FINAL REPORT

Antelope Subbasin

Sustainable Groundwater Management Act

Groundwater Sustainability Plan (Chapter 2C Water Budget)

January 2022 Revised April 2024

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LIST OF ACRONYMS & ABBREVIATIONS

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
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
LMMWC	Los Molinos Mutual Water Company
Maf	Million acre-feet
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

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 2-55**). 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, which 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 Antelope 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 Antelope 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 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

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[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).

spanning from water year 1985 through 2019, although the calibration period is 1990-2019. Detailed documentation associated with the development of the Tehama IHM is included in **Appendix 2-J.**

This section presents the historical, current, and projected water budget results for the Antelope 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-J**. The water budget results presented in this section are rounded to two significant digits consistent with the uncertainty associated with the methods and sources used in the analysis. Water budget component results may not sum to the totals presented because of rounding.

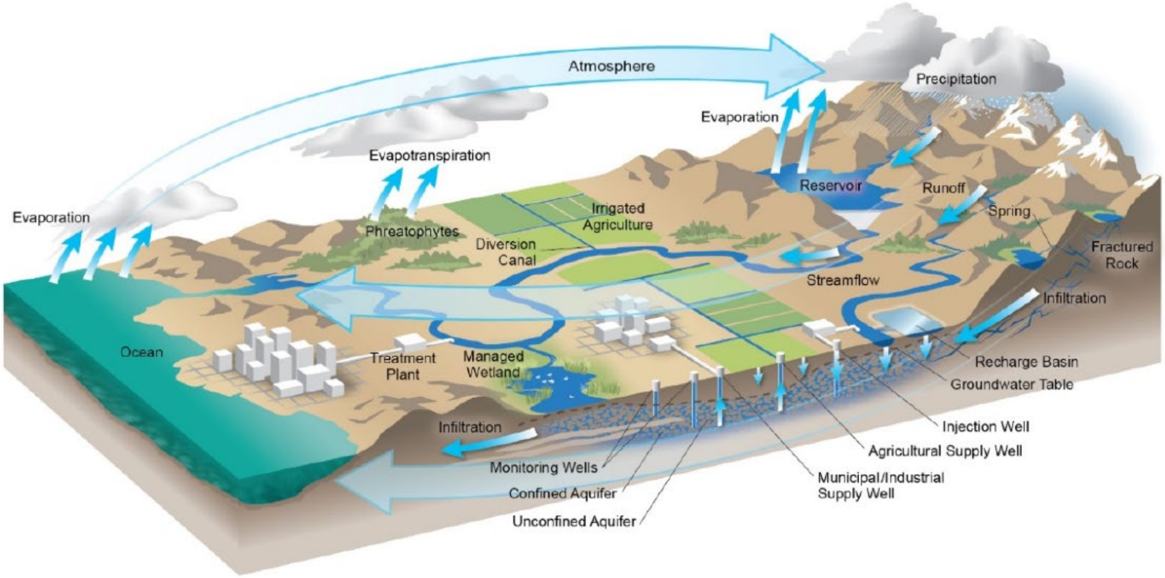

Figure 2-55. The Hydrologic Cycle (Source: DWR, 2016a)

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.

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[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 2-56**.

The conceptual model (or structure) for the Subbasin water budget is presented in **Figure 2-57**, 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-**, 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.

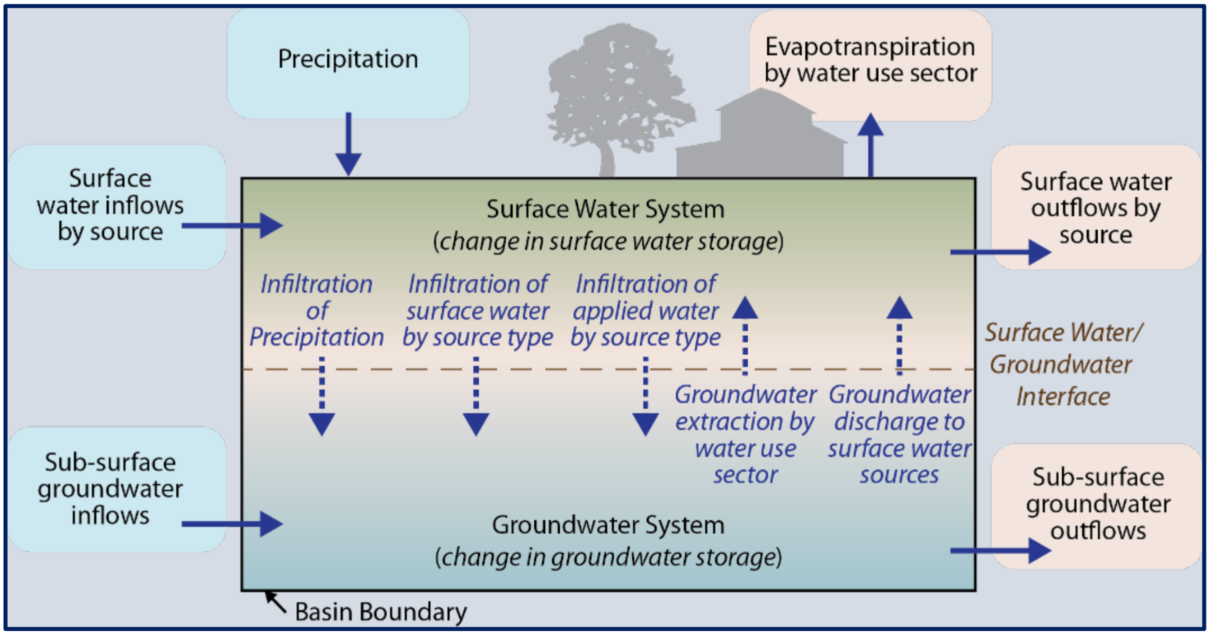

Figure 2-56. Water Budget Accounting Structure (Source: DWR, 2016a)

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

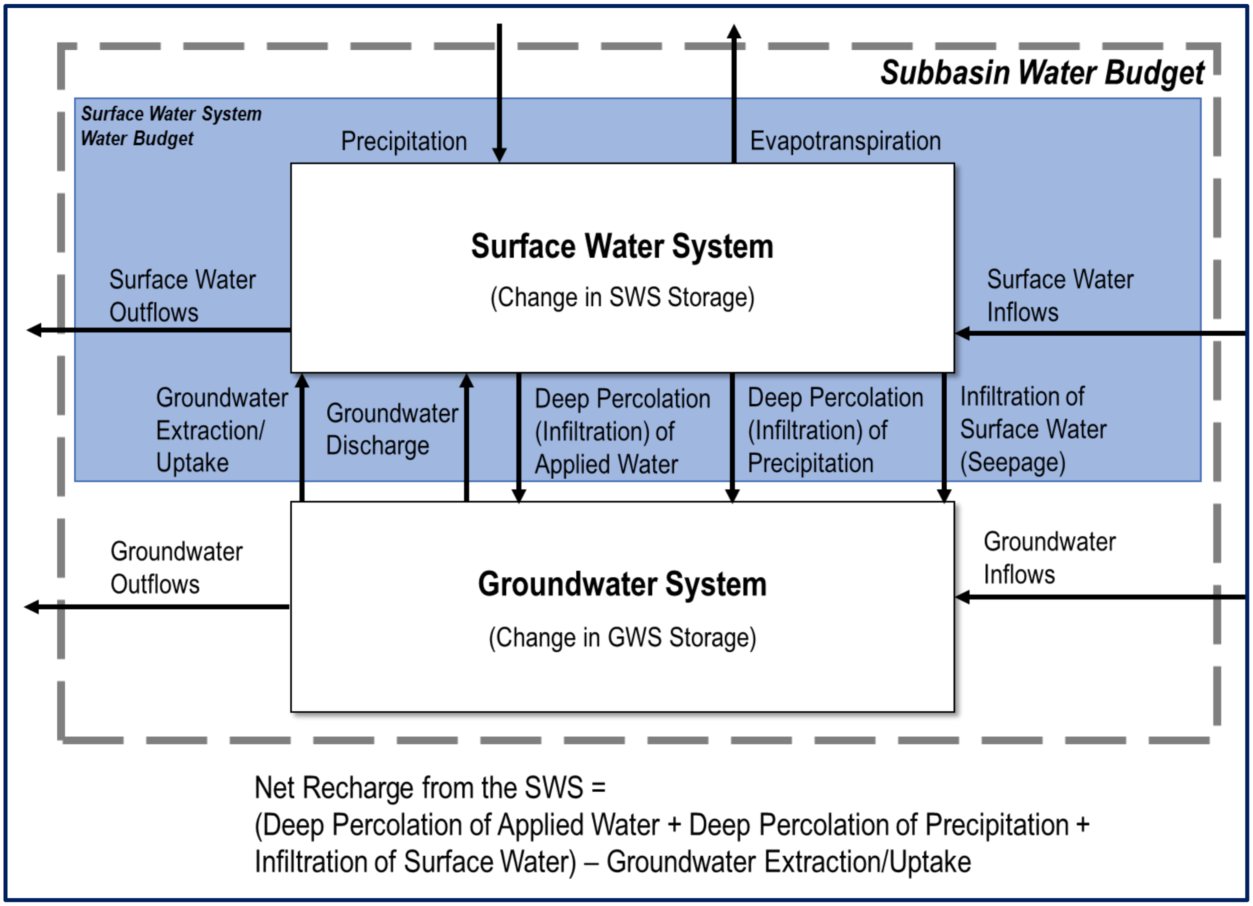

Figure 2-57. Subbasin Water Budget Conceptual Model

Table 2-10. Water Budget Components by Accounting Center and Associated GSP Regulations

ACCOUNTING CENTER	WATER BUDGET COMPONENT (FLOW DIRECTION)	GSP REGULATION SECTION1
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 Periods

Per 23 CCR §354.18, each GSP must quantify the historical, current, and projected water budget conditions for the Subbasin.

2.3.2.1 Historical and Current Water Budget Periods

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 historical 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 2-11**). 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**

Table 2-11. 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 consideration in estimating 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**). Although the model simulations were run for the period 1990-2072, results for 2019 are only shown in the current water budget comparison table for the purpose of considering variability in water budget over different recent time periods. The water budget for year 2019 is not explicitly included in the historical, current, or projected water budgets for the Subbasin although it was simulated in the model to span the years between historical (1990-2018) and projected (2022-2072) water budget periods. Details of model inputs are presented in **Appendix 2-J**. 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.

2.3.2.2 Projected 50-Year Hydrology and Water Budget Period (§354.18c3)

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.

To evaluate projected water budgets, fifty years of future hydrology inputs to the Tehama IHM were developed through consideration of the historical hydrology from 1968 to 2018. Because of the availability of higher quality data and characterization of conditions in the Subbasin during more recent years spanning the historical base period (1990-2018), the projected water budget analyses used surrogate years from the historical period to construct a future hydrology and water budget period representative and consistent with hydrologic conditions over a historical 50-years period from 1968 to 2018. Surrogate years from the historical base period were assigned to represent 50 years of future hydrology based on 1) the Sacramento Valley water year index from DWR for each year, 2) mimicking variability (wet and dry) in the historical precipitation conditions in the Subbasin and replicating precipitation consistent with the annual average historical precipitation, and (3) replicating regional streamflow conditions based on flows in the Sacramento River. The frequency of water year types used in the projected hydrology is representative of the 50 years of hydrology for the period 1968-2018 and includes approximately equal proportions of water years with above normal (wet and above normal; 48%) and below normal (below normal, dry, critical; 52%) hydrologic conditions (**Table 2-12**).

The approach and inputs used in development of the projected water budget are described in greater detail in the Tehama IHM documentation included as **Appendix 2-J**.

Table 2-12. Sacramento Valley Water Year Type Classification Over the Projected Water Budget Period (2022-2072)

SACRAMENTO VALLEY WATER YEAR TYPE	ABBREVIATION	NUMBER OF YEARS, 2022-2072	PERCENT TOTAL YEARS, 2022-2072
Wet	W	18	35%
Above Normal	AN	7	14%
Below Normal	BN	7	14%
Dry	D	9	18%
Critical	C	10	20%
	Total	**51**	**100%**

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 2.3.8** through **2.3.10**. 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-J.**

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 Antelope Subbasin SWS Water Budget Analysis

As shown in **Figure 2-57** and **Table 2-10**, 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 2-57** and **Table 2-10**. This represents the change in root zone soil moisture throughout the year. This is different from 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

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[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 Subbasin. 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 2-10**), 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]).

2.3.3.2.1 *SWS Inflows*

2.3.3.2.1.1 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 Antelope Subbasin are summarized below according to water source type. Additionally, runoff of precipitation from upgradient areas adjacent to the Subbasin represents a potential source of SWS inflow.

Local Supplies

Local supply inflows to the Antelope Subbasin predominantly include runoff from upgradient small watersheds adjacent to the Subbasin; surface water diversions from Antelope Creek to Edwards Ranch; surface water diversions from Antelope Creek, Little Antelope Creek, Mill Creek, and Butler Slough into various reaches of the Los Molinos Mutual Water Company (LMMWC) distribution system.

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[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).

Central Valley Project

Central Valley Project (CVP) inflows to the Antelope Subbasin include surface water diverted by small CVP contractors to irrigated land along the Sacramento River.

2.3.3.2.1.2 Precipitation

Precipitation falling on the landscape within the Subbasin is an inflow to the SWS. Precipitation inflows are accounted for by the land use (water use sector) on which they occur).

2.3.3.2.1.3 Groundwater Extraction and Uptake

Groundwater extraction is an inflow to the SWS (an outflow from the GWS). Groundwater extraction is accounted for by agricultural and urban (urban, residential, semi-agricultural, industrial) water use sectors. Urban groundwater pumping includes domestic well pumping. Groundwater uptake is water taken up by plant roots directly from the GWS.

2.3.3.2.1.4 Groundwater Discharge to Surface Water

Groundwater discharging to surface water features can occur where groundwater is very shallow and where groundwater levels are higher than the stage in surface water bodies. Groundwater discharge to surface water represents an inflow to the SWS (an outflow from the GWS).

2.3.3.2.2 SWS Outflows

2.3.3.2.2.1 Evapotranspiration

Evapotranspiration (ET) is accounted for by water use sector (urban, agriculture, native) and according to the source water (applied water or precipitation). ET from land includes from applied water and precipitation sources. Evaporation also occurs from rivers, streams, canals, and drains throughout the Subbasin.

2.3.3.2.2.2 Infiltration

Infiltration (deep percolation) is water that infiltrates below the root zone and recharges the GWS. Infiltration can occur from applied water (e.g., irrigation) or precipitation occurring on the landscape within the Subbasin. Alternatively, infiltration of surface water (stream seepage) can occur from surface water that seeps through the bottom of surface water features and recharges the GWS.

2.3.3.2.2.3 Surface Water Outflow

In the Antelope Subbasin, surface water outflows consist entirely of local supplies that traverse the Subbasin, or that drain from lands within the Subbasin or runoff into the Subbasin from the upland areas to the east. As described above, substantial local supply volumes enter the Antelope Subbasin along Sacramento River and tributary waterways, although much of this water passes through the Subbasin.

2.3.3.3 SWS Water Budget Overview

Water budget components are defined for each detailed accounting center in **Table 2-13** through

15. 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 Error! Reference source not found.**16**. 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.

Table 2-13. 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.
	Change in SWS Storage	Storage	Change in root zone soil moisture throughout the year; does not represent change in groundwater storage.

[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 2-14 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 2-15. 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 2-16. 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 2.3.6** and **2.3.7** 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 are included in **Section 2.3.8** through **2.3.10**. 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-J.**

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**).

$$\text{Total GWS Inflows} - \text{Total GWS Outflows} = \text{Change in GWS Storage (monthly)}$$

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

As shown in **Figure 2-57** and **Table 2-10**, 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.

2.3.4.1.1 *Lateral Subsurface Flows*

Subsurface groundwater flows to and from the Antelope Subbasin occur between the Bend Subbasin to the north, the Red Bluff Subbasin to the west, and the Los Molinos Subbasin to the east. Additional subsurface groundwater inflows occur from the upland (small watershed) areas adjoining the Antelope Subbasin to the east.

2.3.4.1.2 *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 represent inflows to the GWS and are also included in the SWS water budget as outflows from the SWS.

2.3.4.1.3 *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 in the GWS water budget as a net volume of stream seepage. 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.

2.3.4.1.4 *Groundwater Extraction and Uptake*

Groundwater extractions and groundwater uptake are exchanges that occur between the GWS and the SWS and represent an outflow from the GWS. Groundwater extraction from the GWS occurs through groundwater pumping to meet water demands for urban and agricultural needs whereas groundwater uptake occurs through uptake of water by plants directly from the GWS.

2.3.4.2 GWS Water Budget Overview

Change in GWS storage as represented by change in groundwater storage is also depicted in **Figure 2-57** and **Table 2-10**. 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 2-17** 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.

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Table 2-17. 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 subbasins.
	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 subbasins.
	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 following section summarizes the analyses and results relating to the historical SWS water budget for the Subbasin. Detailed descriptions and presentation of results for each of the individual water budget components, and the processes and data sources used in their development are included in **Appendices 2-J and 2-K**.

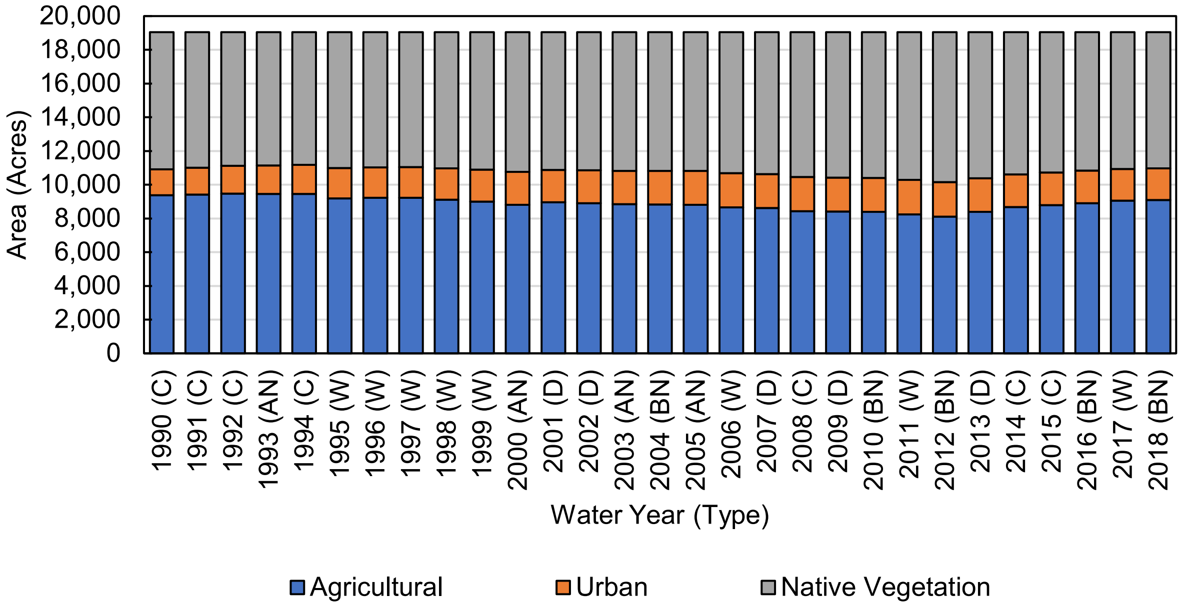
2.3.5.1 Land Use

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-**18** and **Figure 2-58** summarize the annual land use areas over the historical period (1990-2018) in the Antelope Subbasin by water use sector, as defined by the GSP Regulations (23 CCR § 351(al)). In the Antelope 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.

On average, agricultural, urban, and native vegetation land uses covered approximately 8,900 acres, 1,900 acres, and 8,300 acres, respectively, between 1990 and 2018. The total acreage of each water use sector has remained relatively steady over time, with only a slight increase in native vegetation corresponding with a slight decrease in agricultural area during the late 2000s and early 2010s.

Figure 2-58. Antelope Subbasin Land Use Areas, by Water Use Sector



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[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).

Table 2-18. Antelope Subbasin Land Use Areas, by Water Use Sector (acres)

WATER YEAR (TYPE)	AGRICULTURAL	URBAN[1]	NATIVE VEGETATION	TOTAL
1990 (C)	9,377	1,542	8,125	19,043
1991 (C)	9,411	1,590	8,043	19,043
1992 (C)	9,475	1,638	7,931	19,043
1993 (AN)	9,445	1,690	7,909	19,043
1994 (C)	9,457	1,720	7,866	19,043
1995 (W)	9,185	1,802	8,056	19,043
1996 (W)	9,232	1,791	8,020	19,043
1997 (W)	9,217	1,822	8,004	19,043
1998 (W)	9,116	1,849	8,078	19,043
1999 (W)	9,006	1,880	8,158	19,043
2000 (AN)	8,801	1,964	8,278	19,043
2001 (D)	8,955	1,925	8,164	19,043
2002 (D)	8,907	1,944	8,192	19,043
2003 (AN)	8,855	1,971	8,218	19,043
2004 (BN)	8,823	1,999	8,221	19,043
2005 (AN)	8,808	2,010	8,226	19,043
2006 (W)	8,657	2,020	8,366	19,043
2007 (D)	8,625	1,997	8,421	19,043
2008 (C)	8,436	2,023	8,584	19,043
2009 (D)	8,405	2,019	8,620	19,043
2010 (BN)	8,388	2,015	8,640	19,043
2011 (W)	8,249	2,041	8,754	19,043
2012 (BN)	8,115	2,048	8,880	19,043
2013 (D)	8,395	1,996	8,653	19,043
2014 (C)	8,674	1,942	8,428	19,043
2015 (C)	8,788	1,940	8,315	19,043
2016 (BN)	8,902	1,938	8,204	19,043
2017 (W)	9,048	1,878	8,117	19,043
2018 (BN)	9,099	1,873	8,071	19,043
Average (1990-2018)	8,891	1,892	8,260	19,043

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

Agricultural land uses are further detailed in **Table 2-19** and **Figure 2-59**. Historically, a majority of the agricultural area in the Antelope Subbasin has been comprised of orchards (primarily walnuts, prunes, and almonds) and pasture, with varying acreage of grain and hay crops over time. The overall orchard acreage has generally increased since the early 2000s.

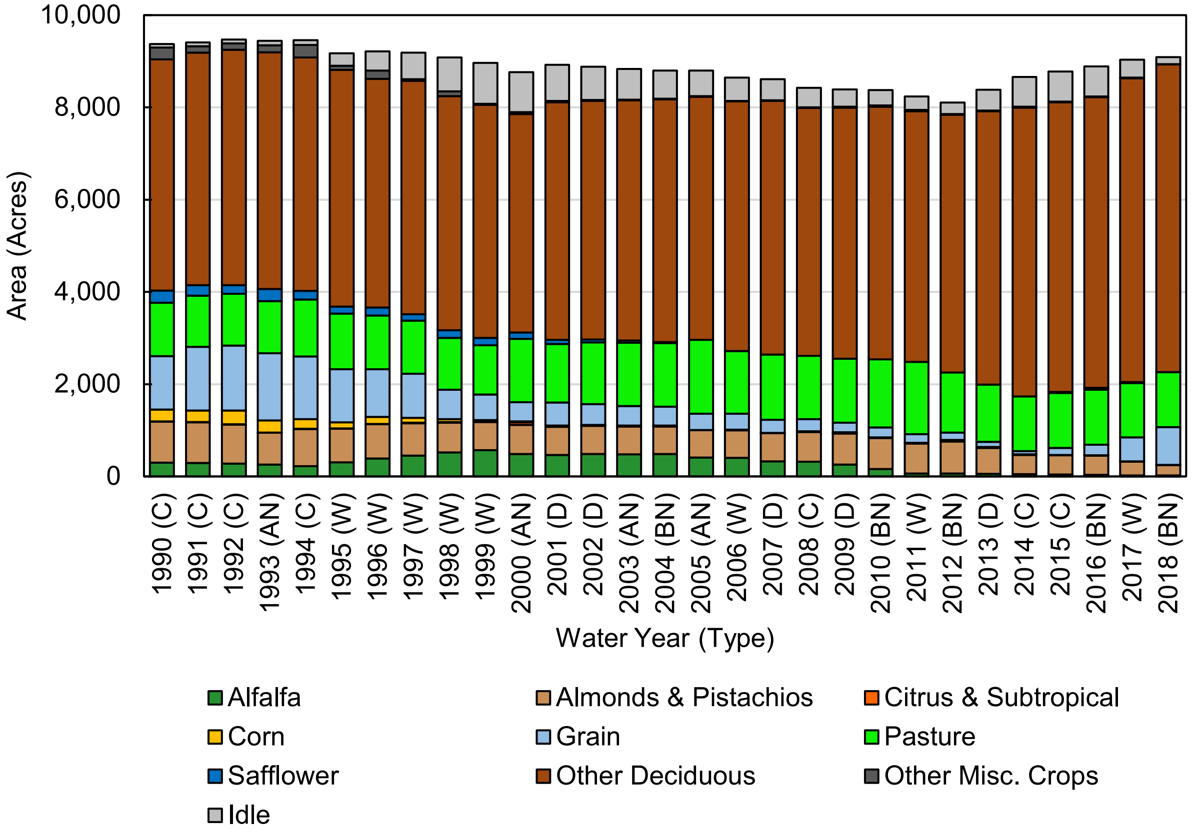

Figure 2-59. Antelope Subbasin Agricultural Land Use Areas

Table 2-19. Antelope 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)	300	885	8	260	1,153	1,160	0	261	5,014	255	82	9,377
1991 (C)	294	881	7	250	1,376	1,113	0	223	5,043	139	85	9,411
1992 (C)	277	846	7	302	1,401	1,127	0	188	5,098	139	90	9,475
1993 (AN)	256	692	6	258	1,461	1,129	0	264	5,131	153	96	9,445
1994 (C)	226	801	6	212	1,354	1,237	0	186	5,059	272	105	9,457
1995 (W)	305	729	7	134	1,146	1,205	11	158	5,128	90	271	9,185
1996 (W)	389	741	10	148	1,034	1,169	15	174	4,952	180	420	9,232
1997 (W)	448	707	12	103	959	1,146	31	142	5,062	30	577	9,217
1998 (W)	521	644	14	60	643	1,119	30	165	5,078	104	737	9,116
1999 (W)	570	609	16	23	554	1,074	38	157	5,051	26	887	9,006
2000 (AN)	484	635	54	20	415	1,370	35	142	4,736	37	872	8,801
2001 (D)	467	611	11	12	499	1,268	30	96	5,150	23	788	8,955
2002 (D)	488	610	9	13	449	1,338	25	63	5,169	22	722	8,907
2003 (AN)	481	604	6	9	423	1,374	21	52	5,201	18	664	8,855
2004 (BN)	488	598	5	13	411	1,375	24	24	5,263	14	609	8,823
2005 (AN)	411	593	3	1	351	1,605	12	0	5,266	17	549	8,808
2006 (W)	406	595	11	2	346	1,360	12	0	5,411	6	507	8,657
2007 (D)	326	608	2	4	285	1,418	12	0	5,497	11	461	8,625
2008 (C)	320	642	2	17	262	1,370	12	0	5,373	15	423	8,436
2009 (D)	258	673	22	5	208	1,389	12	0	5,436	22	379	8,405
2010 (BN)	159	676	12	1	217	1,475	12	0	5,479	23	335	8,388
2011 (W)	67	649	3	8	190	1,568	12	0	5,432	30	290	8,249
2012 (BN)	66	694	17	15	161	1,301	13	0	5,592	13	245	8,115
2013 (D)	58	563	11	9	107	1,243	13	0	5,929	15	447	8,395
2014 (C)	49	419	8	7	67	1,186	13	0	6,261	20	645	8,674
2015 (C)	41	419	5	4	148	1,192	13	20	6,283	16	648	8,788
2016 (BN)	35	419	5	1	228	1,190	13	40	6,303	14	653	8,902
2017 (W)	19	303	4	0	523	1,176	12	20	6,589	12	390	9,048
2018 (BN)	19	227	5	0	817	1,196	12	0	6,666	11	146	9,099
Average (1990-2018)	284	623	10	65	593	1,272	15	82	5,436	60	452	8,891

[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.

2.3.5.2 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 Error! Reference source not found.**20.** 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 volumes of groundwater discharge to surface water that make up a large part of the Subbasin SWS inflows. Over the historical period, groundwater discharge to surface water averaged a little over 53 taf per year. Surface water inflows and precipitation also represent larger SWS inflow components averaging about 43 taf per year and 41 taf per year, respectively. Groundwater extraction and uptake represent a smaller SWS inflow in the Subbasin averaging about 15 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 89 taf per year on average, a value that corresponds with the large volumes of groundwater discharge to surface waterways (about 53 taf per year). By comparison, other SWS outflows in the Subbasin are relatively smaller, with values for ET of precipitation averaging about 25 taf per year and average ET of applied water totaling about 19 taf per year on average. All other outflow components from the SWS are relatively smaller. The outflow of deep percolation of precipitation and applied water to the GWS are about 7.2 and 4.6 taf per year, respectively, and infiltration (seepage) of surface water to the GWS totals about 4.9 taf per year on average. Together, the outflows from the SWS to the GWS for deep percolation of precipitation and applied water and from surface water seepage total about 46.7 taf per year over the historic water budget period.

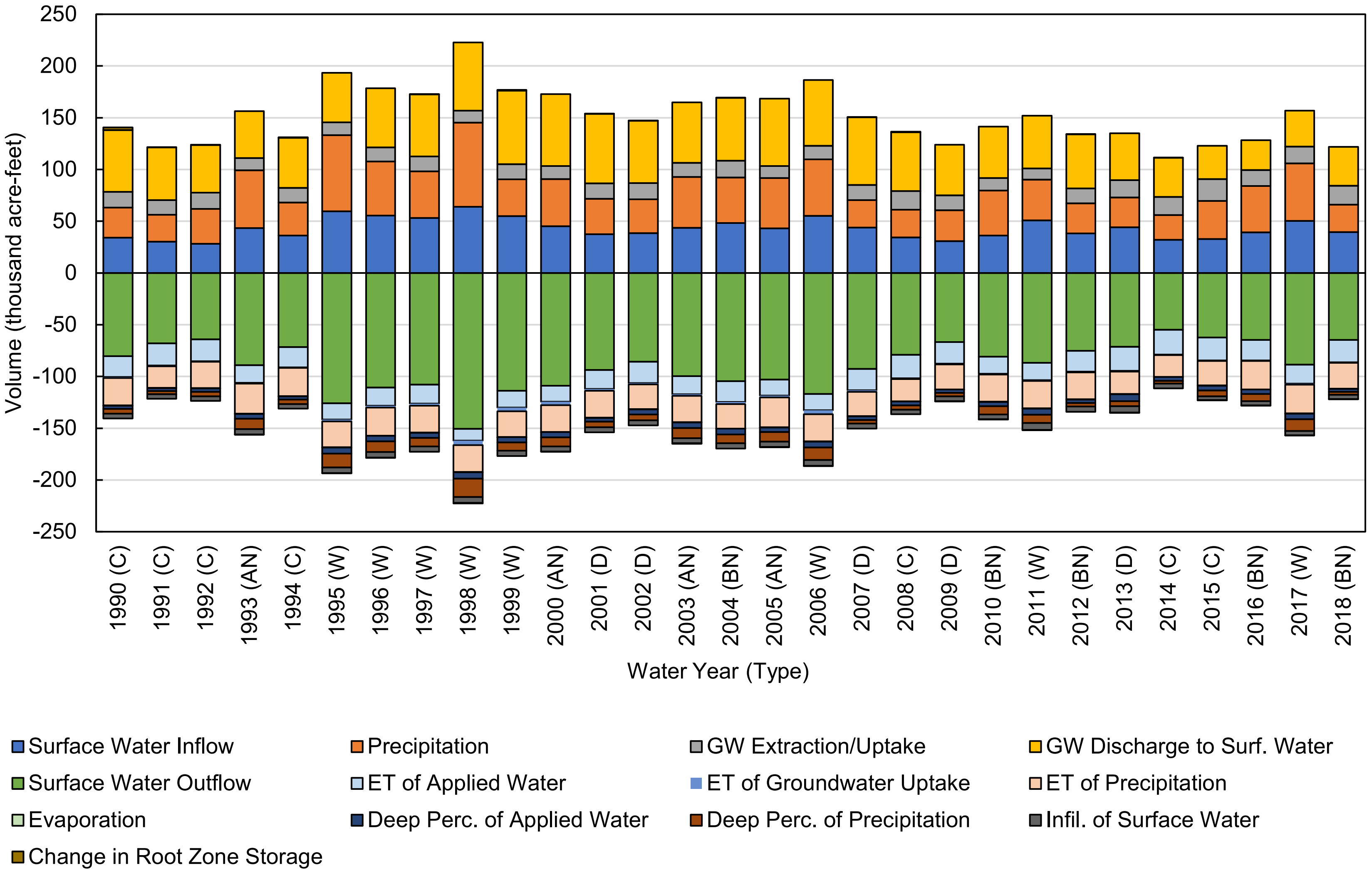

Figure 2-60. Antelope Subbasin Surface Water System Historical Water Budget, 1990-2018

Table 2-20. Antelope Subbasin Surface Water System Historical Water Budget, 1990-2018 (acre-feet)

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[1]	DEEP PERC. OF APPLIED WATER	DEEP PERC. OF PRECIPITATION	INFIL. OF SURFACE WATER	
1990 (C)	34,000	29,000	15,000	60,000	80,000	20,000	1,000	26,000	150	3,100	4,700	4,700	-2,600
1991 (C)	30,000	26,000	14,000	51,000	68,000	21,000	630	21,000	150	2,900	2,900	4,600	-320
1992 (C)	28,000	34,000	16,000	46,000	64,000	21,000	550	25,000	130	3,500	4,500	4,200	-50
1993 (AN)	44,000	56,000	12,000	45,000	89,000	17,000	870	29,000	150	4,700	10,000	5,000	350
1994 (C)	36,000	32,000	14,000	48,000	72,000	19,000	620	27,000	140	3,200	4,300	4,500	-420
1995 (W)	60,000	74,000	12,000	48,000	130,000	15,000	1,900	25,000	150	6,000	13,000	5,400	220
1996 (W)	55,000	52,000	14,000	57,000	110,000	17,000	1,900	27,000	150	5,300	10,000	5,300	80
1997 (W)	53,000	45,000	14,000	60,000	110,000	18,000	2,100	26,000	150	5,000	8,300	5,200	-250
1998 (W)	64,000	81,000	12,000	66,000	150,000	11,000	4,400	26,000	150	6,300	18,000	5,600	500
1999 (W)	55,000	36,000	15,000	71,000	110,000	16,000	3,600	25,000	150	5,100	7,900	5,200	-710
2000 (AN)	45,000	45,000	13,000	69,000	110,000	16,000	3,200	26,000	150	5,100	8,800	5,000	230
2001 (D)	38,000	34,000	15,000	67,000	94,000	18,000	1,800	26,000	150	3,700	5,400	4,700	-50
2002 (D)	38,000	33,000	16,000	60,000	86,000	21,000	1,300	24,000	150	4,800	5,900	4,900	-250
2003 (AN)	44,000	49,000	14,000	58,000	100,000	17,000	1,800	25,000	150	5,400	9,700	5,000	360
2004 (BN)	48,000	44,000	16,000	61,000	100,000	20,000	2,200	24,000	150	5,600	8,400	5,100	-290
2005 (AN)	43,000	49,000	12,000	65,000	100,000	15,000	1,700	29,000	150	4,400	9,300	5,000	300
2006 (W)	55,000	55,000	13,000	63,000	120,000	16,000	3,800	26,000	170	5,800	12,000	5,600	40
2007 (D)	44,000	26,000	15,000	65,000	93,000	20,000	1,600	23,000	160	3,700	3,400	5,000	-50
2008 (C)	34,000	27,000	18,000	57,000	79,000	22,000	920	22,000	130	3,900	4,100	4,400	-500

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[1]	DEEP PERC. OF APPLIED WATER	DEEP PERC. OF PRECIPITATION	INFIL. OF SURFACE WATER	
2009 (D)		31,000	30,000	14,000	49,000	67,000	21,000	670	24,000	140	3,200	3,500	4,400	290
2010 (BN)		36,000	43,000	12,000	50,000	81,000	17,000	700	26,000	140	4,200	8,000	4,600	130
2011 (W)		51,000	39,000	11,000	51,000	87,000	17,000	980	26,000	230	6,000	8,100	6,600	270
2012 (BN)		38,000	29,000	14,000	52,000	75,000	20,000	740	26,000	160	3,300	3,600	5,000	-240
2013 (D)		44,000	29,000	17,000	45,000	71,000	23,000	680	22,000	210	6,800	4,900	6,100	90
2014 (C)		32,000	24,000	18,000	38,000	55,000	24,000	560	21,000	150	3,700	2,500	4,700	-50
2015 (C)		33,000	37,000	21,000	32,000	62,000	22,000	490	24,000	110	4,800	5,600	3,700	50
2016 (BN)		39,000	45,000	16,000	29,000	65,000	20,000	570	27,000	130	4,300	6,800	4,400	160
2017 (W)		50,000	56,000	16,000	35,000	89,000	18,000	1,200	28,000	100	5,400	11,000	4,200	70
2018 (BN)		39,000	27,000	18,000	38,000	65,000	22,000	600	25,000	120	2,900	2,900	4,200	60
Average (1990-2018)		43,000	41,000	15,000	53,000	89,000	19,000	1,500	25,000	150	4,600	7,200	4,900	-90
1990-2018	W	55,000	55,000	13,000	56,000	110,000	16,000	2,500	26,000	160	5,600	11,000	5,400	30
	AN	44,000	50,000	12,000	60,000	100,000	16,000	1,900	27,000	150	4,900	9,500	5,000	310
	BN	40,000	38,000	15,000	46,000	78,000	20,000	960	26,000	140	4,100	6,000	4,600	-40
	D	39,000	30,000	15,000	57,000	82,000	21,000	1,200	24,000	160	4,400	4,600	5,000	10
	C	33,000	30,000	17,000	47,000	69,000	21,000	690	24,000	140	3,600	4,100	4,400	-550

1 Diversions for some years were estimated based on average monthly data, resulting in a generally constant evaporation volume for some years.

2.3.5.3 Historical Groundwater Water Budget Summary

Summarized results for major components of the historical water budget as they relate to the GWS are presented in **Figures 2-61** and **2-62,** and **Table 2-21**. Among the outflows from the Subbasin GWS, groundwater pumping makes up the largest fraction of the total GWS outflows (on average -13 taf per year). Highly negative net seepage values (on average -55 taf per year) represent net groundwater discharging to surface water features and leaving the GWS. Deep percolation is the largest net inflow component averaging about 12 taf per year. Positive net subsurface flows (on average 50 taf per year) represent the combined subsurface inflows from adjacent subbasins and upland areas.

Groundwater (root water) uptake directly from shallow groundwater (on average -1.5 taf per year) represents a smaller outflow from the GWS. Overall, the water budget results for the 29-year historic period indicate a cumulative change in groundwater storage of about -7 taf, which equals an average annual change in groundwater storage of only about -610 af per year. This change in storage estimates equate to total decreases in storage in the Subbasin of about 0.77 acre-feet per acre on average over the 29 years and an annual decrease of less than 0.07 acre-feet per acre across the entire Subbasin (approximately 9,130 acres). **Figure 2-61** provides a conceptual illustration of the historical water budget. **Figure 2-62** 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. The decrease of groundwater storage during relatively dry years is not an indication of overdraft, but likely due to removal of temporary surplus of groundwater. Temporary surplus removal is the extraction of a volume of aquifer storage to enable the capture of recharge and reduction in subsurface outflow from the subbasin without impacting beneficial users of groundwater creating unreasonable results. In contrast, overdraft is defined as “the condition of a groundwater basin or subbasin in which the amount of water withdrawn by pumping exceeds the amount of water that recharges the basin over a period of years, during which the water supply conditions approximate average conditions. Overdraft can be characterized by groundwater levels that decline over a period of years and never fully recover, even in wet years. If overdraft continues for a number of years, significant adverse impacts may occur, including increased extraction costs, costs of well deepening or replacement, land subsidence, water quality degradation, and environmental impacts” (DWR, 2003).

Detailed results for the historical GWS water budget are presented in **Appendix 2-K**.

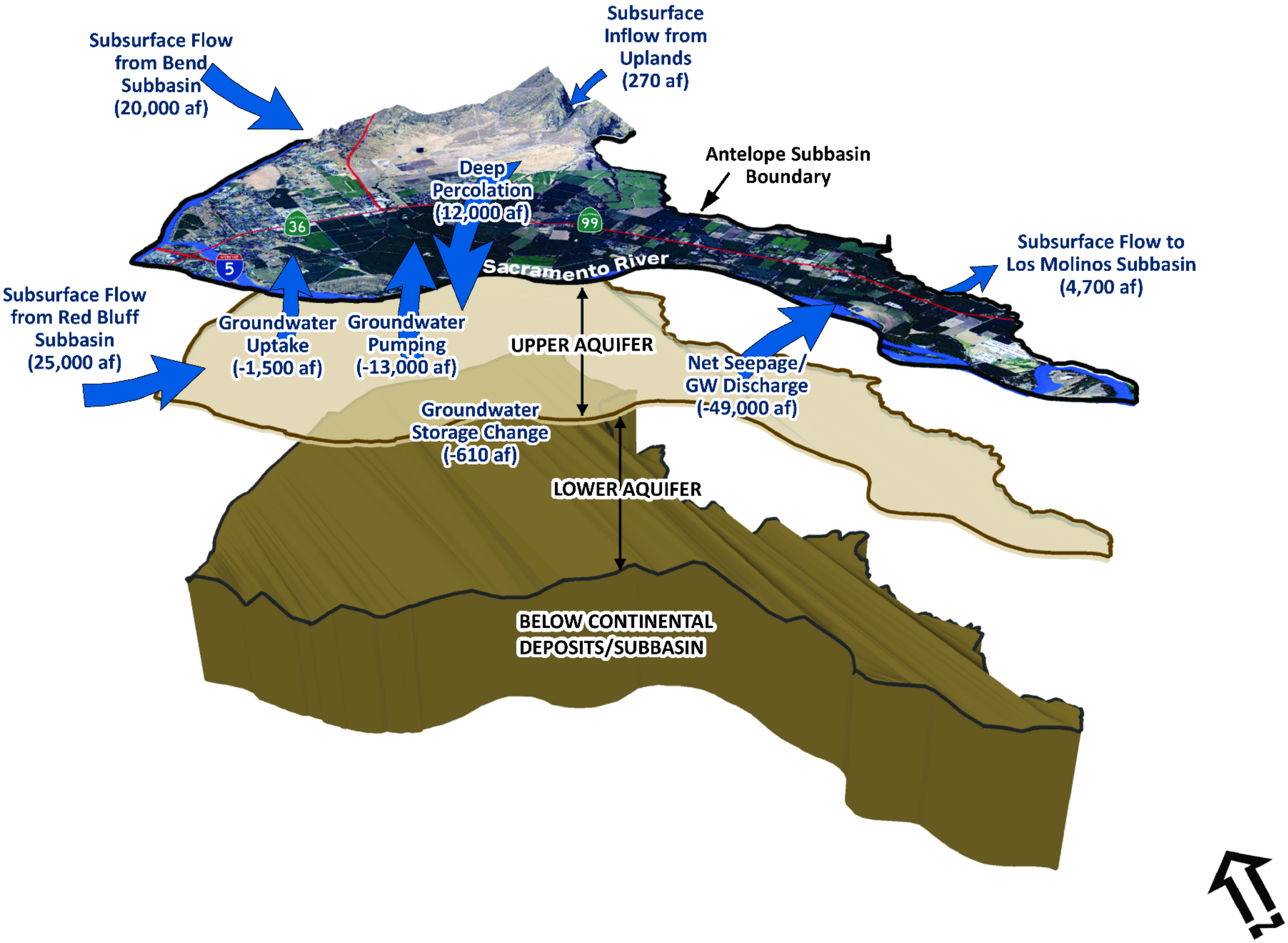

Figure 2-61. Diagram of the Antelope Subbasin Historical Average Annual Water Budget (1990-2018)

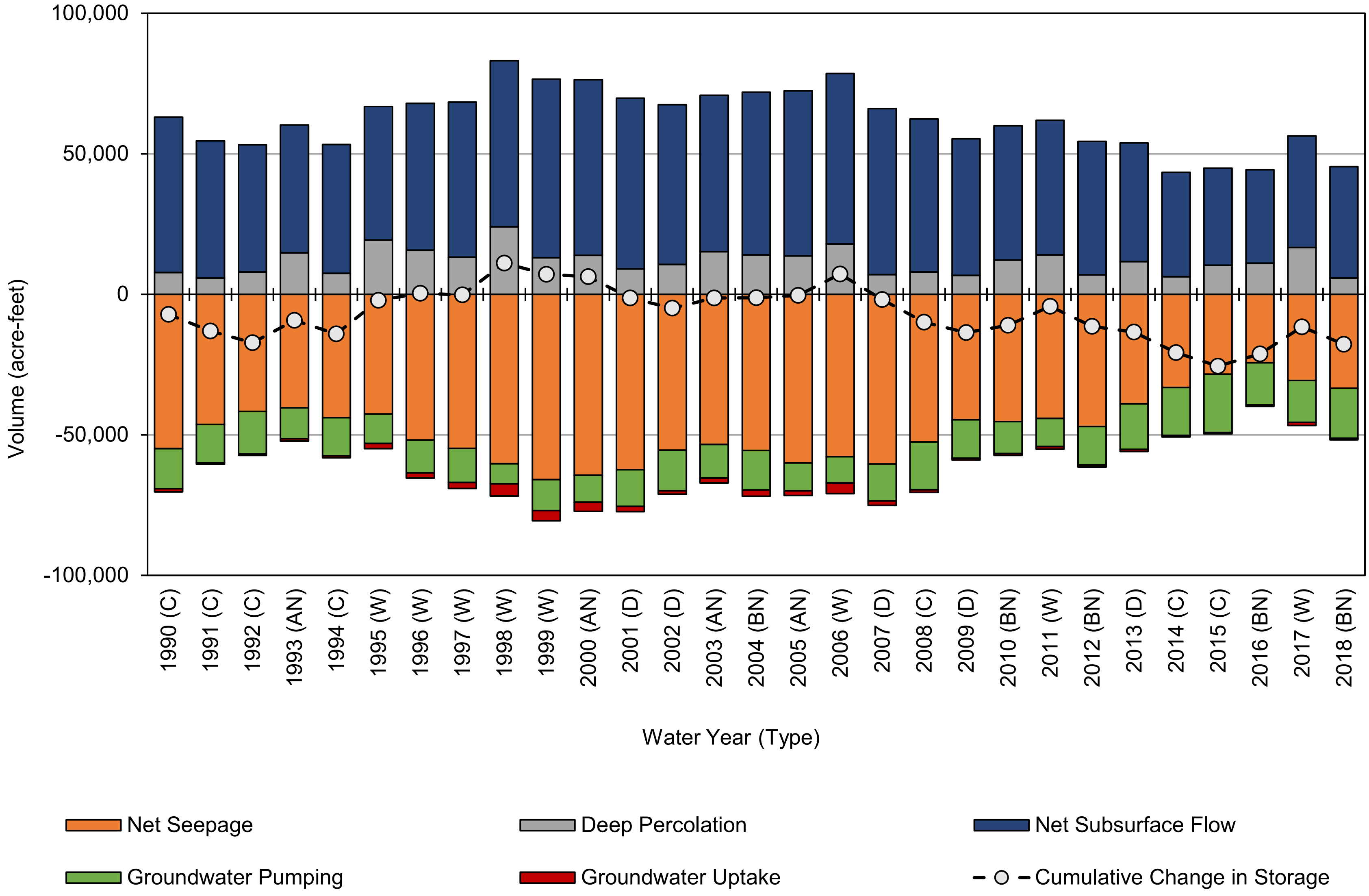

Figure 2-62. Antelope Subbasin Historical Water Budget Summary

Table 2-21. Antelope Subbasin Historical Water Budget Summary (acre-feet)

<table>
<tr><th colspan="2">Water Year (Type)</th><th>Net Seepage</th><th>Deep Percolation</th><th>Net Subsurface Flows</th><th>Ground-water Pumping</th><th>Ground-water Uptake</th><th>Annual Groundwater Storage Change</th><th>Cumulative Groundwater Storage Change</th></tr>
<tr><td colspan="2">1990 (C)</td><td>-55,000</td><td>7,800</td><td>55,000</td><td>-14,000</td><td>-1,000</td><td>-7,200</td><td>-7,200</td></tr>
<tr><td colspan="2">1991 (C)</td><td>-46,000</td><td>5,800</td><td>49,000</td><td>-14,000</td><td>-620</td><td>-5,900</td><td>-13,000</td></tr>
<tr><td colspan="2">1992 (C)</td><td>-42,000</td><td>8,000</td><td>45,000</td><td>-15,000</td><td>-550</td><td>-4,100</td><td>-17,000</td></tr>
<tr><td colspan="2">1993 (AN)</td><td>-40,000</td><td>15,000</td><td>45,000</td><td>-11,000</td><td>-870</td><td>8,000</td><td>-9,200</td></tr>
<tr><td colspan="2">1994 (C)</td><td>-44,000</td><td>7,400</td><td>46,000</td><td>-14,000</td><td>-620</td><td>-4,800</td><td>-14,000</td></tr>
<tr><td colspan="2">1995 (W)</td><td>-43,000</td><td>19,000</td><td>48,000</td><td>-11,000</td><td>-1,900</td><td>12,000</td><td>-2,200</td></tr>
<tr><td colspan="2">1996 (W)</td><td>-52,000</td><td>16,000</td><td>52,000</td><td>-12,000</td><td>-1,900</td><td>2,600</td><td>400</td></tr>
<tr><td colspan="2">1997 (W)</td><td>-55,000</td><td>13,000</td><td>55,000</td><td>-12,000</td><td>-2,100</td><td>-600</td><td>-200</td></tr>
<tr><td colspan="2">1998 (W)</td><td>-60,000</td><td>24,000</td><td>59,000</td><td>-7,200</td><td>-4,400</td><td>11,000</td><td>11,000</td></tr>
<tr><td colspan="2">1999 (W)</td><td>-66,000</td><td>13,000</td><td>64,000</td><td>-11,000</td><td>-3,600</td><td>-4,000</td><td>7,100</td></tr>
<tr><td colspan="2">2000 (AN)</td><td>-64,000</td><td>14,000</td><td>62,000</td><td>-9,600</td><td>-3,200</td><td>-880</td><td>6,200</td></tr>
<tr><td colspan="2">2001 (D)</td><td>-62,000</td><td>9,100</td><td>61,000</td><td>-13,000</td><td>-1,800</td><td>-7,500</td><td>-1,300</td></tr>
<tr><td colspan="2">2002 (D)</td><td>-55,000</td><td>11,000</td><td>57,000</td><td>-14,000</td><td>-1,300</td><td>-3,700</td><td>-5,000</td></tr>
<tr><td colspan="2">2003 (AN)</td><td>-53,000</td><td>15,000</td><td>56,000</td><td>-12,000</td><td>-1,800</td><td>3,700</td><td>-1,300</td></tr>
<tr><td colspan="2">2004 (BN)</td><td>-56,000</td><td>14,000</td><td>58,000</td><td>-14,000</td><td>-2,200</td><td>81</td><td>-1,200</td></tr>
<tr><td colspan="2">2005 (AN)</td><td>-60,000</td><td>14,000</td><td>59,000</td><td>-9,900</td><td>-1,700</td><td>780</td><td>-410</td></tr>
<tr><td colspan="2">2006 (W)</td><td>-58,000</td><td>18,000</td><td>61,000</td><td>-9,400</td><td>-3,800</td><td>7,600</td><td>7,200</td></tr>
<tr><td colspan="2">2007 (D)</td><td>-60,000</td><td>7,000</td><td>59,000</td><td>-13,000</td><td>-1,600</td><td>-9,100</td><td>-1,800</td></tr>
<tr><td colspan="2">2008 (C)</td><td>-53,000</td><td>8,000</td><td>54,000</td><td>-17,000</td><td>-920</td><td>-8,100</td><td>-10,000</td></tr>
<tr><td colspan="2">2009 (D)</td><td>-45,000</td><td>6,700</td><td>49,000</td><td>-14,000</td><td>-670</td><td>-3,700</td><td>-14,000</td></tr>
<tr><td colspan="2">2010 (BN)</td><td>-45,000</td><td>12,000</td><td>48,000</td><td>-11,000</td><td>-700</td><td>2,600</td><td>-11,000</td></tr>
<tr><td colspan="2">2011 (W)</td><td>-44,000</td><td>14,000</td><td>48,000</td><td>-9,900</td><td>-980</td><td>6,800</td><td>-4,200</td></tr>
<tr><td colspan="2">2012 (BN)</td><td>-47,000</td><td>6,900</td><td>47,000</td><td>-14,000</td><td>-740</td><td>-7,100</td><td>-11,000</td></tr>
<tr><td colspan="2">2013 (D)</td><td>-39,000</td><td>12,000</td><td>42,000</td><td>-16,000</td><td>-680</td><td>-2,000</td><td>-13,000</td></tr>
<tr><td colspan="2">2014 (C)</td><td>-33,000</td><td>6,200</td><td>37,000</td><td>-17,000</td><td>-560</td><td>-7,300</td><td>-21,000</td></tr>
<tr><td colspan="2">2015 (C)</td><td>-28,000</td><td>10,000</td><td>35,000</td><td>-21,000</td><td>-490</td><td>-4,800</td><td>-26,000</td></tr>
<tr><td colspan="2">2016 (BN)</td><td>-24,000</td><td>11,000</td><td>33,000</td><td>-15,000</td><td>-570</td><td>4,400</td><td>-21,000</td></tr>
<tr><td colspan="2">2017 (W)</td><td>-31,000</td><td>17,000</td><td>40,000</td><td>-15,000</td><td>-1,200</td><td>9,600</td><td>-12,000</td></tr>
<tr><td colspan="2">2018 (BN)</td><td>-33,000</td><td>5,800</td><td>40,000</td><td>-18,000</td><td>-600</td><td>-6,300</td><td>-18,000</td></tr>
<tr><td colspan="2">Average (1990-2018)</td><td>-48,000</td><td>12,000</td><td>50,000</td><td>-13,000</td><td>-1,500</td><td>-610</td><td></td></tr>
<tr><td rowspan="5">1990-2018</td><td>W</td><td>-51,000</td><td>17,000</td><td>53,000</td><td>-11,000</td><td>-2,500</td><td>5,700</td><td></td></tr>
<tr><td>AN</td><td>-55,000</td><td>14,000</td><td>56,000</td><td>-11,000</td><td>-1,900</td><td>2,900</td><td></td></tr>
<tr><td>BN</td><td>-41,000</td><td>10,000</td><td>45,000</td><td>-14,000</td><td>-960</td><td>-1,300</td><td></td></tr>
<tr><td>D</td><td>-52,000</td><td>9,000</td><td>53,000</td><td>-14,000</td><td>-1,200</td><td>-5,200</td><td></td></tr>
<tr><td>C</td><td>-43,000</td><td>7,700</td><td>46,000</td><td>-16,000</td><td>-690</td><td>-6,000</td><td></td></tr>
</table>

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

2.3.6. Current Water Budget

As described above in **Section 2.3.2**, a number of recent water budget periods have been considered for use in defining 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. Although the 2016 through 2018 period provides a summary of the water budget for recent years that appear to be reasonably representative of recent typical conditions, it is not necessarily representative of any longer-term average conditions. Understanding the recent water budget years is helpful in anticipating longer-term conditions under a scenario where current land uses are maintained in the Subbasin (see **section 2.3.7**). 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 Summary

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 2-22**. 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 40 taf between these two single years. Most of the variability in the total SWS inflows and outflows is a result of variability in precipitation 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 10 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 2-22**) has total SWS inflows and outflows of 140 taf per year, with the largest SWS inflows being Surface Water Inflow (43 taf per year) and the largest SWS outflow being surface water outflow (73 taf per year). Current SWS water budget inflows also include 42 taf per year of precipitation, 17 taf per year of groundwater extraction and uptake, and nearly 34 taf per year of groundwater discharge to surface water. Other SWS outflows in the current SWS water budget include 27 taf per year ET of precipitation, 20 taf per year ET of applied water, 7 taf per year deep percolation of precipitation, 4.2 taf per year infiltration of surface water, 4.2 taf per year of deep percolation of applied water, and additional smaller outflows for ET of groundwater uptake, evaporation from surface water, and change in SWS storage.

Table 2-22. Comparison of Recent SWS Water Budget Periods (acre-feet)

FLOW PATH		RECENT WATER BUDGET PERIODS				
		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	39,000	39,000	43,000	39,000	48,000
	Precipitation	36,000	37,000	42,000	27,000	63,000
	Groundwater Extraction/Uptake	16,000	18,000	17,000	18,000	14,000
	Groundwater Discharge to Surface Water[1]	42,000	34,000	34,000	38,000	39,000
	Total Inflows	130,000	130,000	140,000	120,000	160,000
Outflow	Surface Water Outflow	72,000	67,000	73,000	65,000	94,000
	ET of Applied Water	20,000	21,000	20,000	22,000	18,000
	ET of Groundwater Uptake	720	680	790	600	920
	ET of Precipitation	25,000	25,000	27,000	25,000	30,000
	Evaporation	150	120	120	120	140
	Deep Percolation of Applied Water	4,500	4,200	4,200	2,900	5,100
	Deep Percolation of Precipitation	5,700	5,800	7,000	2,900	11,000
	Infiltration of Surface Water (Seepage)	4,800	4,200	4,200	4,200	4,800
	Change in Root Zone Storage	80	60	100	60	-20
	Total Outflows	130,000	130,000	140,000	120,000	160,000

[1] Average annual net seepage from rivers and streams along Antelope Subbasin boundary.

2.3.6.2 Groundwater System Water Budget Summary

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 2-23**. 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 13 taf ranging from a decrease in storage of about -6.3 taf in 2018 (a below normal year) to an increase in storage of nearly 7.7 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 -800 and -900 acre-feet per year for the recent 10-year and 5-year periods, respectively, and indicates an average increase in storage of about 2.6 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 2016-2018.

The selected current water budget period of 2016-2018 (highlighted blue in **Table 2-23**) has total net seepage of about -29 taf per year, indicating net discharge of groundwater to surface waterways. Net subsurface flows total nearly 37 taf per year of inflow on average over the current water budget period and deep percolation represents an additional 11 taf per year of inflow to the GWS. Groundwater pumping is an outflow from the GWS and averages about -16 taf per year during the current water budget period; groundwater uptake represents an additional GWS outflow of about -780 af per year.

Table 2-23. Comparison of Recent GWS Water Budget Periods (acre-feet)

GWS WATER BUDGET COMPONENT	RECENT WATER BUDGET PERIODS				
	RECENT 10 YEARS	RECENT 5 YEARS	RECENT 3 YEARS	RECENT 1 YEAR	RECENT 1 YEAR
	(2009-2018)	(2014-2018)	(2016-2018)	2018	2019
Net Seepage	-37,000	-30,000	-29,000	-33,000	-34,000
Deep Percolation	10,000	10,000	11,000	5,800	16,000
Net Subsurface Flows	42,000	37,000	37,000	40,000	39,000
Groundwater Pumping	-15,000	-17,000	-16,000	-18,000	-13,000
Groundwater Uptake	-720	-680	-780	-600	-920
Annual Groundwater Storage Chang[1]	***-800***	***-900***	***2,600***	***-6,300***	***7,700***

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

2.3.7. Projected Water Budgets

To evaluate projected water budgets in the future, projected model runs were developed using Tehama IHM. The projected model runs are intended to evaluate the effects of anticipated future conditions of hydrology, water supply availability, and water demand on the Antelope Subbasin water budget and groundwater conditions over a 50-year GSP planning period. The projected model runs also incorporate 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 projected model runs use 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. A number of projected future scenarios were simulated in Tehama IHM to compare possible outcomes, including different projected land uses and potential climate change impacts. Additional information about the development of the projected model scenarios is provided in **Appendix 2-J**.

2.3.7.1 Projected (Current Land Use) Water Budget

This section presents the results of the Projected (Current Land Use) scenario. The Current Land Use scenario assumes constant land use conditions based on 2018 conditions.

2.3.7.1.1 *Projected (Current Land Use) Surface Water System Water Budget Summary*

Annual inflows, outflows, and change in SWS root zone storage during the projected (current land use) water budget period (2022-2072) are summarized in Error! Reference source not found.**63** and Error! Reference source not found.**24**. Inflows in Error! Reference source not found.**63** are shown as positive values, while outflows 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 projected (current land use) SWS water budget results are the volume of surface water inflows that makes up a large part of the Subbasin SWS inflows. Over the projected (current land use) period, surface water inflows average about 43 taf per year. Precipitation also represents a large SWS inflow component averaging about 43 taf per year. Groundwater extraction and groundwater discharge to surface water represent relatively smaller SWS inflows in the Subbasin averaging about 16 and 43 taf per year, respectively over the projected (current land use) 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 29 maf per year on average, a value that corresponds with the large volumes of surface water inflow. ET of applied water and ET of precipitation also represent large SWS outflow components, averaging about 20 taf and 26 taf, respectively, per year. By comparison, other SWS outflows in the Subbasin are relatively smaller, with values for deep percolation of applied water averaging about 4.2 taf per year. The outflows of deep percolation of precipitation and infiltration (seepage) of surface water are about 7.1 and 4.9 taf per year on average, respectively. Evaporation from surface water averages about 150 af per year over the projected (current land use) water budget period.

Detailed results for the projected (current land use) SWS water budget are presented in **Appendix 2-K**.

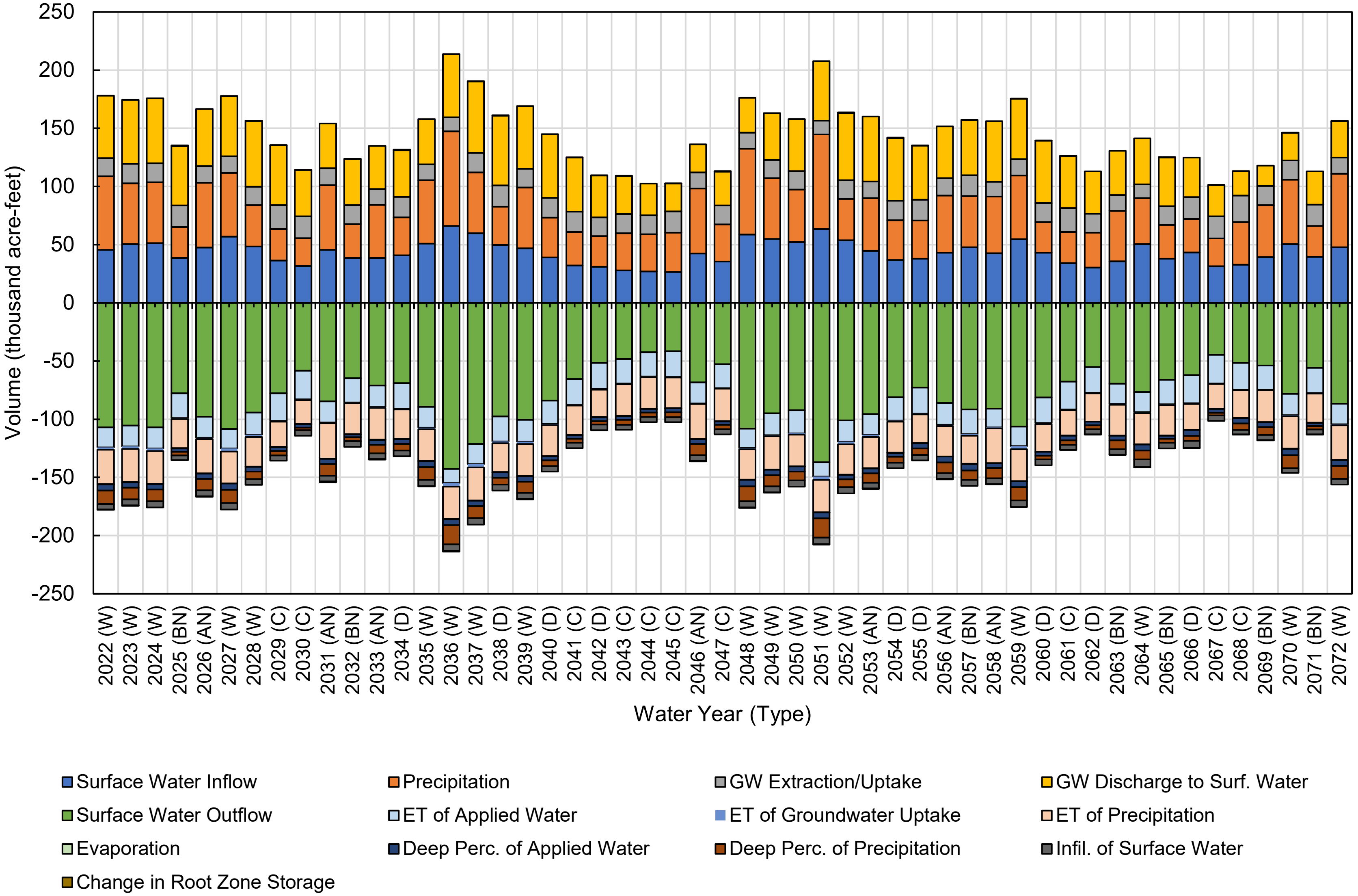

Figure 2-63. Antelope Subbasin Surface Water System Projected (Current Land Use) Water Budget, 2022-2072.

Table 2-24. Antelope Subbasin Surface Water System Projected (Current Land Use) Water Budget, 2022-2072 (acre-feet)

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[1]	DEEP PERC. OF APPLIED WATER	DEEP PERC. OF PRECIPITATION	INFIL. OF SURFACE WATER	
2022 (W)	45,000	63,000	16,000	54,000	110,000	17,000	2,000	30,000	140	5,300	12,000	4,800	280
2023 (W)	50,000	52,000	17,000	55,000	110,000	18,000	2,200	28,000	150	4,700	10,000	5,200	540
2024 (W)	51,000	52,000	16,000	56,000	110,000	18,000	2,300	28,000	150	4,800	10,000	5,200	0
2025 (BN)	39,000	27,000	19,000	51,000	78,000	21,000	810	25,000	120	2,900	3,100	4,200	-540
2026 (AN)	48,000	56,000	14,000	49,000	98,000	18,000	1,200	29,000	150	4,600	9,800	5,100	350
2027 (W)	57,000	55,000	14,000	52,000	110,000	17,000	2,700	27,000	170	5,200	11,000	5,700	-140
2028 (W)	49,000	36,000	16,000	56,000	94,000	19,000	2,000	25,000	150	4,000	6,500	5,100	-180
2029 (C)	36,000	27,000	21,000	51,000	78,000	24,000	820	22,000	130	3,400	3,800	4,400	-250
2030 (C)	32,000	24,000	19,000	40,000	58,000	25,000	600	20,000	150	3,200	2,300	4,700	-60
2031 (AN)	46,000	56,000	15,000	38,000	85,000	18,000	810	30,000	150	4,500	10,000	5,100	630
2032 (BN)	39,000	29,000	16,000	39,000	65,000	21,000	640	27,000	160	2,600	3,200	5,000	-340
2033 (AN)	39,000	45,000	14,000	37,000	71,000	18,000	920	27,000	150	4,100	7,400	4,900	580
2034 (D)	41,000	33,000	18,000	40,000	69,000	22,000	670	25,000	150	4,300	5,600	4,900	-660
2035 (W)	51,000	55,000	14,000	39,000	89,000	18,000	1,500	27,000	170	5,200	11,000	5,500	260
2036 (W)	66,000	81,000	12,000	54,000	140,000	12,000	3,200	28,000	150	5,000	17,000	5,600	520
2037 (W)	60,000	52,000	17,000	61,000	120,000	17,000	2,900	28,000	150	4,700	10,000	5,500	-160
2038 (D)	50,000	33,000	18,000	60,000	98,000	21,000	1,600	25,000	150	4,700	5,900	5,100	-610
2039 (W)	47,000	52,000	16,000	54,000	100,000	19,000	2,000	27,000	150	4,900	9,700	5,100	600
2040 (D)	39,000	34,000	17,000	54,000	84,000	20,000	950	27,000	150	3,400	5,000	4,800	-350

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[1]	DEEP PERC. OF APPLIED WATER	DEEP PERC. OF PRECIPITATION	INFIL. OF SURFACE WATER	
2041 (C)	32,000	29,000	17,000	46,000	65,000	22,000	640	25,000	150	3,200	3,400	4,700	-30
2042 (D)	31,000	26,000	16,000	36,000	52,000	22,000	620	24,000	160	3,400	3,000	4,900	-150
2043 (C)	28,000	32,000	17,000	33,000	48,000	21,000	540	27,000	140	3,400	4,100	4,500	-10
2044 (C)	27,000	32,000	16,000	27,000	42,000	21,000	510	27,000	140	2,900	3,800	4,500	0
2045 (C)	26,000	34,000	18,000	24,000	41,000	22,000	460	26,000	130	3,500	4,400	4,200	-90
2046 (AN)	43,000	56,000	14,000	24,000	68,000	18,000	630	30,000	150	4,300	9,500	4,900	440
2047 (C)	36,000	32,000	16,000	29,000	53,000	20,000	510	28,000	140	2,900	3,900	4,500	-350
2048 (W)	59,000	74,000	14,000	30,000	110,000	17,000	1,100	26,000	150	5,700	13,000	5,400	330
2049 (W)	55,000	52,000	16,000	40,000	95,000	19,000	1,000	29,000	150	4,600	9,700	5,300	200
2050 (W)	52,000	45,000	16,000	44,000	92,000	20,000	1,200	27,000	150	4,500	7,700	5,200	-270
2051 (W)	63,000	81,000	12,000	51,000	140,000	12,000	2,900	28,000	150	5,000	17,000	5,600	450
2052 (W)	54,000	36,000	16,000	58,000	100,000	18,000	2,200	26,000	150	3,900	6,800	5,200	-660
2053 (AN)	45,000	45,000	14,000	56,000	96,000	18,000	2,000	27,000	150	4,300	7,900	5,000	570
2054 (D)	37,000	34,000	17,000	54,000	81,000	20,000	900	27,000	150	3,400	5,000	4,700	-430
2055 (D)	38,000	33,000	18,000	47,000	73,000	22,000	790	25,000	150	4,400	5,500	4,900	-250
2056 (AN)	43,000	49,000	15,000	45,000	86,000	19,000	1,000	26,000	150	5,000	9,200	5,000	310
2057 (BN)	48,000	44,000	18,000	47,000	92,000	21,000	1,300	24,000	150	5,500	8,100	5,100	-250
2058 (AN)	43,000	49,000	13,000	52,000	91,000	16,000	900	30,000	150	4,000	8,800	5,000	370
2059 (W)	55,000	55,000	14,000	52,000	110,000	17,000	2,700	27,000	170	5,100	11,000	5,600	-150
2060 (D)	43,000	26,000	16,000	54,000	81,000	22,000	900	24,000	160	3,300	3,100	5,000	-200

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[1]	DEEP PERC. OF APPLIED WATER	DEEP PERC. OF PRECIPITATION	INFIL. OF SURFACE WATER	
2061 (C)		34,000	27,000	21,000	45,000	68,000	24,000	700	22,000	130	4,000	4,000	4,400	-230
2062 (D)		30,000	30,000	16,000	37,000	55,000	22,000	580	24,000	140	3,000	3,300	4,400	110
2063 (BN)		36,000	43,000	14,000	38,000	70,000	17,000	590	27,000	140	4,000	7,700	4,600	100
2064 (W)		50,000	39,000	12,000	40,000	77,000	17,000	800	27,000	230	5,200	7,600	6,600	390
2065 (BN)		38,000	29,000	16,000	42,000	66,000	21,000	650	26,000	160	2,800	3,300	5,000	-370
2066 (D)		43,000	29,000	19,000	34,000	62,000	24,000	600	22,000	210	5,100	4,400	6,100	90
2067 (C)		32,000	24,000	19,000	27,000	45,000	25,000	500	21,000	150	3,400	2,400	4,700	-380
2068 (C)		33,000	37,000	23,000	21,000	52,000	23,000	440	24,000	110	4,800	5,500	3,700	240
2069 (BN)		39,000	45,000	17,000	17,000	54,000	21,000	480	27,000	130	4,200	6,700	4,400	130
2070 (W)		50,000	56,000	16,000	24,000	78,000	18,000	960	28,000	100	5,300	11,000	4,200	-100
2071 (BN)		39,000	27,000	18,000	29,000	56,000	22,000	550	25,000	120	2,900	2,900	4,200	20
2072 (W)		48,000	63,000	14,000	31,000	87,000	18,000	800	30,000	140	5,100	11,000	4,800	-30
Average (2022-2072)		43,000	43,000	16,000	43,000	81,000	20,000	1,200	26,000	150	4,200	7,100	4,900	10
2022-2072	W	54,000	56,000	15,000	47,000	100,000	17,000	1,900	28,000	150	4,900	11,000	5,300	100
	AN	44,000	51,000	14,000	43,000	85,000	18,000	1,100	29,000	150	4,400	8,900	5,000	460
	BN	40,000	35,000	17,000	38,000	68,000	21,000	720	26,000	140	3,600	5,000	4,600	-180
	D	39,000	31,000	17,000	46,000	73,000	22,000	840	25,000	160	3,900	4,500	5,000	-270
	C	32,000	30,000	19,000	34,000	55,000	23,000	570	24,000	140	3,500	3,700	4,400	-120

[1] Diversions for some years were estimated based on average monthly data, resulting in a generally constant evaporation volume for some years.

2.3.7.2 Projected (Current Land Use) Groundwater System Water Budget Summary

Summarized results for major components of the projected (current land use) water budget as they relate to the GWS are presented in **Figures 2-64** and **2-65** and **Table 2-25**. As previously discussed, the positive net subsurface flows (on average 42 taf per year) represent the combined subsurface flows from adjacent subbasins and upland areas and deep percolation represents another large net inflow averaging about 11 taf per year. The large negative net seepage values (on average -38 taf per year) represent net stream seepage to groundwater and groundwater pumping (on average -15 taf per year) is another large outflow from the GWS. Overall, the water budget results for the 50-year projected (current land use) period indicate a cumulative change in groundwater storage of about -15 taf, which equals an average annual change in groundwater storage of only about -300 af per year. These change in storage estimates equate to total decreases in storage in the Subbasin of about 0.03 acre-feet per acre on average over the 50 years and an annual decrease of less than 0.002 acre-feet per acre across the entire Subbasin (approximately 9,130 acres). **Figure 2-64** provides a conceptual illustration of the projected water budget**. Figure 2-65** highlights the cumulative change in groundwater storage estimated to occur over the 2022-2072 period.

Detailed results for the projected (current land use) GWS water budget are presented in **Appendix 2-K**.

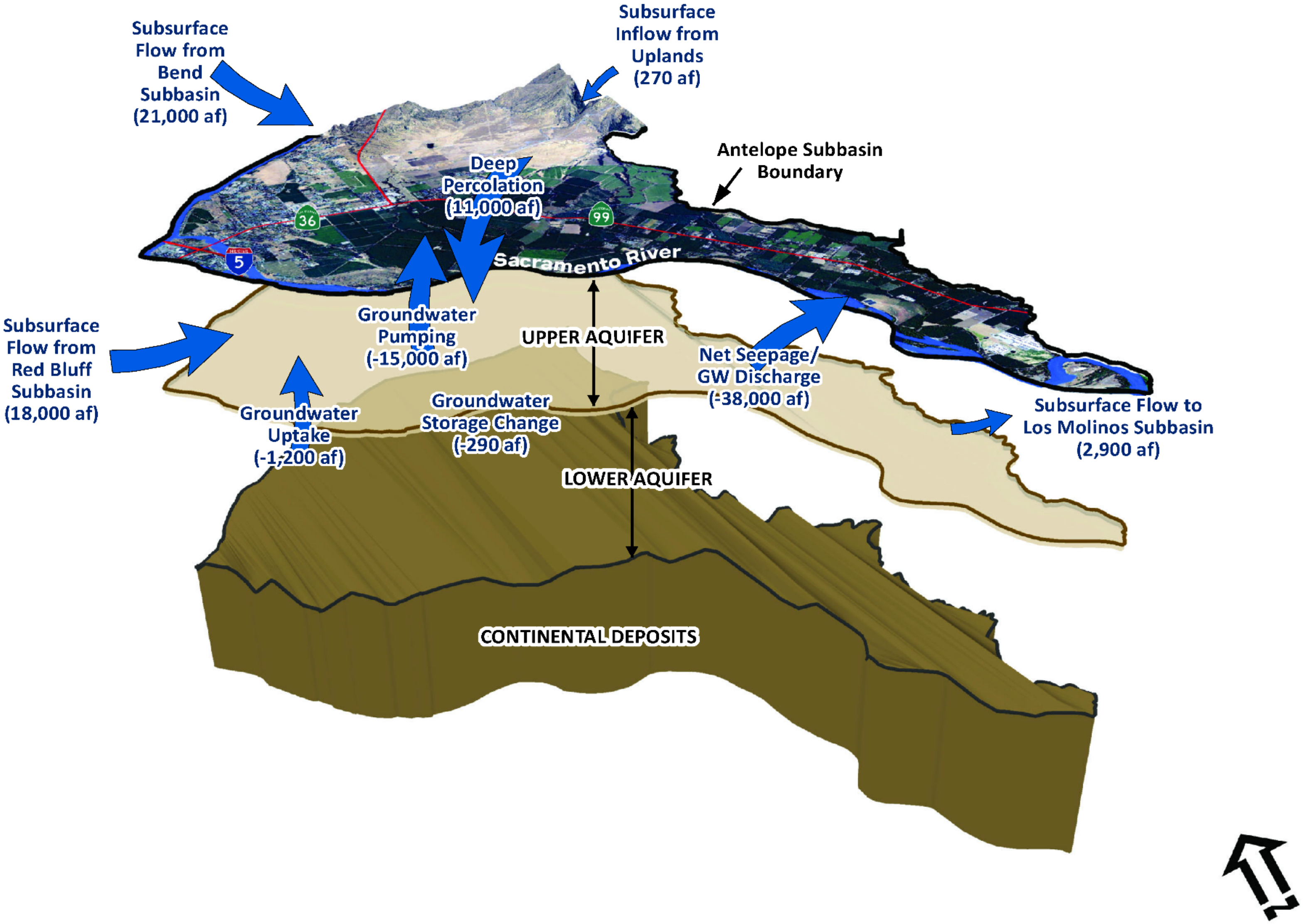

Figure 2-64. Diagram of the Antelope Subbasin Projected (Current Land Use) Average Annual Water Budget, 2022-2072

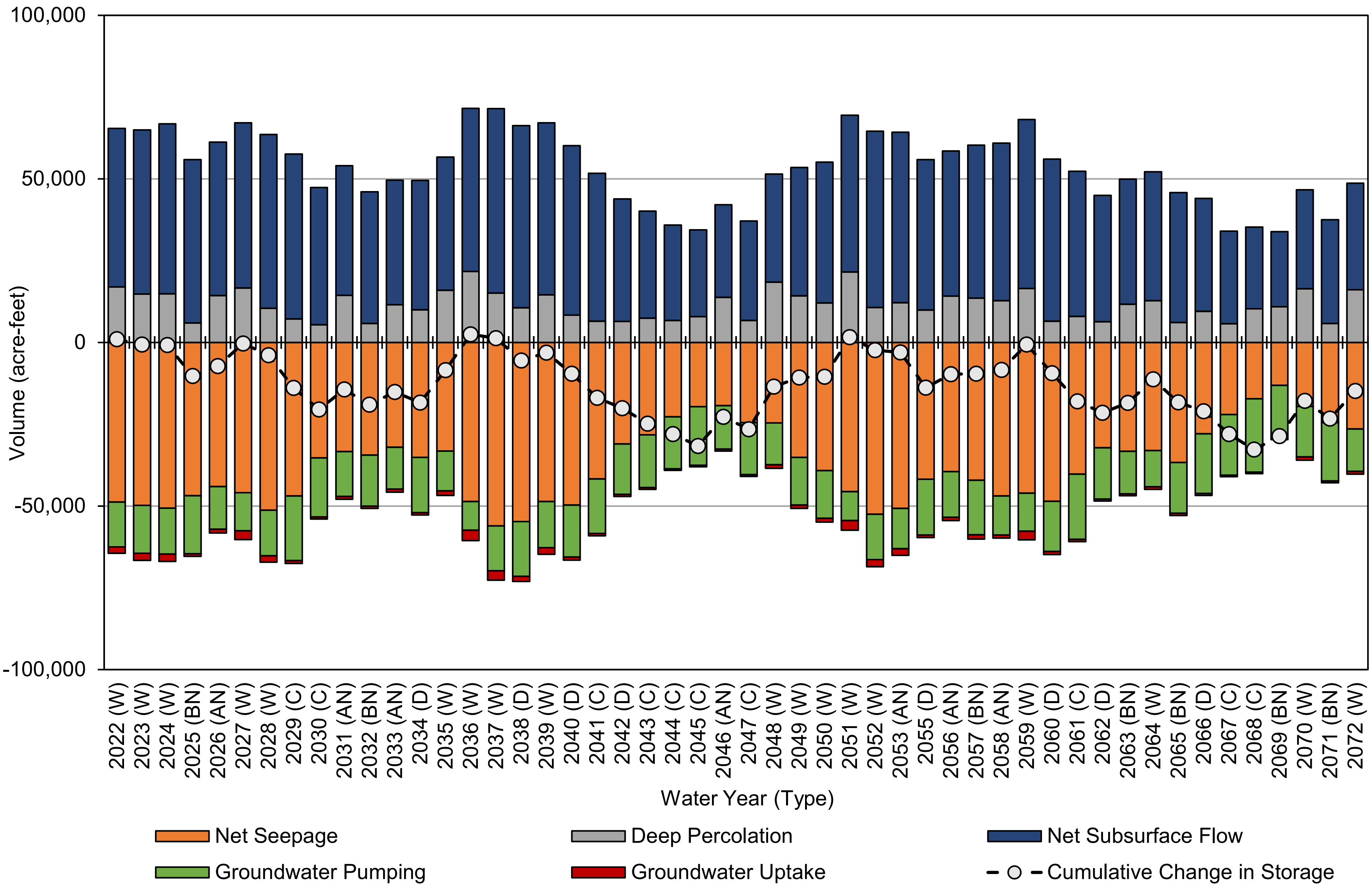

Figure 2-65 Antelope Subbasin Projected (Current Land Use) Water Budget Summary

Table 2-25. Antelope Subbasin Projected (Current Land Use) Water Budget Summary (acre-feet)

WATER YEAR (TYPE)	NET SEEPAGE	DEEP PERCOLATION	NET SUBSURFACE FLOWS	GROUND-WATER PUMPING	ANNUAL GROUNDWATER STORAGE CHANGE	CUMULATIVE GROUNDWATER STORAGE CHANGE
2022 (W)	-49,000	17,000	49,000	-14,000	1,000	1,000
2023 (W)	-50,000	15,000	50,000	-15,000	-1,700	-650
2024 (W)	-51,000	15,000	52,000	-14,000	-150	-800
2025 (BN)	-47,000	6,000	50,000	-18,000	-9,500	-10,000
2026 (AN)	-44,000	14,000	47,000	-13,000	3,000	-7,200
2027 (W)	-46,000	17,000	51,000	-12,000	6,900	-330
2028 (W)	-51,000	10,000	53,000	-14,000	-3,600	-3,900
2029 (C)	-47,000	7,200	50,000	-20,000	-9,900	-14,000
2030 (C)	-35,000	5,400	42,000	-18,000	-6,600	-20,000
2031 (AN)	-33,000	14,000	40,000	-14,000	6,100	-14,000
2032 (BN)	-34,000	5,800	40,000	-16,000	-4,700	-19,000
2033 (AN)	-32,000	12,000	38,000	-13,000	3,800	-15,000
2034 (D)	-35,000	10,000	40,000	-17,000	-3,200	-18,000
2035 (W)	-33,000	16,000	41,000	-12,000	9,900	-8,500
2036 (W)	-49,000	22,000	50,000	-8,800	11,000	2,500
2037 (W)	-56,000	15,000	56,000	-14,000	-1,200	1,300
2038 (D)	-55,000	11,000	56,000	-17,000	-6,800	-5,500
2039 (W)	-49,000	15,000	53,000	-14,000	2,400	-3,100
2040 (D)	-50,000	8,400	52,000	-16,000	-6,400	-9,500
2041 (C)	-42,000	6,500	45,000	-17,000	-7,400	-17,000
2042 (D)	-31,000	6,400	37,000	-15,000	-3,200	-20,000
2043 (C)	-28,000	7,500	33,000	-16,000	-4,700	-25,000
2044 (C)	-23,000	6,800	29,000	-16,000	-3,200	-28,000
2045 (C)	-20,000	7,900	27,000	-18,000	-3,600	-32,000
2046 (AN)	-19,000	14,000	28,000	-13,000	8,900	-23,000
2047 (C)	-25,000	6,800	30,000	-16,000	-3,800	-27,000
2048 (W)	-25,000	18,000	33,000	-13,000	13,000	-13,000
2049 (W)	-35,000	14,000	39,000	-15,000	2,800	-11,000
2050 (W)	-39,000	12,000	43,000	-15,000	190	-10,000
2051 (W)	-46,000	22,000	48,000	-8,900	12,000	1,600
2052 (W)	-53,000	11,000	54,000	-14,000	-3,900	-2,300
2053 (AN)	-51,000	12,000	52,000	-12,000	-740	-3,100
2054 (D)	-49,000	8,400	50,000	-16,000	-7,000	-10,000
2055 (D)	-42,000	9,900	46,000	-17,000	-3,800	-14,000
2056 (AN)	-40,000	14,000	44,000	-14,000	4,100	-9,700
2057 (BN)	-42,000	14,000	47,000	-17,000	190	-9,500
2058 (AN)	-47,000	13,000	48,000	-12,000	1,200	-8,400
2059 (W)	-46,000	17,000	52,000	-12,000	7,800	-600

<table>
<tr><th colspan="2">WATER YEAR (TYPE)</th><th>NET SEEPAGE</th><th>DEEP PERCOLATION</th><th>NET SUBSURFACE FLOWS</th><th>GROUND-WATER PUMPING</th><th>ANNUAL GROUNDWATER STORAGE CHANGE</th><th>CUMULATIVE GROUNDWATER STORAGE CHANGE</th></tr>
<tr><td colspan="2">2060 (D)</td><td>-49,000</td><td>6,500</td><td>50,000</td><td>-15,000</td><td>-8,800</td><td>-9,400</td></tr>
<tr><td colspan="2">2061 (C)</td><td>-40,000</td><td>8,000</td><td>44,000</td><td>-20,000</td><td>-8,600</td><td>-18,000</td></tr>
<tr><td colspan="2">2062 (D)</td><td>-32,000</td><td>6,300</td><td>39,000</td><td>-16,000</td><td>-3,500</td><td>-21,000</td></tr>
<tr><td colspan="2">2063 (BN)</td><td>-33,000</td><td>12,000</td><td>38,000</td><td>-13,000</td><td>3,000</td><td>-18,000</td></tr>
<tr><td colspan="2">2064 (W)</td><td>-33,000</td><td>13,000</td><td>39,000</td><td>-11,000</td><td>7,200</td><td>-11,000</td></tr>
<tr><td colspan="2">2065 (BN)</td><td>-37,000</td><td>6,100</td><td>40,000</td><td>-16,000</td><td>-7,100</td><td>-18,000</td></tr>
<tr><td colspan="2">2066 (D)</td><td>-28,000</td><td>9,500</td><td>35,000</td><td>-18,000</td><td>-2,700</td><td>-21,000</td></tr>
<tr><td colspan="2">2067 (C)</td><td>-22,000</td><td>5,700</td><td>28,000</td><td>-19,000</td><td>-7,000</td><td>-28,000</td></tr>
<tr><td colspan="2">2068 (C)</td><td>-17,000</td><td>10,000</td><td>25,000</td><td>-22,000</td><td>-4,800</td><td>-33,000</td></tr>
<tr><td colspan="2">2069 (BN)</td><td>-13,000</td><td>11,000</td><td>23,000</td><td>-16,000</td><td>4,200</td><td>-29,000</td></tr>
<tr><td colspan="2">2070 (W)</td><td>-20,000</td><td>16,000</td><td>30,000</td><td>-15,000</td><td>11,000</td><td>-18,000</td></tr>
<tr><td colspan="2">2071 (BN)</td><td>-24,000</td><td>5,800</td><td>32,000</td><td>-18,000</td><td>-5,400</td><td>-23,000</td></tr>
<tr><td colspan="2">2072 (W)</td><td>-26,000</td><td>16,000</td><td>33,000</td><td>-13,000</td><td>8,500</td><td>-15,000</td></tr>
<tr><td colspan="2">Average (2022-2072)</td><td>-37,700</td><td>11,400</td><td>42,200</td><td>-15,000</td><td>-300</td><td></td></tr>
<tr><td rowspan="5">2022-2072</td><td>W</td><td>-42,000</td><td>16,000</td><td>46,000</td><td>-13,000</td><td>4,600</td><td></td></tr>
<tr><td>AN</td><td>-38,000</td><td>13,000</td><td>43,000</td><td>-13,000</td><td>3,800</td><td></td></tr>
<tr><td>BN</td><td>-33,000</td><td>8,600</td><td>38,000</td><td>-16,000</td><td>-2,700</td><td></td></tr>
<tr><td>D</td><td>-41,000</td><td>8,400</td><td>45,000</td><td>-16,000</td><td>-5,000</td><td></td></tr>
<tr><td>C</td><td>-32,000</td><td>7,100</td><td>37,000</td><td>-18,000</td><td>-6,800</td><td></td></tr>
</table>

2.3.8. Projected (Future Land Use) Water Budget Summary

This section presents the results of the Projected (Future Land Use) scenario. The Future Land Use scenario assumes a static (held constant over the entire projected period) land use condition reflecting an anticipated future development or land use condition that is expected to exist at the end of the 50-year GSP planning horizon. The future land use condition was developed through discussion with local stakeholders and consultation with the Tehama County Planning Department. The future land use condition includes an increase in urban area reflective of the recent rate of urban increase experienced for the County.

Land use areas are used to distinguish the water use sector in which water is consumed, as required by the GSP Regulations. **Table 2-26** and **Figure 2-66** summarize the annual land use areas over the projected (future land use) period (2022-2072) in the Antelope Subbasin by water use sector, as defined by the GSP Regulations (23 CCR § 351(al)). In the Antelope 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[7] land uses.

On average, agricultural, urban, and native vegetation land uses covered approximately 9,000 acres, 2,000 acres, and 8,000 acres, respectively, between 2022 and 2072.

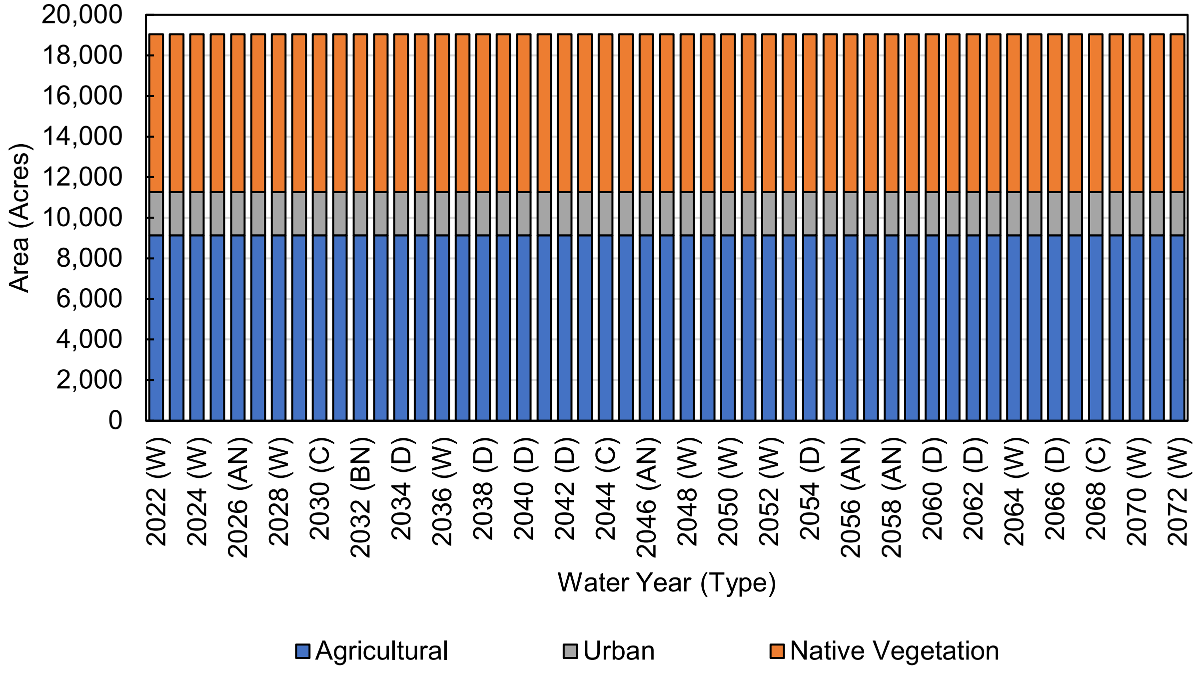

Figure 2-66. Antelope Subbasin Future Land Use Areas, by Water Use Sector

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[7] 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).

Table 2-26. Antelope Subbasin Future Land Use Areas, by Water Use Sector (acres, rounded)

PROJECTED PERIOD (FUTURE LAND USE)	AGRICULTURAL	URBAN[1]	NATIVE VEGETATION	TOTAL
2022-2072	9,130	2,140	7,770	19,040

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

Agricultural land uses are further detailed in **Table 2-27** and Error! Reference source not found.**67**. In the future, a majority of the agricultural area in the Antelope Subbasin is projected to consist of deciduous crops, grain, and pasture. Irrigated agricultural areas within the Antelope Subbasin are projected to remain relatively constant at these acreages during the entire projected period.

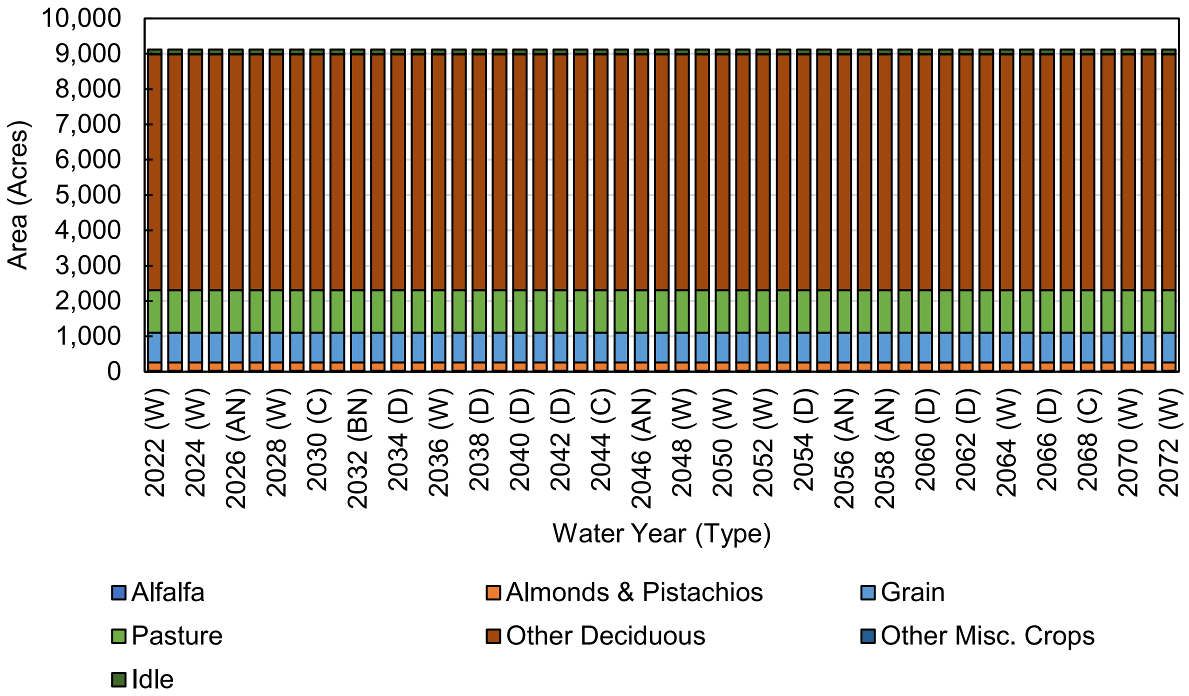

Figure 2-67. Antelope Subbasin Projected Agricultural Land Use Areas

Table 2-27. Antelope Subbasin Projected Agricultural Land Use Areas (acres, rounded)

PROJECTED PERIOD (FUTURE LAND USE)	ALFALFA	ALMONDS & PISTACHIOS	GRAIN	PASTURE	PONDED (RICE, REFUGE)	OTHER DECIDUOUS	OTHER MISC. CROPS	IDLE	TOTAL
2022-2072	30	230	840	1,210	10	6,670	10	130	9,130

2.3.8.1 Projected (Future Land Use) Surface Water System Water Budget Summary

Annual inflows, outflows, and change in SWS root zone storage during the projected (future land use) water budget period (2022-2072) are summarized in Error! Reference source not found.**68** and Error! Reference source not found.**28**. Inflows in Error! Reference source not found.**68** are shown as positive values, while outflows 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 projected (future land use) SWS water budget results are the volume of surface water inflows and precipitation that make up a large part of the Subbasin SWS inflows. Over the projected (future land use) period, surface water inflows and precipitation each average about 43 taf per year. Groundwater Discharge to surface water also represents a large SWS inflow component averaging about 33 taf per year. Groundwater represents a relatively smaller SWS inflow in the Subbasin averaging about 16 taf per year over the projected (future land use) 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 72 taf per year on average, a value that corresponds with the large volumes of surface water inflow. ET of applied water and ET of precipitation also represent large SWS outflow components, averaging about 20 taf and 26 taf, respectively, per year. By comparison, other SWS outflows in the Subbasin are relatively smaller, with values for deep percolation of precipitation averaging about 7 taf per year. The outflows of deep percolation of applied water and infiltration (seepage) of surface water are about 4.3 and 4.9 taf per year on average, respectively. Evaporation from surface water averages about 150 af per year over the projected (future land use) water budget period.

Detailed results for the projected (future land use) SWS water budget are presented in **Appendix 2-K**.

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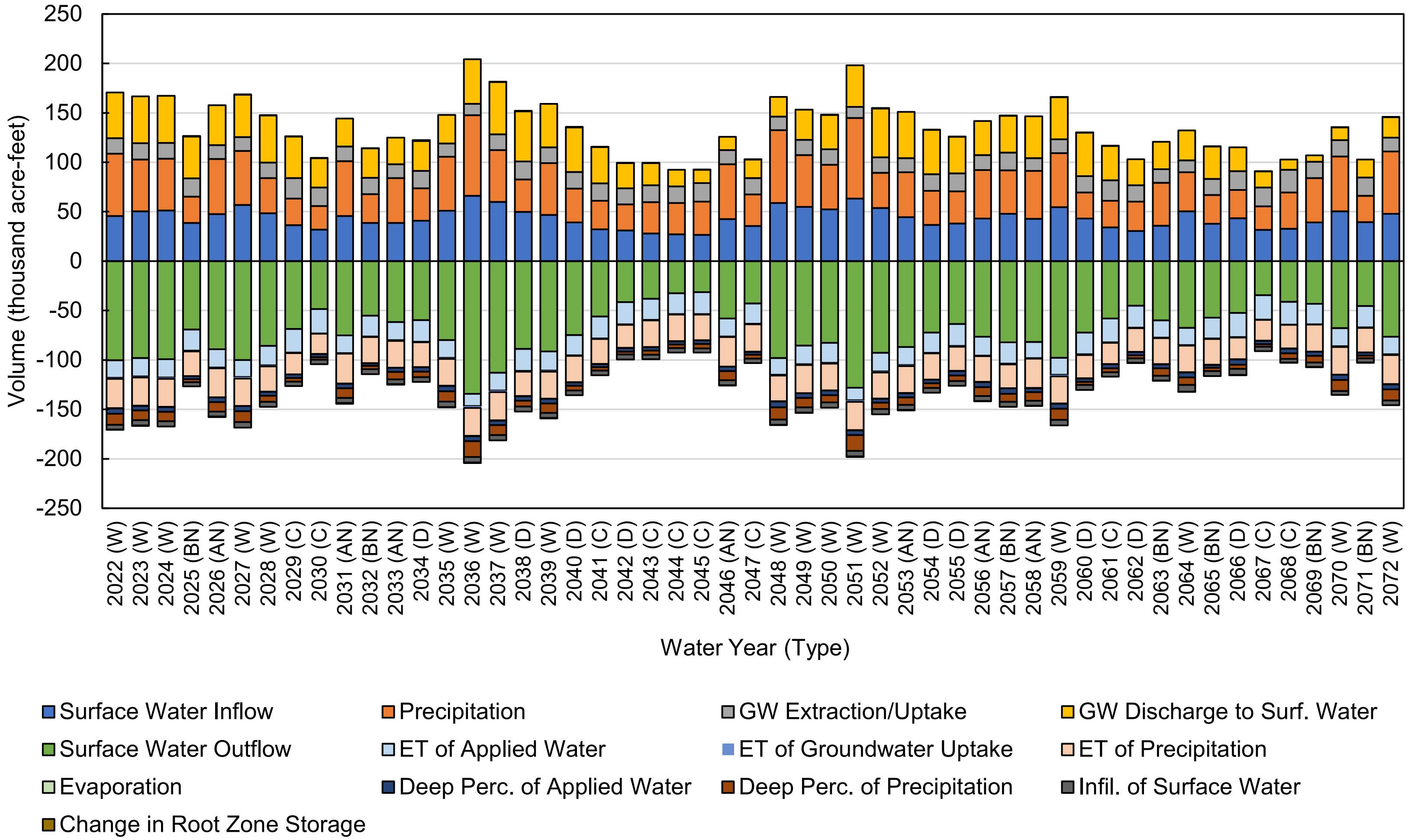

Figure 2-68. Antelope Subbasin Surface Water System Projected (Future Land Use) Water Budget, 2022-2072

Table 2-28. Antelope Subbasin Surface Water System Projected (Future Land Use) Water Budget, 2022-2072 (acre-feet)

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[1]	DEEP PERC. OF APPLIED WATER	DEEP PERC. OF PRECIPITATION	INFIL. OF SURFACE WATER	
2022 (W)	46,000	63,000	16,000	46,000	100,000	17,000	1,300	30,000	140	5,300	11,000	4,800	250
2023 (W)	50,000	52,000	17,000	47,000	98,000	18,000	1,300	29,000	150	4,700	9,800	5,200	540
2024 (W)	51,000	52,000	16,000	48,000	99,000	19,000	1,300	28,000	150	4,800	9,700	5,200	0
2025 (BN)	39,000	27,000	19,000	42,000	69,000	21,000	670	25,000	120	3,000	3,100	4,200	-490
2026 (AN)	48,000	56,000	14,000	40,000	89,000	18,000	820	29,000	150	4,600	9,700	5,100	320
2027 (W)	57,000	55,000	14,000	43,000	100,000	17,000	1,700	28,000	170	5,200	11,000	5,700	-150
2028 (W)	49,000	36,000	16,000	48,000	86,000	19,000	1,100	26,000	150	4,000	6,200	5,100	-160
2029 (C)	37,000	27,000	21,000	42,000	69,000	24,000	650	22,000	130	3,500	3,800	4,400	-230
2030 (C)	32,000	24,000	19,000	30,000	48,000	25,000	530	20,000	150	3,300	2,300	4,700	-80
2031 (AN)	46,000	56,000	15,000	28,000	75,000	18,000	660	30,000	150	4,600	9,900	5,100	620
2032 (BN)	39,000	29,000	16,000	30,000	55,000	21,000	560	26,000	160	2,700	3,200	5,000	-310
2033 (AN)	39,000	45,000	14,000	27,000	62,000	18,000	740	27,000	150	4,200	7,300	4,900	550
2034 (D)	41,000	33,000	18,000	30,000	60,000	22,000	580	25,000	150	4,400	5,600	4,900	-630
2035 (W)	51,000	55,000	14,000	29,000	80,000	18,000	1,000	27,000	170	5,300	11,000	5,500	230
2036 (W)	66,000	81,000	12,000	45,000	130,000	12,000	2,000	28,000	150	5,000	16,000	5,600	470
2037 (W)	60,000	52,000	16,000	53,000	110,000	18,000	1,700	29,000	150	4,700	10,000	5,500	-130
2038 (D)	50,000	33,000	18,000	51,000	89,000	22,000	860	25,000	150	4,600	5,800	5,100	-560
2039 (W)	47,000	52,000	16,000	44,000	91,000	19,000	1,100	27,000	150	4,900	9,400	5,100	560
2040 (D)	39,000	34,000	17,000	45,000	75,000	20,000	680	27,000	150	3,500	4,900	4,800	-320
2041 (C)	32,000	29,000	18,000	37,000	56,000	22,000	560	25,000	150	3,300	3,400	4,700	-30

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[1]	DEEP PERC. OF APPLIED WATER	DEEP PERC. OF PRECIPITATION	INFIL. OF SURFACE WATER	
2042 (D)	31,000	26,000	16,000	26,000	41,000	22,000	540	23,000	160	3,500	3,000	4,900	-150
2043 (C)	28,000	32,000	17,000	23,000	38,000	21,000	480	27,000	140	3,500	4,100	4,500	-10
2044 (C)	27,000	32,000	17,000	17,000	33,000	21,000	450	27,000	140	3,000	3,800	4,500	0
2045 (C)	26,000	34,000	19,000	13,000	31,000	22,000	410	26,000	130	3,600	4,400	4,200	-90
2046 (AN)	43,000	56,000	14,000	14,000	58,000	18,000	540	30,000	150	4,300	9,400	4,900	420
2047 (C)	36,000	32,000	17,000	19,000	43,000	21,000	450	28,000	140	2,900	3,900	4,500	-330
2048 (W)	59,000	74,000	14,000	20,000	98,000	17,000	850	26,000	150	5,800	13,000	5,400	300
2049 (W)	55,000	52,000	16,000	31,000	86,000	19,000	790	28,000	150	4,700	9,500	5,300	190
2050 (W)	52,000	45,000	16,000	35,000	83,000	20,000	840	27,000	150	4,500	7,500	5,200	-250
2051 (W)	63,000	81,000	11,000	42,000	130,000	13,000	1,700	28,000	150	4,900	16,000	5,600	390
2052 (W)	54,000	36,000	16,000	49,000	93,000	19,000	1,200	26,000	150	3,900	6,600	5,200	-600
2053 (AN)	45,000	45,000	14,000	47,000	87,000	18,000	1,200	27,000	150	4,300	7,600	5,000	560
2054 (D)	37,000	34,000	17,000	45,000	72,000	20,000	670	27,000	150	3,500	4,900	4,700	-400
2055 (D)	38,000	33,000	18,000	37,000	64,000	22,000	650	25,000	150	4,500	5,500	4,900	-240
2056 (AN)	43,000	49,000	15,000	35,000	77,000	19,000	750	26,000	150	5,100	9,100	5,000	280
2057 (BN)	48,000	44,000	18,000	37,000	82,000	22,000	900	24,000	150	5,600	8,000	5,100	-230
2058 (AN)	43,000	49,000	13,000	42,000	82,000	16,000	680	30,000	150	4,100	8,700	5,000	350
2059 (W)	55,000	55,000	14,000	43,000	98,000	17,000	1,600	28,000	170	5,100	11,000	5,600	-160
2060 (D)	43,000	26,000	16,000	44,000	72,000	22,000	690	24,000	160	3,400	3,100	5,000	-180
2061 (C)	34,000	27,000	21,000	35,000	58,000	24,000	590	21,000	130	4,100	4,000	4,400	-210
2062 (D)	30,000	30,000	16,000	26,000	45,000	22,000	510	24,000	140	3,100	3,300	4,400	100

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[1]	DEEP PERC. OF APPLIED WATER	DEEP PERC. OF PRECIPITATION	INFIL. OF SURFACE WATER	
2063 (BN)		36,000	43,000	14,000	28,000	60,000	17,000	510	26,000	140	4,100	7,600	4,600	90
2064 (W)		50,000	39,000	12,000	30,000	68,000	17,000	680	27,000	230	5,300	7,500	6,600	380
2065 (BN)		38,000	29,000	16,000	33,000	57,000	21,000	570	26,000	160	2,900	3,300	5,000	-340
2066 (D)		43,000	29,000	19,000	24,000	52,000	24,000	530	22,000	210	5,300	4,400	6,100	80
2067 (C)		32,000	24,000	19,000	16,000	34,000	25,000	450	21,000	150	3,500	2,400	4,700	-390
2068 (C)		33,000	37,000	23,000	10,000	41,000	23,000	390	24,000	110	4,900	5,500	3,700	250
2069 (BN)		39,000	45,000	17,000	6,400	43,000	21,000	420	27,000	130	4,300	6,700	4,400	120
2070 (W)		50,000	56,000	16,000	13,000	68,000	18,000	760	28,000	100	5,400	11,000	4,200	-110
2071 (BN)		39,000	27,000	19,000	18,000	45,000	22,000	480	25,000	120	3,000	2,900	4,200	30
2072 (W)		48,000	63,000	14,000	21,000	77,000	18,000	670	30,000	140	5,200	11,000	4,800	-60
Average (2022-2072)		43,000	43,000	16,000	33,000	72,000	20,000	820	26,000	150	4,300	7,000	4,900	0
2022-2072	W	54,000	56,000	15,000	38,000	94,000	18,000	1,200	28,000	150	4,900	10,000	5,300	90
	AN	44,000	51,000	14,000	33,000	76,000	18,000	770	29,000	150	4,500	8,800	5,000	440
	BN	40,000	35,000	17,000	28,000	59,000	21,000	590	26,000	140	3,700	5,000	4,600	-160
	D	39,000	31,000	17,000	37,000	63,000	22,000	630	25,000	160	4,000	4,500	5,000	-260
	C	32,000	30,000	19,000	24,000	45,000	23,000	500	24,000	140	3,600	3,800	4,400	-110

[1] Diversions for some years were estimated based on average monthly data, resulting in a generally constant evaporation volume for some years.

2.3.8.2 Projected (Future Land Use) Groundwater System Water Budget Summary

Summarized results for major components of the projected (future land use) water budget as they relate to the GWS are presented in **Figure 2-69** and **2-70** and **Table 2-29**. Among the outflows from the Subbasin GWS, net seepage makes up the largest fraction of the total GWS outflows (on average -28 taf per year). Net seepage represents net groundwater discharging to surface waterways and leaving the GWS. Groundwater pumping additionally makes up a large portion of GWS outflows (on average -15 taf per year). Positive net subsurface flows and deep percolation are the largest net inflow components averaging about 33 and 11 taf per year, respectively. Groundwater (root water) uptake directly from shallow groundwater (on average -820 af per year) represents a smaller outflow from the GWS. Overall, the water budget results for the 51-year projected (future land use) period indicate a cumulative change in groundwater storage of about -17 taf, which equals an average annual change in groundwater storage of only about -330 af per year. This change in storage estimates equate to total decreases in storage in the Subbasin of about 0.9 acre-feet per acre on average over the 51 years and an annual decrease of about 0.02 acre-feet per acre across the entire Subbasin (approximately 19,040 acres). **Figure 2-69** provides a conceptual illustration of the projected water budget. **Figure 2-70** highlights the cumulative change in groundwater storage that has occurred over the 2022-2072 period.

Detailed results for the projected (future land use) GWS water budget are presented in **Appendix 2-K**.

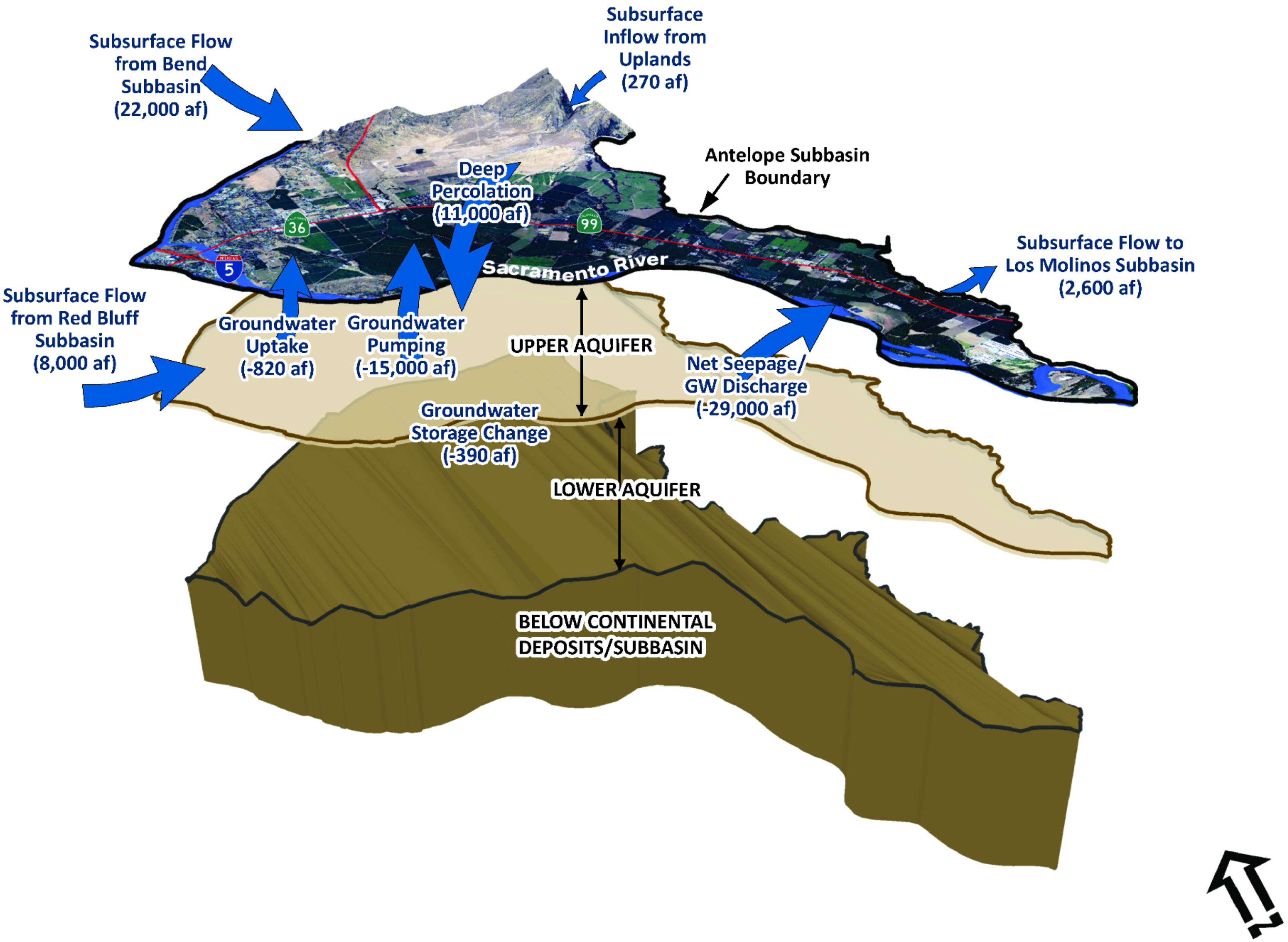

Figure 2-69. Diagram of the Antelope Subbasin Projected (Future Land Use) Average Annual Water Budget, 2022-2072

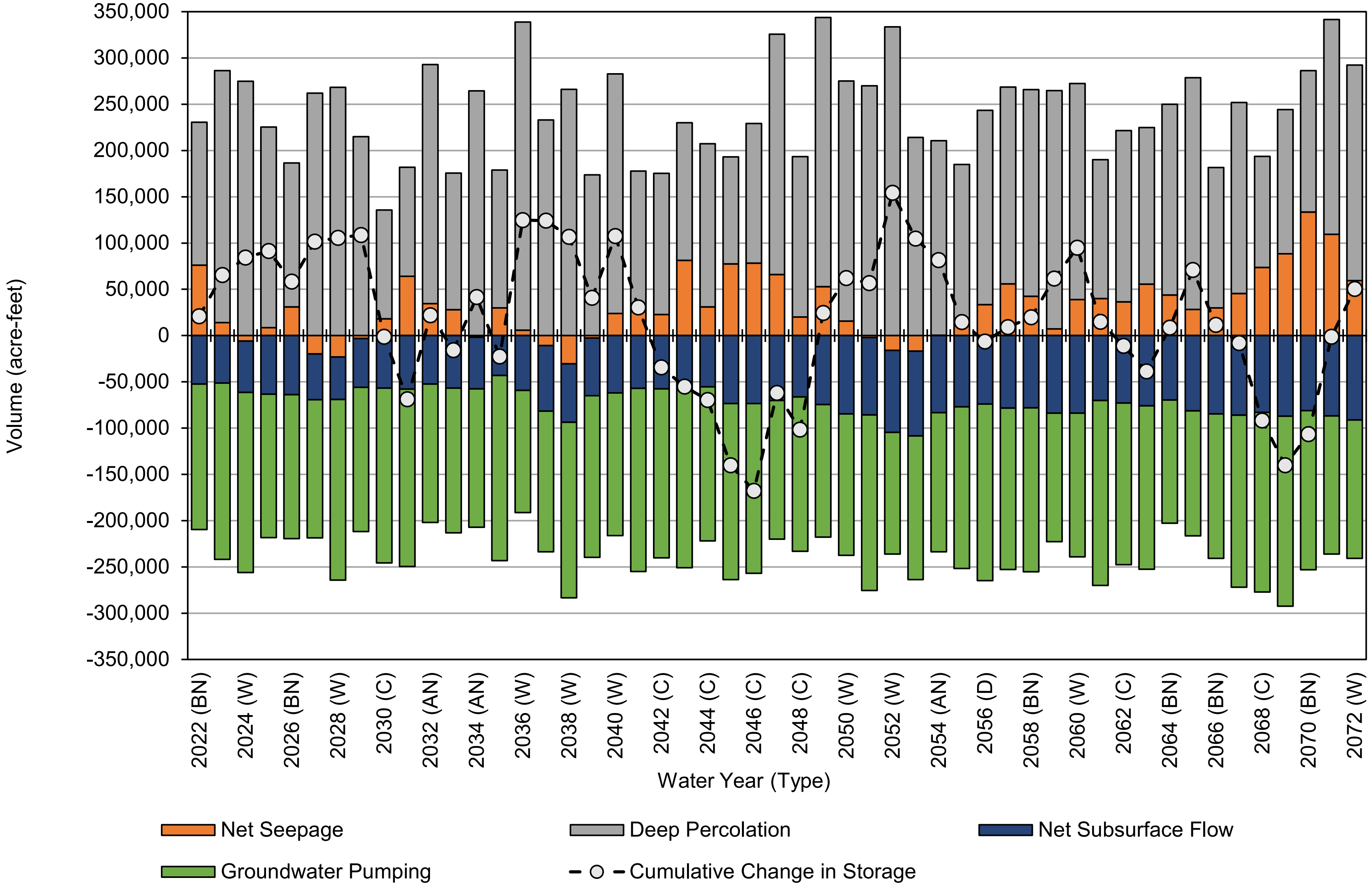

Figure 2-70. Antelope Subbasin Projected (Future Land Use) Water Budget Summary

Table 2-29. Antelope Subbasin Projected (Future Land Use) Water Budget Summary (acre-feet)

WATER YEAR (TYPE)	NET SEEPAGE	DEEP PERCOLATION	NET SUBSURFACE FLOWS	GROUND-WATER PUMPING	ANNUAL GROUNDWATER STORAGE CHANGE	CUMULATIVE GROUNDWATER STORAGE CHANGE
2022 (BN)	-42,000	17,000	41,000	-14,000	620	620
2023 (W)	-42,000	14,000	42,000	-15,000	-2,000	-1,400
2024 (W)	-42,000	14,000	44,000	-15,000	-440	-1,800
2025 (W)	-38,000	6,100	41,000	-18,000	-9,900	-12,000
2026 (BN)	-35,000	14,000	38,000	-13,000	3,100	-8,700
2027 (AN)	-37,000	16,000	42,000	-12,000	7,000	-1,700
2028 (W)	-43,000	10,000	44,000	-15,000	-3,700	-5,400
2029 (W)	-38,000	7,300	41,000	-20,000	-10,000	-16,000
2030 (C)	-25,000	5,600	31,000	-18,000	-7,100	-23,000
2031 (C)	-23,000	14,000	30,000	-14,000	6,600	-16,000
2032 (AN)	-25,000	5,900	30,000	-16,000	-4,700	-21,000
2033 (BN)	-22,000	12,000	28,000	-13,000	4,000	-17,000
2034 (AN)	-25,000	10,000	30,000	-17,000	-3,300	-20,000
2035 (D)	-23,000	16,000	31,000	-13,000	10,000	-10,000
2036 (W)	-40,000	21,000	42,000	-9,500	12,000	1,400
2037 (W)	-47,000	15,000	48,000	-15,000	-1,300	120
2038 (W)	-46,000	10,000	46,000	-17,000	-7,200	-7,100
2039 (D)	-39,000	14,000	43,000	-15,000	2,300	-4,800
2040 (W)	-40,000	8,400	42,000	-16,000	-6,500	-11,000
2041 (D)	-32,000	6,600	35,000	-17,000	-7,600	-19,000
2042 (C)	-21,000	6,600	27,000	-16,000	-3,400	-22,000
2043 (D)	-18,000	7,600	23,000	-16,000	-4,700	-27,000
2044 (C)	-13,000	6,900	19,000	-16,000	-3,300	-30,000
2045 (C)	-9,200	8,000	16,000	-18,000	-3,900	-34,000
2046 (C)	-8,800	14,000	18,000	-14,000	9,300	-25,000
2047 (AN)	-14,000	6,900	20,000	-16,000	-3,800	-29,000
2048 (C)	-14,000	18,000	23,000	-13,000	13,000	-15,000
2049 (W)	-25,000	14,000	30,000	-15,000	2,900	-12,000
2050 (W)	-29,000	12,000	33,000	-15,000	200	-12,000
2051 (W)	-36,000	21,000	39,000	-9,600	13,000	440
2052 (W)	-44,000	10,000	45,000	-14,000	-4,000	-3,600
2053 (W)	-42,000	12,000	43,000	-13,000	-760	-4,300
2054 (AN)	-40,000	8,400	41,000	-16,000	-7,200	-12,000
2055 (D)	-32,000	10,000	36,000	-17,000	-4,100	-16,000
2056 (D)	-30,000	14,000	35,000	-14,000	4,200	-11,000
2057 (AN)	-32,000	14,000	37,000	-17,000	-1	-11,000
2058 (BN)	-37,000	13,000	39,000	-12,000	1,500	-9,900
2059 (AN)	-37,000	16,000	43,000	-12,000	7,900	-2,000

WATER YEAR (TYPE)		NET SEEPAGE	DEEP PERCOLATION	NET SUBSURFACE FLOWS	GROUND-WATER PUMPING	ANNUAL GROUNDWATER STORAGE CHANGE	CUMULATIVE GROUNDWATER STORAGE CHANGE
2060 (W)		-39,000	6,500	40,000	-16,000	-9,100	-11,000
2061 (D)		-31,000	8,100	34,000	-20,000	-9,000	-20,000
2062 (C)		-22,000	6,500	28,000	-16,000	-3,700	-24,000
2063 (D)		-23,000	12,000	29,000	-13,000	3,400	-20,000
2064 (BN)		-24,000	13,000	31,000	-11,000	7,600	-13,000
2065 (W)		-28,000	6,200	31,000	-16,000	-7,200	-20,000
2066 (BN)		-18,000	9,600	24,000	-18,000	-3,200	-23,000
2067 (D)		-12,000	5,800	17,000	-19,000	-7,500	-31,000
2068 (C)		-6,500	10,000	14,000	-23,000	-5,000	-36,000
2069 (C)		-2,100	11,000	12,000	-16,000	4,300	-31,000
2070 (BN)		-8,800	16,000	20,000	-16,000	11,000	-20,000
2071 (W)		-14,000	5,900	21,000	-18,000	-5,500	-26,000
2072 (W)		-16,000	16,000	23,000	-13,000	8,900	-17,000
Average (2022-2072)		-28,000	11,000	33,000	-15,000	-330	
2022-2072	W	-33,000	15,000	37,000	-13,000	4,700	
	AN	-28,000	13,000	33,000	-13,000	4,000	
	BN	-23,000	8,600	29,000	-16,000	-2,800	
	D	-32,000	8,500	35,000	-17,000	-5,300	
	C	-20,000	7,300	25,000	-18,000	-6,200	

2.3.9. Projected Water Budgets with Climate Change

Additional projected scenarios were developed to model potential climate change scenarios. Climate change scenarios were developed using the DWR guidance for the 2030 and 2070 central tendencies. Additional detail about the development and results of these scenarios can be found in **Appendix 2-J and Appendix 2-K**. The climate change scenarios were implemented following DWR's guidance related to the 2030 and 2070 central tendency climate change scenarios and associated adjustment factors applied to model inputs such as precipitation, ET, and surface water inflows. In the Tehama IHM area, the DWR climate change guidance and adjustment factors tend to result in increases in precipitation, ET, and streamflows.

2.3.9.1 Projected (Current Land Use) Water Budget

A comparison of the major components of the projected (current land use) water budget as they relate to the GWS are presented in **Table 2-30**. Net seepage becomes less negative under climate change scenarios, indicating less groundwater flow to SWS. However, the decrease in the net volume of groundwater discharging to surface water (less negative net seepage) is partly a result of greater streamflow entering the Subbasin under the climate change scenarios and resulting in greater stream seepage. Deep percolation and net subsurface flows remain nearly unchanged under climate change scenarios. Groundwater pumping increases under climate change scenarios, becoming a greater outflow from the groundwater system.

Table 2-30. Comparison of Annual Projected (Current Land Use) GWS Water Budgets with Climate Change Adjustments (acre-feet)

GWS WATER BUDGET COMPONENT	PROJECTED (CURRENT LAND USE)		
	NO CLIMATE CHANGE ADJUSTMENT	CLIMATE CHANGE (2030)	CLIMATE CHANGE (2070)
Net Seepage	-38,000	-38,000	-34,000
Deep Percolation	11,000	12,000	11,000
Net Subsurface Flows	42,000	41,000	39,000
Groundwater Extractions (Pumping and Uptake)	-16,000	-17,000	-18,000
Annual Groundwater Storage Change	***-290***	***-300***	***-340***

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

2.3.9.2 Projected (Future Land Use) Water Budget

A comparison of the major components of the projected (future land use) water budget as they relate to the GWS are presented in **Table 2-31**. Overall, the climate change scenarios to not appear to change the overall Subbasin GWS water budget in a considerable way. Net seepage becomes less negative under climate change scenarios indicating a reduction of the net volume of groundwater discharging to the surface waters. However, as noted above the decrease in the net volume of groundwater discharging to surface water is partly a result of greater streamflow entering the Subbasin under the climate change scenarios. Deep percolation remains nearly unchanged under climate change scenarios. Net subsurface flows to the Subbasin decrease slightly under climate change scenarios, primarily a result of reduced subsurface inflows from Red Bluff Subbasin. Groundwater extractions increase very slightly under climate change scenarios, becoming a greater outflow from the groundwater system.

Table 2-31. Comparison of Annual Projected (Future Land Use) GWS Water Budgets with Climate Change Adjustments (acre-feet)

GWS WATER BUDGET COMPONENT	PROJECTED (FUTURE LAND USE)		
	NO CLIMATE CHANGE ADJUSTMENT	CLIMATE CHANGE (2030)	CLIMATE CHANGE (2070)
Net Seepage	-28,000	-27,000	-22,000
Deep Percolation	11,000	11,000	11,000
Net Subsurface Flows	33,000	31,000	29,000
Groundwater Extractions (Pumping and Uptake)	-16,000	-17,000	-18,000
Annual Groundwater Storage Change	***-330***	***-340***	***-390***

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

2.3.10. Projected Groundwater Storage Change

This section presents the projected groundwater storage change in the Upper Aquifer and Lower Aquifer under Current Land Use and Future Land Use conditions with and without the climate change conditions. Additional detail about the development and results of these scenarios can be found in **Appendices 2-J and 2-K**.

2.3.10.1 Projected (Current Land Use) Storage Change

A comparison of the groundwater storage change, including by primary aquifer, under the projected (current land use) conditions with different climate change assumptions is presented in **Table 2-32**. The water budget results suggest reduction of storage is only slightly greater under climate change scenarios, with the magnitude of storage change in the Lower and Upper Aquifers very similar. Note that the cumulative numbers presented in **Table 2-32** may differ from the sum of the average annual values because of rounding. Overall projected storage change in the Subbasin is small and differs little between the different climate change conditions. The projected storage changes of -15 to -17 taf are equivalent to changes of -0.79 to -0.89 acre-feet per acre over the 51 years or about -0.02 acre-feet per acre per year. Projected storage changes in the Upper Aquifer equate to basinwide storage decreases of about 0.37 acre-feet per acre over the entire 51-year projected period without any climate change and about 0.47 acre-feet per acre with 2070 climate change conditions. Storage changes in the Lower Aquifer equate to basinwide storage decreases of about 0.42 acre-feet per acre on average over the 51 years without climate change and with 2070 climate change conditions. These small amounts of change are within the range of uncertainty of the water budget results.

Table 2-32. Comparison of Projected (Current Land Use) Aquifer-Specific GWS Water Budgets with Climate Change Adjustments

PROJECTED (CURRENT LAND USE)		AVERAGE ANNUAL CHANGE			CUMULATIVE CHANGE IN STORAGE		
		UPPER AQUIFER	LOWER AQUIFER	TOTAL	UPPER AQUIFER	LOWER AQUIFER	TOTAL
No Climate Change Adjustment	acre-feet	-160	-130	-290	-6,900	-7,900	-15,000
	acre-feet per acre	*-0.01*	*-0.01*	*-0.02*	*-0.37*	*-0.42*	*-0.79*
Climate Change 2030	acre-feet	-160	-140	-300	-8,200	-7,100	-15,000
	acre-feet per acre	*-0.01*	*-0.01*	*-0.02*	*-0.43*	*-0.37*	*-0.80*
Climate Change 2070	acre-feet	-180	-160	-340	-9,300	-8,000	-17,000
	acre-feet per acre	*-0.01*	*-0.01*	*-0.02*	*-0.47*	*-0.42*	*-0.89*

Note: positive values indicate increasing storage, negative values indicate decreasing storage.

2.3.10.2 2.3.11.2 Projected (Future Land Use) Water Budget

A comparison of the groundwater storage change, including by primary aquifer, under the projected (future land use) conditions with different climate change assumptions is presented in **Table 2-33**. Similar to results for the project current land use condition, the water budget results suggest reduction of storage is only slightly greater under climate change scenarios, with the magnitude of storage change in the Lower and Upper Aquifers very similar. As noted above, the cumulative numbers presented in **Table 2-33** may differ from the sum of the average annual values because of rounding. Overall projected storage change in the Subbasin is small and differs little between the different climate change conditions. The projected storage changes of -17 to -20 taf are equivalent to changes of -0.89 to -1.05 acre-feet per acre over the 51 years or about -0.02 acre-feet per acre per year. These storage decreases are slightly greater than under the projected current land use scenarios, but only by very little. Projected storage changes in the Upper Aquifer equate to basinwide storage decreases of about 0.46 acre-feet per acre over the entire 51-year projected period without any climate change and about 0.53 acre-feet per acre with 2070 climate change conditions. Storage changes in the Lower Aquifer equate to basinwide storage decreases of about 0.42 acre-feet per acre on average over the 51 years without climate change and 0.49 with 2070 climate change conditions. As noted previously, such small amounts of storage change over the projected period under all of the future land use scenarios are within the range of uncertainty of the water budget results.

Table 2-33. Comparison of Projected (Future Land Use) Aquifer-Specific GWS Water Budgets with Climate Change Adjustments

PROJECTED (FUTURE LAND USE)		AVERAGE ANNUAL CHANGE			CUMULATIVE CHANGE IN STORAGE		
		UPPER AQUIFER	LOWER AQUIFER	TOTAL	UPPER AQUIFER	LOWER AQUIFER	TOTAL
No Climate Change Adjustment	acre-feet	-170	-160	-330	-8,700	-8,000	-17,000
	acre-feet per acre	*-0.01*	*-0.01*	*-0.02*	*-0.46*	*-0.42*	*-0.89*
Climate Change 2030	acre-feet	-180	-160	-340	-9,000	-8,300	-17,000
	acre-feet per acre	*-0.01*	*-0.01*	*-0.02*	*-0.47*	*-0.44*	*-0.89*
Climate Change 2070	acre-feet	-200	-180	-390	-10,000	-9,400	-20,000
	acre-feet per acre	*-0.01*	*-0.01*	*-0.02*	*-0.53*	*-0.49*	*-1.05*

Note: positive values indicate increasing storage, negative values indicate decreasing storage.

2.3.11. Uncertainty in Water Budget Estimates

2.3.11.1 Uncertainty in SWS Water Budget

Uncertainties associated with each SWS water budget component have been computed or estimated following the process described by Clemmens and Burt (1997). In summary:

1. The uncertainty of each independently-estimated water budget component (excluding the closure term) is calculated or estimated as a percentage that approximately represents a 95 percent confidence interval for the average annual component volume of the component. Uncertainty percentages are based on the accuracy of measurement devices, the uncertainty of supporting calculations and estimation procedures, and professional judgement.
2. Assuming random, normally-distributed error, the standard deviation is calculated for each independently-estimated component as the average uncertainty on a volumetric basis (uncertainty percentage multiplied by the average annual component volume) divided by two.
3. The variance is calculated for each independently-estimated component as the square of the standard deviation.
4. The variance of the closure term is estimated as the sum of variances of all independently-estimated components.
5. The standard deviation of the closure term is estimated as the square root of the sum of variances.
6. The 95 percent confidence interval of the closure term is estimated as twice the estimated standard deviation.

Estimated uncertainties were calculated following the above procedure for the Subbasin water budget and all GSA water budgets. **Table 2-34** provides a summary of typical uncertainty values associated with major SWS inflows and outflows, along with the sources of these uncertainty values. For surface water flows, deliveries, and diversions, the uncertainty is estimated based on typical accuracy of streamflow gages and measurement devices. For IDC root zone water budget inflows and outflows, the uncertainty is based on typical accuracies given in technical literature and the cumulative estimated accuracy of all inputs used to calculate the components. These uncertainties provide a basis for evaluating confidence in water budget results and help to identify data needs that may be addressed during GSP implementation.

Table 2-34. Estimated Uncertainty of Major Water Budget Components

FLOWPATH DIRECTION (RELATIVE TO SWS)	WATER BUDGET COMPONENT	DATA SOURCE	ESTIMATED UNCERTAINTY (%)	SOURCE
Inflows	Surface Water Inflows	Measurement	5%[1]	Accuracy of USGS streamflow gages, with adjustment for infiltration and evaporation of inflows upstream/downstream of nearest measurement site.
	Deliveries	Measurement	6%	Required delivery measurement accuracy for Reclamation contractors, per the USGS 2017 Standard Criteria for Agricultural Water Management Plans)
	Water Rights Diversions	Measurement/ Estimate	10%	Required diversion measurement accuracy, per California Senate Bill 88.
	Precipitation	Calculation	20%[2]	Clemmens, A.J. and C.M. Burt, 1997.
	Groundwater Extraction	Calculation	20%	Typical uncertainty when calculated for Land Surface System water budget closure. The uncertainty of the accounting center closure is a product of the combined uncertainty of all other inflows and outflows, and the relative magnitude of each component.
Outflows	Surface Water Outflows	Measurement	15%	Estimated streamflow measurement accuracy with adjustment for infiltration and evaporation.
	Evaporation	Calculation	20%	Clemmens and Burt, 1997; typical accuracy of calculation based on CIMIS reference ET and free water surface evaporation coefficient.

FLOWPATH DIRECTION (RELATIVE TO SWS)	WATER BUDGET COMPONENT	DATA SOURCE	ESTIMATED UNCERTAINTY (%)	SOURCE
	ET of Applied Water	Calculation	10%	Clemmens and Burt, 1997; typical accuracy of total irrigation water consumption on irrigated land, parsed into ET of Applied Water and ET of Precipitation by daily root zone water budget component based on reference ET, precipitation, surface energy balance crop coefficients, and annual land use.
	ET of Precipitation	Calculation	10%[2]	Clemmens and Burt, 1997; accuracy of total water consumption on irrigated land, parsed into ET of Applied Water and ET of Precipitation by daily root zone water budget component based on reference ET, precipitation, surface energy balance crop coefficients, and annual land use.
	Infiltration of Applied Water	Calculation	20%[2]	Estimated accuracy of daily IDC root zone water budget based on annual land use and NRCS soils characteristics. Similar accuracy anticipated for monthly results.
	Infiltration of Precipitation	Calculation	20%[2]	Estimated accuracy of daily IDC root zone water budget based on annual land use, NRCS soils characteristics, and CIMIS precipitation.
	Infiltration of Surface Water	Calculation	15%	Typical accuracy of daily seepage calculation using NRCS soils characteristics and measured streamflow data compared to field measurements.

[1] Higher uncertainty of 10-20 percent is typical for estimated surface water inflows, including ungaged inflows from small watersheds into creeks that enter the Subbasin.

[2] IDC root zone water budget inflows and outflows. The uncertainty of these water budget components is based on typical accuracies given in technical literature and the cumulative estimated accuracy of all inputs used to calculate the components.

2.3.11.2 GWS Water Budget Uncertainty

Uncertainty associated with the GWS water budget results estimated using the Tehama IHM depends in part on the model inputs relating to the SWS with additional sources of uncertainty associated with model inputs relating to the GWS, including aquifer and streambed properties, specification of boundary conditions, and other factors. The uncertainty estimates associated with SWS water budget components that are also inputs or outputs of the GWS water budget are noted above. The overall uncertainty of other water budget components simulated for the GWS, including subsurface flows, groundwater discharging to surface water, and change in groundwater storage are estimated to be slightly higher, in the range of 15 to 30 percent. These GWS water budget components are subject to higher uncertainty as a result of limitations in available input data and simplification required in modeling of the subsurface heterogeneity. However, the uncertainty in GWS water budget results derived from a numerical model such as the Tehama IHM depends to a considerable degree on the calibration of the model and can vary by location and depth within the Subbasin. The Tehama IHM is a product of local refinement and improvements made to the SVSim model and calibration at a more local scale. The Tehama IHM simulates the integrated groundwater and surface water system and metrics relating to the calibration of the model indicate the model is reasonably well calibrated in accordance with generally accepted professional guidelines and is sufficient for GSP-related applications. The calibration and sensitivity of the model and different model parameters are presented in **Appendix 2-J**.

2.3.12. Estimate of Sustainable Yield

GSP Regulations require the GSP quantify the sustainable yield for the Subbasin. Sustainable yield is defined as “the maximum quantity of water, calculated over a base period representative of long-term conditions in the basin and including any temporary surplus, that can be withdrawn annually from a groundwater supply without causing an undesirable result” (CWC Section 10721(w)). Historical and projected model results show that the conditions in the Subbasin under the historical and anticipated future land use conditions and hydrology, including with potential climate change conditions (2030 and 2070), will not cause the occurrence of undesirable results in the Subbasin over the 50-year GSP planning period based on sustainability indicator Minimum Thresholds (MTs) developed for the Subbasin.

The Antelope Subbasin has historically pumped on average about 13,000 acre-feet per year of groundwater. An additional 1,500 acre-feet of groundwater is estimated to be taken up and consumed directly by plants reflecting a total historical groundwater extraction volume of between 14,000 and 15,000 acre-feet per year on average. Observed groundwater level conditions and simulated water budget results suggest there has been little or no historical long-term change in groundwater storage in the Subbasin. Although some of the water budget components change under the different projected scenarios as a result of changes in land use and climate conditions being simulated, total groundwater extraction (combination of groundwater pumping and uptake) within the Subbasin does not change considerably with estimated increases in groundwater extraction of only a few thousand acre-feet per year. Under the projected future land use with 2070 climate change, groundwater extractions total about 18,000 acre-feet per year on average. The groundwater extraction water budget component is relatively small in comparison to the net seepage and subsurface flow components. Under all of the projected scenarios, the change in storage is simulated to be approximately zero (recognizing uncertainty associated with water budget estimates).

Accordingly, for the purpose of the GSP, the sustainable yield is estimated to be 18,000 acre-feet per year, which is equal to the volume of groundwater extracted annually in the Subbasin (by pumping and by uptake) minus the simulated change in storage in the projected model scenario with future land use and 2070 climate change conditions. Assuming potential uncertainty of 25 percent associated with the water budget estimates, an associated range of values for the estimated sustainable yield would be 13,000 to 23,000 acre-feet per year. It is possible that the true sustainable yield is higher as no model scenarios were developed to test the maximum possible volume of groundwater extraction. The sustainable yield estimate provided here is consistent with the sustainability goal for the Subbasin and will be reviewed as the Subbasin implements the GSP, including through periodic review and updates to the Tehama IHM and water budget results and ongoing monitoring of Subbasin conditions as required by GSP Regulations.

2.4. References

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