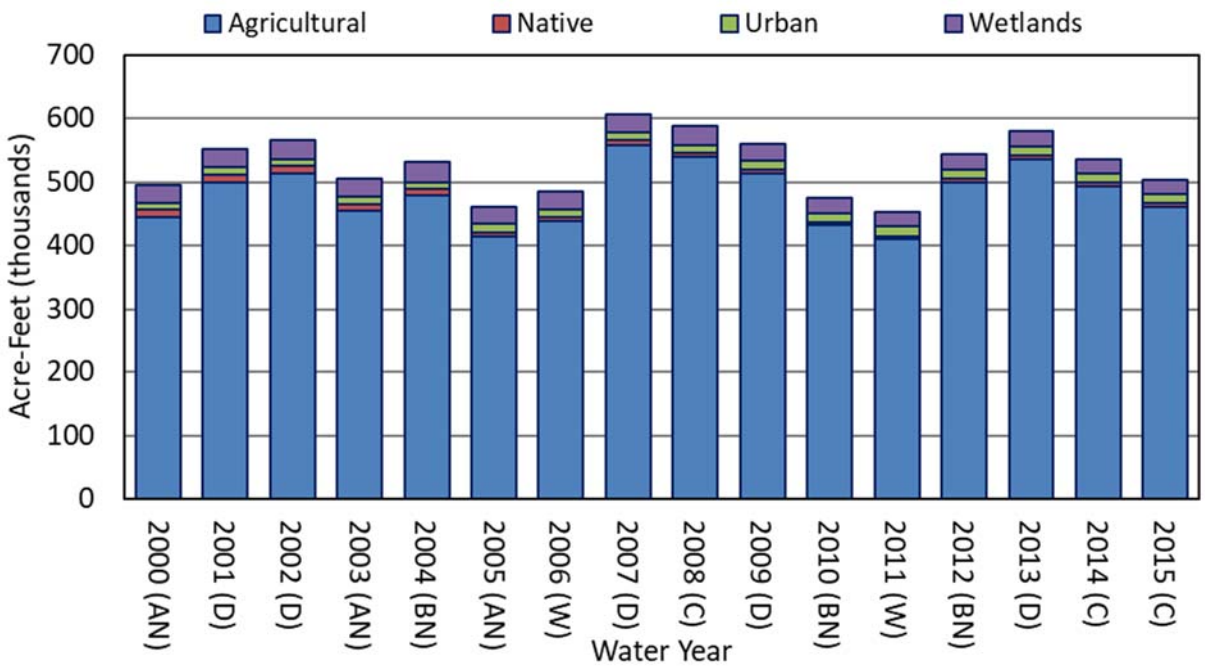

Figure 5.7. Colusa Subbasin Evapotranspiration of Applied Water by Water Use Sector.

Table 5.7. Colusa Subbasin Evapotranspiration of Applied Water by Water Use Sector (Acre-Feet).

Water Year	Agricultural	Native	Urban	Wetlands	Total
2000 (AN)	444,840	11,021	11,057	28,483	495,401
2001 (D)	499,866	11,886	10,709	30,055	552,516
2002 (D)	513,585	11,540	9,639	31,434	566,198
2003 (AN)	454,432	10,115	12,225	28,804	505,576
2004 (BN)	479,776	9,654	10,315	30,650	530,395
2005 (AN)	413,184	7,164	14,224	26,146	460,718
2006 (W)	438,106	6,800	12,536	26,747	484,189
2007 (D)	556,688	8,713	12,056	28,811	606,268
2008 (C)	538,759	7,573	12,177	28,953	587,462
2009 (D)	513,257	6,218	13,608	25,657	558,740
2010 (BN)	431,401	4,900	15,147	22,515	473,963
2011 (W)	410,067	4,801	15,916	21,484	452,268
2012 (BN)	498,242	6,207	15,144	23,917	543,510
2013 (D)	534,718	6,908	13,064	24,632	579,322
2014 (C)	492,374	7,165	12,916	23,798	536,253
2015 (C)	460,105	6,924	13,780	22,031	502,840
Average	479,963	7,974	12,782	26,507	527,226
W	424,087	5,801	14,226	24,116	468,229
AN	437,485	9,433	12,502	27,811	487,232
BN	469,806	6,920	13,535	25,694	515,956
D	523,623	9,053	11,815	28,118	572,609
C	497,079	7,221	12,958	24,927	542,185

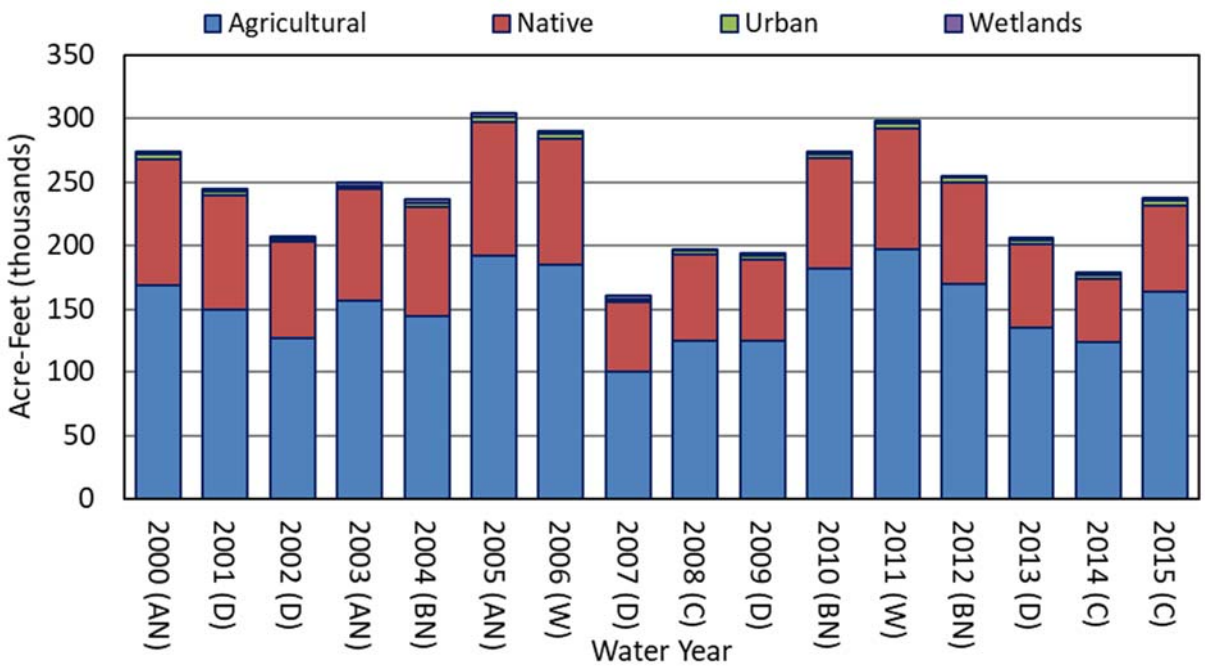

Figure 5.8. Colusa Subbasin Evapotranspiration of Precipitation by Water Use Sector.

Table 5.8. Colusa Subbasin Evapotranspiration of Precipitation by Water Use Sector (Acre-Feet).

Water Year	Agricultural	Native	Urban	Wetlands	Total
2000 (AN)	169,202	98,931	3,429	2,486	274,048
2001 (D)	149,597	89,524	3,092	2,660	244,873
2002 (D)	126,639	75,912	2,496	1,651	206,698
2003 (AN)	156,757	87,437	2,718	2,647	249,559
2004 (BN)	144,507	86,148	2,912	2,558	236,125
2005 (AN)	192,424	105,054	3,532	3,420	304,430
2006 (W)	185,275	98,927	3,508	2,613	290,323
2007 (D)	100,367	55,437	2,230	2,331	160,365
2008 (C)	124,229	68,830	2,436	1,822	197,317
2009 (D)	124,366	64,753	2,323	2,050	193,492
2010 (BN)	181,366	87,140	3,444	2,073	274,023
2011 (W)	196,730	94,837	4,048	2,174	297,789
2012 (BN)	169,738	79,538	3,962	1,542	254,780
2013 (D)	135,634	65,610	3,292	1,201	205,737
2014 (C)	122,867	51,211	2,900	1,675	178,653
2015 (C)	163,420	68,344	3,928	1,696	237,388
Average	152,695	79,852	3,141	2,162	237,850
W	191,003	96,882	3,778	2,394	294,056
AN	172,794	97,141	3,226	2,851	276,012
BN	165,204	84,275	3,439	2,058	254,976
D	127,321	70,247	2,687	1,979	202,233
C	136,839	62,795	3,088	1,731	204,453

5.2.2.2 Surface Water Outflow by Water Source Type

Surface water outflows by water source type are summarized in Figure 5.9 and Table 5.9. Irrigation return flows consist of runoff of local imported supplies (irrigation runoff from CVP contractors is assumed negligible). Other surface outflows include runoff of precipitation and groundwater discharge to drains and streams that leave the study area. In 2014 and 2015, groundwater discharge from the study area was estimated to be negative, representing a loss of water from drains and streams to the groundwater system as seepage. Estimated surface outflows were greatest in 2005 at 760 taf and least in 2014 at 100 taf.

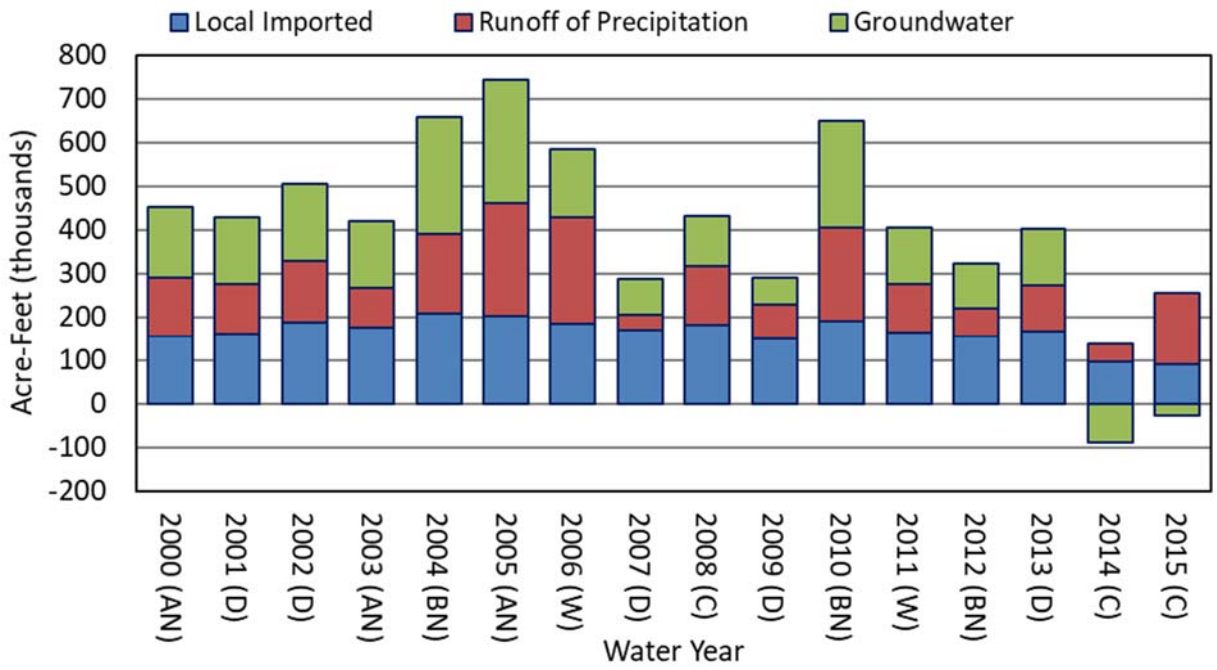

Figure 5.9. Colusa Subbasin Surface Outflows by Water Source Type.

Table 5.9. Colusa Subbasin Surface Outflows by Water Source Type (Acre-Feet).

Water Year	Local Imported	CVP	Runoff of Precipitation	Groundwater	Total
2000 (AN)	154,106	0	136,667	183,785	474,558
2001 (D)	160,137	0	114,773	129,828	404,739
2002 (D)	186,164	0	141,706	156,882	484,752
2003 (AN)	176,905	0	88,750	167,636	433,291
2004 (BN)	207,662	0	183,134	253,613	644,409
2005 (AN)	203,357	0	257,094	301,489	761,940
2006 (W)	183,667	0	245,941	147,321	576,929
2007 (D)	171,061	0	34,546	78,082	283,689
2008 (C)	182,831	0	133,699	98,993	415,522
2009 (D)	149,560	0	79,137	72,323	301,021
2010 (BN)	191,229	0	212,260	272,138	675,627
2011 (W)	164,979	0	110,176	129,831	404,986
2012 (BN)	154,961	0	63,413	85,048	303,422
2013 (D)	166,416	0	105,498	148,053	419,967
2014 (C)	95,031	0	41,866	-38,474	98,424
2015 (C)	90,324	0	164,404	-73,822	180,906
Average	164,899	0	132,066	132,045	429,011
W	174,323	0	178,059	138,576	490,958
AN	178,123	0	160,837	217,637	556,596
BN	184,617	0	152,936	203,600	541,153
D	166,668	0	95,132	117,034	378,833
C	122,729	0	113,323	-4,434	231,617

5.2.2.3 Subsurface Groundwater Outflow

Subsurface groundwater outflow was estimated based on DWR's C2VSim fine grid application of IWFM, version R374 Beta. The fine grid beta version is equivalent to the coarse grid R374 public release version of the application, but includes a more detailed element grid to allow for improved definition of zones to extract groundwater budget results along county and subbasin boundaries. C2VSim results for water years 2000 to 2009 were available as model outputs; estimates for 2010 to 2015 were interpolated based on changes in annual subsurface outflows over time.

Subsurface outflow estimates for the Glenn County portion of the Colusa Subbasin are provided in Figure 5.10 and Table 5.10. C2VSim suggests that subsurface outflow has decreased over time, from around 56 taf in 2000 to 50 taf in 2015; however, groundwater outflow is small compared to surface water outflows.

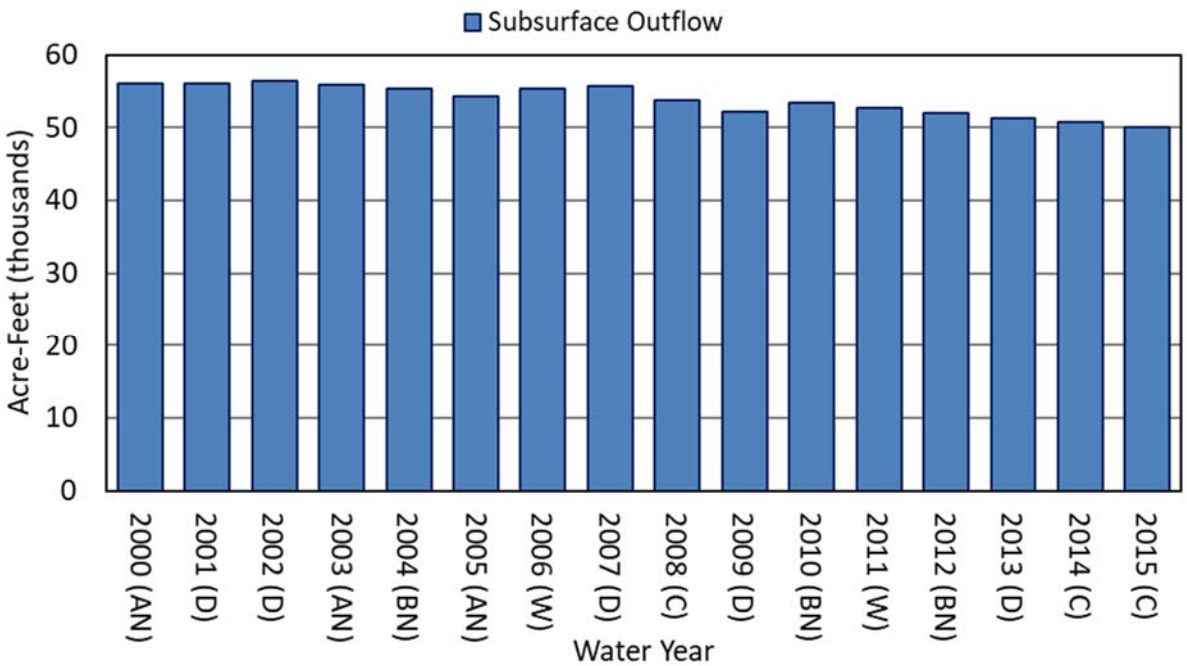

Figure 5.10. Colusa Subbasin Subsurface Outflows.

Table 5.10. Colusa Subbasin Subsurface Outflows (Acre-Feet).

Water Year	Subsurface Outflow
2000 (AN)	55,975
2001 (D)	56,040
2002 (D)	56,473
2003 (AN)	55,898
2004 (BN)	55,323
2005 (AN)	54,237
2006 (W)	55,347
2007 (D)	55,738
2008 (C)	53,790
2009 (D)	52,218
2010 (BN)	53,348
2011 (W)	52,681
2012 (BN)	52,013
2013 (D)	51,345
2014 (C)	50,678
2015 (C)	50,010
Average	53,820
W	54,014
AN	55,370
BN	53,561
D	54,363
C	51,493

5.2.3 Change in Storage

Estimates of total change in storage within the basin are provided in Figure 5.11 and Table 5.11. Total change in storage includes both the surface water system and the groundwater system. Change in storage for the surface water system and groundwater system are reported individually in Sections 5.3.3 and 5.4.3, respectively. The estimates suggest a net decrease in storage in all years between 2000 and 2015, with the exception of the wet years of 2006 and 2011. Total change in storage appears to be relatively strongly correlated to water year type.

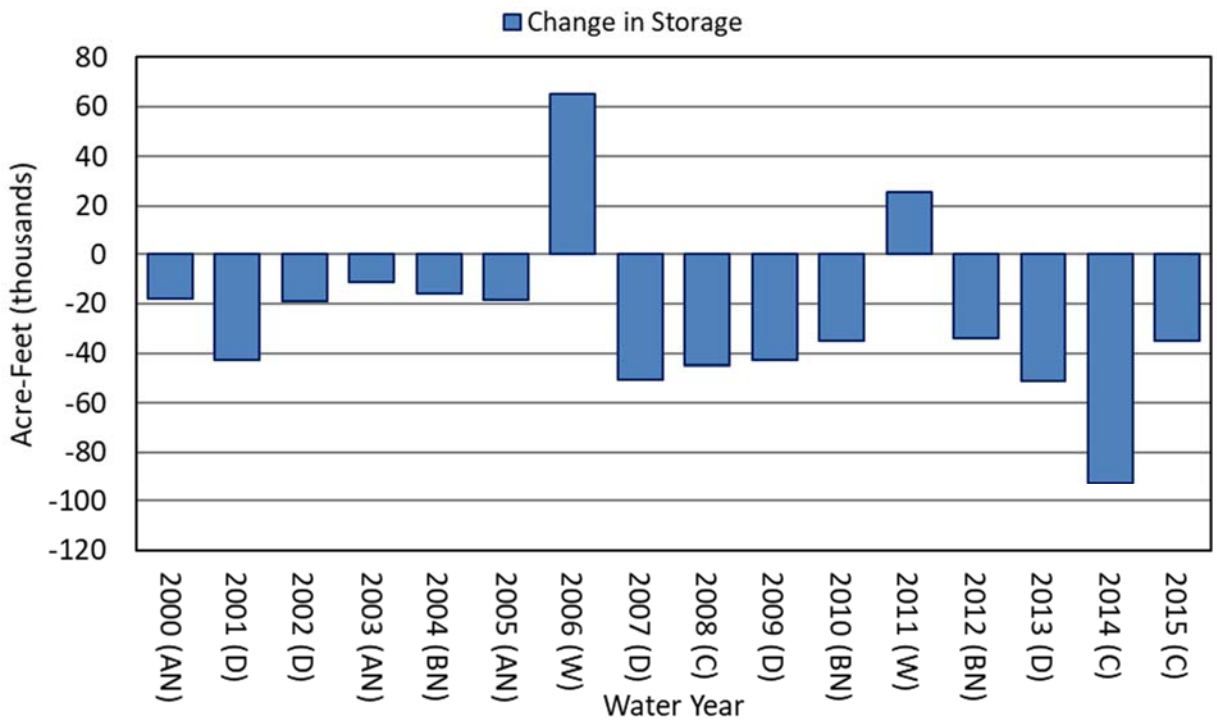

Figure 5.11. Colusa Subbasin Change in Storage.

Table 5.11. Colusa Subbasin Change in Storage (Acre-Feet).

Water Year	Change in Storage
2000 (AN)	-17,852
2001 (D)	-42,538
2002 (D)	-19,070
2003 (AN)	-11,094
2004 (BN)	-16,023
2005 (AN)	-18,164
2006 (W)	65,284
2007 (D)	-50,547
2008 (C)	-45,066
2009 (D)	-42,843
2010 (BN)	-35,251
2011 (W)	25,706
2012 (BN)	-34,217
2013 (D)	-50,901
2014 (C)	-92,307
2015 (C)	-34,819
Average	-26,231
W	45,495
AN	-15,703
BN	-28,497
D	-41,180
C	-57,397

5.2.4 Historical Water Budget Summary

Annual inflows, outflows, and change in storage for the basin are summarized in Figure 5.12 and Table 5.12. Inflows are shown as positive values, while outflows and change in storage are shown as negative values. As a result, a positive value for change in storage actually reflects a decrease in storage. Review of the variability in component volumes across years provides insight into the impacts of hydrology on the overall basin water budget.

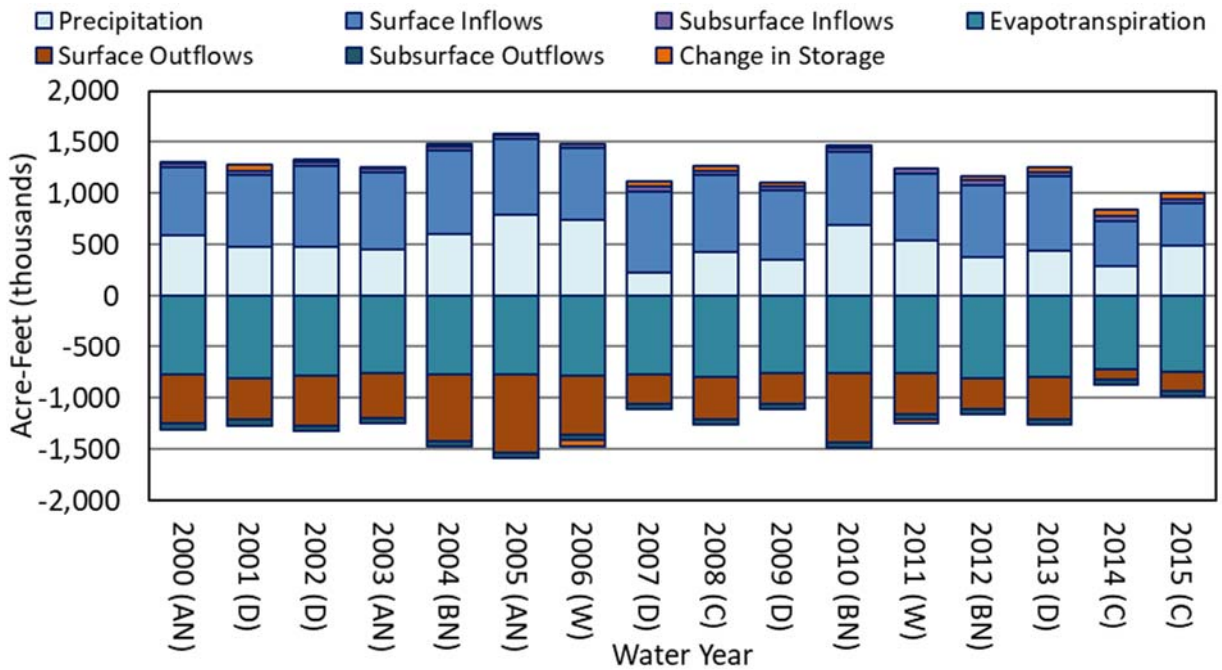

Figure 5.12. Colusa Subbasin Boundary Budget, 2000 – 2015.

Table 5.12. Colusa Subbasin Boundary Budget, 2000 – 2015 (Acre-Feet).

Water Year	Precipi-tation	Surface Inflows	Subsurface Inflows	Evapotrans-piration	Surface Outflows	Subsurface Outflows	Change in Storage
2000 (AN)	587,592	662,978	38,430	-776,320	-474,558	-55,975	17,852
2001 (D)	475,762	709,047	37,975	-804,543	-404,739	-56,040	42,538
2002 (D)	482,309	781,962	37,802	-779,918	-484,752	-56,473	19,070
2003 (AN)	457,969	743,983	38,333	-762,190	-433,291	-55,898	11,094
2004 (BN)	608,783	809,322	39,204	-773,601	-644,409	-55,323	16,023
2005 (AN)	798,261	733,040	39,258	-772,546	-761,940	-54,237	18,164
2006 (W)	738,441	700,871	39,733	-781,484	-576,929	-55,347	-65,284
2007 (D)	229,099	794,365	39,211	-773,795	-283,689	-55,738	50,547
2008 (C)	428,082	747,656	40,361	-791,853	-415,522	-53,790	45,066
2009 (D)	355,172	672,719	41,381	-758,877	-301,021	-52,218	42,843
2010 (BN)	697,738	709,581	41,169	-754,764	-675,627	-53,348	35,251
2011 (W)	545,466	652,668	41,502	-756,263	-404,986	-52,681	-25,706
2012 (BN)	381,889	702,552	41,835	-805,058	-303,422	-52,013	34,217
2013 (D)	438,136	731,716	42,169	-791,609	-419,967	-51,345	50,901
2014 (C)	290,682	445,083	42,502	-721,472	-98,424	-50,678	92,307
2015 (C)	499,358	400,464	42,835	-746,560	-180,906	-50,010	34,819
Average	500,921	687,375	40,231	-771,928	-429,011	-53,820	26,231
W	641,954	676,770	40,617	-768,874	-490,958	-54,014	-45,495
AN	614,607	713,334	38,674	-770,352	-556,596	-55,370	15,703
BN	562,803	740,485	40,736	-777,808	-541,153	-53,561	28,497
D	396,096	737,962	39,708	-781,748	-378,833	-54,363	41,180
C	406,041	531,068	41,899	-753,295	-231,617	-51,493	57,397

5.3 SURFACE WATER SYSTEM BUDGET

This section presents the surface water system water budget for the Colusa Subbasin in Glenn County.

5.3.1 Inflows

5.3.1.1 Surface Water Inflow by Water Source Type

Surface water inflows by water source type are described in Section 5.2.1.1.

5.3.1.2 Precipitation

Precipitation inflow is described in Section 5.2.1.2.

5.3.1.3 Groundwater Extraction by Water Use Sector

Estimates of groundwater extraction by water use sector are provided in Figure 5.13 and Table 5.13. For agricultural and urban lands, groundwater extraction represents pumping, while for native lands, groundwater extraction represents estimated groundwater extraction by riparian vegetation. Groundwater extraction is dominated by irrigated agriculture, varying substantially from year to year based on variability in surface water supplies and crop water demands. Groundwater extraction is not known to occur for managed wetlands and assumed negligible for this study.

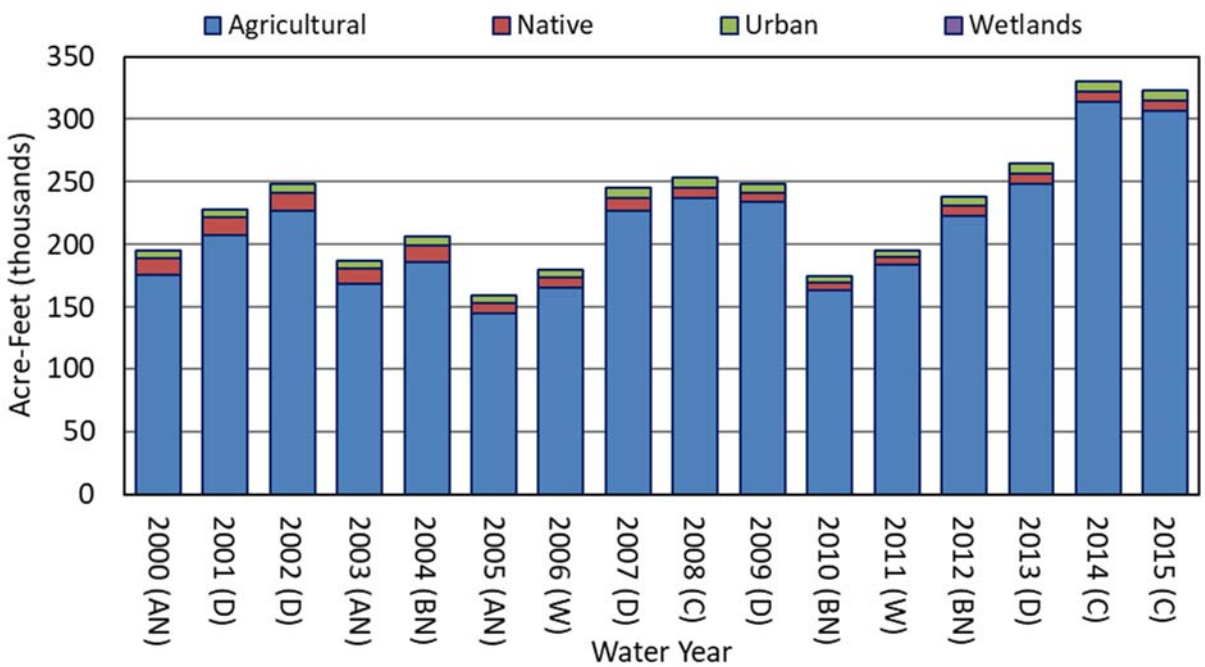

Figure 5.13. Colusa Subbasin Groundwater Extraction by Water Use Sector.

Table 5.13. Colusa Subbasin Groundwater Extraction by Water Use Sector (Acre-Feet).

Water Year	Agricultural	Native	Urban	Wetlands	Total
2000 (AN)	175,518	13,294	5,830	0	194,642
2001 (D)	207,140	14,414	6,686	0	228,240
2002 (D)	226,457	14,217	7,578	0	248,252
2003 (AN)	168,805	12,181	5,699	0	186,685
2004 (BN)	185,620	13,161	7,170	0	205,951
2005 (AN)	144,953	8,601	5,405	0	158,959
2006 (W)	165,587	8,446	6,048	0	180,081
2007 (D)	226,845	10,481	7,921	0	245,247
2008 (C)	236,605	8,876	7,816	0	253,297
2009 (D)	234,456	7,040	7,103	0	248,599
2010 (BN)	163,187	5,985	5,255	0	174,427
2011 (W)	184,007	6,139	5,309	0	195,455
2012 (BN)	223,216	7,459	7,269	0	237,944
2013 (D)	248,029	8,043	8,936	0	265,008
2014 (C)	313,597	8,105	8,017	0	329,719
2015 (C)	306,384	8,327	8,583	0	323,294
Average	213,150	9,673	6,914	0	229,737
W	174,797	7,293	5,679	0	187,768
AN	163,092	11,359	5,645	0	180,095
BN	190,675	8,868	6,565	0	206,108
D	228,585	10,839	7,645	0	247,069
C	285,528	8,436	8,139	0	302,103

5.3.1.4 Groundwater Discharge to Surface Water Sources

Estimated groundwater discharge to surface water sources is provided in Figure 5.14 and Table 5.14. Negative values for 2014 and 2015 represent net losses (seepage) of surface water to the groundwater system. Discharge from the groundwater system is independent of estimated infiltration of surface water to the groundwater system presented in Section 5.3.2.4. Estimated groundwater discharge was greatest in 2005 at around 320 taf and least in 2014 at around -60 taf.

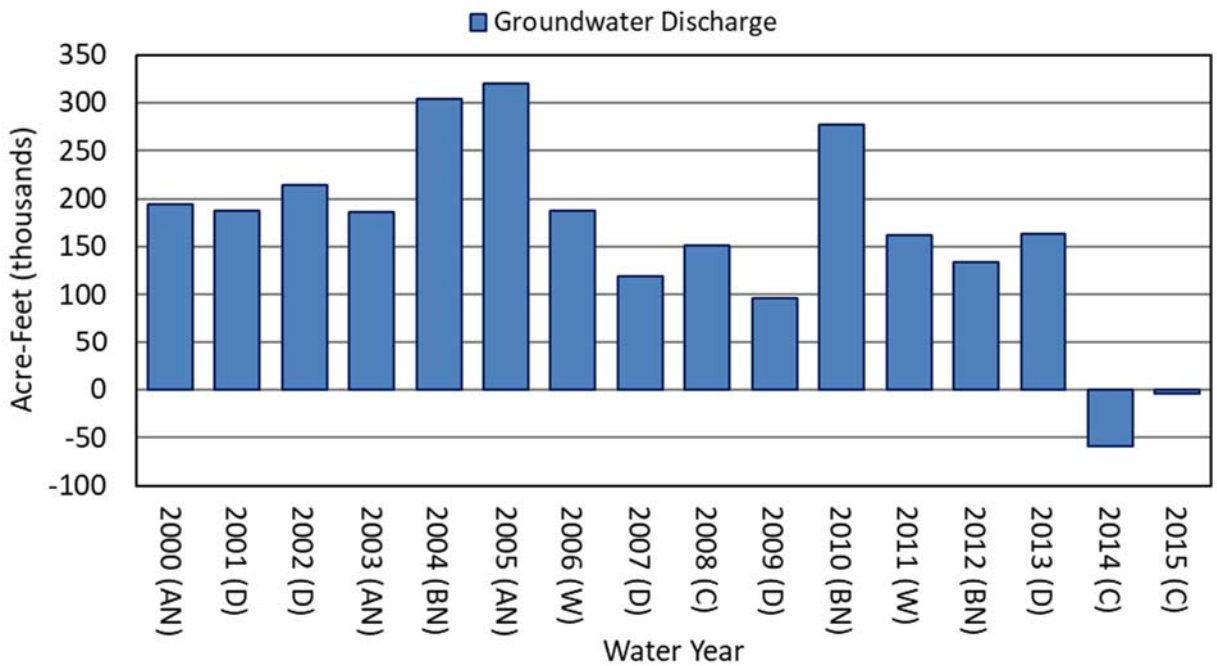

Figure 5.14. Colusa Subbasin Groundwater Discharge to Surface Water Sources.

Table 5.14. Colusa Subbasin Groundwater Discharge to Surface Water Sources (Acre-Feet).

Water Year	Groundwater Discharge
2000 (AN)	194,445
2001 (D)	187,839
2002 (D)	213,985
2003 (AN)	186,167
2004 (BN)	304,214
2005 (AN)	319,444
2006 (W)	187,799
2007 (D)	118,766
2008 (C)	151,441
2009 (D)	96,854
2010 (BN)	277,301
2011 (W)	162,075
2012 (BN)	134,436
2013 (D)	163,174
2014 (C)	-59,433
2015 (C)	-4,058
Average	164,653
W	174,937
AN	233,352
BN	238,650
D	156,124
C	29,317

5.3.2 Outflows

5.3.2.1 Evapotranspiration by Water Use Sector

Evapotranspiration by water use sector is described in Section 5.2.2.1.

5.3.2.2 Surface Water Outflow by Water Source Type

Surface water outflows by water source type are described in Section 5.2.2.2.

5.3.2.3 Infiltration of Precipitation

Estimated infiltration of precipitation by water use sector is provided in Figure 5.15 and Table 5.15. Infiltration of precipitation to the groundwater system is highly variable from year to year due to variation in the timing and amount of precipitation, ranging from less than 20 taf annually in 2007 and 2014 to more than 100 taf annually between 2004 and 2006.

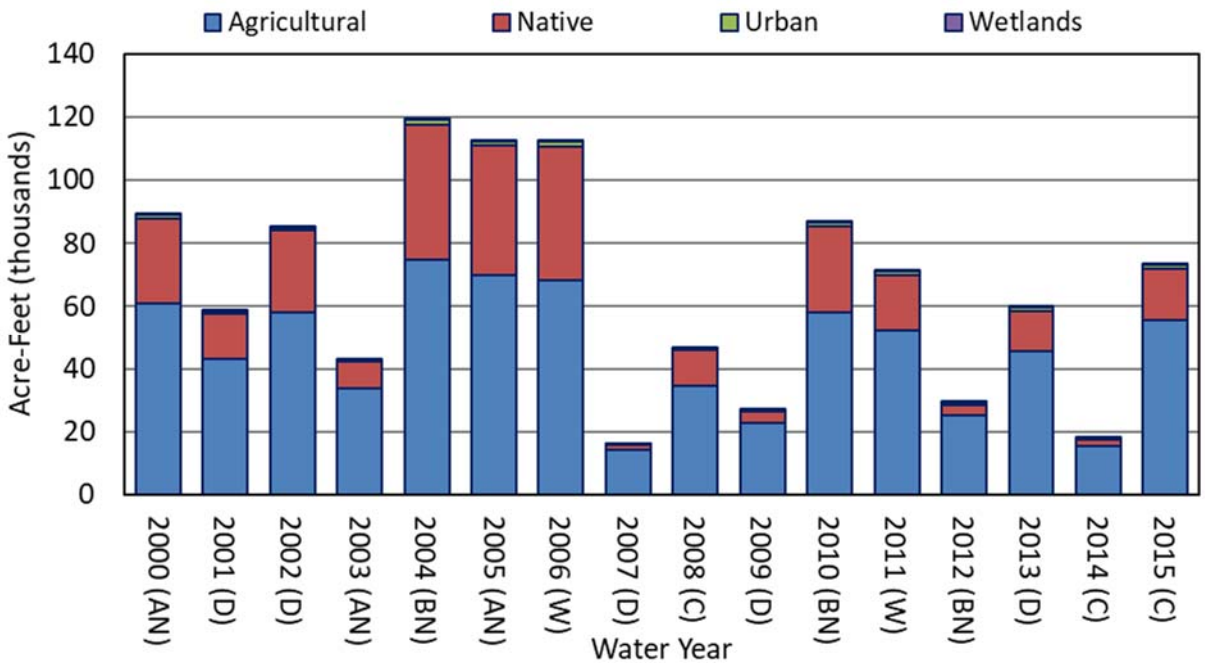

Figure 5.15. Colusa Subbasin Infiltration of Precipitation by Water Use Sector.

Table 5.15. Colusa Subbasin Infiltration of Precipitation by Water Use Sector (Acre-Feet).

Water Year	Agricultural	Native	Urban	Wetlands	Total
2000 (AN)	60,929	26,665	1,295	130	89,019
2001 (D)	43,084	14,668	801	149	58,702
2002 (D)	58,154	25,832	1,046	115	85,147
2003 (AN)	33,675	8,547	505	106	42,833
2004 (BN)	74,700	42,802	1,561	159	119,222
2005 (AN)	69,834	41,028	1,497	163	112,522
2006 (W)	68,058	42,390	1,762	152	112,362
2007 (D)	14,175	1,484	93	117	15,869
2008 (C)	34,432	11,306	603	105	46,446
2009 (D)	22,632	3,716	298	103	26,749
2010 (BN)	58,000	27,274	1,175	116	86,565
2011 (W)	52,401	17,572	1,174	146	71,293
2012 (BN)	25,073	3,548	456	95	29,172
2013 (D)	45,565	13,067	905	73	59,610
2014 (C)	15,565	1,868	342	82	17,857
2015 (C)	55,636	16,171	1,144	103	73,054
Average	45,745	18,621	916	120	65,401
W	60,230	29,981	1,468	149	91,828
AN	54,813	25,413	1,099	133	81,458
BN	52,591	24,541	1,064	123	78,320
D	36,722	11,753	629	111	49,215
C	35,211	9,782	696	97	45,786

5.3.2.4 Infiltration of Surface Water

Estimated infiltration of surface water by source is provided in Figure 5.16 and Table 5.16. Infiltration of surface water is believed to be dominated by canal seepage, which is relatively steady over time. Seepage from drains and streams exhibits greater variability, but contributes less than canal seepage in the subbasin.

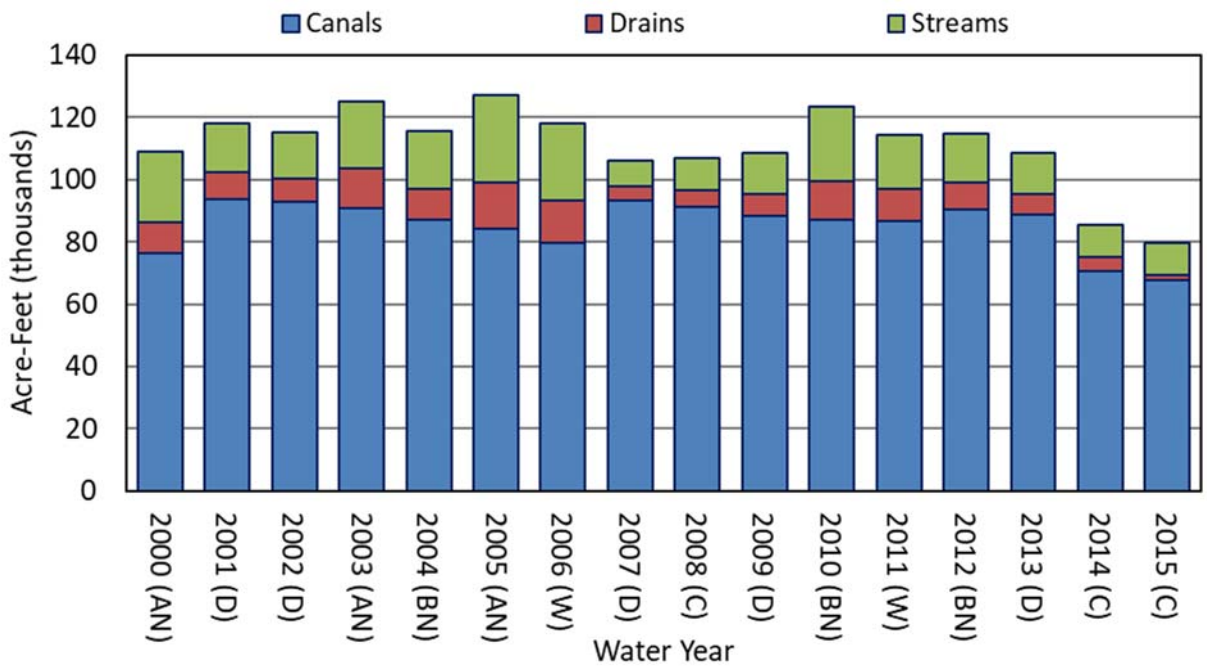

Figure 5.16. Colusa Subbasin Infiltration of Surface Water.

Table 5.16. Colusa Subbasin Infiltration of Surface Water (Acre-Feet).

Water Year	Canals	Drains	Streams	Total
2000 (AN)	76,284	10,204	22,270	108,759
2001 (D)	93,622	8,851	15,666	118,140
2002 (D)	92,789	7,431	15,034	115,254
2003 (AN)	90,970	12,758	21,396	125,123
2004 (BN)	87,173	9,894	18,478	115,545
2005 (AN)	84,322	14,734	28,034	127,090
2006 (W)	79,615	13,790	24,385	117,790
2007 (D)	93,248	4,511	8,236	105,995
2008 (C)	91,382	5,287	10,393	107,062
2009 (D)	88,174	7,054	13,134	108,362
2010 (BN)	86,988	12,287	23,998	123,273
2011 (W)	86,636	10,172	17,540	114,348
2012 (BN)	90,440	8,536	15,917	114,893
2013 (D)	88,848	6,707	13,093	108,649
2014 (C)	70,859	4,148	10,284	85,291
2015 (C)	67,963	1,446	10,378	79,787
Average	85,582	8,613	16,765	110,960
W	83,126	11,981	20,962	116,069
AN	83,859	12,565	23,900	120,324
BN	88,200	10,239	19,464	117,904
D	91,336	6,911	13,033	111,280
C	76,734	3,627	10,352	90,713

5.3.2.5 Infiltration of Applied Water

Estimated infiltration of applied water by water use sector is provided in Figure 5.17 and Table 5.17. Infiltration (percolation) of applied water is dominated by agricultural irrigation and has remained relatively steady over time, with the exception of 2014 and 2015, when surface water supplies in the subbasin were significantly reduced due to drought conditions and fewer acres were irrigated.

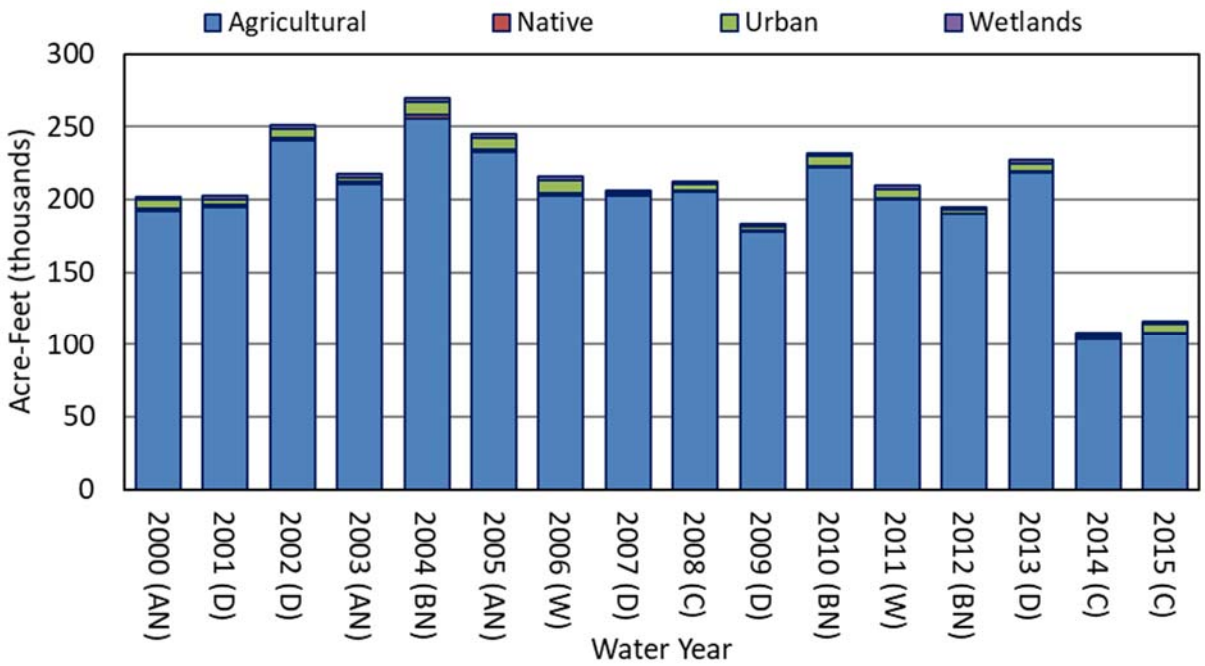

Figure 5.17. Colusa Subbasin Infiltration of Applied Water by Water Use Sector.

Table 5.17. Colusa Subbasin Infiltration of Applied Water by Water Use Sector (Acre-Feet).

Water Year	Agricultural	Native	Urban	Wetlands	Total
2000 (AN)	192,310	1,869	5,404	2,315	201,898
2001 (D)	194,828	1,799	3,640	2,336	202,603
2002 (D)	240,417	2,246	5,851	2,452	250,966
2003 (AN)	210,164	1,715	3,326	2,454	217,659
2004 (BN)	255,918	2,501	8,669	2,451	269,539
2005 (AN)	232,275	1,765	8,646	2,290	244,976
2006 (W)	202,665	1,490	9,225	2,286	215,666
2007 (D)	202,661	922	669	2,192	206,444
2008 (C)	204,883	894	4,473	2,177	212,427
2009 (D)	178,241	637	2,405	2,057	183,340
2010 (BN)	221,591	852	7,482	2,010	231,935
2011 (W)	200,234	672	6,402	1,947	209,255
2012 (BN)	189,839	585	2,084	1,895	194,403
2013 (D)	218,730	788	5,515	1,869	226,902
2014 (C)	104,025	567	1,887	1,792	108,271
2015 (C)	107,440	897	5,787	1,701	115,825
Average	197,264	1,262	5,092	2,139	205,757
W	201,449	1,081	7,814	2,117	212,460
AN	211,583	1,783	5,792	2,353	221,511
BN	222,449	1,313	6,078	2,119	231,959
D	206,976	1,278	3,616	2,181	214,051
C	138,783	786	4,049	1,890	145,508

5.3.3 Change in Storage

Estimates of change in storage within the surface water system are provided in Figure 5.18 and Table 5.18. Inter-annual changes in storage within the surface water system consist primarily of root zone soil moisture storage, are relatively small, and tend to average near zero over time.

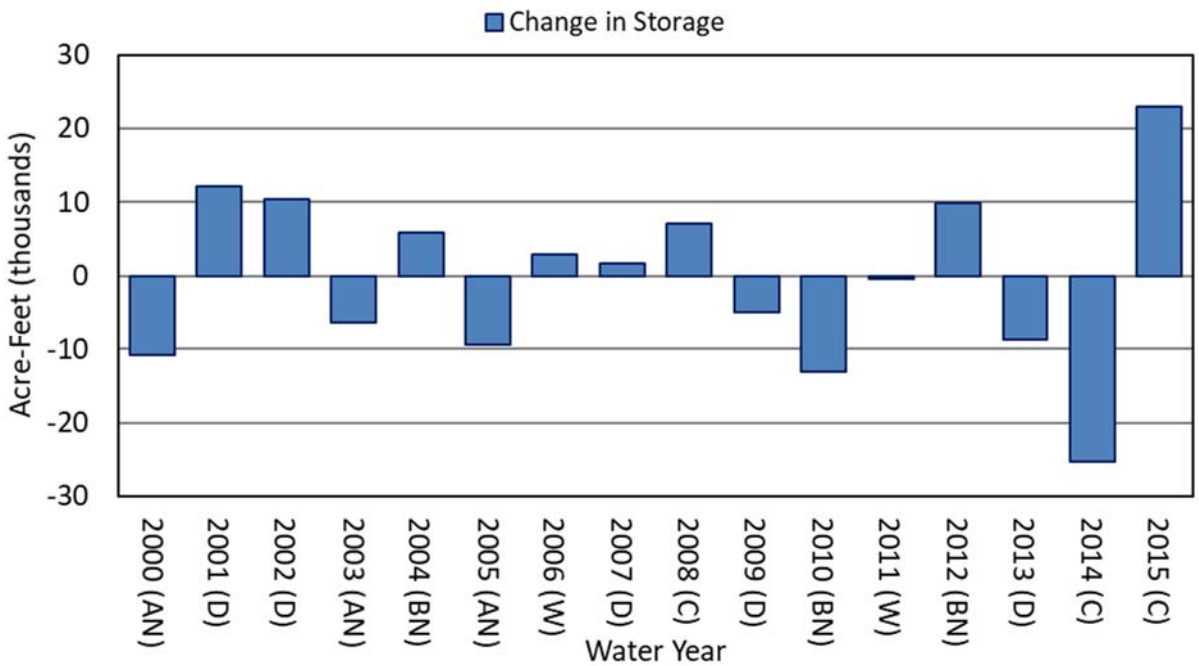

Figure 5.18. Colusa Subbasin Surface Water System Change in Storage.

Table 5.18. Colusa Subbasin Surface Water System Change in Storage (Acre-Feet).

Water Year	Change in Storage
2000 (AN)	-10,897
2001 (D)	12,162
2002 (D)	10,471
2003 (AN)	-6,292
2004 (BN)	5,954
2005 (AN)	-9,370
2006 (W)	2,961
2007 (D)	1,684
2008 (C)	7,165
2009 (D)	-5,004
2010 (BN)	-13,116
2011 (W)	-481
2012 (BN)	9,873
2013 (D)	-8,702
2014 (C)	-25,264
2015 (C)	22,927
Average	-371
W	1,240
AN	-8,853
BN	904
D	2,122
C	1,609

5.3.4 Historical Water Budget Summary

Annual inflows, outflows, and change in storage for the surface water system are summarized in Figure 5.19 and Table 5.19. Inflows are shown as positive values, while outflows and change in storage are shown as negative values. As a result, a positive value for change in storage actually reflects a decrease in storage. Review of the variability in component volumes across years provides insight into the impacts of hydrology on the surface water system water budget.

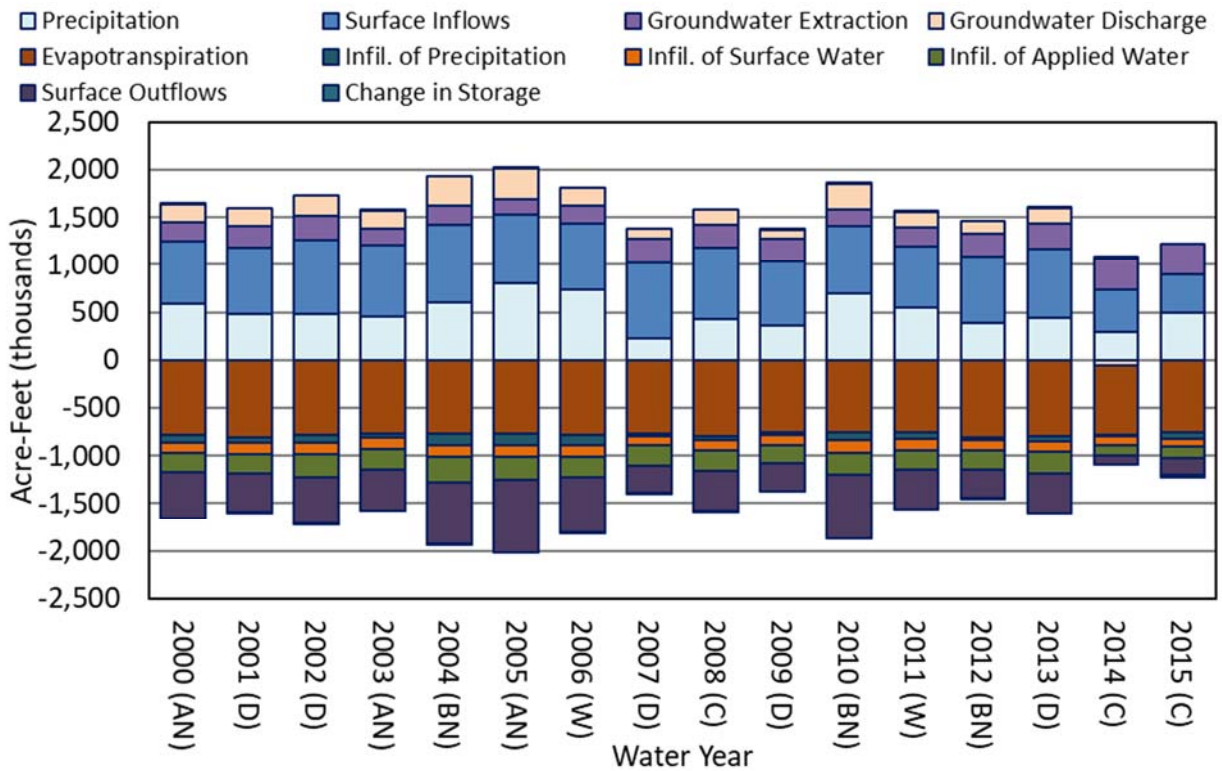

Figure 5.19. Colusa Subbasin Surface Water System Budget, 2000 – 2015.

Table 5.19. Colusa Subbasin Surface Water System Budget, 2000 – 2015 (Acre-Feet).

Water Year	Precipi-tation	Surface Inflows	Ground-water Extrac-tion	Ground-water Dis-charge	Evapo-trans-piration	Infil. of Precipitation	Infil. of Surface Water	Infil. of Applied Water	Surface Outflows	Change in Storage
2000 (AN)	587,592	662,978	194,642	194,445	-776,320	-89,019	-108,759	-201,898	-474,558	10,897
2001 (D)	475,762	709,047	228,240	187,839	-804,543	-58,702	-118,140	-202,603	-404,739	-12,162
2002 (D)	482,309	781,962	248,252	213,985	-779,918	-85,147	-115,254	-250,966	-484,752	-10,471
2003 (AN)	457,969	743,983	186,685	186,167	-762,190	-42,833	-125,123	-217,659	-433,291	6,292
2004 (BN)	608,783	809,322	205,951	304,214	-773,601	-119,222	-115,545	-269,539	-644,409	-5,954
2005 (AN)	798,261	733,040	158,959	319,444	-772,546	-112,522	-127,090	-244,976	-761,940	9,370
2006 (W)	738,441	700,871	180,081	187,799	-781,484	-112,362	-117,790	-215,666	-576,929	-2,961
2007 (D)	229,099	794,365	245,247	118,766	-773,795	-15,869	-105,995	-206,444	-283,689	-1,684
2008 (C)	428,082	747,656	253,297	151,441	-791,853	-46,446	-107,062	-212,427	-415,522	-7,165
2009 (D)	355,172	672,719	248,599	96,854	-758,877	-26,749	-108,362	-183,340	-301,021	5,004
2010 (BN)	697,738	709,581	174,427	277,301	-754,764	-86,565	-123,273	-231,935	-675,627	13,116
2011 (W)	545,466	652,668	195,455	162,075	-756,263	-71,293	-114,348	-209,255	-404,986	481
2012 (BN)	381,889	702,552	237,944	134,436	-805,058	-29,172	-114,893	-194,403	-303,422	-9,873
2013 (D)	438,136	731,716	265,008	163,174	-791,609	-59,610	-108,649	-226,902	-419,967	8,702
2014 (C)	290,682	445,083	329,719	-59,433	-721,472	-17,857	-85,291	-108,271	-98,424	25,264
2015 (C)	499,358	400,464	323,294	-4,058	-746,560	-73,054	-79,787	-115,825	-180,906	-22,927
Average	500,921	687,375	229,737	164,653	-771,928	-65,401	-110,960	-205,757	-429,011	371
W	641,954	676,770	187,768	174,937	-768,874	-91,828	-116,069	-212,460	-490,958	-1,240
AN	614,607	713,334	180,095	233,352	-770,352	-81,458	-120,324	-221,511	-556,596	8,853
BN	562,803	740,485	206,108	238,650	-777,808	-78,320	-117,904	-231,959	-541,153	-904
D	396,096	737,962	247,069	156,124	-781,748	-49,215	-111,280	-214,051	-378,833	-2,122
C	406,041	531,068	302,103	29,317	-753,295	-45,786	-90,713	-145,508	-231,617	-1,609

5.4 GROUNDWATER SYSTEM BUDGET

This section presents the groundwater system water budget for the Colusa Subbasin in Glenn County.

5.4.1 Inflows

5.4.1.1 Subsurface Groundwater Inflow

Subsurface groundwater inflow is described in Section 5.2.1.3.

5.4.1.2 Infiltration of Precipitation

Infiltration of precipitation is described in Section 5.3.2.3.

5.4.1.3 Infiltration of Surface Water

Infiltration of surface water is described in Section 5.3.2.4.

5.4.1.4 Infiltration of Applied Water

Infiltration of applied water is described in Section 5.3.2.5.

5.4.2 Outflows

5.4.2.1 Subsurface Groundwater Outflow

Subsurface groundwater outflow is described in Section 5.2.2.3.

5.4.2.2 Groundwater Extraction by Water Use Sector

Groundwater extraction by water use sector is described in Section 5.3.1.3.

5.4.2.3 Groundwater Discharge to Surface Water Sources

Groundwater discharge to surface water sources is described in Section 5.3.1.4.

5.4.3 Change in Storage

Estimates of change in storage within the groundwater system are provided in Figure 5.20 and Table 5.20. The estimates suggest a net decrease in storage in all years between 2000 and 2015, with the exception of the wet years of 2006 and 2011. Total change in storage appears to be relatively strongly correlated to water year type.

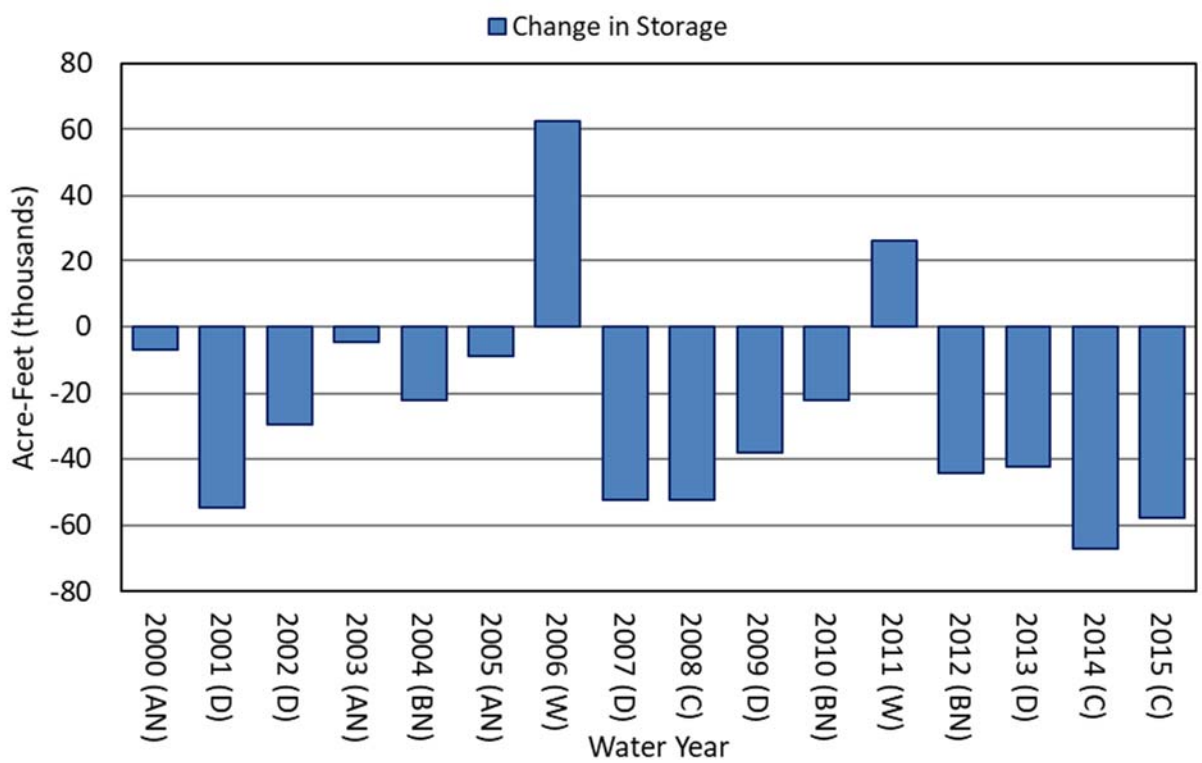

Figure 5.20. Colusa Subbasin Groundwater System Change in Storage (Acre-Feet).

Table 5.20. Colusa Subbasin Groundwater System Change in Storage.

Water Year	Change in Storage
2000 (AN)	-6,955
2001 (D)	-54,700
2002 (D)	-29,541
2003 (AN)	-4,802
2004 (BN)	-21,977
2005 (AN)	-8,794
2006 (W)	62,323
2007 (D)	-52,231
2008 (C)	-52,231
2009 (D)	-37,839
2010 (BN)	-22,135
2011 (W)	26,187
2012 (BN)	-44,090
2013 (D)	-42,199
2014 (C)	-67,043
2015 (C)	-57,746
Average	-25,861
W	44,255
AN	-6,850
BN	-29,401
D	-43,302
C	-59,006

5.4.4 Historical Water Budget Summary

Annual inflows, outflows, and change in storage for the groundwater system are summarized in Figure 5.21 and Table 5.21. Inflows are shown as positive values, while outflows and change in storage are shown as negative values. As a result, a positive value for change in storage actually reflects a decrease in storage. Review of the variability in component volumes across years provides insight into the impacts of hydrology on the groundwater system water budget.

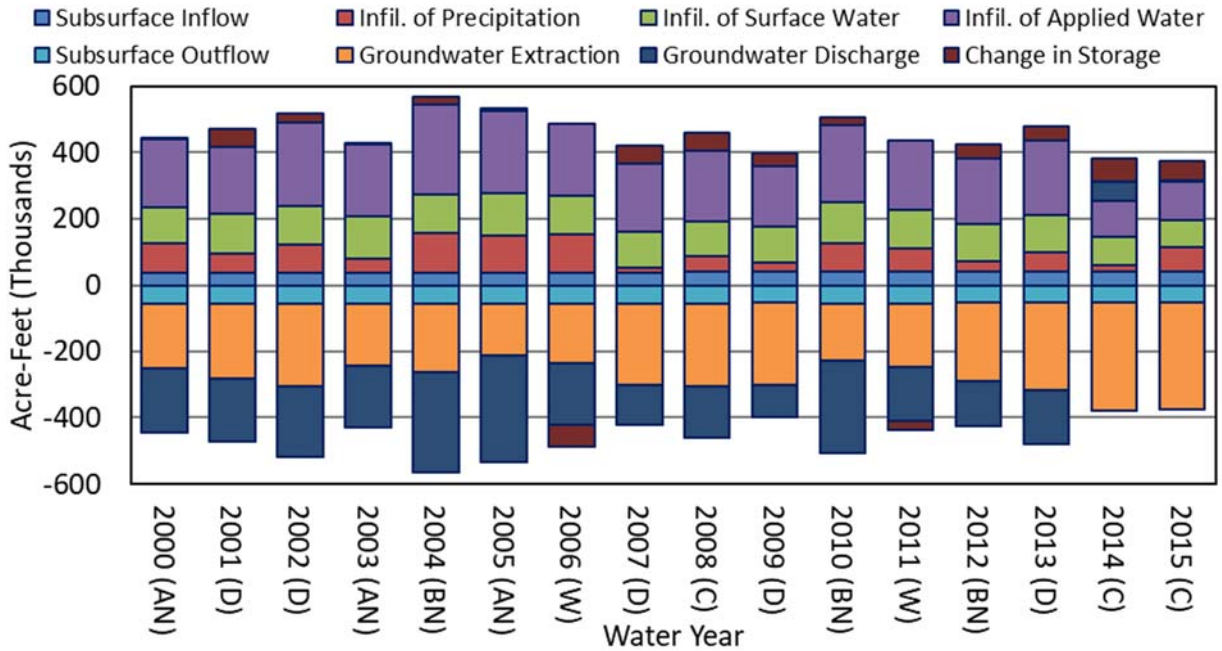

Figure 5.21. Colusa Subbasin Groundwater System Budget, 2000 – 2015.

Table 5.21. Colusa Subbasin Groundwater System Budget, 2000 – 2015 (Acre-Feet).

Water Year	Subsur-face Inflow	Infil. of Precip-itation	Infil. of Surface Water	Infil. of Applied Water	Subsur-face Outflow	Ground-water Extraction	Ground-water Discharge	Change in Storage
2000 (AN)	38,430	89,019	108,759	201,898	-55,975	-194,642	-194,445	6,955
2001 (D)	37,975	58,702	118,140	202,603	-56,040	-228,240	-187,839	54,700
2002 (D)	37,802	85,147	115,254	250,966	-56,473	-248,252	-213,985	29,541
2003 (AN)	38,333	42,833	125,123	217,659	-55,898	-186,685	-186,167	4,802
2004 (BN)	39,204	119,222	115,545	269,539	-55,323	-205,951	-304,214	21,977
2005 (AN)	39,258	112,522	127,090	244,976	-54,237	-158,959	-319,444	8,794
2006 (W)	39,733	112,362	117,790	215,666	-55,347	-180,081	-187,799	-62,323
2007 (D)	39,211	15,869	105,995	206,444	-55,738	-245,247	-118,766	52,231
2008 (C)	40,361	46,446	107,062	212,427	-53,790	-253,297	-151,441	52,231
2009 (D)	41,381	26,749	108,362	183,340	-52,218	-248,599	-96,854	37,839
2010 (BN)	41,169	86,565	123,273	231,935	-53,348	-174,427	-277,301	22,135
2011 (W)	41,502	71,293	114,348	209,255	-52,681	-195,455	-162,075	-26,187
2012 (BN)	41,835	29,172	114,893	194,403	-52,013	-237,944	-134,436	44,090
2013 (D)	42,169	59,610	108,649	226,902	-51,345	-265,008	-163,174	42,199
2014 (C)	42,502	17,857	85,291	108,271	-50,678	-329,719	59,433	67,043
2015 (C)	42,835	73,054	79,787	115,825	-50,010	-323,294	4,058	57,746
Average	40,231	65,401	110,960	205,757	-53,820	-229,737	-164,653	25,861
W	40,617	91,828	116,069	212,460	-54,014	-187,768	-174,937	-44,255
AN	38,674	81,458	120,324	221,511	-55,370	-180,095	-233,352	6,850
BN	40,736	78,320	117,904	231,959	-53,561	-206,108	-238,650	29,401
D	39,708	49,215	111,280	214,051	-54,363	-247,069	-156,124	43,302
C	41,899	45,786	90,713	145,508	-51,493	-302,103	-29,317	59,006

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6.1 LAND USE

While the water budget analysis was performed for water years 2000-2015, land use has been summarized for the period from 1990-2015 to provide a broader context of historical land (and water) use in the County. General land use estimates for 1990-2015 corresponding to water use sectors (as defined by the GSP Regulations) are summarized in Figure 6.1 and Table 6.1 for the Corning Subbasin within Glenn County. The "Developed" land use category includes urban and industrial lands. These water use sectors have not been described individually due to very few industrial lands existing in the Subbasin.

As indicated, agricultural lands have remained relatively steady since 1990, at approximately 23,000 acres, on average. Native vegetation has represented approximately 18,000 acres over time. Developed lands have increased from around 2,000 acres in the early 1990s to approximately 3,500 acres in recent years. This is due in part to changes in DWR's delineation of developed lands in land use surveys over time.

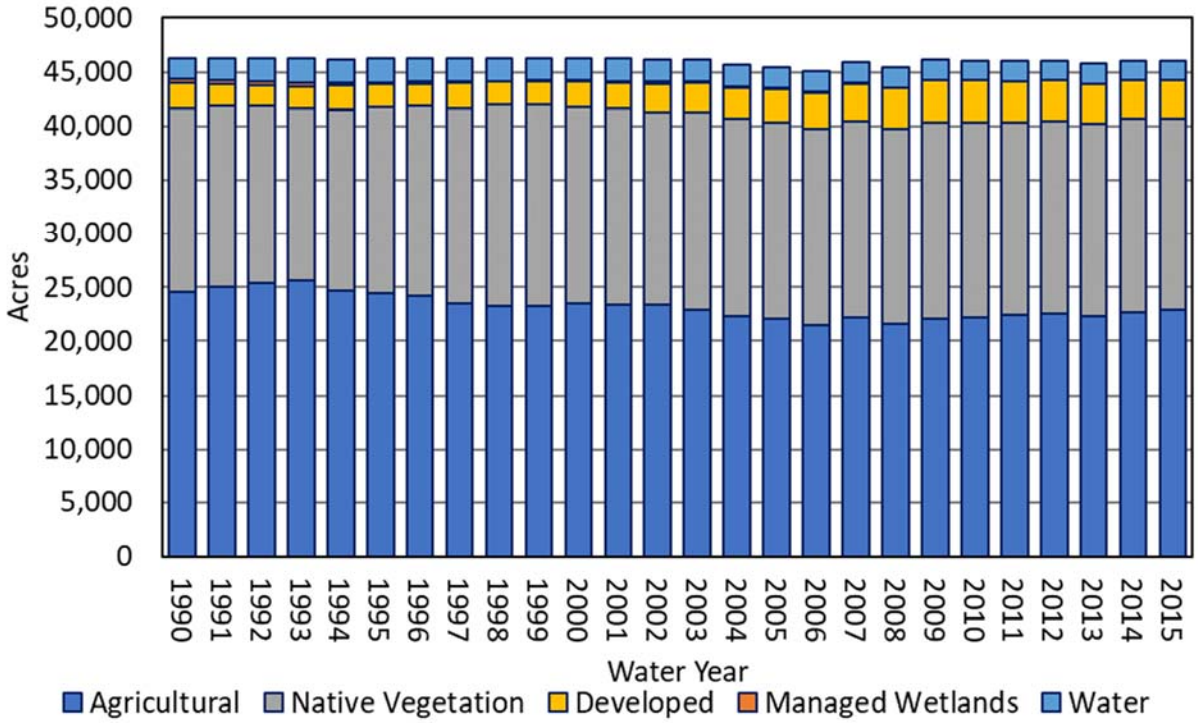

Figure 6.1. Corning Subbasin General Land Uses.

Table 6.1. Corning Subbasin General Land Uses (Acres).

Year	Agricultural	Managed Wetlands	Native Vegetation	Developed	Water
1990	24,510	304	17,076	2,416	1,897
1991	25,025	299	16,864	2,034	2,013
1992	25,356	290	16,548	1,920	2,132
1993	25,610	266	15,989	2,094	2,240
1994	24,685	219	16,804	2,247	2,215
1995	24,437	172	17,267	2,138	2,189
1996	24,189	125	17,700	2,050	2,163
1997	23,456	78	18,208	2,336	2,137
1998	23,301	31	18,669	2,166	2,111
1999	23,289	59	18,643	2,200	2,086
2000	23,482	88	18,310	2,307	2,063
2001	23,428	116	18,196	2,438	2,039
2002	23,354	145	17,967	2,610	2,016
2003	22,912	173	18,410	2,666	1,992
2004	22,331	148	18,346	2,882	1,963
2005	22,024	123	18,290	3,099	1,935
2006	21,493	98	18,257	3,316	1,906
2007	22,193	73	18,217	3,532	1,877
2008	21,555	48	18,205	3,749	1,848
2009	22,072	23	18,200	3,966	1,820
2010	22,232	21	18,072	3,887	1,822
2011	22,414	18	17,919	3,809	1,824
2012	22,552	16	17,924	3,731	1,826
2013	22,258	13	18,000	3,652	1,828
2014	22,629	10	18,007	3,574	1,831
2015	22,838	10	17,837	3,517	1,849
Average	23,216	114	17,843	2,859	1,985

Agricultural land uses are further detailed in Figure 6.2 and Table 6.2. Orchard acreage has increased from around 8,000 acres in 1990 to approximately 15,000 acres in recent years, with corresponding decreases in pasture and alfalfa, grain crops, and other field and annual crops.

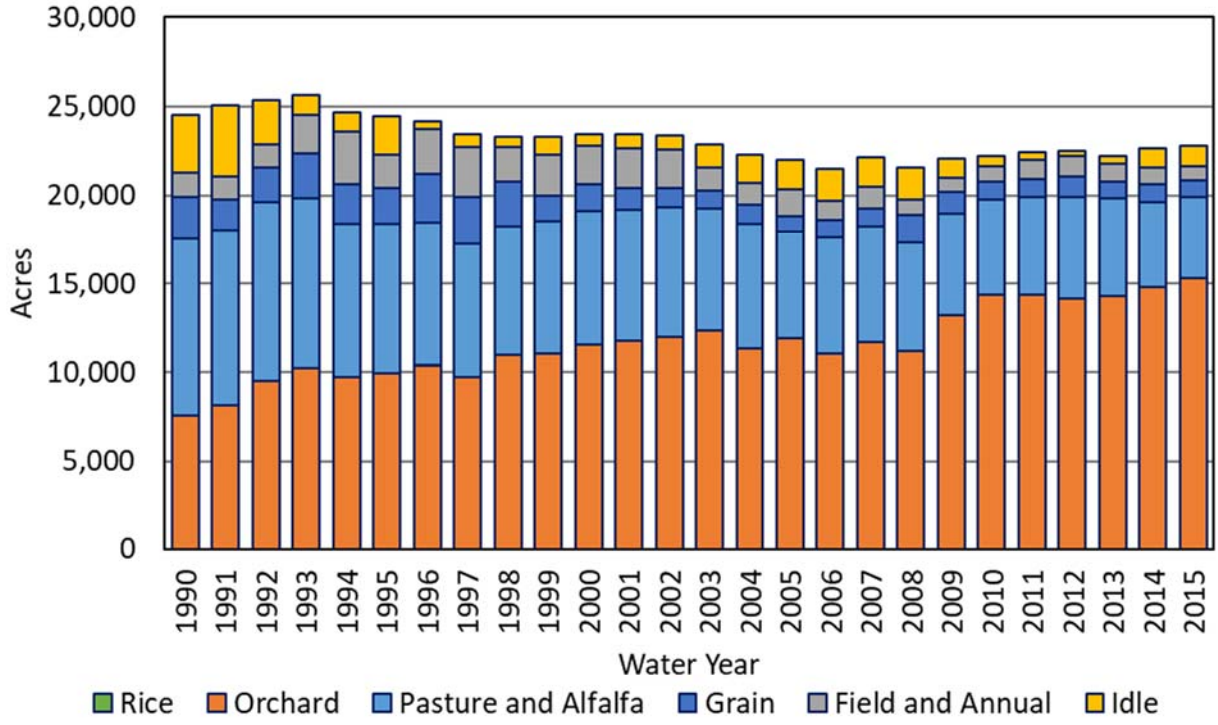

Figure 6.2. Corning Subbasin Agricultural Land Uses.

Table 6.2. Corning Subbasin Agricultural Land Uses (Acres).

Year	Field and Annual	Grain	Idle	Orchard	Pasture and Alfalfa	Rice
1990	1,350	2,409	3,247	7,554	9,949	0
1991	1,254	1,786	3,970	8,175	9,841	0
1992	1,277	1,921	2,498	9,528	10,131	0
1993	2,172	2,541	1,076	10,254	9,567	0
1994	2,913	2,293	1,103	9,737	8,639	0
1995	1,906	2,031	2,120	9,984	8,396	0
1996	2,555	2,722	411	10,371	8,129	0
1997	2,779	2,688	750	9,716	7,523	0
1998	1,957	2,484	583	10,937	7,340	0
1999	2,267	1,458	1,012	11,042	7,509	0
2000	2,178	1,468	675	11,545	7,615	0
2001	2,248	1,286	730	11,757	7,407	0
2002	2,180	1,089	777	12,003	7,304	0
2003	1,316	1,024	1,319	12,366	6,888	0
2004	1,223	1,123	1,597	11,308	7,081	0
2005	1,531	875	1,641	11,912	6,065	0
2006	1,067	1,063	1,786	11,067	6,509	0
2007	1,279	972	1,669	11,707	6,566	0
2008	903	1,571	1,776	11,159	6,147	0
2009	808	1,224	1,056	13,219	5,765	0
2010	893	1,037	545	14,364	5,392	0
2011	1,062	1,058	403	14,359	5,532	0
2012	1,184	1,130	320	14,140	5,778	0
2013	972	970	463	14,289	5,563	0
2014	894	1,056	1,082	14,805	4,792	0
2015	815	905	1,187	15,291	4,640	0
Average	1,576	1,546	1,300	11,638	7,157	0

6.2 BOUNDARY BUDGET

This section presents the basin boundary water budget for the Corning Subbasin in Glenn County.

6.2.1 Inflows

6.2.1.1 Surface Water Inflow by Water Source Type

Surface water inflows include surface water flowing into the basin across the basin boundary. Per the Regulations, surface inflows must be reported by water source type. According to the Regulations:

> *"Water source type" represents the source from which water is derived to meet the applied beneficial uses, including groundwater, recycled water, reused water, and surface water sources identified as Central Valley Project, the State Water Project, the Colorado River Project, local supplies, and local imported supplies.*

Additionally, runoff of precipitation from upgradient areas adjacent to the basin represents a potential source of surface water inflow.

Primary surface water inflows to the Corning Subbasin in Glenn County include diversions from the Sacramento River by GCID and diversions from Stony Creek by OUWUA.

6.2.1.1.1 Local Imported Supplies

For purposes of this preliminary water budget, diversions by GCID have been classified as local imported supplies, although under diversion agreements with the U.S. Bureau of Reclamation (USBR), these diversions include a combination of "Base" (local) and "Project" (Central Valley Project or CVP) supplies, with the majority of diversions being based on senior, local water rights. Estimated diversions for these preliminary water budgets represent "net" diversions for use in the Corning Subbasin and do not include diversions that occur in the Corning Subbasin but pass through to the Colusa Subbasin.

The OUWUA diverts water from Stony Creek made available via one of USBRs earliest water supply projects, which predates the CVP. As a result, these supplies are considered local imported supplies for purposes of this preliminary water budget.

Additional riparian and other small diversions likely occur but have not been included as part of this preliminary effort. It is anticipated that additional diversions will be addressed as part of subsequent phases of GSP development.

6.2.1.1.2 CVP Supplies

There are no significant CVP supplies known to be used in the Glenn County portion of the Corning Subbasin, though water is conveyed through the subbasin via the Tehama-Colusa Canal. For purposes of this preliminary water budget, these flows are not included at this time.

6.2.1.1.3 Recycling and Reuse

For purposes of this analysis, recycled water, as locally defined, represents recovery and reuse of drainwater by surface water suppliers. Reuse refers to reuse by individual growers. Limited recycling and reuse occurs within the study area, and recycled or reused water generated outside of the basin does not flow into the basin in significant quantities.

6.2.1.1.4 Groundwater

Groundwater pumped outside of the study area does not flow into the study area through surface water conveyances; therefore, groundwater is not included as part of the estimation of boundary surface water inflows.

6.2.1.1.5 Other Surface Inflows

Colorado River Project supplies are not applicable to the study area.

There are no State Water Project (SWP) contractors within the study area.

Some precipitation runoff enters the study area as runoff from small watersheds along the western boundary of the subbasin. For the preliminary water budgets presented herein, it is assumed that these inflows are relatively small. It is anticipated that these surface inflows will be quantified as part of GSP development.

6.2.1.1.6 Summary of Surface Inflows

Surface water inflows by water year type are summarized in Figure 6.3 and Table 6.3. During the study period, surface water supplies varied from approximately 25,000 acre-feet to 46,000 acre-feet.

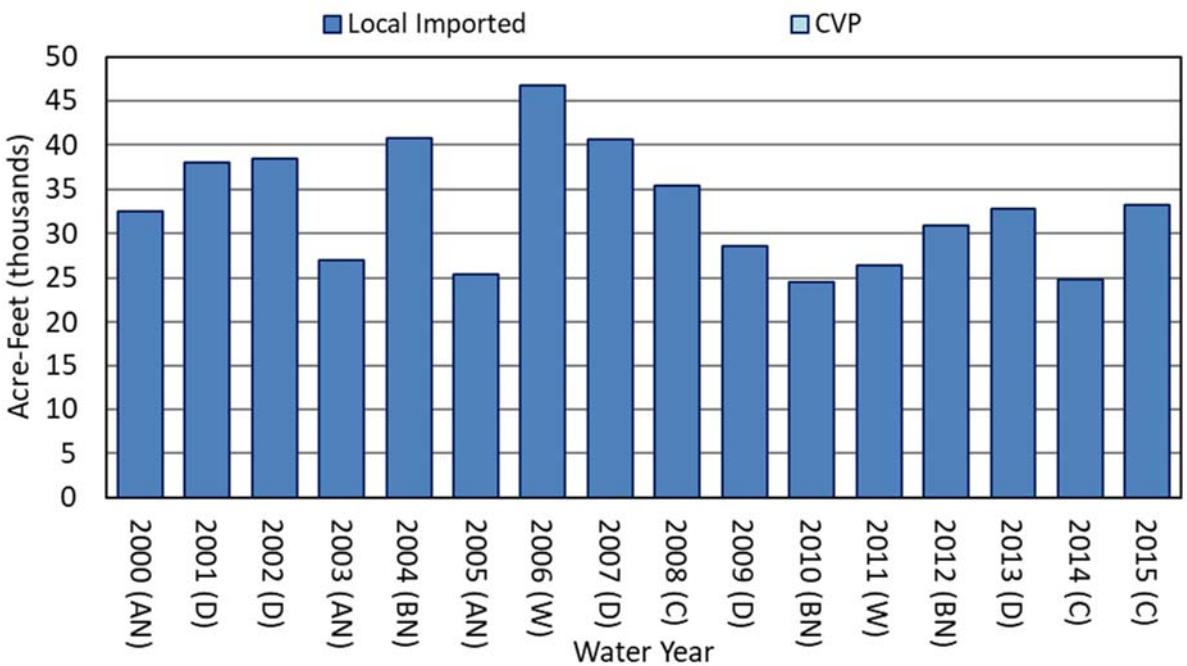

Figure 6.3. Corning Subbasin Surface Water Inflows by Water Source Type.

Table 6.3. Corning Subbasin Surface Water Inflows by Water Source Type (Acre-Feet).

Water Year	Local Imported	CVP	Total
2000 (AN)	32,573	0	32,573
2001 (D)	38,091	0	38,091
2002 (D)	38,530	0	38,530
2003 (AN)	26,948	0	26,948
2004 (BN)	40,821	0	40,821
2005 (AN)	25,376	0	25,376
2006 (W)	46,763	0	46,763
2007 (D)	40,654	0	40,654
2008 (C)	35,364	0	35,364
2009 (D)	28,641	0	28,641
2010 (BN)	24,518	0	24,518
2011 (W)	26,362	0	26,362
2012 (BN)	30,849	0	30,849
2013 (D)	32,841	0	32,841
2014 (C)	24,800	0	24,800
2015 (C)	33,178	0	33,178
Average	32,894	0	32,894
W	36,562	0	36,562
AN	28,299	0	28,299
BN	32,063	0	32,063
D	35,751	0	35,751
C	31,114	0	31,114

6.2.1.2 Precipitation

Precipitation estimates for the Glenn County portion of the Corning Subbasin are provided in Figure 6.4 and Table 6.4. Precipitation estimates are reported by water use sector. According to the Regulations:

> *"Water use sector" refers to categories of water demand based on the general land uses to which the water is applied, including urban, industrial, agricultural, managed wetlands, managed recharge, and native vegetation.*

For Glenn County, minimal industrial water use is present, and industrial uses have been combined with urban uses for this study. Additionally, there is no known managed recharge occurring within the County.

Precipitation is highly variable in the study area, ranging from approximately 33 taf in 2007 to 116 taf in 2005.

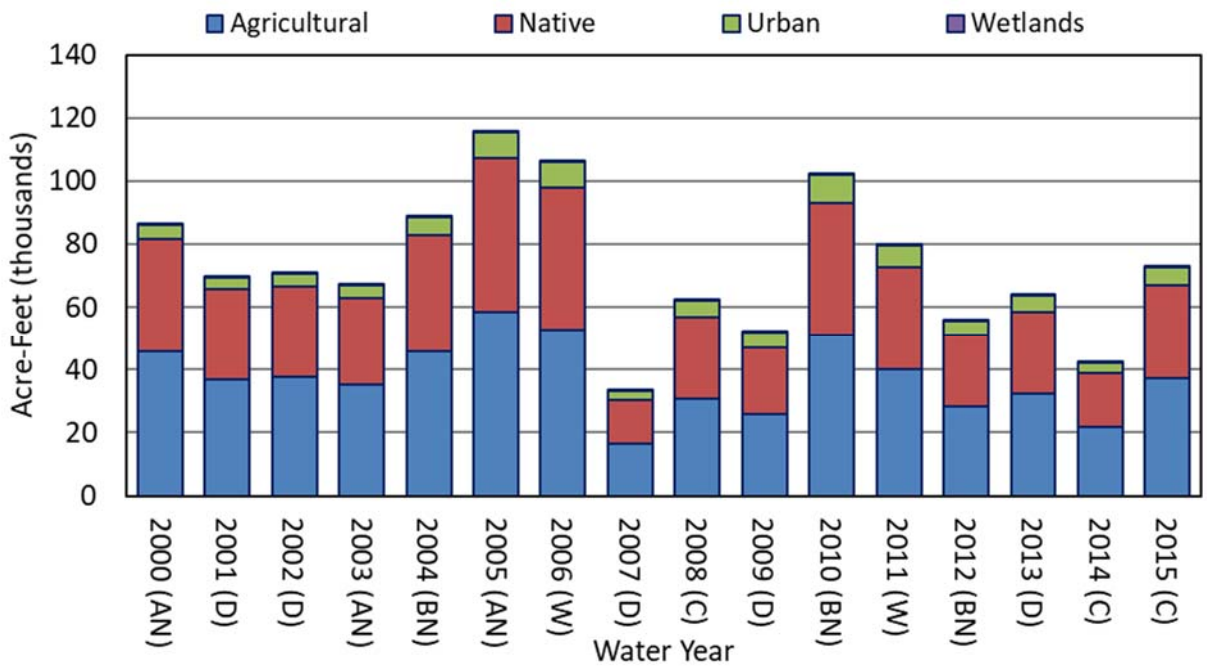

Figure 6.4. Corning Subbasin Precipitation by Water Use Sector.

Table 6.4. Corning Subbasin Precipitation by Water Use Sector (Acre-Feet).

Water Year	Agricultural	Native	Urban	Wetlands	Total
2000 (AN)	45,741	35,786	4,469	163	86,159
2001 (D)	37,009	28,758	3,822	177	69,766
2002 (D)	37,494	29,044	3,984	197	70,719
2003 (AN)	35,062	27,816	4,030	250	67,158
2004 (BN)	45,829	37,203	5,599	326	88,957
2005 (AN)	58,424	48,866	8,033	355	115,678
2006 (W)	52,642	45,218	8,001	265	106,126
2007 (D)	16,568	13,921	2,622	62	33,173
2008 (C)	30,819	25,885	5,271	76	62,051
2009 (D)	25,751	21,401	4,579	37	51,768
2010 (BN)	51,251	41,800	9,020	50	102,121
2011 (W)	40,324	32,454	6,932	35	79,745
2012 (BN)	28,397	22,612	4,734	20	55,763
2013 (D)	32,534	25,975	5,371	19	63,899
2014 (C)	21,669	17,256	3,427	10	42,362
2015 (C)	37,329	29,568	5,859	17	72,773
Average	37,303	30,223	5,360	129	73,014
W	46,483	38,836	7,467	150	92,936
AN	46,409	37,489	5,511	256	89,665
BN	41,826	33,872	6,451	132	82,280
D	29,871	23,820	4,076	98	57,865
C	29,939	24,236	4,852	34	59,062

6.2.1.3 Subsurface Groundwater Inflow

Subsurface groundwater inflow was estimated based on DWR's C2VSim fine grid application of the Integrated Water Flow Model (IWFM), version R374 Beta. The fine grid beta version is equivalent to the coarse grid R374 public release version of the application, but includes a more detailed element grid to allow for improved definition of zones to extract groundwater budget results along county and subbasin boundaries. C2VSim results for water years 2000 to 2009 were available as model outputs; estimates for 2010 to 2015 were interpolated based on changes in annual subsurface inflows over time.

Subsurface inflow estimates for the Glenn County portion of the Corning Subbasin are provided in Figure 6.5 and Table 6.5. C2VSim suggests that subsurface inflow has remained steady over time, at approximately 45 taf.

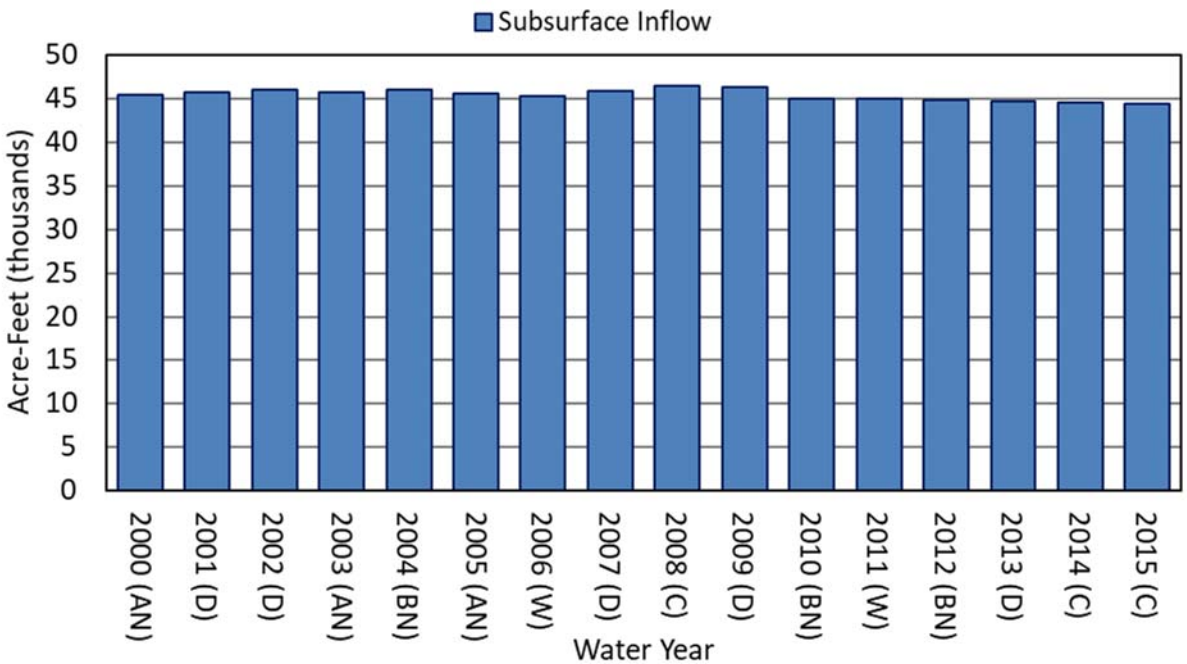

Figure 6.5. Corning Subbasin Subsurface Inflows.

Table 6.5. Corning Subbasin Subsurface Inflows (Acre-Feet).

Water Year	Subsurface Inflow
2000 (AN)	45,331
2001 (D)	45,625
2002 (D)	46,010
2003 (AN)	45,637
2004 (BN)	45,992
2005 (AN)	45,516
2006 (W)	45,249
2007 (D)	45,768
2008 (C)	46,330
2009 (D)	46,258
2010 (BN)	44,983
2011 (W)	44,869
2012 (BN)	44,755
2013 (D)	44,642
2014 (C)	44,528
2015 (C)	44,414
Average	45,369
W	45,059
AN	45,494
BN	45,243
D	45,661
C	45,091

6.2.2 Outflows

6.2.2.1 Evapotranspiration by Water Use Sector

Evapotranspiration (ET) by water use sector is reported in Figures 6.6 to 6.8 and Tables 6.6 to 6.8. First, total ET is reported, followed by ET from applied water and ET from precipitation. "Urban" lands include urban, industrial, and rural residential lands. Other than the community of Hamilton City, these lands are primarily rural residential.

In addition to ET from land surfaces, estimates of evaporation from canals, drains, lakes, and streams are included. ET of applied water for native lands represents estimated ET of groundwater by riparian vegetation.

ET was least in 2009, at approximately 90 taf, and greatest in 2001, at approximately 101 taf. Agricultural ET tends to increase in drier years, while native ET decreases. Total ET has remained relatively steady over time.

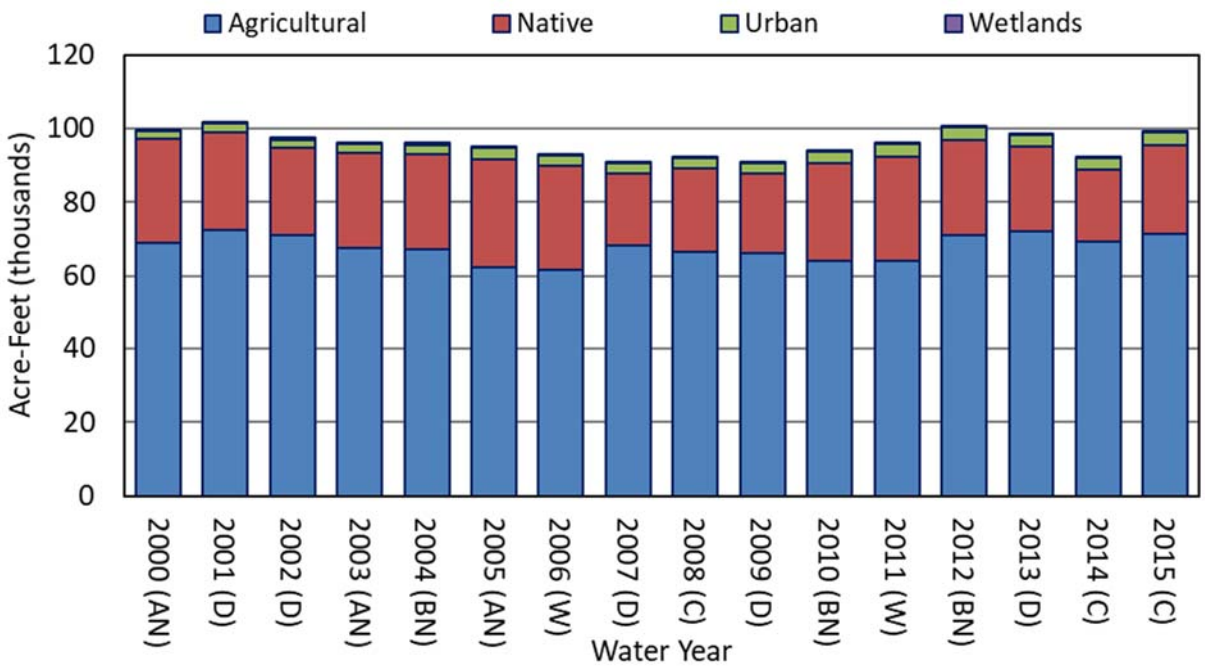

Figure 6.6. Corning Subbasin Evapotranspiration by Water Use Sector.

Table 6.6. Corning Subbasin Evapotranspiration by Water Use Sector (Acre-Feet).

Water Year	Agricultural	Native	Urban	Wetlands	Total
2000 (AN)	68,890	28,127	2,310	288	99,615
2001 (D)	72,324	26,583	2,345	409	101,661
2002 (D)	71,116	23,543	2,234	502	97,395
2003 (AN)	67,434	25,753	2,523	562	96,272
2004 (BN)	67,271	25,780	2,438	541	96,030
2005 (AN)	62,143	29,491	2,961	413	95,008
2006 (W)	61,447	28,433	2,857	342	93,079
2007 (D)	68,326	19,538	2,779	277	90,920
2008 (C)	66,420	22,712	2,871	192	92,195
2009 (D)	66,137	21,451	3,032	93	90,713
2010 (BN)	64,136	26,339	3,313	69	93,857
2011 (W)	64,033	28,384	3,481	57	95,955
2012 (BN)	70,924	25,853	3,495	53	100,325
2013 (D)	72,068	23,074	3,224	46	98,412
2014 (C)	69,150	19,757	3,072	39	92,018
2015 (C)	71,513	23,980	3,418	36	98,947
Average	67,708	24,925	2,897	245	95,775
W	62,740	28,409	3,169	200	94,517
AN	66,156	27,790	2,598	421	96,965
BN	67,444	25,991	3,082	221	96,737
D	69,994	22,838	2,723	265	95,820
C	69,028	22,150	3,120	89	94,387

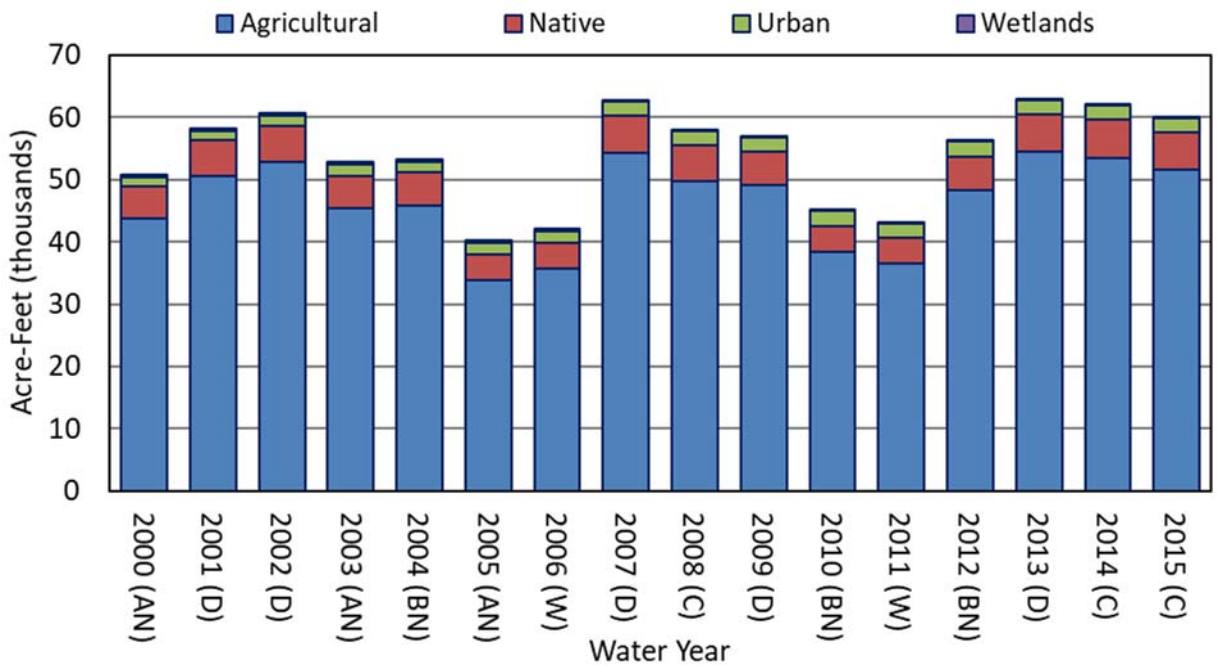

Figure 6.7. Corning Subbasin Evapotranspiration of Applied Water by Water Use Sector.

Table 6.7. Corning Subbasin Evapotranspiration of Applied Water by Water Use Sector (Acre-Feet).

Water Year	Agricultural	Native	Urban	Wetlands	Total
2000 (AN)	43,712	5,241	1,466	267	50,686
2001 (D)	50,501	5,796	1,547	377	58,221
2002 (D)	52,883	5,774	1,557	480	60,694
2003 (AN)	45,409	5,195	1,747	515	52,866
2004 (BN)	45,921	5,271	1,603	500	53,295
2005 (AN)	33,809	4,194	1,937	367	40,307
2006 (W)	35,649	4,307	1,835	314	42,105
2007 (D)	54,281	6,034	2,127	261	62,703
2008 (C)	49,815	5,779	2,154	183	57,931
2009 (D)	49,068	5,330	2,344	87	56,829
2010 (BN)	38,375	4,240	2,306	64	44,985
2011 (W)	36,549	4,146	2,312	54	43,061
2012 (BN)	48,329	5,355	2,369	53	56,106
2013 (D)	54,485	5,942	2,299	46	62,772
2014 (C)	53,464	6,155	2,263	37	61,919
2015 (C)	51,630	5,836	2,324	35	59,825
Average	46,493	5,287	2,012	228	54,019
W	36,099	4,227	2,074	184	42,583
AN	40,977	4,877	1,717	383	47,953
BN	44,208	4,955	2,093	206	51,462
D	52,244	5,775	1,975	250	60,244
C	51,636	5,923	2,247	85	59,892

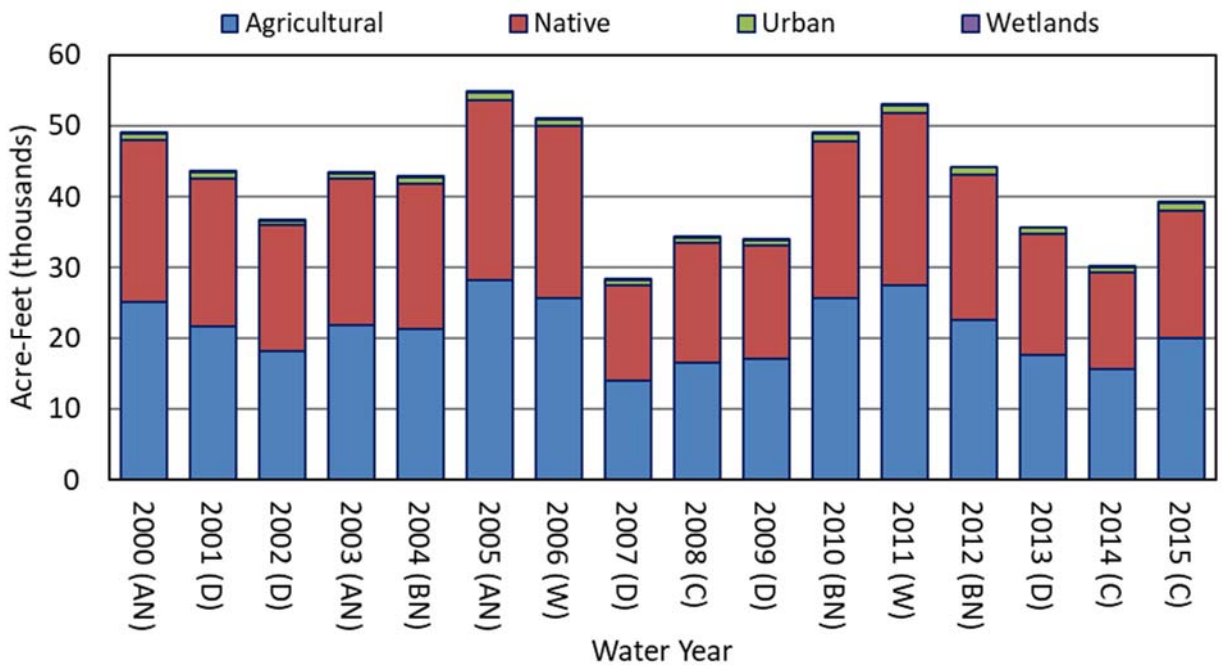

Figure 6.8. Corning Subbasin Evapotranspiration of Precipitation by Water Use Sector.

Table 6.8. Corning Subbasin Evapotranspiration of Precipitation by Water Use Sector (Acre-Feet).

Water Year	Agricultural	Native	Urban	Wetlands	Total
2000 (AN)	25,178	22,886	844	21	48,929
2001 (D)	21,823	20,787	798	32	43,440
2002 (D)	18,233	17,769	677	22	36,701
2003 (AN)	22,025	20,558	776	47	43,406
2004 (BN)	21,350	20,509	835	41	42,735
2005 (AN)	28,334	25,297	1,024	46	54,701
2006 (W)	25,798	24,126	1,022	28	50,974
2007 (D)	14,045	13,504	652	16	28,217
2008 (C)	16,605	16,933	717	9	34,264
2009 (D)	17,069	16,121	688	6	33,884
2010 (BN)	25,761	22,099	1,007	5	48,872
2011 (W)	27,484	24,238	1,169	3	52,894
2012 (BN)	22,595	20,498	1,126	0	44,219
2013 (D)	17,583	17,132	925	0	35,640
2014 (C)	15,686	13,602	809	2	30,099
2015 (C)	19,883	18,144	1,094	1	39,122
Average	21,216	19,638	885	17	41,756
W	26,641	24,182	1,096	16	51,934
AN	25,179	22,914	881	38	49,012
BN	23,235	21,035	989	15	45,275
D	17,751	17,063	748	15	35,576
C	17,391	16,226	873	4	34,495

6.2.2.2 Surface Water Outflow by Water Source Type

Surface water outflows by water source type are summarized in Figure 6.9 and Table 6.9. Irrigation return flows consist of runoff of local imported supplies. Other surface outflows include runoff of precipitation and groundwater discharge to drains and streams that leave the study area. In most years, groundwater discharge from the study area was estimated to be negative, representing a loss of water from drains and streams to the groundwater system as seepage. These streams may include Stony Creek and the Sacramento River. Estimated surface outflows were greatest in 2005 at 43 taf and least in 2014 at -19 taf.

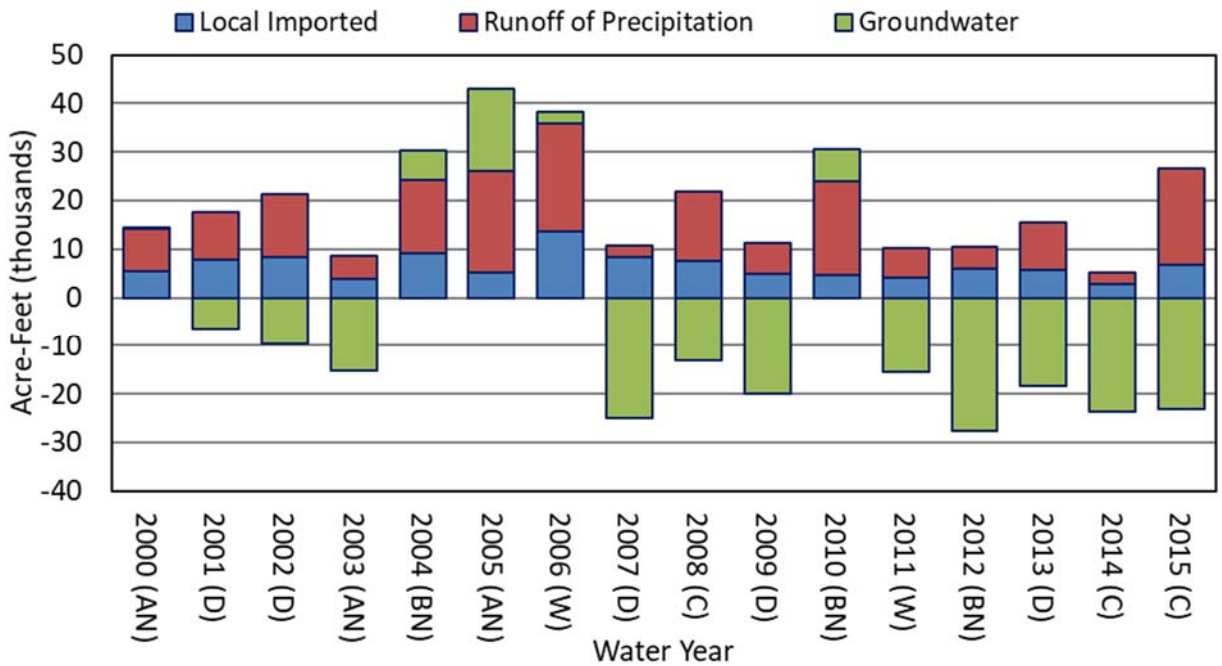

Figure 6.9. Corning Subbasin Surface Outflows by Water Source Type.

Table 6.9. Corning Subbasin Surface Outflows by Water Source Type (Acre-Feet).

Water Year	Local Imported	CVP	Runoff of Precipitation	Groundwater	Total
2000 (AN)	5,446	0	8,728	349	14,524
2001 (D)	7,932	0	9,679	-6,413	11,197
2002 (D)	8,302	0	12,931	-9,534	11,700
2003 (AN)	3,975	0	4,592	-15,073	-6,506
2004 (BN)	9,089	0	15,137	6,182	30,408
2005 (AN)	5,118	0	20,999	16,914	43,030
2006 (W)	13,565	0	22,226	2,321	38,112
2007 (D)	8,430	0	2,222	-25,063	-14,411
2008 (C)	7,482	0	14,434	-12,994	8,923
2009 (D)	4,777	0	6,546	-20,034	-8,711
2010 (BN)	4,632	0	19,212	6,831	30,675
2011 (W)	4,183	0	6,141	-15,347	-5,023
2012 (BN)	5,886	0	4,640	-27,644	-17,118
2013 (D)	5,731	0	9,761	-18,452	-2,961
2014 (C)	2,773	0	2,401	-23,783	-18,608
2015 (C)	6,671	0	19,860	-23,224	3,306
Average	6,499	0	11,219	-10,310	7,409
W	8,874	0	14,183	-6,513	16,544
AN	4,846	0	11,440	730	17,016
BN	6,535	0	12,996	-4,877	14,655
D	7,034	0	8,228	-15,899	-637
C	5,642	0	12,232	-20,000	-2,126

6.2.2.3 Subsurface Groundwater Outflow

Subsurface groundwater outflow was estimated based on DWR's C2VSim fine grid application of IWFM, version R374 Beta. The fine grid beta version is equivalent to the coarse grid R374 public release version of the application, but includes a more detailed element grid to allow for improved definition of zones to extract groundwater budget results along county and subbasin boundaries. C2VSim results for water years 2000 to 2009 were available as model outputs; estimates for 2010 to 2015 were interpolated based on changes in annual subsurface outflows over time.

Subsurface outflow estimates for the Glenn County portion of the Corning Subbasin are provided in Figure 6.10 and Table 6.10. C2VSim suggests that subsurface outflow has increased slightly over time, from approximately 48 taf in 2000 to around 51 taf in recent years.

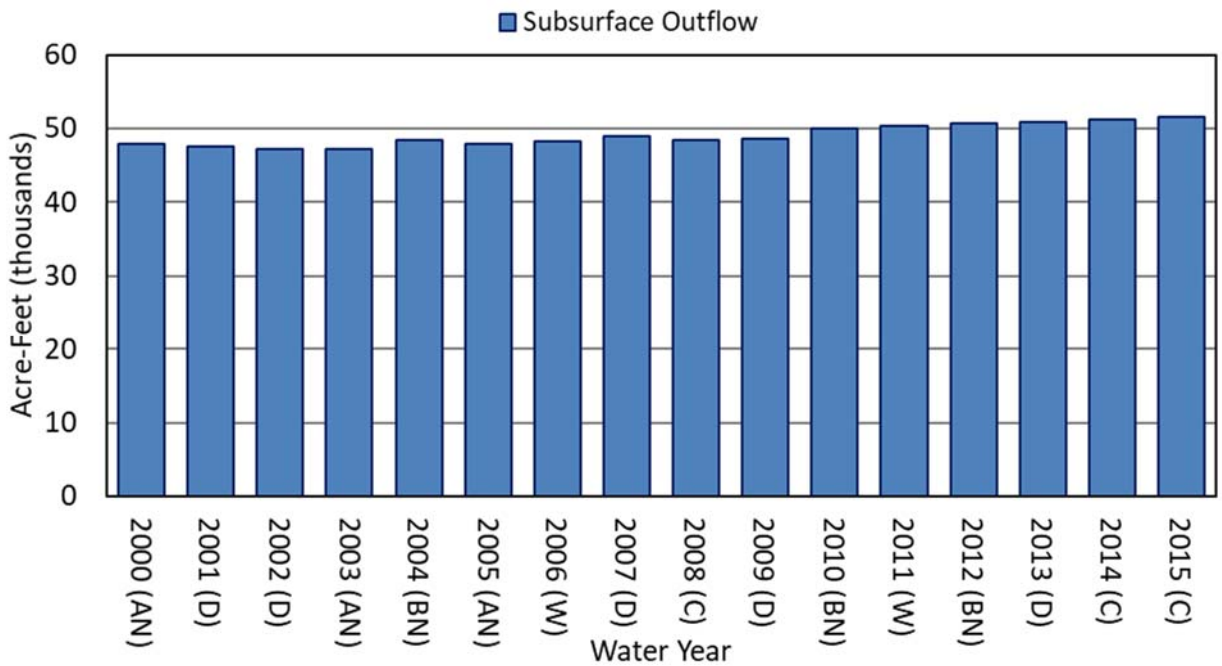

Figure 6.10. Corning Subbasin Subsurface Outflows.

Table 6.10. Corning Subbasin Subsurface Outflows (Acre-Feet).

Water Year	Subsurface Outflow
2000 (AN)	47,967
2001 (D)	47,500
2002 (D)	47,196
2003 (AN)	47,233
2004 (BN)	48,336
2005 (AN)	47,863
2006 (W)	48,264
2007 (D)	48,920
2008 (C)	48,497
2009 (D)	48,568
2010 (BN)	49,908
2011 (W)	50,252
2012 (BN)	50,596
2013 (D)	50,940
2014 (C)	51,284
2015 (C)	51,628
Average	49,060
W	49,258
AN	47,688
BN	49,613
D	48,625
C	50,470

6.2.3 Change in Storage

Estimates of total change in storage within the basin are provided in Figure 6.11 and Table 6.11. Total change in storage includes both the surface water system and the groundwater system. Change in storage for the surface water system and groundwater system are reported individually in Sections 6.3.3 and 6.4.3, respectively. The estimates suggest a net decrease in storage in most years between 2000 and 2015, with the exception of increases in 2000, 2003-2006, and 2011. Total change in storage appears to be relatively strongly correlated to water year type.

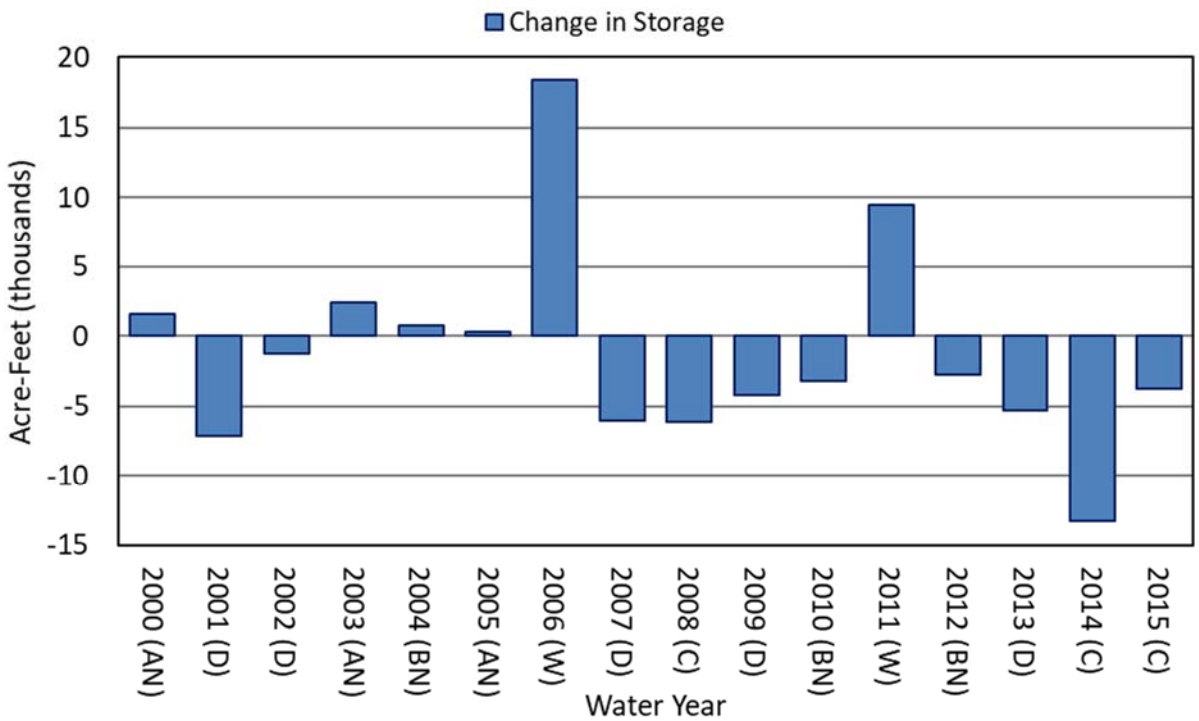

Figure 6.11. Corning Subbasin Change in Storage.

Table 6.11. Corning Subbasin Change in Storage (Acre-Feet).

Water Year	Change in Storage
2000 (AN)	1,610
2001 (D)	-7,171
2002 (D)	-1,308
2003 (AN)	2,439
2004 (BN)	715
2005 (AN)	277
2006 (W)	18,363
2007 (D)	-6,078
2008 (C)	-6,114
2009 (D)	-4,162
2010 (BN)	-3,158
2011 (W)	9,509
2012 (BN)	-2,710
2013 (D)	-5,267
2014 (C)	-13,269
2015 (C)	-3,755
Average	-1,255
W	13,936
AN	1,442
BN	-1,718
D	-4,797
C	-7,713

6.2.4 Historical Water Budget Summary

Annual inflows, outflows, and change in storage for the basin are summarized in Figure 6.12 and Table 6.12. Inflows are shown as positive values, while outflows and change in storage are shown as negative values. As a result, a positive value for change in storage actually reflects a decrease in storage. Review of the variability in component volumes across years provides insight into the impacts of hydrology on the overall basin water budget.

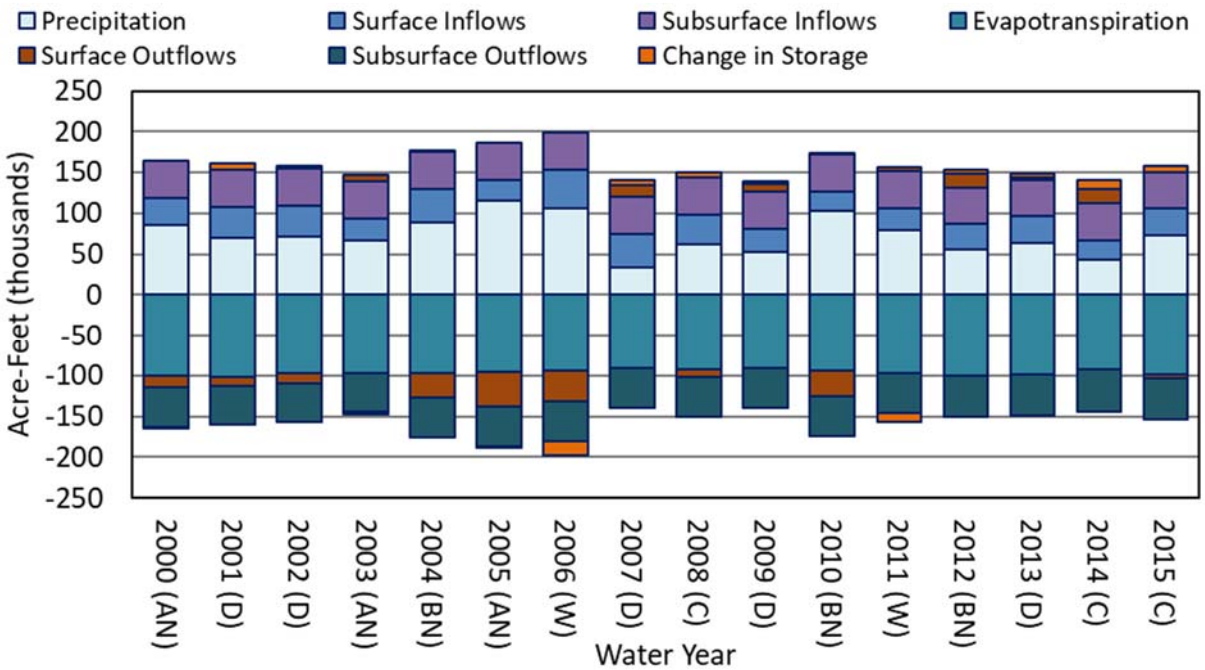

Figure 6.12. Corning Subbasin Boundary Budget, 2000 – 2015.

Table 6.12. Corning Subbasin Boundary Budget, 2000 – 2015 (Acre-Feet).

Water Year	Precipi-tation	Surface Inflows	Subsurface Inflows	Evapotrans-piration	Surface Outflows	Subsurface Outflows	Change in Storage
2000 (AN)	86,159	32,573	45,331	-99,961	-14,524	-47,967	-1,610
2001 (D)	69,766	38,091	45,625	-101,956	-11,197	-47,500	7,171
2002 (D)	70,719	38,530	46,010	-97,672	-11,700	-47,196	1,308
2003 (AN)	67,158	26,948	45,637	-96,577	6,506	-47,233	-2,439
2004 (BN)	88,957	40,821	45,992	-96,311	-30,408	-48,336	-715
2005 (AN)	115,678	25,376	45,516	-95,400	-43,030	-47,863	-277
2006 (W)	106,126	46,763	45,249	-93,399	-38,112	-48,264	-18,363
2007 (D)	33,173	40,654	45,768	-91,163	14,411	-48,920	6,078
2008 (C)	62,051	35,364	46,330	-92,440	-8,923	-48,497	6,114
2009 (D)	51,768	28,641	46,258	-90,973	8,711	-48,568	4,162
2010 (BN)	102,121	24,518	44,983	-94,197	-30,675	-49,908	3,158
2011 (W)	79,745	26,362	44,869	-96,238	5,023	-50,252	-9,509
2012 (BN)	55,763	30,849	44,755	-100,599	17,118	-50,596	2,710
2013 (D)	63,899	32,841	44,642	-98,669	2,961	-50,940	5,267
2014 (C)	42,362	24,800	44,528	-92,283	18,608	-51,284	13,269
2015 (C)	72,773	33,178	44,414	-99,185	-3,306	-51,628	3,755
Average	73,014	32,894	45,369	-96,064	-7,409	-49,060	1,255
W	92,936	36,563	45,059	-94,819	-16,544	-49,258	-13,936
AN	89,665	28,299	45,494	-97,313	-17,016	-47,688	-1,442
BN	82,280	32,063	45,243	-97,036	-14,655	-49,613	1,718
D	57,865	35,751	45,661	-96,087	637	-48,625	4,797
C	59,062	31,114	45,091	-94,636	2,126	-50,470	7,713

6.3 SURFACE WATER SYSTEM BUDGET

This section presents the surface water system water budget for the Corning Subbasin in Glenn County.

6.3.1 Inflows

6.3.1.1 Surface Water Inflow by Water Source Type

Surface water inflows by water source type are described in Section 6.2.1.1.

6.3.1.2 Precipitation

Precipitation inflow is described in Section 6.2.1.2.

6.3.1.3 Groundwater Extraction by Water Use Sector

Estimates of groundwater extraction by water use sector are provided in Figure 6.13 and Table 6.13. For agricultural and urban lands, groundwater extraction represents pumping, while for native lands, groundwater extraction represents estimated groundwater extraction by riparian vegetation. Groundwater extraction is dominated by irrigated agriculture, varying substantially from year to year based on variability in surface water supplies and crop water demands. Groundwater extraction is not known to occur for managed wetlands and assumed negligible for this study.

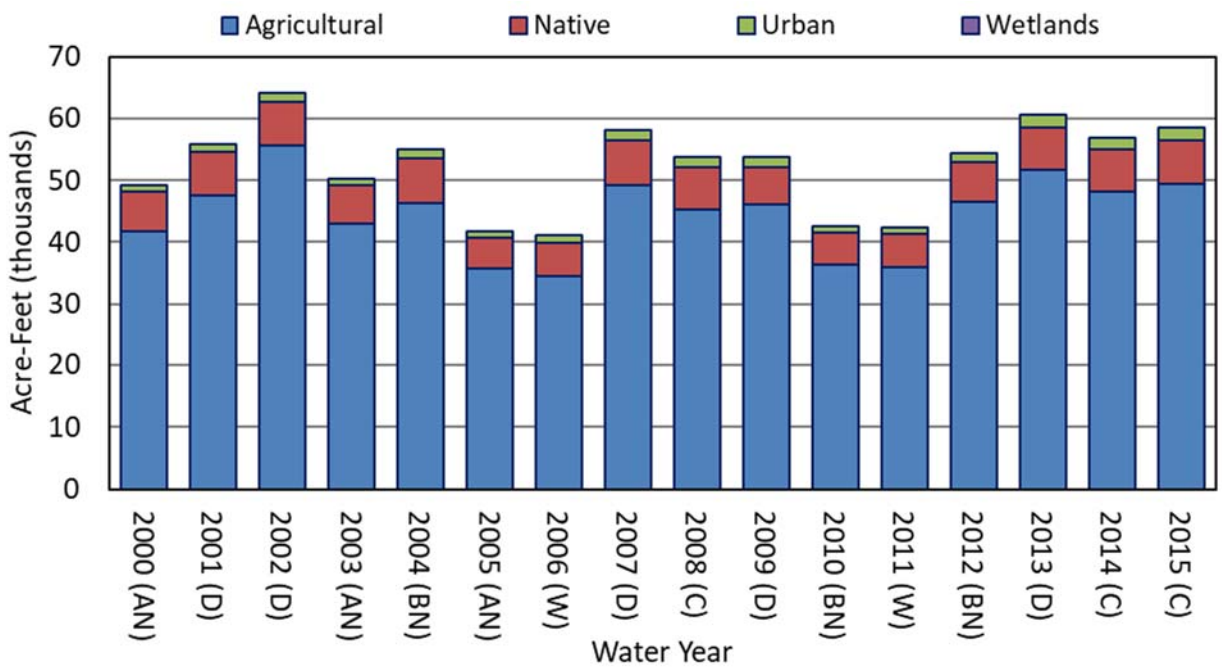

Figure 6.13. Corning Subbasin Groundwater Extraction by Water Use Sector.

Table 6.13. Corning Subbasin Groundwater Extraction by Water Use Sector (Acre-Feet).

Water Year	Agricultural	Native	Urban	Wetlands	Total
2000 (AN)	41,795	6,326	992	0	49,113
2001 (D)	47,625	7,033	1,244	0	55,902
2002 (D)	55,576	7,121	1,507	0	64,204
2003 (AN)	42,994	6,254	1,061	0	50,309
2004 (BN)	46,393	7,195	1,468	0	55,056
2005 (AN)	35,675	5,073	974	0	41,722
2006 (W)	34,597	5,374	1,170	0	41,141
2007 (D)	49,223	7,246	1,696	0	58,165
2008 (C)	45,268	6,815	1,693	0	53,776
2009 (D)	46,119	6,061	1,522	0	53,702
2010 (BN)	36,376	5,166	1,048	0	42,590
2011 (W)	36,015	5,290	1,097	0	42,402
2012 (BN)	46,433	6,416	1,607	0	54,456
2013 (D)	51,691	6,901	2,062	0	60,654
2014 (C)	48,074	6,960	1,841	0	56,875
2015 (C)	49,474	6,998	2,058	0	58,530
Average	44,583	6,389	1,440	0	52,412
W	35,306	5,332	1,134	0	41,772
AN	40,155	5,884	1,009	0	47,048
BN	43,068	6,259	1,374	0	50,701
D	50,047	6,872	1,606	0	58,525
C	47,605	6,924	1,864	0	56,394

6.3.1.4 Groundwater Discharge to Surface Water Sources

Estimated groundwater discharge to surface water sources is provided in Figure 6.14 and Table 6.14. Negative values represent net losses (seepage) of surface water to the groundwater system. Discharge from the groundwater system is independent of estimated infiltration of surface water to the groundwater system presented in Section 6.3.2.4. In most years, groundwater discharge is estimated to be negative, denoting net losses from drains and streams to the groundwater system. Estimated groundwater discharge was greatest in 2005 at around 13 taf and least in 2014 at around -30 taf.

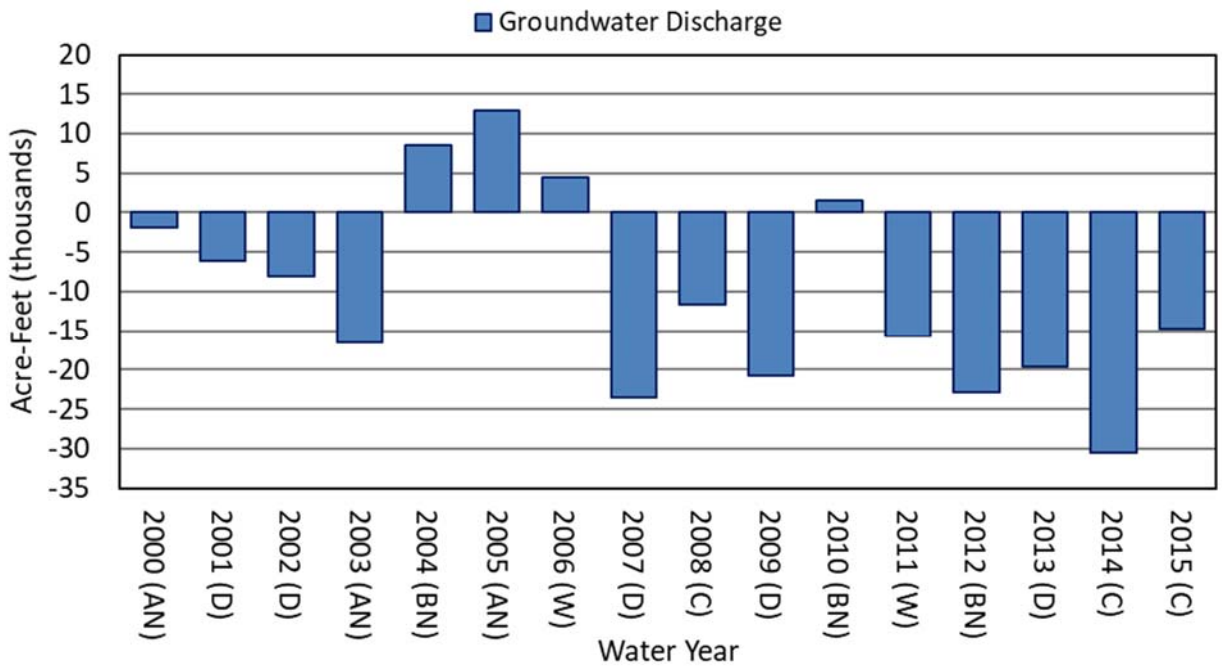

Figure 6.14. Corning Subbasin Groundwater Discharge to Surface Water Sources.

Table 6.14. Corning Subbasin Groundwater Discharge to Surface Water Sources (Acre-Feet).

Water Year	Groundwater Discharge
2000 (AN)	-1,815
2001 (D)	-6,045
2002 (D)	-8,012
2003 (AN)	-16,453
2004 (BN)	8,584
2005 (AN)	12,882
2006 (W)	4,547
2007 (D)	-23,560
2008 (C)	-11,575
2009 (D)	-20,767
2010 (BN)	1,494
2011 (W)	-15,674
2012 (BN)	-22,859
2013 (D)	-19,577
2014 (C)	-30,465
2015 (C)	-14,784
Average	-10,255
W	-5,564
AN	-1,795
BN	-4,260
D	-15,592
C	-18,941

6.3.2 Outflows

6.3.2.1 Evapotranspiration by Water Use Sector

Evapotranspiration by water use sector is described in Section 6.2.2.1.

6.3.2.2 Surface Water Outflow by Water Source Type

Surface water outflows by water source type are described in Section 6.2.2.2.

6.3.2.3 Infiltration of Precipitation

Estimated infiltration of precipitation by water use sector is provided in Figure 6.15 and Table 6.15. Infiltration of precipitation to the groundwater system is highly variable from year to year due to variation in the timing and amount of precipitation, ranging from around 3 taf annually in 2007 and 2014 to approximately 25 taf between 2004 and 2006.

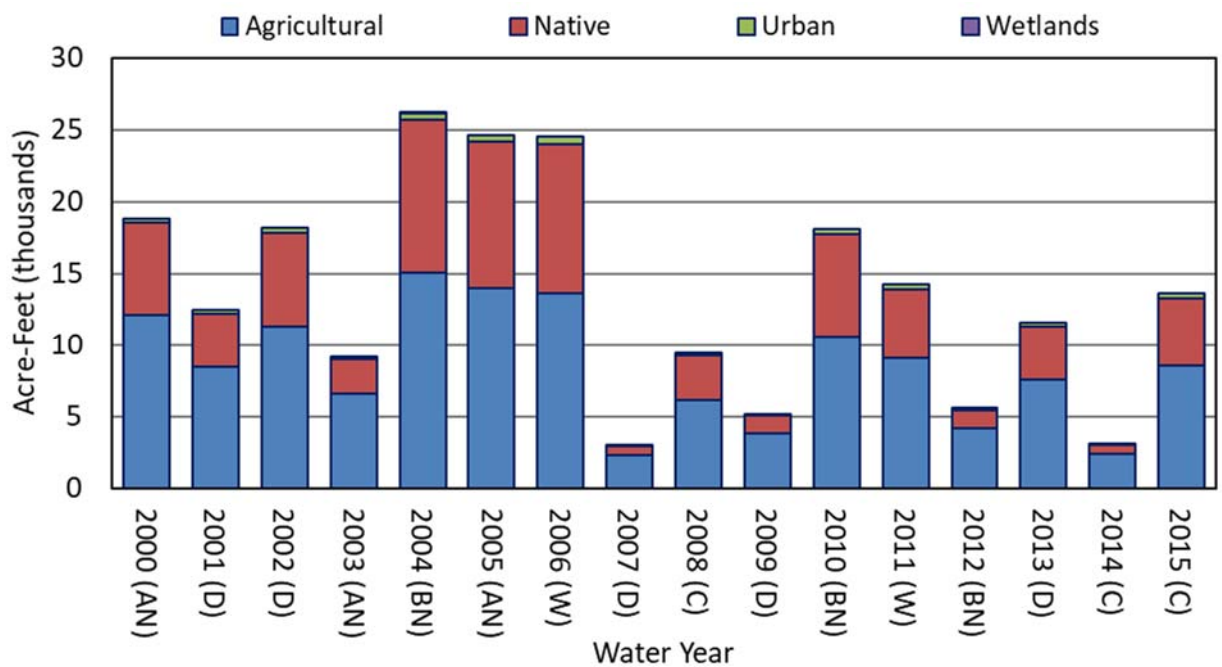

Figure 6.15. Corning Subbasin Infiltration of Precipitation by Water Use Sector.

Table 6.15. Corning Subbasin Infiltration of Precipitation by Water Use Sector (Acre-Feet).

Water Year	Agricultural	Native	Urban	Wetlands	Total
2000 (AN)	12,105	6,393	331	0	18,829
2001 (D)	8,434	3,800	216	0	12,450
2002 (D)	11,322	6,515	300	0	18,137
2003 (AN)	6,536	2,426	154	0	9,116
2004 (BN)	15,053	10,579	471	1	26,104
2005 (AN)	14,017	10,131	459	0	24,607
2006 (W)	13,612	10,396	531	0	24,539
2007 (D)	2,286	644	36	0	2,966
2008 (C)	6,126	3,137	186	0	9,449
2009 (D)	3,802	1,210	95	0	5,107
2010 (BN)	10,557	7,151	359	0	18,067
2011 (W)	9,060	4,803	352	0	14,215
2012 (BN)	4,157	1,255	135	0	5,547
2013 (D)	7,550	3,781	272	0	11,603
2014 (C)	2,359	677	91	0	3,127
2015 (C)	8,524	4,747	332	0	13,603
Average	8,469	4,853	270	0	13,592
W	11,336	7,600	442	0	19,377
AN	10,886	6,317	315	0	17,517
BN	9,922	6,328	322	0	16,573
D	6,679	3,190	184	0	10,053
C	5,670	2,854	203	0	8,726

6.3.2.4 Infiltration of Surface Water

Estimated infiltration of surface water by source is provided in Figure 6.16 and Table 6.16. Infiltration of surface water is believed to be dominated by canal and drain seepage, which is relatively steady over time. Seepage from streams exhibits greater variability, but contributes less than canal seepage in the subbasin.

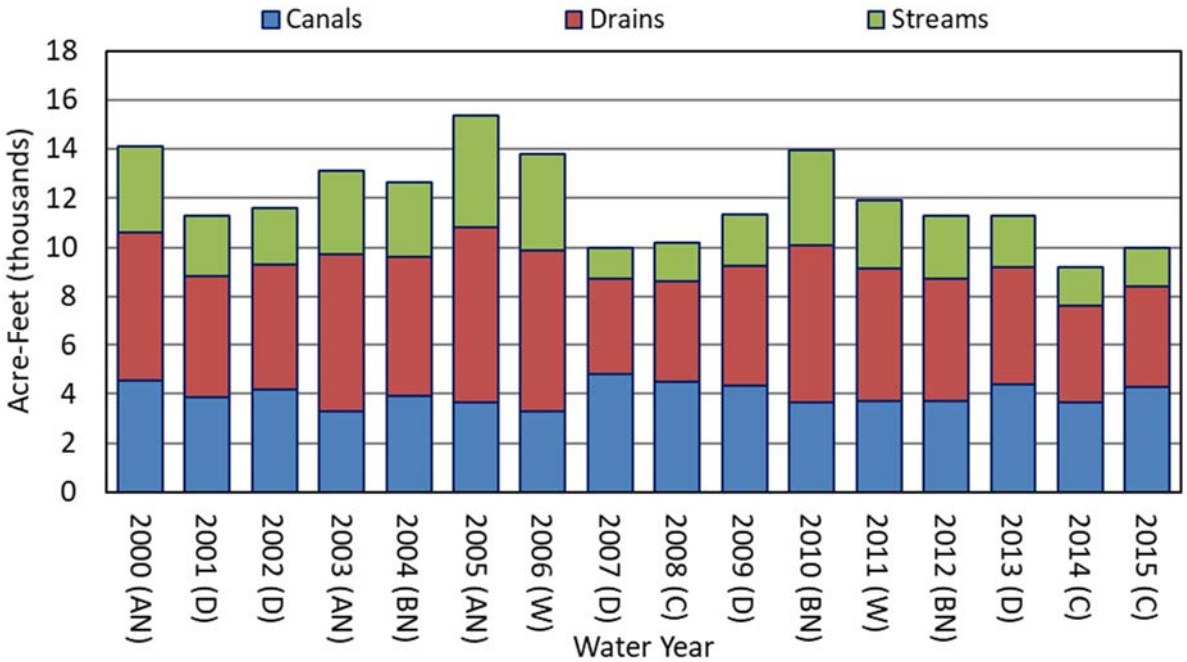

Figure 6.16. Corning Subbasin Infiltration of Surface Water.

Table 6.16. Corning Subbasin Infiltration of Surface Water (Acre-Feet).

Water Year	Canals	Drains	Streams	Total
2000 (AN)	4,555	6,042	3,493	14,090
2001 (D)	3,849	5,003	2,409	11,261
2002 (D)	4,200	5,080	2,343	11,624
2003 (AN)	3,274	6,467	3,387	13,129
2004 (BN)	3,891	5,697	3,068	12,655
2005 (AN)	3,675	7,138	4,524	15,337
2006 (W)	3,297	6,569	3,952	13,818
2007 (D)	4,829	3,881	1,273	9,983
2008 (C)	4,502	4,093	1,614	10,209
2009 (D)	4,320	4,920	2,116	11,356
2010 (BN)	3,675	6,392	3,907	13,975
2011 (W)	3,711	5,434	2,746	11,890
2012 (BN)	3,695	5,023	2,558	11,275
2013 (D)	4,394	4,814	2,083	11,291
2014 (C)	3,675	3,929	1,600	9,204
2015 (C)	4,284	4,116	1,592	9,992
Average	3,989	5,287	2,667	11,943
W	3,504	6,001	3,349	12,854
AN	3,835	6,549	3,801	14,185
BN	3,753	5,704	3,178	12,635
D	4,318	4,740	2,045	11,103
C	4,154	4,046	1,602	9,802

6.3.2.5 Infiltration of Applied Water

Estimated infiltration of applied water by water use sector is provided in Figure 6.17 and Table 6.17. Infiltration (percolation) of applied water is dominated by agricultural irrigation.

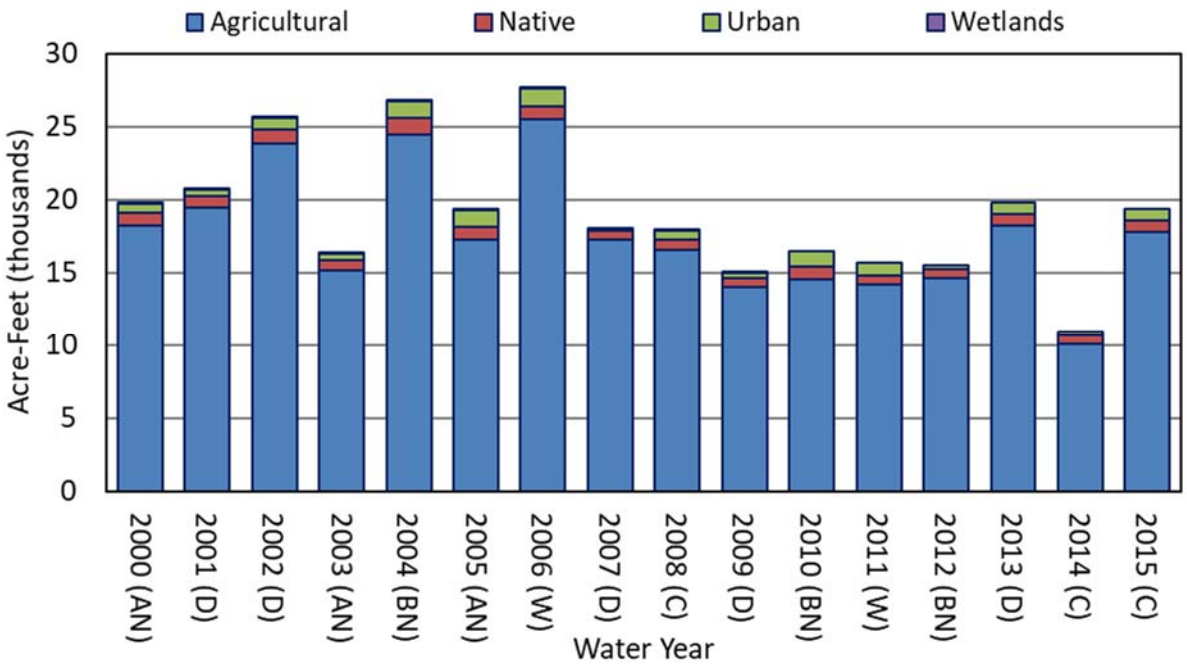

Figure 6.17. Corning Subbasin Infiltration of Applied Water by Water Use Sector.

Table 6.17. Corning Subbasin Infiltration of Applied Water by Water Use Sector (Acre-Feet).

Water Year	Agricultural	Native	Urban	Wetlands	Total
2000 (AN)	18,232	827	638	24	19,721
2001 (D)	19,464	753	446	25	20,688
2002 (D)	23,855	920	770	29	25,574
2003 (AN)	15,174	711	439	42	16,366
2004 (BN)	24,477	1,127	1,130	37	26,771
2005 (AN)	17,220	917	1,160	29	19,326
2006 (W)	25,467	899	1,228	23	27,617
2007 (D)	17,236	619	123	17	17,995
2008 (C)	16,514	710	661	11	17,896
2009 (D)	13,995	614	382	3	14,994
2010 (BN)	14,573	814	1,095	0	16,482
2011 (W)	14,141	647	891	0	15,679
2012 (BN)	14,636	579	299	0	15,514
2013 (D)	18,208	770	800	0	19,778
2014 (C)	10,103	560	245	0	10,908
2015 (C)	17,747	860	785	0	19,392
Average	17,565	770	693	15	19,044
W	19,804	773	1,060	12	21,648
AN	16,875	818	746	32	18,471
BN	17,895	840	841	12	19,589
D	18,552	735	504	15	19,806
C	14,788	710	564	4	16,065

6.3.3 Change in Storage

Estimates of change in storage within the surface water system are provided in Figure 6.18 and Table 6.18. Inter-annual changes in storage within the surface water system consist primarily of root zone soil moisture storage, are relatively small, and tend to average near zero over time.

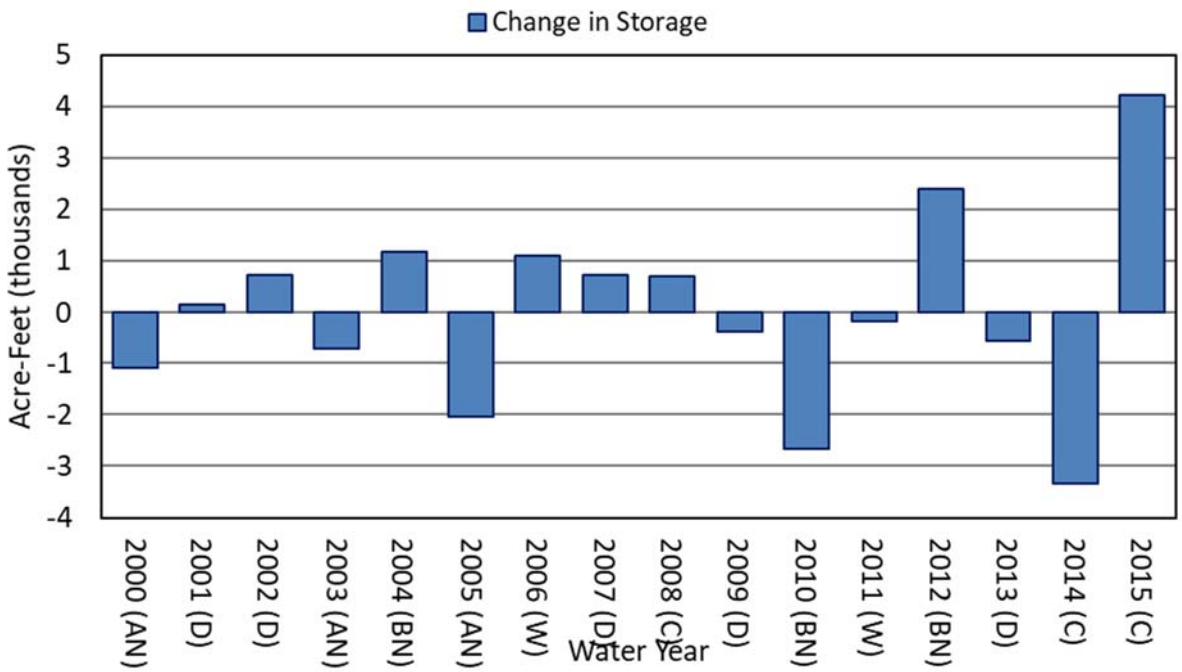

Figure 6.18. Corning Subbasin Surface Water System Change in Storage.

Table 6.18. Corning Subbasin Surface Water System Change in Storage (Acre-Feet).

Water Year	Change in Storage
2000 (AN)	-1,095
2001 (D)	161
2002 (D)	735
2003 (AN)	-719
2004 (BN)	1,168
2005 (AN)	-2,042
2006 (W)	1,093
2007 (D)	735
2008 (C)	699
2009 (D)	-374
2010 (BN)	-2,672
2011 (W)	-164
2012 (BN)	2,392
2013 (D)	-563
2014 (C)	-3,342
2015 (C)	4,218
Average	14
W	465
AN	-1,285
BN	296
D	139
C	525

6.3.4 Historical Water Budget Summary

Annual inflows, outflows, and change in storage for the surface water system are summarized in Figure 6.19 and Table 6.19. Inflows are shown as positive values, while outflows and change in storage are shown as negative values. As a result, a positive value for change in storage actually reflects a decrease in storage. Review of the variability in component volumes across years provides insight into the impacts of hydrology on the surface water system water budget.

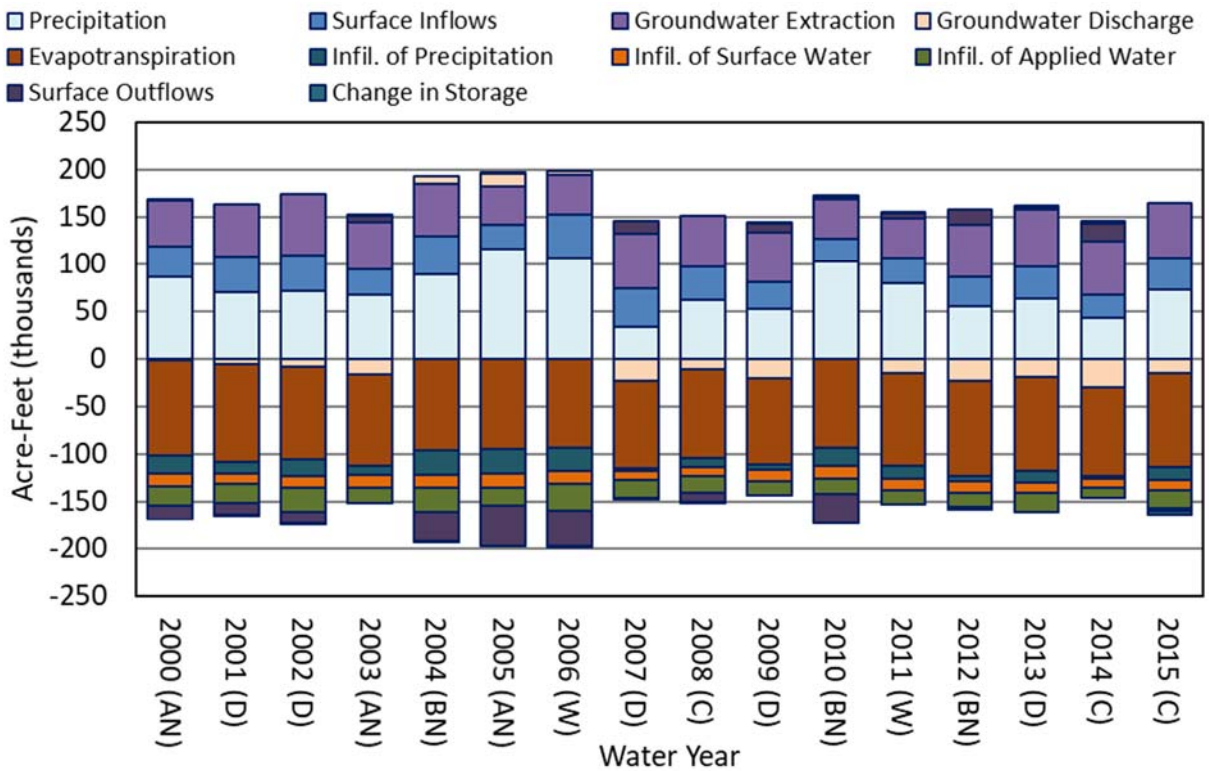

Figure 6.19. Corning Subbasin Surface Water System Budget, 2000 – 2015.

Table 6.19. Corning Subbasin Surface Water System Budget, 2000 – 2015 (Acre-Feet).

Water Year	Precipi-tation	Surface Inflows	Ground-water Extrac-tion	Ground-water Dis-charge	Evapo-trans-piration	Infil. of Precipitation	Infil. of Surface Water	Infil. of Applied Water	Surface Outflows	Change in Storage
2000 (AN)	86,159	32,573	49,113	-1,815	-99,961	-18,829	-14,090	-19,721	-14,524	1,095
2001 (D)	69,766	38,091	55,902	-6,045	-101,956	-12,450	-11,261	-20,688	-11,197	-161
2002 (D)	70,719	38,530	64,204	-8,012	-97,672	-18,137	-11,624	-25,574	-11,700	-735
2003 (AN)	67,158	26,948	50,309	-16,453	-96,577	-9,116	-13,129	-16,366	6,506	719
2004 (BN)	88,957	40,821	55,056	8,584	-96,311	-26,104	-12,655	-26,771	-30,408	-1,168
2005 (AN)	115,678	25,376	41,722	12,882	-95,400	-24,607	-15,337	-19,326	-43,030	2,042
2006 (W)	106,126	46,763	41,141	4,547	-93,399	-24,539	-13,818	-27,617	-38,112	-1,093
2007 (D)	33,173	40,654	58,165	-23,560	-91,163	-2,966	-9,983	-17,995	14,411	-735
2008 (C)	62,051	35,364	53,776	-11,575	-92,440	-9,449	-10,209	-17,896	-8,923	-699
2009 (D)	51,768	28,641	53,702	-20,767	-90,973	-5,107	-11,356	-14,994	8,711	374
2010 (BN)	102,121	24,518	42,590	1,494	-94,197	-18,067	-13,975	-16,482	-30,675	2,672
2011 (W)	79,745	26,362	42,402	-15,674	-96,238	-14,215	-11,890	-15,679	5,023	164
2012 (BN)	55,763	30,849	54,456	-22,859	-100,599	-5,547	-11,275	-15,514	17,118	-2,392
2013 (D)	63,899	32,841	60,654	-19,577	-98,669	-11,603	-11,291	-19,778	2,961	563
2014 (C)	42,362	24,800	56,875	-30,465	-92,283	-3,127	-9,204	-10,908	18,608	3,342
2015 (C)	72,773	33,178	58,530	-14,784	-99,185	-13,603	-9,992	-19,392	-3,306	-4,218
Average	73,014	32,894	52,412	-10,255	-96,064	-13,592	-11,943	-19,044	-7,409	-14
W	92,936	36,563	41,772	-5,564	-94,819	-19,377	-12,854	-21,648	-16,544	-465
AN	89,665	28,299	47,048	-1,795	-97,313	-17,517	-14,185	-18,471	-17,016	1,285
BN	82,280	32,063	50,701	-4,260	-97,036	-16,573	-12,635	-19,589	-14,655	-296
D	57,865	35,751	58,525	-15,592	-96,087	-10,053	-11,103	-19,806	637	-139
C	59,062	31,114	56,394	-18,941	-94,636	-8,726	-9,802	-16,065	2,126	-525

6.4 GROUNDWATER SYSTEM BUDGET

This section presents the groundwater system water budget for the Corning Subbasin in Glenn County.

6.4.1 Inflows

6.4.1.1 Subsurface Groundwater Inflow

Subsurface groundwater inflow is described in Section 6.2.1.3.

6.4.1.2 Infiltration of Precipitation

Infiltration of precipitation is described in Section 6.3.2.3.

6.4.1.3 Infiltration of Surface Water

Infiltration of surface water is described in Section 6.3.2.4.

6.4.1.4 Infiltration of Applied Water

Infiltration of applied water is described in Section 6.3.2.5.

6.4.2 Outflows

6.4.2.1 Subsurface Groundwater Outflow

Subsurface groundwater outflow is described in Section 6.2.2.3.

6.4.2.2 Groundwater Extraction by Water Use Sector

Groundwater extraction by water use sector is described in Section 6.3.1.3.

6.4.2.3 Groundwater Discharge to Surface Water Sources

Groundwater discharge to surface water sources is described in Section 6.3.1.4.

6.4.3 Change in Storage

Estimates of change in storage within the groundwater system are provided in Figure 6.20 and Table 6.20. The estimates suggest a net decrease in storage in most years between 2000 and 2015, with the exception of 2000, 2003, 2005-2006, and 2011. Total change in storage appears to be relatively strongly correlated to water year type.

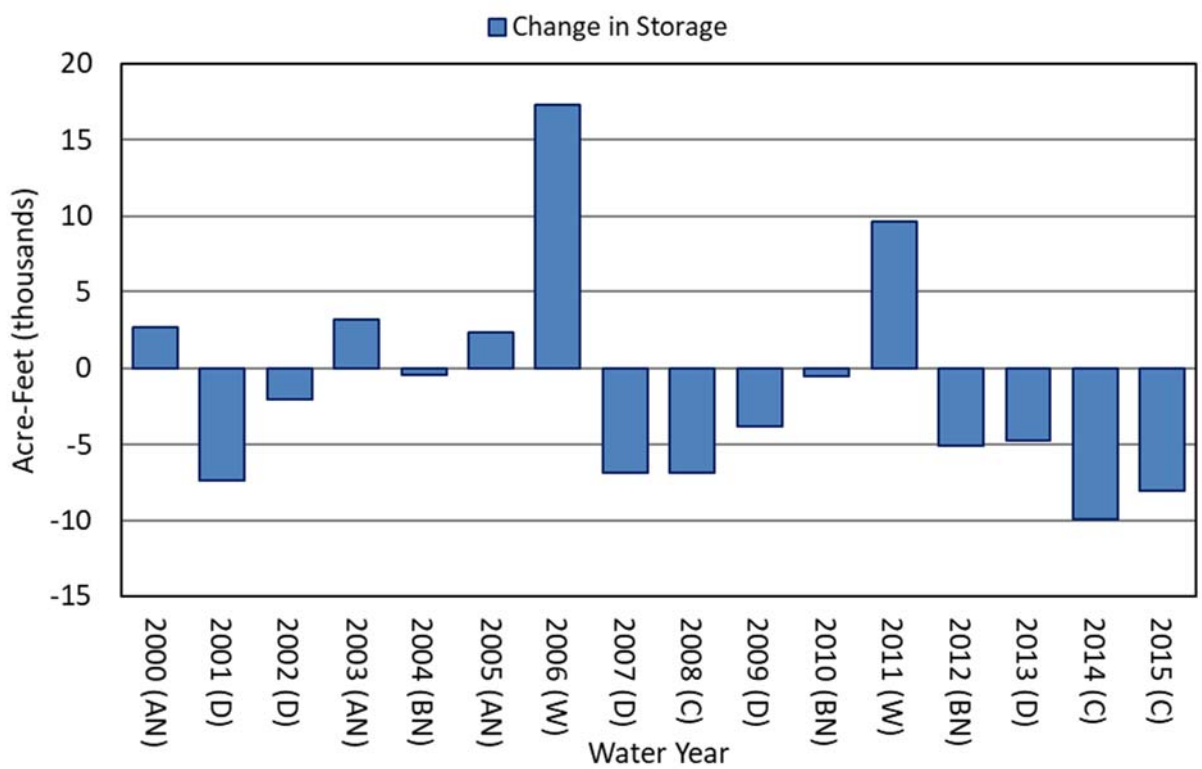

Figure 6.20. Corning Subbasin Groundwater System Change in Storage.

Table 6.20. Corning Subbasin Groundwater System Change in Storage (Acre-Feet).

Water Year	Change in Storage
2000 (AN)	2,705
2001 (D)	-7,332
2002 (D)	-2,043
2003 (AN)	3,158
2004 (BN)	-453
2005 (AN)	2,319
2006 (W)	17,270
2007 (D)	-6,813
2008 (C)	-6,813
2009 (D)	-3,788
2010 (BN)	-486
2011 (W)	9,673
2012 (BN)	-5,102
2013 (D)	-4,704
2014 (C)	-9,927
2015 (C)	-7,973
Average	-1,269
W	13,472
AN	2,727
BN	-2,014
D	-4,936
C	-8,238

6.4.4 Historical Water Budget Summary

Annual inflows, outflows, and change in storage for the groundwater system are summarized in Figure 6.21 and Table 6.21. Inflows are shown as positive values, while outflows and change in storage are shown as negative values. As a result, a positive value for change in storage actually reflects a decrease in storage. Review of the variability in component volumes across years provides insight into the impacts of hydrology on the groundwater system water budget.

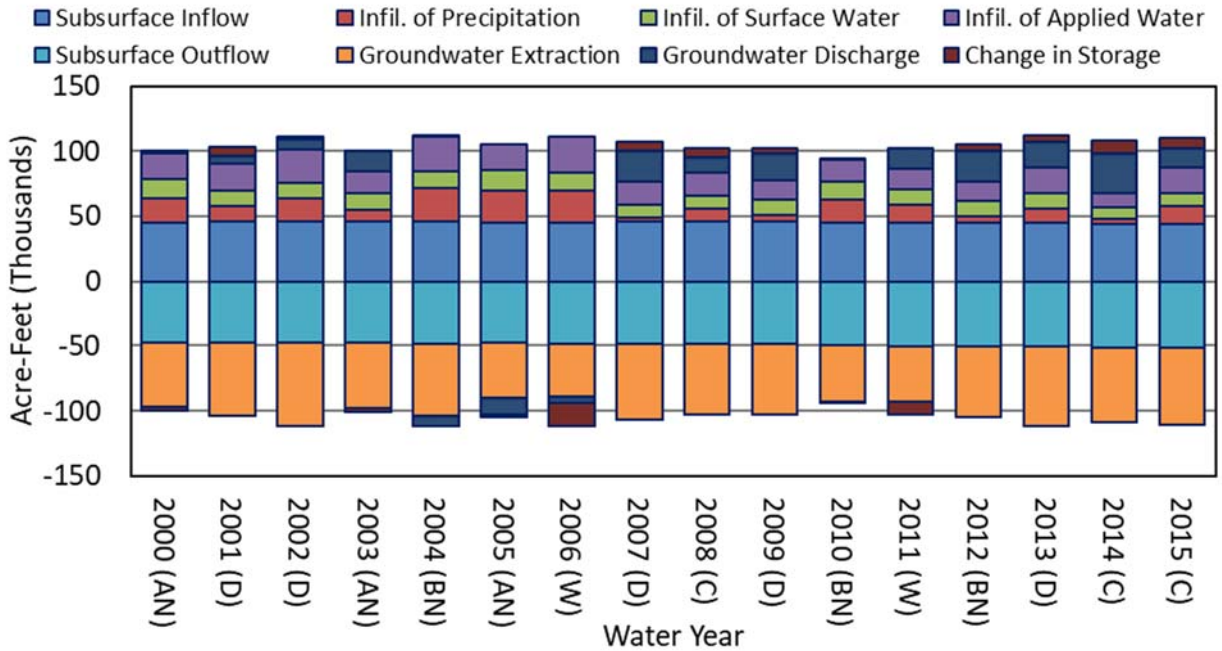

Figure 6.21. Corning Subbasin Groundwater System Budget, 2000 – 2015.

Table 6.21. Corning Subbasin Groundwater System Budget, 2000 – 2015 (Acre-Feet).

Water Year	Subsur-face Inflow	Infil. of Precip-itation	Infil. of Surface Water	Infil. of Applied Water	Subsur-face Outflow	Ground-water Extraction	Ground-water Discharge	Change in Storage
2000 (AN)	45,331	18,829	14,090	19,721	-47,967	-49,113	1,815	-2,705
2001 (D)	45,625	12,450	11,261	20,688	-47,500	-55,902	6,045	7,332
2002 (D)	46,010	18,137	11,624	25,574	-47,196	-64,204	8,012	2,043
2003 (AN)	45,637	9,116	13,129	16,366	-47,233	-50,309	16,453	-3,158
2004 (BN)	45,992	26,104	12,655	26,771	-48,336	-55,056	-8,584	453
2005 (AN)	45,516	24,607	15,337	19,326	-47,863	-41,722	-12,882	-2,319
2006 (W)	45,249	24,539	13,818	27,617	-48,264	-41,141	-4,547	-17,270
2007 (D)	45,768	2,966	9,983	17,995	-48,920	-58,165	23,560	6,813
2008 (C)	46,330	9,449	10,209	17,896	-48,497	-53,776	11,575	6,813
2009 (D)	46,258	5,107	11,356	14,994	-48,568	-53,702	20,767	3,788
2010 (BN)	44,983	18,067	13,975	16,482	-49,908	-42,590	-1,494	486
2011 (W)	44,869	14,215	11,890	15,679	-50,252	-42,402	15,674	-9,673
2012 (BN)	44,755	5,547	11,275	15,514	-50,596	-54,456	22,859	5,102
2013 (D)	44,642	11,603	11,291	19,778	-50,940	-60,654	19,577	4,704
2014 (C)	44,528	3,127	9,204	10,908	-51,284	-56,875	30,465	9,927
2015 (C)	44,414	13,603	9,992	19,392	-51,628	-58,530	14,784	7,973
Average	45,369	13,592	11,943	19,044	-49,060	-52,412	10,255	1,269
W	45,059	19,377	12,854	21,648	-49,258	-41,772	5,564	-13,472
AN	45,494	17,517	14,185	18,471	-47,688	-47,048	1,795	-2,727
BN	45,243	16,573	12,635	19,589	-49,613	-50,701	4,260	2,014
D	45,661	10,053	11,103	19,806	-48,625	-58,525	15,592	4,936
C	45,091	8,726	9,802	16,065	-50,470	-56,394	18,941	8,238

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7.1 LAND USE

While the water budget analysis was performed for water years 2000-2015, land use has been summarized for the period from 1990-2015 to provide a broader context of historical land (and water) use in the County. General land use estimates for 1990-2015 corresponding to water use sectors (as defined by the GSP Regulations) are summarized in Figure 7.1 and Table 7.1 for the West Butte Subbasin within Glenn County. The "Developed" land use category includes urban and industrial lands. These water use sectors have not been described individually due to very few industrial lands existing in the Subbasin.

As indicated below, agricultural lands decreased somewhat over time, from approximately 39,000 acres to 33,000 acres between the early 1990's and recent years. The reduction in agricultural lands has been offset by an increase in native vegetation, developed lands, and managed wetlands. Increases in developed lands are due in part to changes in DWR's delineation of developed lands in land use surveys over time. Similarly, water acreage is shown to have nearly doubled between 1990 and 2015, which is likely due to changes in DWR's delineation of water bodies over time.

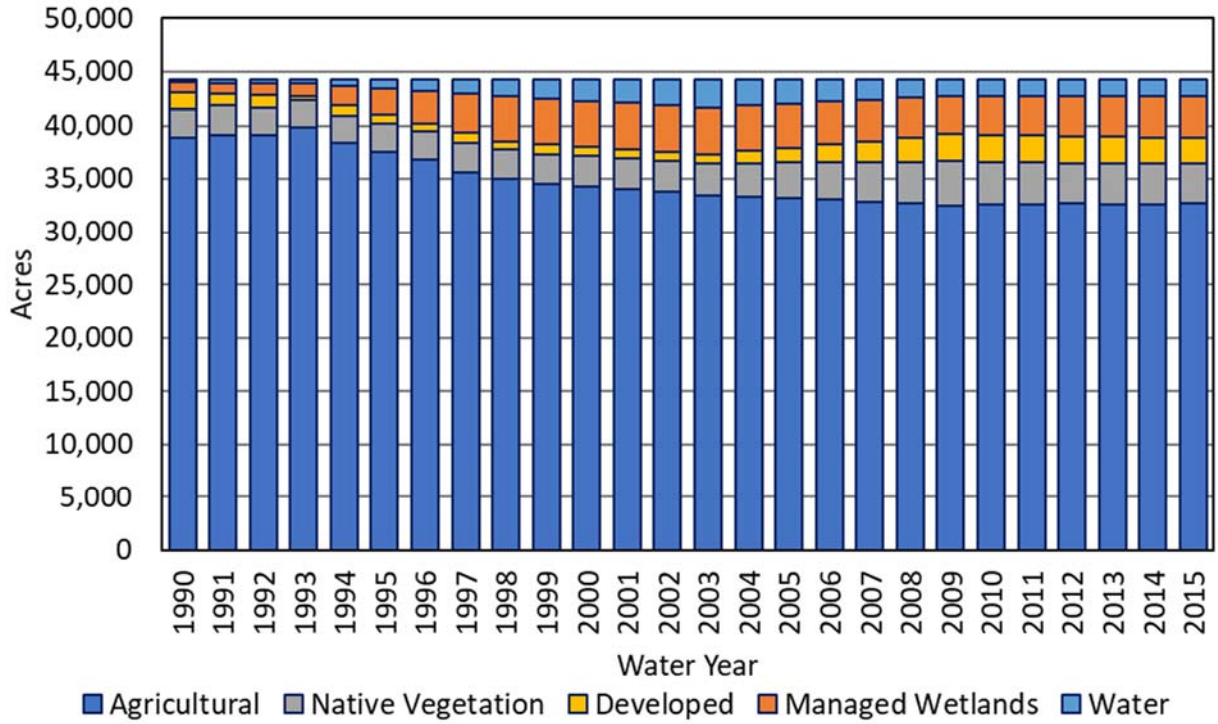

Figure 7.1. West Butte Subbasin General Land Uses.

Table 7.1. West Butte Subbasin General Land Uses (Acres).

Year	Agricultural	Managed Wetlands	Native Vegetation	Developed	Water
1990	38,811	982	2,701	1,500	301
1991	39,135	1,013	2,686	1,129	337
1992	39,135	1,059	2,546	1,186	377
1993	39,835	1,146	2,486	413	422
1994	38,319	1,752	2,615	952	665
1995	37,528	2,356	2,669	842	907
1996	36,772	2,960	2,719	702	1,150
1997	35,578	3,564	2,776	992	1,393
1998	34,959	4,165	2,827	716	1,635
1999	34,473	4,199	2,860	935	1,835
2000	34,292	4,231	2,862	884	2,034
2001	34,065	4,263	2,881	860	2,233
2002	33,862	4,296	2,887	826	2,432
2003	33,431	4,328	3,050	860	2,631
2004	33,339	4,203	3,170	1,137	2,452
2005	33,192	4,078	3,342	1,414	2,273
2006	33,031	3,953	3,529	1,690	2,094
2007	32,873	3,828	3,716	1,968	1,916
2008	32,710	3,704	3,908	2,244	1,737
2009	32,512	3,579	4,132	2,522	1,558
2010	32,594	3,631	4,006	2,509	1,563
2011	32,658	3,683	3,897	2,496	1,568
2012	32,661	3,736	3,849	2,484	1,573
2013	32,626	3,788	3,834	2,471	1,578
2014	32,612	3,841	3,791	2,459	1,583
2015	32,762	3,851	3,698	2,436	1,553
Average	34,760	3,315	3,209	1,486	1,531

Agricultural land uses are further detailed in Figure 7.2 and Table 7.2. In general, there has been an increase in orchard acres over time, offset largely by a decrease in pasture and alfalfa, grain, and other field and annual crops.

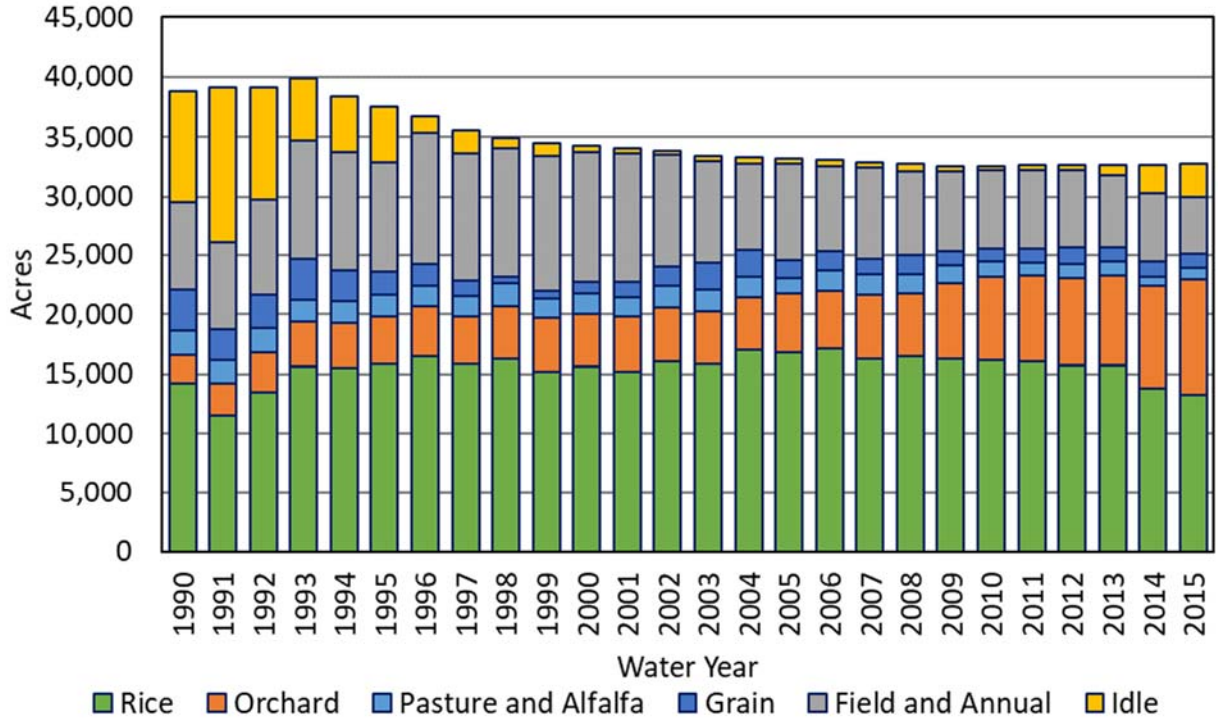

Figure 7.2. West Butte Subbasin Agricultural Land Uses.

Table 7.2. West Butte Subbasin Agricultural Land Uses (Acres).

Year	Field and Annual	Grain	Idle	Orchard	Pasture and Alfalfa	Rice
1990	7,422	3,488	9,304	2,416	1,974	14,207
1991	7,323	2,585	13,047	2,749	1,961	11,470
1992	8,102	2,729	9,409	3,334	2,056	13,504
1993	9,961	3,507	5,154	3,726	1,843	15,643
1994	9,984	2,643	4,590	3,734	1,837	15,530
1995	9,317	1,875	4,643	4,000	1,854	15,839
1996	11,162	1,810	1,389	4,213	1,753	16,444
1997	10,797	1,254	1,957	3,928	1,758	15,884
1998	10,844	550	955	4,428	1,939	16,242
1999	11,446	595	1,070	4,472	1,687	15,203
2000	10,939	958	579	4,522	1,727	15,567
2001	10,847	1,268	463	4,546	1,703	15,238
2002	9,443	1,597	364	4,511	1,887	16,060
2003	8,581	2,274	447	4,442	1,834	15,853
2004	7,354	2,263	548	4,428	1,761	16,985
2005	8,184	1,507	484	4,950	1,217	16,850
2006	7,168	1,612	521	4,797	1,796	17,136
2007	7,760	1,310	459	5,442	1,647	16,254
2008	7,102	1,661	571	5,243	1,665	16,468
2009	6,824	1,202	357	6,316	1,543	16,270
2010	6,690	1,079	384	7,003	1,305	16,132
2011	6,719	1,166	431	7,281	1,046	16,015
2012	6,608	1,318	457	7,293	1,221	15,764
2013	6,182	1,201	828	7,586	1,100	15,729
2014	5,788	1,387	2,315	8,569	733	13,822
2015	4,855	1,192	2,826	9,706	907	13,275
Average	8,362	1,694	2,444	5,140	1,606	15,515

7.2 BOUNDARY BUDGET

This section presents the basin boundary water budget for the West Butte Subbasin in Glenn County.

7.2.1 Inflows

7.2.1.1 Surface Water Inflow by Water Source Type

Surface water inflows include surface water flowing into the basin across the basin boundary. Per the Regulations, surface inflows must be reported by water source type. According to the Regulations:

> *"Water source type" represents the source from which water is derived to meet the applied beneficial uses, including groundwater, recycled water, reused water, and surface water sources identified as Central Valley Project, the State Water Project, the Colorado River Project, local supplies, and local imported supplies.*

Additionally, runoff of precipitation from upgradient areas adjacent to the basin represents a potential source of surface water inflow.

Primary surface water inflows to the West Butte Subbasin in Glenn County include diversions from the Thermalito Afterbay (which lies in Butte County) by Western Canal Water District (WCWD).

7.2.1.1.1 Local Imported Supplies

For purposes of this preliminary water budget, diversions by WCWD have been classified as local imported supplies, although under diversion agreements with the State of California, diversions are made from State Water Project (SWP) facilities. WCWD's right to divert surface water from the Feather River via Thermalito is based on senior, local water rights that predate the SWP.

Additional riparian and other small diversions likely occur but have not been included as part of this preliminary effort. It is anticipated that additional diversions will be addressed as part of subsequent phases of GSP development.

7.2.1.1.2 CVP Supplies

There are no significant CVP supplies known to be used in the Glenn County portion of the West Butte Subbasin.

7.2.1.1.3 Recycling and Reuse

For purposes of this analysis, recycled water, as locally defined, represents recovery and reuse of drainwater by surface water suppliers. Reuse refers to reuse by individual growers. Recycling and reuse occurring within the study area does not cross basin boundaries in significant quantities.

7.2.1.1.4 Groundwater

Groundwater pumped outside of the study area does not flow into the study area through surface water conveyances; therefore, groundwater is not included as part of the estimation of boundary surface water inflows.

7.2.1.1.5 Other Surface Inflows

Colorado River Project supplies are not applicable to the study area.

There are no State Water Project (SWP) contractors within the study area.

Some precipitation runoff enters the study area as runoff from areas in the Butte County portion of the subbasin. For the preliminary water budgets presented herein, it is assumed that these inflows tend to flow through the subbasin and do not represent a substantial source of supply. It is anticipated that these surface inflows will be quantified as part of GSP development.

7.2.1.1.6 Summary of Surface Inflows

Surface water inflows by water year type are summarized in Figure 7.3 and Table 7.3. During the study period, surface water supplies varied from approximately 72,000 acre-feet to 98,000 acre-feet. Surface inflows have been relatively steady over time, with the greatest reduction in 2015 due to curtailment by the State of California as a result of extreme drought.

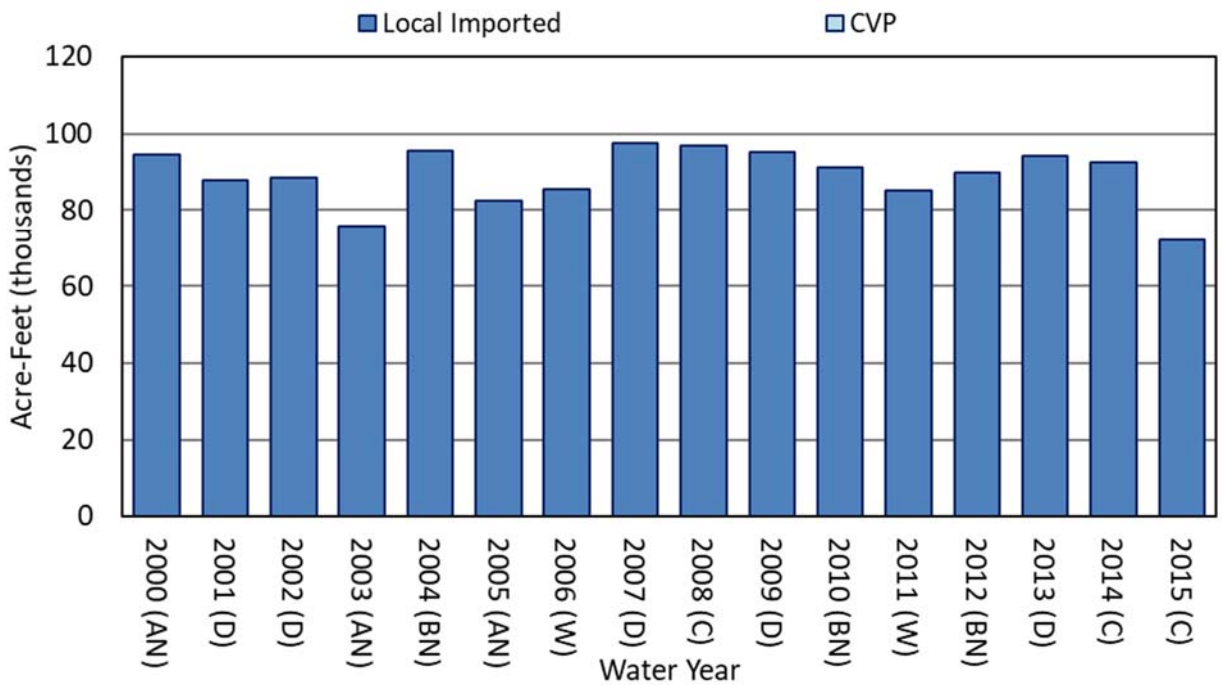

Figure 7.3. West Butte Subbasin Surface Water Inflows by Water Source Type.

Table 7.3. West Butte Subbasin Surface Water Inflows by Water Source Type (Acre-Feet).

Water Year	Local Imported	CVP	Total
2000 (AN)	94,367	0	94,367
2001 (D)	87,815	0	87,815
2002 (D)	88,595	0	88,595
2003 (AN)	75,747	0	75,747
2004 (BN)	95,621	0	95,621
2005 (AN)	82,419	0	82,419
2006 (W)	85,544	0	85,544
2007 (D)	97,649	0	97,649
2008 (C)	96,773	0	96,773
2009 (D)	95,329	0	95,329
2010 (BN)	91,028	0	91,028
2011 (W)	85,165	0	85,165
2012 (BN)	89,754	0	89,754
2013 (D)	94,030	0	94,030
2014 (C)	92,574	0	92,574
2015 (C)	72,113	0	72,113
Average	89,033	0	89,033
W	85,355	0	85,355
AN	84,177	0	84,177
BN	92,134	0	92,134
D	92,683	0	92,683
C	87,153	0	87,153

7.2.1.2 Precipitation

Precipitation estimates for the Glenn County portion of the West Butte Subbasin are provided in Figure 7.4 and Table 7.4. Precipitation estimates are reported by water use sector. According to the Regulations:

> *"Water use sector" refers to categories of water demand based on the general land uses to which the water is applied, including urban, industrial, agricultural, managed wetlands, managed recharge, and native vegetation.*

For Glenn County, minimal industrial water use is present, and industrial uses have been combined with urban uses. Additionally, there is no known managed recharge occurring within the County.

Precipitation is highly variable in the study area, ranging from approximately 32 taf in 2007 to 110 taf in 2005.

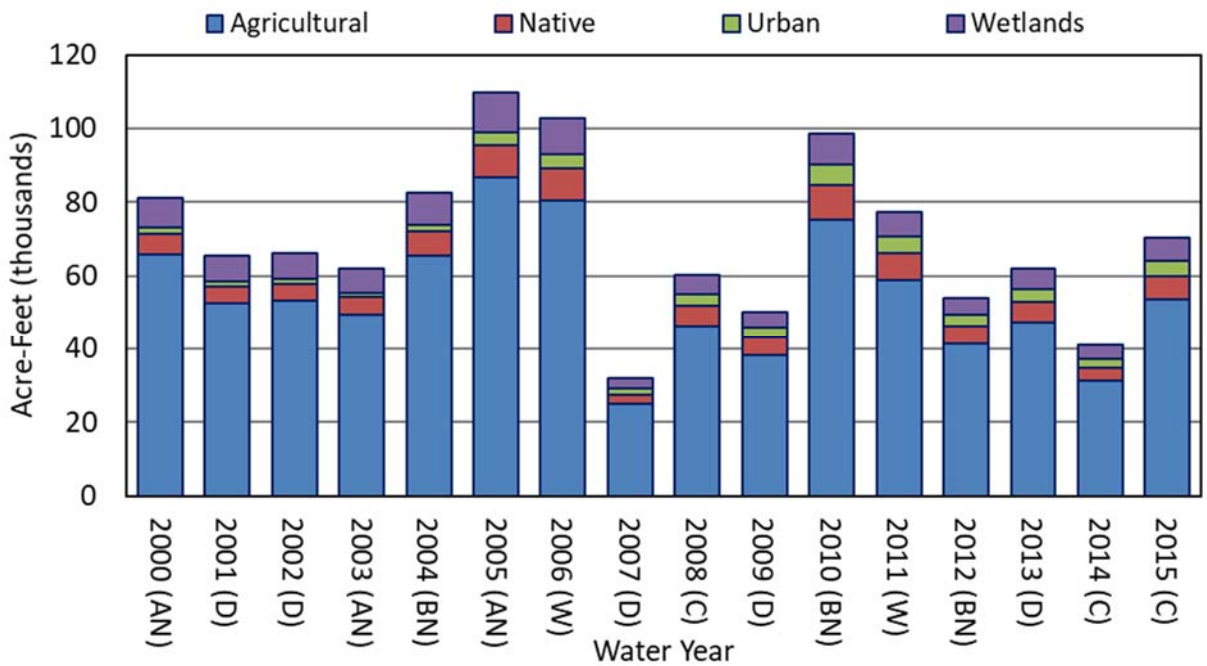

Figure 7.4. West Butte Subbasin Precipitation by Water Use Sector.

Table 7.4. West Butte Subbasin Precipitation by Water Use Sector (Acre-Feet).

Water Year	Agricultural	Native	Urban	Wetlands	Total
2000 (AN)	65,634	5,578	1,736	8,242	81,190
2001 (D)	52,664	4,546	1,362	6,725	65,297
2002 (D)	53,207	4,616	1,362	6,842	66,027
2003 (AN)	49,533	4,569	1,296	6,569	61,967
2004 (BN)	65,594	6,288	2,003	8,642	82,527
2005 (AN)	86,637	8,729	3,467	11,020	109,853
2006 (W)	80,416	8,558	3,923	9,903	102,800
2007 (D)	24,814	2,774	1,410	2,964	31,962
2008 (C)	46,243	5,503	3,115	5,299	60,160
2009 (D)	38,238	4,769	2,857	4,257	50,121
2010 (BN)	75,219	9,319	5,799	8,359	98,696
2011 (W)	58,902	7,112	4,515	6,612	77,141
2012 (BN)	41,204	4,875	3,138	4,690	53,907
2013 (D)	47,262	5,567	3,591	5,427	61,847
2014 (C)	31,255	3,634	2,357	3,680	40,926
2015 (C)	53,740	6,200	4,037	6,327	70,304
Average	54,410	5,790	2,873	6,597	69,670
W	69,659	7,835	4,219	8,258	89,971
AN	67,268	6,292	2,166	8,610	84,337
BN	60,672	6,827	3,647	7,230	78,377
D	43,237	4,454	2,116	5,243	55,051
C	43,746	5,112	3,170	5,102	57,130

7.2.1.3 Subsurface Groundwater Inflow

Subsurface groundwater inflow was estimated based on DWR's C2VSim fine grid application of the Integrated Water Flow Model (IWFM), version R374 Beta. The fine grid beta version is equivalent to the coarse grid R374 public release version of the application, but includes a more detailed element grid to allow for improved definition of zones to extract groundwater budget results along county and subbasin boundaries. C2VSim results for water years 2000 to 2009 were available as model outputs; estimates for 2010 to 2015 were interpolated based on changes in annual subsurface inflows over time.

Subsurface inflow estimates for the Glenn County portion of the West Butte Subbasin are provided in Figure 7.5 and Table 7.5. C2VSim suggests that subsurface inflow has remained steady over time, at approximately 18 taf.

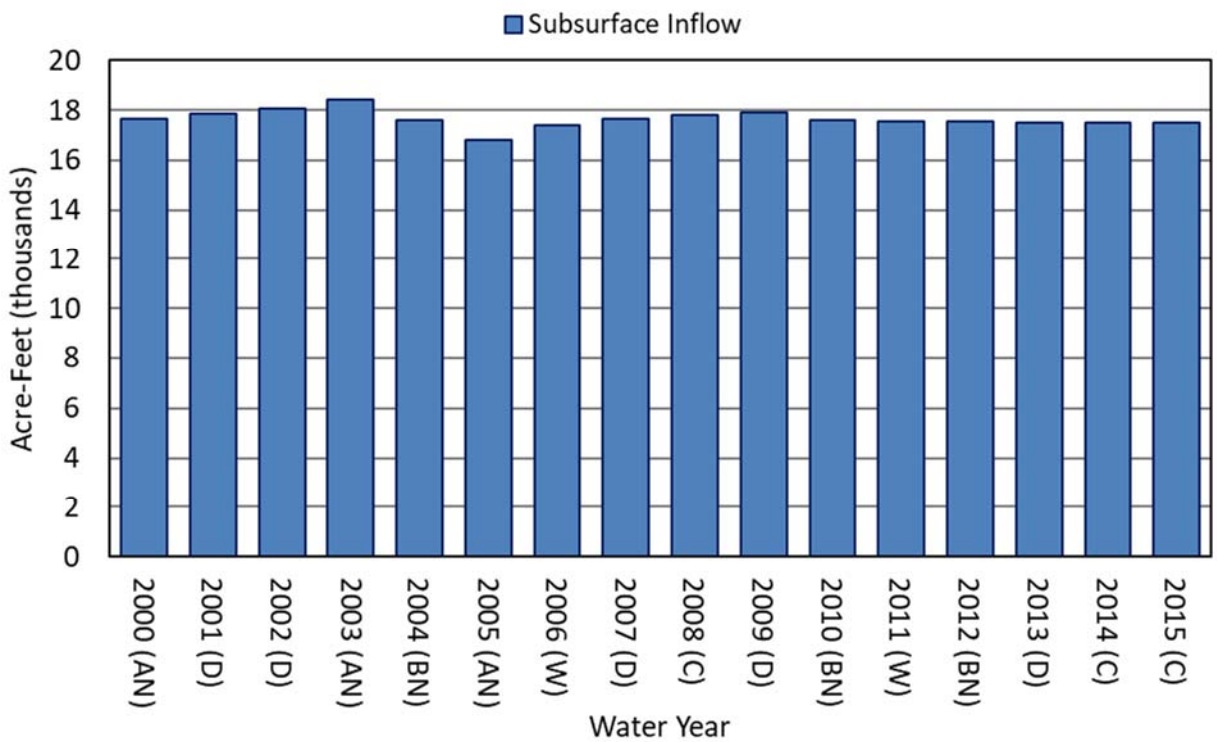

Figure 7.5. West Butte Subbasin Subsurface Inflows.

Table 7.5. West Butte Subbasin Subsurface Inflows (Acre-Feet).

Water Year	Subsurface Inflow
2000 (AN)	17,627
2001 (D)	17,866
2002 (D)	18,044
2003 (AN)	18,445
2004 (BN)	17,619
2005 (AN)	16,807
2006 (W)	17,410
2007 (D)	17,639
2008 (C)	17,812
2009 (D)	17,896
2010 (BN)	17,587
2011 (W)	17,563
2012 (BN)	17,540
2013 (D)	17,516
2014 (C)	17,493
2015 (C)	17,469
Average	17,646
W	17,487
AN	17,626
BN	17,582
D	17,792
C	17,591

7.2.2 Outflows

7.2.2.1 Evapotranspiration by Water Use Sector

Evapotranspiration (ET) by water use sector is reported in Figures 7.6 to 7.8 and Tables 7.6 to 7.8. First, total ET is reported, followed by ET from applied water and ET from precipitation. "Urban" lands include urban, industrial, and rural residential lands. Other than the communities of Butte City and Afton, these lands are primarily rural residential.

In addition to ET from land surfaces, estimates of evaporation from canals, drains, lakes, and streams are included. ET of applied water for native lands represents estimated ET of groundwater by riparian vegetation.

ET was least in 2011, at approximately 126 taf, and greatest in 2008, at approximately 141 taf. Agricultural ET tends to increase in drier years, while native ET decreases. Total ET has remained relatively steady over time.

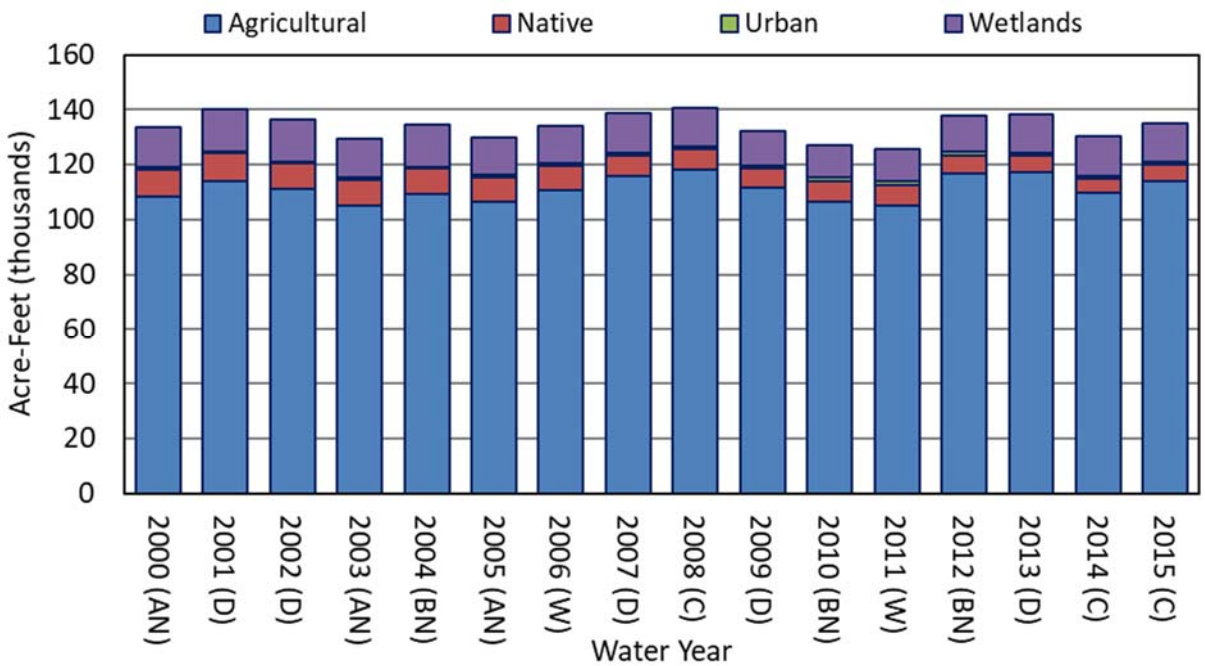

Figure 7.6. West Butte Subbasin Evapotranspiration by Water Use Sector.

Table 7.6. West Butte Subbasin Evapotranspiration by Water Use Sector (Acre-Feet).

Water Year	Agricultural	Native	Urban	Wetlands	Total
2000 (AN)	108,283	9,998	639	14,805	133,725
2001 (D)	114,161	10,111	586	15,396	140,254
2002 (D)	111,148	9,552	499	15,353	136,552
2003 (AN)	105,300	9,259	610	14,389	129,558
2004 (BN)	109,413	9,246	581	15,182	134,422
2005 (AN)	106,376	8,887	933	13,529	129,725
2006 (W)	110,917	8,702	883	13,452	133,954
2007 (D)	115,949	7,533	750	14,287	138,519
2008 (C)	118,102	7,664	801	14,134	140,701
2009 (D)	111,835	6,857	999	12,740	132,431
2010 (BN)	106,653	7,330	1,335	11,755	127,073
2011 (W)	104,976	7,400	1,459	11,830	125,665
2012 (BN)	116,551	6,898	1,263	13,325	138,037
2013 (D)	117,040	6,188	932	14,174	138,334
2014 (C)	109,681	5,260	901	14,633	130,475
2015 (C)	114,080	5,992	1,040	14,106	135,218
Average	111,279	7,930	888	13,943	134,040
W	107,947	8,051	1,171	12,641	129,810
AN	106,653	9,381	727	14,241	131,003
BN	110,872	7,825	1,060	13,421	133,177
D	114,027	8,048	753	14,390	137,218
C	113,954	6,305	914	14,291	135,465

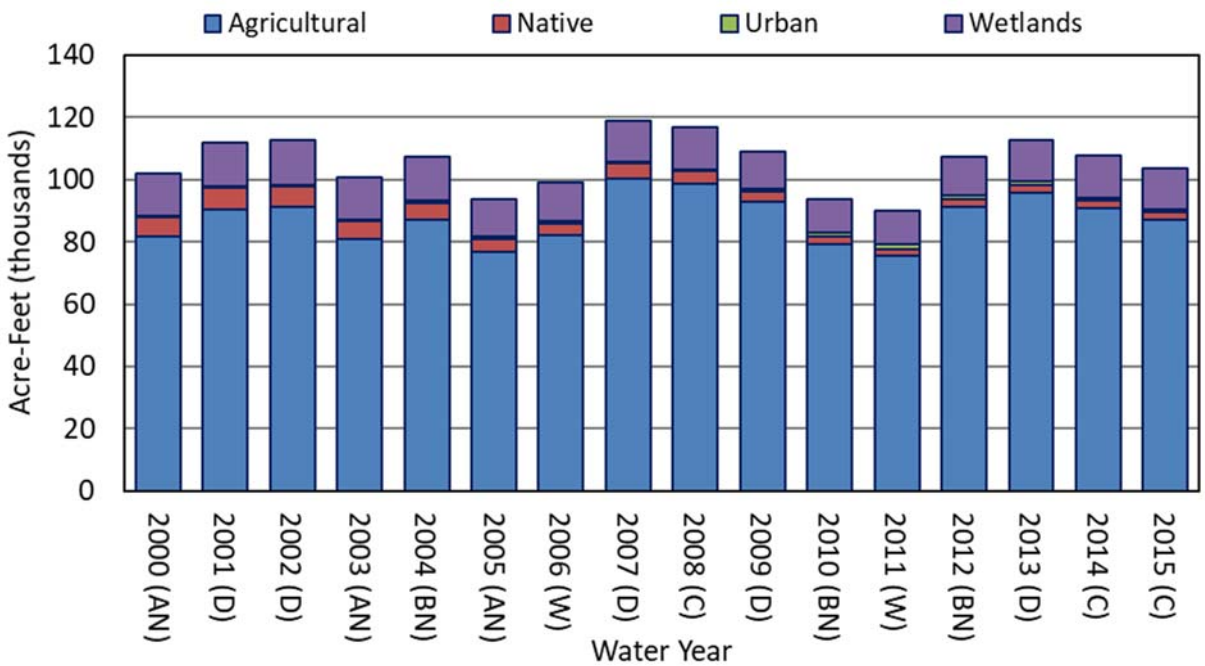

Figure 7.7. West Butte Subbasin Evapotranspiration of Applied Water by Water Use Sector.

Table 7.7. West Butte Subbasin Evapotranspiration of Applied Water by Water Use Sector (Acre-Feet).

Water Year	Agricultural	Native	Urban	Wetlands	Total
2000 (AN)	81,653	6,314	488	13,614	102,069
2001 (D)	90,477	6,865	446	14,144	111,932
2002 (D)	91,069	6,726	383	14,584	112,762
2003 (AN)	80,896	5,948	486	13,179	100,509
2004 (BN)	87,038	5,630	458	14,009	107,135
2005 (AN)	76,683	4,121	803	11,960	93,567
2006 (W)	82,007	3,854	772	12,253	98,886
2007 (D)	100,244	4,832	690	13,214	118,980
2008 (C)	98,517	4,091	749	13,297	116,654
2009 (D)	92,956	3,249	964	11,796	108,965
2010 (BN)	79,251	2,370	1,274	10,758	93,653
2011 (W)	75,726	2,128	1,382	10,738	89,974
2012 (BN)	91,234	2,520	1,181	12,512	107,447
2013 (D)	95,882	2,544	859	13,509	112,794
2014 (C)	90,903	2,397	832	13,660	107,792
2015 (C)	87,330	2,231	945	13,096	103,602
Average	87,617	4,114	795	12,895	105,420
W	78,867	2,991	1,077	11,496	94,430
AN	79,744	5,461	592	12,918	98,715
BN	85,841	3,507	971	12,426	102,745
D	94,126	4,843	668	13,449	113,087
C	92,250	2,906	842	13,351	109,349

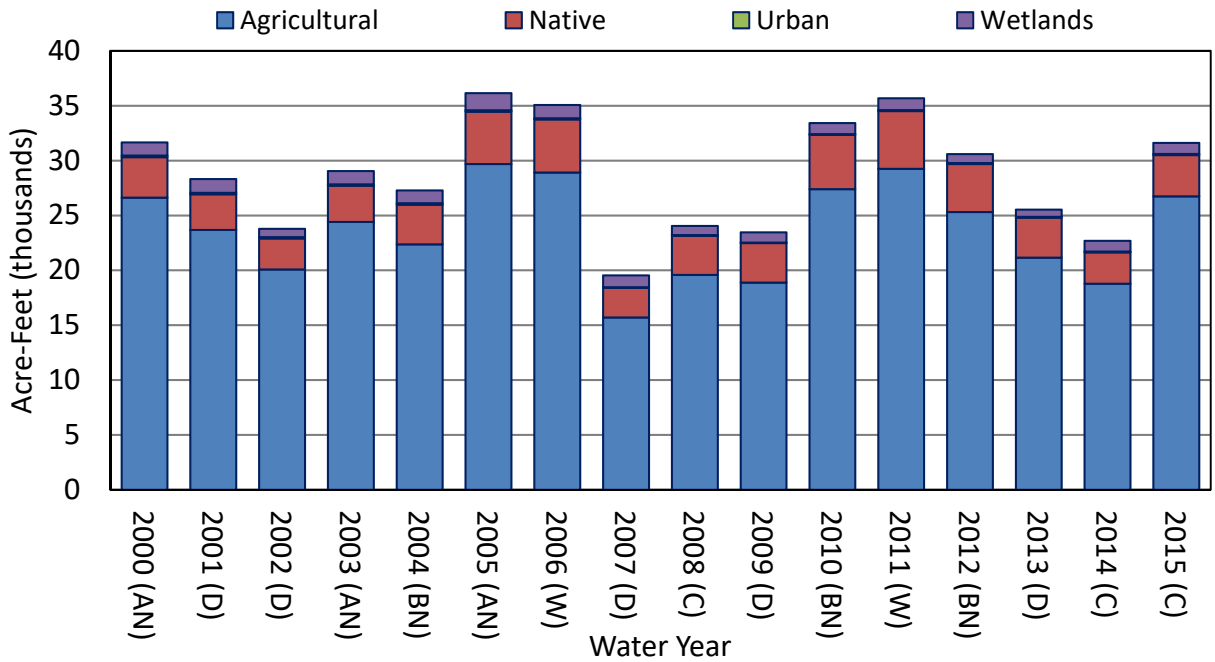

Figure 7.8. West Butte Subbasin Evapotranspiration of Precipitation by Water Use Sector.

Table 7.8. West Butte Subbasin Evapotranspiration of Precipitation by Water Use Sector (Acre-Feet).

Water Year	Agricultural	Native	Urban	Wetlands	Total
2000 (AN)	26,630	3,684	151	1,191	31,656
2001 (D)	23,684	3,246	140	1,252	28,322
2002 (D)	20,079	2,826	116	769	23,790
2003 (AN)	24,404	3,311	124	1,210	29,049
2004 (BN)	22,375	3,616	123	1,173	27,287
2005 (AN)	29,693	4,766	130	1,569	36,158
2006 (W)	28,910	4,848	111	1,199	35,068
2007 (D)	15,705	2,701	60	1,073	19,539
2008 (C)	19,585	3,573	52	837	24,047
2009 (D)	18,879	3,608	35	944	23,466
2010 (BN)	27,402	4,960	61	997	33,420
2011 (W)	29,250	5,272	77	1,092	35,691
2012 (BN)	25,317	4,378	82	813	30,590
2013 (D)	21,158	3,644	73	665	25,540
2014 (C)	18,778	2,863	69	973	22,683
2015 (C)	26,750	3,761	95	1,010	31,616
Average	23,662	3,816	94	1,048	28,620
W	29,080	5,060	94	1,146	35,380
AN	26,909	3,920	135	1,323	32,288
BN	25,031	4,318	89	994	30,432
D	19,901	3,205	85	941	24,131
C	21,704	3,399	72	940	26,115

7.2.2.2 Surface Water Outflow by Water Source Type

Surface water outflows by water source type are summarized in Figure 7.9 and Table 7.9. Irrigation return flows consist of runoff of local imported supplies. Other surface outflows include runoff of precipitation and groundwater discharge to drains and streams that leave the study area. In all years, groundwater discharge from the study area was estimated to be negative, representing a loss of water from drains and streams to the groundwater system as seepage. Estimated surface outflows were greatest in 2010 at 66 taf and least in 2007 at -3 taf.

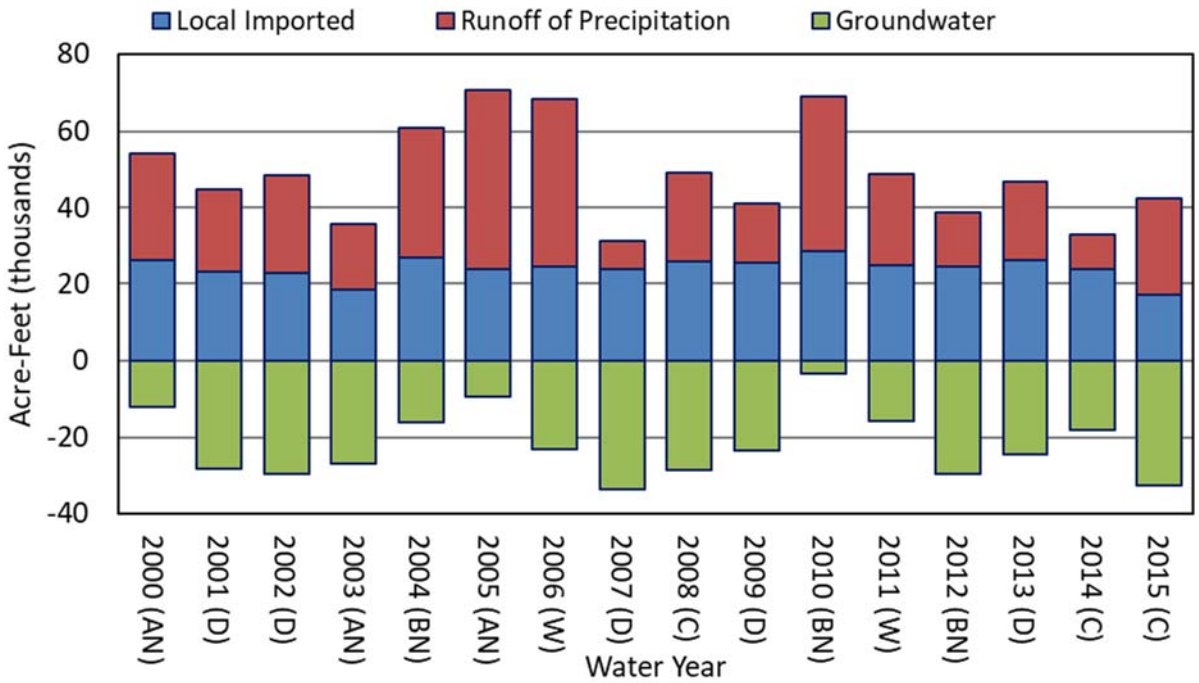

Figure 7.9. West Butte Subbasin Surface Outflows by Water Source Type.

Table 7.9. West Butte Subbasin Surface Outflows by Water Source Type (Acre-Feet).

Water Year	Local Imported	CVP	Runoff of Precipitation	Groundwater	Total
2000 (AN)	26,080	0	28,207	-12,074	42,213
2001 (D)	23,038	0	21,904	-28,586	16,356
2002 (D)	22,711	0	25,881	-29,781	18,811
2003 (AN)	18,224	0	17,423	-27,076	8,571
2004 (BN)	26,699	0	34,218	-16,213	44,705
2005 (AN)	23,749	0	46,845	-9,516	61,078
2006 (W)	24,416	0	43,887	-23,143	45,160
2007 (D)	23,733	0	7,231	-33,751	-2,788
2008 (C)	25,907	0	23,200	-28,726	20,382
2009 (D)	25,425	0	15,705	-23,554	17,575
2010 (BN)	28,418	0	40,509	-3,399	65,528
2011 (W)	24,837	0	24,048	-15,592	33,293
2012 (BN)	24,253	0	14,560	-29,612	9,200
2013 (D)	26,186	0	20,768	-24,389	22,565
2014 (C)	23,773	0	8,984	-18,086	14,672
2015 (C)	17,189	0	25,302	-32,702	9,788
Average	24,040	0	24,917	-22,262	26,694
W	24,626	0	33,967	-19,367	39,226
AN	22,684	0	30,825	-16,222	37,287
BN	26,457	0	29,763	-16,408	39,811
D	24,218	0	18,297	-28,012	14,504
C	22,290	0	19,162	-26,505	14,947

7.2.2.3 Subsurface Groundwater Outflow

Subsurface groundwater outflow was estimated based on DWR's C2VSim fine grid application of IWFM, version R374 Beta. The fine grid beta version is equivalent to the coarse grid R374 public release version of the application, but includes a more detailed element grid to allow for improved definition of zones to extract groundwater budget results along county and subbasin boundaries. C2VSim results for water years 2000 to 2009 were available as model outputs; estimates for 2010 to 2015 were interpolated based on changes in annual subsurface outflows over time.

Subsurface outflow estimates for the Glenn County portion of the West Butte Subbasin are provided in Figure 7.10 and Table 7.10. C2VSim suggests that subsurface outflow has decreased slightly over time, from approximately 15 taf in 2000 to around 14 taf in recent years.

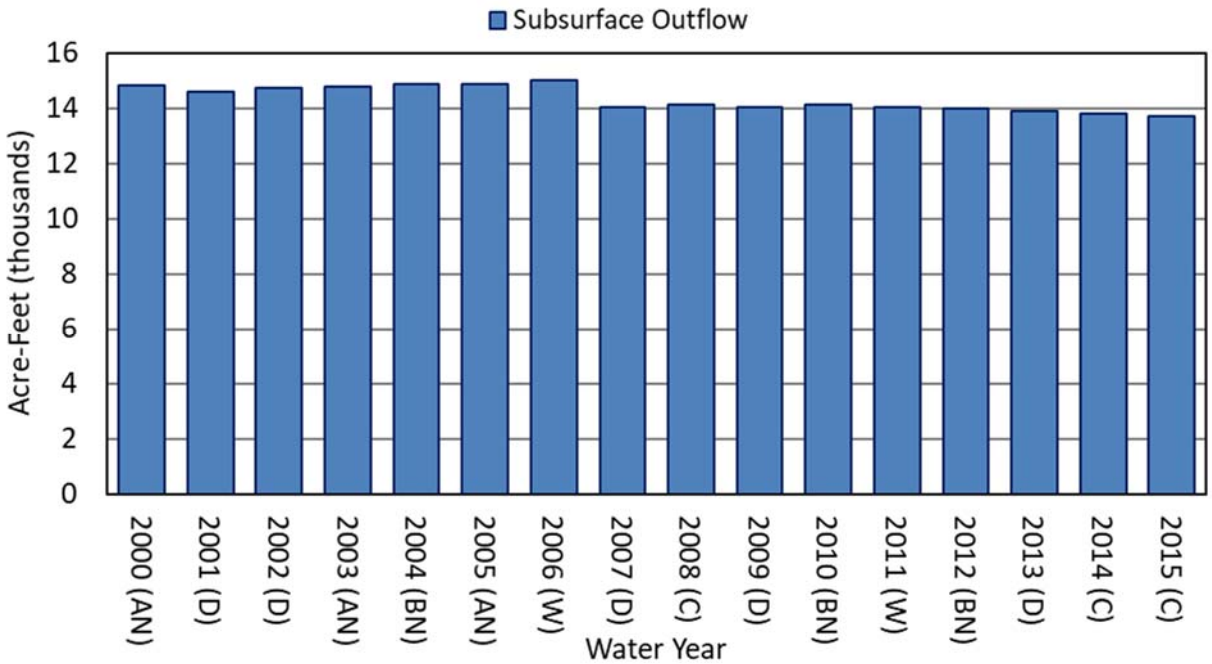

Figure 7.10. West Butte Subbasin Subsurface Outflows.

Table 7.10. West Butte Subbasin Subsurface Outflows (Acre-Feet).

Water Year	Subsurface Outflow
2000 (AN)	14,814
2001 (D)	14,604
2002 (D)	14,733
2003 (AN)	14,770
2004 (BN)	14,863
2005 (AN)	14,849
2006 (W)	14,993
2007 (D)	14,023
2008 (C)	14,114
2009 (D)	14,007
2010 (BN)	14,123
2011 (W)	14,041
2012 (BN)	13,958
2013 (D)	13,876
2014 (C)	13,794
2015 (C)	13,711
Average	14,329
W	14,517
AN	14,811
BN	14,315
D	14,248
C	13,873

7.2.3 Change in Storage

Estimates of total change in storage within the basin are provided in Figure 7.11 and Table 7.11. Total change in storage includes both the surface water system and the groundwater system. Change in storage for the surface water system and groundwater system are reported individually in Sections 7.3.3 and 7.4.3, respectively. The estimates suggest small changes in most years with notable increases in storage in 2006 and 2011 and a notable decrease in storage in 2014.

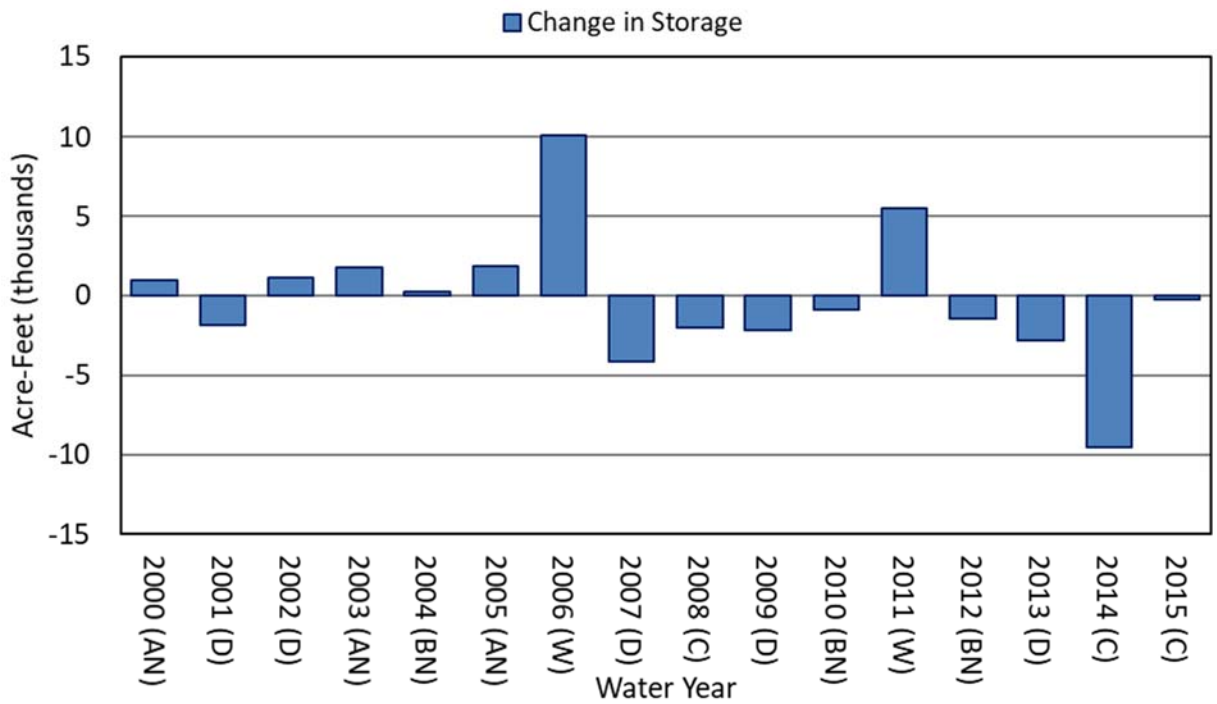

Figure 7.11. West Butte Subbasin Change in Storage.

Table 7.11. West Butte Subbasin Change in Storage (Acre-Feet).

Water Year	Change in Storage
2000 (AN)	927
2001 (D)	-1,846
2002 (D)	1,103
2003 (AN)	1,707
2004 (BN)	216
2005 (AN)	1,803
2006 (W)	10,067
2007 (D)	-4,129
2008 (C)	-2,044
2009 (D)	-2,182
2010 (BN)	-904
2011 (W)	5,530
2012 (BN)	-1,513
2013 (D)	-2,857
2014 (C)	-9,532
2015 (C)	-239
Average	-243
W	7,798
AN	1,479
BN	-733
D	-1,982
C	-3,938

7.2.4 Historical Water Budget Summary

Annual inflows, outflows, and change in storage for the basin are summarized in Figure 7.12 and Table 7.12. Inflows are shown as positive values, while outflows and change in storage are shown as negative values. As a result, a positive value for change in storage actually reflects a decrease in storage. Review of the variability in component volumes across years provides insight into the impacts of hydrology on the overall basin water budget.

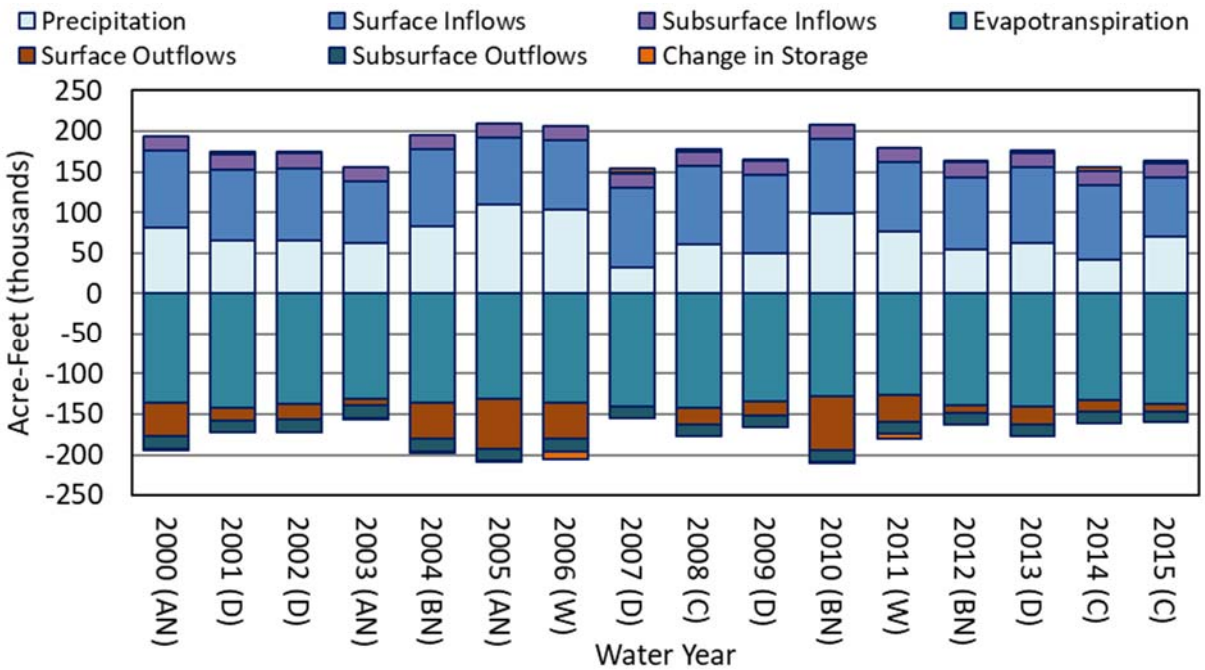

Figure 7.12. West Butte Subbasin Boundary Budget, 2000 – 2015.

Table 7.12. West Butte Subbasin Boundary Budget, 2000 – 2015 (Acre-Feet).

Water Year	Precipi-tation	Surface Inflows	Subsurface Inflows	Evapotrans-piration	Surface Outflows	Subsurface Outflows	Change in Storage
2000 (AN)	81,190	94,365	17,627	-135,229	-42,213	-14,814	-927
2001 (D)	65,297	87,814	17,866	-141,864	-16,356	-14,604	1,846
2002 (D)	66,027	88,593	18,044	-138,018	-18,811	-14,733	-1,103
2003 (AN)	61,967	75,746	18,445	-131,110	-8,571	-14,770	-1,707
2004 (BN)	82,527	95,620	17,619	-135,982	-44,705	-14,863	-216
2005 (AN)	109,853	82,421	16,807	-131,351	-61,078	-14,849	-1,803
2006 (W)	102,800	85,544	17,410	-135,535	-45,160	-14,993	-10,067
2007 (D)	31,962	97,649	17,639	-140,145	2,788	-14,023	4,129
2008 (C)	60,160	96,772	17,812	-142,292	-20,382	-14,114	2,044
2009 (D)	50,121	95,329	17,896	-133,946	-17,575	-14,007	2,182
2010 (BN)	98,696	91,029	17,587	-128,564	-65,528	-14,123	904
2011 (W)	77,141	85,163	17,563	-127,004	-33,293	-14,041	-5,530
2012 (BN)	53,907	89,754	17,540	-139,555	-9,200	-13,958	1,513
2013 (D)	61,847	94,031	17,516	-139,811	-22,565	-13,876	2,857
2014 (C)	40,926	92,573	17,493	-132,058	-14,672	-13,794	9,532
2015 (C)	70,304	72,115	17,469	-136,627	-9,788	-13,711	239
Average	69,670	89,032	17,646	-135,568	-26,694	-14,329	243
W	89,971	85,354	17,487	-131,270	-39,226	-14,517	-7,798
AN	84,337	84,177	17,626	-132,563	-37,287	-14,811	-1,479
BN	78,377	92,134	17,582	-134,701	-39,811	-14,315	733
D	55,051	92,683	17,792	-138,757	-14,504	-14,248	1,982
C	57,130	87,153	17,591	-136,992	-14,947	-13,873	3,938

7.3 SURFACE WATER SYSTEM BUDGET

This section presents the surface water system water budget for the West Butte Subbasin in Glenn County.

7.3.1 Inflows

7.3.1.1 Surface Water Inflow by Water Source Type

Surface water inflows by water source type are described in Section 7.2.1.1.

7.3.1.2 Precipitation

Precipitation inflow is described in Section 7.2.1.2.

7.3.1.3 Groundwater Extraction by Water Use Sector

Estimates of groundwater extraction by water use sector are provided in Figure 7.13 and Table 7.13. For agricultural and urban lands, groundwater extraction represents pumping, while for native lands, groundwater extraction represents estimated groundwater extraction by riparian vegetation. Groundwater extraction is dominated by irrigated agriculture, varying substantially from year to year based on variability in surface water supplies and crop water demands. Groundwater extraction is not known to occur for managed wetlands and assumed negligible for this study.

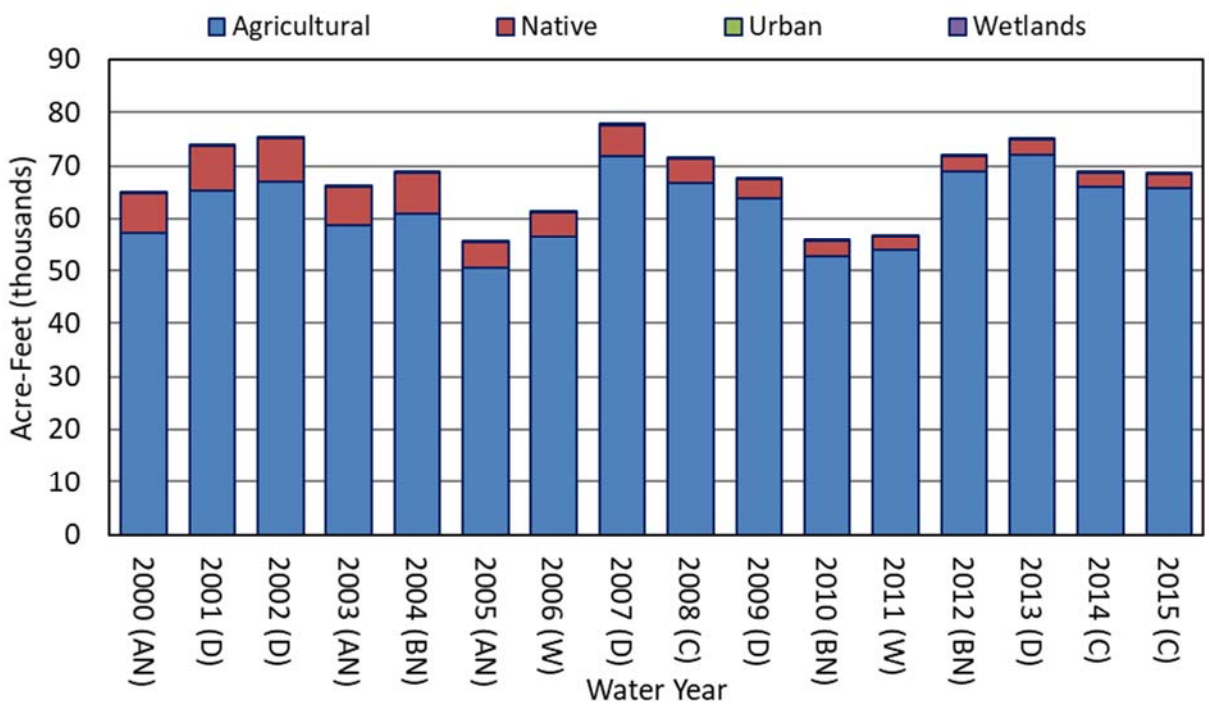

Figure 7.13. West Butte Subbasin Groundwater Extraction by Water Use Sector.

Table 7.13. West Butte Subbasin Groundwater Extraction by Water Use Sector (Acre-Feet).

Water Year	Agricultural	Native	Urban	Wetlands	Total
2000 (AN)	57,245	7,606	166	0	65,017
2001 (D)	65,398	8,319	202	0	73,919
2002 (D)	66,941	8,282	241	0	75,464
2003 (AN)	58,812	7,156	163	0	66,131
2004 (BN)	61,037	7,662	203	0	68,902
2005 (AN)	50,545	4,932	112	0	55,589
2006 (W)	56,505	4,775	118	0	61,398
2007 (D)	71,822	5,802	143	0	77,767
2008 (C)	66,686	4,777	113	0	71,576
2009 (D)	63,910	3,667	79	0	67,656
2010 (BN)	52,787	2,870	58	0	55,715
2011 (W)	53,830	2,702	71	0	56,603
2012 (BN)	68,817	2,990	116	0	71,923
2013 (D)	72,031	2,934	160	0	75,125
2014 (C)	65,992	2,691	153	0	68,836
2015 (C)	65,691	2,673	178	0	68,542
Average	62,378	4,990	142	0	67,510
W	55,167	3,739	95	0	59,000
AN	55,534	6,565	147	0	62,246
BN	60,880	4,507	126	0	65,513
D	68,020	5,801	165	0	73,986
C	66,123	3,380	148	0	69,651

7.3.1.4 Groundwater Discharge to Surface Water Sources

Estimated groundwater discharge to surface water sources is provided in Figure 7.14 and Table 7.14. Negative values represent net losses (seepage) of surface water to the groundwater system. Discharge from the groundwater system is independent of estimated infiltration of surface water to the groundwater system presented in Section 7.3.2.4. In all years but 2010, groundwater discharge is estimated to be negative, denoting net losses from drains and streams to the groundwater system. Estimated groundwater discharge was greatest in 2010 at around 2 taf and least in 2007 at around -27 taf.

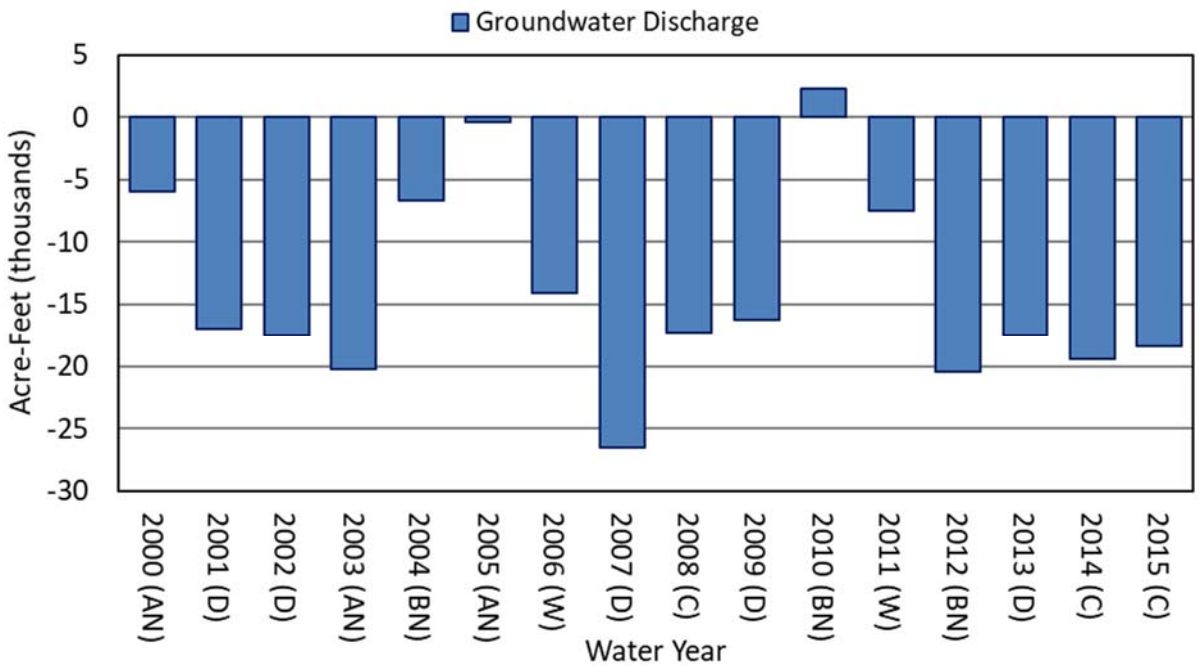

Figure 7.14. West Butte Subbasin Groundwater Discharge to Surface Water Sources.

Table 7.14. West Butte Subbasin Groundwater Discharge to Surface Water Sources (Acre-Feet).

Water Year	Groundwater Discharge
2000 (AN)	-5,915
2001 (D)	-16,938
2002 (D)	-17,457
2003 (AN)	-20,250
2004 (BN)	-6,680
2005 (AN)	-407
2006 (W)	-14,085
2007 (D)	-26,576
2008 (C)	-17,224
2009 (D)	-16,284
2010 (BN)	2,227
2011 (W)	-7,545
2012 (BN)	-20,423
2013 (D)	-17,511
2014 (C)	-19,472
2015 (C)	-18,369
Average	-13,932
W	-10,815
AN	-8,857
BN	-8,292
D	-18,953
C	-18,355

7.3.2 Outflows

7.3.2.1 Evapotranspiration by Water Use Sector

Evapotranspiration by water use sector is described in Section 7.2.2.1.

7.3.2.2 Surface Water Outflow by Water Source Type

Surface water outflows by water source type are described in Section 7.2.2.2.

7.3.2.3 Infiltration of Precipitation

Estimated infiltration of precipitation by water use sector is provided in Figure 7.15 and Table 7.15. Infiltration of precipitation to the groundwater system is highly variable from year to year due to variation in the timing and amount of precipitation, ranging from around 2 taf annually in 2007 and 2014 to approximately 12 taf between 2004 and 2006.

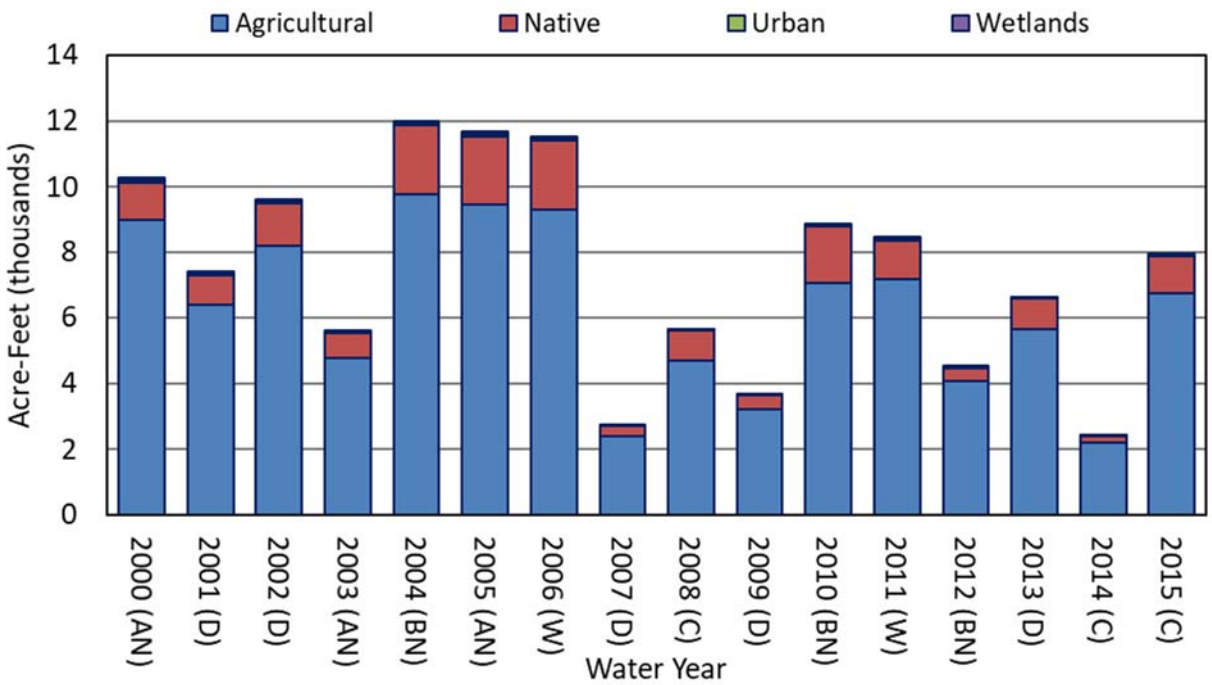

Figure 7.15. West Butte Subbasin Infiltration of Precipitation by Water Use Sector.

Table 7.15. West Butte Subbasin Infiltration of Precipitation by Water Use Sector (Acre-Feet).

Water Year	Agricultural	Native	Urban	Wetlands	Total
2000 (AN)	8,990	1,154	56	68	10,268
2001 (D)	6,389	896	34	75	7,394
2002 (D)	8,170	1,342	49	55	9,616
2003 (AN)	4,795	731	23	52	5,601
2004 (BN)	9,793	2,079	65	78	12,015
2005 (AN)	9,466	2,083	51	80	11,680
2006 (W)	9,325	2,097	51	73	11,546
2007 (D)	2,388	325	0	58	2,771
2008 (C)	4,695	891	10	50	5,646
2009 (D)	3,226	426	4	44	3,700
2010 (BN)	7,063	1,721	18	59	8,861
2011 (W)	7,145	1,195	19	79	8,438
2012 (BN)	4,063	412	8	51	4,534
2013 (D)	5,625	951	16	41	6,633
2014 (C)	2,201	202	7	45	2,455
2015 (C)	6,727	1,140	24	62	7,953
Average	6,254	1,103	27	61	7,444
W	8,235	1,646	35	76	9,992
AN	7,750	1,323	43	67	9,183
BN	6,973	1,404	30	63	8,470
D	5,160	788	21	55	6,023
C	4,541	744	14	52	5,351

7.3.2.4 Infiltration of Surface Water

Estimated infiltration of surface water by source is provided in Figure 7.16 and Table 7.16. Infiltration of surface water is believed to be dominated by canal and drain seepage, which is relatively steady over time. Seepage from streams is assumed negligible for the preliminary water budget, as all streams in the area have been classified as drains due to primarily serving an agricultural drainage function.

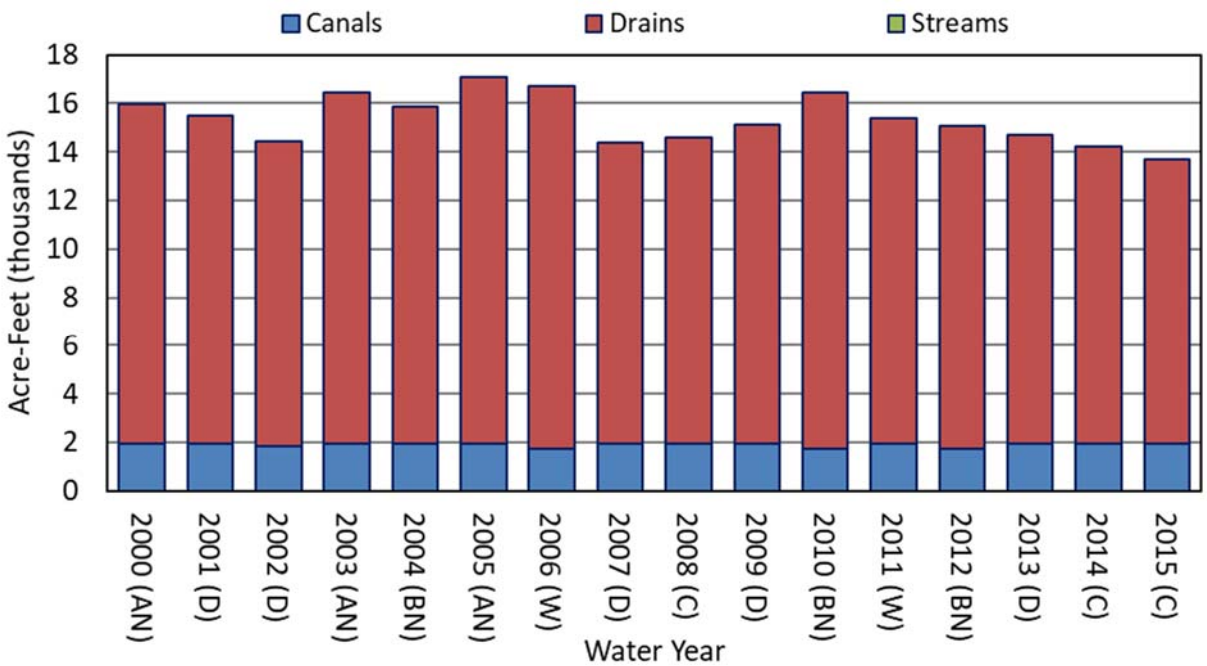

Figure 7.16. West Butte Subbasin Infiltration of Surface Water.

Table 7.16. West Butte Subbasin Infiltration of Surface Water (Acre-Feet).

Water Year	Canals	Drains	Streams	Total
2000 (AN)	1,931	14,030	0	15,961
2001 (D)	1,931	13,566	0	15,497
2002 (D)	1,819	12,605	0	14,425
2003 (AN)	1,931	14,519	0	16,450
2004 (BN)	1,931	13,918	0	15,849
2005 (AN)	1,931	15,168	0	17,099
2006 (W)	1,738	14,950	0	16,688
2007 (D)	1,931	12,466	0	14,397
2008 (C)	1,931	12,679	0	14,610
2009 (D)	1,931	13,178	0	15,109
2010 (BN)	1,738	14,719	0	16,457
2011 (W)	1,931	13,428	0	15,359
2012 (BN)	1,738	13,316	0	15,054
2013 (D)	1,931	12,763	0	14,694
2014 (C)	1,932	12,290	0	14,222
2015 (C)	1,931	11,757	0	13,688
Average	1,888	13,459	0	15,347
W	1,834	14,189	0	16,023
AN	1,931	14,572	0	16,503
BN	1,802	13,984	0	15,787
D	1,909	12,916	0	14,824
C	1,931	12,242	0	14,173

7.3.2.5 Infiltration of Applied Water

Estimated infiltration of applied water by water use sector is provided in Figure 7.17 and Table 7.17. Infiltration (percolation) of applied water is dominated by agricultural irrigation.

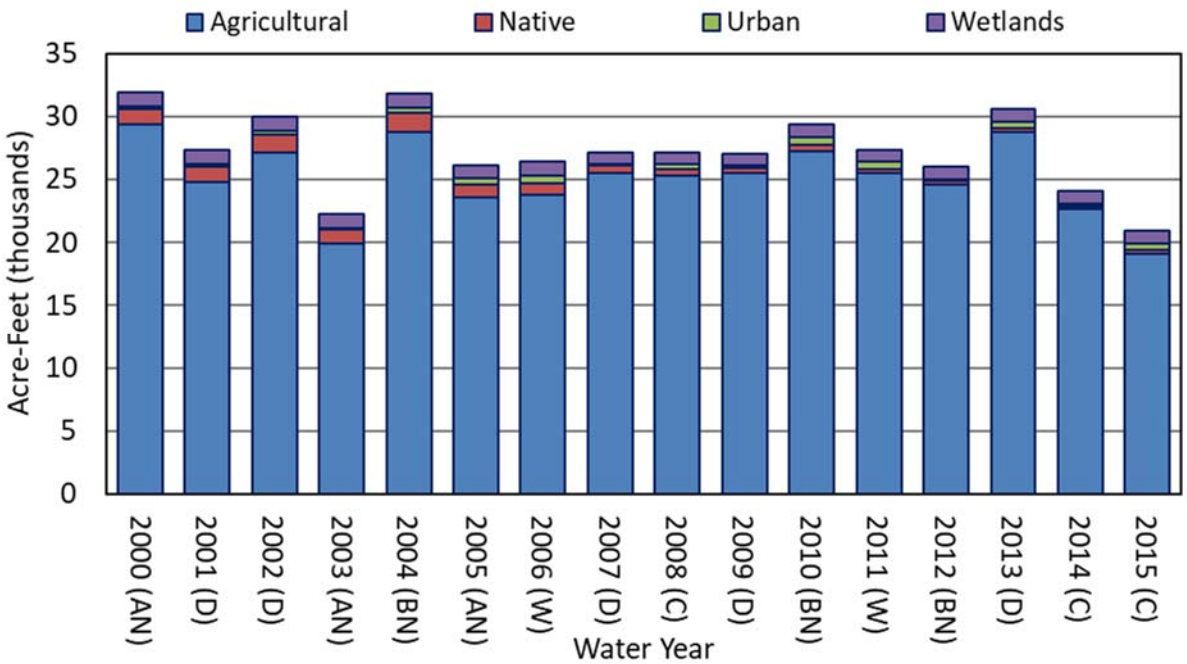

Figure 7.17. West Butte Subbasin Infiltration of Applied Water by Water Use Sector.

Table 7.17. West Butte Subbasin Infiltration of Applied Water by Water Use Sector (Acre-Feet).

Water Year	Agricultural	Native	Urban	Wetlands	Total
2000 (AN)	29,329	1,257	249	1,111	31,946
2001 (D)	24,806	1,246	156	1,105	27,313
2002 (D)	27,093	1,504	247	1,142	29,986
2003 (AN)	19,940	1,091	131	1,123	22,285
2004 (BN)	28,741	1,521	410	1,116	31,788
2005 (AN)	23,532	1,050	496	1,045	26,123
2006 (W)	23,823	875	637	1,050	26,385
2007 (D)	25,550	579	36	1,005	27,170
2008 (C)	25,250	544	369	999	27,162
2009 (D)	25,525	404	194	942	27,065
2010 (BN)	27,238	460	676	953	29,327
2011 (W)	25,496	330	582	966	27,374
2012 (BN)	24,593	266	174	983	26,016
2013 (D)	28,733	324	473	1,016	30,546
2014 (C)	22,676	211	169	1,021	24,077
2015 (C)	19,102	301	502	1,009	20,914
Average	25,089	748	344	1,037	27,217
W	24,659	603	610	1,008	26,879
AN	24,267	1,133	292	1,093	26,784
BN	26,857	749	420	1,017	29,044
D	26,341	811	221	1,042	28,416
C	22,343	352	347	1,010	24,051

7.3.3 Change in Storage

Estimates of change in storage within the surface water system are provided in Figure 7.18 and Table 7.18. Inter-annual changes in storage within the surface water system consisting primarily of root zone soil moisture storage, are relatively small, and tend to average near zero over time.

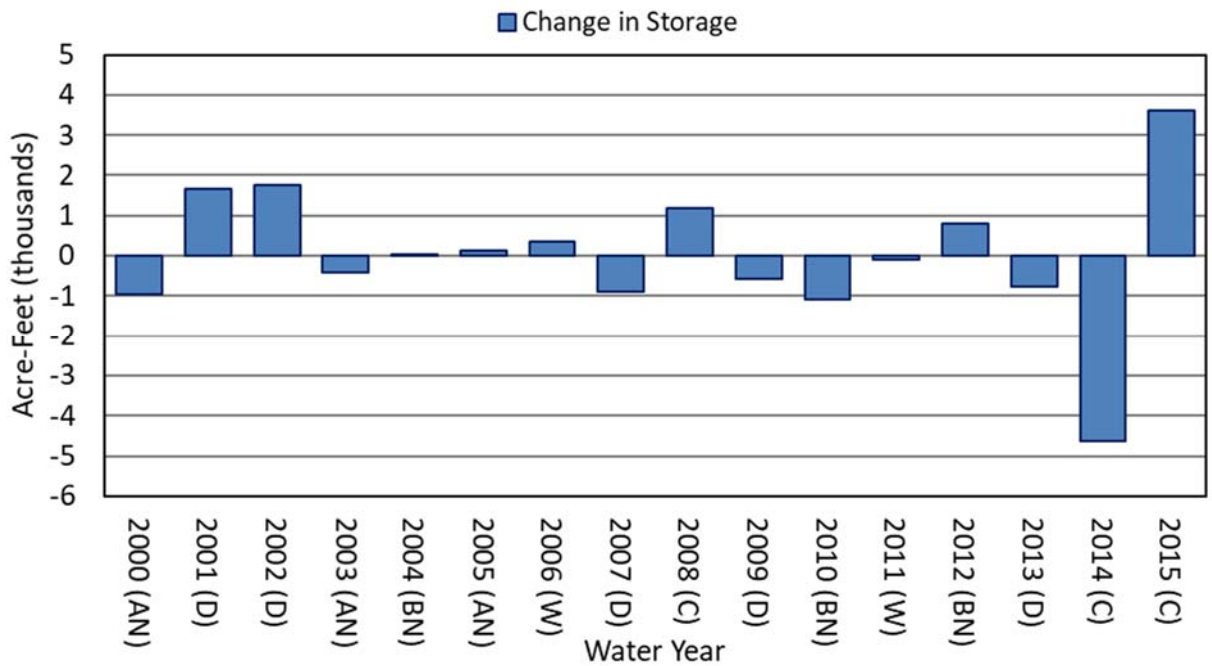

Figure 7.18. West Butte Subbasin Surface Water System Change in Storage.

Table 7.18. West Butte Subbasin Surface Water System Change in Storage (Acre-Feet).

Water Year	Change in Storage
2000 (AN)	-959
2001 (D)	1,669
2002 (D)	1,772
2003 (AN)	-422
2004 (BN)	30
2005 (AN)	125
2006 (W)	344
2007 (D)	-893
2008 (C)	1,192
2009 (D)	-574
2010 (BN)	-1,072
2011 (W)	-105
2012 (BN)	802
2013 (D)	-756
2014 (C)	-4,620
2015 (C)	3,621
Average	10
W	120
AN	-419
BN	-80
D	244
C	64

7.3.4 Historical Water Budget Summary

Annual inflows, outflows, and change in storage for the surface water system are summarized in Figure 7.19 and Table 7.19. Inflows are shown as positive values, while outflows and change in storage are shown as negative values. As a result, a positive value for change in storage actually reflects a decrease in storage. Review of the variability in component volumes across years provides insight into the impacts of hydrology on the surface water system water budget.

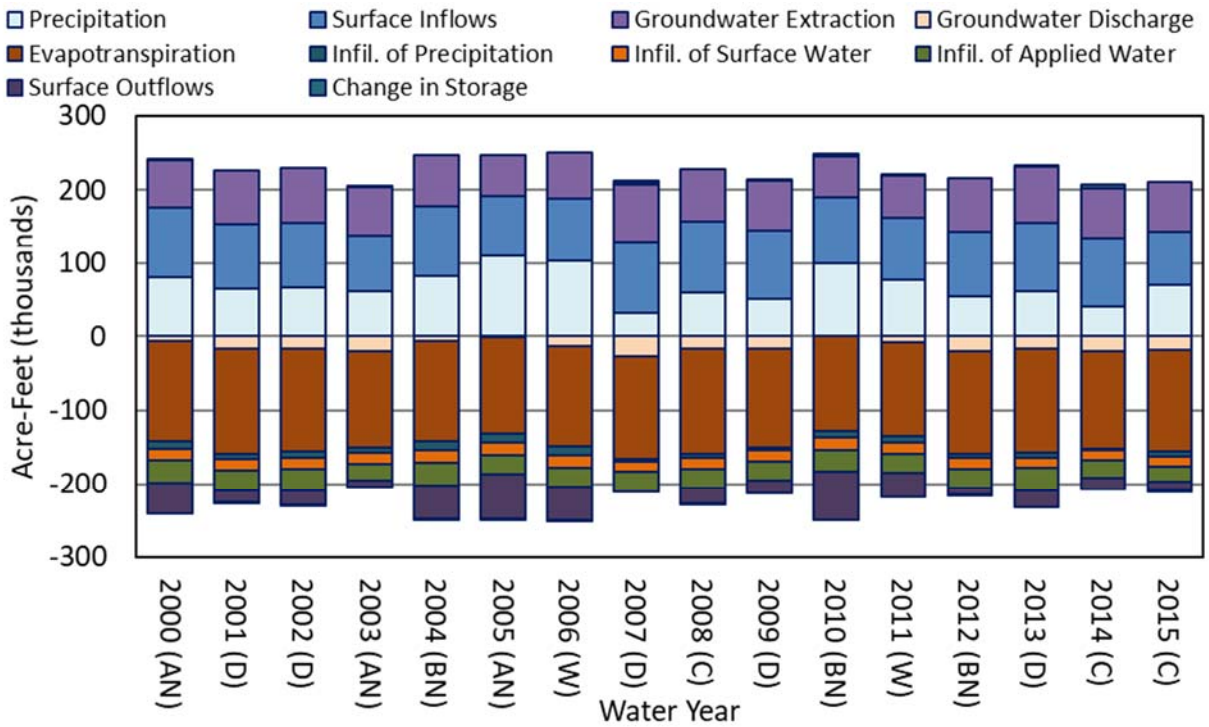

Figure 7.19. West Butte Subbasin Surface Water System Budget, 2000 – 2015.

Table 7.19. West Butte Subbasin Surface Water System Budget, 2000 – 2015 (Acre-Feet).

Water Year	Precipi-tation	Surface Inflows	Ground-water Extrac-tion	Ground-water Dis-charge	Evapo-trans-piration	Infil. of Precipitation	Infil. of Surface Water	Infil. of Applied Water	Surface Outflows	Change in Storage
2000 (AN)	81,190	94,365	65,017	-5,915	-135,229	-10,268	-15,961	-31,946	-42,213	959
2001 (D)	65,297	87,814	73,919	-16,938	-141,864	-7,394	-15,497	-27,313	-16,356	-1,669
2002 (D)	66,027	88,593	75,464	-17,457	-138,018	-9,616	-14,425	-29,986	-18,811	-1,772
2003 (AN)	61,967	75,746	66,131	-20,250	-131,110	-5,601	-16,450	-22,285	-8,571	422
2004 (BN)	82,527	95,620	68,902	-6,680	-135,982	-12,015	-15,849	-31,788	-44,705	-30
2005 (AN)	109,853	82,421	55,589	-407	-131,351	-11,680	-17,099	-26,123	-61,078	-125
2006 (W)	102,800	85,544	61,398	-14,085	-135,535	-11,546	-16,688	-26,385	-45,160	-344
2007 (D)	31,962	97,649	77,767	-26,576	-140,145	-2,771	-14,397	-27,170	2,788	893
2008 (C)	60,160	96,772	71,576	-17,224	-142,292	-5,646	-14,610	-27,162	-20,382	-1,192
2009 (D)	50,121	95,329	67,656	-16,284	-133,946	-3,700	-15,109	-27,065	-17,575	574
2010 (BN)	98,696	91,029	55,715	2,227	-128,564	-8,861	-16,457	-29,327	-65,528	1,072
2011 (W)	77,141	85,163	56,603	-7,545	-127,004	-8,438	-15,359	-27,374	-33,293	105
2012 (BN)	53,907	89,754	71,923	-20,423	-139,555	-4,534	-15,054	-26,016	-9,200	-802
2013 (D)	61,847	94,031	75,125	-17,511	-139,811	-6,633	-14,694	-30,546	-22,565	756
2014 (C)	40,926	92,573	68,836	-19,472	-132,058	-2,455	-14,222	-24,077	-14,672	4,620
2015 (C)	70,304	72,115	68,542	-18,369	-136,627	-7,953	-13,688	-20,914	-9,788	-3,621
Average	69,670	89,032	67,510	-13,932	-135,568	-7,444	-15,347	-27,217	-26,694	-10
W	89,971	85,354	59,000	-10,815	-131,270	-9,992	-16,023	-26,879	-39,226	-120
AN	84,337	84,177	62,246	-8,857	-132,563	-9,183	-16,503	-26,784	-37,287	419
BN	78,377	92,134	65,513	-8,292	-134,701	-8,470	-15,787	-29,044	-39,811	80
D	55,051	92,683	73,986	-18,953	-138,757	-6,023	-14,824	-28,416	-14,504	-244
C	57,130	87,153	69,651	-18,355	-136,992	-5,351	-14,173	-24,051	-14,947	-64

7.4 GROUNDWATER SYSTEM BUDGET

This section presents the groundwater system water budget for the West Butte Subbasin in Glenn County.

7.4.1 Inflows

7.4.1.1 Subsurface Groundwater Inflow

Subsurface groundwater inflow is described in Section 7.2.1.3.

7.4.1.2 Infiltration of Precipitation

Infiltration of precipitation is described in Section 7.3.2.3.

7.4.1.3 Infiltration of Surface Water

Infiltration of surface water is described in Section 7.3.2.4.

7.4.1.4 Infiltration of Applied Water

Infiltration of applied water is described in Section 7.3.2.5.

7.4.2 Outflows

7.4.2.1 Subsurface Groundwater Outflow

Subsurface groundwater outflow is described in Section 7.2.2.3.

7.4.2.2 Groundwater Extraction by Water Use Sector

Groundwater extraction by water use sector is described in Section 7.3.1.3.

7.4.2.3 Groundwater Discharge to Surface Water Sources

Groundwater discharge to surface water sources is described in Section 7.3.1.4.

7.4.3 Change in Storage

Estimates of change in storage within the groundwater system are provided in Figure 7.20 and Table 7.20. The estimates suggest a net decrease in storage in 9 of 16 years between 2000 and 2015 with increases in 7 of 16 years. Total change in storage appears to be relatively strongly correlated to water year type.

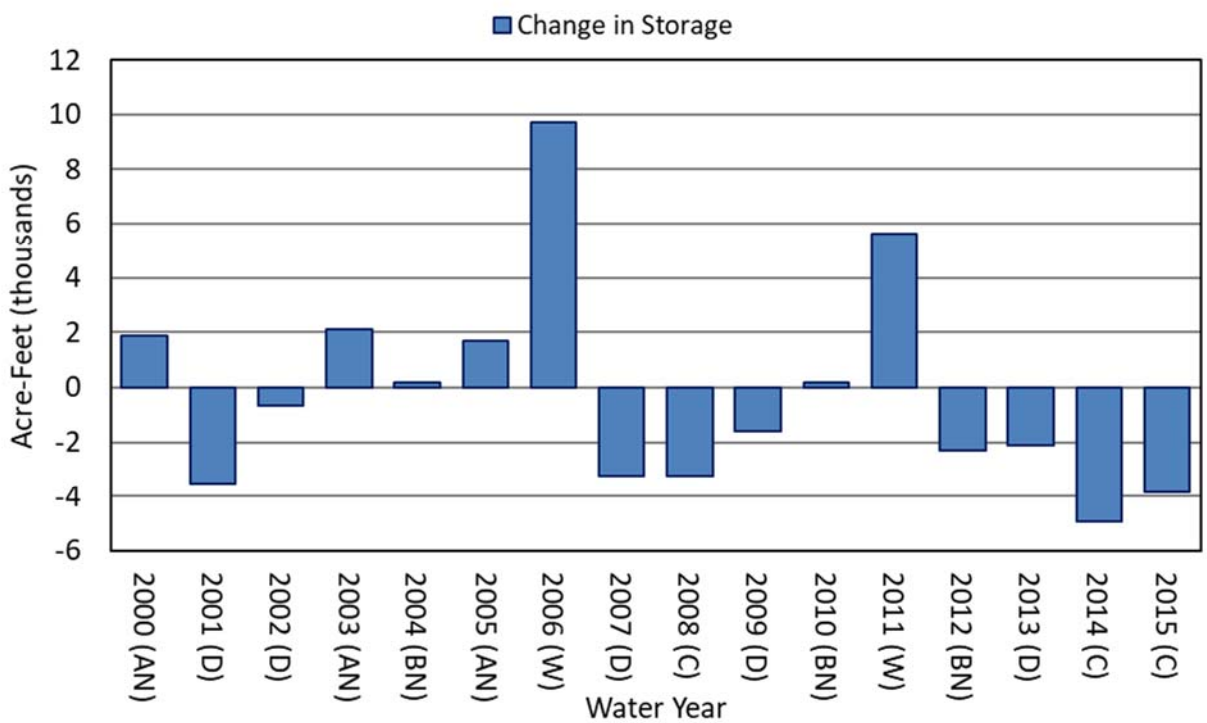

Figure 7.20. West Butte Subbasin Groundwater System Change in Storage.

Table 7.20. West Butte Subbasin Groundwater System Change in Storage (Acre-Feet).

Water Year	Change in Storage
2000 (AN)	1,886
2001 (D)	-3,515
2002 (D)	-669
2003 (AN)	2,129
2004 (BN)	186
2005 (AN)	1,678
2006 (W)	9,723
2007 (D)	-3,236
2008 (C)	-3,236
2009 (D)	-1,608
2010 (BN)	168
2011 (W)	5,635
2012 (BN)	-2,315
2013 (D)	-2,101
2014 (C)	-4,912
2015 (C)	-3,860
Average	-253
W	7,679
AN	1,897
BN	-653
D	-2,226
C	-4,003

7.4.4 Historical Water Budget Summary

Annual inflows, outflows, and change in storage for the groundwater system are summarized in Figure 7.21 and Table 7.21. Inflows are shown as positive values, while outflows and change in storage are shown as negative values. As a result, a positive value for change in storage actually reflects a decrease in storage. Review of the variability in component volumes across years provides insight into the impacts of hydrology on the groundwater system water budget.

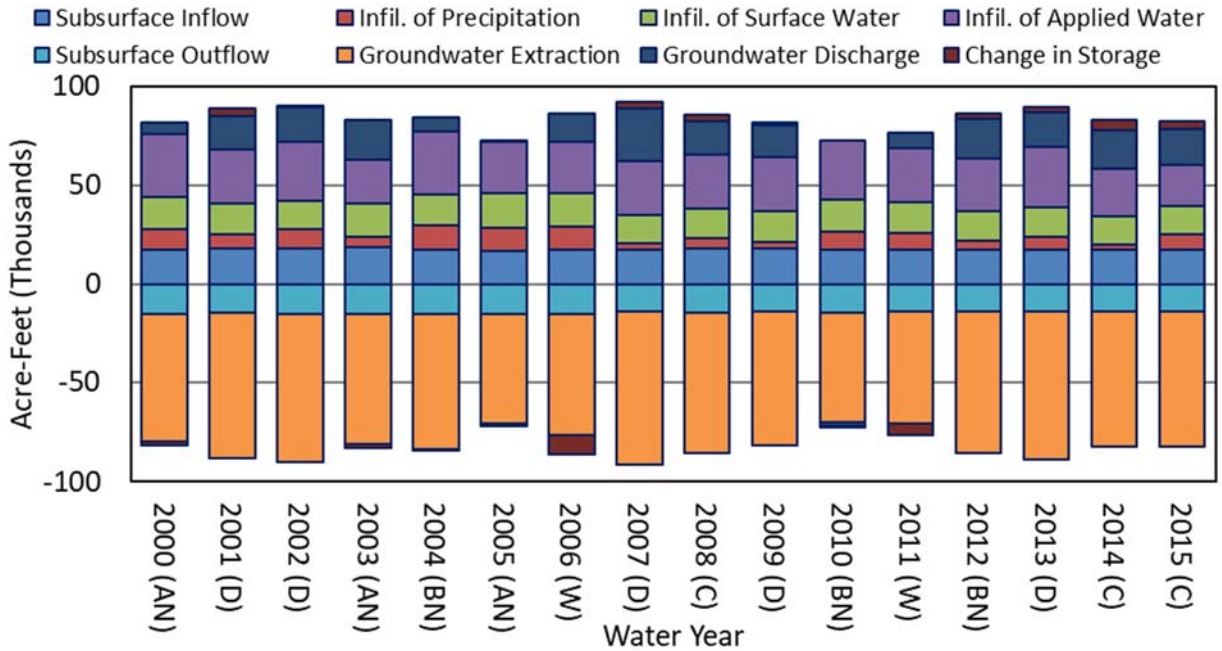

Figure 7.21. West Butte Subbasin Groundwater System Budget, 2000 – 2015.

Table 7.21. West Butte Subbasin Groundwater System Budget, 2000 – 2015 (Acre-Feet).

Water Year	Subsur-face Inflow	Infil. of Precip-itation	Infil. of Surface Water	Infil. of Applied Water	Subsur-face Outflow	Ground-water Extraction	Ground-water Discharge	Change in Storage
2000 (AN)	17,627	10,268	15,961	31,946	-14,814	-65,017	5,915	-1,886
2001 (D)	17,866	7,394	15,497	27,313	-14,604	-73,919	16,938	3,515
2002 (D)	18,044	9,616	14,425	29,986	-14,733	-75,464	17,457	669
2003 (AN)	18,445	5,601	16,450	22,285	-14,770	-66,131	20,250	-2,129
2004 (BN)	17,619	12,015	15,849	31,788	-14,863	-68,902	6,680	-186
2005 (AN)	16,807	11,680	17,099	26,123	-14,849	-55,589	407	-1,678
2006 (W)	17,410	11,546	16,688	26,385	-14,993	-61,398	14,085	-9,723
2007 (D)	17,639	2,771	14,397	27,170	-14,023	-77,767	26,576	3,236
2008 (C)	17,812	5,646	14,610	27,162	-14,114	-71,576	17,224	3,236
2009 (D)	17,896	3,700	15,109	27,065	-14,007	-67,656	16,284	1,608
2010 (BN)	17,587	8,861	16,457	29,327	-14,123	-55,715	-2,227	-168
2011 (W)	17,563	8,438	15,359	27,374	-14,041	-56,603	7,545	-5,635
2012 (BN)	17,540	4,534	15,054	26,016	-13,958	-71,923	20,423	2,315
2013 (D)	17,516	6,633	14,694	30,546	-13,876	-75,125	17,511	2,101
2014 (C)	17,493	2,455	14,222	24,077	-13,794	-68,836	19,472	4,912
2015 (C)	17,469	7,953	13,688	20,914	-13,711	-68,542	18,369	3,860
Average	17,646	7,444	15,347	27,217	-14,329	-67,510	13,932	253
W	17,487	9,992	16,023	26,879	-14,517	-59,000	10,815	-7,679
AN	17,626	9,183	16,503	26,784	-14,811	-62,246	8,857	-1,897
BN	17,582	8,470	15,787	29,044	-14,315	-65,513	8,292	653
D	17,792	6,023	14,824	28,416	-14,248	-73,986	18,953	2,226
C	17,591	5,351	14,173	24,051	-13,873	-69,651	18,355	4,003

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This section provides a preliminary estimate of the Sustainable Yield for the portion of each subbasin subject to SGMA in Glenn County. Preliminary estimates recognize that ultimately, sustainable yield will be defined based on the local definition of sustainability developed through a collaborative public outreach process and informed by the best available science and data.

Under SGMA, sustainable yield is defined as follows:

> *"Sustainable yield" means the maximum quantity of water, calculated over a base period representative of long-term conditions in the basin and including any temporary surplus, that can be withdrawn annually from a groundwater supply without causing an undesirable result.*

Further, undesirable results are defined as follows:

> *"Undesirable result" means one or more of the following effects caused by groundwater conditions occurring throughout the basin:*
>
> > *(1) Chronic lowering of groundwater levels indicating a significant and unreasonable depletion of supply if continued over the planning and implementation horizon. Overdraft during a period of drought is not sufficient to establish a chronic lowering of groundwater levels if extractions and groundwater recharge are managed as necessary to ensure that reductions in groundwater levels or storage during a period of drought are offset by increases in groundwater levels or storage during other periods.*
> >
> > *(2) Significant and unreasonable reduction of groundwater storage.*
> >
> > *(3) Significant and unreasonable seawater intrusion.*
> >
> > *(4) Significant and unreasonable degraded water quality, including the migration of contaminant plumes that impair water supplies.*
> >
> > *(5) Significant and unreasonable land subsidence that substantially interferes with surface land uses.*
> >
> > *(6) Depletions of interconnected surface water that have significant and unreasonable adverse impacts on beneficial uses of the surface water.*

Undesirable results and associated sustainability indicators, minimum thresholds, and measurable objectives will be defined locally within each subbasin subject to SGMA wholly or partially within Glenn County as part of GSP development. As a result, it is not possible to definitively determine sustainable yield at this time; however, for purposes of this study, a preliminary estimate of sustainable yield has been developed based on the 2000 to 2015 water budget results and the concept of *safe yield*. Safe yield can be defined as the amount of annual groundwater extraction that can occur without causing long term declines in groundwater levels or storage, inelastic subsidence, or other adverse effects based on current conditions (land use, surface water supplies, etc.). In contrast, sustainable yield considers each of the undesirable results and relies on specific

minimum thresholds to be defined through the future GSP development process. In addition to current conditions, sustainable yield considers potential future conditions related to land use, population, climate change, surface water supply reliability, and potentially other factors.

To estimate safe yield, the average sum of groundwater extraction and change in basin storage (with a positive change reflecting an increase in storage) was calculated by Sacramento River hydrologic year type for the 2000 to 2015 water budget period. Then, a weighted-average safe yield was calculated based on the probability of each year type occurring using the 111-year period of Sacramento River water year types based on the Sacramento WYI from 1906 to 2016. Results of this analysis are presented in Tables 8.1, 8.2, and 8.3 for the Colusa, Corning, and West Butte subbasins, respectively.

Table 8.1. Colusa Subbasin Estimated Safe Yield.

Water Year Type	Probability	Groundwater Extraction + Change in Storage
Wet	0.32	233,263
Above Normal	0.14	164,392
Below Normal	0.19	177,611
Dry	0.21	205,890
Critical	0.14	244,706
	Estimated Safe Yield	**209,405**

As indicated in Table 8.1, the estimated safe yield for the Colusa Subbasin in Glenn County is approximately 210,000 acre-feet, which is approximately 20,000 acre-feet less than average estimated extraction between 2000 and 2015. This provides a preliminary estimate of the sustainable yield of the portion of the Colusa Subbasin in Glenn County, but will require additional refinement as part of GSP development, as described previously.

Table 8.2. Corning Subbasin Estimated Safe Yield.

Water Year Type	Probability	Groundwater Extraction + Change in Storage
Wet	0.32	55,708
Above Normal	0.14	48,490
Below Normal	0.19	48,983
Dry	0.21	53,728
Critical	0.14	48,681
	Estimated Safe Yield	**52,037**

As indicated in Table 8.2, the estimated safe yield for the Corning Subbasin in Glenn County is approximately 52,000 acre-feet, which is approximately equal to average estimated extraction between 2000 and 2015. This provides a preliminary estimate of the sustainable yield of the portion of the Corning Subbasin in Glenn County, but will require additional refinement as part of GSP development, as described previously.

Table 8.3. West Butte Subbasin Estimated Safe Yield.

Water Year Type	Probability	Groundwater Extraction + Change in Storage
Wet	0.32	66,799
Above Normal	0.14	63,725
Below Normal	0.19	64,780
Dry	0.21	72,004
Critical	0.14	65,713
	Estimated Safe Yield	**66,923**

As indicated in Table 8.3, the estimated safe yield for the West Butte Subbasin in Glenn County is approximately 67,000 acre-feet, which is approximately equal to average estimated extraction between 2000 and 2015. This provides a preliminary estimate of the sustainable yield of the portion of the West Butte Subbasin in Glenn County, but will require additional refinement as part of GSP development, as described previously.

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9.1 DISCUSSION

Results of the preliminary water budgets for each subbasin provide insight into potential overdraft conditions in recent years. Based on estimates of safe yield, which provide a preliminary estimate of sustainable yield, current levels of groundwater extraction in the Corning and West Butte subbasins in Glenn County appear to be balanced by recharge, suggesting that overdraft may not be occurring under existing conditions. In the Colusa Subbasin, however, overdraft on the order of 20,000 acre-feet per year may be occurring. This volume is of substantial uncertainty due to uncertainty in other water budget components. Insight into uncertainties in water budget components helps to identify potential data gaps and assess data reliability to support additional data gathering and development efforts, as needed.

Beyond providing initial estimates of sustainable yield, the preliminary water budgets provide insight into recent historical (i.e. 2000 to 2015) land and water use, water budgets, and inter-annual variability in water budget components (inflows, outflows, and change in storage) related to hydrology and other factors. The preliminary water budgets suggest substantial interaction between the surface water system and groundwater system in each subbasin. Reductions in storage in relatively dry years are offset in part or whole by reduced discharge from the groundwater system. This "feedback" helps to reduce impacts of increased groundwater extraction in these years.

The information compiled to support preliminary water budget development will support refined water budget development as part of GSP preparation. Additionally, the preliminary water budgets and associated information provide a basis for review and refinements of regional models that could be utilized locally to support SGMA compliance, such as the California Central Valley Simulation model (C2VSim), the Sacramento Valley Simulation model (SVSim), and the Central Valley Hydrologic Model (CVHM).

9.2 RECOMMENDATIONS

The following recommendations are provided for consideration:

- Consider individual outreach with water suppliers and other local stakeholders to review data and assumptions used to estimate water budget components at the subarea scale.
- As part of GSP development, expand the preliminary water budgets to the full subbasins partially covered by Glenn County through coordination with neighboring Groundwater Sustainability Agencies. The most efficient approach is likely to be refinement of regional models developed by DWR, USGS, or others.
- In developing projected water budgets to comply with the GSP Regulations, leverage information developed as part of this effort to ensure consistency and efficiency.
- Evaluate opportunities to streamline updates to historical water budgets developed for the GSP to support annual reporting of water budget information following plan adoption.

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