PUBLIC REVIEW

Bowman Subbasin

Sustainable Groundwater Management Act

Groundwater Sustainability Plan (Chapter 2C Water Budget - Draft)

March 2021

Prepared For:

Tehama County Flood Control and Water Conservation District

Prepared By:

Luhdorff & Scalmanini, Consulting Engineers

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

LIST OF ACRONYMS & ABBREVIATIONS

ACID	Anderson-Cottonwood Irrigation District
af	Acre-feet
AN	Above normal Sacramento Valley water year type
AWMP	Agricultural Water Management Plan
BMP	Best Management Practice
BN	Below normal Sacramento Valley water year type
C	Critical (dry) Sacramento Valley water year type
CCR	California Code of Regulations
CVP	Central Valley Project
D	Dry Sacramento Valley water year type
DWR	Department of Water Resources
ET	Evapotranspiration
GMP	Groundwater Management Plan
GSP	Groundwater Sustainability Plan
GWS	Groundwater System
SWS	Surface Water System
taf	Thousand acre-feet
Tehama IHM	Tehama Integrated Hydrologic Model
UWMP	Urban Water Management Plan
W	Wet Sacramento Valley water year type
WMP	Water Management Plan

1 INTRODUCTION

2 SUBBASIN PLAN AREA AND BASIN SETTING (REG. § 354.8)

2.1 Description of Plan Area

2.2 Basin Setting

2.3 Water Budget (Reg. § 354.18)

An integral component of the GSP is the quantification of the water budget, which is an accounting of water movement and storage between the different systems of the hydrologic cycle (**Figure 2-40**). The Subbasin water budget includes an accounting of all inflows and outflows to the Subbasin. The difference between the volume of inflow and outflow to the Subbasin is equal to the change in storage as illustrated in **Equation 2-1**.

$$\text{Inflows} - \text{Outflows} = \text{Change in Storage}$$

Equation 2-1. Water Budget Equation

DWR has published guidance and Best Management Practice (BMP) documents related to the development of GSPs, including Water Budget BMPs (DWR, 2016a). The Water Budget BMPs recommend a water budget accounting structure, or conceptual model, that distinguishes the subbasin surface water system (SWS) and groundwater system (GWS). The SWS represents the land surface down to the bottom of plant root zone[1], within the lateral boundaries of the Subbasin. The GWS extends from the bottom of the root zone to the definable bottom of the Subbasin, within the lateral boundaries of the Subbasin. The complete Subbasin water budget is a product of the interconnected SWS and GWS water budgets. The lateral and vertical boundaries of the Subbasin are described in **Section 2.2** of the GSP.

Consistent with these BMPs, this section presents the methodology and results for the historical, current, and projected water budgets of the Bowman Subbasin. The water budgets were developed through application of the Tehama Integrated Hydrologic Model (Tehama IHM), a numerical groundwater flow model developed for the Subbasin area that characterizes surface water and groundwater movement and storage across the entire Subbasin, including extending into areas extending outside of the Subbasin. The Tehama IHM is an integrated groundwater and surface water model developed for the purpose of conducting sustainability analyses within Tehama County, including for the Bowman Subbasin. The model utilized foundational elements of DWR's SVSim regional model for the Sacramento Valley (DWR, 2021) and was refined locally for improved application in the Subbasin area. Key model refinements made during development of the Tehama IHM include, but are not limited to, extending of the simulation period through water year 2019, refinement of land use conditions based on recent land use mapping information, review and modification to land use crop coefficients based on local remote sensing energy

[1] The root zone is defined as "the upper portion of the soil where water extraction by plant roots occurs." The depth to the bottom of the root zone varies by crop, but typically ranges from 2-7 feet (ASCE, 2016).

balance data, refinement of surface water supplies and diversions, and enhancements to the sediment textural model used for aquifer parameter. After conducting refinements, the Tehama IHM was calibrated using local groundwater level and streamflow data. The Tehama IHM has a historical simulation period spanning from water year 1985 through 2019. Detailed documentation associated with the development of the Tehama IHM is included in **Appendix 2-B.**

This section presents the historical, current, and projected water budget results for the Bowman Subbasin. Water budget results for the SWS and GWS are presented individually and as part of a complete water budget for the Subbasin. This section describes the different water budget components and the results of water budget estimates derived from the Tehama IHM. The section includes discussion of the estimated uncertainties associated with the water budget analysis, data sources, and results with additional details related to these topics also described in the model documentation included as **Appendix 2-B**.

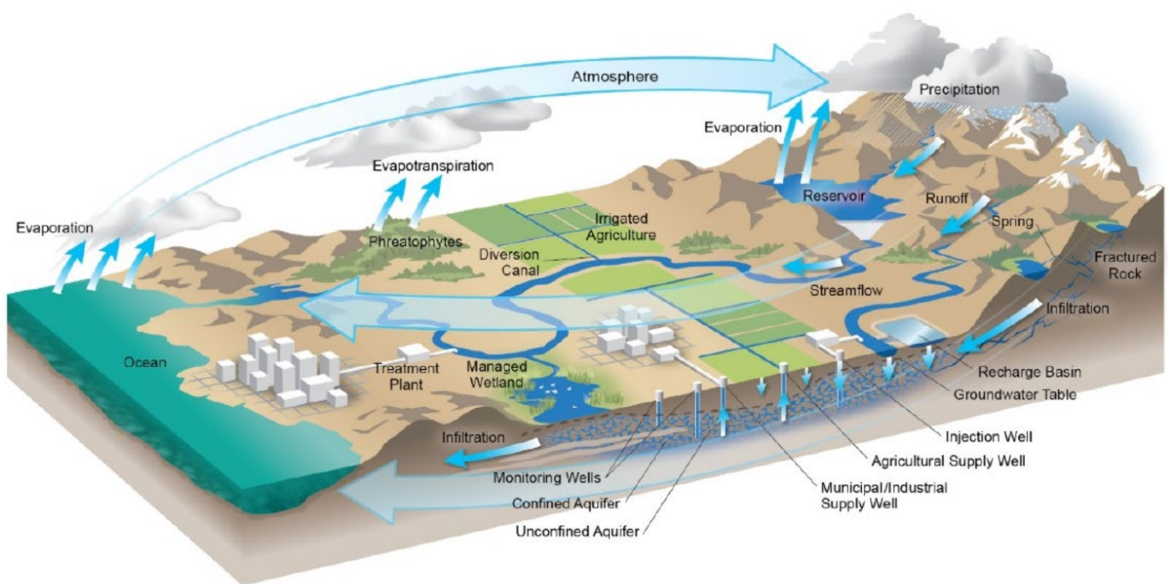


Figure 2-40. The Hydrologic Cycle (Source: DWR, 2016a)

2.3.1 Water Budget Conceptual Model

A water budget is defined as a complete accounting of all water flowing into and out of a defined volume[2] over a specified period of time. When the water budget is computed for a subbasin, the water budget facilitates assessment of the total volume of groundwater and surface water entering and leaving the subbasin over time, along with the change in volume of water stored within the subbasin.

[2] Where 'volume' refers to a space with length, width and depth properties, which for purposes of the GSP means the defined aquifer and associated surface water system.

2.3.1.1 Water Budget Structure

For accounting purposes, the Subbasin's water budget is divided into the surface water system (SWS) and groundwater system (GWS), described above. These systems are referred to as *accounting centers*. Flows between accounting centers and storage within each accounting center are water budget *components*. A schematic of the general water budget accounting structure is provided in **Figure 2-41**.

The conceptual model (or structure) for the Subbasin water budget is presented in **Figure 2-42**, including presentation of terms used in the following section to describe individual aspects of the water budget. The required components for each accounting center are listed in **Table 2-3**, along with the corresponding section of the GSP Regulations (California Code of Regulations Title 23[3] (23 CCR) §354). Separate but related water budgets were prepared for each accounting center that together represent the overall water budget for the Subbasin.

This section discusses the inflows and outflows from each of the SWS and GWS parts of the Subbasin. The water budgets are calculated using the Tehama IHM, which integrates flows between the SWS and GWS. The GWS water budget incorporates all inflows and outflows from the SWS into an accounting of the net effect of the hydrology and water use on groundwater storage in the Subbasin.

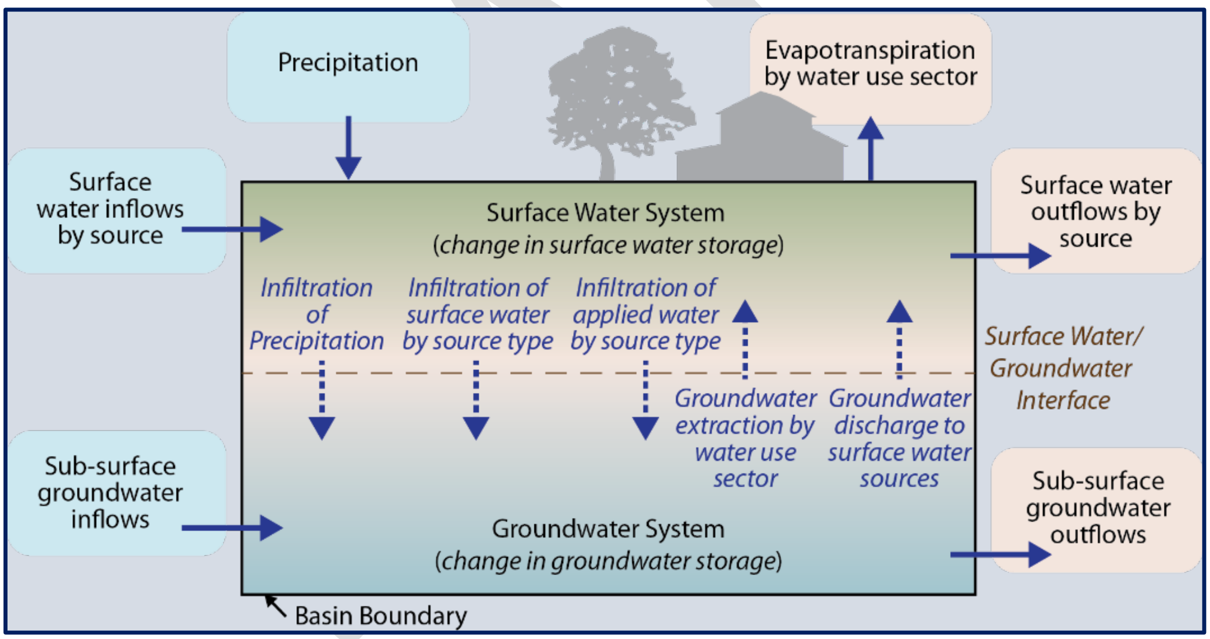
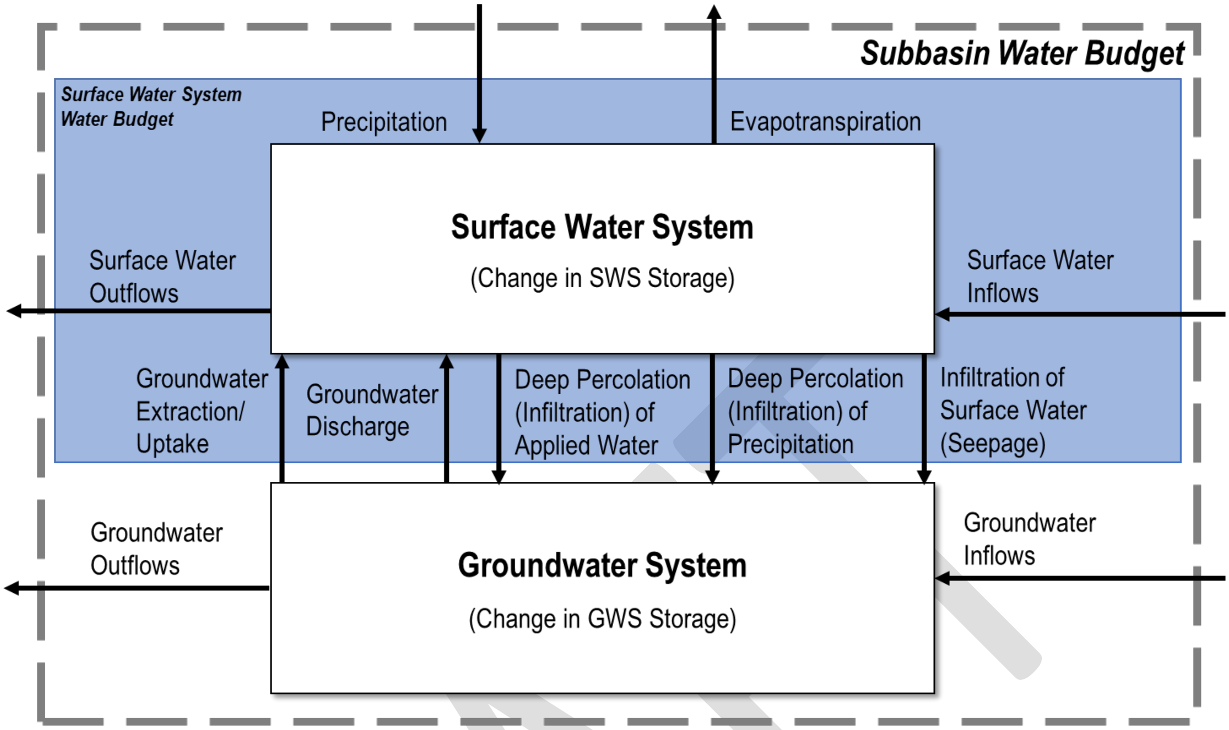


Figure 2-41. Water Budget Accounting Structure (Source: DWR, 2016a)

[3] California Code of Regulations, Title 23, Division 2, Chapter 1.5, Subchapter 2 Groundwater Sustainability Plans, Article 5 Plan Contents



Net Recharge from the SWS =
(Deep Percolation of Applied Water + Deep Percolation of Precipitation + Infiltration of Surface Water) – Groundwater Extraction/Uptake

Figure 2-42. Subbasin Water Budget Conceptual Model

Table 2-3. Water Budget Components by Accounting Center and Associated GSP Regulations

Accounting Center	Water Budget Component (flow direction)	GSP Regulation Section[1]
Basin	Surface Water Inflow[2] (+)	§354.18(b)(1)
	Precipitation (+)	Implied
	Subsurface Groundwater Inflow (+)	§354.18(b)(2)
	Evapotranspiration[3] (-)	§354.18(b)(3)
	Surface Water Outflow[2] (-)	§354.18(b)(1)
	Subsurface Groundwater Outflow (-)	§354.18(b)(3)
	Change in Storage	§354.18(b)(4)
Surface Water System	Surface Water Inflow[2] (+)	§354.18(b)(1)
	Precipitation (+)	Implied
	Groundwater Extraction (+)	§354.18(b)(3)
	Groundwater Discharge (+)	§354.18(b)(3)
	Evapotranspiration[3] (-)	§354.18(b)(3)
	Surface Water Outflow[2] (-)	§354.18(b)(1)
	Infiltration of Applied Water[4,5] (-)	§354.18(b)(2)
	Infiltration of Precipitation[4] (-)	§354.18(b)(2)
	Infiltration of Surface Water[6] (-)	§354.18(b)(2)
	Change in SWS Storage[7]	§354.18(a)
Groundwater System	Subsurface Groundwater Inflow (+)	§354.18(b)(2)
	Infiltration of Applied Water[4,5] (+)	§354.18(b)(2)
	Infiltration of Precipitation[4] (+)	§354.18(b)(2)
	Infiltration of Surface Water[6] (+)	§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 GWS Storage	§354.18(b)(4)

1. California Code of Regulations, Title 23, Division 2, Chapter 1.5, Subchapter 2 Groundwater Sustainability Plans, Article 5 Plan Contents
2. By water source type.
3. Evapotranspiration includes total evapotranspiration and evaporation, by water use sector. Total evapotranspiration includes the combined evaporation from the soil and transpiration from plants, resulting from both applied water and precipitation. In this context, evaporation is the direct evaporation from open water surfaces.
4. Synonymous with deep percolation.
5. Includes infiltration of applied surface water, groundwater, and reused water
6. Synonymous with seepage. Includes infiltration of lakes, streams, canals, drains, and springs.
7. Change in storage of root zone soil moisture, not groundwater.

2.3.2 Water Budget Analysis Period

Per 23 CCR §354.18, each GSP must quantify the historical, current, and projected water budget conditions for the Subbasin. The historical water budget for the Subbasin must quantify all required water budget components starting with the most recently available information and extending back a minimum of 10 years, or as is sufficient to calibrate and reduce the uncertainty of the water budget (23 CCR § 354.18(c)(2)(B)). The historical water budget period effectively represents long-term average hydrologic conditions. The current water budget must include the most recent hydrology, water supply, water demand, and land use information (23 CCR § 354.18(c)(1)). The historical water budget enables evaluation of the effects of historical hydrologic conditions and water demands on the water budget and groundwater conditions within the Subbasin over a period representative of long-term hydrologic conditions. The current water budget presents information on the effects of recent hydrologic and water demand conditions on the groundwater system.

The historical and current water budget periods were selected to evaluate conditions over discrete representative periods considering the following criteria: Sacramento Valley water year type; long-term mean annual water supply; inclusion of both wet and dry periods, antecedent dry conditions, adequate data availability; and inclusion of current hydrologic, cultural, and water management conditions in the Subbasin. Water years, as opposed to calendar years, are used as the time unit for defining analysis, following the DWR standard water year period (October 1 through September 30). Unless otherwise noted, all years referenced in this section are water years.

Based on these criteria, the following periods were identified for presentation of historical and current water budgets:

- **Historical Water Budget Period**: Water years 1990-2019 (29 years) using historical hydrologic, climate, water supply, and land use data.
- **Current Water Budget Periods**: Consideration of five different recent water year periods (listed below) using the historical hydrologic, climate, water supply, and land use data over each period.
    - Recent 10 years (2009-2018)
    - Recent 5 years (2014-2018)
    - Recent 3 years (2016-2018)
    - Recent 1 year (2018)
    - Recent 1 year (2019)

For the historical water budget, the period from 1990-2018 was selected to represent long-term average hydrologic conditions following evaluation of precipitation records and DWR Sacramento Valley water year type classification (**Table 2-2**). Further information and discussion of the historical water budget period, including discussion of historical hydrology and the base period selection process, are presented in **Section 2.2** of this GSP. Discussion of the historical water budget water results is included in **Section 2.3.5**

Table2-4. Sacramento Valley Water Year Type Classification during the Historical Water Budget Period (1990-2018)

Sacramento Valley Water Year Type	Abbreviation	Number of Years, 1990-2018	Percent Total Years, 1990-2018
Wet	W	8	28%
Above Normal	AN	4	14%
Below Normal	BN	5	17%
Dry	D	5	17%
Critical	C	7	24%
	Total	29	100%

For the current water budget, the results for several recent periods were presented, including recent 1-year, 3-year, 5-year, and 10-year periods. These various periods result in widely varied inflows and outflows, much of which is attributed to varied precipitation and water supplies in individual years (see results in **Section 2.3.6**). Because of the year-to-year variability in water budget results, the current water budget summarizes results from the various recent periods considered to provide an appropriate and reasonable representation of the current water budget based on recent conditions.

The projected water budget is intended to evaluate the effects of anticipated future conditions of hydrology, water supply availability, and water demand over a 50-year GSP planning period on the Subbasin water budget and groundwater conditions. The projected water budget incorporates consideration of potential climate change and water supply availability scenarios and evaluation of the need for and benefit of any projects and management actions to be implemented in the Subbasin to maintain or achieve sustainability. The 50-year projected water budget uses hydrologic conditions representative of the most recent 50 years of hydrology in the Subbasin, with adjustments applied in scenarios for evaluating the water budget under climate change and/or altered water supply and demand conditions. The approach and inputs used in development of the projected water budget are described in **Section 2.3.7** and are also discussed in the Tehama IHM documentation included as **Appendix 2-B**

2.3.3 Surface Water System (SWS) Water Budget Description

Water budgets for the SWS were developed to characterize historical and current conditions in the Subbasin relating to the individual inflows and outflows and overall SWS water budget. The general approach used in the SWS water budget calculations is described in **Section 2.3.3.1**. **Section 2.3.5** presents the results of the historical SWS water budgets within the boundary of the Subbasin and **Section 2.3.6** presents results for current SWS water budget analyses. The analyses and results relating to the projected water budget are presented in **Section 2.3.7**. Additional detailed discussion of the procedures and results of the SWS water budgets is included in documentation of the Tehama IHM development and results presented in **Appendix 2-B.**

2.3.3.1 General SWS Water Budget Components and Calculations

SWS inflows and outflows were quantified on a monthly basis, including accounting for any changes in SWS storage, such as changes in water stored in the root zone (**Equation 2-2**).

Total SWS Inflows – Total SWS Outflows = Change in SWS Storage (monthly)

Equation 2-2. Equation for Bowman Subbasin SWS Water Budget Analysis

As shown in **Figure 2-41** and **Table 2-1**, inflows to the SWS include surface water inflows (in various rivers, streams, and canals), precipitation, groundwater extraction (pumping and groundwater uptake), and groundwater discharge to surface water sources (from areas of high groundwater levels). Outflows include evapotranspiration (ET), surface water outflows (in various rivers, streams, and canals), infiltration of applied water (deep percolation from irrigation), infiltration of precipitation (deep percolation from precipitation), and infiltration of surface water (seepage).

The ET outflow component includes the following: ET of applied water (ET from soil and crop surfaces, of water that is derived from applied surface water, groundwater, and reused water); ET of precipitation (ET from soil and crop surfaces, of water that is derived from precipitation); and evaporation from rivers, streams, canals, reservoirs, and other water bodies. 'ET of applied water' differs from 'applied water' in that applied water is the volume of water that is directly applied to the land surface by irrigators (from all water sources), whereas ET of applied water is the volume of that applied water that is consumptively used by crops, vegetation, and soil surfaces.

Change in SWS storage is also depicted in **Figure 2-41** and **Table 2-3**. This represents the change in root zone soil moisture throughout the year. This is not the same as change in groundwater storage.

Net recharge from the SWS is defined as the total groundwater recharge (total infiltration from all sources) minus groundwater outflows to the surface water system, including both groundwater extraction and groundwater uptake by crops and vegetation.[4] Groundwater discharge to the SWS is not included in the net recharge term but is summarized separately as an exchange between the SWS and GWS. Net recharge from the SWS is a useful metric that equates only the impacts of the SWS on recharge and extraction from the GWS, providing valuable insight to the combined effects of land surface processes on the underlying GWS.

However, it should be recognized that net recharge from the SWS does not account for the complete GWS water budget, including subsurface groundwater flows. Thus, net recharge from the SWS is not meant to evaluate overdraft, but rather is most useful for evaluating how management of the surface layer impacts the GWS in the Subbasin. Net recharge from the SWS does not precisely express the effective availability of recharge in upgradient areas, which would be unable to utilize recharge that occurs in the downgradient

[4] Groundwater discharge to surface water is not included in the calculation of net recharge from the SWS, as groundwater discharge is more dependent on shallow groundwater and soil characteristics along waterways and is much less dependent on the management of the surface layer. Net recharge from the SWS is intended to describe the impacts of the SWS on the GWS, but groundwater discharge is more reflective of the GWS effects on the SWS.

areas of the Subbasins. More information about the net exchanges of surface water and groundwater in the Subbasin is provided below in the describing of components of the GWS water budget.

2.3.3.2 Detailed SWS Water Budget Accounting Centers and Components

To estimate the water budget components required by the GSP Regulations (**Table 2-3**), the SWS water budget accounting center is subdivided into detailed accounting centers representing the Land Surface System, the Canal System, and the Rivers, Streams, and Small Watersheds System (waterways conveying natural flow and surface water supplies into the Subbasin).

The Land Surface System represents inflows and outflows from irrigated and non-irrigated land. The Canals System represents flows through the canals and conveyance systems of diverters with access to surface water. The Rivers, Streams, and Small Watershed Systems represent inflows and outflows through waterways that convey natural flow, upgradient runoff, and drainage.

The Land Surface System is further subdivided into water use sectors, defined in the GSP Regulations as "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" (23 CCR Section 351(al)). Principal water use sectors in the Subbasin include Agricultural (irrigated crop land and idle agricultural land), Native Vegetation (native and riparian vegetation), and Urban (urban, residential, industrial, and semi-agricultural[5]).

Water budget components are defined for each detailed accounting center in **Table 2-5 through Table 2-6**. Within the Land Surface System accounting center, water budget components are also defined for each water use sector. These detailed water budget accounting centers and components are quantified based on the best available data and science, including information from water management plans (WMPs), groundwater management plans (GMPs), agricultural water management plans (AWMPs), urban water management plans (UWMPs), and other sources.

Each detailed accounting center was computed for the Subbasin. The Subbasin boundary SWS water budget components are identified in **Table 2-8**. The water budget includes the crop demands, available water supplies, and other characteristics specific to the Subbasin, including diversions, evaporation, and infiltration of surface water within the Subbasin.

.

[5] As defined in the DWR crop mapping metadata, semi-agricultural land includes farmsteads and miscellaneous land use incidental to agriculture (small roads, ditches, etc.) (DWR, 2016b).

Table 2-5. Land Surface System Water Budget Components

Detailed Accounting Center	Detailed Component	Flow Direction	Description
Land Surface System *Water Use Sectors: Agricultural, Native Vegetation, Urban*			
	Deliveries	Inflow	Deliveries of surface water supply for use within the Subbasin.
	Groundwater Extraction	Inflow	Groundwater pumping to meet water demands, and groundwater uptake by crops and vegetation.
	Precipitation	Inflow	Direct precipitation on the land surface.
	Reuse	Inflow	Reuse of percolated water from the unsaturated zone[1].
	ET of Applied Water	Outflow	Consumptive use of applied irrigation water.
	ET of Groundwater Uptake	Outflow	Consumptive use of shallow groundwater uptake.
	ET of Precipitation	Outflow	Consumptive use of infiltrated precipitation.
	Net Return Flow	Outflow	Net runoff of applied irrigation water, accounting for reuse[2].
	Runoff of Precipitation	Outflow	Direct runoff of precipitation.
	Infiltration of Applied Water	Outflow	Deep percolation of applied water below the root zone.
	Infiltration of Precipitation	Outflow	Deep percolation of precipitation below the root zone.

[1] "The unsaturated zone is below the land surface system and represents the portion of the basin that receives percolated water from the root zone and either transmits it as deep percolation to the GWS or to reuse within the land surface system, or both." (DWR, 2016a).

[2] Includes tailwater and pond drainage for ponded crops.

Table 2-6. Canal System Water Budget Components

Detailed Accounting Center	Detailed Component	Flow Direction	Description
Canal System	Diversions	Inflow	Diversions of surface water supply from waterways, a portion of which is delivered and used within the Subbasin.
	Deliveries	Outflow	Deliveries of surface water supply for use within the Subbasin.
	Infiltration of Surface Water (Seepage)	Outflow	Seepage from canals to the GWS.
	Evaporation	Outflow	Direct evaporation from canal water surfaces.
	Spillage	Outflow	Spillage from canals used for conveyance.

Table 2-7. Rivers, Streams, and Small Watersheds System Water Budget Components

Detailed Accounting Center	Detailed Component	Flow Direction	Description
Rivers, Streams, and Small Watersheds System	Stream Inflows	Inflow	Surface water inflows at the upstream boundary of waterways that traverse the Subbasin; includes natural flow and spillage, drainage, and runoff from canals and land surfaces upgradient of the Subbasin.
	Small Watershed Inflows	Inflow	Surface water inflows of drainage from upgradient small watersheds.
	Groundwater Discharge	Inflow	Discharge from shallow groundwater into rivers and streams.
	Spillage	Inflow	Spillage from canals used for conveyance.
	Stream Outflows	Outflow	Surface water outflows at the downstream boundary of waterways that traverse the Subbasin; includes natural flow and spillage, drainage, and runoff from canals and land surfaces.
	Small Watershed Outflows	Outflow	Surface water outflows of drainage from upgradient small watersheds at the downgradient boundary of the Subbasin.
	Diversions	Outflow	Diversions of surface water supply from waterways, a portion of which is delivered and used within the Subbasin.
	Infiltration of Surface Water (Seepage)	Outflow	Seepage from rivers, streams, and small watershed inflows to the GWS.
	Evaporation	Outflow	Direct evaporation from river and stream water surfaces.

Table 2-8. Subbasin Boundary Surface Water System Water Budget Components

Detailed Accounting Center	Detailed Component	Flow Direction	Description
Rivers, Streams, and Small Watersheds System	Stream Inflows	Inflow	Surface water inflows at the upstream boundary of waterways that traverse the Subbasin; includes natural flow and spillage, drainage, and runoff from canals and land surfaces upgradient of the Subbasin.
	Small Watershed Inflows	Inflow	Surface water inflows of drainage from upgradient small watersheds.
	Groundwater Discharge	Inflow	Discharge from shallow groundwater into rivers and streams.
Canal System	Diversions *(in select cases)*	Inflow	Diversions of surface water supply from waterways *at a point outside or along the boundary of the Subbasin*, a portion of which is delivered and used within the Subbasin
Land Surface System *Water Use Sectors: Agricultural, Native Vegetation, Urban*	Groundwater Extraction	Inflow	Groundwater pumping to meet water demands, and groundwater uptake by crops and vegetation.
	Precipitation	Inflow	Direct precipitation on the land surface.
	ET of Applied Water	Outflow	Consumptive use of applied irrigation water.
	ET of Groundwater Uptake	Outflow	Consumptive use of shallow groundwater uptake.
	ET of Precipitation	Outflow	Consumptive use of infiltrated precipitation.
	Runoff of Applied Water	Outflow	Direct runoff of applied irrigation water[2].
	Runoff of Precipitation	Outflow	Direct runoff of precipitation.
	Infiltration of Applied Water	Outflow	Deep percolation of applied water below the root zone.
	Infiltration of Precipitation	Outflow	Deep percolation of precipitation below the root zone.
	Change in SWS Storage	Storage	Change in root zone soil moisture throughout the year; (not change in groundwater storage)
Canal System; and Rivers, Streams, and Small Watersheds System	Infiltration of Surface Water (Seepage)	Outflow	Seepage from canals, streams, and small watershed inflows to the GWS.
	Evaporation	Outflow	Direct evaporation from canals, rivers, and streams.
Canal System	Spillage	Outflow	Spillage from canals used for interior conveyance.
Rivers, Streams, and Small Watersheds System	Stream Outflows	Outflow	Surface water outflows at the downstream boundary of waterways that traverse the Subbasin; includes natural flow and spillage, drainage, and runoff from canals and land surfaces.
	Small Watershed Outflows	Outflow	Surface water outflows of drainage from upgradient small watersheds at the downgradient boundary of the Subbasin.

2.3.4 Groundwater System (GWS) Water Budget Description

Water budgets for the GWS were developed to characterize historical and current conditions in the Subbasin utilizing the Tehama IHM for different historical and current time periods described above. **Sections 2.3.5 and 2.3.6** present the results of the historical and current GWS water budgets within the lateral and vertical boundaries of the Subbasin. Discussion of the general approach used in developing model scenarios to evaluate projected GWS water budgets for the Subbasin with the Tehama IHM and the results from these projected water budget analyses is included in **Section 2.3.7**. More detail related to the procedures and results of the GWS water budgets are also included in documentation of the Tehama IHM development presented in **Appendix 2-B.**

2.3.4.1 GWS Water Budget Components and Calculations

Inflows and outflows of the GWS were quantified on a monthly basis, including accounting for any changes in GWS storage (**Equation 2-3**).

Total GWS Inflows – Total GWS Outflows = Change in GWS Storage (monthly)

Equation 2-3. Equation for Bowman Subbasin GWS Water Budget Analysis

As shown in **Figure 2-41** and **Table 2-1**, inflows to the GWS include some of the outflow components from the SWS including infiltration (deep percolation) of precipitation and applied water and infiltration (seepage) of surface water. Additional GWS inflows include lateral subsurface groundwater inflows from adjacent subbasins and from adjacent upland or foothill areas outside the Subbasin (small watersheds). GWS outflows include exchanges with the SWS including groundwater discharge to surface waterways, groundwater extraction through pumping, and root water uptake by plants occurring directly from shallow groundwater. Lateral subsurface groundwater flows to adjacent subbasins represent additional GWS outflows. Water budget components representing exchanges between the GWS and the SWS are also included in discussions and presentations of the SWS conceptual water budget and results.

Change in GWS storage as represented by change in groundwater storage is also depicted in **Figure 2-41** and **Table 2-3**. The change in groundwater storage represents the total change in the volume of water in storage in the groundwater system as a result of exchanges between the GWS and the SWS and the balance of all inflows and outflows of the GWS. The change in groundwater storage is directly related to changes in water levels in the groundwater system, both of which are sustainability indicators to be considered during development of a sustainable yield for the Subbasin. Each of the detailed components of the Subbasin boundary GWS water budget are identified in **Table 2-9** and were computed for the Subbasin to develop a complete GWS water budget. The HCM discussed in **Section 2.2** identifies two principal aquifers within the GWS: an Upper Aquifer and Lower Aquifer. Vertical groundwater flow does occur between these aquifers and change in storage of the entire GWS and also within each principal aquifer zone are considerations for sustainable groundwater management.

.

Table 2-9. Subbasin Boundary Groundwater System Water Budget Components

Accounting Center	Detailed Component	Flow Direction	Description
Groundwater System	Lateral Subsurface Groundwater Flows Between Adjacent Subbasins	Inflow	Lateral subsurface groundwater inflow from adjacent subbasin.
	Lateral Subsurface Groundwater Flows Between Adjacent Upland or Foothill Areas	Inflow	Lateral subsurface groundwater inflow from adjacent upland or foothill areas.
	Infiltration of Surface Water (Seepage)	Inflow	Seepage from canal, streams, and small watershed inflows from the SWS.
	Infiltration (Deep Percolation) of Applied Water	Inflow	Deep percolation of applied water below the root zone from the SWS.
	Infiltration (Deep Percolation) of Precipitation	Inflow	Deep percolation of precipitation below the root zone from the SWS.
	Lateral Subsurface Groundwater Flows Between Adjacent Subbasins	Outflow	Lateral subsurface groundwater outflow to adjacent subbasin.
	Groundwater Extraction	Outflow	Groundwater pumping to meet water demands, and groundwater uptake by crops and vegetation.
	Groundwater Discharge	Outflow	Discharge from shallow groundwater into rivers and streams.
	Vertical Subsurface Groundwater Flows within the GWS	Storage	Vertical subsurface groundwater flows between the Upper and Lower Aquifers within the GWS
	Change in GWS Storage	Storage	Change in volume of water stored within the groundwater system, representative of total accrual or depletion of groundwater storage.

2.3.5 Historical Water Budget

The results of the historical water budget are subject to some change after the model calibration is finalized, although the overall changes are not anticipated to be great. The historical water budget results will be updated in a subsequent draft of the section.

Characterizing historical land use is foundational for accurately quantifying how and where water is beneficially used. Land use areas are also used to distinguish the water use sector in which water is consumed, as required by the GSP Regulations.

Table 2-10 and **Figure 2-43** summarize the annual land use areas over the historical period (1990-2018) in the Bowman Subbasin by water use sector, as defined by the GSP Regulations (23 CCR § 351(al)). In the Bowman Subbasin, water use sectors include agricultural, urban, and native vegetation land uses. The urban water use sector covers all urban, residential, industrial, and semi-agricultural[6] land uses. See Plan Area section 2.1.1.2, Land Use.

Agricultural, urban, and native vegetation land uses covered an average of 5,800 acres, 1,500 acres, and 115,100 acres, respectively, between 1990 and 2018. Since 1990, approximately 1,200 acres of native vegetation in the Bowman Subbasin has been converted to agricultural and urban land uses.

[6] As defined in the DWR crop mapping metadata, semi-agricultural land use subclasses include farmsteads, livestock feed lot operations, dairies, poultry farms, and miscellaneous semi-agricultural land use incidental to agriculture (small roads, ditches, non-planted areas of cropped fields (DWR, 2016b).

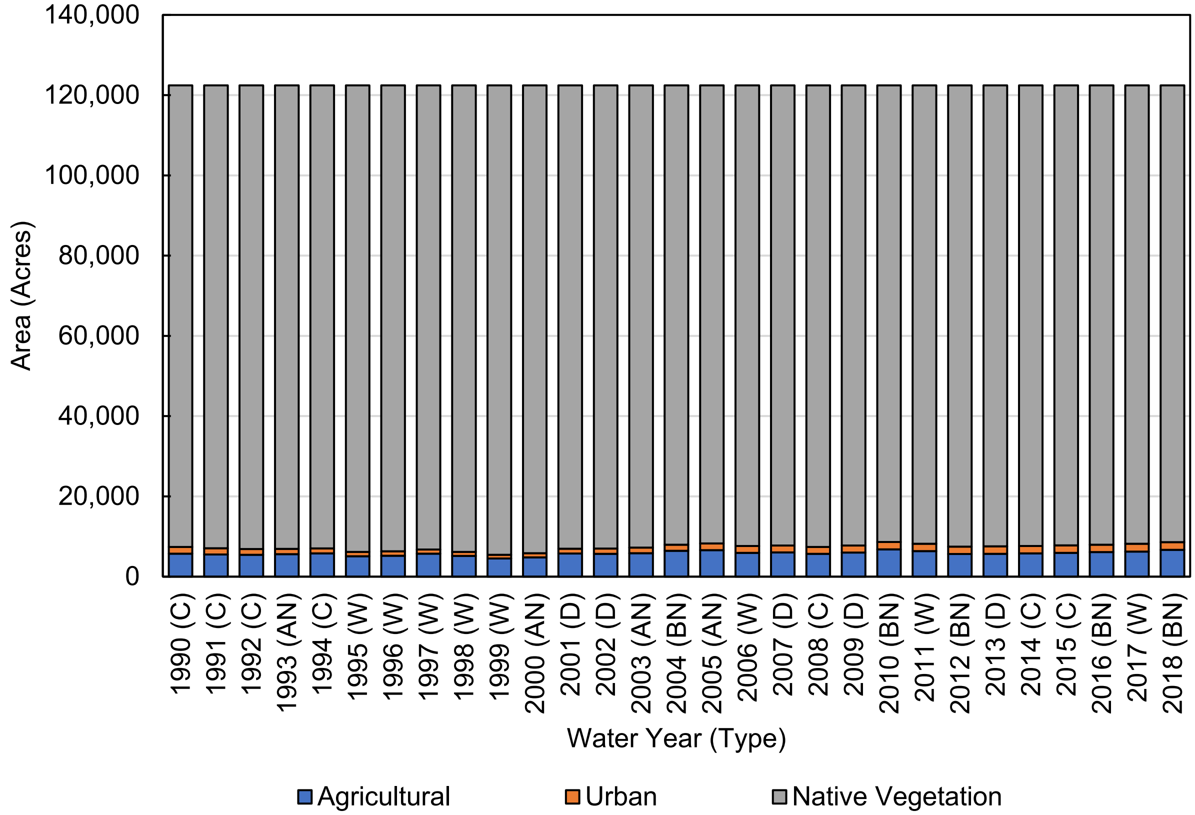


Figure 2-43. Bowman Subbasin Land Use Areas, by Water Use Sector

Table 2-10. Bowman Subbasin Land Use Areas, by Water Use Sector

Water Year (Type)	Agricultural	Urban[1]	Native Vegetation	Total
1990 (C)	5,713	1,670	115,042	122,425
1991 (C)	5,506	1,559	115,360	122,425
1992 (C)	5,430	1,432	115,563	122,425
1993 (AN)	5,613	1,324	115,488	122,425
1994 (C)	5,821	1,208	115,396	122,425
1995 (W)	5,070	1,111	116,245	122,425
1996 (W)	5,219	1,095	116,110	122,425
1997 (W)	5,728	1,033	115,664	122,425
1998 (W)	5,178	973	116,274	122,425
1999 (W)	4,523	923	116,979	122,425
2000 (AN)	4,817	1,019	116,589	122,425
2001 (D)	5,775	1,167	115,482	122,425
2002 (D)	5,692	1,293	115,440	122,425
2003 (AN)	5,828	1,418	115,179	122,425
2004 (BN)	6,448	1,523	114,453	122,425
2005 (AN)	6,601	1,683	114,141	122,425
2006 (W)	5,936	1,683	114,805	122,425
2007 (D)	6,054	1,719	114,652	122,425
2008 (C)	5,671	1,711	115,043	122,425
2009 (D)	6,004	1,757	114,663	122,425
2010 (BN)	6,813	1,825	113,787	122,425
2011 (W)	6,357	1,842	114,226	122,425
2012 (BN)	5,626	1,869	114,930	122,425
2013 (D)	5,701	1,858	114,866	122,425
2014 (C)	5,798	1,839	114,788	122,425
2015 (C)	5,935	1,852	114,638	122,425
2016 (BN)	6,108	1,860	114,457	122,425
2017 (W)	6,263	1,917	114,245	122,425
2018 (BN)	6,663	1,947	113,815	122,425
Average (1990-2018)	5,789	1,521	115,115	122,425

[1] Area includes land classified as urban, residential, industrial, and semi-agricultural.

Agricultural land uses are further detailed in **Table 2-11** and **Figure 2-44**. Historically, irrigated pasture has been the predominant agricultural land use in the Bowman Subbasin. Other irrigated crops include mainly alfalfa, grain, and various orchard crops, especially walnuts, almonds, and prunes. Flood irrigation is typically used to support pasture, alfalfa, and grain crops in the Bowman Subbasin.

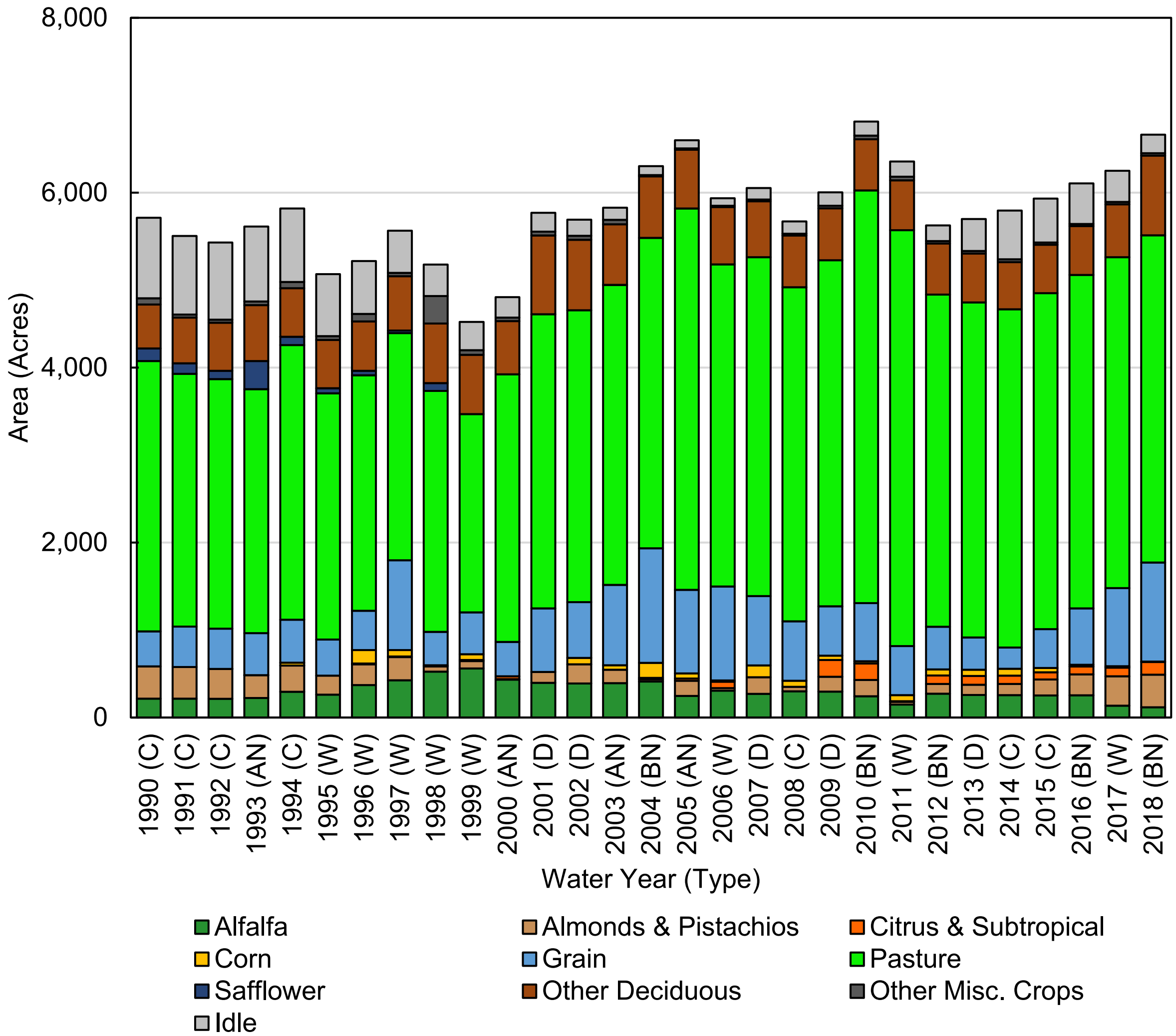


Figure 2-44. Bowman Subbasin Agricultural Land Use Areas

Table 2-11. Bowman Subbasin Agricultural Land Use Areas (acres)

Water Year (Type)	Alfalfa	Almonds & Pistachios	Citrus & Subtropical	Corn	Grain	Pasture	Ponded (Rice)	Safflower	Other Deciduous[1]	Other Misc. Crops[2]	Idle	Total
1990 (C)	217	369	0	0	400	3,090	0	144	503	71	919	5,713
1991 (C)	217	361	0	0	463	2,890	0	119	523	35	898	5,506
1992 (C)	214	341	0	0	461	2,853	0	95	549	36	881	5,430
1993 (AN)	223	261	0	0	479	2,790	0	322	639	42	856	5,613
1994 (C)	294	300	0	33	491	3,139	0	96	556	71	841	5,821
1995 (W)	262	217	0	0	413	2,814	1	59	552	43	708	5,070
1996 (W)	371	237	9	154	450	2,692	0	51	564	86	604	5,219
1997 (W)	426	264	9	72	1,028	2,597	161	29	621	37	483	5,728
1998 (W)	525	61	2	9	382	2,754	0	90	682	314	360	5,178
1999 (W)	561	84	13	67	478	2,267	0	0	677	54	323	4,523
2000 (AN)	434	5	32	0	393	3,060	10	0	608	40	234	4,817
2001 (D)	397	124	0	0	727	3,363	5	0	901	44	214	5,775
2002 (D)	390	219	0	73	638	3,337	0	0	804	46	185	5,692
2003 (AN)	394	152	0	51	920	3,428	0	2	691	53	137	5,828
2004 (BN)	412	25	16	172	1,310	3,549	144	0	704	14	103	6,448
2005 (AN)	248	173	25	59	955	4,359	2	0	674	14	92	6,601
2006 (W)	307	30	73	15	1,073	3,682	0	0	656	16	85	5,936
2007 (D)	271	191	0	134	793	3,875	0	0	640	19	132	6,054
2008 (C)	300	52	0	68	680	3,819	0	0	593	20	139	5,671
2009 (D)	296	170	192	49	563	3,958	0	0	593	30	153	6,004
2010 (BN)	243	186	188	25	666	4,718	0	0	585	41	161	6,813
2011 (W)	148	32	8	69	561	4,754	0	0	570	42	174	6,357
2012 (BN)	272	112	97	69	487	3,798	0	0	585	27	179	5,626
2013 (D)	259	117	100	72	368	3,832	1	0	558	29	367	5,701
2014 (C)	256	127	97	78	242	3,867	1	0	540	32	557	5,798
2015 (C)	253	183	82	49	445	3,841	2	0	553	27	502	5,935
2016 (BN)	254	239	89	21	644	3,813	1	0	558	24	464	6,108
2017 (W)	135	337	98	15	895	3,782	12	0	605	26	357	6,263
2018 (BN)	117	374	144	6	1,132	3,741	0	0	911	28	211	6,663
Average (1990-2018)	300	184	44	47	639	3,464	12	35	627	47	390	5,789

[1] Includes primarily walnuts and prunes.

[2] Area includes land classified as cotton, cucurbits, dry beans, onions & garlic, potatoes, sugar beets, tomatoes, vineyards, other field crops, and other truck crops.

2.3.5.1 Surface Water System Water Budget Results

2.3.5.1.1 *Inflows*

2.3.5.1.1.1 Surface Water Inflow by Water Source Type

Per the GSP Regulations, surface inflows must be reported by water source type. According to the Regulations (23 CCR § 351(ak)):

> *"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.*

Major surface water inflows to the Bowman Subbasin are summarized below according to water source type.

Local Supplies

Local supply inflows to the Bowman Subbasin predominantly include runoff from upgradient small watersheds adjacent to the Subbasin and surface inflows along Cottonwood Creek. A portion of the local supplies are diverted by local water rights users for beneficial use within the Subbasin. There are about 140 riparian diverters in the Subbasin with active water rights. These water rights users divert water primarily from Cottonwood Creek and its tributaries, but there are a few diversions along the Sacramento River. The average annual diversions total approximately 2.4 acre-feet per acre over 940 acres, varying between years depending on water year type and other land use changes over time.

Central Valley Project

Central Valley Project (CVP) inflows to the Bowman Subbasin primarily include surface water diverted from the Sacramento River by the Anderson-Cottonwood Irrigation District (ACID). ACID holds the third oldest water rights on the Sacramento River, and has a total Settlement Contract of more than 100,000 AF per year. While the majority of the ACID service area overlies the Anderson Subbasin, a portion of ACID's CVP supplies are delivered to parcels that overlie the Bowman Subbasin. Surface water is also diverted by small CVP contractors to irrigated land along the Sacramento River.

Summary of Surface Inflows

The annual volume of surface water inflows is summarized by water source type in **Table 2-12** and **Figure 2-45**. Between 1990 and 2018, total surface inflows from all sources averaged approximately 454 thousand acre-feet (taf) per year. Of this total, local supplies averaged approximately 436 taf per year, while CVP supplies averaged 18 taf per year.

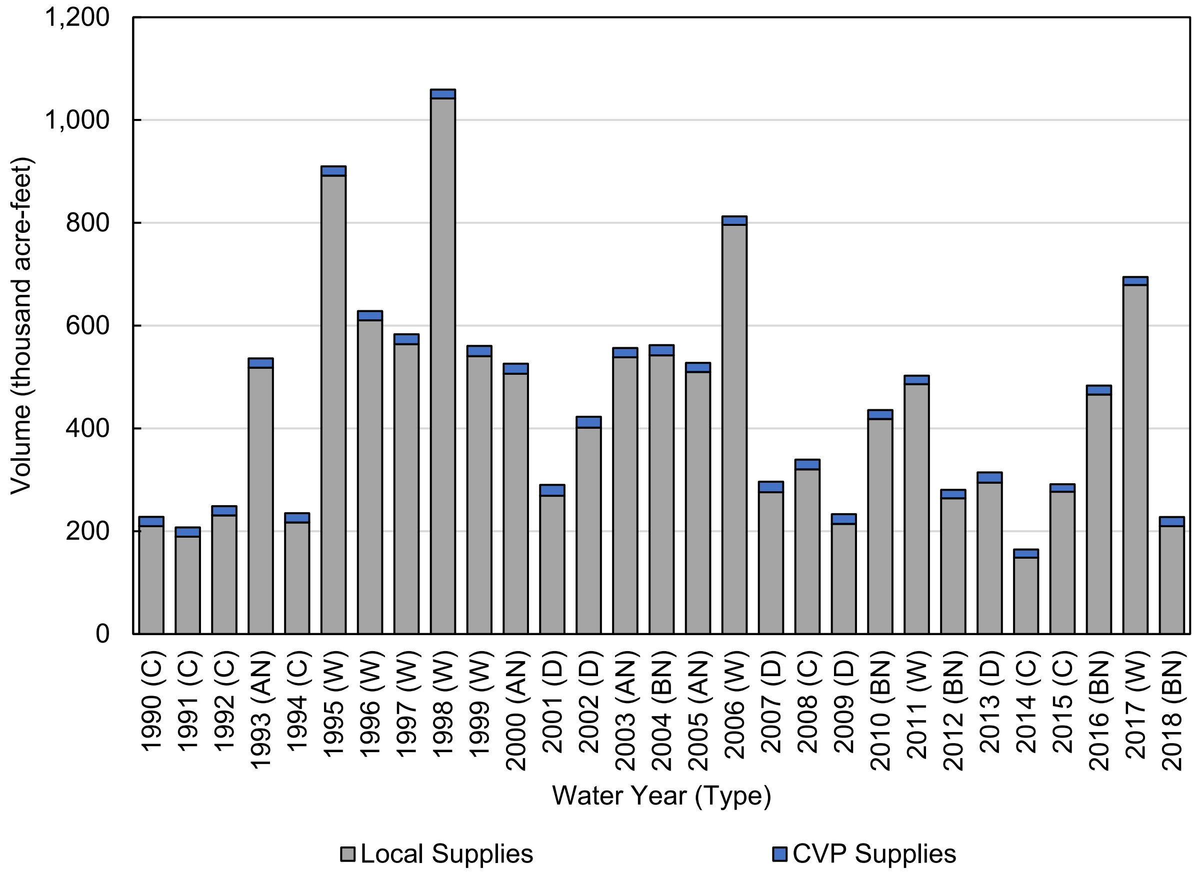


Figure 2-45. Bowman Subbasin Surface Water Inflows, by Water Source Type

—Table 2-12. Bowman Subbasin Surface Water Inflows, by Water Source Type (acre-feet, rounded)

<table>
<tr><th colspan="2">Water Year (Type)</th><th>CVP Supplies</th><th>Local Supplies</th><th>Total</th></tr>
<tr><td colspan="2">1990 (C)</td><td>18,050</td><td>209,890</td><td>227,940</td></tr>
<tr><td colspan="2">1991 (C)</td><td>18,050</td><td>189,380</td><td>207,430</td></tr>
<tr><td colspan="2">1992 (C)</td><td>18,050</td><td>230,750</td><td>248,800</td></tr>
<tr><td colspan="2">1993 (AN)</td><td>18,050</td><td>518,350</td><td>536,400</td></tr>
<tr><td colspan="2">1994 (C)</td><td>18,050</td><td>217,210</td><td>235,260</td></tr>
<tr><td colspan="2">1995 (W)</td><td>18,050</td><td>892,030</td><td>910,080</td></tr>
<tr><td colspan="2">1996 (W)</td><td>18,050</td><td>610,360</td><td>628,410</td></tr>
<tr><td colspan="2">1997 (W)</td><td>19,270</td><td>563,850</td><td>583,120</td></tr>
<tr><td colspan="2">1998 (W)</td><td>17,230</td><td>1,042,030</td><td>1,059,260</td></tr>
<tr><td colspan="2">1999 (W)</td><td>19,790</td><td>540,700</td><td>560,490</td></tr>
<tr><td colspan="2">2000 (AN)</td><td>19,740</td><td>506,370</td><td>526,110</td></tr>
<tr><td colspan="2">2001 (D)</td><td>21,070</td><td>269,180</td><td>290,250</td></tr>
<tr><td colspan="2">2002 (D)</td><td>20,960</td><td>401,620</td><td>422,580</td></tr>
<tr><td colspan="2">2003 (AN)</td><td>18,040</td><td>538,320</td><td>556,360</td></tr>
<tr><td colspan="2">2004 (BN)</td><td>20,000</td><td>542,110</td><td>562,110</td></tr>
<tr><td colspan="2">2005 (AN)</td><td>17,710</td><td>509,790</td><td>527,500</td></tr>
<tr><td colspan="2">2006 (W)</td><td>16,690</td><td>795,980</td><td>812,670</td></tr>
<tr><td colspan="2">2007 (D)</td><td>20,550</td><td>275,960</td><td>296,510</td></tr>
<tr><td colspan="2">2008 (C)</td><td>18,820</td><td>320,420</td><td>339,240</td></tr>
<tr><td colspan="2">2009 (D)</td><td>19,030</td><td>214,310</td><td>233,340</td></tr>
<tr><td colspan="2">2010 (BN)</td><td>17,630</td><td>418,310</td><td>435,940</td></tr>
<tr><td colspan="2">2011 (W)</td><td>16,410</td><td>486,160</td><td>502,570</td></tr>
<tr><td colspan="2">2012 (BN)</td><td>16,450</td><td>263,990</td><td>280,440</td></tr>
<tr><td colspan="2">2013 (D)</td><td>19,970</td><td>294,480</td><td>314,450</td></tr>
<tr><td colspan="2">2014 (C)</td><td>15,660</td><td>148,730</td><td>164,390</td></tr>
<tr><td colspan="2">2015 (C)</td><td>14,770</td><td>276,730</td><td>291,500</td></tr>
<tr><td colspan="2">2016 (BN)</td><td>17,230</td><td>466,070</td><td>483,300</td></tr>
<tr><td colspan="2">2017 (W)</td><td>15,500</td><td>679,200</td><td>694,700</td></tr>
<tr><td colspan="2">2018 (BN)</td><td>17,800</td><td>210,010</td><td>227,810</td></tr>
<tr><td colspan="2">Average (1990-2018)</td><td>18,160</td><td>435,600</td><td>453,760</td></tr>
<tr><td rowspan="5">1990-2018</td><td>W</td><td>17,620</td><td>701,290</td><td>718,910</td></tr>
<tr><td>AN</td><td>18,390</td><td>518,210</td><td>536,590</td></tr>
<tr><td>BN</td><td>17,820</td><td>380,100</td><td>397,920</td></tr>
<tr><td>D</td><td>20,320</td><td>291,110</td><td>311,430</td></tr>
<tr><td>C</td><td>17,350</td><td>227,590</td><td>244,940</td></tr>
</table>

2.3.5.1.1.2 Precipitation

Precipitation estimates for the Bowman Subbasin are provided in **Table 2-13** and **Figure 2-46** by water use sector. Total precipitation is highly variable between years in the study area, ranging from approximately 209 taf (20.4 inches) during average critical water years to 392 taf (38.3 inches) during average wet years.

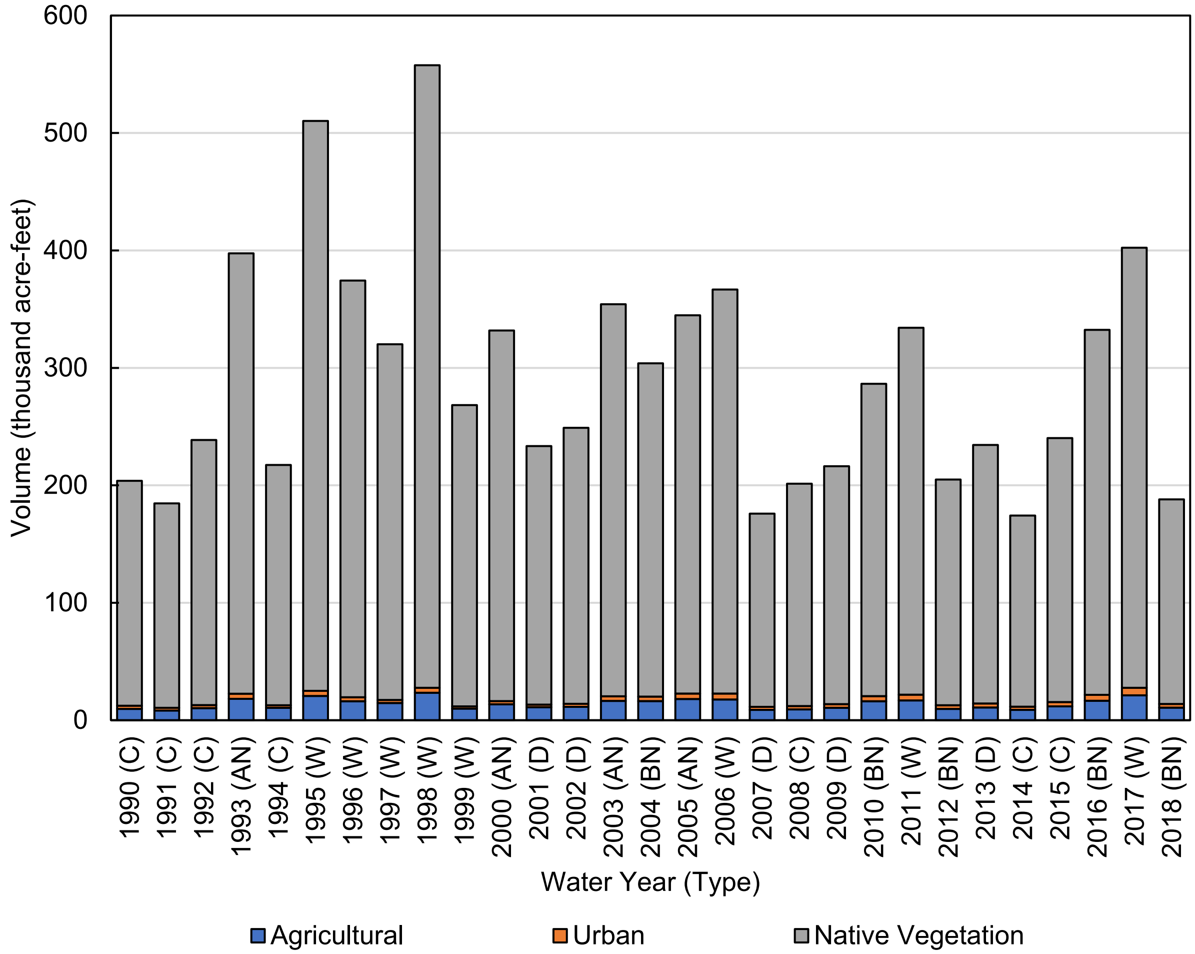


Figure 2-46. Bowman Subbasin Precipitation, by Water Use Sector

Table 2-13. Bowman Subbasin Precipitation, by Water Use Sector (acre-feet, rounded)

Water Year (Type)	Agricultural	Urban	Native Vegetation	Total
1990 (C)	9,570	2,820	191,420	203,810
1991 (C)	8,240	2,300	174,060	184,600
1992 (C)	10,300	2,630	225,660	238,590
1993 (AN)	18,250	4,290	374,950	397,490
1994 (C)	10,620	2,180	204,490	217,290
1995 (W)	20,640	4,420	485,240	510,300
1996 (W)	16,240	3,390	354,740	374,370
1997 (W)	14,730	2,530	302,900	320,160
1998 (W)	23,350	4,270	530,010	557,630
1999 (W)	9,890	1,960	256,460	268,310
2000 (AN)	13,540	2,810	315,430	331,780
2001 (D)	11,090	2,220	220,140	233,450
2002 (D)	11,450	2,530	235,030	249,010
2003 (AN)	16,500	3,970	333,710	354,180
2004 (BN)	16,340	3,850	283,720	303,910
2005 (AN)	18,140	4,600	322,100	344,840
2006 (W)	17,660	5,020	344,010	366,690
2007 (D)	8,870	2,520	164,500	175,890
2008 (C)	9,260	2,780	189,380	201,420
2009 (D)	10,610	3,050	202,570	216,230
2010 (BN)	16,220	4,270	265,960	286,450
2011 (W)	16,880	4,870	312,430	334,180
2012 (BN)	9,660	3,140	192,090	204,890
2013 (D)	10,800	3,520	220,090	234,410
2014 (C)	8,770	2,720	162,770	174,260
2015 (C)	11,860	3,690	224,710	240,260
2016 (BN)	16,590	5,020	310,800	332,410
2017 (W)	21,250	6,410	374,580	402,240
2018 (BN)	10,710	3,090	174,220	188,020
Average (1990-2018)	13,730	3,480	274,070	291,280
1990-2018 W	17,580	4,110	370,050	391,740
1990-2018 AN	16,610	3,920	336,550	357,070
1990-2018 BN	13,900	3,870	245,360	263,140
1990-2018 D	10,560	2,770	208,470	221,800
1990-2018 C	9,800	2,730	196,070	208,600

2.3.5.1.1.3 Groundwater Extraction and Uptake by Water Use Sector

Total groundwater extraction in the Bowman Subbasin represents a combination of groundwater pumping to support agricultural and urban water demands, including rural residential use, and groundwater uptake by crops, urban vegetation, and native vegetation.

Estimates of groundwater pumping by water use sector are provided in **Figure 2-47** and **Table 2-14**. Virtually all groundwater pumping in the Bowman Subbasin is used to meet agricultural demand, averaging 4.4 taf per year. The total groundwater extraction varies from an average of 3.5 taf in wet years to more than 5 taf in some below normal, dry, and critical water years depending on variability in surface water supplies, precipitation, and crop water demand.

When groundwater is near the land surface, groundwater uptake can also be a source of supply for vegetation. Estimates of groundwater uptake by vegetation are provided in **Figure 2-48** and **Table 2-15**. The majority of groundwater uptake is consumed directly by agricultural crops and native vegetation, totaling 0.9 taf and 1.7 taf per year, on average.

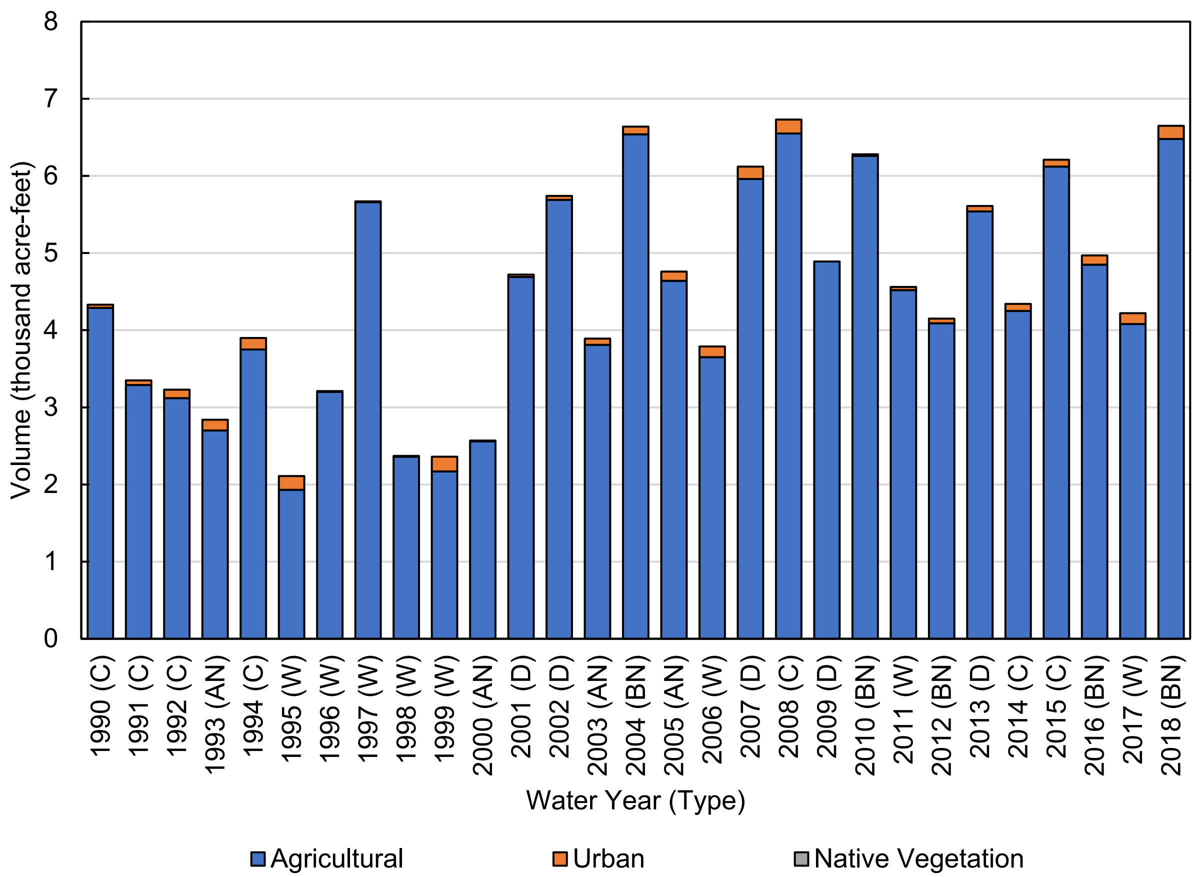


Figure 2-47. Bowman Subbasin Groundwater Pumping, by Water Use Sector

Table 2-14. Bowman Subbasin Groundwater Pumping, by Water Use Sector (acre-feet, rounded)

Water Year (Type)	Agricultural	Urban	Native Vegetation	Total
1990 (C)	4,290	40	0	4,330
1991 (C)	3,290	60	0	3,350
1992 (C)	3,120	110	0	3,230
1993 (AN)	2,700	140	0	2,840
1994 (C)	3,750	150	0	3,900
1995 (W)	1,930	180	0	2,110
1996 (W)	3,200	10	0	3,210
1997 (W)	5,660	10	0	5,670
1998 (W)	2,360	10	0	2,370
1999 (W)	2,170	190	0	2,360
2000 (AN)	2,560	10	0	2,570
2001 (D)	4,690	30	0	4,720
2002 (D)	5,690	50	0	5,740
2003 (AN)	3,810	80	0	3,890
2004 (BN)	6,540	100	0	6,640
2005 (AN)	4,640	120	0	4,760
2006 (W)	3,650	140	0	3,790
2007 (D)	5,960	160	0	6,120
2008 (C)	6,550	180	0	6,730
2009 (D)	4,890	0	0	4,890
2010 (BN)	6,260	20	0	6,280
2011 (W)	4,520	40	0	4,560
2012 (BN)	4,090	60	0	4,150
2013 (D)	5,540	70	0	5,610
2014 (C)	4,250	90	0	4,340
2015 (C)	6,120	90	0	6,210
2016 (BN)	4,850	120	0	4,970
2017 (W)	4,080	140	0	4,220
2018 (BN)	6,480	170	0	6,650
Average (1990-2018)	4,400	90	0	4,490
1990-2018 W	3,450	90	0	3,540
1990-2018 AN	3,430	90	0	3,520
1990-2018 BN	5,640	90	0	5,740
1990-2018 D	5,350	60	0	5,420
1990-2018 C	4,480	100	0	4,580

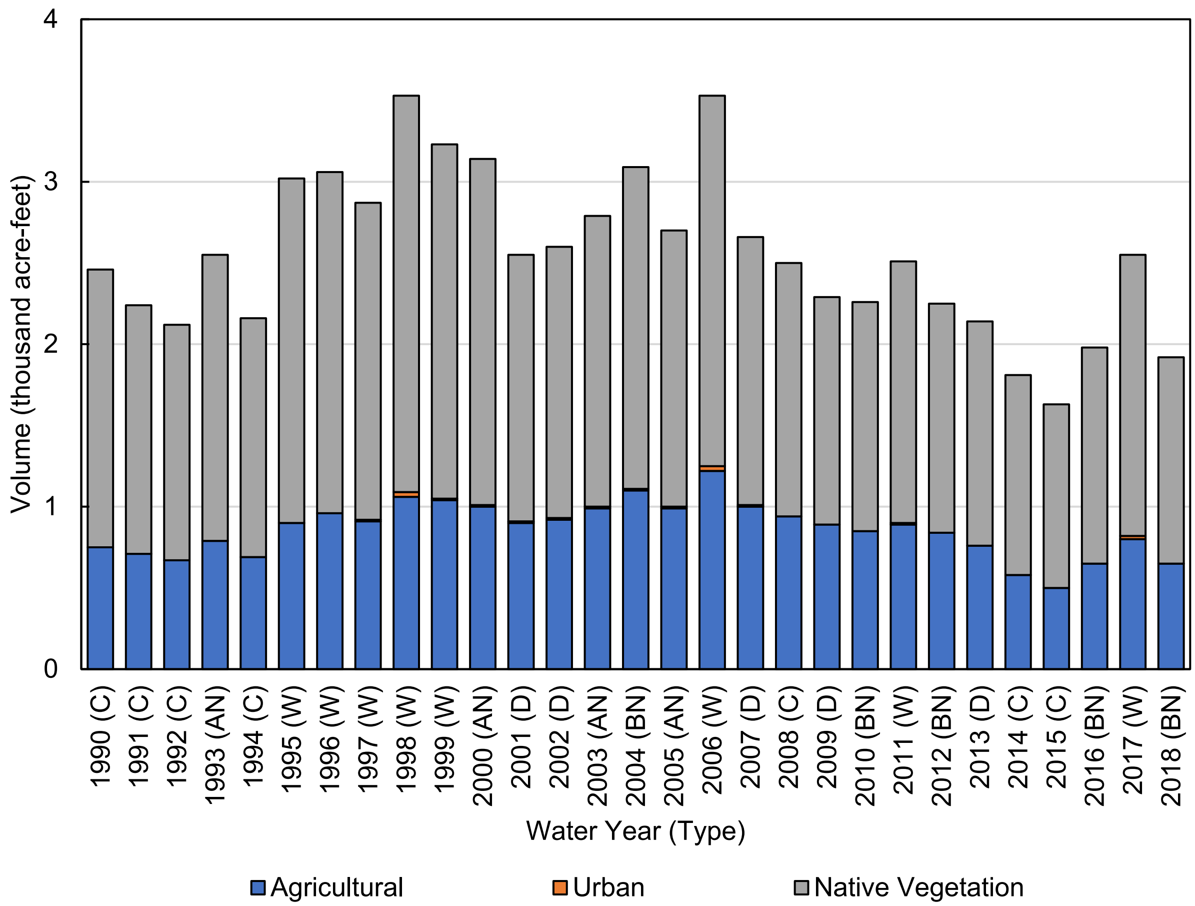


Figure 2-48. Bowman Subbasin Groundwater Uptake, by Water Use Sector

Table 2-15. Bowman Subbasin Groundwater Uptake, by Water Use Sector (acre-feet, rounded)

Water Year (Type)		Agricultural	Urban	Native Vegetation	Total
1990 (C)		750	0	1,710	2,460
1991 (C)		710	0	1,530	2,240
1992 (C)		670	0	1,450	2,120
1993 (AN)		790	0	1,760	2,550
1994 (C)		690	0	1,470	2,160
1995 (W)		900	0	2,120	3,020
1996 (W)		960	0	2,100	3,060
1997 (W)		910	10	1,950	2,870
1998 (W)		1,060	30	2,440	3,530
1999 (W)		1,040	10	2,180	3,230
2000 (AN)		1,000	10	2,130	3,140
2001 (D)		900	10	1,640	2,550
2002 (D)		920	10	1,670	2,600
2003 (AN)		990	10	1,790	2,790
2004 (BN)		1,100	10	1,980	3,090
2005 (AN)		990	10	1,700	2,700
2006 (W)		1,220	30	2,280	3,530
2007 (D)		1,000	10	1,650	2,660
2008 (C)		940	0	1,560	2,500
2009 (D)		890	0	1,400	2,290
2010 (BN)		850	0	1,410	2,260
2011 (W)		890	10	1,610	2,510
2012 (BN)		840	0	1,410	2,250
2013 (D)		760	0	1,380	2,140
2014 (C)		580	0	1,230	1,810
2015 (C)		500	0	1,130	1,630
2016 (BN)		650	0	1,330	1,980
2017 (W)		800	20	1,730	2,550
2018 (BN)		650	0	1,270	1,920
Average (1990-2018)		860	10	1,690	2,560
1990-2018	W	970	10	2,050	3,040
	AN	940	10	1,850	2,800
	BN	820	0	1,480	2,300
	D	890	10	1,550	2,450
	C	690	0	1,440	2,130

2.3.5.1.1.4 Groundwater Discharge to Surface Waterways

Groundwater discharge to surface water, as described herein, represents a gain, or increase of flow, in waterways that traverse or flow along the boundary of the Bowman Subbasin. Groundwater discharge in the Bowman Subbasin is calculated from the Tehama IHM as the net groundwater outflow to water reaches (i.e., groundwater discharge) in excess of groundwater inflows from waterway reaches (i.e., seepage). The total volume of estimated groundwater discharge to surface water is summarized in **Figure 2-49** and **Table 2-16**, averaging approximately 16 taf per year.

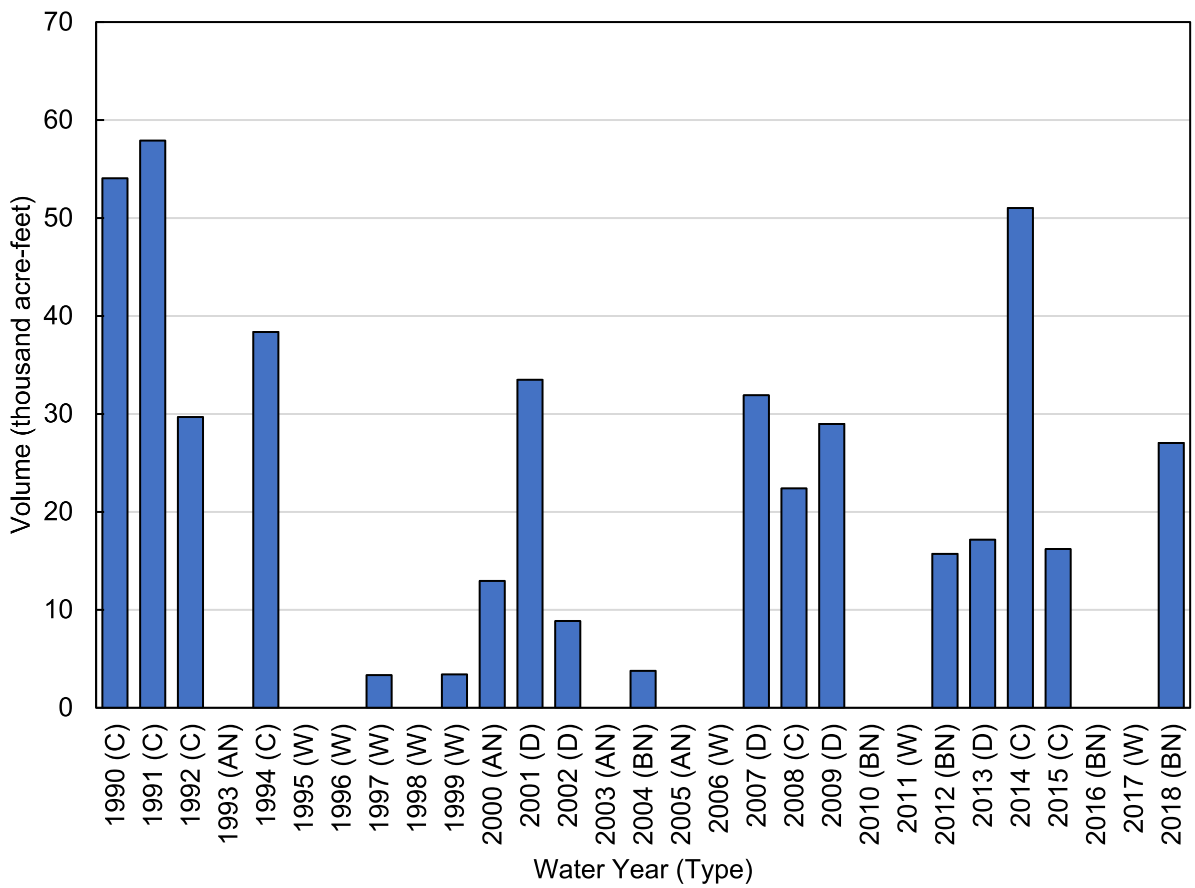


Figure 2-49. Bowman Subbasin Groundwater Discharge to Surface Water

Table 2-16. Bowman Subbasin Groundwater Discharge to Surface Water (acre-feet, rounded)

<table>
<tr><th colspan="2">Water Year (Type)</th><th>Groundwater Discharge to Surface Water</th></tr>
<tr><td colspan="2">1990 (C)</td><td>54,040</td></tr>
<tr><td colspan="2">1991 (C)</td><td>57,900</td></tr>
<tr><td colspan="2">1992 (C)</td><td>29,670</td></tr>
<tr><td colspan="2">1993 (AN)</td><td>0</td></tr>
<tr><td colspan="2">1994 (C)</td><td>38,370</td></tr>
<tr><td colspan="2">1995 (W)</td><td>0</td></tr>
<tr><td colspan="2">1996 (W)</td><td>0</td></tr>
<tr><td colspan="2">1997 (W)</td><td>3,330</td></tr>
<tr><td colspan="2">1998 (W)</td><td>0</td></tr>
<tr><td colspan="2">1999 (W)</td><td>3,410</td></tr>
<tr><td colspan="2">2000 (AN)</td><td>12,940</td></tr>
<tr><td colspan="2">2001 (D)</td><td>33,500</td></tr>
<tr><td colspan="2">2002 (D)</td><td>8,840</td></tr>
<tr><td colspan="2">2003 (AN)</td><td>0</td></tr>
<tr><td colspan="2">2004 (BN)</td><td>3,770</td></tr>
<tr><td colspan="2">2005 (AN)</td><td>0</td></tr>
<tr><td colspan="2">2006 (W)</td><td>0</td></tr>
<tr><td colspan="2">2007 (D)</td><td>31,890</td></tr>
<tr><td colspan="2">2008 (C)</td><td>22,390</td></tr>
<tr><td colspan="2">2009 (D)</td><td>28,990</td></tr>
<tr><td colspan="2">2010 (BN)</td><td>0</td></tr>
<tr><td colspan="2">2011 (W)</td><td>0</td></tr>
<tr><td colspan="2">2012 (BN)</td><td>15,710</td></tr>
<tr><td colspan="2">2013 (D)</td><td>17,170</td></tr>
<tr><td colspan="2">2014 (C)</td><td>51,020</td></tr>
<tr><td colspan="2">2015 (C)</td><td>16,190</td></tr>
<tr><td colspan="2">2016 (BN)</td><td>0</td></tr>
<tr><td colspan="2">2017 (W)</td><td>0</td></tr>
<tr><td colspan="2">2018 (BN)</td><td>27,050</td></tr>
<tr><td colspan="2">Average (1990-2018)</td><td>15,730</td></tr>
<tr><td rowspan="5">1990-2018</td><td>W</td><td>840</td></tr>
<tr><td>AN</td><td>3,240</td></tr>
<tr><td>BN</td><td>9,310</td></tr>
<tr><td>D</td><td>24,080</td></tr>
<tr><td>C</td><td>38,510</td></tr>
</table>

2.3.5.1.2 Outflows

2.3.5.1.2.1 Evapotranspiration by Water Use Sector

Evapotranspiration (ET) by water use sector is reported in **Figure 2-50 through Figure 2-53**, and **Table 2-17 through Table 2-20**. First, total ET is reported, followed by ET from applied water (ET of water actively applied from surface water deliveries or groundwater pumping), ET of groundwater uptake (ET of shallow water extracted directly by vegetation), and ET from precipitation (ET of water supplied through rainfall).

Total ET varies between years, with the lowest observed in 2014, at approximately 140 taf, and greatest in 2005, at approximately 200 taf. Agricultural ET tends to increase slightly in drier years due to increased climatic demand, while the ET of native vegetation typically decreases due to reduced water supply.

ET of applied water occurs primarily from agricultural land, averaging 9 taf in wet years and more than 11 taf in years classified as below normal, dry, or critical. Flood irrigation practices that are typically used to support major crops in the Bowman Subbasin, such as pasture, alfalfa, and grain crops, generally result in lower irrigation efficiencies than are achieved by pressurized irrigation systems, resulting in higher volumes of applied water relative to ET demand. These trends in applied water and irrigation efficiencies in the Bowman Subbasin are supported by irrigation assessments offered and conducted by the Resource Conservation District of Tehama County.

Agricultural crops and native vegetation in the Bowman Subbasin also directly consume shallow groundwater to meet a portion of their consumptive use requirements. ET of groundwater uptake by agricultural crops and native vegetation totals 0.9 taf and 1.7 taf per year, on average. The average volume of ET contributed by shallow groundwater uptake represents approximately 5 percent and 1 percent of the total ET in the agricultural and native vegetation water use sectors, respectively.

ET of precipitation generally follows the pattern of precipitation, with higher volumes occurring in wet years when more precipitation occurs. Across all water use sectors, ET of precipitation in the Bowman Subbasin averages 167 taf in wet years and 149 taf in critical water years. Much of the total ET of precipitation results from the large acreage of native vegetation in the Bowman Subbasin.

Evaporation from rivers, streams, and canals in the Bowman Subbasin is reported in **Figure 2-54** and **Table 2-19**. The total volume is relatively small and constant between years, averaging less than 1 taf per year. Evaporation from upgradient small watersheds is minimal, and is also not considered to substantially contribute to the Subbasin SWS water budget.

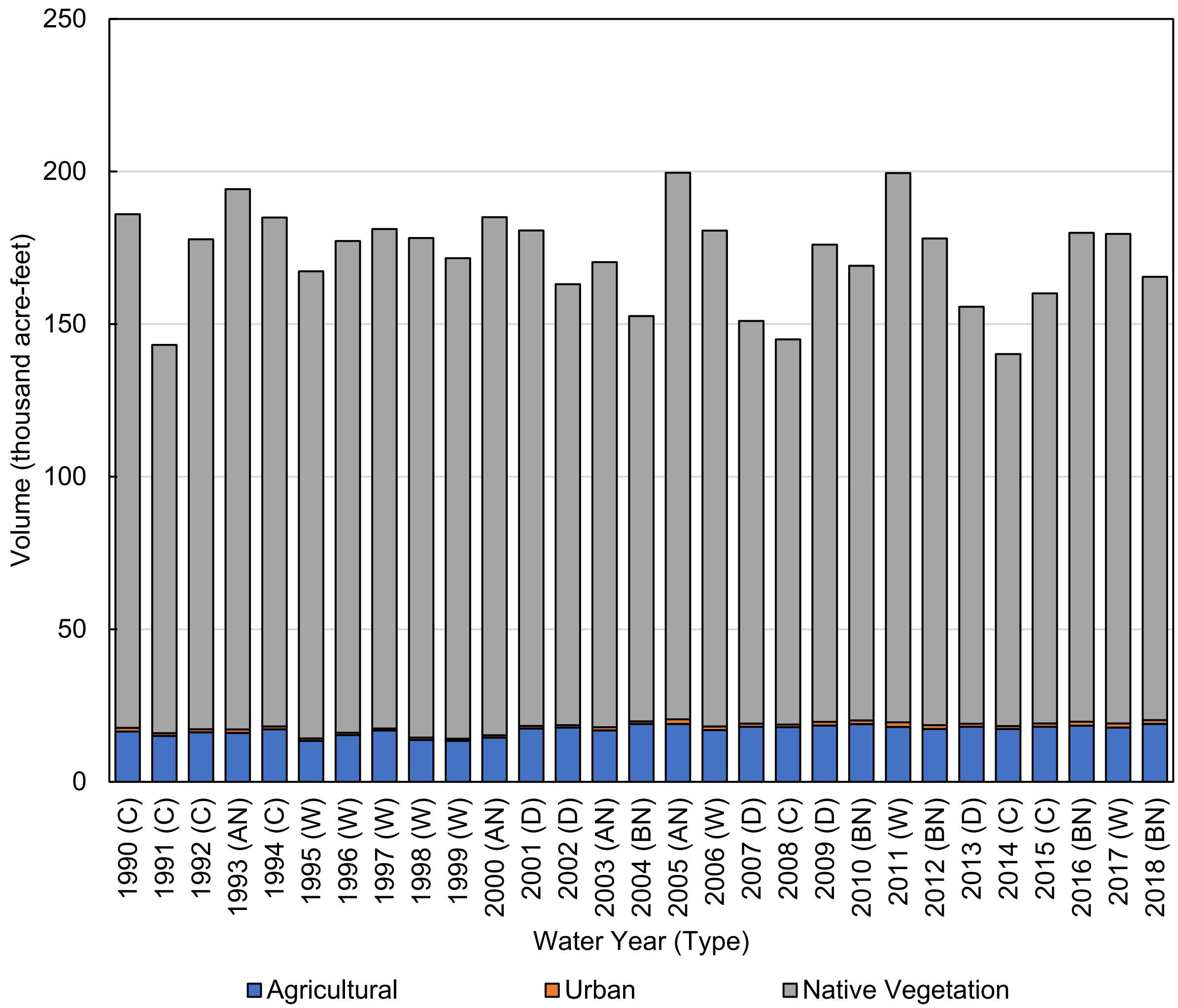


Figure 2-50. Bowman Subbasin Total Evapotranspiration, by Water Use Sector

Table 2-17. Bowman Subbasin Total Evapotranspiration, by Water Use Sector (acre-feet, rounded)

<table>
<tr><th colspan="2">Water Year (Type)</th><th>Agricultural</th><th>Urban</th><th>Native Vegetation</th><th>Total</th></tr>
<tr><td colspan="2">1990 (C)</td><td>16,520</td><td>1,160</td><td>168,350</td><td>186,030</td></tr>
<tr><td colspan="2">1991 (C)</td><td>15,080</td><td>840</td><td>127,280</td><td>143,200</td></tr>
<tr><td colspan="2">1992 (C)</td><td>16,240</td><td>990</td><td>160,570</td><td>177,800</td></tr>
<tr><td colspan="2">1993 (AN)</td><td>16,060</td><td>1,120</td><td>177,060</td><td>194,240</td></tr>
<tr><td colspan="2">1994 (C)</td><td>17,220</td><td>930</td><td>166,800</td><td>184,950</td></tr>
<tr><td colspan="2">1995 (W)</td><td>13,450</td><td>780</td><td>153,100</td><td>167,330</td></tr>
<tr><td colspan="2">1996 (W)</td><td>15,320</td><td>780</td><td>161,160</td><td>177,260</td></tr>
<tr><td colspan="2">1997 (W)</td><td>16,790</td><td>700</td><td>163,660</td><td>181,150</td></tr>
<tr><td colspan="2">1998 (W)</td><td>13,730</td><td>770</td><td>163,710</td><td>178,210</td></tr>
<tr><td colspan="2">1999 (W)</td><td>13,480</td><td>650</td><td>157,480</td><td>171,610</td></tr>
<tr><td colspan="2">2000 (AN)</td><td>14,470</td><td>780</td><td>169,780</td><td>185,030</td></tr>
<tr><td colspan="2">2001 (D)</td><td>17,510</td><td>800</td><td>162,400</td><td>180,710</td></tr>
<tr><td colspan="2">2002 (D)</td><td>17,800</td><td>790</td><td>144,490</td><td>163,080</td></tr>
<tr><td colspan="2">2003 (AN)</td><td>16,880</td><td>1,010</td><td>152,430</td><td>170,320</td></tr>
<tr><td colspan="2">2004 (BN)</td><td>18,960</td><td>830</td><td>132,860</td><td>152,650</td></tr>
<tr><td colspan="2">2005 (AN)</td><td>18,980</td><td>1,480</td><td>179,130</td><td>199,590</td></tr>
<tr><td colspan="2">2006 (W)</td><td>16,990</td><td>1,190</td><td>162,470</td><td>180,650</td></tr>
<tr><td colspan="2">2007 (D)</td><td>18,080</td><td>1,020</td><td>131,950</td><td>151,050</td></tr>
<tr><td colspan="2">2008 (C)</td><td>17,880</td><td>890</td><td>126,230</td><td>145,000</td></tr>
<tr><td colspan="2">2009 (D)</td><td>18,480</td><td>1,200</td><td>156,370</td><td>176,050</td></tr>
<tr><td colspan="2">2010 (BN)</td><td>18,920</td><td>1,210</td><td>148,990</td><td>169,120</td></tr>
<tr><td colspan="2">2011 (W)</td><td>17,990</td><td>1,500</td><td>180,020</td><td>199,510</td></tr>
<tr><td colspan="2">2012 (BN)</td><td>17,330</td><td>1,250</td><td>159,460</td><td>178,040</td></tr>
<tr><td colspan="2">2013 (D)</td><td>18,030</td><td>1,010</td><td>136,660</td><td>155,700</td></tr>
<tr><td colspan="2">2014 (C)</td><td>17,310</td><td>970</td><td>121,910</td><td>140,190</td></tr>
<tr><td colspan="2">2015 (C)</td><td>18,030</td><td>1,090</td><td>140,960</td><td>160,080</td></tr>
<tr><td colspan="2">2016 (BN)</td><td>18,440</td><td>1,290</td><td>160,210</td><td>179,940</td></tr>
<tr><td colspan="2">2017 (W)</td><td>17,790</td><td>1,360</td><td>160,390</td><td>179,540</td></tr>
<tr><td colspan="2">2018 (BN)</td><td>18,990</td><td>1,230</td><td>145,270</td><td>165,490</td></tr>
<tr><td colspan="2">Average (1990-2018)</td><td>16,990</td><td>1,030</td><td>154,180</td><td>172,190</td></tr>
<tr><td rowspan="5">1990-2018</td><td>W</td><td>15,690</td><td>960</td><td>162,750</td><td>179,410</td></tr>
<tr><td>AN</td><td>16,600</td><td>1,110</td><td>169,610</td><td>187,300</td></tr>
<tr><td>BN</td><td>18,530</td><td>1,160</td><td>149,360</td><td>169,050</td></tr>
<tr><td>D</td><td>17,970</td><td>970</td><td>146,380</td><td>165,320</td></tr>
<tr><td>C</td><td>16,900</td><td>980</td><td>144,590</td><td>162,460</td></tr>
</table>

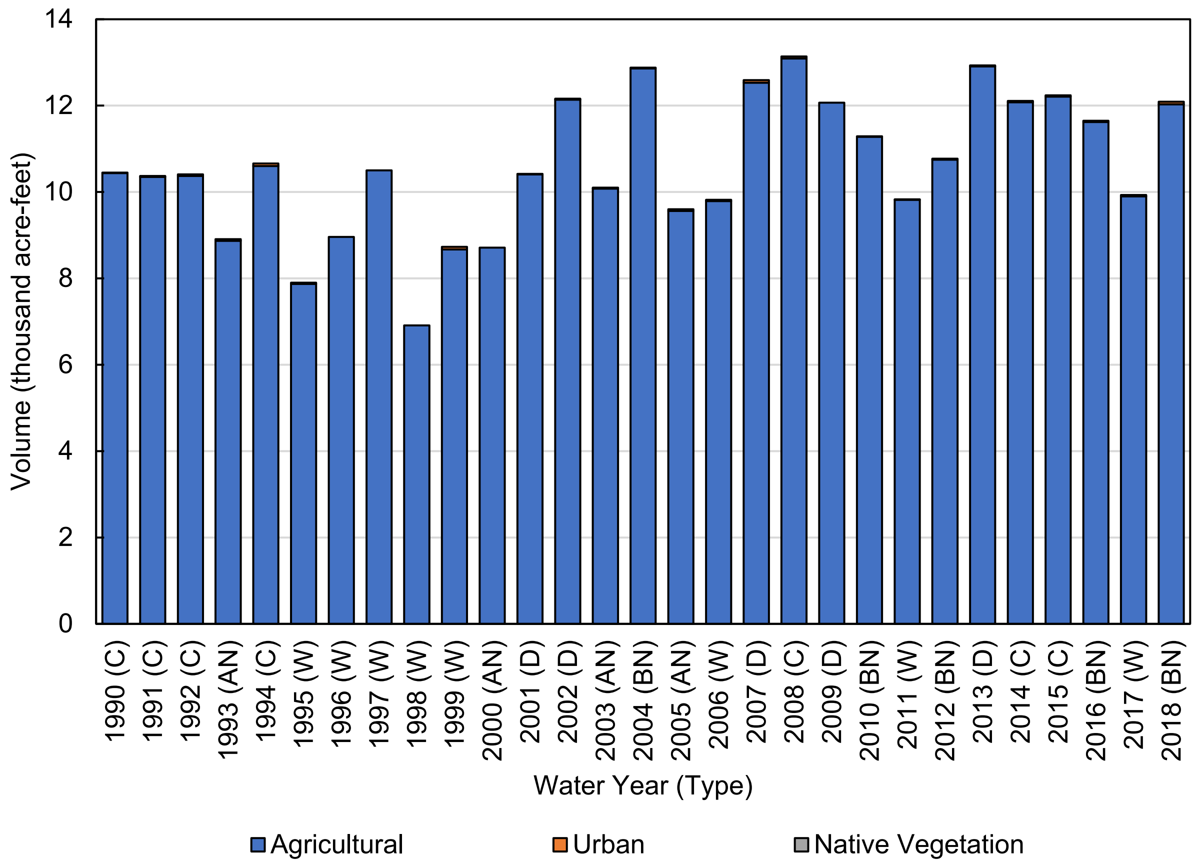


Figure 2-51. Bowman Subbasin Evapotranspiration of Applied Water, by Water Use Sector

Table 2-18. Bowman Subbasin Evapotranspiration of Applied Water, by Water Use Sector (acre-feet, rounded)

Water Year (Type)	Agricultural	Urban	Native Vegetation	Total
1990 (C)	10,440	10	0	10,450
1991 (C)	10,350	20	0	10,370
1992 (C)	10,370	40	0	10,410
1993 (AN)	8,870	40	0	8,910
1994 (C)	10,600	60	0	10,660
1995 (W)	7,870	30	0	7,900
1996 (W)	8,960	0	0	8,960

Water Year (Type)		Agricultural	Urban	Native Vegetation	Total
1997 (W)		10,500	0	0	10,500
1998 (W)		6,910	0	0	6,910
1999 (W)		8,670	60	0	8,730
2000 (AN)		8,710	0	0	8,710
2001 (D)		10,410	10	0	10,420
2002 (D)		12,140	20	0	12,160
2003 (AN)		10,080	20	0	10,100
2004 (BN)		12,860	20	0	12,880
2005 (AN)		9,560	40	0	9,600
2006 (W)		9,790	30	0	9,820
2007 (D)		12,530	60	0	12,590
2008 (C)		13,090	50	0	13,140
2009 (D)		12,070	0	0	12,070
2010 (BN)		11,280	10	0	11,290
2011 (W)		9,820	10	0	9,830
2012 (BN)		10,750	20	0	10,770
2013 (D)		12,910	20	0	12,930
2014 (C)		12,080	30	0	12,110
2015 (C)		12,210	30	0	12,240
2016 (BN)		11,620	30	0	11,650
2017 (W)		9,900	30	0	9,930
2018 (BN)		12,030	60	0	12,090
Average (1990-2018)		10,600	30	0	10,630
1990-2018	W	9,050	20	0	9,070
	AN	9,310	30	0	9,330
	BN	11,710	30	0	11,740
	D	12,010	20	0	12,030
	C	11,310	30	0	11,340

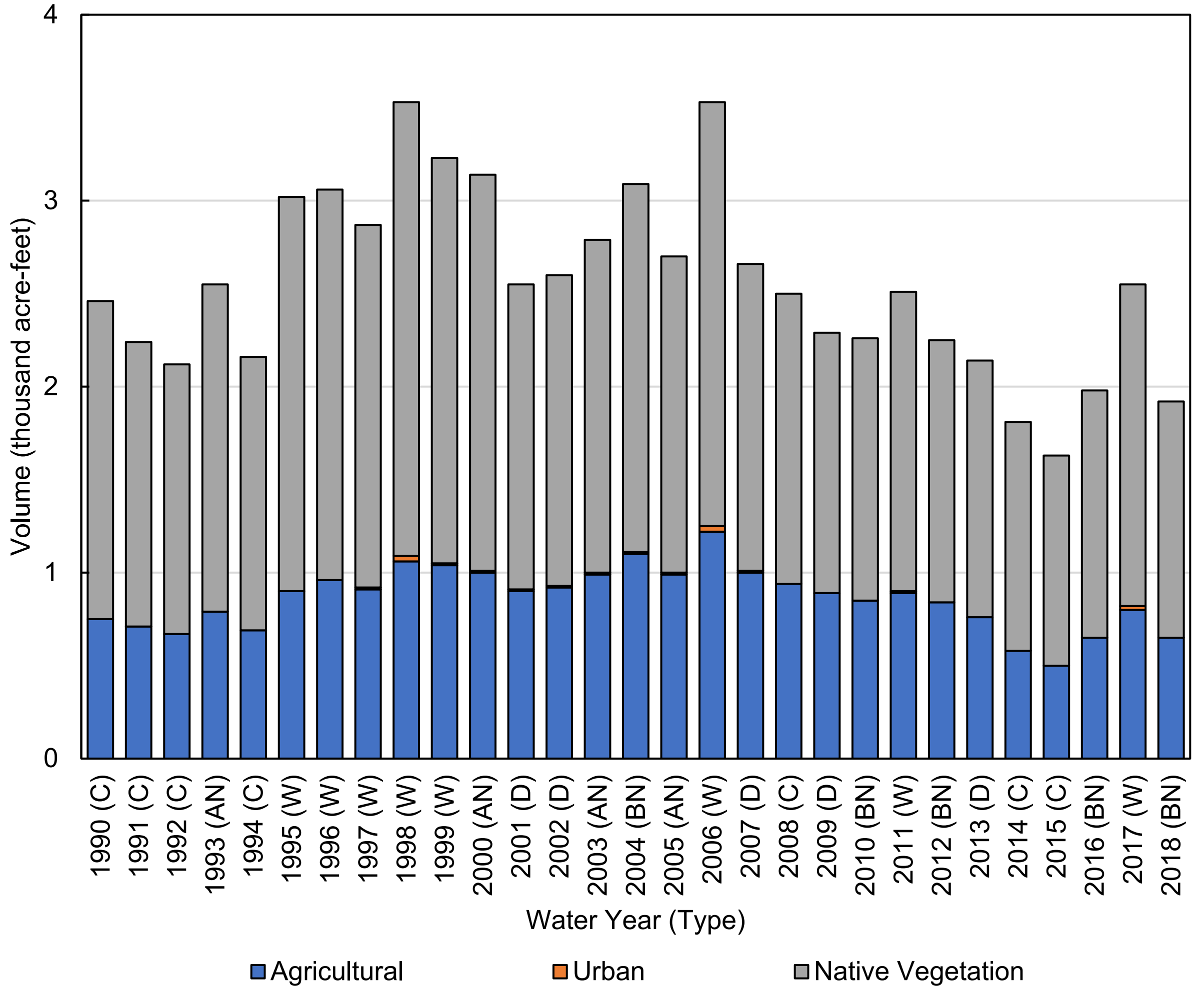


Figure 2-52. Bowman Subbasin Evapotranspiration of Groundwater Uptake, by Water Use Sector

Table 2-19. Bowman Subbasin Evapotranspiration of Groundwater Uptake, by Water Use Sector (acre-feet, rounded)

Water Year (Type)		Agricultural	Urban	Native Vegetation	Total
1990 (C)		750	0	1,710	2,460
1991 (C)		710	0	1,530	2,240
1992 (C)		670	0	1,450	2,120
1993 (AN)		790	0	1,760	2,550
1994 (C)		690	0	1,470	2,160
1995 (W)		900	0	2,120	3,020
1996 (W)		960	0	2,100	3,060
1997 (W)		910	10	1,950	2,870
1998 (W)		1,060	30	2,440	3,530
1999 (W)		1,040	10	2,180	3,230
2000 (AN)		1,000	10	2,130	3,140
2001 (D)		900	10	1,640	2,550
2002 (D)		920	10	1,670	2,600
2003 (AN)		990	10	1,790	2,790
2004 (BN)		1,100	10	1,980	3,090
2005 (AN)		990	10	1,700	2,700
2006 (W)		1,220	30	2,280	3,530
2007 (D)		1,000	10	1,650	2,660
2008 (C)		940	0	1,560	2,500
2009 (D)		890	0	1,400	2,290
2010 (BN)		850	0	1,410	2,260
2011 (W)		890	10	1,610	2,510
2012 (BN)		840	0	1,410	2,250
2013 (D)		760	0	1,380	2,140
2014 (C)		580	0	1,230	1,810
2015 (C)		500	0	1,130	1,630
2016 (BN)		650	0	1,330	1,980
2017 (W)		800	20	1,730	2,550
2018 (BN)		650	0	1,270	1,920
Average (1990-2018)		860	10	1,690	2,560
1990-2018	W	970	10	2,050	3,040
	AN	940	10	1,850	2,800
	BN	820	0	1,480	2,300
	D	890	10	1,550	2,450
	C	690	0	1,440	2,130

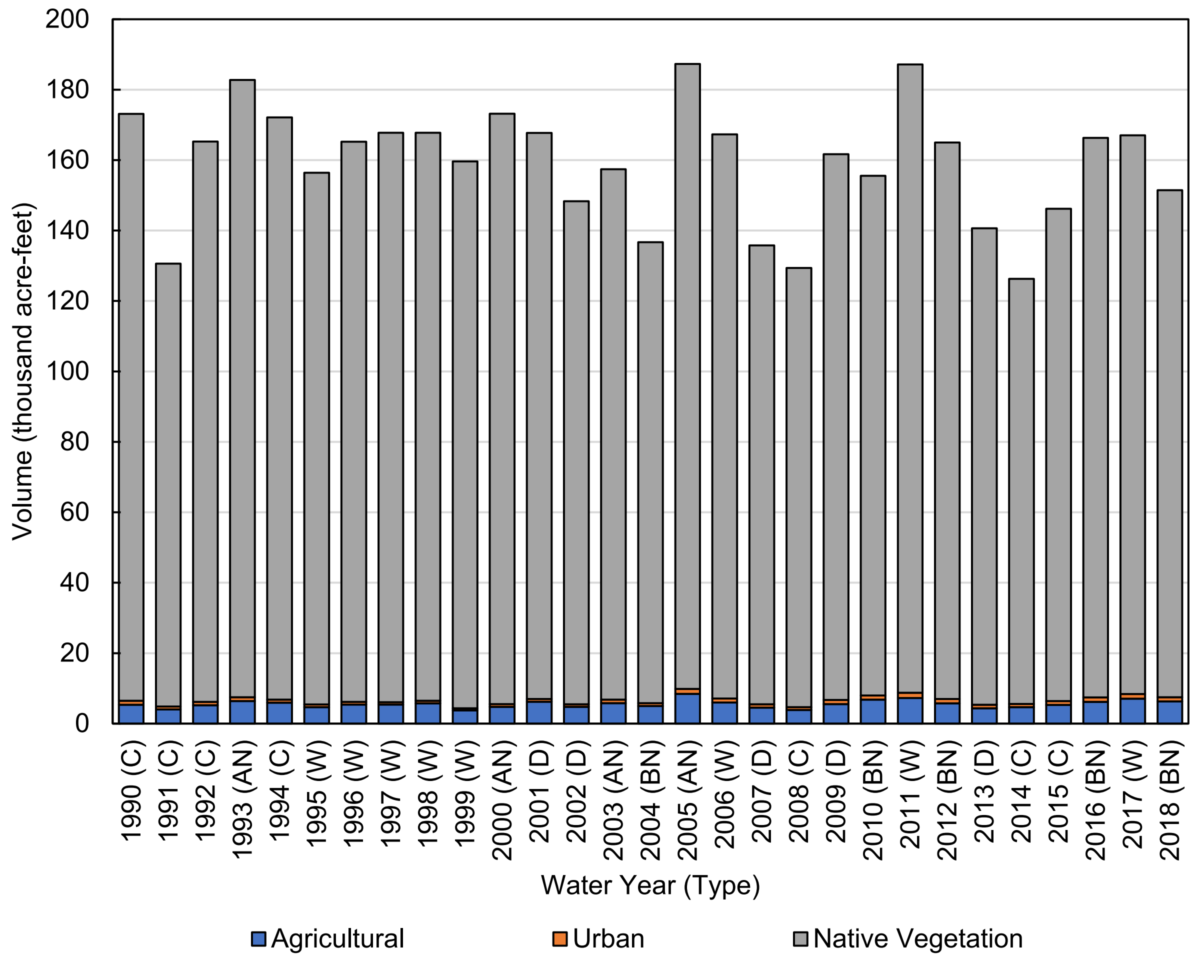


Figure 2-53. Bowman Subbasin Evapotranspiration of Precipitation, by Water Use Sector

Table 2-20. Bowman Subbasin Evapotranspiration of Precipitation, by Water Use Sector (acre-feet, rounded)

<table>
<tr><th colspan="2">Water Year (Type)</th><th>Agricultural</th><th>Urban</th><th>Native Vegetation</th><th>Total</th></tr>
<tr><td colspan="2">1990 (C)</td><td>5,330</td><td>1,150</td><td>166,640</td><td>173,120</td></tr>
<tr><td colspan="2">1991 (C)</td><td>4,020</td><td>820</td><td>125,750</td><td>130,590</td></tr>
<tr><td colspan="2">1992 (C)</td><td>5,200</td><td>950</td><td>159,120</td><td>165,270</td></tr>
<tr><td colspan="2">1993 (AN)</td><td>6,400</td><td>1,080</td><td>175,300</td><td>182,780</td></tr>
<tr><td colspan="2">1994 (C)</td><td>5,930</td><td>870</td><td>165,330</td><td>172,130</td></tr>
<tr><td colspan="2">1995 (W)</td><td>4,680</td><td>750</td><td>150,980</td><td>156,410</td></tr>
<tr><td colspan="2">1996 (W)</td><td>5,400</td><td>780</td><td>159,060</td><td>165,240</td></tr>
<tr><td colspan="2">1997 (W)</td><td>5,380</td><td>690</td><td>161,710</td><td>167,780</td></tr>
<tr><td colspan="2">1998 (W)</td><td>5,760</td><td>740</td><td>161,270</td><td>167,770</td></tr>
<tr><td colspan="2">1999 (W)</td><td>3,770</td><td>580</td><td>155,300</td><td>159,650</td></tr>
<tr><td colspan="2">2000 (AN)</td><td>4,760</td><td>770</td><td>167,650</td><td>173,180</td></tr>
<tr><td colspan="2">2001 (D)</td><td>6,200</td><td>780</td><td>160,760</td><td>167,740</td></tr>
<tr><td colspan="2">2002 (D)</td><td>4,740</td><td>760</td><td>142,820</td><td>148,320</td></tr>
<tr><td colspan="2">2003 (AN)</td><td>5,810</td><td>980</td><td>150,640</td><td>157,430</td></tr>
<tr><td colspan="2">2004 (BN)</td><td>5,000</td><td>800</td><td>130,880</td><td>136,680</td></tr>
<tr><td colspan="2">2005 (AN)</td><td>8,430</td><td>1,430</td><td>177,430</td><td>187,290</td></tr>
<tr><td colspan="2">2006 (W)</td><td>5,980</td><td>1,130</td><td>160,190</td><td>167,300</td></tr>
<tr><td colspan="2">2007 (D)</td><td>4,550</td><td>950</td><td>130,300</td><td>135,800</td></tr>
<tr><td colspan="2">2008 (C)</td><td>3,850</td><td>840</td><td>124,670</td><td>129,360</td></tr>
<tr><td colspan="2">2009 (D)</td><td>5,520</td><td>1,200</td><td>154,970</td><td>161,690</td></tr>
<tr><td colspan="2">2010 (BN)</td><td>6,790</td><td>1,200</td><td>147,580</td><td>155,570</td></tr>
<tr><td colspan="2">2011 (W)</td><td>7,280</td><td>1,480</td><td>178,410</td><td>187,170</td></tr>
<tr><td colspan="2">2012 (BN)</td><td>5,740</td><td>1,230</td><td>158,050</td><td>165,020</td></tr>
<tr><td colspan="2">2013 (D)</td><td>4,360</td><td>990</td><td>135,280</td><td>140,630</td></tr>
<tr><td colspan="2">2014 (C)</td><td>4,650</td><td>940</td><td>120,680</td><td>126,270</td></tr>
<tr><td colspan="2">2015 (C)</td><td>5,320</td><td>1,060</td><td>139,830</td><td>146,210</td></tr>
<tr><td colspan="2">2016 (BN)</td><td>6,170</td><td>1,260</td><td>158,880</td><td>166,310</td></tr>
<tr><td colspan="2">2017 (W)</td><td>7,090</td><td>1,310</td><td>158,660</td><td>167,060</td></tr>
<tr><td colspan="2">2018 (BN)</td><td>6,310</td><td>1,170</td><td>144,000</td><td>151,480</td></tr>
<tr><td colspan="2">Average (1990-2018)</td><td>5,530</td><td>990</td><td>152,490</td><td>159,010</td></tr>
<tr><td rowspan="5">1990-2018</td><td>W</td><td>5,670</td><td>930</td><td>160,700</td><td>167,300</td></tr>
<tr><td>AN</td><td>6,350</td><td>1,070</td><td>167,760</td><td>175,170</td></tr>
<tr><td>BN</td><td>6,000</td><td>1,130</td><td>147,880</td><td>155,010</td></tr>
<tr><td>D</td><td>5,070</td><td>940</td><td>144,830</td><td>150,840</td></tr>
<tr><td>C</td><td>4,900</td><td>950</td><td>143,150</td><td>148,990</td></tr>
</table>

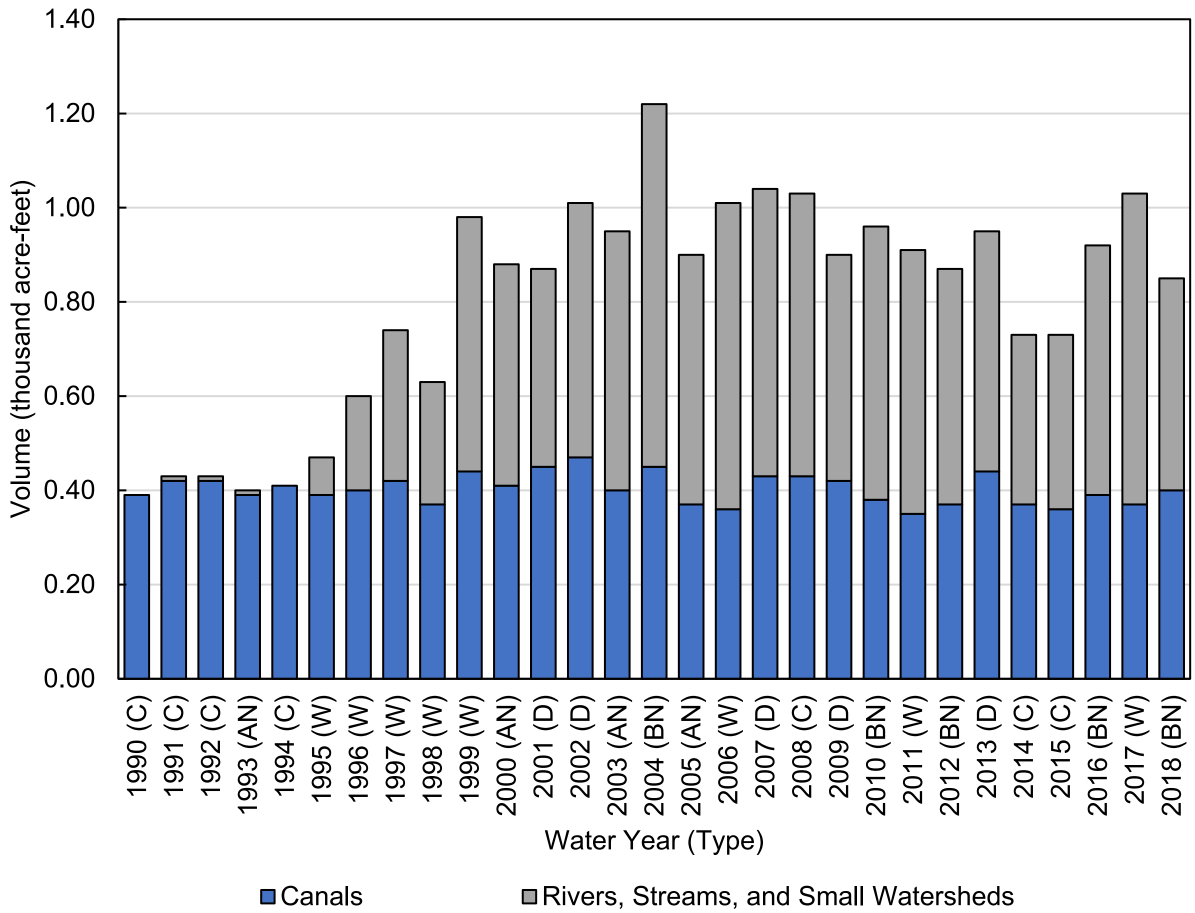


Figure 2-54. Bowman Subbasin Evaporation of Surface Water Sources

Table 2-21. Bowman Subbasin Evaporation of Surface Water Sources,

by Water Use Sector (acre-feet, rounded)

<table>
<tr><th colspan="2">Water Year (Type)</th><th>Canals</th><th>Rivers, Streams, and Small Watersheds[1]</th><th>Total</th></tr>
<tr><td colspan="2">1990 (C)</td><td>390</td><td>0</td><td>390</td></tr>
<tr><td colspan="2">1991 (C)</td><td>420</td><td>10</td><td>430</td></tr>
<tr><td colspan="2">1992 (C)</td><td>420</td><td>10</td><td>430</td></tr>
<tr><td colspan="2">1993 (AN)</td><td>390</td><td>10</td><td>400</td></tr>
<tr><td colspan="2">1994 (C)</td><td>410</td><td>0</td><td>410</td></tr>
<tr><td colspan="2">1995 (W)</td><td>390</td><td>80</td><td>470</td></tr>
<tr><td colspan="2">1996 (W)</td><td>400</td><td>200</td><td>600</td></tr>
<tr><td colspan="2">1997 (W)</td><td>420</td><td>320</td><td>740</td></tr>
<tr><td colspan="2">1998 (W)</td><td>370</td><td>260</td><td>630</td></tr>
<tr><td colspan="2">1999 (W)</td><td>440</td><td>540</td><td>980</td></tr>
<tr><td colspan="2">2000 (AN)</td><td>410</td><td>470</td><td>880</td></tr>
<tr><td colspan="2">2001 (D)</td><td>450</td><td>420</td><td>870</td></tr>
<tr><td colspan="2">2002 (D)</td><td>470</td><td>540</td><td>1,010</td></tr>
<tr><td colspan="2">2003 (AN)</td><td>400</td><td>550</td><td>950</td></tr>
<tr><td colspan="2">2004 (BN)</td><td>450</td><td>770</td><td>1,220</td></tr>
<tr><td colspan="2">2005 (AN)</td><td>370</td><td>530</td><td>900</td></tr>
<tr><td colspan="2">2006 (W)</td><td>360</td><td>650</td><td>1,010</td></tr>
<tr><td colspan="2">2007 (D)</td><td>430</td><td>610</td><td>1,040</td></tr>
<tr><td colspan="2">2008 (C)</td><td>430</td><td>600</td><td>1,030</td></tr>
<tr><td colspan="2">2009 (D)</td><td>420</td><td>480</td><td>900</td></tr>
<tr><td colspan="2">2010 (BN)</td><td>380</td><td>580</td><td>960</td></tr>
<tr><td colspan="2">2011 (W)</td><td>350</td><td>560</td><td>910</td></tr>
<tr><td colspan="2">2012 (BN)</td><td>370</td><td>500</td><td>870</td></tr>
<tr><td colspan="2">2013 (D)</td><td>440</td><td>510</td><td>950</td></tr>
<tr><td colspan="2">2014 (C)</td><td>370</td><td>360</td><td>730</td></tr>
<tr><td colspan="2">2015 (C)</td><td>360</td><td>370</td><td>730</td></tr>
<tr><td colspan="2">2016 (BN)</td><td>390</td><td>530</td><td>920</td></tr>
<tr><td colspan="2">2017 (W)</td><td>370</td><td>660</td><td>1,030</td></tr>
<tr><td colspan="2">2018 (BN)</td><td>400</td><td>450</td><td>850</td></tr>
<tr><td colspan="2">Average (1990-2018)</td><td>400</td><td>400</td><td>800</td></tr>
<tr><td rowspan="5">1990-2018</td><td>W</td><td>390</td><td>410</td><td>800</td></tr>
<tr><td>AN</td><td>390</td><td>390</td><td>780</td></tr>
<tr><td>BN</td><td>400</td><td>570</td><td>960</td></tr>
<tr><td>D</td><td>440</td><td>510</td><td>950</td></tr>
<tr><td>C</td><td>400</td><td>190</td><td>590</td></tr>
</table>

[1] Includes ET of riparian vegetation along rivers and streams.

2.3.5.1.2.2 Surface Water Outflow by Water Source Type

Surface water outflows from the Bowman Subbasin are summarized in **Figure 2-55** and **Table 2-22** by water source type. In the Bowman Subbasin, local supply outflows primarily include outflows of runoff, tailwater, and net drainage from land surfaces, in addition to runoff from small watersheds and stream outflows to the Sacramento River. Local supply outflows average approximately 502 taf per year, and range from 250 taf or less in certain dry and critical water years up to 1,290 taf in 1998. Approximately 1.6 taf of CVP supplies also leave the Subbasin each year in spillage from ACID canals to Cottonwood Creek. Other surface water outflows that leave the Subbasin include outflow of groundwater discharge to the Sacramento River and Cottonwood Creek. This water travels along each respective waterway as part of the flow in the river or creek.

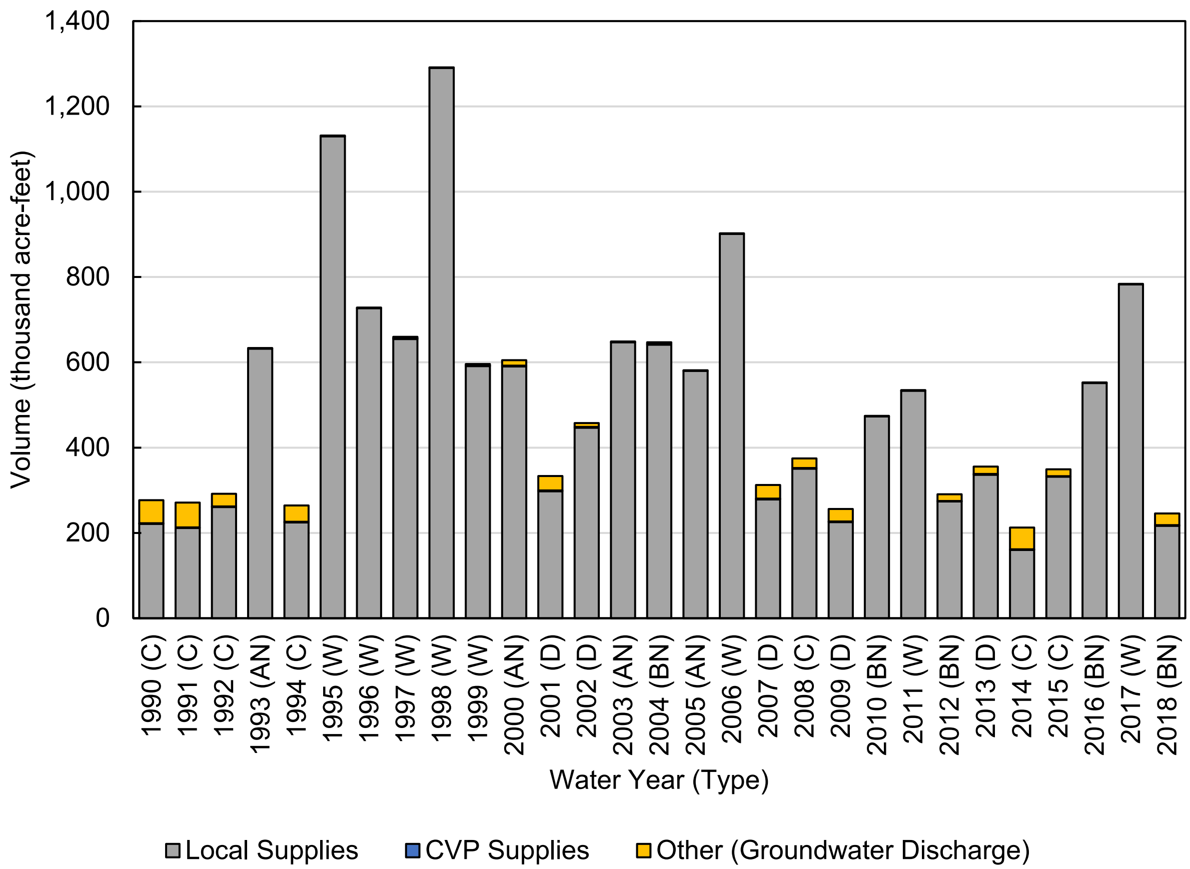


Figure 2-55. Bowman Subbasin Surface Water Outflows, by Water Source Type

Table 2-22. Bowman Subbasin Surface Water Outflows, by Water Source Type (acre-feet, rounded)

Water Year (Type)		CVP Supplies	Local Supplies	Other (Groundwater Discharge)	Total
1990 (C)		1,610	221,250	54,040	276,900
1991 (C)		1,610	211,520	57,900	271,030
1992 (C)		1,610	260,510	29,670	291,790
1993 (AN)		1,610	631,850	0	633,460
1994 (C)		1,610	224,560	38,370	264,540
1995 (W)		1,610	1,129,930	0	1,131,540
1996 (W)		1,610	727,000	0	728,610
1997 (W)		1,720	654,680	3,330	659,730
1998 (W)		1,530	1,290,080	0	1,291,610
1999 (W)		1,770	590,960	3,410	596,140
2000 (AN)		1,770	590,370	12,940	605,080
2001 (D)		1,890	297,950	33,500	333,340
2002 (D)		1,880	446,870	8,840	457,590
2003 (AN)		1,610	647,200	0	648,810
2004 (BN)		1,790	641,500	3,770	647,060
2005 (AN)		1,580	579,930	0	581,510
2006 (W)		1,480	901,120	0	902,600
2007 (D)		1,840	278,670	31,890	312,400
2008 (C)		1,680	350,640	22,390	374,710
2009 (D)		1,700	225,360	28,990	256,050
2010 (BN)		1,570	473,060	0	474,630
2011 (W)		1,460	533,300	0	534,760
2012 (BN)		1,460	273,640	15,710	290,810
2013 (D)		1,790	336,430	17,170	355,390
2014 (C)		1,390	160,110	51,020	212,520
2015 (C)		1,300	331,820	16,190	349,310
2016 (BN)		1,530	551,420	0	552,950
2017 (W)		1,380	782,680	0	784,060
2018 (BN)		1,580	216,870	27,050	245,500
Average (1990-2018)		1,620	502,110	15,730	519,460
1990-2018	W	1,570	826,220	840	828,630
	AN	1,640	612,340	3,240	617,220
	BN	1,590	431,300	9,310	442,190
	D	1,820	317,060	24,080	342,950
	C	1,540	251,490	38,510	291,540

2.3.5.1.2.3 Deep Percolation of Applied Water

Estimated deep percolation of applied water (equal to infiltration of applied water in 23 CCR § 354.18(b)(2)) is summarized in **Figure 2-56** and **Table 2-23** by water use sector. Deep percolation of applied water is dominated by agricultural irrigation and varies between years, following the pattern of surface water diversions and deliveries to irrigated lands.

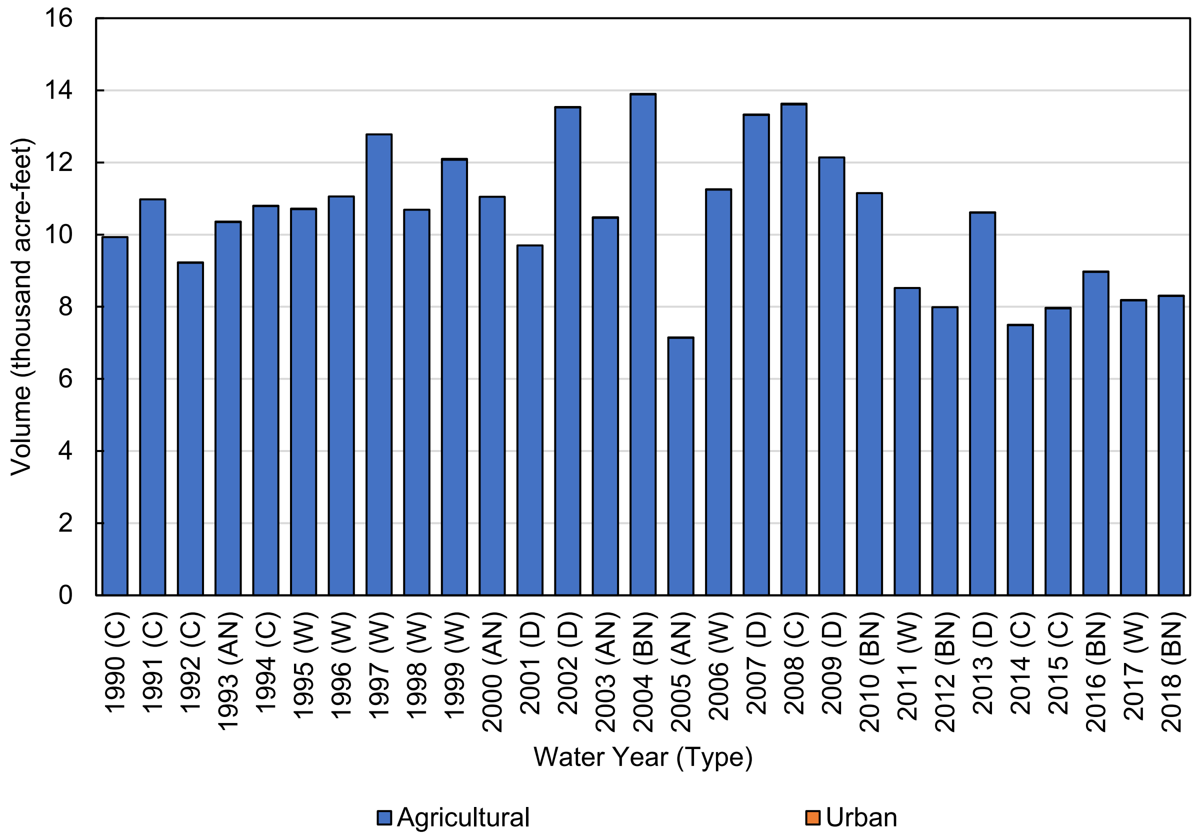


Figure 2-56. Bowman Subbasin Deep Percolation of Applied Water, by Water Use Sector

Table 2-21. Bowman Subbasin Deep Percolation of Applied Water, by Water Use Sector (acre-feet, rounded)

Water Year (Type)		Agricultural	Urban	Native Vegetation	Total
1990 (C)		9,930	0	0	9,930
1991 (C)		10,980	0	0	10,980
1992 (C)		9,220	10	0	9,230
1993 (AN)		10,350	10	0	10,360
1994 (C)		10,790	10	0	10,800
1995 (W)		10,710	10	0	10,720
1996 (W)		11,060	0	0	11,060
1997 (W)		12,780	0	0	12,780
1998 (W)		10,690	0	0	10,690
1999 (W)		12,080	20	0	12,100
2000 (AN)		11,050	0	0	11,050
2001 (D)		9,700	0	0	9,700
2002 (D)		13,530	10	0	13,540
2003 (AN)		10,470	10	0	10,480
2004 (BN)		13,890	10	0	13,900
2005 (AN)		7,140	10	0	7,150
2006 (W)		11,250	10	0	11,260
2007 (D)		13,320	10	0	13,330
2008 (C)		13,610	20	0	13,630
2009 (D)		12,140	0	0	12,140
2010 (BN)		11,150	0	0	11,150
2011 (W)		8,520	0	0	8,520
2012 (BN)		7,990	0	0	7,990
2013 (D)		10,610	10	0	10,620
2014 (C)		7,490	10	0	7,500
2015 (C)		7,960	10	0	7,970
2016 (BN)		8,970	10	0	8,980
2017 (W)		8,180	10	0	8,190
2018 (BN)		8,300	10	0	8,310
Average (1990-2018)		10,480	10	0	10,480
1990-2018	W	10,660	10	0	10,670
	AN	9,750	10	0	9,760
	BN	10,060	10	0	10,070
	D	11,860	10	0	11,870
	C	10,000	10	0	10,010

2.3.5.1.2.4 Deep Percolation of Precipitation

Estimated deep percolation of precipitation (equal to infiltration of precipitation in 23 CCR § 354.18(b)(2)) is provided in **Figure 2-57** and **Table 2-24** by water use sector. Deep percolation of precipitation to the GWS is highly variable from year to year due to variation in the timing and amount of precipitation, ranging from less than 20 taf annually during some critical and dry years to about 105 taf in 1998.

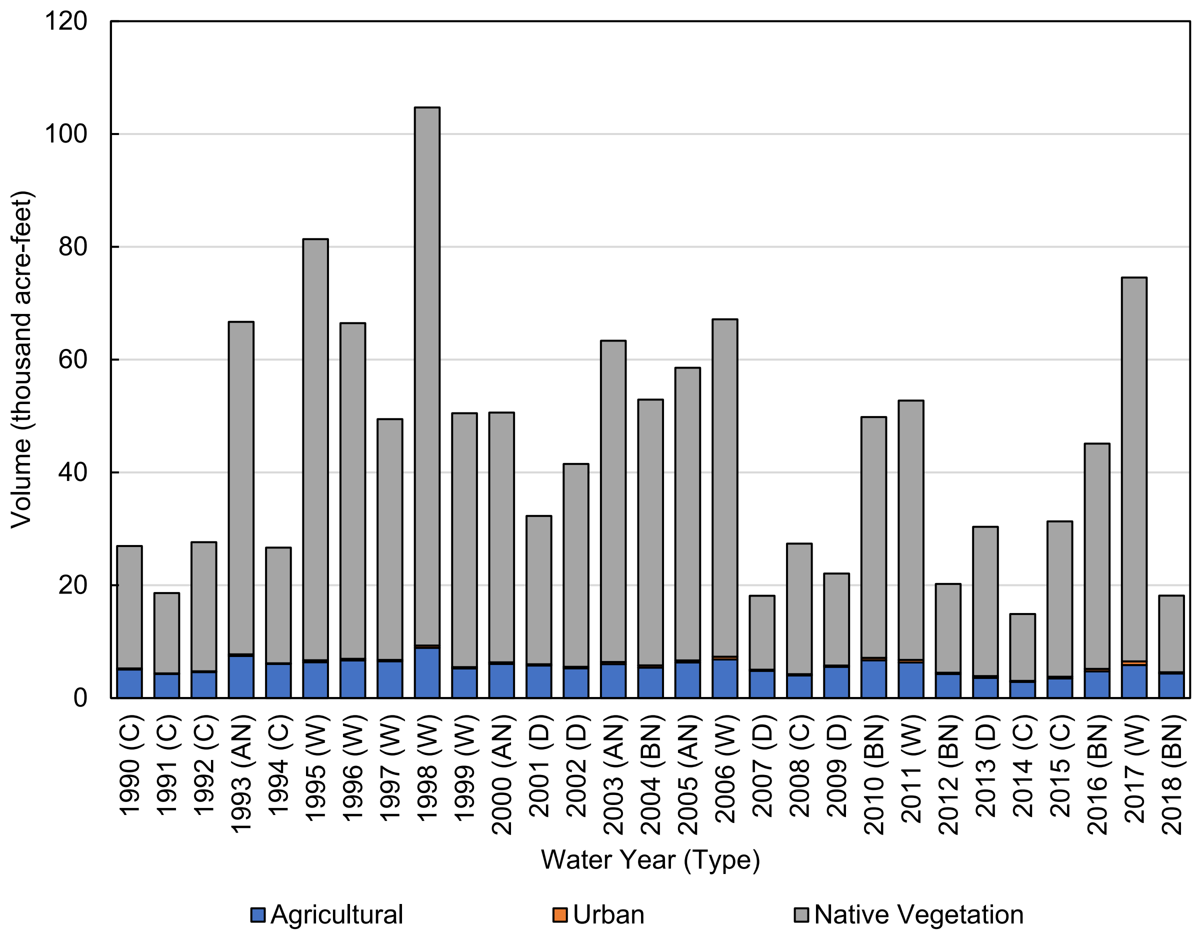


Figure 2-57. Bowman Subbasin Deep Percolation of Precipitation, by Water Use Sector

Table 2-22. Bowman Subbasin Deep Percolation of Precipitation, by Water Use Sector (acre-feet, rounded)

Water Year (Type)		Agricultural	Urban	Native Vegetation	Total
1990 (C)		5,070	200	21,680	26,950
1991 (C)		4,270	120	14,230	18,620
1992 (C)		4,620	140	22,880	27,640
1993 (AN)		7,470	290	58,950	66,710
1994 (C)		6,040	130	20,510	26,680
1995 (W)		6,370	340	74,640	81,350
1996 (W)		6,670	280	59,520	66,470
1997 (W)		6,540	220	42,680	49,440
1998 (W)		8,910	400	95,400	104,710
1999 (W)		5,260	220	45,020	50,500
2000 (AN)		6,040	300	44,280	50,620
2001 (D)		5,770	220	26,300	32,290
2002 (D)		5,280	260	35,970	41,510
2003 (AN)		6,030	370	56,940	63,340
2004 (BN)		5,410	390	47,110	52,910
2005 (AN)		6,300	390	51,870	58,560
2006 (W)		6,860	480	59,820	67,160
2007 (D)		4,840	190	13,120	18,150
2008 (C)		4,000	240	23,130	27,370
2009 (D)		5,550	230	16,310	22,090
2010 (BN)		6,710	410	42,700	49,820
2011 (W)		6,320	440	45,990	52,750
2012 (BN)		4,270	220	15,740	20,230
2013 (D)		3,580	310	26,460	30,350
2014 (C)		2,880	180	11,830	14,890
2015 (C)		3,470	300	27,570	31,340
2016 (BN)		4,760	400	39,940	45,100
2017 (W)		5,860	650	68,040	74,550
2018 (BN)		4,350	230	13,590	18,170
Average (1990-2018)		5,500	290	38,700	44,490
1990-2018	W	6,600	380	61,390	68,370
	AN	6,460	340	53,010	59,810
	BN	5,100	330	31,820	37,250
	D	5,000	240	23,630	28,880
	C	4,340	190	20,260	24,780

2.3.5.1.2.5 Infiltration of Surface Water

Estimated infiltration of surface water (seepage) by water source is provided in **Figure 2-58** and **Table 2-25.** Seepage in the Bowman Subbasin partly comes from conveyance of surface water delivered to irrigators in ACID. The total seepage from all canals and diversions is approximately 12 taf per year, on average. Flows along Cottonwood Creek and runoff from upgradient small watersheds also contribute seepage to the Bowman Subbasin, averaging about 9 taf per year.

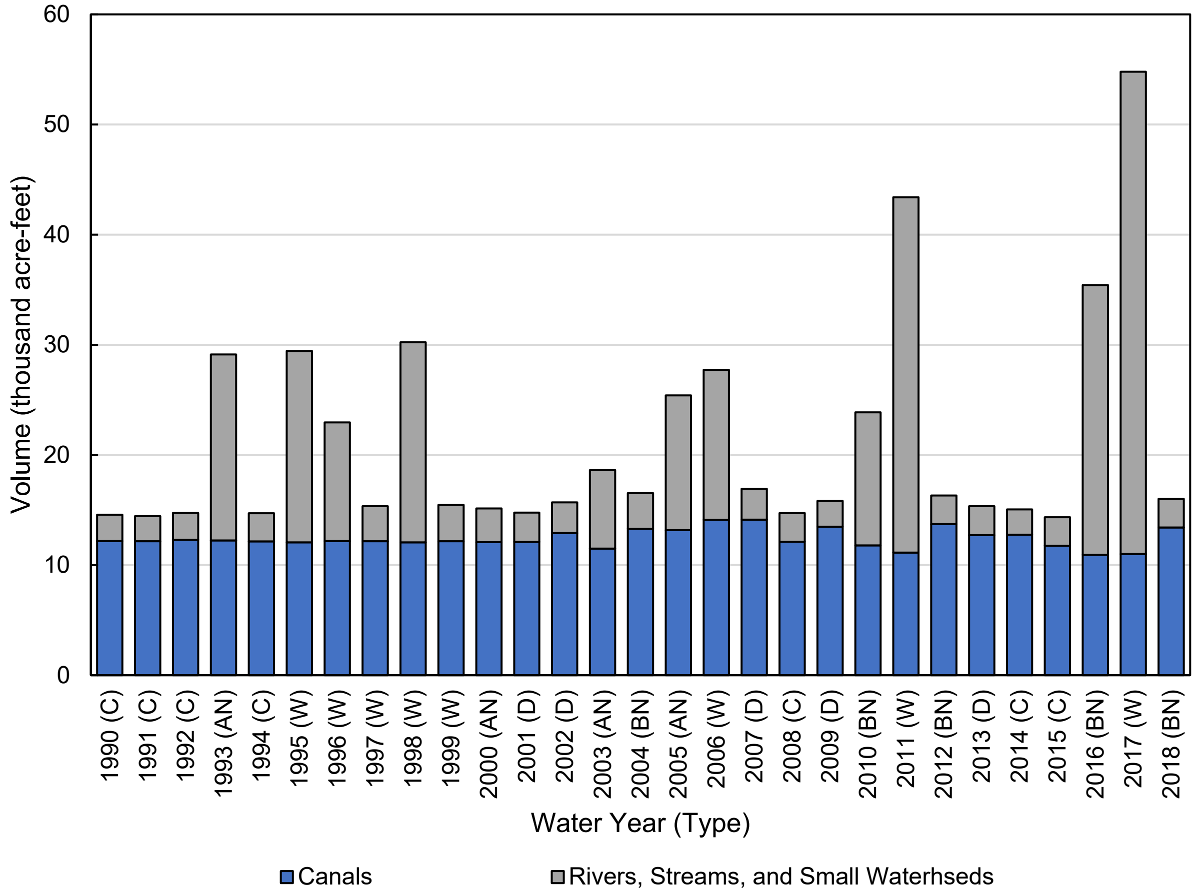


Figure 2-58. Bowman Subbasin Infiltration of Surface Water, by Water Use Sector

Table 2-23. Bowman Subbasin Infiltration of Surface Water, by Water Use Sector (acre-feet, rounded)

Water Year (Type)	Canals	Rivers, Streams, and Small Watersheds	Total
1990 (C)	12,180	2,400	14,580
1991 (C)	12,170	2,280	14,450
1992 (C)	12,290	2,450	14,740
1993 (AN)	12,240	16,880	29,120
1994 (C)	12,150	2,560	14,710
1995 (W)	12,070	17,370	29,440
1996 (W)	12,180	10,770	22,950
1997 (W)	12,170	3,170	15,340
1998 (W)	12,070	18,160	30,230
1999 (W)	12,160	3,300	15,460
2000 (AN)	12,080	3,060	15,140
2001 (D)	12,110	2,650	14,760
2002 (D)	12,900	2,790	15,690
2003 (AN)	11,490	7,130	18,620
2004 (BN)	13,300	3,230	16,530
2005 (AN)	13,170	12,230	25,400
2006 (W)	14,110	13,620	27,730
2007 (D)	14,130	2,790	16,920
2008 (C)	12,120	2,600	14,720
2009 (D)	13,490	2,340	15,830
2010 (BN)	11,790	12,080	23,870
2011 (W)	11,130	32,260	43,390
2012 (BN)	13,720	2,600	16,320
2013 (D)	12,720	2,630	15,350
2014 (C)	12,760	2,300	15,060
2015 (C)	11,760	2,580	14,340
2016 (BN)	10,930	24,490	35,420
2017 (W)	11,000	43,790	54,790
2018 (BN)	13,420	2,590	16,010
Average (1990-2018)	12,410	8,870	21,270
1990-2018 W	12,110	17,810	29,920
1990-2018 AN	12,250	9,830	22,070
1990-2018 BN	12,630	9,000	21,630
1990-2018 D	13,070	2,640	15,710
1990-2018 C	12,200	2,450	14,660

2.3.5.1.3 *Change in Root Zone Storage*

Estimates of change in root zone storage are provided in **Figure 2-59** and **Table 2-26**. Inter-annual changes in storage within the SWS consist primarily of root zone soil moisture storage changes, are relatively small, and tend to average near zero over many years.

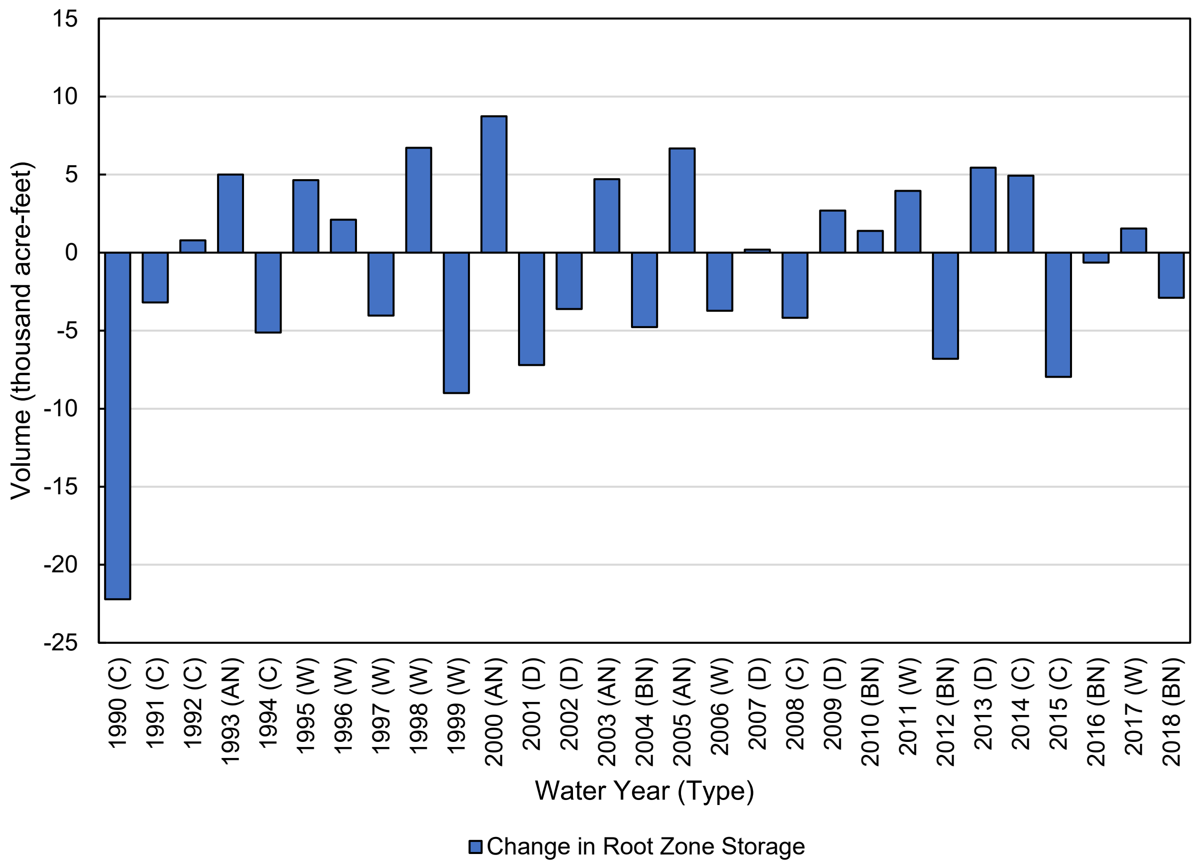


Figure 2-59. Bowman Subbasin Change in Root Zone Storage,

Table 2-24. Bowman Subbasin Change in Root Zone Storage (acre-feet, rounded)

Water Year (Type)		Change in Root Zone Storage
1990 (C)		-22,210
1991 (C)		-3,190
1992 (C)		790
1993 (AN)		5,000
1994 (C)		-5,120
1995 (W)		4,640
1996 (W)		2,110
1997 (W)		-4,030
1998 (W)		6,720
1999 (W)		-9,000
2000 (AN)		8,740
2001 (D)		-7,200
2002 (D)		-3,610
2003 (AN)		4,710
2004 (BN)		-4,770
2005 (AN)		6,680
2006 (W)		-3,730
2007 (D)		190
2008 (C)		-4,180
2009 (D)		2,700
2010 (BN)		1,390
2011 (W)		3,960
2012 (BN)		-6,800
2013 (D)		5,440
2014 (C)		4,930
2015 (C)		-7,960
2016 (BN)		-640
2017 (W)		1,550
2018 (BN)		-2,900
Average (1990-2018)		-890
1990-2018	W	280
	AN	6,280
	BN	-2,740
	D	-500
	C	-5,280

2.3.5.1.4 *Historical Surface Water System Water Budget Summary*

Annual inflows, outflows, and change in SWS root zone storage during the historical water budget period (1990-2018) are summarized in **Figure 2-60** and **Table 2-27.** Inflows in **Figure 2-60** are shown as positive values, while outflows and change in SWS root zone storage are shown as negative values. Review of the variability in component volumes across years provides insight into the impacts of hydrology on the SWS water budget.

Of particular note in the historical SWS water budget results are the volume of surface water inflows that makes up a large part of the Subbasin SWS inflows. Over the historical period, surface water inflows to surface water averaged about 454 taf per year. Precipitation also represents a large SWS inflow component averaging about 291 taf per year. Groundwater discharge to surface water represents a relatively small SWS inflow averaging about 16 taf per year. Groundwater extraction and uptake represent a smaller SWS inflow in the Subbasin averaging about 7.0 taf per year over the historical water budget period.

Among the outflows from the Subbasin SWS, surface water outflow makes up a large fraction of the total Subbasin SWS outflows. The surface water outflows total about 519 taf per year on average, a value that corresponds with the large volumes of surface water inflow and precipitation (a total of about 745 taf per year). By comparison, other SWS outflows in the Subbasin are relatively smaller, with values for ET of precipitation about 159 taf per year and deep percolation of precipitation about 44 taf per year on average. The outflows of infiltration (seepage) of surface water, ET of applied water, and deep percolation of applied water are about 21, 10.6, and 10.5 taf per year on average, respectively. The outflows of ET of groundwater uptake and evaporation from surface water average about 2.6 and 0.8 taf per year, respectively.

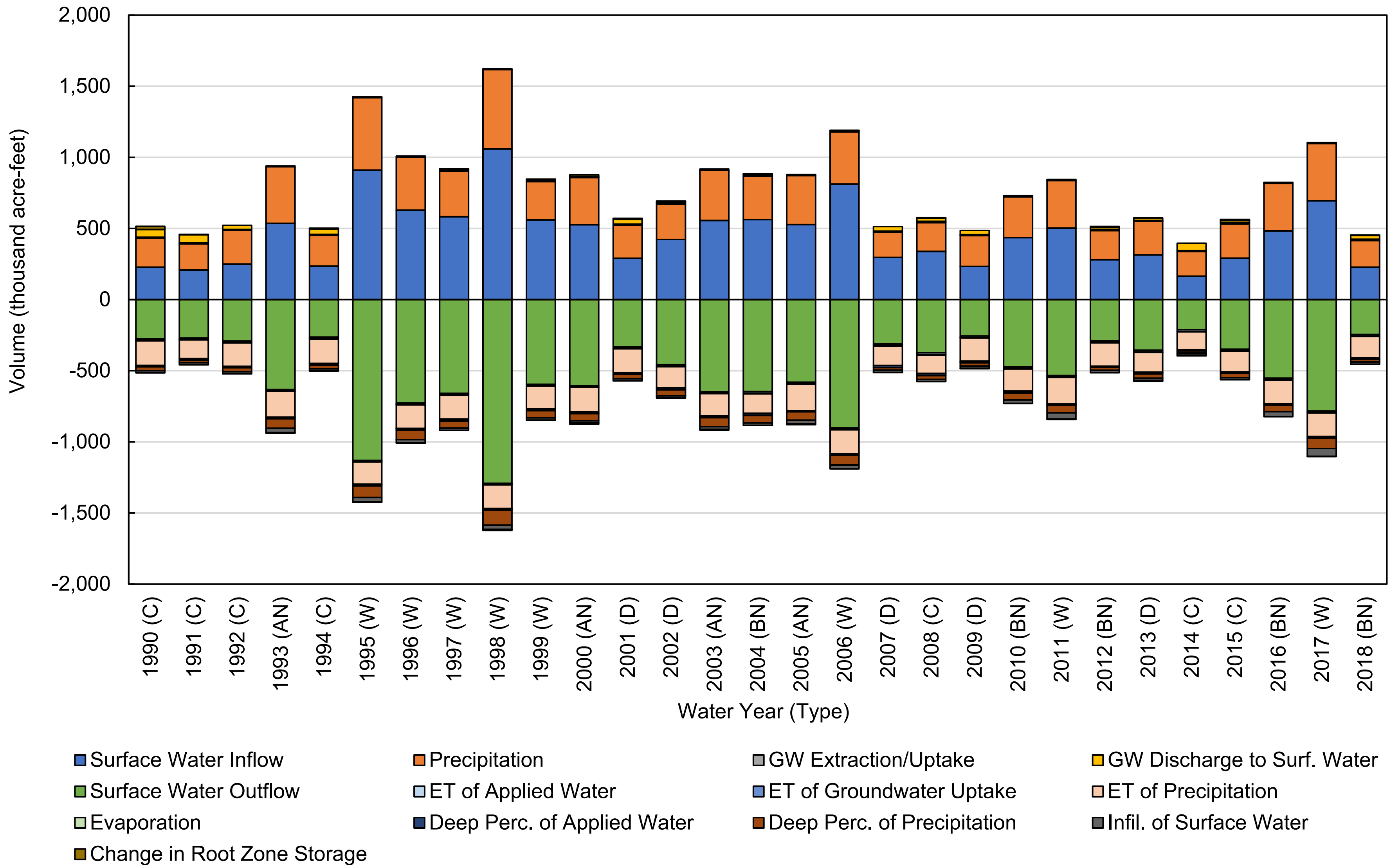


Figure 2-60. Bowman Subbasin Surface Water System Historical Water Budget, 1990-2018

Table 2-27. Bowman Subbasin Surface Water System Historical Water Budget, 1990-2018 (acre-feet, rounded)

Water Year (Type)	Inflows				Outflows								Change in Root Zone Storage
	Surface Water Inflow	Precip-itation	Ground-water Extraction / Uptake	Ground-water Discharge	Surface Water Outflow	ET of Applied Water	ET of Ground-water Uptake	ET of Precip-itation	Evapo-ration	Deep Perc. of Applied Water	Deep Perc. of Precip-itation	Infil. of Surface Water	
1990 (C)	227,940	203,810	6,790	54,040	276,900	10,450	2,460	173,120	390	9,930	26,950	14,580	-22,210
1991 (C)	207,430	184,600	5,590	57,900	271,030	10,370	2,240	130,590	430	10,980	18,620	14,450	-3,190
1992 (C)	248,800	238,590	5,350	29,670	291,790	10,410	2,120	165,270	430	9,230	27,640	14,740	790
1993 (AN)	536,400	397,490	5,390	0	633,460	8,910	2,550	182,780	400	10,360	66,710	29,120	5,000
1994 (C)	235,260	217,290	6,060	38,370	264,540	10,660	2,160	172,130	410	10,800	26,680	14,710	-5,120
1995 (W)	910,080	510,300	5,130	0	1,131,540	7,900	3,020	156,410	470	10,720	81,350	29,440	4,640
1996 (W)	628,410	374,370	6,270	0	728,610	8,960	3,060	165,240	600	11,060	66,470	22,950	2,110
1997 (W)	583,120	320,160	8,540	3,330	659,730	10,500	2,870	167,780	740	12,780	49,440	15,340	-4,030
1998 (W)	1,059,260	557,630	5,900	0	1,291,610	6,910	3,530	167,770	630	10,690	104,710	30,230	6,720
1999 (W)	560,490	268,310	5,590	3,410	596,140	8,730	3,230	159,650	980	12,100	50,500	15,460	-9,000
2000 (AN)	526,110	331,780	5,710	12,940	605,080	8,710	3,140	173,180	880	11,050	50,620	15,140	8,740
2001 (D)	290,250	233,450	7,270	33,500	333,340	10,420	2,550	167,740	870	9,700	32,290	14,760	-7,200
2002 (D)	422,580	249,010	8,340	8,840	457,590	12,160	2,600	148,320	1,010	13,540	41,510	15,690	-3,610
2003 (AN)	556,360	354,180	6,680	0	648,810	10,100	2,790	157,430	950	10,480	63,340	18,620	4,710
2004 (BN)	562,110	303,910	9,730	3,770	647,060	12,880	3,090	136,680	1,220	13,900	52,910	16,530	-4,770
2005 (AN)	527,500	344,840	7,460	0	581,510	9,600	2,700	187,290	900	7,150	58,560	25,400	6,680
2006 (W)	812,670	366,690	7,320	0	902,600	9,820	3,530	167,300	1,010	11,260	67,160	27,730	-3,730
2007 (D)	296,510	175,890	8,780	31,890	312,400	12,590	2,660	135,800	1,040	13,330	18,150	16,920	190
2008 (C)	339,240	201,420	9,230	22,390	374,710	13,140	2,500	129,360	1,030	13,630	27,370	14,720	-4,180

Water Year (Type)	Inflows				Outflows								Change in Root Zone Storage
	Surface Water Inflow	Precipitation	Groundwater Extraction / Uptake	Groundwater Discharge	Surface Water Outflow	ET of Applied Water	ET of Groundwater Uptake	ET of Precipitation	Evaporation	Deep Perc. of Applied Water	Deep Perc. of Precipitation	Infil. of Surface Water	
2009 (D)	233,340	216,230	7,180	28,990	256,050	12,070	2,290	161,690	900	12,140	22,090	15,830	2,700
2010 (BN)	435,940	286,450	8,540	0	474,630	11,290	2,260	155,570	960	11,150	49,820	23,870	1,390
2011 (W)	502,570	334,180	7,070	0	534,760	9,830	2,510	187,170	910	8,520	52,750	43,390	3,960
2012 (BN)	280,440	204,890	6,400	15,710	290,810	10,770	2,250	165,020	870	7,990	20,230	16,320	-6,800
2013 (D)	314,450	234,410	7,750	17,170	355,390	12,930	2,140	140,630	950	10,620	30,350	15,350	5,440
2014 (C)	164,390	174,260	6,150	51,020	212,520	12,110	1,810	126,270	730	7,500	14,890	15,060	4,930
2015 (C)	291,500	240,260	7,840	16,190	349,310	12,240	1,630	146,210	730	7,970	31,340	14,340	-7,960
2016 (BN)	483,300	332,410	6,950	0	552,950	11,650	1,980	166,310	920	8,980	45,100	35,420	-640
2017 (W)	694,700	402,240	6,770	0	784,060	9,930	2,550	167,060	1,030	8,190	74,550	54,790	1,550
2018 (BN)	227,810	188,020	8,570	27,050	245,500	12,090	1,920	151,480	850	8,310	18,170	16,010	-2,900
Average (1990-2018)	453,760	291,280	7,050	15,730	519,460	10,630	2,560	159,010	800	10,480	44,490	21,270	-890
1990-2018 W	718,910	391,740	6,570	840	828,630	9,070	3,040	167,300	800	10,670	68,370	29,920	280
1990-2018 AN	536,590	357,070	6,310	3,240	617,220	9,330	2,800	175,170	780	9,760	59,810	22,070	6,280
1990-2018 BN	397,920	263,140	8,040	9,310	442,190	11,740	2,300	155,010	960	10,070	37,250	21,630	-2,740
1990-2018 D	311,430	221,800	7,860	24,080	342,950	12,030	2,450	150,840	950	11,870	28,880	15,710	-500
1990-2018 C	244,940	208,600	6,720	38,510	291,540	11,340	2,130	148,990	590	10,010	24,780	14,660	-5,280

2.3.5.1.5 *Net Recharge from Surface Water System*

Net recharge from the SWS is a useful metric that equates only the impacts of the SWS on recharge and extraction from the GWS, providing valuable insight to the combined effects of land surface processes on the underlying GWS. Net recharge from the SWS is calculated as the total groundwater recharge minus the total groundwater extraction and uptake. When calculated for the historical water budget, average net recharge from the SWS represents the average surplus of recharge (when positive) or shortage of recharge (when negative) that has resulted from historical cropping, land use practices, and average hydrologic conditions. When calculated from the current land use water budget, average net recharge represents the average recharge or shortage based on current cropping, land use practices, and average hydrologic conditions, when comparing groundwater extractions with deep percolation and infiltration from the SWS to the GWS. Net recharge does not include groundwater discharges to surface water and is not a full accounting of all exchanges occurring between the SWS and GWS. Although net recharge is a useful water balance metric.

Groundwater sustainability is not defined by the balance of net recharge from the SWS. Other important factors must be considered in the complete assessment of groundwater sustainability, including but not limited to subsurface groundwater flows and groundwater discharge to surface water. The sustainable yield and management criteria for the Red Bluff Subbasin are described in later sections of the GSP.

Annual values for net recharge from the SWS over the historical water budget period are presented below for the Bowman Subbasin. **Figure 2-61** and **Table 2-28** show the average net recharge from the SWS over 1990-2018 based on the historical water budget results. Historically, the average net recharge in the Bowman Subbasin was approximately 69 taf per year between 1990-2018, indicating that recharge exceeded extraction, on average, during the historical water budget period. As illustrated on the cumulative net recharge plot in **Figure 2-61**, this results in a cumulative positive net recharge of about 2000 taf over the 29-year historical water budget period. Although this means there has historically been more recharge from the SWS to the GWS than extractions and discharges from the GWS to the SWS, this alone does not necessarily mean that groundwater storage is increasing or that the Subbasin groundwater system has been sustainable. The complete Subbasin water budget, including the GWS water budget results, provide an indication of whether total groundwater inflows and outflows are in balance.

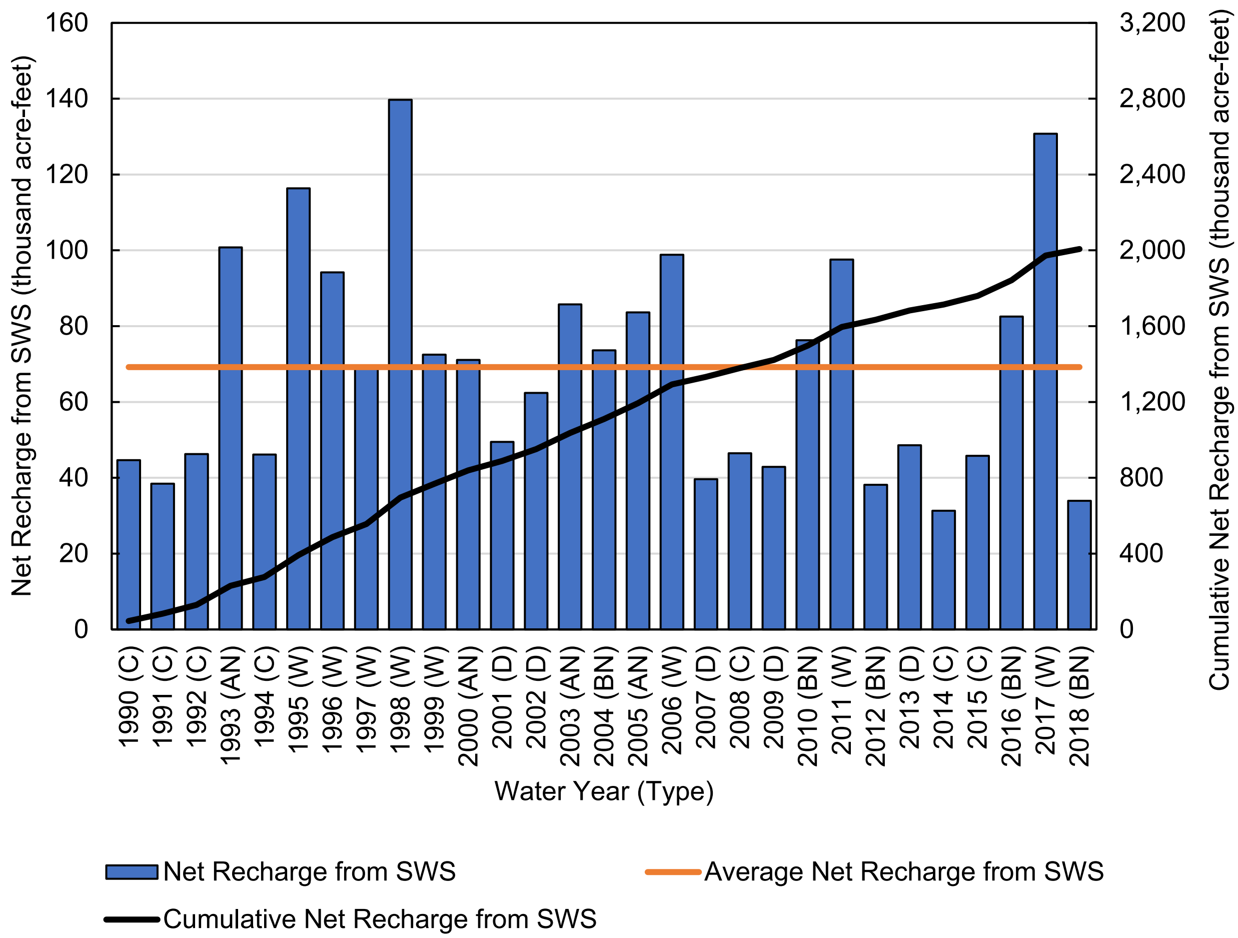


Figure 2-61. Bowman Subbasin Net Recharge Overview, 1990-2018

Table 2-28. Historical Water Budget: Average Net Recharge from SWS in Bowman Subbasin, by Water Year Type, 1990-2018 (acre-feet, rounded)

Year Type	Number of Years	Deep Perc. of Applied Water (a)	Deep Perc. of Precipitation (b)	Infil. of Surface Water (c)	Groundwater Extraction/ Uptake (d)	Net Recharge from SWS (a+b+c-d)
W	8	10,670	68,370	29,920	6,570	102,390
AN	4	9,760	59,810	22,070	6,310	85,330
BN	5	10,070	37,250	21,630	8,040	60,910
D	5	11,870	28,880	15,710	7,860	48,600
C	7	10,010	24,780	14,660	6,720	42,730
Annual Average (1990-2018)	29	10,480	44,490	21,270	7,050	69,190

2.3.5.2 Groundwater System Water Budget Results

Historical water budget results for different components of the GWS are presented in the sections below. Inflows and outflows from the GWS that occur through exchanges with the SWS are discussed in the SWS water budget results, although these components are also noted in the sections below relating to the GWS water budget. In contrast to the SWS water budget, many of the GWS water budget components change in flow direction over time representing inflows during some periods and outflows during other periods, depending on Subbasin conditions. The GWS water budget results are presented with net inflows indicated by positive values and net outflows as negative values.

2.3.5.2.1 *Lateral Subsurface Groundwater Flows*

Subsurface groundwater flows to and from the Bowman Subbasin occur between the Red Bluff Subbasin to the south, the Anderson Subbasin to the north, and the South Battle Creek Subbasin to the east. Additional subsurface groundwater inflows occur from the upland foothill (small watershed) areas adjoining the Bowman Subbasin to the west.

2.3.5.2.1.1 Lateral Subsurface Flows to/from Adjacent Subbasins

Historical lateral subsurface flows occurring from and to adjacent subbasin are summarized in **Table 2-29** and **Figure 2-62**. The total historical net subsurface flows to and from all adjacent subbasins averages about -59 taf per year occurring as outflow from the Bowman Subbasin. Historical subsurface flows across the boundary with the Red Bluff Subbasin average an outflow of nearly 340 taf per year. The magnitude of these subsurface flows does not fluctuate much from year to year, although the subsurface outflows to the Red Bluff Subbasin tend to be somewhat greater during wet years than in dry years. In contrast to the subsurface outflows across the boundary with Red Bluff Subbasin, the flows across the northern boundary with the Anderson Subbasin occur as large inflows averaging about 281 taf per year, with very little variability by water year type. Subsurface flows across the boundary with the South Battle Creek Subbasin are very limited and vary as inflows and outflows between years. On average the subsurface flows across the South Battle Creek Subbasin boundary occur as net outflows of less than 1 taf per year.

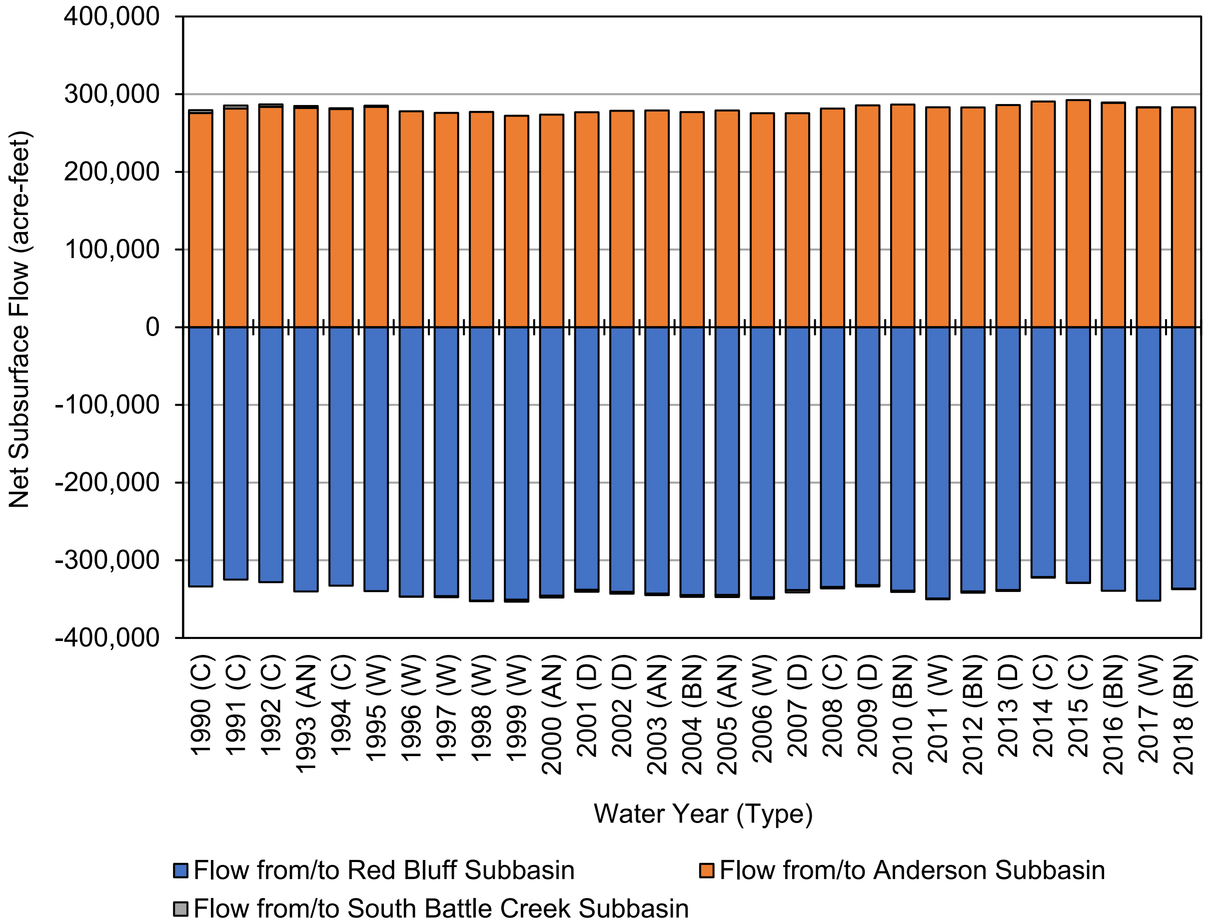


Figure 2-62. Bowman Subbasin Lateral Subsurface Groundwater Flows to/from Adjacent Subbasins

Table 2-29. Bowman Subbasin Lateral Subsurface Groundwater Flows Between Adjacent Subbasins (net flows as acre-feet, rounded)

Water Year (Type)		Red Bluff	Anderson	South Battle Creek	Total
1990 (C)		-333,780	275,620	3,750	-54,410
1991 (C)		-324,810	281,420	3,870	-39,520
1992 (C)		-328,260	283,700	3,200	-41,360
1993 (AN)		-340,150	282,300	2,560	-55,290
1994 (C)		-332,770	280,900	970	-50,900
1995 (W)		-339,780	283,750	1,520	-54,510
1996 (W)		-346,630	278,010	-160	-68,780
1997 (W)		-346,330	275,990	-1,160	-71,500
1998 (W)		-352,120	277,150	-550	-75,520
1999 (W)		-350,840	272,270	-2,420	-80,990
2000 (AN)		-345,710	273,670	-2,330	-74,370
2001 (D)		-338,070	276,710	-2,390	-63,750
2002 (D)		-340,680	278,600	-2,380	-64,460
2003 (AN)		-342,930	279,100	-1,860	-65,690
2004 (BN)		-344,860	276,870	-2,320	-70,310
2005 (AN)		-344,640	278,990	-2,610	-68,260
2006 (W)		-347,690	275,570	-1,880	-74,000
2007 (D)		-338,500	275,540	-2,940	-65,900
2008 (C)		-334,420	281,430	-1,870	-54,860
2009 (D)		-332,070	285,590	-1,650	-48,130
2010 (BN)		-339,360	286,520	-1,360	-54,200
2011 (W)		-349,170	283,160	-1,120	-67,130
2012 (BN)		-340,050	282,860	-1,710	-58,900
2013 (D)		-338,230	286,010	-1,250	-53,470
2014 (C)		-321,630	290,460	-800	-31,970
2015 (C)		-328,930	292,340	-80	-36,670
2016 (BN)		-339,310	288,940	150	-50,220
2017 (W)		-352,130	282,830	260	-69,040
2018 (BN)		-336,690	283,180	-640	-54,150
Average (1990-2018)		-339,670	281,020	-590	-59,250
1990-2018	W	-348,090	278,590	-690	-70,180
	AN	-342,570	280,130	-640	-63,080
	BN	-339,930	284,550	-960	-56,330
	D	-337,510	280,490	-2,120	-59,140
	C	-329,230	283,700	1,290	-44,240

Note: positive values represent net inflows, negative values represent net outflows.

2.3.5.2.1.2 Lateral Subsurface Flows from Upland Areas (Small Watersheds)

Historical lateral subsurface inflows occurring from upland or foothill areas (small watersheds outside of the Central Valley Floor) to the west of the Bowman Subbasin are summarized in **Table 2-30** and **Figure 2-63**. This component does not include surface water inflows to the Bowman Subbasin which are discussed as part of the SWS water budget. The average historical subsurface inflow from the upland areas is about 1.2 taf per year and varies only very minimally from year-to-year. The volume of subsurface inflows from upland areas is small relative to the net subsurface inflows occurring between adjacent subbasins.

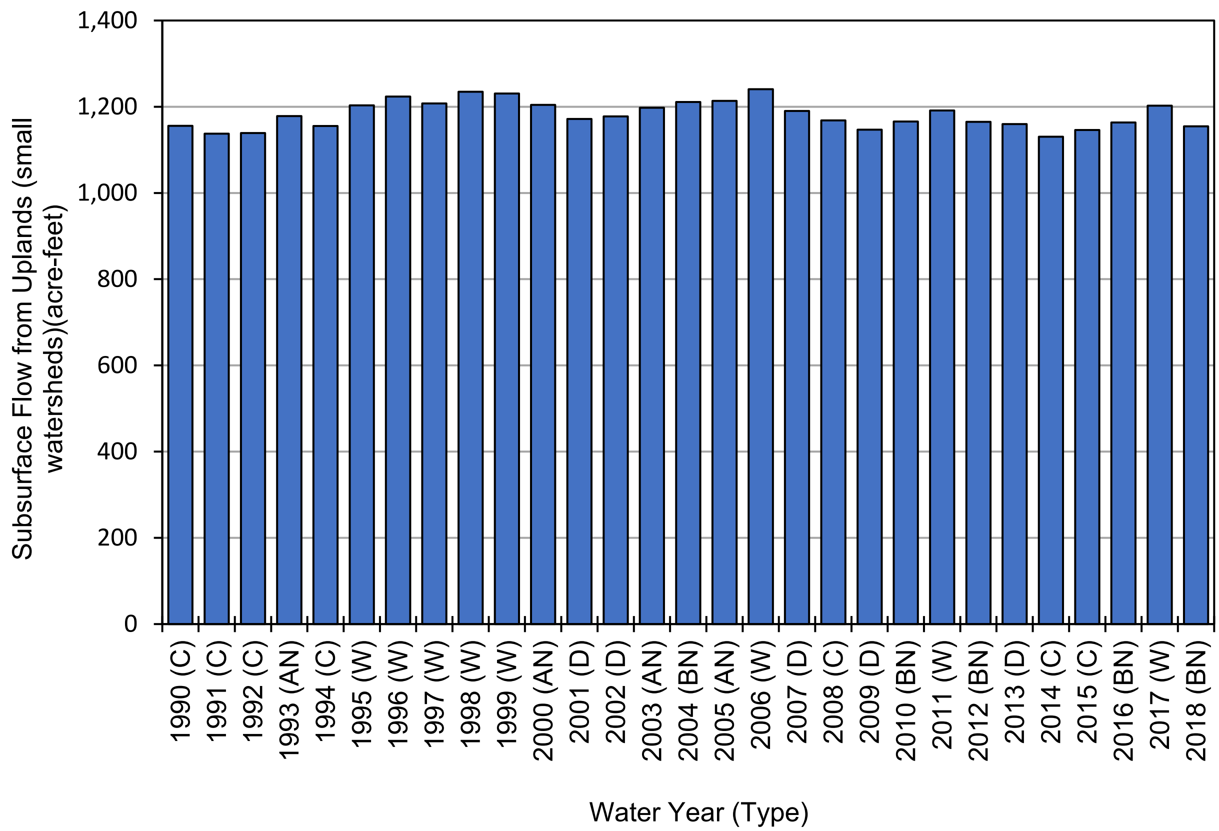


Figure 2-63. Bowman Subbasin Subsurface Groundwater Inflows from Upland Areas

Table 2-30. Bowman Subbasin Subsurface Groundwater Inflows from Adjacent Uplands (small watersheds) (acre-feet, rounded)

Water Year (Type)	Subsurface Inflow from Uplands
1990 (C)	1,160
1991 (C)	1,140
1992 (C)	1,140
1993 (AN)	1,180
1994 (C)	1,160
1995 (W)	1,200
1996 (W)	1,220
1997 (W)	1,210
1998 (W)	1,230
1999 (W)	1,230
2000 (AN)	1,200
2001 (D)	1,170
2002 (D)	1,180
2003 (AN)	1,200
2004 (BN)	1,210
2005 (AN)	1,210
2006 (W)	1,240
2007 (D)	1,190
2008 (C)	1,170
2009 (D)	1,150
2010 (BN)	1,170
2011 (W)	1,190
2012 (BN)	1,160
2013 (D)	1,160
2014 (C)	1,130
2015 (C)	1,150
2016 (BN)	1,160
2017 (W)	1,200
2018 (BN)	1,150
Average (1990-2018)	1,180

1990-2018	W	1,220
	AN	1,200
	BN	1,170
	D	1,170
	C	1,150

2.3.5.2.2 *Deep Percolation From the SWS*

Deep percolation from the SWS includes infiltration of water below the root zone (deep percolation) from precipitation and applied water. These two water budget components are summarized in the SWS water budget as outflows to the SWS and are presented as aggregated deep percolation inflows to the GWS in **Table 2-31** and **Figure 2-64**. The average annual deep percolation from the SWS over the historical water budget period is 55 taf per year. Greater volumes of deep percolation occur during wetter years when infiltration of precipitation is higher.

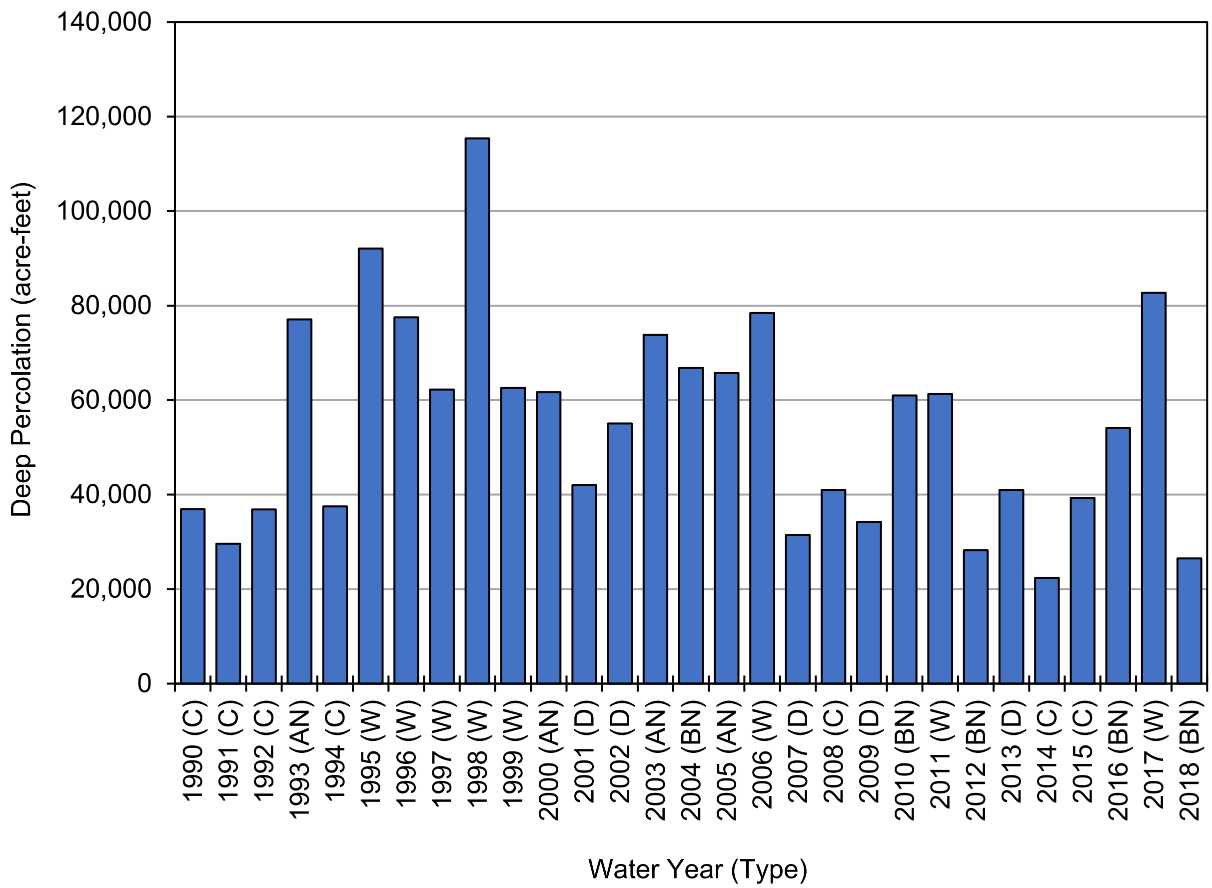


Figure 2-64. Bowman Subbasin Deep Percolation

Table 2-31. Bowman Subbasin Deep Percolation from the SWS (acre-feet, rounded)

<table>
<tr><th colspan="2">Water Year (Type)</th><th>Deep Percolation from the SWS</th></tr>
<tr><td colspan="2">1990 (C)</td><td>36,880</td></tr>
<tr><td colspan="2">1991 (C)</td><td>29,600</td></tr>
<tr><td colspan="2">1992 (C)</td><td>36,870</td></tr>
<tr><td colspan="2">1993 (AN)</td><td>77,070</td></tr>
<tr><td colspan="2">1994 (C)</td><td>37,490</td></tr>
<tr><td colspan="2">1995 (W)</td><td>92,080</td></tr>
<tr><td colspan="2">1996 (W)</td><td>77,520</td></tr>
<tr><td colspan="2">1997 (W)</td><td>62,230</td></tr>
<tr><td colspan="2">1998 (W)</td><td>115,390</td></tr>
<tr><td colspan="2">1999 (W)</td><td>62,600</td></tr>
<tr><td colspan="2">2000 (AN)</td><td>61,670</td></tr>
<tr><td colspan="2">2001 (D)</td><td>41,990</td></tr>
<tr><td colspan="2">2002 (D)</td><td>55,040</td></tr>
<tr><td colspan="2">2003 (AN)</td><td>73,820</td></tr>
<tr><td colspan="2">2004 (BN)</td><td>66,810</td></tr>
<tr><td colspan="2">2005 (AN)</td><td>65,720</td></tr>
<tr><td colspan="2">2006 (W)</td><td>78,420</td></tr>
<tr><td colspan="2">2007 (D)</td><td>31,480</td></tr>
<tr><td colspan="2">2008 (C)</td><td>41,000</td></tr>
<tr><td colspan="2">2009 (D)</td><td>34,220</td></tr>
<tr><td colspan="2">2010 (BN)</td><td>60,970</td></tr>
<tr><td colspan="2">2011 (W)</td><td>61,280</td></tr>
<tr><td colspan="2">2012 (BN)</td><td>28,220</td></tr>
<tr><td colspan="2">2013 (D)</td><td>40,960</td></tr>
<tr><td colspan="2">2014 (C)</td><td>22,400</td></tr>
<tr><td colspan="2">2015 (C)</td><td>39,300</td></tr>
<tr><td colspan="2">2016 (BN)</td><td>54,080</td></tr>
<tr><td colspan="2">2017 (W)</td><td>82,740</td></tr>
<tr><td colspan="2">2018 (BN)</td><td>26,490</td></tr>
<tr><td colspan="2">Average (1990-2018)</td><td>54,980</td></tr>
<tr><td rowspan="5">1990-2018</td><td>W</td><td>79,030</td></tr>
<tr><td>AN</td><td>72,200</td></tr>
<tr><td>BN</td><td>48,440</td></tr>
<tr><td>D</td><td>40,740</td></tr>
<tr><td>C</td><td>34,790</td></tr>
</table>

2.3.5.2.3 *Net Stream Seepage/Groundwater Discharge to Surface Water*

The flow of water between the GWS and SWS through seepage of water from streams and canals and groundwater discharging into streams is discussed as part of the SWS water budget. These components are combined for presentation in the GWS water budget as a net volume of stream seepage (**Table 2-32** and **Figure 2-65**). Positive total net seepage values represent a net inflow of water from the SWS to the GWS via stream and canal seepage indicating that the overall volume of stream seepage is greater than the volume of any groundwater discharging into surface waterways. Negative net seepage values represent a net outflow of groundwater from the GWS to the SWS through groundwater discharge to surface water. When net seepage is negative, it means that more groundwater is discharging into the surface waterways than is seeping from surface waterways into the GWS.

In the Bowman Subbasin, the historical annual net seepage values vary from positive (indicating net addition of water to the GWS through the exchanges with surface waterways) to negative values indicating that groundwater discharge is providing flow to the surface waterways. The range of net seepage values is typically between 20 taf and -20 taf, although net seepage is more negative during dry years and more positive during wet years. The historical average net seepage is 2.5 taf per year.

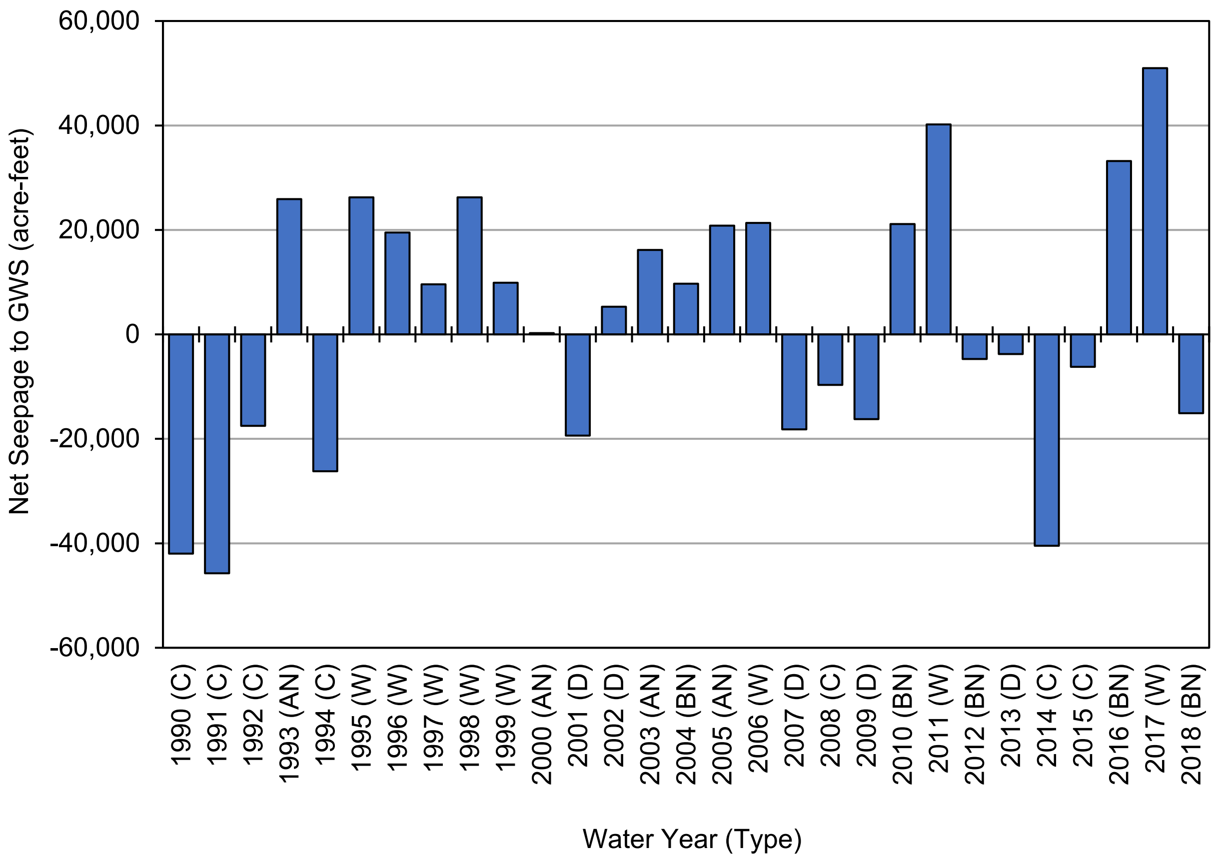


Figure 2-65. Bowman Subbasin Net Stream Seepage to GWS/Discharge to Surface Water

Table 2-32. Bowman Subbasin Net Stream Seepage (net flows as acre-feet, rounded)

<table>
<tr><th colspan="2">Water Year (Type)</th><th>Total Net Seepage from Surface Waterways and Canals</th></tr>
<tr><td colspan="2">1990 (C)</td><td>-41,970</td></tr>
<tr><td colspan="2">1991 (C)</td><td>-45,730</td></tr>
<tr><td colspan="2">1992 (C)</td><td>-17,500</td></tr>
<tr><td colspan="2">1993 (AN)</td><td>25,890</td></tr>
<tr><td colspan="2">1994 (C)</td><td>-26,210</td></tr>
<tr><td colspan="2">1995 (W)</td><td>26,230</td></tr>
<tr><td colspan="2">1996 (W)</td><td>19,500</td></tr>
<tr><td colspan="2">1997 (W)</td><td>9,570</td></tr>
<tr><td colspan="2">1998 (W)</td><td>26,240</td></tr>
<tr><td colspan="2">1999 (W)</td><td>9,890</td></tr>
<tr><td colspan="2">2000 (AN)</td><td>230</td></tr>
<tr><td colspan="2">2001 (D)</td><td>-19,390</td></tr>
<tr><td colspan="2">2002 (D)</td><td>5,290</td></tr>
<tr><td colspan="2">2003 (AN)</td><td>16,160</td></tr>
<tr><td colspan="2">2004 (BN)</td><td>9,720</td></tr>
<tr><td colspan="2">2005 (AN)</td><td>20,830</td></tr>
<tr><td colspan="2">2006 (W)</td><td>21,340</td></tr>
<tr><td colspan="2">2007 (D)</td><td>-18,170</td></tr>
<tr><td colspan="2">2008 (C)</td><td>-9,660</td></tr>
<tr><td colspan="2">2009 (D)</td><td>-16,230</td></tr>
<tr><td colspan="2">2010 (BN)</td><td>21,120</td></tr>
<tr><td colspan="2">2011 (W)</td><td>40,210</td></tr>
<tr><td colspan="2">2012 (BN)</td><td>-4,700</td></tr>
<tr><td colspan="2">2013 (D)</td><td>-3,750</td></tr>
<tr><td colspan="2">2014 (C)</td><td>-40,470</td></tr>
<tr><td colspan="2">2015 (C)</td><td>-6,210</td></tr>
<tr><td colspan="2">2016 (BN)</td><td>33,190</td></tr>
<tr><td colspan="2">2017 (W)</td><td>50,970</td></tr>
<tr><td colspan="2">2018 (BN)</td><td>-15,100</td></tr>
<tr><td colspan="2">Average (1990-2018)</td><td>2,460</td></tr>
<tr><td rowspan="5">1990-2018</td><td>W</td><td>25,490</td></tr>
<tr><td>AN</td><td>20,960</td></tr>
<tr><td>BN</td><td>12,900</td></tr>
<tr><td>D</td><td>-10,450</td></tr>
<tr><td>C</td><td>-26,820</td></tr>
</table>

Note: negative values indicate net groundwater discharge to surface water

2.3.5.2.4 *Groundwater Extraction*

Groundwater extractions are exchanges that occur between the GWS and the SWS. Groundwater extraction from the GWS occurs through groundwater pumping to meet water demands for urban and agricultural needs and also through groundwater (root water) uptake by plants directly from shallow groundwater during times and at locations of sufficiently shallow groundwater conditions. Historical groundwater extractions are summarized in **Table 2-33** and **Figure 2-66** and also presented and discussed in the SWS water budget sections. Total groundwater extractions over the historical water budget period average about -7 taf per year. Overall, groundwater pumping represents a larger fraction of the groundwater extractions than groundwater uptake. Groundwater pumping averaged about -4.5 taf over the historical period and groundwater uptake averaged about -2.6 taf. In wetter periods, groundwater uptake increases and groundwater pumping decreases. During drier periods groundwater pumping increases and water uptake by plants from shallow groundwater decreases in response to the higher water demands for irrigation and other uses and the greater depths to groundwater that also tend to occur during dry periods.

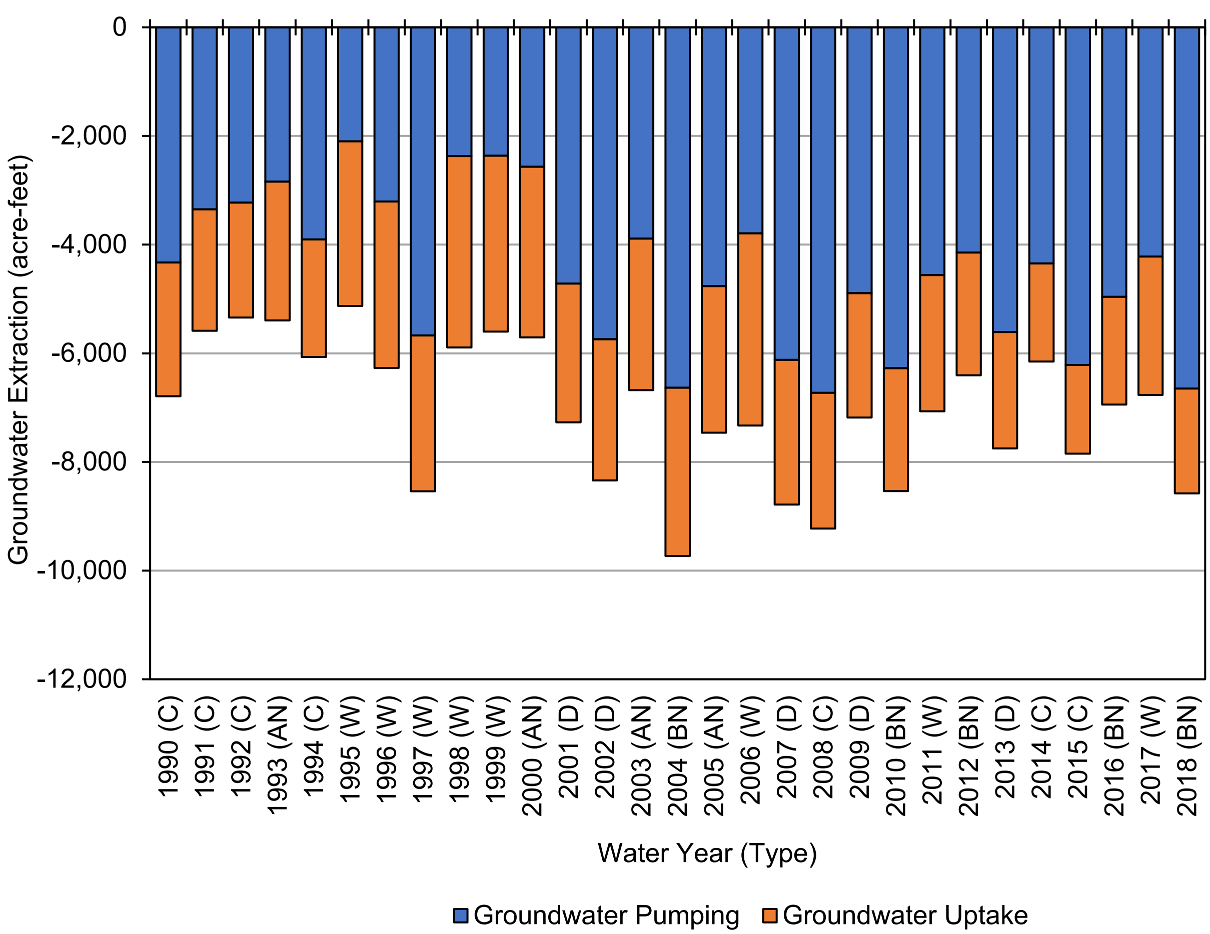


Figure 2-66. Bowman Subbasin Groundwater Extractions

Table 2-33. Bowman Subbasin Groundwater Extractions (acre-feet, rounded)

Water Year (Type)		Groundwater Pumping	Groundwater (Root Water) Uptake	Total Extractions
1990 (C)		-4,330	-2,460	-6,790
1991 (C)		-3,350	-2,240	-5,590
1992 (C)		-3,230	-2,110	-5,340
1993 (AN)		-2,840	-2,550	-5,390
1994 (C)		-3,900	-2,170	-6,070
1995 (W)		-2,100	-3,030	-5,130
1996 (W)		-3,210	-3,070	-6,280
1997 (W)		-5,670	-2,870	-8,540
1998 (W)		-2,370	-3,520	-5,890
1999 (W)		-2,370	-3,240	-5,610
2000 (AN)		-2,570	-3,140	-5,710
2001 (D)		-4,720	-2,550	-7,270
2002 (D)		-5,740	-2,600	-8,340
2003 (AN)		-3,890	-2,790	-6,680
2004 (BN)		-6,630	-3,100	-9,730
2005 (AN)		-4,770	-2,700	-7,470
2006 (W)		-3,790	-3,540	-7,330
2007 (D)		-6,120	-2,660	-8,780
2008 (C)		-6,730	-2,500	-9,230
2009 (D)		-4,890	-2,290	-7,180
2010 (BN)		-6,280	-2,260	-8,540
2011 (W)		-4,560	-2,510	-7,070
2012 (BN)		-4,150	-2,260	-6,410
2013 (D)		-5,610	-2,140	-7,750
2014 (C)		-4,350	-1,810	-6,160
2015 (C)		-6,220	-1,630	-7,850
2016 (BN)		-4,960	-1,980	-6,940
2017 (W)		-4,220	-2,550	-6,770
2018 (BN)		-6,650	-1,930	-8,580
Average (1990-2018)		-4,490	-2,560	-7,050
1990-2018	W	-3,540	-3,040	-6,580
	AN	-3,830	-2,680	-6,510
	BN	-5,610	-2,250	-7,860
	D	-5,420	-2,450	-7,860
	C	-4,590	-2,130	-6,720

2.3.5.2.5 *Vertical Subsurface Flows within the Groundwater System*

Vertical subsurface flows within the GWS occur between the Upper and Lower Aquifers and represent an internal flow of water within the GWS. These exchanges between the principal aquifers do not directly affect the total volume of groundwater in storage, but do highlight the net vertical movement of water within the GWS. Historical vertical flows between the Upper Aquifer and Lower Aquifer are summarized in **Table 2-34** and **Figure 2-67** and show consistent downward vertical flow from the Upper Aquifer to the Lower Aquifer. On average, vertical flows from the Upper Aquifer to the Lower Aquifer total about 103 taf per year over the historical water budget period. The magnitude of the downward vertical flows appears to increase during wet years and decrease during dry years.

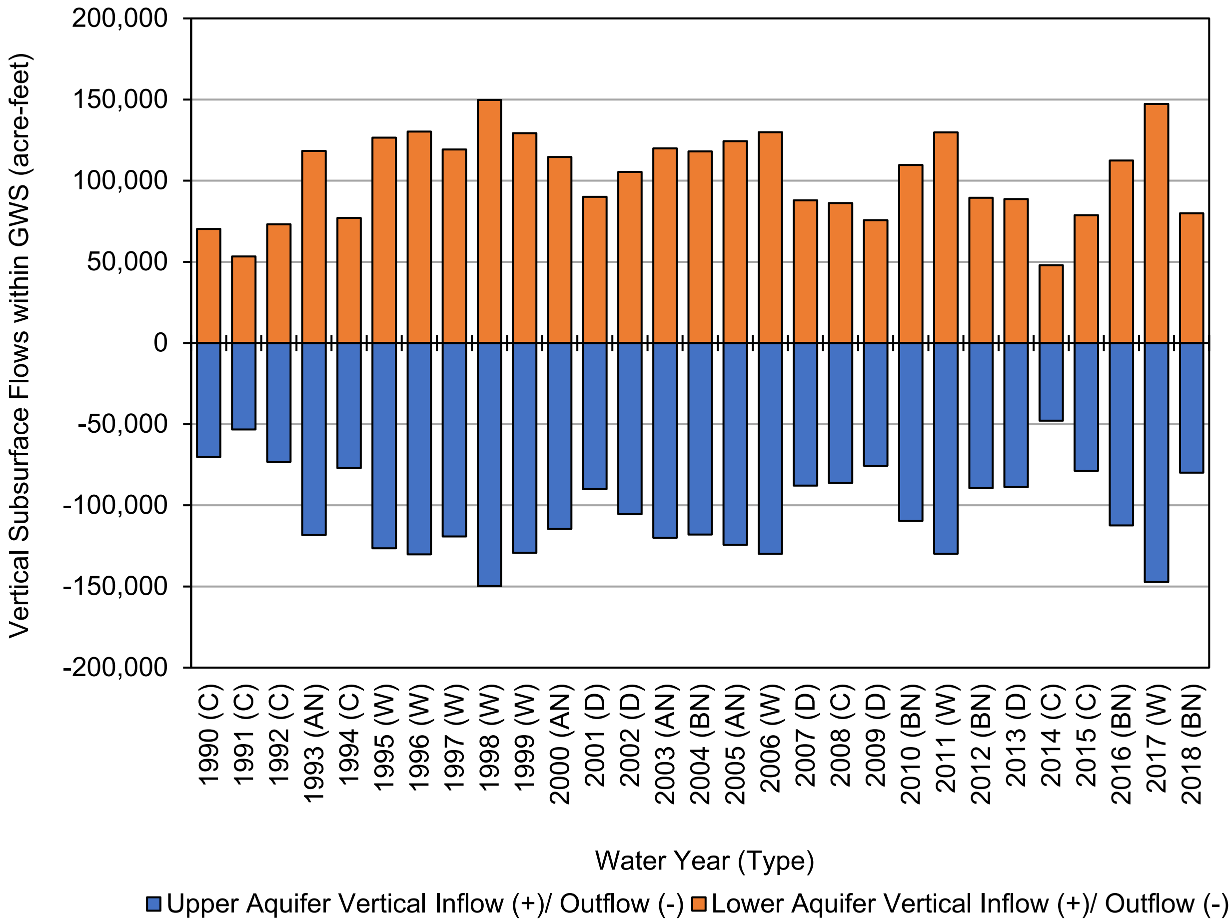


Figure 2-67. Bowman Subbasin Vertical Subsurface Flow within the GWS

Table 2-34. Bowman Subbasin Vertical Subsurface Flows within the GWS (acre-feet, rounded)

Water Year (Type)		Upper Aquifer to (-) / from (+) Lower Aquifer
1990 (C)		-70,250
1991 (C)		-53,300
1992 (C)		-73,170
1993 (AN)		-118,340
1994 (C)		-77,100
1995 (W)		-126,530
1996 (W)		-130,240
1997 (W)		-119,240
1998 (W)		-149,740
1999 (W)		-129,250
2000 (AN)		-114,580
2001 (D)		-90,070
2002 (D)		-105,470
2003 (AN)		-119,940
2004 (BN)		-118,010
2005 (AN)		-124,360
2006 (W)		-129,850
2007 (D)		-87,910
2008 (C)		-86,210
2009 (D)		-75,650
2010 (BN)		-109,680
2011 (W)		-129,810
2012 (BN)		-89,470
2013 (D)		-88,740
2014 (C)		-47,920
2015 (C)		-78,740
2016 (BN)		-112,440
2017 (W)		-147,320
2018 (BN)		-79,890
Average (1990-2018)		-102,870
1990-2018	W	-132,750
	AN	-119,090
	BN	-101,900
	D	-89,570
	C	-69,530

2.3.5.2.6 *Change in Groundwater Storage*

Historical change in groundwater storage values for the Bowman Subbasin are summarized in **Table 2-35** and **Figures 2-68** and **2-69**. Values for total change in storage in the GWS and cumulative change in storage over the historical water budget period are presented in conjunction with the volumes of groundwater storage change within each of the two principal aquifers present in the Subbasin. Over the 29-year historical period, the average annual change in groundwater storage is about -4.8 taf per year, indicating a decrease in storage every year, on average. The corresponding cumulative total change in storage over the historical period is about -140 taf per year. The annual change in storage numbers reflect the effects of the water year type with increase in storage occurring during wetter years and decreases in storage occurring during dry years. Within the GWS, the year-to-year changes in storage are similar for both the Upper Aquifer and the Lower Aquifer, averaging storage decreases of approximately 2.5 taf per year in both aquifers. The Upper Aquifer exhibits larger magnitude annual changes in storage in both the positive and negative direction reflecting the close communication between the Upper Aquifer and the SWS and effects from wet and dry periods.

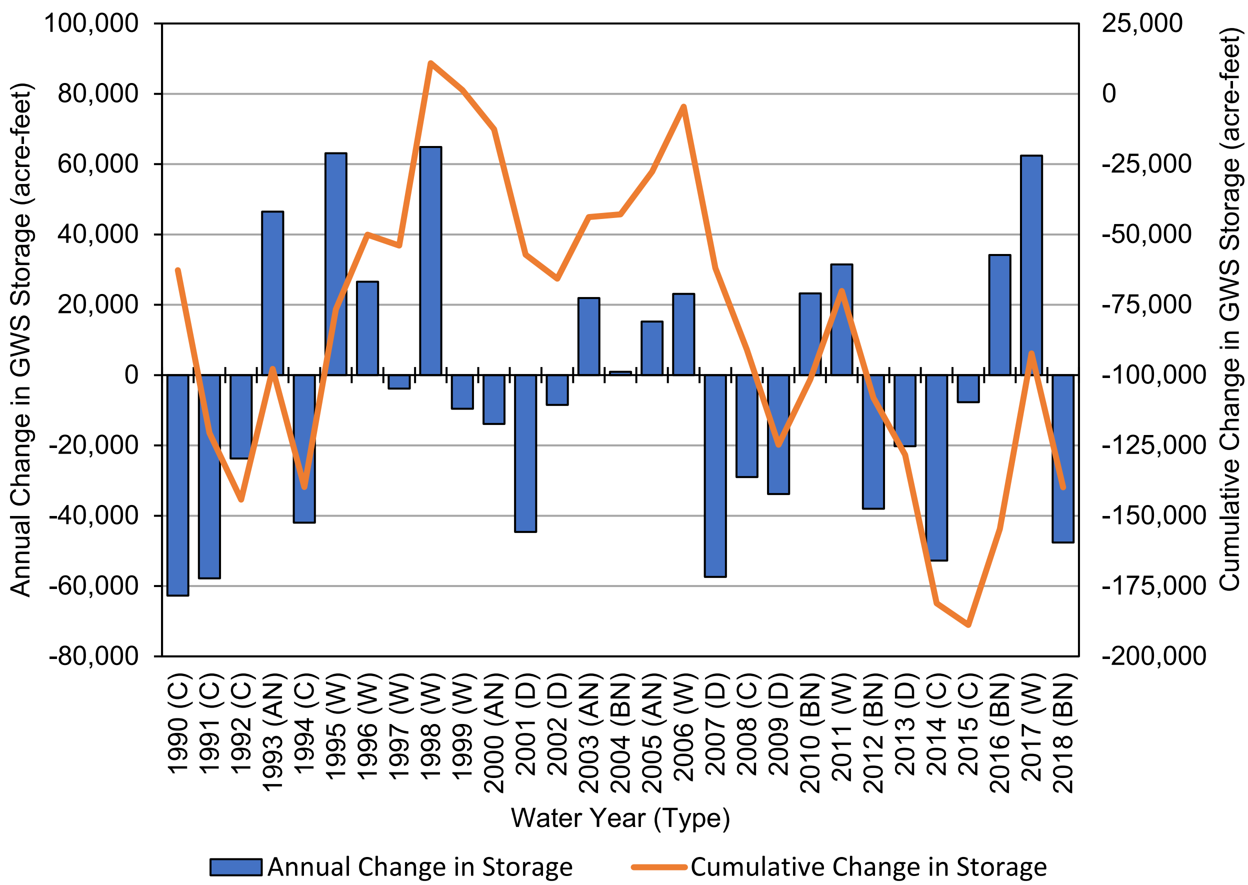


Figure 2-68. Bowman Subbasin Total Change in Storage within the GWS

Table 2-35. Bowman Subbasin Change in Groundwater Storage (acre-feet, rounded)

Water Year (Type)	Upper Aquifer	Lower Aquifer	Total Annual Change	Total Cumulative Change
1990 (C)	-31,790	-30,940	-62,730	-62,730
1991 (C)	-24,950	-32,860	-57,820	-120,550
1992 (C)	-9,020	-14,730	-23,750	-144,290
1993 (AN)	29,310	17,200	46,510	-97,780
1994 (C)	-22,960	-19,010	-41,970	-139,760
1995 (W)	37,210	25,880	63,090	-76,670
1996 (W)	10,060	16,500	26,560	-50,110
1997 (W)	-6,660	2,800	-3,860	-53,970
1998 (W)	35,910	28,940	64,850	10,890
1999 (W)	-13,460	3,890	-9,570	1,310
2000 (AN)	-9,820	-4,090	-13,920	-12,600
2001 (D)	-25,260	-19,350	-44,610	-57,210
2002 (D)	-4,120	-4,380	-8,500	-65,710
2003 (AN)	13,000	8,890	21,890	-43,820
2004 (BN)	-1,070	2,010	930	-42,880
2005 (AN)	5,690	9,550	15,230	-27,650
2006 (W)	12,270	10,800	23,080	-4,570
2007 (D)	-34,510	-22,880	-57,390	-61,960
2008 (C)	-14,380	-14,610	-28,990	-90,950
2009 (D)	-15,630	-18,210	-33,840	-124,790
2010 (BN)	14,430	8,810	23,240	-101,550
2011 (W)	15,440	16,020	31,460	-70,090
2012 (BN)	-22,420	-15,610	-38,030	-108,120
2013 (D)	-8,940	-11,300	-20,230	-128,350
2014 (C)	-21,810	-30,960	-52,770	-181,120
2015 (C)	-2,160	-5,540	-7,700	-188,820
2016 (BN)	18,580	15,570	34,150	-154,680
2017 (W)	30,610	31,790	62,400	-92,280
2018 (BN)	-26,240	-21,360	-47,600	-139,880
Average (1990-2018)	-2,510	-2,320	-4,820	
1990-2018 W	15,170	17,080	32,250	
AN	8,390	7,550	27,880	
BN	-3,340	-2,120	1,140	
D	-17,690	-15,220	-32,910	
C	-18,150	-21,240	-39,390	

Note: positive values indicate increases in groundwater storage, negative values indicate decreases in groundwater storage.

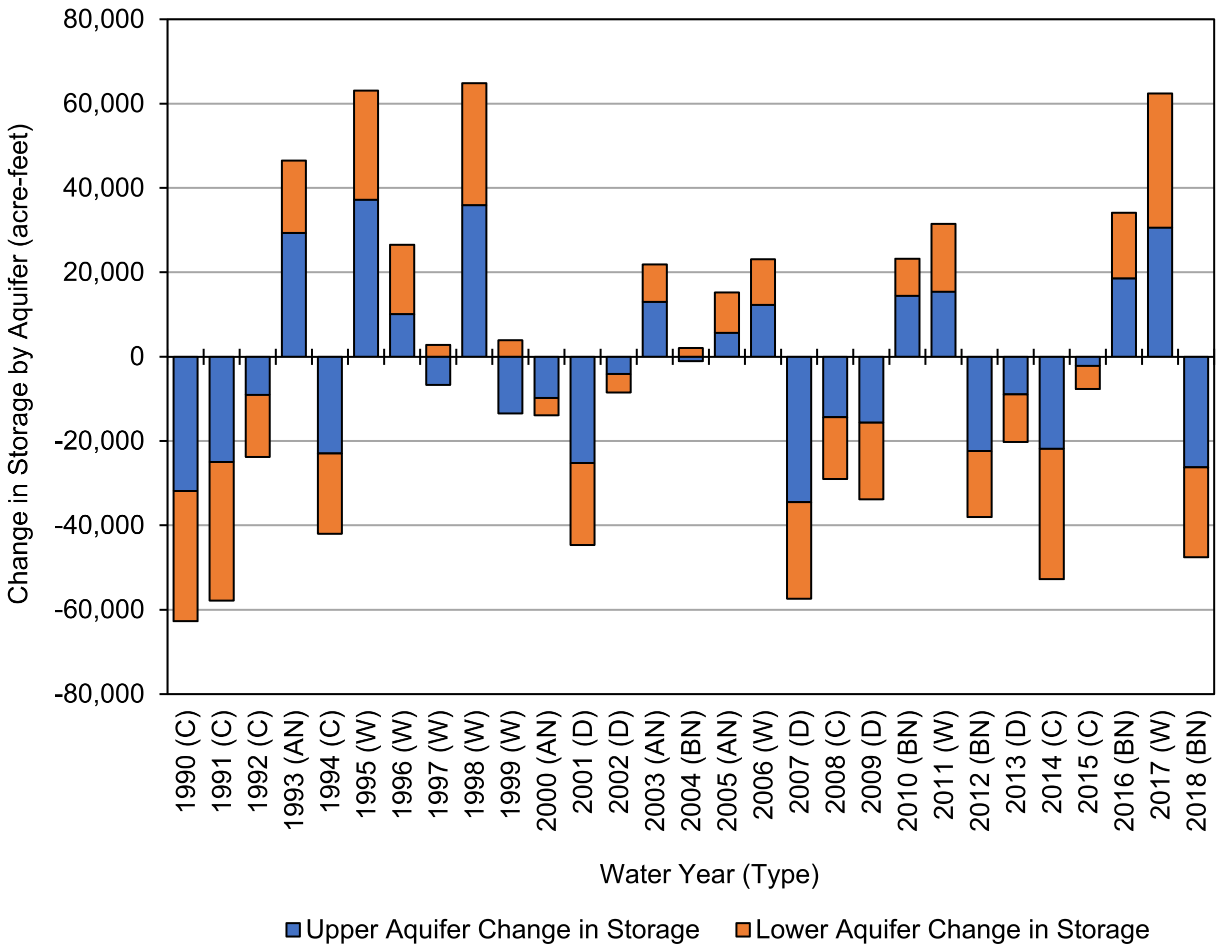


Figure 2-69. Bowman Subbasin Change in Groundwater Storage by Aquifer

2.3.5.3 Historical Water Budget Summary

Summarized results for major components of the historical water budget as they relate to the GWS are presented in **Figure 2-70** and **Table 2-36**. Deep percolation represents the largest inflow averaging nearly 55 taf per year while net subsurface flows (combined subsurface flows with adjacent subbasins and upland areas) represent the largest net outflow totaling about -58 taf per year of outflow from the Bowman Subbasin on average. Net seepage represents a small inflow of about 2.5 taf per year. Groundwater pumping (on average -4.5 taf per year) and groundwater (root water) uptake directly from shallow groundwater (on average -2.6 taf per year) represent smaller outflows from the GWS. Overall, the water budget results for the 29-year historic period indicate a cumulative change in groundwater storage of about -140 taf, which equals an average annual change in groundwater storage of only about -4.8 taf per year. These change in storage estimates equate to total decreases in storage in the Subbasin of about 1.1 acre-feet per acre over the 29 years and an annual decrease of less than 0.04 acre-feet per acre across the entire Subbasin (approximately 122,425 acres). **Figure 2-70** highlights the cumulative change in groundwater storage that has occurred over the 1990-2018 period, with a notable decline in storage over the generally dry period since the mid-2000s. **Figure 2-71** provides a conceptual illustration of the historical water budget.

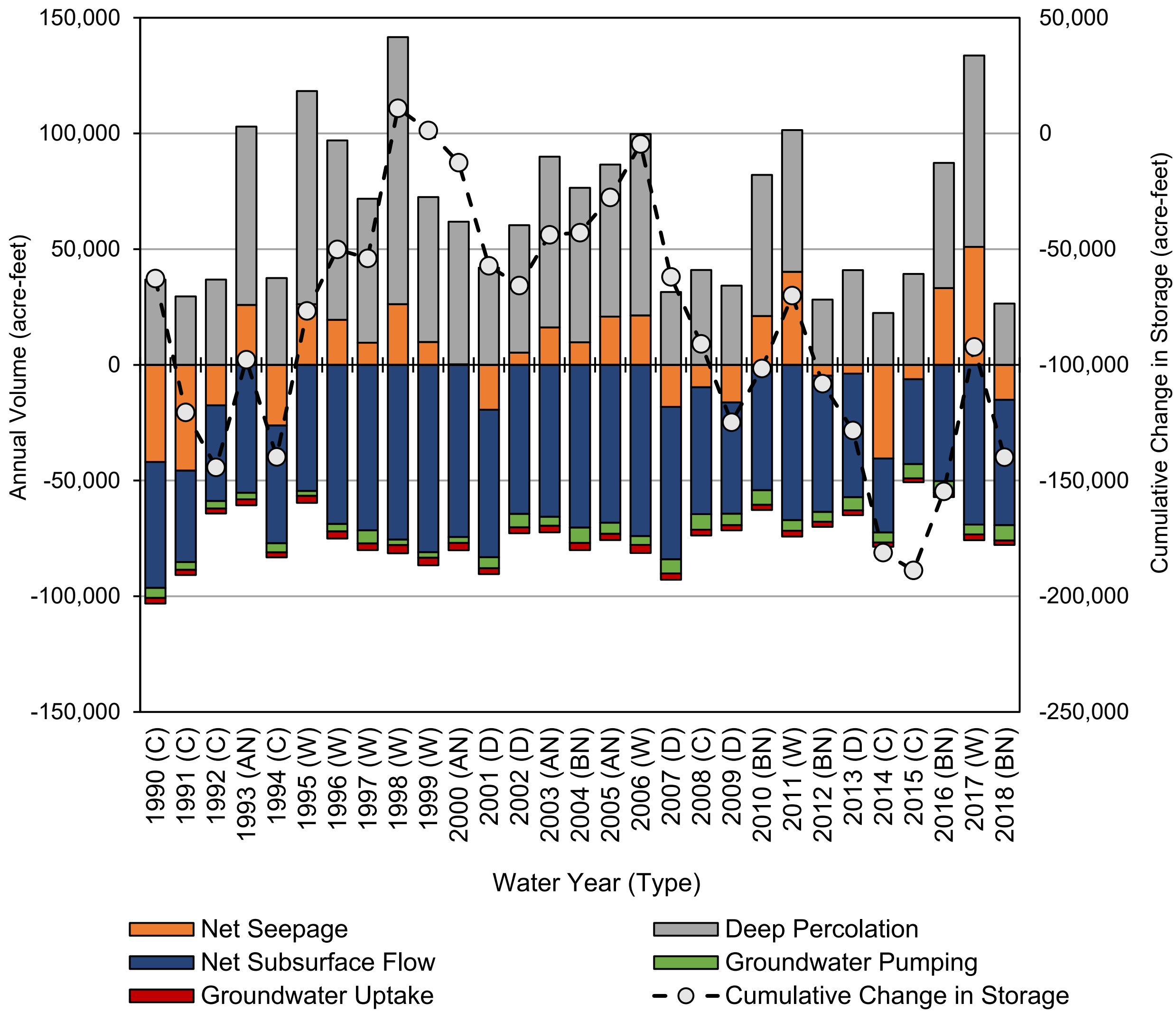


Figure 2-70. Bowman Subbasin Historical Water Budget Summary

Table 2-36. Bowman Subbasin Historical Water Budget Summary (acre-feet, rounded)

Water Year (Type)		Net Seepage	Deep Percolation	Net Subsurface Flows	Ground-water Pumping	Ground-water Uptake	Annual Groundwater Storage Change	Cumulative Groundwater Storage Change
1990 (C)		-41,970	36,880	-53,250	-4,330	-2,460	-62,730	-62,730
1991 (C)		-45,730	29,600	-38,380	-3,350	-2,240	-57,820	-120,550
1992 (C)		-17,500	36,870	-40,220	-3,230	-2,110	-23,750	-144,290
1993 (AN)		25,890	77,070	-54,110	-2,840	-2,550	46,510	-97,780
1994 (C)		-26,210	37,490	-49,740	-3,900	-2,170	-41,970	-139,760
1995 (W)		26,230	92,080	-53,310	-2,100	-3,030	63,090	-76,670
1996 (W)		19,500	77,520	-67,560	-3,210	-3,070	26,560	-50,110
1997 (W)		9,570	62,230	-70,290	-5,670	-2,870	-3,860	-53,970
1998 (W)		26,240	115,390	-74,290	-2,370	-3,520	64,850	10,890
1999 (W)		9,890	62,600	-79,760	-2,370	-3,240	-9,570	1,310
2000 (AN)		230	61,670	-73,170	-2,570	-3,140	-13,920	-12,600
2001 (D)		-19,390	41,990	-62,580	-4,720	-2,550	-44,610	-57,210
2002 (D)		5,290	55,040	-63,280	-5,740	-2,600	-8,500	-65,710
2003 (AN)		16,160	73,820	-64,490	-3,890	-2,790	21,890	-43,820
2004 (BN)		9,720	66,810	-69,100	-6,630	-3,100	930	-42,880
2005 (AN)		20,830	65,720	-67,050	-4,770	-2,700	15,230	-27,650
2006 (W)		21,340	78,420	-72,760	-3,790	-3,540	23,080	-4,570
2007 (D)		-18,170	31,480	-64,710	-6,120	-2,660	-57,390	-61,960
2008 (C)		-9,660	41,000	-53,690	-6,730	-2,500	-28,990	-90,950
2009 (D)		-16,230	34,220	-46,980	-4,890	-2,290	-33,840	-124,790
2010 (BN)		21,120	60,970	-53,030	-6,280	-2,260	23,240	-101,550
2011 (W)		40,210	61,280	-65,940	-4,560	-2,510	31,460	-70,090
2012 (BN)		-4,700	28,220	-57,740	-4,150	-2,260	-38,030	-108,120
2013 (D)		-3,750	40,960	-52,310	-5,610	-2,140	-20,230	-128,350
2014 (C)		-40,470	22,400	-30,840	-4,350	-1,810	-52,770	-181,120
2015 (C)		-6,210	39,300	-35,520	-6,220	-1,630	-7,700	-188,820
2016 (BN)		33,190	54,080	-49,060	-4,960	-1,980	34,150	-154,680
2017 (W)		50,970	82,740	-67,840	-4,220	-2,550	62,400	-92,280
2018 (BN)		-15,100	26,490	-53,000	-6,650	-1,930	-47,600	-139,880
Average (1990-2018)		2,460	54,980	-58,070	-4,490	-2,560	-4,820	
1990-2018	W	25,490	79,030	-68,970	-3,540	-3,040	32,250	
	AN	20,960	72,200	-61,880	-3,830	-2,680	27,880	
	BN	12,900	48,440	-55,170	-5,610	-2,250	1,140	
	D	-10,450	40,740	-57,970	-5,420	-2,450	-32,910	
	C	-26,820	34,790	-43,090	-4,590	-2,130	-39,390	

Note: positive values indicate inflows/increasing storage, negative values indicate outflows/decreasing storage.

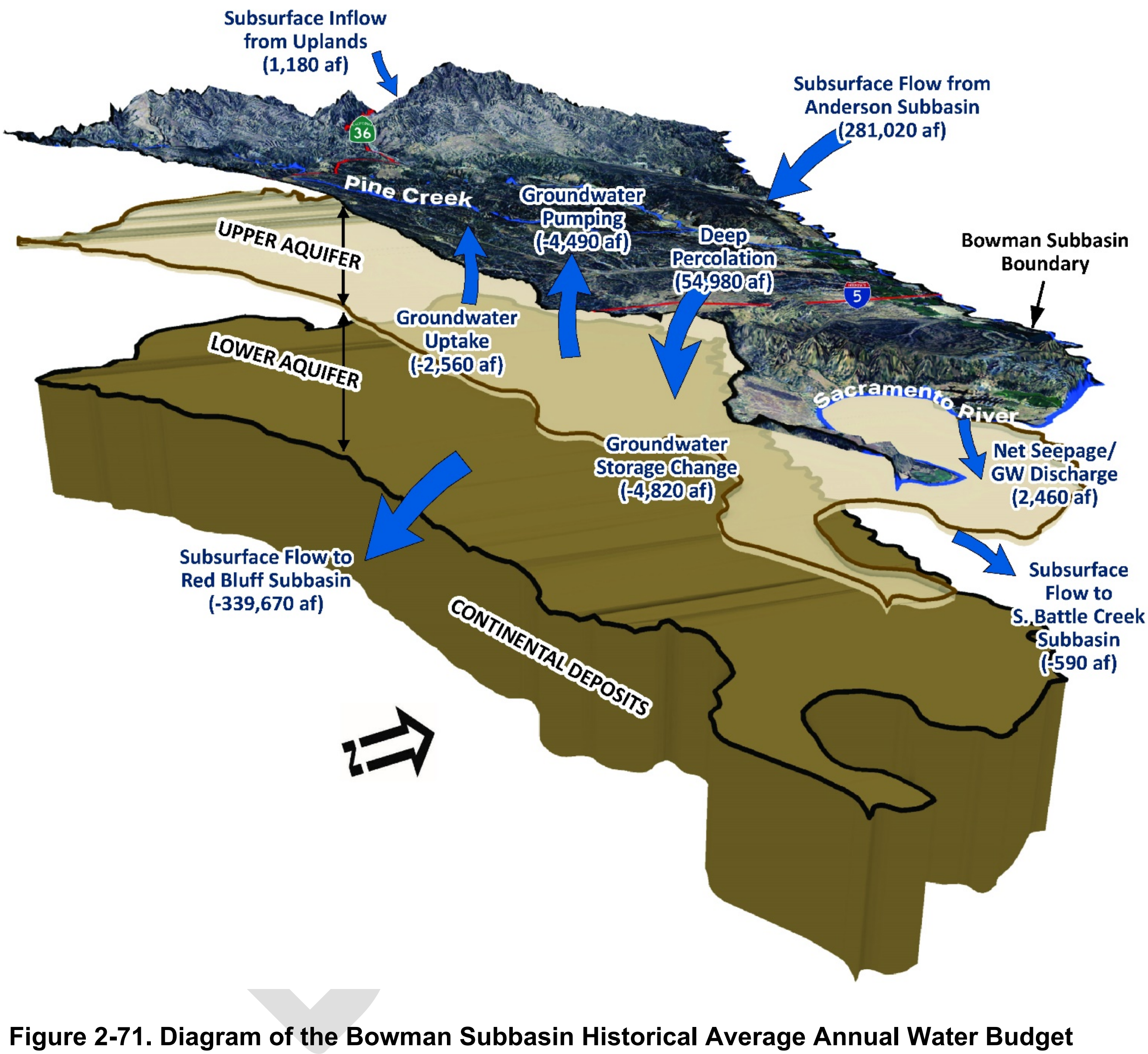


Figure 2-71. Diagram of the Bowman Subbasin Historical Average Annual Water Budget (1990-2018)

2.3.6 Current Water Budget

As noted for the historical water budget results, the current water budget values are subject to some change as the model calibration is finalized, although the overall changes are not anticipated to be great. The current water budget results will be updated in a subsequent draft of the section.

As described above in **Section 2.3.2**, several recent water budget periods have been considered for use in representing the current water budget. Because the hydrology and land use conditions can vary year to year, estimating the current water budget can be challenging. To evaluate the current water budget, water budget results from the historical model run were summarized for five different recent time periods to evaluate variability and trends. The five different recent water budget periods evaluated include the following:

- Most recent 10 years (2009-2018)
- Most recent 5 year (2014-2018)
- Most recent 3 years (2016-2018)
- Recent single year 2018
- Recent single year 2019

Comparison of these recent water budget periods provides a representation of how water use varies with precipitation and water supply conditions from year to year. Based on these comparisons and consideration of the hydrologic conditions over these recent periods, the recent three-year period from 2016 through 2018 is believed to provide a reasonable representation of the recent water budget conditions. For reporting a current water budget in the GSP, the average water budget for the three-year period between 2016 and 2018 is considered to be representative of the current water budget and representative of current hydrologic and land use conditions. This period incorporates recent land use conditions and spans three years (two below normal years and one wet year) that collectively have precipitation and hydrology similar to the long-term average. The results from comparisons of the recent water budget periods evaluated are presented below, including the results and discussion of the selected current water budget period of 2016-2018.

2.3.6.1 Surface Water System Water Budget Results

The comparison of the different recent SWS water budget periods provides a representation of how individual SWS water budget components vary from year to year depending on water demands, precipitation, and water supply conditions. The SWS water budget results for these different recent time periods are presented in **Table 2-37**. The single year SWS water budget results highlight the high variability between these two years, which included a below normal year in 2018 and a wet year in 2019. The water budget inflows and outflows from the SWS vary by about 580 taf between these two single years. Most of the variability in the total SWS inflows and outflows is a result of variability in precipitation, surface water inflow and surface water outflow. When comparing the average annual water budget results for recent multi-year periods, the variability is considerably reduced with a maximum difference in both inflows and outflows of about 146 taf per year between the three different recent multi-year periods evaluated.

The selected current water budget period of 2016-2018 (highlighted blue in **Table 2-37**) has total SWS inflows and outflows of about 793 taf per year, with the largest SWS inflows being surface water inflow (469 taf per year) and the largest SWS outflow being surface water outflow (528 taf per year). Current SWS water budget inflows also include 308 taf per year of precipitation, 9.0 taf per year of groundwater discharge to surface water, and 7.4 taf per year of groundwater extraction and uptake. Other SWS outflows in the current SWS water budget include 162 taf per year ET of precipitation, 46 taf per year deep percolation of precipitation, 35 taf of infiltration (seepage) of surface water, 11 taf per year ET of applied water, 8.5 taf per year of deep percolation of applied water, and additional smaller outflows for ET of groundwater uptake, and evaporation from surface water.

Table 2-37. Comparison of Recent SWS Water Budget Periods (acre-feet, rounded).

Flow Path		Recent Water Budget Period				
		Recent 10 Years	Recent 5 Years	Recent 3 Years	Recent 1 Year	Recent 1 Year
		(2009-2018)	(2014-2018)	(2016-2018)	2018	2019
Inflow	Surface Water Inflow	362,840	372,340	468,600	227,810	601,130
	Precipitation	261,340	267,440	307,560	188,020	423,670
	Groundwater Extraction/Uptake	7,320	7,260	7,430	8,570	6,960
	Groundwater Discharge to Surface Water	15,610	18,850	9,020	27,050	0
	Total Inflows[1]	***647,100***	***665,900***	***792,600***	***451,500***	***1,031,800***
Outflow	Surface Water Outflow	405,600	428,870	527,500	245,500	728,270
	ET of Applied Water	11,490	11,600	11,220	12,090	9,830
	ET of Groundwater Uptake	2,130	1,980	2,150	1,920	2,450
	ET of Precipitation	156,740	151,470	161,620	151,480	177,620
	Evaporation	890	850	930	850	930
	Deep Percolation of Applied Water	9,140	8,190	8,490	8,310	9,090
	Deep Percolation of Precipitation	35,930	36,810	45,940	18,170	65,480
	Infiltration of Surface Water (Seepage)	25,040	27,120	35,410	16,010	31,510
	Change in Root Zone Storage	170	-1,000	-660	-2,900	6,550
	Total Outflows[1]	***647,100***	***665,900***	***792,600***	***451,500***	***1,031,800***

[1] Total volumes rounded to 100 af.

2.3.6.2 Groundwater System Water Budget Results

Comparing the different recent water budget periods provides a representation of how the overall GWS water budget components vary from year to year depending on conditions including inflows/outflows between the SWS and subsurface flows. The GWS water budget results for these different recent time periods are presented in **Table 2-38**. As with the results for the current SWS water budget summaries, the single year results for the GWS water budget highlight the high variability between the two individual years of 2018 and 2019, which included a below normal year (2018) and a wet year (2019). Although some of the individual water budget components are relatively stable between the two different recent water budget years, the total change in groundwater storage varied by over 90 taf ranging from a decrease in storage of about -47.6 taf in 2018 (a below normal year) to an increase in storage of nearly 43.7 taf in 2019 (a wet year). There is considerably less variability in most of the different water budget components when comparing between the three different recent multi-year periods, although the net seepage and net subsurface flows do show relatively higher differences between the three recent periods. Average annual change in storage varies between -4.9 and -2.3 taf per year for the recent 10-year and 5-year periods, respectively, and indicates an average increase in storage of about 16.3 taf per year for the recent three-year period. This difference is likely attributable to the drought years consisting of dry and critical years that occurred between 2013 and 2015, which are included in the recent five- and ten-year periods, but not included in the most recent three-year period from 2016 to 2018.

The selected current water budget period of 2016-2018 (highlighted blue in **Table 2-38**) has total net seepage of about -23 taf per year, indicating net contribution of water to the GWS through exchanges occurring in surface waterways. Net subsurface flows total about -56.6 taf per year on average over the current water budget period occurring as outflow. Deep percolation represents a considerable inflow to the GWS averaging more than 54 taf per year. Groundwater pumping is an outflow from the GWS and averages about -5.3 taf per year during the current water budget period while groundwater uptake represents an additional GWS outflow of about -2.2 taf per year.

Table 2-38. Comparison of Recent GWS Water Budget Periods (acre-feet, rounded)

GWS Water Budget Component	Recent Water Budget Periods				
	Recent 10 Years (2009-2018)	Recent 5 Years (2014-2018)	Recent 3 Years (2016-2018)	Recent 1 Year 2018	Recent 1 Year 2019
Net Seepage	5,900	4,480	23,020	-15,100	27,950
Deep Percolation	45,070	45,000	54,440	26,490	74,580
Net Subsurface Flows	-51,230	-47,250	-56,630	-53,000	-54,930
Groundwater Pumping	-5,190	-5,280	-5,280	-6,650	-4,510
Groundwater Uptake	-2,140	-1,980	-2,150	-1,930	-2,450
Annual Groundwater Storage Change[1]	***-4,900***	***-2,300***	***16,300***	***-47,600***	***43,700***

[1] Annual storage change volumes rounded to 100 af.
Note: positive values indicate inflows/increasing storage, negative values indicate outflows/decreasing storage.

2.3.7 Projected Water Budget (STILL IN PROGRESS)

Projected water budget analyses are still in progress. Sections related to the projected water budget will be prepared as part of a subsequent draft when the projected water budget analyses have been completed.

2.3.7.1 Approach to Developing Projected Water Budget

2.3.7.2 Surface Water System

2.3.7.3 Groundwater System

2.3.7.4 Uncertainty in Projected Water Budget Estimates

2.3.7.5 Estimate of Sustainable Yield

REFERENCES

California Department of Water Resources (DWR). 2021. SVSim: Sacramento Valley Groundwater-Surface Water Simulation Model. Downloaded May 5, 2020. Available online: https://data.cnra.ca.gov/dataset/svsim.

California Department of Water Resources (DWR). 2016a. Best Management Practices for Sustainable Management of Groundwater, Water Budget, BMP. California DWR Sustainable Groundwater Management Program. December 2016. Available online: https://water.ca.gov/-/media/DWR-Website/Web-Pages/Programs/Groundwater-Management/Sustainable-Groundwater-Management/Best-Management-Practices-and-Guidance-Documents/Files/BMP-4-Water-Budget_ay_19.pdf.

California Department of Water Resources (DWR). 2016b. 2016 Statewide Crop Mapping Metadata. Updated January 2020. Available online: https://data.cnra.ca.gov/dataset/statewide-crop-mapping/resource/d5841996-ba8b-455c-819f-222006db7b85.