DRAFT

Chapter 6

San Luis Obispo Valley Basin Groundwater Sustainability Plan

Available for viewing in the July 8, 2020 Agenda Packet:	**June 29, 2020**
Recommended the GSAs to receive and file for public comments:	**July 8, 2020**
Available for public comments on www.slowaterbasin.com:	**July 10, 2020**
Close of public comment period:	**Sep 30, 2020**

Per the GSC's recommendation on July 8, 2020, GSP Draft Chapter 6 will be distributed to the City and County GSAs to receive and file. This draft document is now posted on the web portal: www.slowaterbasin.com for public comments. Comments from the public are being collected using a comment form available at www.slowaterbasin.com by clicking on "Submit Comment". If you require a paper form to submit by postal mail, please contact your local Groundwater Sustainability Agency (GSA). All comments submitted will also be posted online for viewing.

Draft

Groundwater Sustainability Plan
Chapter 6 – Water Budget

for the

San Luis Obispo Valley Groundwater Basin Groundwater Sustainability Agencies

Prepared by

6/25/2020

TABLE OF CONTENTS

The grey highlighted sections in the Table of Contents (TOC) indicate that the section has been previously released (Chapters 1 through 5) or will be released in the future (Chapters 7 through 14). The complete list of the anticipated TOC is presented to give the reader context as to how Chapter 6 – Water Budget, connects with the complete Groundwater Sustainability Plan.

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LIST OF TERMS USED

Abbreviation	**Definition**
AB	Assembly Bill
ADD	Average Day Demand
AF	Acre Feet
AFY	Acre Feet per Year
AMSL	Above Mean Sea Level
Basin Plan	Water Quality Control Plan for the Central Coast Basin
Cal Poly	California Polytechnic State University
CASGEM	California State Groundwater Elevation Monitoring program
CCR	California Code of Regulations
CCRWQCB	Central Coast Regional Water Quality Control Board
CCGC	Central Coast Groundwater Coalition
CDFM	Cumulative departure from the mean
CDPH	California Department of Public Health
CIMIS	California Irrigation Management Information System
City	City of San Luis Obispo
County	County of San Luis Obispo
CPUC	California Public Utilities Commission
CPWS-52	Cal Poly Weather Station 52
CRWQCB	California Regional Water Quality Control Board
CWC	California Water Code
DDW	Division of Drinking Water
Du/ac	Dwelling Units per Acre
DWR	Department of Water Resources
EPA	Environmental Protection Agency
ERMWC	Edna Ranch Mutual Water Company
ET_0	Evapotranspiration
EVGMWC	Edna Valley Growers Ranch Mutual Water Company
°F	Degrees Fahrenheit
FAR	Floor Area Ratio
FY	Fiscal Year
GAMA	Groundwater Ambient Monitoring and Assessment program
GHG	Greenhouse Gas
GMP	Groundwater Management Plan
GPM	Gallons per Minute
GSA	Groundwater Sustainability Agency
GSC	Groundwater Sustainability Commission
GSP	Groundwater Sustainability Plan
GSWC	Golden State Water Company
IRWMP	San Luis Obispo County Integrated Regional Water Management Plan
kWh	Kilowatt-Hour
LUCE	Land Use and Circulation Element
LUFTs	Leaky Underground Fuel Tanks
MAF	Million Acre Feet
MCL	Maximum Contaminant Level

Abbreviation	Definition
MG	Million Gallons
MGD	Million Gallons per Day
Mg/L	Milligrams per Liter
MOA	Memorandum of Agreement
MOU	Memorandum of Understanding
MWR	Master Water Report
NCDC	National Climate Data Center
NOAA	National Oceanic and Atmospheric Administration
NWIS	National Water Information System
RW	Recycled Water
RWQCB	Regional Water Quality Control Board
SB	Senate Bill
SGMA	Sustainable Groundwater Management Act
SGMP	Sustainable Groundwater Management Planning
SGWP	Sustainable Groundwater Planning
SLO Basin	San Luis Obispo Valley Groundwater Basin
SLOFCWCD	San Luis Obispo Flood Control and Water Conservation District
SCML	Secondary Maximum Contaminant Level
SOI	Sphere of Influence
SNMP	Salt and Nutrient Management Plan
SWRCB	California State Water Resources Control Board
TDS	Total Dissolved Solids
TMDL	Total Maximum Daily Load
USGS	United States Geological Survey
USFW	United States Fish and Wildlife Service
USTs	Underground Storage Tanks
UWMP	Urban Water Management Plan
UWMP Act	Urban Water Management Planning Act
UWMP Guidebook	Department of Water Resources 2015 Urban Water Management Plan Guidebook
VRMWC	Varian Ranch Mutual Water Company
WCS	Water Code Section
WMP	Water Master Plan
WPA	Water Planning Areas
WRF	Water Reclamation Facility
WRCC	Western Regional Climate Center
WRRF	Water Resource Recovery Facility
WSA	Water Supply Assessment
WTP	Water Treatment Plant
WWTP	Wastewater Treatment Plant

EXECUTIVE SUMMARY

This section to be completed after GSP is complete.

6 WATER BUDGET (§ 354.18)

The purpose of a water budget is to provide an accounting and assessment of the total annual volume of groundwater and surface water entering and leaving the Basin, including historical, current, and projected water budget conditions, and the change in volume stored. Both numerical and analytical methods have been used during water budget preparations for the GSP. The analytical method as used in this document refers to application of the water budget equation and the inventory method using spreadsheets, with groundwater flow estimates based on Darcy's Law and change in storage calculations based on the specific yield method.

Numerical methods refer to surface water and groundwater flow modeling, which provide a dynamic and more rigorous analysis of both surface-groundwater interactions and the impacts from pumping on groundwater in storage. The historical and current analytical groundwater budget will be used as part of the Basin conceptual model to prepare input estimates and provide a check for the numerical model, from which the projected water budget will be produced. This chapter presents the analytical water budget for the historical and current periods and the numerical model water budget for the projected future period. Once the numerical model water budget is calibrated, the results will be presented as comparisons to the analytical water budget.

A water budget identifies and quantifies various components of the hydrologic cycle within a user-defined area, in this case the San Luis Obispo Valley groundwater Basin. Water circulates between the atmospheric system, land surface system, surface water bodies, and the groundwater system, as shown in Figure 6-1(DWR, 2016). The water budget equation used for the analytical method is as follows:

INFLOW – OUTFLOW = CHANGE IN STORAGE

Inflow is the sum of all surface water and groundwater entering the Basin and outflow is the sum of all surface water and groundwater leaving the Basin. The difference between total inflow and total outflow over a selected time period is equal to the change in total storage (surface water and groundwater) within the Basin over the same period. Components of inflow and outflow represented in the water budget are shown in Figure 6-2. Not all of the components shown are needed for the San Luis Obispo Valley Groundwater Basin GSP. A key using letters to represent components in this water budget has been added to Figure 6-2 for reference with the main water budget tables. Some components have been modified and renamed from the original DWR figure to better represent this specific water budget.

The water budget equation given above is simple in concept, but it is challenging to measure and account for all the components of inflow and outflow within a Basin. Some of these components can be measured or estimated independently, while others are calculated using the water budget equation. The water budget for this GSP has been prepared for the two subareas that cover the Basin, the San Luis Valley subarea and the Edna Valley subarea (Figure 6-3). Subareas are not to be confused with subbasins, and are defined for this water budget analysis. They are then combined into a single water budget for the entire Basin. Both subarea water budgets and the Basin water budget are included herein. Surface water (combined atmospheric, land surface, and stream systems) and groundwater budgets have been prepared for each subarea and for the Basin. The subarea approach for water budget calculations follows the approach used by prior investigators (Boyle, 1991; DWR, 1997).

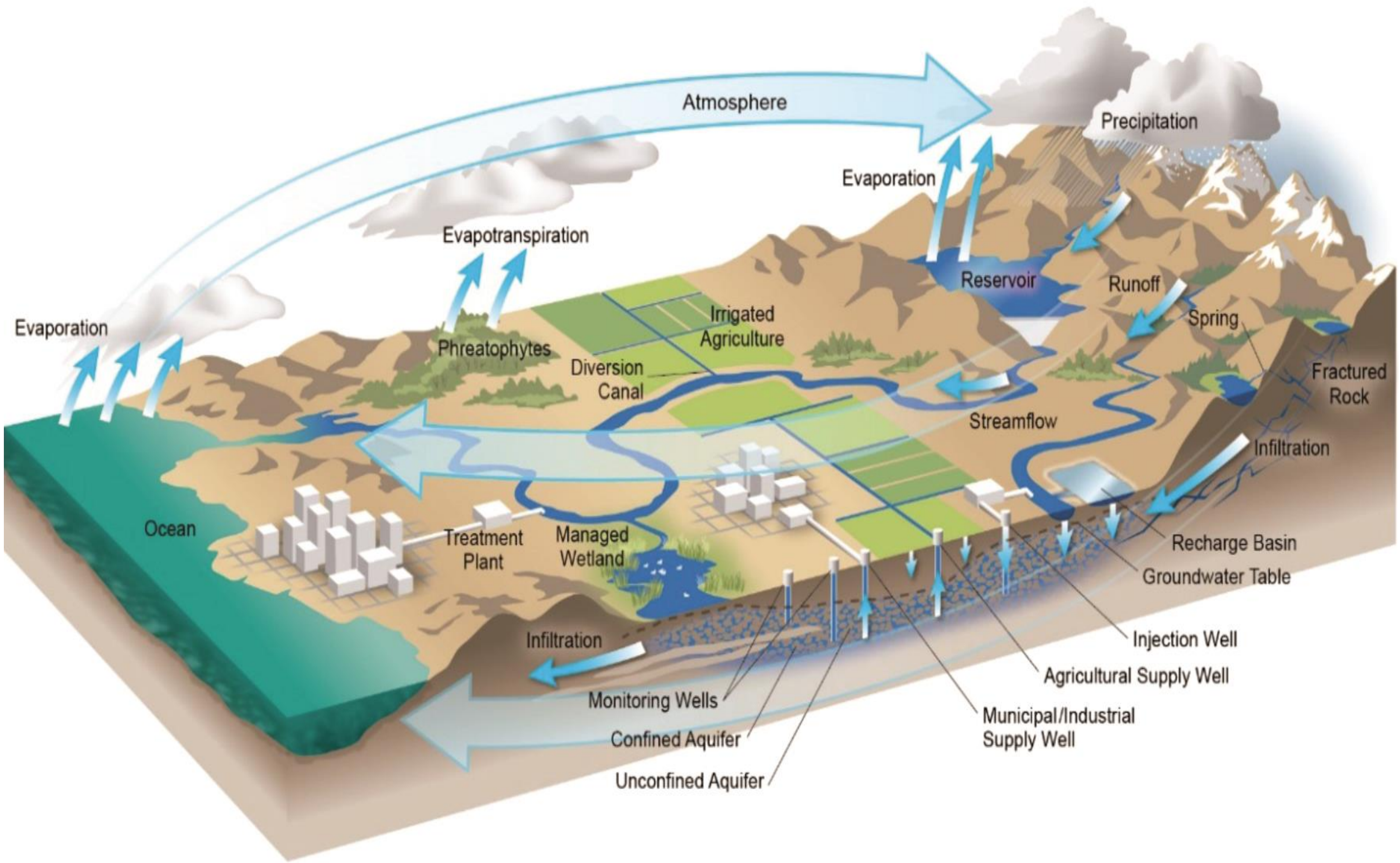


Figure 6-1: The Hydrologic Cycle. Source: Department of Water Resources (Water Budget BMP, 2016)

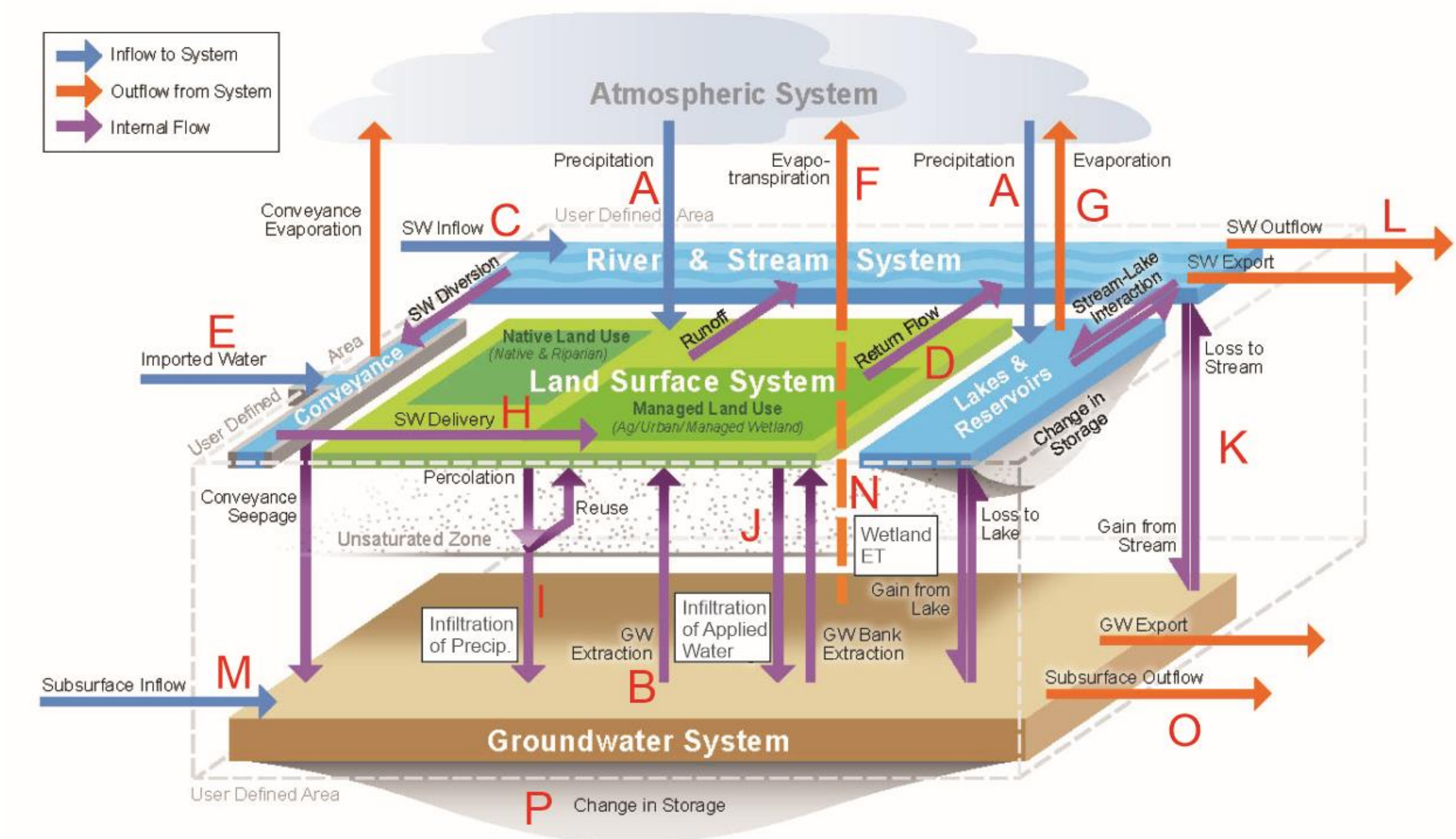
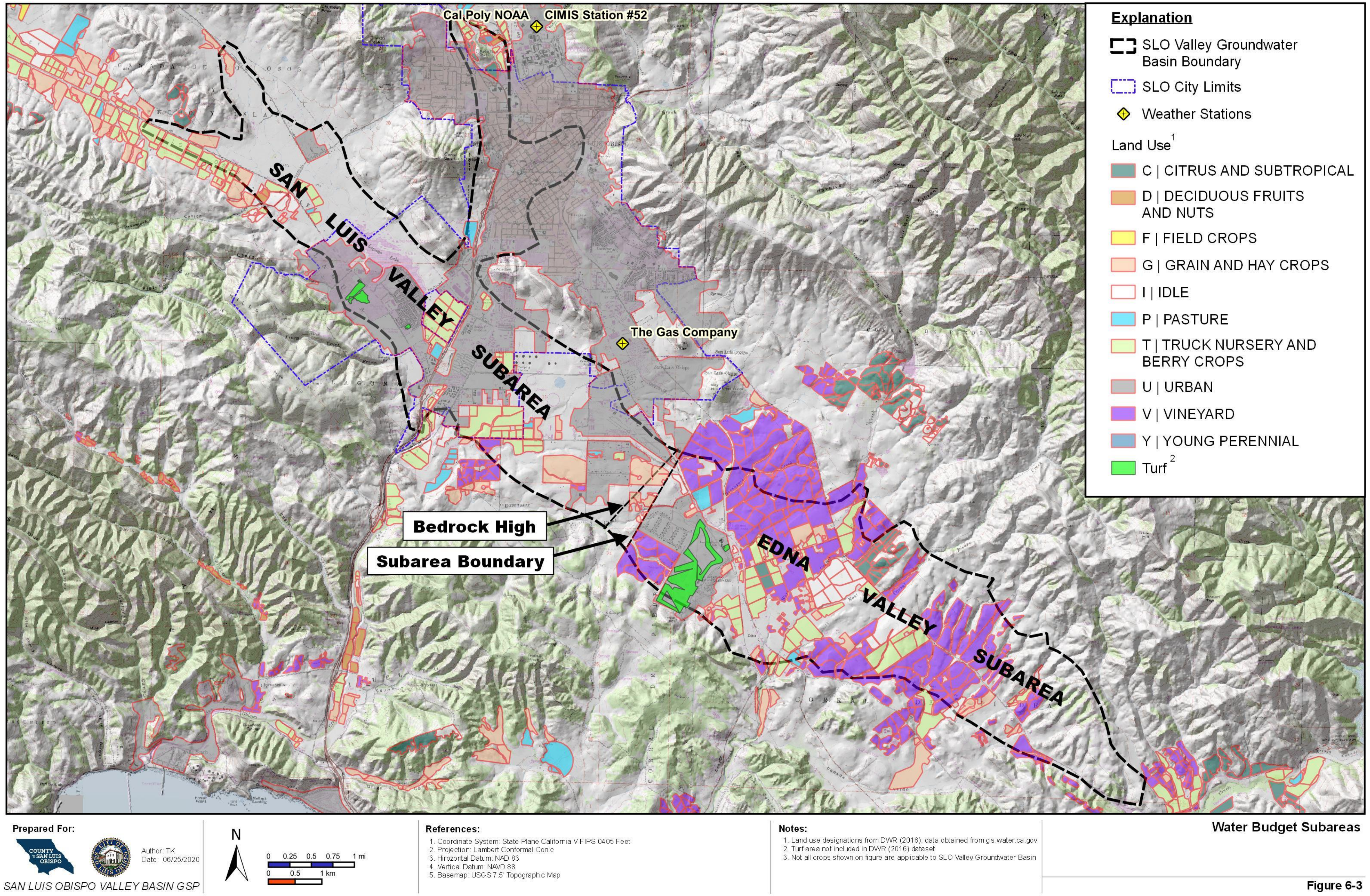


Figure 6-2: Components of the Water Budget. Source: Modified from Department of Water Resources (Water Budget BMP, 2016)



Water Budget Subareas

Figure 6-3

As presented in Chapter 4, there is a topographic high point in bedrock elevations underlying the Basin that creates a bedrock high between the San Luis Valley and Edna Valley subareas (Figure 4-4). This bedrock high partially isolates the deeper portions of the Basin aquifers (Figure 4-5) and restricts underflow between the two subareas. Figure 6-3 shows the San Luis Valley and Edna Valley subareas used for the water budget, with the subarea boundary located along Hidden Springs Road. Note that the boundary between the subareas is shifted slightly to the west of the bedrock high (Figure 6-3) in order to better correlate with overlying land use. Land use for 2016 (DWR, 2016) is shown on the map to help illustrate differences across the subarea boundary. Immediately west of the subarea boundary is rural residential land and the County airport. To the east of the subarea boundary are residential subdivisions, a golf course, and irrigated agricultural lands. The two subareas of the Basin are hydrologically distinct, as evidenced by the differences in watershed area (Figure 3-10), sediment thickness (Figure 4-4), and water level hydrographs (Figure 5-11). The groundwater budgets are also very different between the subareas, and separating the two is necessary to properly characterize the Basin. The two subarea water budgets have also been combined to create a total Basin water budget.

The San Luis Valley subarea is 6,773 acres (10.6 square miles), and the Edna Valley subarea is 5,948 acres (9.3 square miles), with a total Basin area of 12,271 acres (19.2 square miles). The San Luis Valley subarea receives surface inflow from a watershed of 28,823 acres (45 square miles) and the Edna Valley subarea receives surface inflow from a watershed of 10,145 acres (15.9 square miles). The watershed divide between San Luis Obispo Creek and Pismo Creek is not coincident with the bedrock high or subarea boundary, and watershed area draining to Davenport Creek in the Edna Valley subarea is part of the San Luis Obispo Creek watershed (Figure 3-10; Chapter 3).

Table 6-1, Table 6-2, and Table 6-3 present the historical surface water and groundwater budgets for the San Luis Valley subarea, the Edna Valley subarea, and the Basin total, respectively. Bar graphs are included in Figure 6-4 through Figure 6-9. The three main water budget tables contain a detailed accounting of the water budget for the Basin and will be referred to throughout this chapter. A letter key has been added to provide a visual reference with Figure 6-3.

Note that Figure 6-3 breaks the water budget into four components (atmospheric system, land surface system, river & stream system, and groundwater system). The atmospheric system transfers evaporation to precipitation and overlies the other systems. The land surface system is the portion of the water budget that includes land surface and the unsaturated zone extending to the top of the groundwater system. The rivers & streams system is the portion of the water budget that includes rivers, streams, conveyance facilities and diversion ditches, and lakes and reservoirs. The atmospheric, land surface, and river & streams water budgets for this Basins have been combined into a single surface water budget. As a result, not all the components in Figure 6-3 have corresponding budget items listed for the Basin. For example, the runoff and return flow components of the land surface system into the river & stream system in Figure 6-3 are part of the surface water outflow component (Labeled "L").

The six bar graphs are graphical representations of the water budget that allow quick comparisons of the various budget quantities, but are not individually referenced. Figure 6-4, Figure 6-5, and Figure 6-6 illustrate the surface water budget portions of Table 6-1, Table 6-2, and Table 6-3, while Figure 6-7, Figure 6-8, and Figure 6-9 illustrate the groundwater budget portions of the tables. Water budget climate, historical time period, methodology, sustainable yield, and overdraft interpretation are also presented in this chapter.

Some general observations on the water budget are worth noting. First, the surface water budget for the two subareas shows similar patterns of increasing and decreasing total flow from year to year, which is expected given similar precipitation with somewhat proportional stream flow. The San Luis Valley subarea surface water budget is close to double the Edna Valley surface water budget, however. This is due to a larger watershed area for the San Luis Valley subarea and to the significant volume of surface water imported by the City of San Luis Obispo. Secondly, the groundwater budget for the Edna Valley subarea shows high groundwater recharge events during all wet years, which is expected, while the San Luis Obispo shows a more attenuated response, with some wet years (1993, 2017) providing greater recharge than others. This is because during some wet years, the aquifers in the San Luis Valley subarea fill up to the point where there is no more available storage volume, and therefore no additional recharge occurs (also inferred by the relatively flat water level hydrographs in Figure 5-11). In 1993 and 2017, there was sufficient storage room following drought to allow greater recharge than during other wet years when the subarea was effectively full.

Table 6-1: Historical Water Budget - San Luis Valley Subarea.

Water Year	SURFACE WATER INFLOW (AF)							SURFACE WATER OUTFLOW (AF)												GROUNDWATER INFLOW (AF)						GROUNDWATER OUTFLOW (AF)					Change in GW Storage (AF)
	Precipitation	GW extractions (Urban)	GW extractions (Ag)	Stream Inflow	Wastewater discharge	Local Imported Supplies	TOTAL IN	ET of Precipitation	ET of Applied Water (Urban)	ET of Applied Water (Ag)	Wetland/Lake Riparian ET	Surface Water delivery offset	Infiltration of Precipitation	Infilt. of Applied Water (Urban)	Infilt. of Applied Water (Ag)	GW-SW interaction	Stream outflow	TOTAL OUT	Infiltration of Precipitation	Infilt. of Applied Water (Urban)	Infilt. of Applied Water (Ag)	GW-SW interaction	Subsurface Inflow	TOTAL IN	GW Extractions (Urban)	GW Extractions (Ag)	Wetland direct ET	Subsurface Outflow	TOTAL OUT	
KEY	A	B	B	C	D	E		F	F	F	F/G	H	I	J	J	K	L		I	J	J	K	M		B	B	N	O		P
1987	7,720	410	1,300	6,410	5,520	8,490	29,850	7,450	2,850	1,050	740	5,520	220	530	260	1,090	10,150	29,860	220	530	260	1,090	340	2,440	410	1,300	1,050	120	2,880	-440
1988	10,080	430	1,750	9,660	5,320	8,180	35,420	8,540	2,780	1,410	780	5,320	1,260	520	350	1,640	12,840	35,440	1,260	520	350	1,640	340	4,110	430	1,750	1,320	120	3,620	490
1989	7,850	660	1,580	3,600	4,070	6,020	23,780	7,550	2,180	1,270	380	4,070	250	430	310	610	6,730	23,780	250	430	310	610	340	1,940	660	1,580	1,130	120	3,490	-1,550
1990	6,790	2,180	1,850	2,140	1,970	1,280	16,210	6,660	1,200	1,490	410	1,970	110	290	370	360	3,360	16,220	110	290	370	360	340	1,470	2,180	1,850	1,250	120	5,400	-3,930
1991	9,450	2,350	1,790	5,790	2,520	1,960	23,860	8,250	1,460	1,440	380	2,520	980	320	350	980	7,160	23,840	980	320	350	980	340	2,970	2,350	1,790	1,190	120	5,450	-2,480
1992	11,250	2,240	1,820	11,250	3,070	2,910	32,540	8,590	1,720	1,460	700	3,070	2,200	360	360	1,910	12,160	32,530	2,200	360	360	1,910	340	5,170	2,240	1,820	1,090	120	5,270	-100
1993	15,700	1,030	1,790	17,350	3,630	4,980	44,480	8,640	1,980	1,440	660	3,630	5,950	400	350	1,210	20,210	44,470	5,950	400	350	1,210	340	8,250	1,030	1,790	1,190	120	4,130	4,120
1994	8,620	790	1,690	7,640	3,750	5,400	27,890	7,900	2,030	1,360	740	3,750	580	410	330	1,300	9,480	27,880	580	410	330	1,300	340	2,960	790	1,690	1,090	120	3,690	-730
1995	16,930	660	1,870	26,690	3,780	5,590	55,520	8,630	2,060	1,500	540	3,780	6,070	410	370	1,870	30,300	55,530	6,070	410	370	1,870	340	9,060	660	1,870	1,110	120	3,760	5,300
1996	11,740	740	1,910	11,930	4,210	6,160	36,690	8,530	2,250	1,530	680	4,210	1,820	440	380	830	16,010	36,680	1,820	440	380	830	340	3,810	740	1,910	1,040	120	3,810	0
1997	15,930	780	2,280	17,670	4,400	6,440	47,500	8,580	2,370	1,830	690	4,400	2,690	460	450	530	25,510	47,510	2,690	460	450	530	340	4,470	780	2,280	1,290	120	4,470	0
1998	16,930	680	1,870	26,460	4,150	6,130	56,220	8,580	2,230	1,500	520	4,150	1,770	440	370	790	35,880	56,230	1,770	440	370	790	340	3,710	680	1,870	1,040	120	3,710	0
1999	8,670	660	2,510	7,720	4,350	6,470	30,380	7,870	2,340	2,020	810	4,350	650	450	500	1,310	10,100	30,400	650	450	500	1,310	340	3,250	660	2,510	1,330	120	4,620	-1,370
2000	12,620	670	1,810	13,130	4,410	6,560	39,200	8,530	2,360	1,450	670	4,410	2,950	450	360	920	17,090	39,190	2,950	450	360	920	340	5,020	670	1,810	1,040	120	3,640	1,380
2001	12,470	710	1,740	12,920	4,250	6,270	38,360	8,570	2,290	1,400	670	4,250	1,590	440	340	900	17,900	38,350	1,590	440	340	900	340	3,610	710	1,740	1,040	120	3,610	0
2002	7,510	630	1,850	6,130	4,530	6,340	26,990	7,240	2,000	1,490	770	4,530	220	440	360	1,040	8,900	26,990	220	440	360	1,040	340	2,400	630	1,850	1,140	120	3,740	-1,340
2003	11,630	610	1,470	11,780	4,610	6,300	36,400	8,640	1,860	1,180	680	4,610	2,490	440	290	820	15,390	36,400	2,490	440	290	820	340	4,380	610	1,470	1,040	120	3,240	1,140
2004	8,140	620	1,500	6,990	4,340	6,740	28,330	7,780	2,560	1,200	760	4,340	300	460	290	1,190	9,450	28,330	300	460	290	1,190	340	2,580	620	1,500	1,140	120	3,380	-800
2005	15,120	620	1,370	16,560	5,390	6,250	45,310	8,720	1,040	1,100	600	5,390	1,850	440	270	1,160	24,730	45,300	1,850	440	270	1,160	340	4,060	620	1,370	950	120	3,060	1,000
2006	13,180	610	1,280	6,500	4,950	6,280	32,800	8,710	1,500	1,030	660	4,950	1,580	440	250	450	13,220	32,790	1,580	440	250	450	340	3,060	610	1,280	1,050	120	3,060	0
2007	4,340	610	1,510	6,140	4,200	6,840	23,640	4,330	2,770	1,210	840	4,200	0	480	290	1,040	8,440	23,600	0	480	290	1,040	340	2,150	610	1,510	1,250	120	3,490	-1,340
2008	7,800	520	1,550	11,030	4,010	6,730	31,640	7,540	2,770	1,250	790	4,010	210	470	300	1,870	12,410	31,620	210	470	300	1,870	340	3,190	520	1,550	1,260	120	3,450	-260
2009	5,890	560	1,430	7,670	3,930	6,580	26,060	5,840	2,740	1,150	790	3,930	40	480	280	1,300	9,500	26,050	40	480	280	1,300	340	2,440	560	1,430	1,140	120	3,250	-810
2010	11,980	580	1,160	22,860	4,160	5,860	46,600	8,680	1,850	940	650	4,160	2,590	450	220	1,600	25,460	46,600	2,590	450	220	1,600	340	5,200	580	1,160	960	120	2,820	2,380
2011	16,930	530	1,260	21,360	4,480	5,530	50,090	8,750	1,170	1,020	610	4,480	1,400	430	240	640	31,350	50,090	1,400	430	240	640	340	3,050	530	1,260	1,150	120	3,060	-10
2012	8,470	530	1,420	5,430	3,950	5,770	25,570	7,940	1,910	1,150	770	3,950	430	450	270	920	7,770	25,560	430	450	270	920	340	2,410	530	1,420	1,200	120	3,270	-860
2013	5,290	510	1,790	3,670	4,060	6,330	21,650	5,260	2,320	1,450	430	4,060	30	470	340	620	6,670	21,650	30	470	340	620	340	1,800	510	1,790	1,350	120	3,770	-1,970
2014	5,220	540	1,560	3,270	3,660	6,190	20,440	5,190	2,620	1,260	420	3,660	20	470	300	560	5,940	20,440	20	470	300	560	340	1,690	540	1,560	1,290	120	3,510	-1,820
2015	5,960	400	1,680	1,620	3,420	5,750	18,830	5,900	2,300	1,360	410	3,420	50	440	330	270	4,340	18,820	50	440	330	270	340	1,430	400	1,680	1,270	120	3,470	-2,040
2016	10,150	400	1,690	4,850	3,550	5,490	26,130	8,490	1,920	1,360	730	3,550	1,350	430	330	820	7,130	26,110	1,350	430	330	820	340	3,270	400	1,690	1,170	120	3,380	-110
2017	16,930	400	1,550	18,450	4,400	5,370	47,100	8,730	960	1,250	590	4,400	6,910	440	300	550	22,970	47,100	6,910	440	300	550	340	8,540	400	1,550	1,260	120	3,330	5,210
2018	6,980	400	1,190	2,630	3,330	5,790	20,320	6,870	2,430	970	800	3,330	90	450	230	180	4,970	20,320	90	450	230	180	340	1,290	400	1,190	1,270	120	2,980	-1,690
2019	15,040	400	1,030	16,360	4,360	5,080	42,270	8,800	720	830	630	4,360	4,430	420	200	490	21,400	42,280	4,430	420	200	490	340	5,880	400	1,030	1,070	120	2,620	3,260

Type Year: Dry / Below Normal / Above Normal / Wet

AF = Acre-Feet; KEY = Referenced Components on Figure 6-3

Table 6-2: Historical Water Budget - Edna Valley Subarea.

Water Year	SURFACE WATER INFLOW (AF)					SURFACE WATER OUTFLOW (AF)										GROUNDWATER INFLOW (AF)						GROUNDWATER OUTFLOW (AF)				Change in GW Storage (AF)
	Precipitation	GW extractions (Urban)	GW extractions (Ag)	Stream Inflow	TOTAL IN	ET of Precipitation	ET of Applied Water (Urban)	ET of Applied Water (Ag)	Riparian ET	Infiltration of Precipitation	Infilt. of Applied Water (Urban)	Infilt. of Applied Water (Ag)	GW-SW interaction	Stream outflow	TOTAL OUT	Infiltration of Precipitation	Infilt. of Applied Water (Urban)	Infilt. of Applied Water (Ag)	GW-SW interaction	Subsurface Inflow	TOTAL IN	GW Extractions (Urban)	GW Extractions (Ag)	Subsurface Outflow	TOTAL OUT	
KEY	A	B	B	C		F	F	F	F	I	J	J	K	L		I	J	J	K	M		B	B	O		P
1987	6,780	630	2,450	2,150	12,010	6,610	450	2,000	40	140	190	440	300	1,840	12,010	140	190	440	300	110	1,180	630	2,450	100	3,180	-2,000
1988	8,860	760	2,750	3,240	15,610	7,970	560	2,240	40	660	210	510	450	2,960	15,600	660	210	510	450	110	1,940	760	2,750	100	3,610	-1,670
1989	6,900	640	2,670	1,210	11,420	6,670	470	2,190	20	180	180	480	170	1,070	11,430	180	180	480	170	110	1,120	640	2,670	100	3,410	-2,290
1990	5,960	740	3,040	730	10,470	5,860	530	2,490	20	90	220	550	100	620	10,480	90	220	550	100	110	1,070	740	3,040	100	3,880	-2,810
1991	8,300	760	2,810	1,940	13,810	7,550	530	2,300	20	570	240	510	270	1,840	13,830	570	240	510	270	110	1,700	760	2,810	100	3,670	-1,970
1992	9,880	790	2,810	3,770	17,250	8,030	530	2,300	40	1,460	270	510	530	3,590	17,260	1,460	270	510	530	110	2,880	790	2,810	100	3,700	-820
1993	13,780	840	2,710	5,810	23,140	8,000	570	2,220	40	4,800	290	490	810	5,940	23,160	4,800	290	490	810	110	6,500	840	2,710	100	3,650	2,850
1994	7,570	760	2,640	2,560	13,530	7,050	500	2,170	40	400	270	470	360	2,280	13,540	400	270	470	360	110	1,610	760	2,640	100	3,500	-1,890
1995	14,870	820	2,820	8,930	27,440	7,930	550	2,320	40	5,740	280	500	1,250	8,840	27,450	5,740	280	500	1,250	110	7,880	820	2,820	100	3,740	4,140
1996	10,310	850	3,000	3,990	18,150	7,880	550	2,470	40	1,920	310	530	560	3,900	18,160	1,920	310	530	560	110	3,430	850	3,000	100	3,950	-520
1997	13,990	1,030	3,460	5,910	24,390	7,840	690	2,850	40	5,010	350	610	830	6,190	24,410	5,010	350	610	830	110	6,910	1,030	3,460	100	4,590	2,320
1998	14,870	860	3,000	9,730	28,460	7,790	570	2,480	40	5,750	300	520	1,360	9,660	28,470	5,750	300	520	1,360	110	8,040	860	3,000	100	3,960	4,080
1999	7,620	1,020	3,720	2,590	14,950	6,990	690	3,070	40	470	340	650	360	2,340	14,950	470	340	650	360	110	1,930	1,020	3,720	100	4,840	-2,910
2000	11,080	940	2,700	4,400	19,120	7,710	600	2,230	40	2,650	350	480	620	4,470	19,150	2,650	350	480	620	110	4,210	940	2,700	100	3,740	470
2001	10,950	980	3,320	4,330	19,580	7,670	630	2,750	40	2,550	360	570	610	4,400	19,580	2,550	360	570	610	110	4,200	980	3,320	100	4,400	-200
2002	6,600	960	3,220	2,060	12,840	6,400	630	2,660	40	170	340	570	290	1,760	12,860	170	340	570	290	110	1,480	960	3,220	100	4,280	-2,800
2003	10,220	870	3,030	3,950	18,070	7,600	570	2,500	40	2,000	320	520	550	3,970	18,070	2,000	320	520	550	110	3,500	870	3,030	100	4,000	-500
2004	7,150	970	3,040	2,340	13,500	6,740	630	2,520	40	320	350	530	330	2,070	13,530	320	350	530	330	110	1,640	970	3,040	100	4,110	-2,470
2005	13,280	840	2,870	5,540	22,530	7,610	550	2,370	40	4,450	300	500	780	5,930	22,530	4,450	300	500	780	110	6,140	840	2,870	100	3,810	2,330
2006	11,570	900	3,040	2,180	17,690	7,580	590	2,520	40	3,100	320	530	310	2,730	17,720	3,100	320	530	310	110	4,370	900	3,040	100	4,040	330
2007	3,810	1,180	3,830	2,160	10,980	3,800	770	3,170	40	0	430	660	300	1,820	10,990	0	430	660	300	110	1,500	1,180	3,830	100	5,110	-3,610
2008	6,850	1,210	3,750	3,750	15,560	6,580	780	3,100	40	220	440	650	520	3,230	15,560	220	440	650	520	110	1,940	1,210	3,750	100	5,060	-3,120
2009	5,170	950	3,660	2,740	12,520	5,100	650	3,040	40	50	310	620	380	2,330	12,520	50	310	620	380	110	1,470	950	3,660	100	4,710	-3,240
2010	10,520	820	3,360	7,490	22,190	7,560	550	2,790	40	2,260	270	570	1,050	7,100	22,190	2,260	270	570	1,050	110	4,260	820	3,360	100	4,280	-20
2011	14,870	840	3,330	7,840	26,880	7,550	580	2,760	40	5,760	270	570	1,100	8,260	26,890	5,760	270	570	1,100	110	7,810	840	3,330	100	4,270	3,540
2012	7,440	940	3,560	1,810	13,750	6,830	650	2,950	40	450	290	610	250	1,660	13,730	450	290	610	250	110	1,710	940	3,560	100	4,600	-2,890
2013	4,640	1,040	3,780	1,260	10,720	4,600	740	3,120	20	40	310	660	180	1,070	10,740	40	310	660	180	110	1,300	1,040	3,780	100	4,920	-3,620
2014	4,590	960	3,580	1,120	10,250	4,550	680	2,960	20	30	280	620	160	950	10,250	30	280	620	160	110	1,200	960	3,580	100	4,640	-3,440
2015	5,230	880	4,230	490	10,830	5,160	650	3,500	20	60	230	720	70	410	10,820	60	230	720	70	110	1,190	880	4,230	100	5,210	-4,020
2016	8,920	790	3,200	1,560	14,470	7,550	580	2,680	40	980	220	530	220	1,680	14,480	980	220	530	220	110	2,060	790	3,200	100	4,090	-2,030
2017	14,870	850	3,640	6,240	25,600	7,570	640	3,030	40	5,730	220	610	870	6,890	25,600	5,730	220	610	870	110	7,540	850	3,640	100	4,590	2,950
2018	6,130	880	3,550	650	11,210	6,020	650	2,960	40	90	240	590	90	540	11,220	90	240	590	90	110	1,120	880	3,550	100	4,530	-3,410
2019	13,210	770	3,350	5,480	22,810	7,630	580	2,800	40	4,370	210	550	770	5,870	22,820	4,370	210	550	770	110	6,010	770	3,350	100	4,220	1,790

Type Year: **Dry** / **Below Normal** / **Above Normal** / **Wet**

AF = Acre-Feet; KEY = Referenced Components on Figure 6-3

Table 6-3: Historical Water Budget - San Luis Obispo Valley Groundwater Basin.

Water Year	SURFACE WATER INFLOW (GW)							SURFACE WATER OUTFLOW (GW)											GROUNDWATER INFLOW (GW)						GROUNDWATER OUTFLOW (GW)					Change in GW Storage (AF)
	Precipitation	GW extractions (Urban)	GW extractions (Ag)	Stream Inflow	Wastewater discharge	Local Imported Supplies	TOTAL IN	ET of Precipitation	ET of Applied Water (Urban)	ET of Applied Water (Ag)	Wetland/Lake Riparian ET	Surface Water deliveries	Infiltration of Precipitation	Infilt. of Applied Water (Urban)	Infilt. of Applied Water (Ag)	GW-SW interaction	Stream outflow	TOTAL OUT	Infiltration of Precipitation	Infilt. of Applied Water (Urban)	Infilt. of Applied Water(Ag)	GW-SW interaction	Subsurface Inflow	TOTAL IN	GW Extractions (Urban)	GW Extractions (Ag)	Wetland direct ET	Subsurface Outflow	TOTAL OUT	
KEY	A	B	B	C	D	E		F	F	F	F/G	H	I	J	J	K	L		I	J	J	K	M		B	B	N	O		P
1987	14,500	1,040	3,750	8,560	5,520	8,490	41,860	14,060	3,300	3,050	780	5,520	360	720	700	1,390	11,990	41,870	360	720	700	1,390	450	3,620	1,040	3,750	1,050	220	6,060	-2,440
1988	18,940	1,190	4,500	12,900	5,320	8,180	51,030	16,510	3,340	3,650	820	5,320	1,920	730	860	2,090	15,800	51,040	1,920	730	860	2,090	450	6,050	1,190	4,500	1,320	220	7,230	-1,180
1989	14,750	1,300	4,250	4,810	4,070	6,020	35,200	14,220	2,650	3,460	400	4,070	430	610	790	780	7,800	35,210	430	610	790	780	450	3,060	1,300	4,250	1,130	220	6,900	-3,840
1990	12,750	2,920	4,890	2,870	1,970	1,280	26,680	12,520	1,730	3,980	430	1,970	200	510	920	460	3,980	26,700	200	510	920	460	450	2,540	2,920	4,890	1,250	220	9,280	-6,740
1991	17,750	3,110	4,600	7,730	2,520	1,960	37,670	15,800	1,990	3,740	400	2,520	1,550	560	860	1,250	9,000	37,670	1,550	560	860	1,250	450	4,670	3,110	4,600	1,190	220	9,120	-4,450
1992	21,130	3,030	4,630	15,020	3,070	2,910	49,790	16,620	2,250	3,760	740	3,070	3,660	630	870	2,440	15,750	49,790	3,660	630	870	2,440	450	8,050	3,030	4,630	1,090	220	8,970	-920
1993	29,480	1,870	4,500	23,160	3,630	4,980	67,620	16,640	2,550	3,660	700	3,630	10,750	690	840	2,020	26,150	67,630	10,750	690	840	2,020	450	14,750	1,870	4,500	1,190	220	7,780	6,970
1994	16,190	1,550	4,330	10,200	3,750	5,400	41,420	14,950	2,530	3,530	780	3,750	980	680	800	1,660	11,760	41,420	980	680	800	1,660	450	4,570	1,550	4,330	1,090	220	7,190	-2,620
1995	31,800	1,480	4,690	35,620	3,780	5,590	82,960	16,560	2,610	3,820	580	3,780	11,810	690	870	3,120	39,140	82,980	11,810	690	870	3,120	450	16,940	1,480	4,690	1,110	220	7,500	9,440
1996	22,050	1,590	4,910	15,920	4,210	6,160	54,840	16,410	2,800	4,000	720	4,210	3,740	750	910	1,390	19,910	54,840	3,740	750	910	1,390	450	7,240	1,590	4,910	1,040	220	7,760	-520
1997	29,920	1,810	5,740	23,580	4,400	6,440	71,890	16,420	3,060	4,680	730	4,400	7,700	810	1,060	1,360	31,700	71,920	7,700	810	1,060	1,360	450	11,380	1,810	5,740	1,290	220	9,060	2,320
1998	31,800	1,540	4,870	36,190	4,150	6,130	84,680	16,370	2,800	3,980	560	4,150	7,520	740	890	2,150	45,540	84,700	7,520	740	890	2,150	450	11,750	1,540	4,870	1,040	220	7,670	4,080
1999	16,290	1,680	6,230	10,310	4,350	6,470	45,330	14,860	3,030	5,090	850	4,350	1,120	790	1,150	1,670	12,440	45,350	1,120	790	1,150	1,670	450	5,180	1,680	6,230	1,330	220	9,460	-4,280
2000	23,700	1,610	4,510	17,530	4,410	6,560	58,320	16,240	2,960	3,680	710	4,410	5,600	800	840	1,540	21,560	58,340	5,600	800	840	1,540	450	9,230	1,610	4,510	1,040	220	7,380	1,850
2001	23,420	1,690	5,060	17,250	4,250	6,270	57,940	16,240	2,920	4,150	710	4,250	4,140	800	910	1,510	22,300	57,930	4,140	800	910	1,510	450	7,810	1,690	5,060	1,040	220	8,010	-200
2002	14,110	1,590	5,070	8,190	4,530	6,340	39,830	13,640	2,630	4,150	810	4,530	390	780	930	1,330	10,660	39,850	390	780	930	1,330	450	3,880	1,590	5,070	1,140	220	8,020	-4,140
2003	21,850	1,480	4,500	15,730	4,610	6,300	54,470	16,240	2,430	3,680	720	4,610	4,490	760	810	1,370	19,360	54,470	4,490	760	810	1,370	450	7,880	1,480	4,500	1,040	220	7,240	640
2004	15,290	1,590	4,540	9,330	4,340	6,740	41,830	14,520	3,190	3,720	800	4,340	620	810	820	1,520	11,520	41,860	620	810	820	1,520	450	4,220	1,590	4,540	1,140	220	7,490	-3,270
2005	28,400	1,460	4,240	22,100	5,390	6,250	67,840	16,330	1,590	3,470	640	5,390	6,300	740	770	1,940	30,660	67,830	6,300	740	770	1,940	450	10,200	1,460	4,240	950	220	6,870	3,330
2006	24,750	1,510	4,320	8,680	4,950	6,280	50,490	16,290	2,090	3,550	700	4,950	4,680	760	780	760	15,950	50,510	4,680	760	780	760	450	7,430	1,510	4,320	1,050	220	7,100	330
2007	8,150	1,790	5,340	8,300	4,200	6,840	34,620	8,130	3,540	4,380	880	4,200	0	910	950	1,340	10,260	34,590	0	910	950	1,340	450	3,650	1,790	5,340	1,250	220	8,600	-4,950
2008	14,650	1,730	5,300	14,780	4,010	6,730	47,200	14,120	3,550	4,350	830	4,010	430	910	950	2,390	15,640	47,180	430	910	950	2,390	450	5,130	1,730	5,300	1,260	220	8,510	-3,380
2009	11,060	1,510	5,090	10,410	3,930	6,580	38,580	10,940	3,390	4,190	830	3,930	90	790	900	1,680	11,830	38,570	90	790	900	1,680	450	3,910	1,510	5,090	1,140	220	7,960	-4,050
2010	22,500	1,400	4,520	30,350	4,160	5,860	68,790	16,240	2,400	3,730	690	4,160	4,850	720	790	2,650	32,560	68,790	4,850	720	790	2,650	450	9,460	1,400	4,520	960	220	7,100	2,360
2011	31,800	1,370	4,590	29,200	4,480	5,530	76,970	16,300	1,750	3,780	650	4,480	7,160	700	810	1,740	39,610	76,980	7,160	700	810	1,740	450	10,860	1,370	4,590	1,150	220	7,330	3,530
2012	15,910	1,470	4,980	7,240	3,950	5,770	39,320	14,770	2,560	4,100	810	3,950	880	740	880	1,170	9,430	39,290	880	740	880	1,170	450	4,120	1,470	4,980	1,200	220	7,870	-3,750
2013	9,930	1,550	5,570	4,930	4,060	6,330	32,370	9,860	3,060	4,570	450	4,060	70	780	1,000	800	7,740	32,390	70	780	1,000	800	450	3,100	1,550	5,570	1,350	220	8,690	-5,590
2014	9,810	1,500	5,140	4,390	3,660	6,190	30,690	9,740	3,300	4,220	440	3,660	50	750	920	720	6,890	30,690	50	750	920	720	450	2,890	1,500	5,140	1,290	220	8,150	-5,260
2015	11,190	1,280	5,910	2,110	3,420	5,750	29,660	11,060	2,950	4,860	430	3,420	110	670	1,050	340	4,750	29,640	110	670	1,050	340	450	2,620	1,280	5,910	1,270	220	8,680	-6,060
2016	19,070	1,190	4,890	6,410	3,550	5,490	40,600	16,040	2,500	4,040	770	3,550	2,330	650	860	1,040	8,810	40,590	2,330	650	860	1,040	450	5,330	1,190	4,890	1,170	220	7,470	-2,140
2017	31,800	1,250	5,190	24,690	4,400	5,370	72,700	16,300	1,600	4,280	630	4,400	12,640	660	910	1,420	29,860	72,700	12,640	660	910	1,420	450	16,080	1,250	5,190	1,260	220	7,920	8,160
2018	13,110	1,280	4,740	3,280	3,330	5,790	31,530	12,890	3,080	3,930	840	3,330	180	690	820	270	5,510	31,540	180	690	820	270	450	2,410	1,280	4,740	1,270	220	7,510	-5,100
2019	28,250	1,170	4,380	21,840	4,360	5,080	65,080	16,430	1,300	3,630	670	4,360	8,800	630	750	1,260	27,270	65,100	8,800	630	750	1,260	450	11,890	1,170	4,380	1,070	220	6,840	5,050

Type Year: **Dry** / **Below Normal** / **Above Normal** / **Wet**

AF = Acre-Feet; KEY = Referenced Components on Figure 6-3

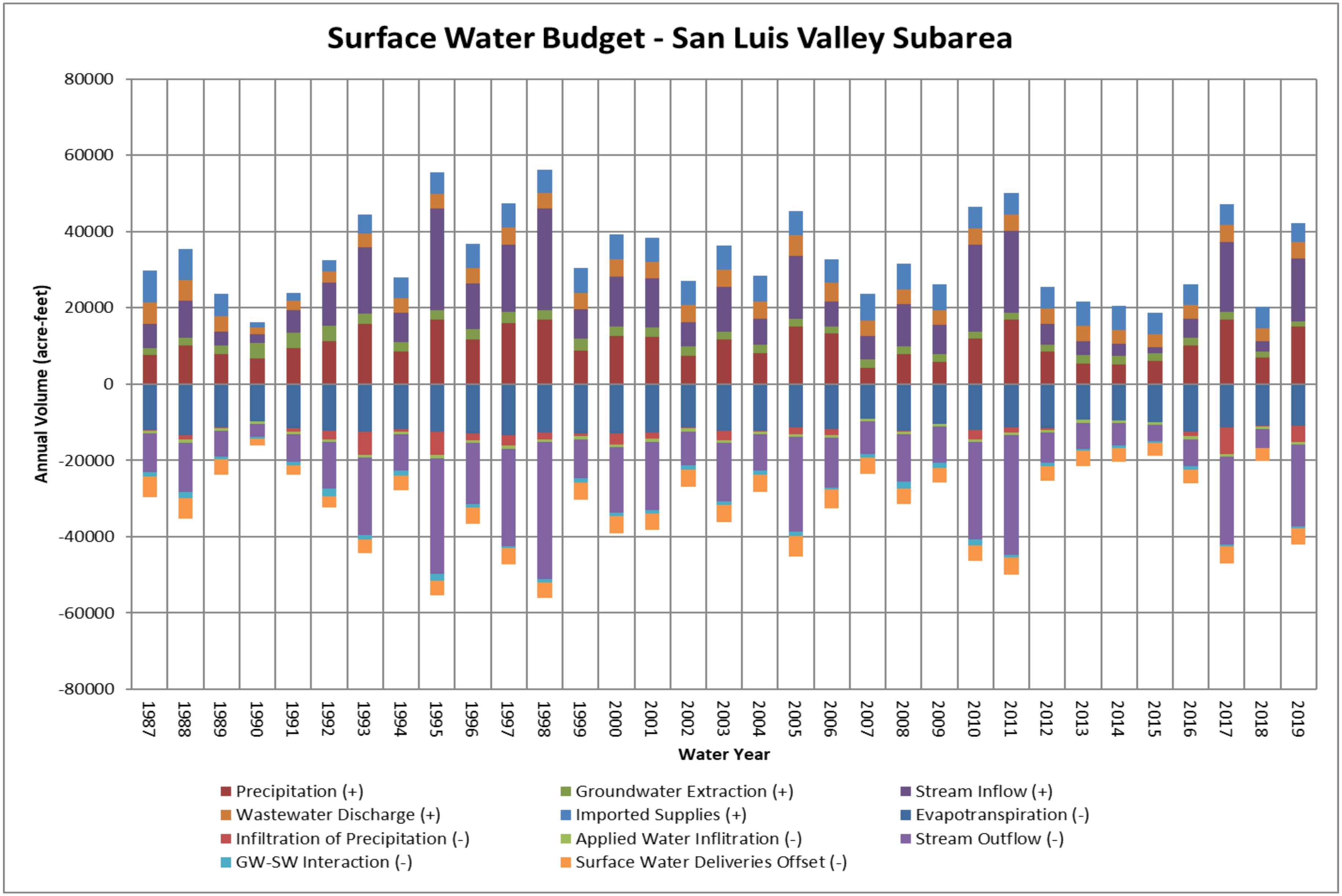


Figure 6-4: Surface Water Budget – San Luis Valley Subarea.

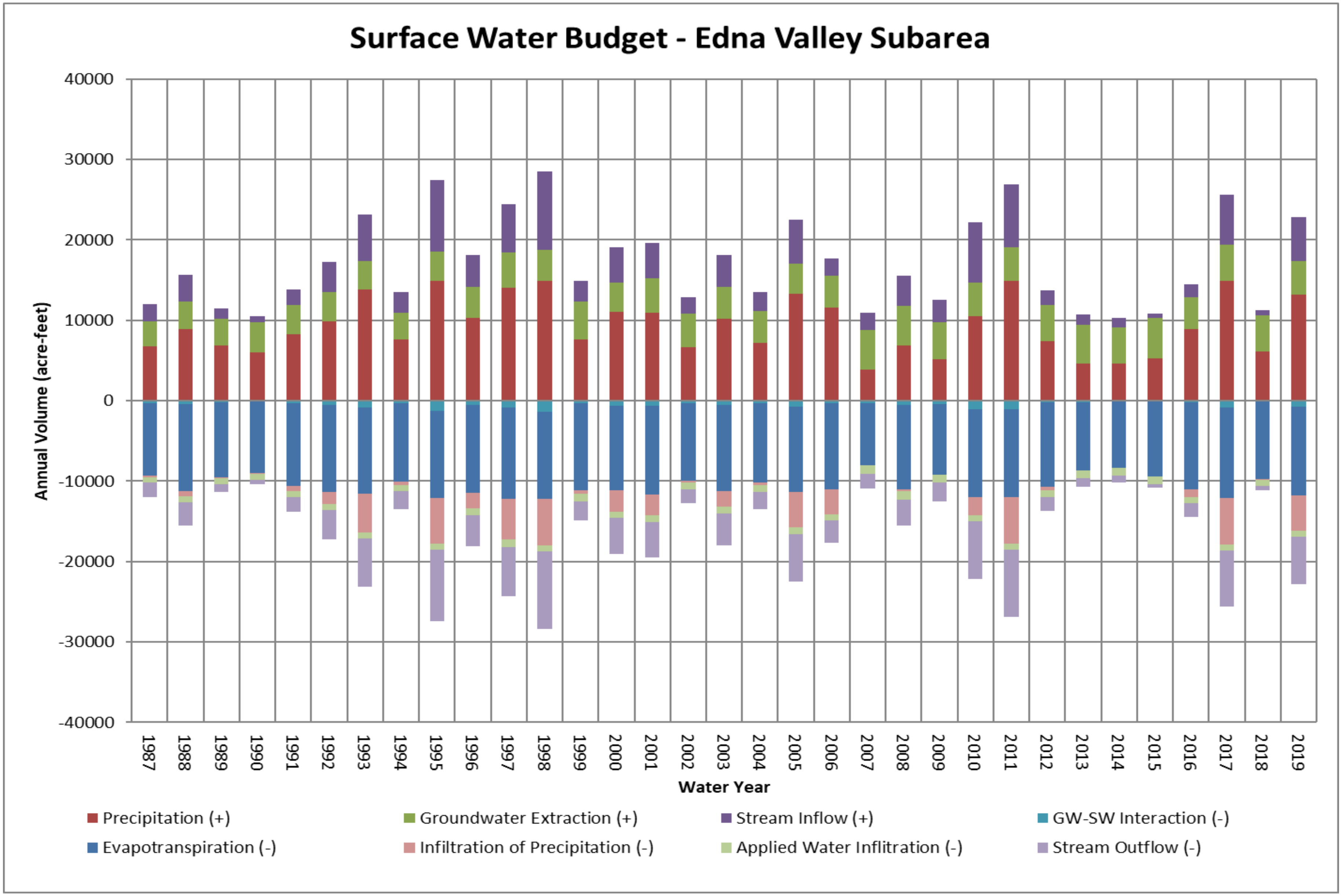


Figure 6-5: Surface Water Budget – Edna Valley Subarea.

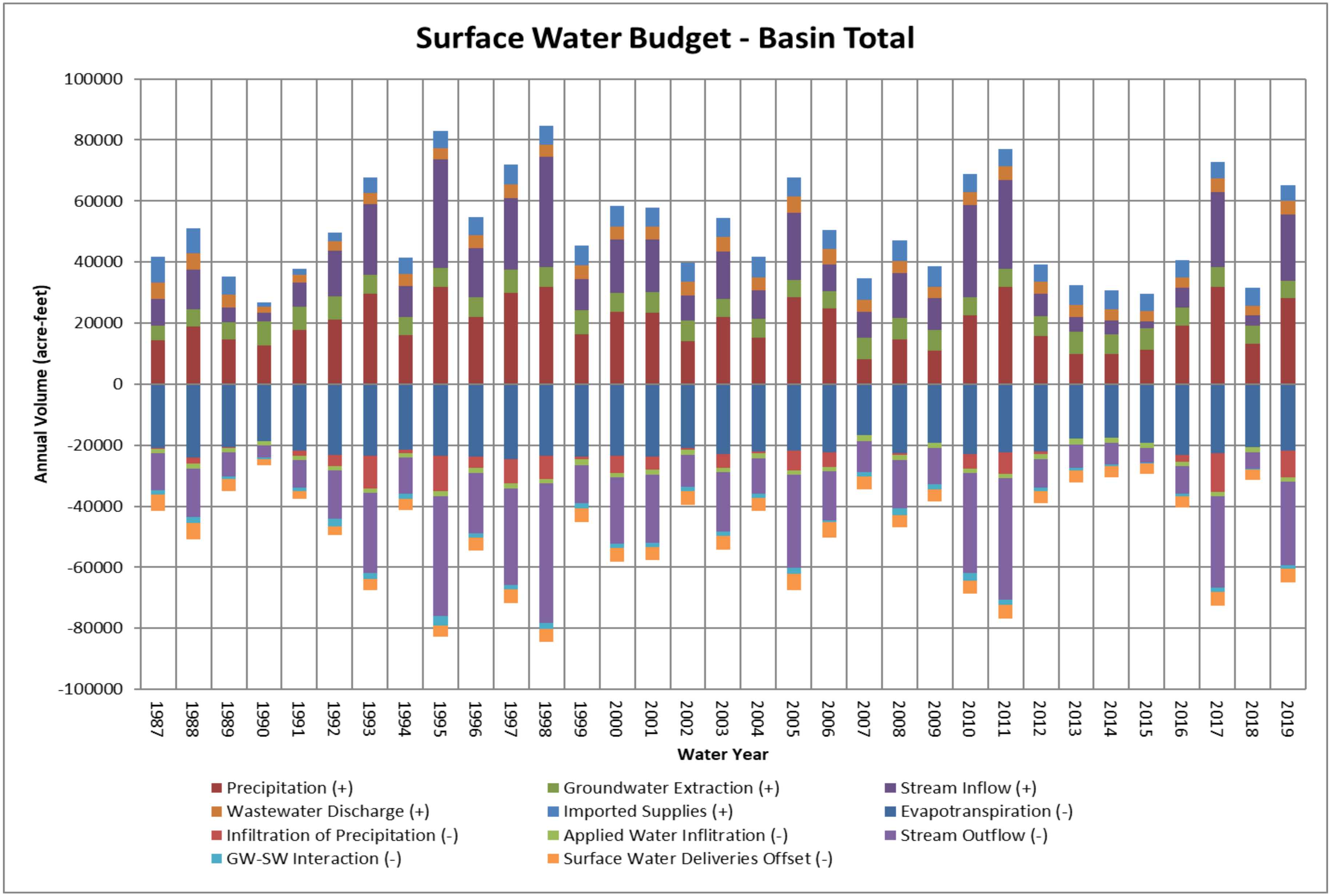


Figure 6-6: Surface Water Budget – Basin Total.

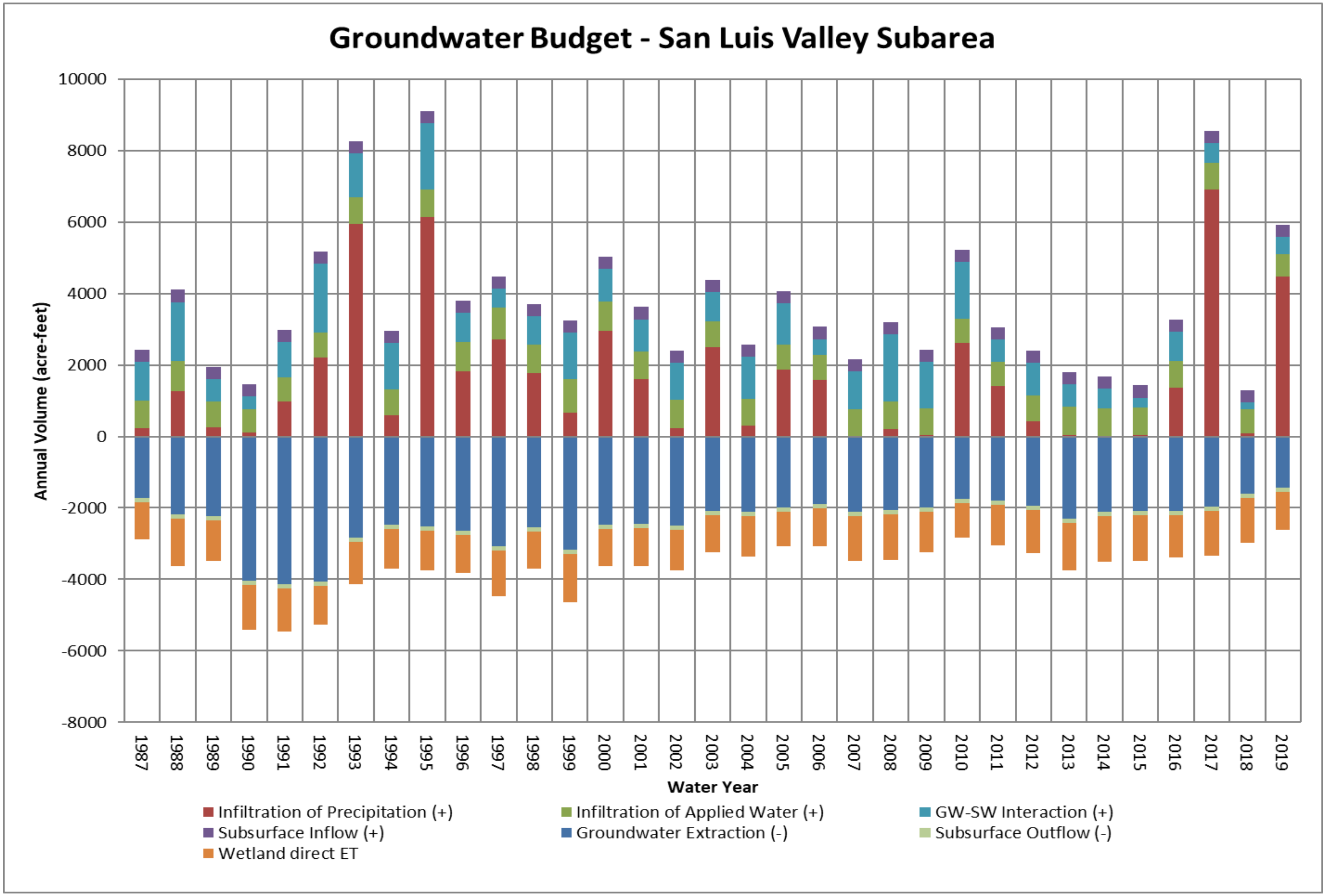


Figure 6-7: Groundwater Budget – San Luis Valley Subarea.

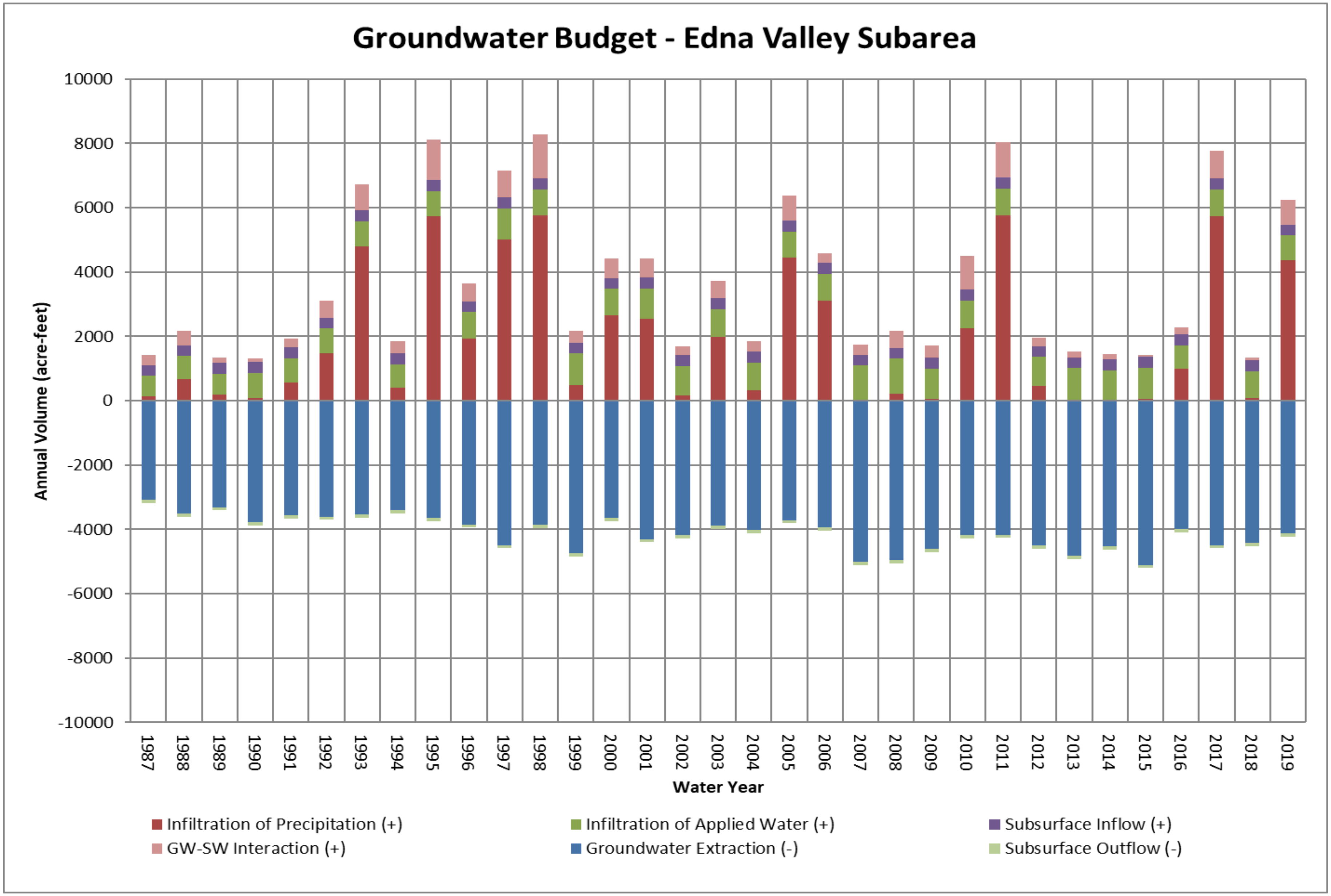


Figure 6-8: Groundwater Budget – Edna Valley Subarea.

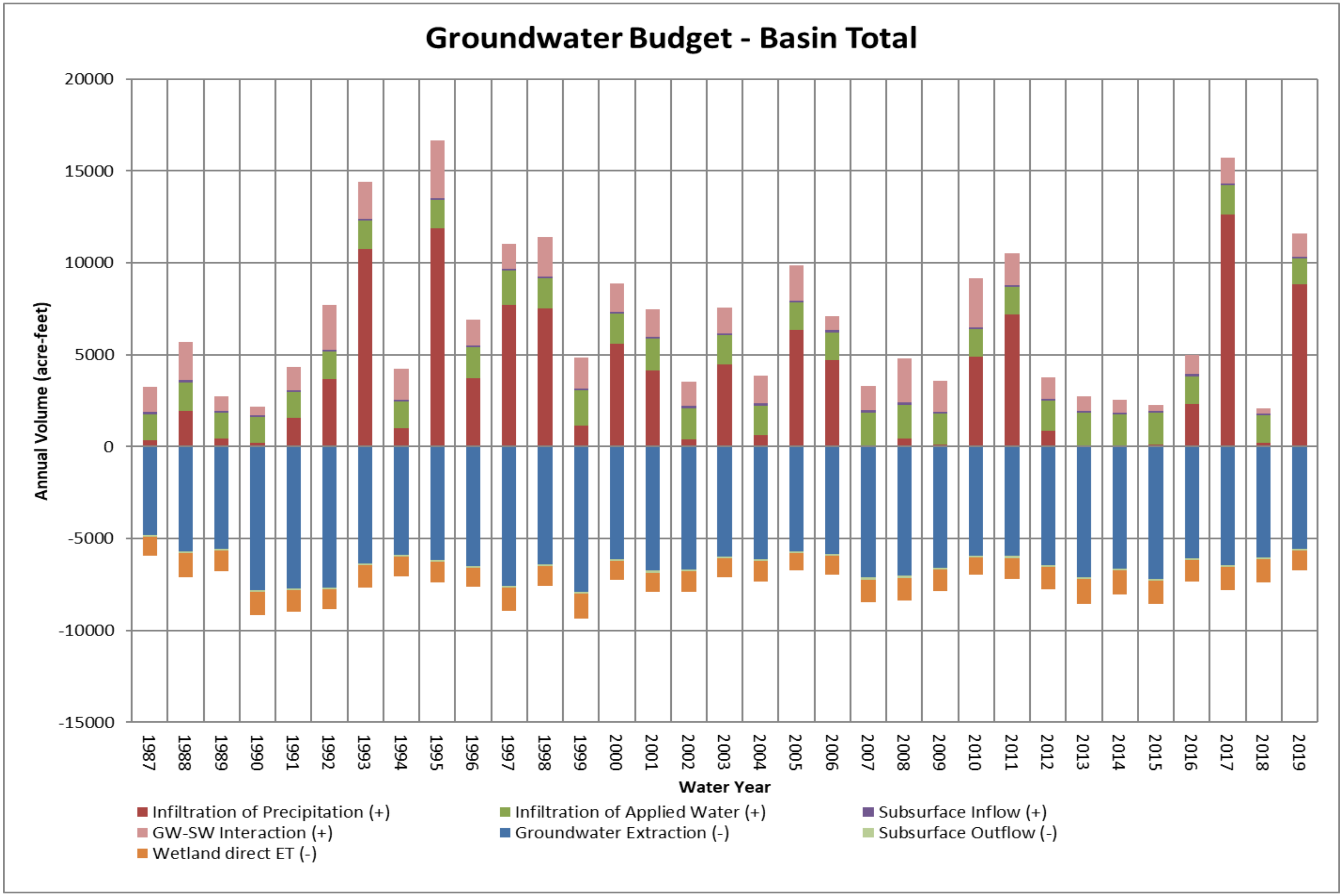


Figure 6-9: Groundwater Budget – Basin Total.

6.1 CLIMATE

Climate is one of the principal measures of water supply conditions and is used for hydrologic base period definition and for developing evapotranspiration estimates. The main component of climate monitoring in the Basin is rainfall, with records at the Cal Poly NOAA Station (formerly Cal Poly #1) beginning in the 1870-71 rainfall year. Rainfall is used in the water budget for establishing the hydrologic base period needed for representing long-term water supply conditions.

Another climate parameter used in the water budget is evapotranspiration. Evapotranspiration is calculated from a combination of monitored parameters, such as air temperature, wind speed, solar radiation, vapor pressure, and relative humidity. These parameters, along with precipitation, have been monitored at CIMIS Station #52 (San Luis Obispo – Cal Poly) since 1986. The water budget uses crop evapotranspiration for estimating the applied irrigation requirements for crops (see Section 6.3.4.2). Cal Poly, the San Luis Valle, and the Edna Valley are all within DWR reference evapotranspiration Zone 6, which is one of 18 climate zones in California based on long-term monthly average reference evapotranspiration (CIMIS, 1999).

6.1.1 Historical Climate/Base Period

The historical rainfall record at the Cal Poly NOAA Station has been used to define a period of years, referred to as a base period, which represents long-term hydrologic conditions. As described by DWR (2002):

> *The base period should be representative of long-term hydrologic conditions, encompassing dry, wet, and average years of precipitation. It must be contained in the historical record and should include recent cultural conditions to assist in determining projected Basin operations. To minimize the amount of water in transit in the zone of aeration, the beginning and end of the base period should be preceded by comparatively similar rainfall quantities.*

The historical rainfall record for the Cal Poly NOAA Station, which is the longest record in the San Luis Obispo area, was presented in Figure 3-11; Chapter 3. The water year in San Luis Obispo County for rainfall runs from July 1 through June 30 (also referred to as rainfall year), while other hydrologic data is reported from October 1 through September 30 (San Luis Obispo County, 2005). These conventions are maintained for the water budget, and water years are referenced herein based on the ending year.

The hydrologic base period selected to represent historical climatic conditions for the Basin encompasses the years 1987 through 2019 (33 years). Average precipitation at the Cal Poly NOAA gage over this base period was 21.76 inches, compared to the long-term average of 21.95 inches, and included wet, average, and dry periods (Figure 6-10). These periods are visually defined by the movement of the cumulative departure from mean precipitation curve, which declines over dry periods, is flat through average periods, and rises over wet periods.

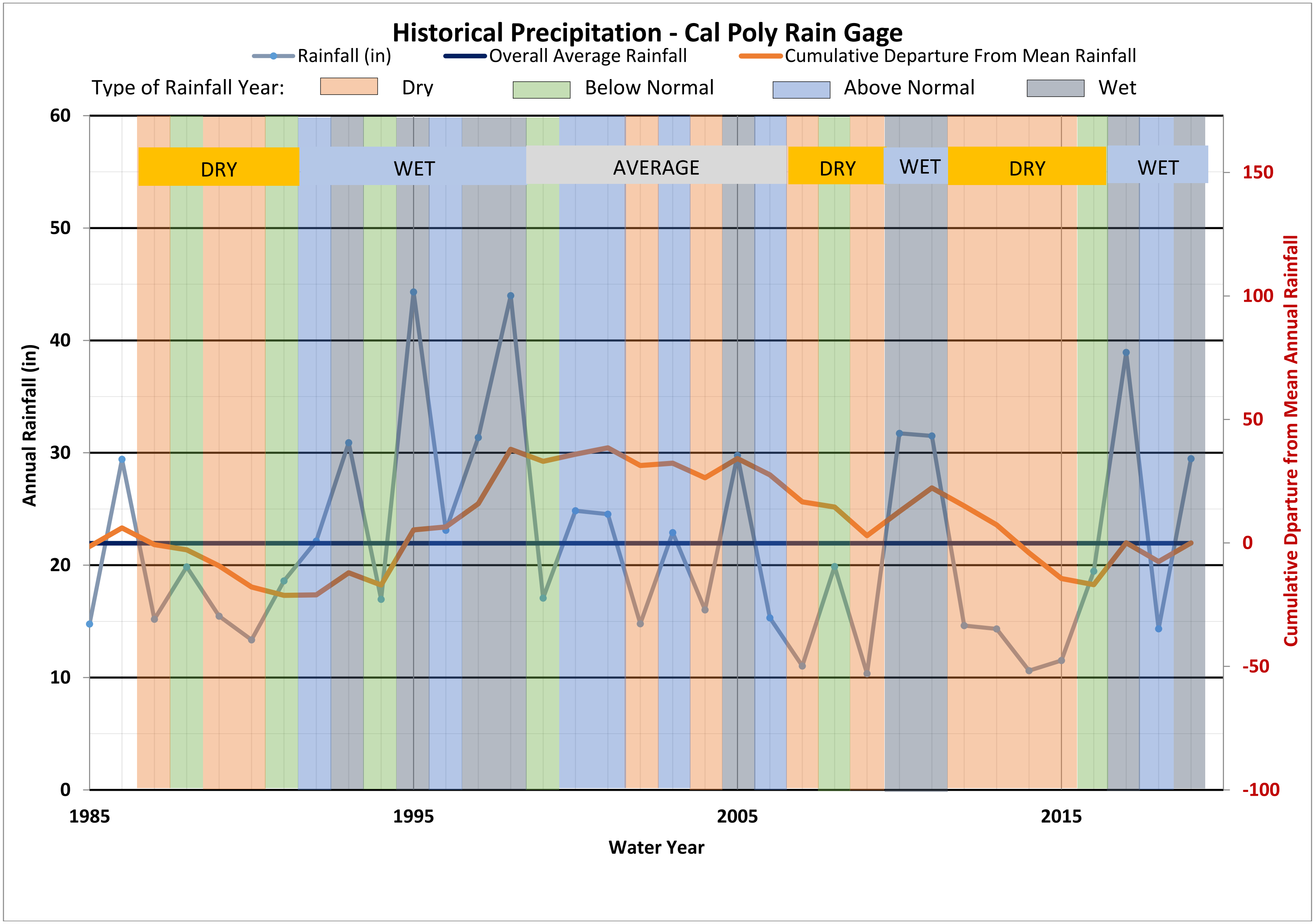


Figure 6-10: 1987-2019 Historical Base Period Climate.

Water year types for this water budget have been developed and classified based on annual precipitation as a percentage of the previous 30-year average precipitation. Each July 1 through June 30 rainfall year of the historical base period was given a ranking of 1 (wettest) through 30 (driest) based on a comparison to a 30-year (rolling) data set. The minimum precipitation threshold for wet type years was assigned based on the average for the 10th ranked year (26.3 inches). The maximum precipitation threshold for dry type years was assigned based on the average for the 21st ranked year (16.8 inches). Below normal (from 16.8 to less than 20.5 inches) represents the 16th through 20th ranked years, while above normal (from 20.5 to 26.3 inches) represents the 10th through 15th ranked years. Note that the division between below normal and above normal rainfall (20.5 inches) is less than the average over the base period (21.76 inches) because there are more below average rainfall years than above average years. The water year types were developed from Cal Poly NOAA rainfall records, with one exception. The exception is the 2006 rainfall year, which would be classified as dry based on 15.31 inches reported at Cal Poly NOAA, but which is considered above normal when reviewing other local rain gages, including the Gas Company rain gage (23.35 inches in 2006).

The base period includes recent cultural conditions, such as expanded recycled water use by the City and water conservation by Basin users in response to the recent drought period. Differences between water in transit in the vadose zone (deep percolation of precipitation and stream seepage) are minimal, based on comparing the two rainfall years leading up to the beginning and ending of the base period. The 1985 and 1986 rainfall years leading in the base period have 14.77 inches and 29.43 inches, respectively, compared to 14.34 and 29.48 inches of rainfall at the end of the base period in 2018 and 2019 (Figure 6-10).

There are other rainfall gages in the Basin (Table 3-5 and Figure 3-10; Chapter 3), and an isohyetal map of average annual rainfall is shown in Figure 4-3 (Chapter 4). The average annual precipitation across the Basin between 1981 and 2010 was approximately 19 inches (Figure 4-3; Chapter 4), compared to the Cal Poly NOAA rainfall gage, which averaged 23.03 inches over that same period.

Although the water budget uses the Cal Poly NOAA gage (formerly Cal Poly #1) to identify the historical base period and water year types due to the extensive period of record, the Gas Company rain gage is used in water budget calculations that involve precipitation volumes to account for the difference between rainfall at Cal Poly and the Basin. A correlation between the Gas Company and Cal Poly NOAA was performed to estimate rainfall prior to 2006 for the historical water budget (Figure 6-11). Based on linear regression using data recorded between 2006 and 2019, rainfall at the Gas Company gage is approximately 90 percent of rainfall at the Cal Poly NOAA gage. No precipitation data was recorded for the Gas Company rain gage prior to 2006, and the 90 percent correlation was used to estimate precipitation at the gage between 1987 and 2005 to complete the historical base period. Climate data from CIMIS Station #52 (located within same enclosure as the Cal Poly NOAA rain gage) has been used for evapotranspiration and applied agricultural water estimates.

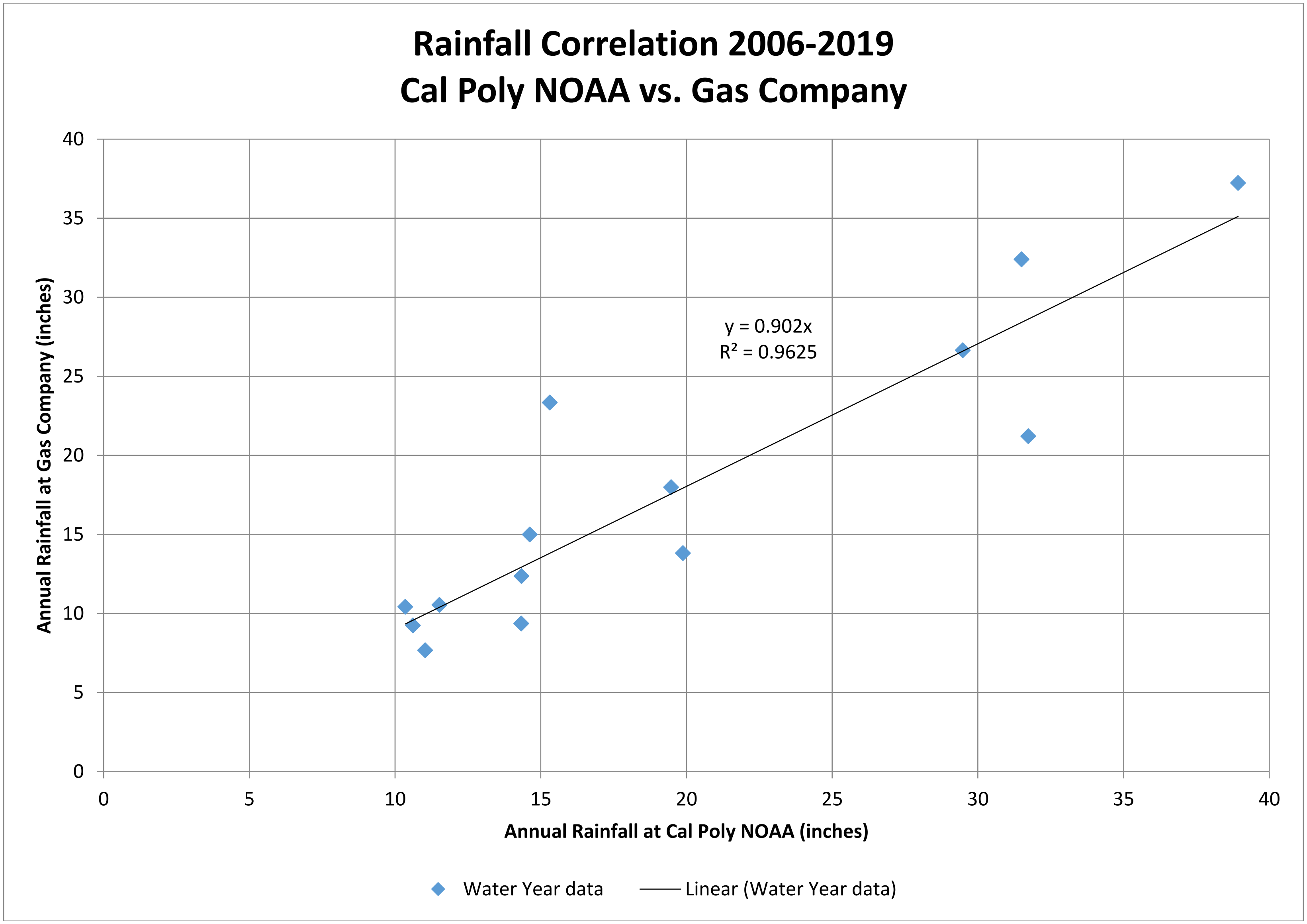


Figure 6-11: Rainfall Correlation Cal Poly vs. Gas Company.

Table 6-4 presents the annual rainfall for the historical water budget. Average annual rainfall within the Basin over the historical base period is estimated to be 19.6 inches. This average closely matches the estimated value for average rainfall across the Basin on the 30-year isohyetal map (Figure 4-3; Chapter 4).

Table 6-4: Historical Base Period Rainfall.

Year	Type	Cal Poly NOAA	Gas Company
		Rainfall (in.)	
1987	Dry	15.19	13.67
1988	Below Normal	19.85	17.87
1989	Dry	15.46	13.91
1990	Dry	13.36	12.02
1991	Below Normal	18.6	16.74
1992	Above Normal	22.14	19.93
1993	Wet	30.9	27.81
1994	Below Normal	16.96	15.26
1995	Wet	44.31	39.88
1996	Above Normal	23.11	20.8
1997	Wet	31.36	28.22
1998	Wet	43.98	39.58
1999	Below Normal	17.07	15.36
2000	Above Normal	24.84	22.36
2001	Above Normal	24.54	22.09
2002	Dry	14.79	13.31
2003	Above Normal	22.9	20.61
2004	Dry	16.02	14.42
2005	Wet	29.76	26.78
2006	Above Normal*	15.31	23.35
2007	Dry	11.03	7.68
2008	Below Normal	19.88	13.82
2009	Dry	10.35	10.43
2010	Wet	31.73	21.22
2011	Wet	31.5	32.4
2012	Dry	14.62	15
2013	Dry	14.33	9.37
2014	Dry	10.61	9.25
2015	Dry	11.52	10.55
2016	Below Normal	19.47	17.99
2017	Wet	38.93	37.23
2018	Dry	14.34	12.37
2019	Wet	29.48	26.65
Average		21.8	19.6

Gas Company Estimates **in blue** (approximately 90% of Cal Poly)

*2006 type year based on Gas Company gage reporting

6.2 WATER BUDGET DATA SOURCES

The following sources and types of data have been used for the water budget:

- Hydrogeologic and geologic studies and maps
- Groundwater monitoring reports
- County stream flow gages
- County and NOAA precipitation Stations
- PRISM 30-year normal dataset (1981-2010)
- CIMIS weather station data
- Aerial Imagery
- County water level monitoring program
- San Luis Obispo City, County and DWR land use data and planning documentation
- County Ag commissioner's office data sets
- County Water Master Plan
- Geotracker Groundwater Information System
- Stakeholder supplied information
- Environmental Impact Reports
- Water rights filings
- SRWQCB Drinking Water Division Water systems
- Wastewater discharge reports

6.3 HISTORICAL WATER BUDGET

In accordance with GSP regulations, the historical water budget shall quantify the following, either through direct measurement or estimates based on data (reference to location of data in Chapter 6 also listed):

(1) Total surface water entering and leaving a Basin by water source type (Table 6-3).
(2) Inflow to the groundwater system by water source type, including subsurface groundwater inflow and infiltration of precipitation, applied water, and surface water systems, such as lakes, streams, rivers, canals, springs, and conveyance systems (Table 6-3).
(3) Outflows from the groundwater system by water use sector, including evapotranspiration, groundwater extraction, groundwater discharge to surface water sources, and subsurface groundwater outflow (Table 6-3).
(4) The change in annual volume of groundwater in storage between seasonal high conditions (Table 6-3).
(5) If overdraft occurs, as defined in Bulletin 118, the water budget shall include a quantification of overdraft over a period of years during which water year and water supply conditions approximate average conditions (Section 6.3.8).
(6) The water year type associated with the annual supply, demand, and change in groundwater stored (Table 6-3).
(7) An estimate of sustainable yield for the Basin (Section 6.3.7).

6.3.1 Historical Time Period

The time period over which the historical water budget is estimated is the hydrologic base period from 1987-2019 (33 years). Groundwater storage calculations using the specific yield method were performed for 1986, 1990, 1995, 1998, 2005, 2011, 2014, and 2019. These years include the beginning and ending years in the base period, along with sufficient intervening years to characterize change in storage trends through the base period.

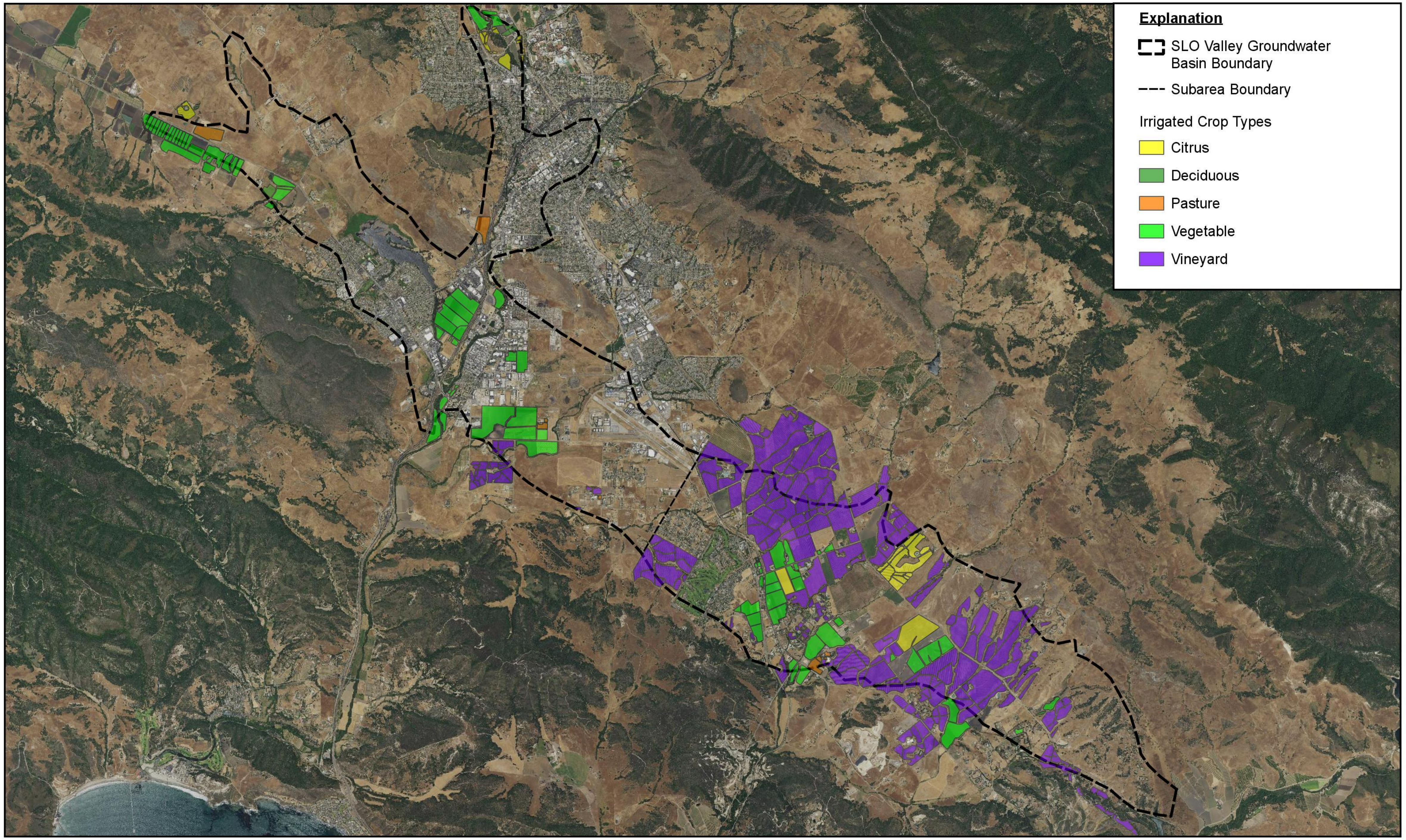
6.3.2 Historical Land Use

Land use is one of the primary data sets used in developing a water budget. Several types of land use/land cover in the basin have been used to estimate components of the water budget. For example, the acreages of various crops are multiplied by their respective water use factors to estimate agricultural groundwater extractions (Section 6.3.4.2), and acreages of various land covers are multiplied by empirical correlations to estimate their respective evapotranspiration and percolation of precipitation (Section 6.3.4.1). The land uses/land covers including the following:

- Irrigated Agriculture
  - Citrus
  - Deciduous
  - Pasture
  - Vegetable
  - Vineyard
- Native Vegetation
  - Brush, trees, native grasses
  - Wetlands/open water
- Urban/Suburban
  - Developed (City, subdivisions)
  - Open space (parks, empty lots)
  - Turf (golf courses, play fields)

Irrigated Agriculture

Irrigated crop acreage was estimated from aerial imagery of the Basin for the following years: 1987, 1994, 1999, 2003, 2005, 2007, 2009, 2010, and 2011. San Luis Obispo County land use data was used for crop acreage from 2013 to 2018. DWR land use surveys for 1985, 1995, and 2014 were also reviewed during the interpretation of aerial imagery. Figure 6-12 shows an example of the County irrigated crop data set for 2016.



Prepared For:

Author: TK
Date: 05/21/2020

SAN LUIS OBISPO VALLEY BASIN GSP

N

0 0.25 0.5 0.75 1 mi
0 0.5 1 km

References:

1. Coordinate System: State Plane California V FIPS 0405 Feet
2. Projection: Lambert Conformal Conic
3. Hirozontal Datum: NAD 83
4. Vertical Datum: NAVD 88
5. Basemap: 2016 NAIP Satellite Imagery

Notes:

1.
2.
3.

San Luis Obispo Valley Basin Irrigted Crops 2016

Figure 6-12

Irrigated acreage for years in the historical base period without aerial imagery, surveys, or County data were estimated from the nearest available year with data. Acreages for irrigated crops, estimated from aerial imagery and County datasets within the historical base period are shown in Table 6-5.

Table 6-5: Irrigated Agriculture Acreages.

Crop Type	1987	1994	1999	2003	2005	2007	2009	2010	2011	2013	2014	2015	2016	2017	2018
	San Luis Valley Subarea (acres)														
Citrus	26	26	30	51	49	49	49	49	49	45	44	44	44	46	46
Deciduous	12	12	12	12	12	12	12	12	12	67	21	17	17	17	17
Pasture	33	22	27	28	28	28	28	28	28	28	37	37	53	28	28
Vegetable	594	766	880	647	592	487	526	494	495	488	490	532	593	492	363
Vineyard	0	5	6	6	8	58	58	58	58	92	86	86	86	86	86
Subtotal	665	831	955	744	689	634	673	641	642	720	678	716	793	669	540
	Edna Valley Subarea (acres)														
Citrus	12	6	47	49	51	51	53	49	105	105	111	111	191	191	210
Deciduous	0	0	0	0	0	0	0	0	0	0	2	2	2	4	3
Pasture	138	19	19	19	19	19	19	19	19	16	19	19	15	14	13
Vegetable	533	703	685	686	646	699	663	679	647	671	670	691	394	505	453
Vineyard	1,180	1,344	1,900	2,252	2,297	2,377	2,377	2,372	2,380	2,423	2,419	2,419	2,454	2,415	2,323
Subtotal	1,863	2,072	2,651	3,006	3,013	3,146	3,112	3,119	3,151	3,215	3,221	3,242	3,056	3,129	3,002

Native Vegetation and Urban Areas

Native vegetation acreages were compiled using data sets from the National Land Cover Database (NLCD), which is derived primarily from satellite imagery. The years for which NLCD coverage is available are 2001, 2004, 2006, 2008, 2011, 2013, and 2016. Adjustments to the acreages in the NLCD data were performed to reconcile with the agricultural acreages and urban turf areas (golf course, play fields) compiled using the aerial imagery and crop survey data set. Where the NLCD data sets showed less agricultural acreage than the aerial imagery, the native vegetation (brush, trees, grassland) acreage was reduced so the total basin acreage remained constant. The estimated acreages for native vegetation and urban areas, along with irrigated agriculture interpolated from Table 6-5, are presented in Table 6-6 below.

Table 6-6: Land Cover Acreages.

Land cover	2001	2004	2006	2008	2011	2013	2016
	San Luis Valley Subarea (acres)						
Native - brush, trees, grassland	2,315	2,450	2,482	2,466	2,386	2,315	2,203
Native - wetlands/open water	566	566	573	571	569	569	575
Urban - Developed	2,150	2,142	2,219	2,219	2,325	2,312	2,353
Urban - Open Space	870	875	841	841	829	835	825
Urban - Turf	23	23	23	23	23	23	23
Irrigated Agriculture	849	716	636	653	642	720	793
Subarea Total	6,773	6,773	6,773	6,773	6,773	6,773	6,773
	Edna Valley Subarea (acres)						
Native - brush, trees, grassland	2,659	2,473	2,406	2,356	2,333	2,266	2,423
Native - wetlands/open water	13	17	13	13	15	13	13
Urban - Developed	230	230	232	232	232	235	237
Urban - Open Space	77	77	77	77	77	78	79
Urban - Turf	141	141	141	141	141	141	141
Irrigated Agriculture	2,829	3,010	3,079	3,129	3,150	3,215	3,056
Subarea Total	5,948	5,948	5,948	5,948	5,948	5,948	5,948

6.3.3 Historical Surface Water Budget

The surface water system is represented by water at the land surface within the boundaries of the Basin. Surface water systems for the water budget include streams and Laguna Lake.

6.3.3.1 Components of Surface Water Inflow

The surface water budget includes the following sources of inflow:

- Local Supplies
  - Precipitation
  - Groundwater extractions
  - Stream inflow at Basin boundary
  - Groundwater-Surface Water Interactions
  - Treated wastewater discharge into streams
- Local Imported Supplies
  - Nacimiento Project Water
  - Salinas Reservoir Water
  - Whale Rock Reservoir Water

Precipitation

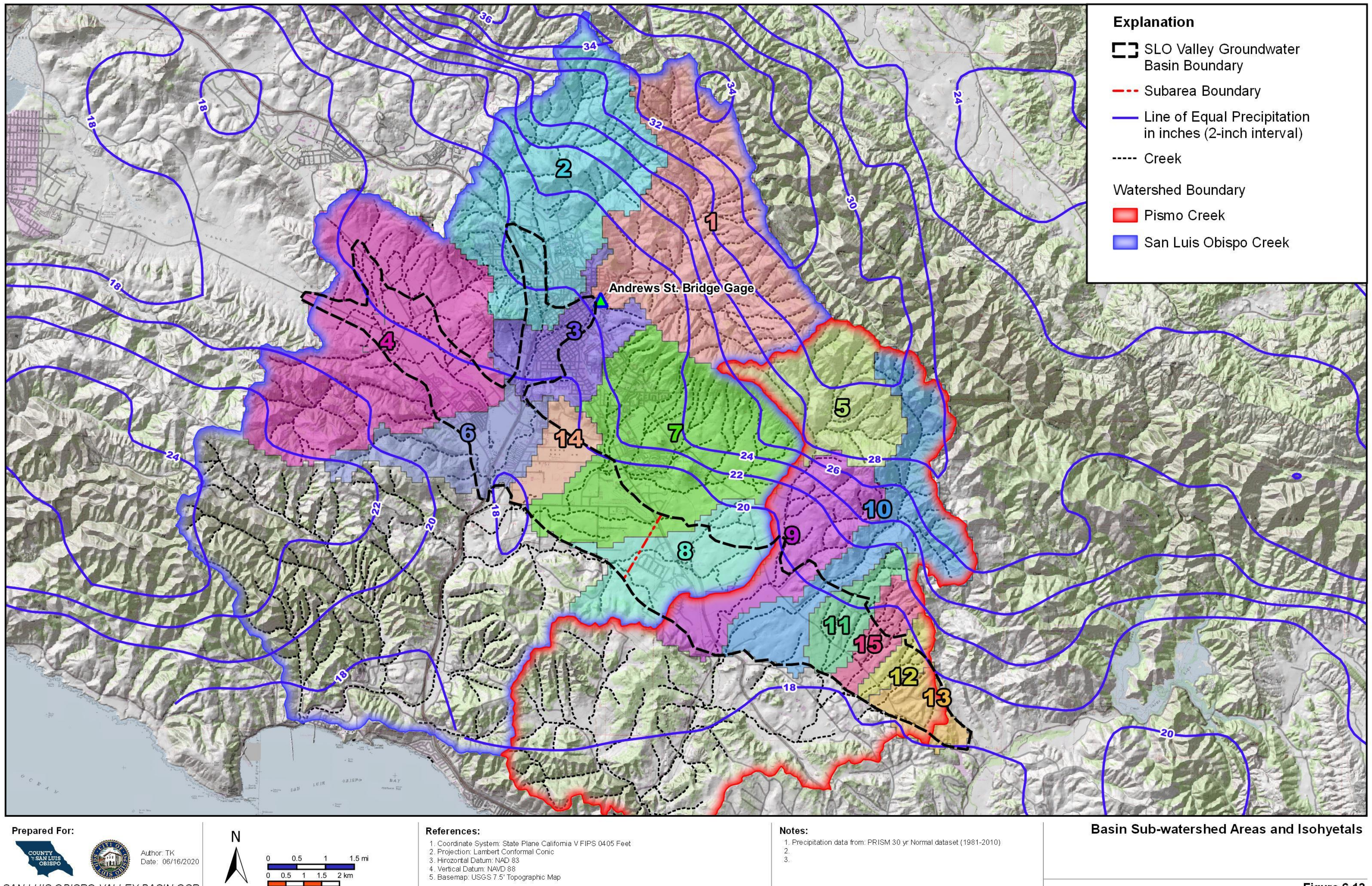
Precipitation occurs as rainfall. The annual volume of rainfall within the Basin has been estimated by multiplying the rainfall year totals in Table 6-4 by each Basin subarea. Rainfall volumes falling within the Basin boundary are shown as precipitation in the surface water inflow budget of Table 6-1, Table 6-2, and Table 6-3.

Groundwater Extractions

Groundwater extractions are included in the surface water budget as inflow because after extraction groundwater is distributed and applied at land surface. The surface water budget includes the land surface system and rivers & streams system (Figure 6-2). These extractions are the divided into Urban and Agricultural water use sectors and match the groundwater extraction outflow values from the groundwater budget. Details on data collection and groundwater pumping estimates are provided in the Historical Groundwater Budget section (Section 6.3.3).

Stream Inflow at Basin Boundary

Inflow along stream channels at the Basin boundary has been estimated based on paired watershed methodology. The total watershed area drained by the Basin was divided into 15 sub-watershed areas, one of which was the subarea drained by San Luis Obispo Creek upstream of the Andrews Street gage (sub-watershed 1, Figure 6-13). Flow from 2007 through 2018 at the Andrews Street gage was reconstructed using stage records and a stage-discharge curve. The resulting annual flows were then processed using a watershed area factor and an isohyetal factor to estimate annual flows for each of the other 14 subareas. The watershed area factor was the ratio of the watershed area for which flow was being estimated to the Andrews Street gage watershed area. The isohyetal factor addressed differences between the average annual rainfall across each of the sub-watersheds being compared (Figure 6-13), and consisted of the ratio of average annual precipitation over 15 inches between sub-watersheds. Correlation between rainfall and runoff for the paired watersheds are shown in Figure 6-14. A drought period adjustment was also made for 1989-1991 inflow estimates (Figure 6-14) consisting of 3,000 AFY less inflow for the San Luis Valley subarea and 1,000 AFY less inflow for the Edna Valley subarea. Once these factors were applied, the estimated stream flow entering the respective SLO subarea watershed and Edna Valley subarea watershed were totaled.



References:
1. Coordinate System: State Plane California V FIPS 0405 Feet
2. Projection: Lambert Conformal Conic
3. Hirozontal Datum: NAD 83
4. Vertical Datum: NAVD 88
5. Basemap: USGS 7.5' Topographic Map

Notes:
1. Precipitation data from: PRISM 30 yr Normal dataset (1981-2010)
2.
3.

Basin Sub-watershed Areas and Isohyetals

Figure 6-13

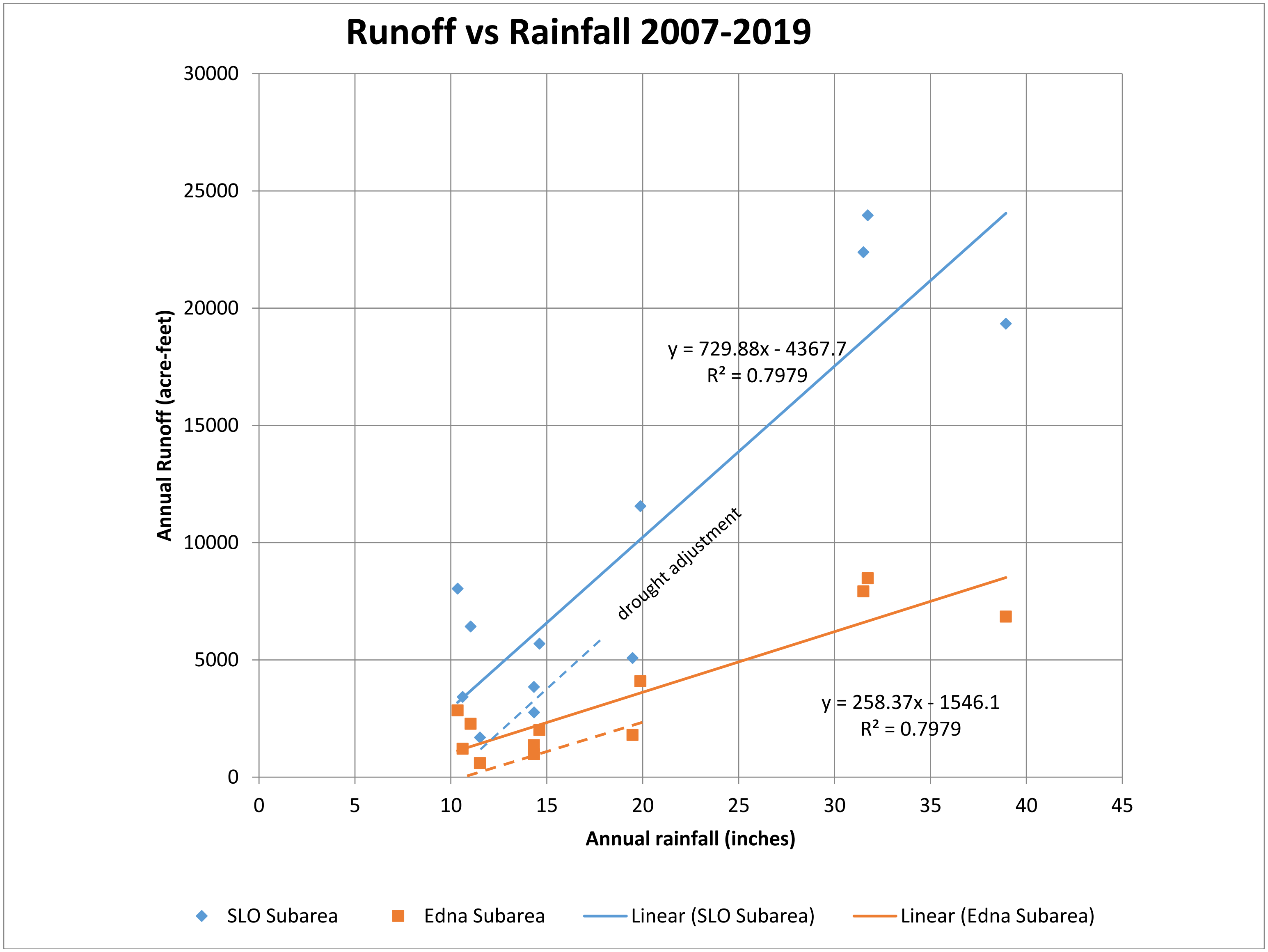


Figure 6-14: Runoff vs Rainfall Correlation for Subareas.

Stream inflow on the West Coral de Piedra sub-watershed 5 (Figure 6-13) was reduced to account for surface water diversions. There is a permitted reservoir where surface water diversion is utilized mainly for agricultural irrigation (SWRCB, 1990). The stream inflow adjustment consisted of correlating the total reported diversions from Statements of Diversion and Use between 2010 and 2018 with annual precipitation, and applying the correlation to other years in the base period (the r-squared value of the correlation 0.71) is. Reported annual surface water diversions ranged from 14 acre-feet to 900 acre-feet, with average annual diversion over the base period estimated at 350 acre-feet per year (AFY), including estimated reservoir evaporation which was added to the diversion. The resulting estimated stream inflow estimates for the historical base period are shown in the surface water budget of Table 6-1, Table 6-2, and Table 6-3.

Groundwater-Surface Water Interaction (Net)

Groundwater-surface water interactions take place primarily along stream channels. When groundwater is rising into streams (gaining reaches of a stream), the interaction is a surface water budget inflow and a groundwater budget outflow. Conversely, when stream flow is percolating to groundwater (losing reaches of a stream), the interaction is a surface water budget outflow and groundwater budget inflow. This water budget has combined the gaining and losing stream reaches into single (net) term, the result of which are net losing streams in the Basin which is an outflow component of the surface water budget and inflow component of the groundwater budget. Net groundwater-surface water interaction was estimated by adjusting the percent of stream inflow that recharges groundwater while optimizing the water balance. The optimization consisted of minimizing the sum of squares of the residual error between the calculated change in storage and measured change in storage (Section 6.3.4.1).

Treated wastewater discharge to streams

The City of San Luis Obispo discharges treated wastewater into San Luis Obispo Creek. Available records of wastewater treatment plant discharges have been compiled by water year. Daily discharge records provided by the City were compiled for water years 2001-2019. For water years 1987-2000, treated wastewater discharges were estimated as a nominal 65 percent of total City water deliveries, based on the average ratio of annual wastewater flows to water deliveries in the years 2001-2019. The treated wastewater discharges to San Luis Obispo creek are presented in the surface water budget of Table 6-1.

Local Imported Supplies

The City of San Luis Obispo imports water from three reservoirs. Surface water deliveries from Salinas and Whale Rock reservoirs occurred through the historical base period, while Nacimiento reservoir water deliveries to the City began in 2011. Surface water reservoirs have historically provided most of the water supply used by the City. Local imported water supplies are based on City records and Boyle (1991). Local imported supplies are presented in the surface water budget of Table 6-1.

Cal Poly imports surface water and also pumps groundwater for agricultural irrigation. Fields overlying and adjacent to the Basin are typically irrigated with groundwater, while imported surface water is generally used for irrigation outside of the Basin boundary. Therefore, only the local imported supplies used for potable water deliveries by the City have been accounted for in the GSP water budgets.

6.3.3.2 Components of Surface Water Outflow

The surface water budget includes the following sources of outflow:

- Evapotranspiration of Precipitation
- Evapotranspiration of Applied Water
- Infiltration of Precipitation
- Infiltration of Applied Water

- Surface Water Deliveries Offset
- Wetland/Lake ET
- Groundwater-Surface Water Interaction
- Stream outflow (runoff)

Evapotranspiration of Precipitation

The fate of precipitation that falls within the Basin boundaries can be divided into three components: evapotranspiration, infiltration, and runoff. Of these three, infiltration has the greatest influence on the groundwater budget and ultimately, Basin sustainable yield. Therefore, the approach to estimating the fate of precipitation uses a methodology focused primarily on infiltration, but from which the other two components may also be estimated. This methodology is based on work by Blaney (1933, 1963), and which has been used for other analytical water budgets in major studies of central coast Basins (DWR, 2002; Fugro, 2002).

Evapotranspiration is the evaporation of water from surfaces and the transpiration of water from plants. The first seasonal rains falling on the Basin are mostly evaporated directly from surfaces (vegetative canopy, soil, urban area hardscapes) and used to replenish soil moisture deficits that accumulate during the dry season. For the Arroyo Grande – Nipomo Mesa area of the Santa Maria groundwater Basin, DWR (2002) assumed that precipitation could begin to infiltrate to groundwater (deep percolate) only after 11 inches of annual precipitation had fallen in urban and agricultural irrigation areas, and when 17 inches of rainfall had fallen in areas of native vegetation. In the Paso Robles groundwater Basin, an estimated 12 inches of annual rainfall was needed for infiltration below agricultural lands, while 18 inches of rainfall was needed for infiltration beneath native ground cover and urban/suburban areas (Fugro, 2002).

These threshold values for minimum annual rainfall prior to infiltration are assumed to approximate the annual evapotranspiration of precipitation. Once these thresholds are exceeded, infiltration to groundwater and runoff would become dominant. It is recognized that a portion of the initial annual rainfall may result in runoff, depending on rain intensity, but this is assumed to be offset by the portion of the late season rainfall that is evapotranspired. Since infiltration is the critical component of precipitation with respect to Basin safe yield, offsetting of early wet season runoff with late wet season evapotranspiration in the water budget is considered a reasonable approach.

The specific thresholds for annual rainfall that is estimated to evapotranspire prior to infiltration and runoff have been developed from Blaney's field studies. Evapotranspiration of precipitation has been estimated by multiplying land use/land cover acreages by the infiltration threshold values. Results of these estimates are shown in the surface water budget of Table 6-1, Table 6-2, and Table 6-3. Additional details of the methodology are provided in section 6.3.4.1 (Components of Groundwater Inflow).

Evapotranspiration of Applied Water

The evapotranspiration of applied irrigation water has been divided into urban and agricultural sectors. Urban applied water includes residential outdoor irrigation, urban recycled water use, and golf course/play field irrigation. Much of the urban applied water is accounted for by City of San Luis Obispo or other water purveyor records. Estimation of applied water for urban and agricultural irrigation not supplied by purveyors involves a soil-moisture balance approach discussed in section 6.3.4.1 (Components of Groundwater Outflow).

Most water applied for irrigation is taken up by plants and transpired. Some water, however, is lost to evaporation or infiltrates to groundwater as return flow. The evapotranspiration of applied irrigation water has been calculated by subtracting the estimated return flow from the applied water estimates. Both applied water and return flow estimates are presented under the historical groundwater budget section. Results of the calculations of evapotranspiration of applied water are shown in the surface water budget of Table 6-1, Table 6-2, and Table 6-3.

Riparian Corridor Evapotranspiration

Riparian plant communities present along the creeks can access surface flows and creek underflow. Riparian areas are included within the native brush, trees, and grasses acreage for the subareas (Table 6-6). Besides evapotranspiration of precipitation, however, an additional 0.8 acre-feet per acre of consumptive water use is estimated for riparian corridors (Fugro, 2002; Robinson, 1958) that lie within potential Groundwater Dependent Ecosystems, which cover approximately 200 acres in the San Luis Valley subarea and 50 acres in the Edna Valley Subarea (Figure 5-15; Chapter 5). Riparian corridor water use during severe drought is reduced a nominal 50 percent to reflect lack of creek underflow. Riparian evapotranspiration is included in Table 6-1, Table 6-2, and Table 6-3.

Infiltration of Precipitation and Applied Water

Infiltration of precipitation and applied water are both outflow components from the surface water budget and inflow components to the groundwater budget. Discussion of these components is provided in Section 6.3.4.1 (Components of Groundwater Inflow).

Surface Water Deliveries Offset

When imported surface water is brought into the Basin from local supplies (Salinas Reservoir, Whale Rock Reservoir, and Nacimiento Reservoir), it is counted as surface water inflow. This imported water is then provided to customers through surface water deliveries from the City water treatment plant. After residential and business use, most of the delivered water is conveyed by sewer to the wastewater treatment plant for recycling and discharge into San Luis Obispo Creek. Since wastewater discharges to the creek are also counted as surface water inflow, an offset factor is needed to avoid double counting that portion of imported surface water. The surface water deliveries offset is an outflow equal to the wastewater discharges inflow and is shown in the surface water budget of Table 6-1.

Laguna Lake

Laguna Lake is an approximate 100-acre open water body within the San Luis Valley subarea (Figure 3-10; Chapter 3). There are an additional 100 acres of adjacent wetlands connected to the lake. Evaporation from the water surface and transpiration by phreatophytes in the wetlands are included in the water budget as surface water outflow. Local pan evaporation is estimated at 70 inches per year (for all years), with a reservoir coefficient of 0.7, based on a review of information from nearby reservoirs (San Luis Obispo County, 2005). The resulting estimated annual evaporation rate for this water budget component is 4.1 feet (not including offset from direct precipitation). Evapotranspiration by phreatophytes were estimated to use lake water at a rate equal to irrigated pasture applied water demand. Results for Wetland/Lake ET outflow from the surface water budget are shown in Table 6-1. As with riparian water use, during severe drought the lake and wetland evapotranspiration is reduced by 50 percent.

Groundwater-Surface Water Interaction (Net)

Groundwater-surface water interaction involves both surface water and groundwater budgets. The net interaction is an outflow component for the surface water budget and an inflow component for the groundwater budget (losing streams. Details of the methodology used to develop the groundwater-surface water interaction are presented in the Sections 6.3.4.1 and 6.3.6.

Stream Outflow from Basin

Stream outflow from each subarea was estimated using the water balance method and compared to available flow records. No significant changes to surface water in storage are assumed in the water budget from year to year. Storm water runoff exits the Basin annually, and Laguna Lake storage fluctuations are considered minor compared to the total surface water budget. Surface water supply reservoirs are outside of the Basin boundary.

Using the water budget equation, stream outflow is estimated as the difference between total surface water inflow and all other components of surface water outflow. Results of stream outflow calculations are presented in the main water budget Tables.

There are limited annual stream flow records available for comparison to the estimates in the historical surface water budget. For the San Luis Valley subarea, the only applicable published records for stream outflow from the San Luis Valley subarea are two years of data recorded on Lower San Luis Obispo Creek at San Luis Bay Drive. In the 1971 water year, 20.46 inches of rainfall was recorded at Cal Poly and approximately 14,000 acre-feet of stream flow was reported at the San Luis Bay Drive gage (records missing in October). In the 1972 water year, 12.42 inches of rainfall was recorded at Cal Poly with 4,260 acre-feet of stream flow at the San Luis Bay Drive gage (San Luis Obispo County, 1974). These two years are outside of the historical water budget base period, and a comparison of flow for water years with similar precipitation suggests that the estimated Basin outflows are reasonable.

Measured annual flows on Pismo Creek downstream of the Basin boundary are also available for only two water years, 1991 and 1992 (Balance Hydrologics, 2008). These are years within the historical base period, although the flows were measured at Highway 101, where Pismo Creek has a watershed of 38 square miles, compared to 25 square miles upstream of the Basin boundary. Estimated outflow in the water budget from the Edna Valley subarea for 1991 and 1992 are lower than the flows measured at Highway 101, as would be expected. Table 6-7 shows the stream outflow comparisons.

Table 6-7: Stream Outflow Comparison.

Location	Water Year	Precipitation at Cal Poly (in.)	Flow (acre-feet)
San Luis Obispo Creek at San Luis Bay Drive gage	1971	20.46	13,705*
San Luis Valley subarea stream outflow estimate	2003	22.9	15,390
San Luis Obispo Creek at San Luis Bay Drive gage	1972	12.42	4,260
San Luis Valley subarea stream outflow estimate	1990	13.36	3,360
Pismo Creek at Highway 101 gage	1991	18.6	2,033
Edna Valley subarea stream outflow estimate			1,840
Pismo Creek at Highway 101 gage	1992	22.14	4,640
Edna Valley subarea stream outflow estimate			3,590

*October 1970 missing – estimate 300 acre-feet = approx. 14,000 acre-feet for year

6.3.4 Historical Groundwater Budget

The groundwater budget includes the following sources of inflow:

- Infiltration of Precipitation
- Groundwater-Surface Water Interaction
- Subsurface Inflow
- Infiltration of Applied Water

The groundwater budget includes the following sources of outflow:

- Groundwater Extractions
- Subsurface Outflow
- Groundwater-Surface Water Interaction

6.3.4.1 Components of Groundwater Inflow

Infiltration of Precipitation

Infiltration of precipitation refers to the amount of rainfall that directly recharges groundwater after moving through the soil and unsaturated zone (Figure 6-2). Direct measurement of infiltration has not been performed in the Basin, and estimates have been prepared based on prior work by Blaney (1933) in Ventura County Basins and Blaney et al. (1963) in the Lompoc Area. These studies involved soil moisture measurements at rainfall penetration test plots with various types of land cover, and the resulting deep percolation versus rainfall correlations have been considered applicable to central coast Basins (DWR, 2002; Fugro, 2002). The work by Blaney is several decades old, however, modeling efforts have shown the generalizations are relatively accurate for semi-arid climates (Rosenberg, 2001). The main advantage of Blaney's approach is that it is based on direct measurements of infiltration of precipitation.

Criteria based on Blaney et al. (1963) were used for analytical water budgets in the Santa Maria Valley and Tri-Cities Mesa areas , where it was assumed that precipitation could infiltrate only in urban and agricultural areas when 11 inches of precipitation had fallen annually, and on areas of native vegetation when 17 inches of precipitation had fallen annually. Any amount of rainfall above 30 inches annually was not considered to contribute to deep percolation of precipitation, regardless of the land use classification (DWR, 2002). Correlations between infiltration and annual rainfall based on Blaney (1933) were also used for the 2002 Paso Robles groundwater Basin analytical water budget (Fugro, 2002).

Estimates for infiltration of precipitation for the SLO Basin have been developed by applying Blaney correlations that restrict deep percolation to precipitation in agricultural areas that occurs after 11-12 inches of rainfall, and in native vegetation areas after approximately 18 inches of rainfall. Native vegetation was the most restrictive land cover for infiltration when tested by Blaney due to high initial soil moisture deficiencies.

Urban areas were not part of the original studies by Blaney. The low permeability of hardscape (buildings and paving) limits infiltration and increases surface evaporation, compared to other types of land cover, but hardscape also increases runoff, which can lead to greater infiltration in adjacent areas receiving the runoff. Therefore, the infiltration threshold was set higher than irrigated agricultural land, but not as high as native grasslands. The Blaney correlation that produces infiltration between irrigated agriculture and native grassland is the curve for non-irrigated grain, with an infiltration threshold of approximately 14 inches of rainfall. Figure 6-15 plots the data collected by Blaney (1933).

As with prior work by the DWR in northern Santa Barbara and southern San Luis Obispo Counties, rainfall above 30 inches was not considered to contribute to deep percolation in the Basin (DWR, 2002). Infiltration of precipitation results are shown in the water budget tables and graphs.

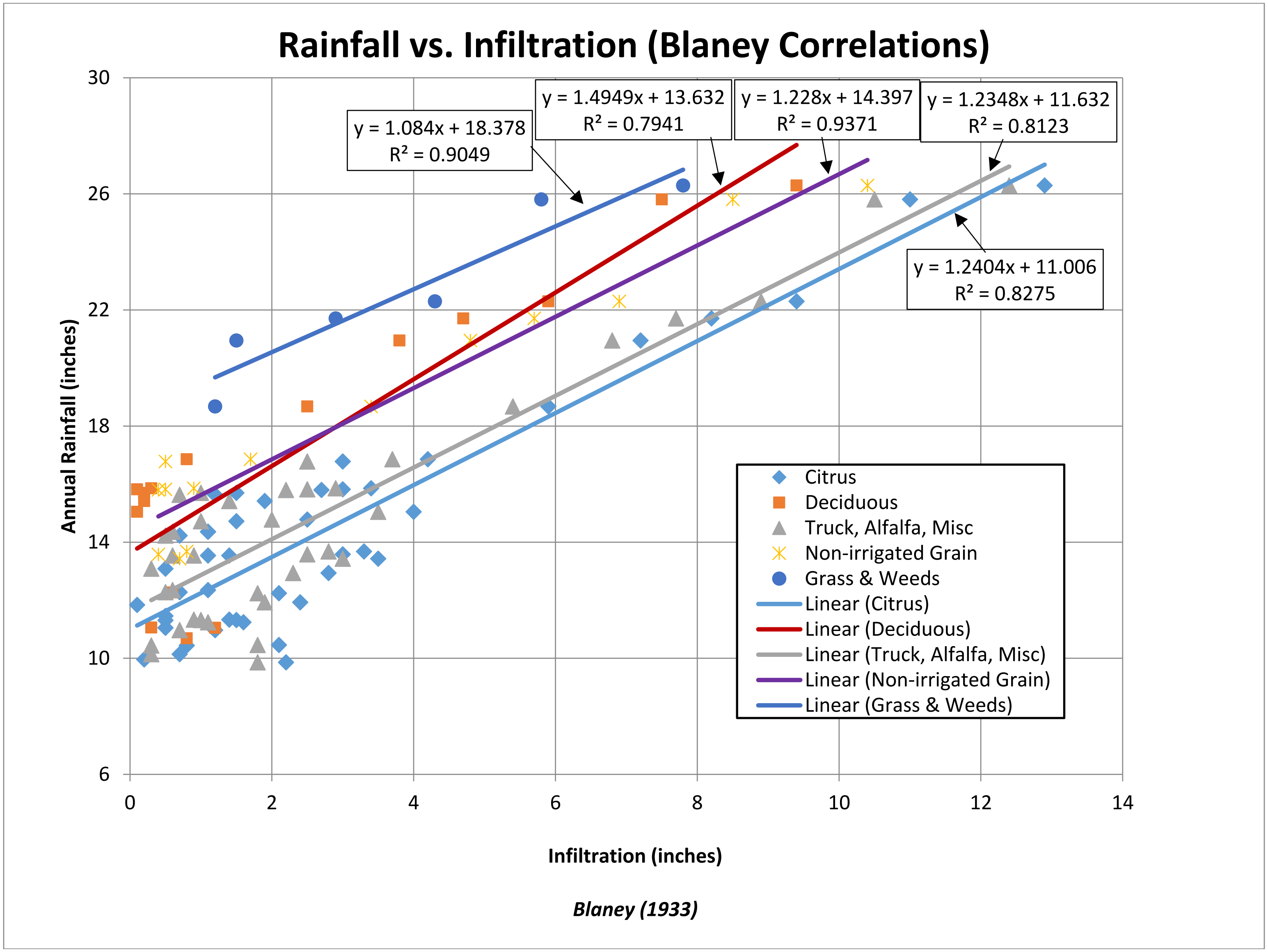


Figure 6-15: Rainfall vs Infiltration.

The land use classifications for which infiltration thresholds have been developed for this GSP include citrus, deciduous, pasture, vegetable, vineyard, native brush/grassland (includes riparian corridors), wetland, urban developed/open space, and Urban turf. The minimum rainfall needed before infiltration of precipitation can occur for various land uses and covers are summarized in Table 6-8.

Table 6-8: Minimum Rainfall for Infiltration.

Land Use/Cover	Infiltration Threshold (in.)
Citrus	11.0
Deciduous	13.6
Pasture	11.6
Vegetable	11.6
Vineyard	13.6
Native brush/grassland	18.4
Wetland*	11.6
Urban developed/open space	14.4
Urban turf	11.6

* ET of precip. prior to runoff (no infiltration)

Wetland soils are assumed to be close to field capacity due to shallow groundwater and the infiltration threshold is only used for estimating ET in the surface water budget, with the remaining precipitation as runoff (mainly into Laguna Lake).

Groundwater-Surface Water Interaction (Net)

As previously mentioned, groundwater-surface water Interaction involves both components of the surface water and groundwater budgets. The net interaction is an outflow component of the surface water budget and inflow component of the groundwater budget (losing streams).

The groundwater-surface water interaction component is estimated using a mass balance approach for the Edna Valley subarea by adjusting the percent of stream inflow that percolates to groundwater (as Basin recharge) while minimizing the sum of squares of the residual error between the calculated change in storage and the measured change in storage (specific yield method) for multiple years. A similar optimization was performed for the San Luis Valley subarea except a variable percentage was used depending on the type of year (a greater percentage of stream flow percolation during lower rainfall years). A spill mechanism was developed in the budget to allow groundwater outflow to streams when storage reached full capacity, which was set to a nominal 37,000 acre-feet based on historical storage estimates using the specific yield method. The groundwater-surface water interaction estimates are in the water budget tables. Additional details of the calibration methodology used to minimize the residual error are presented in Change in Storage (Section 6.3.6).

Subsurface inflow

Subsurface inflow from bedrock surrounding the groundwater Basin flows into both subareas. Subsurface inflows were estimated using Darcy's Law, which is an empirical formula describing the flow of fluid though a porous material, and expressed as:

$$Q = -K \frac{dh}{dl} A$$

Where:
Q = groundwater discharge rate through a cross-sectional area of the porous material
K = hydraulic conductivity of the material
$\frac{dh}{dl}$ = hydraulic gradient at the cross-section
A = cross-sectional area

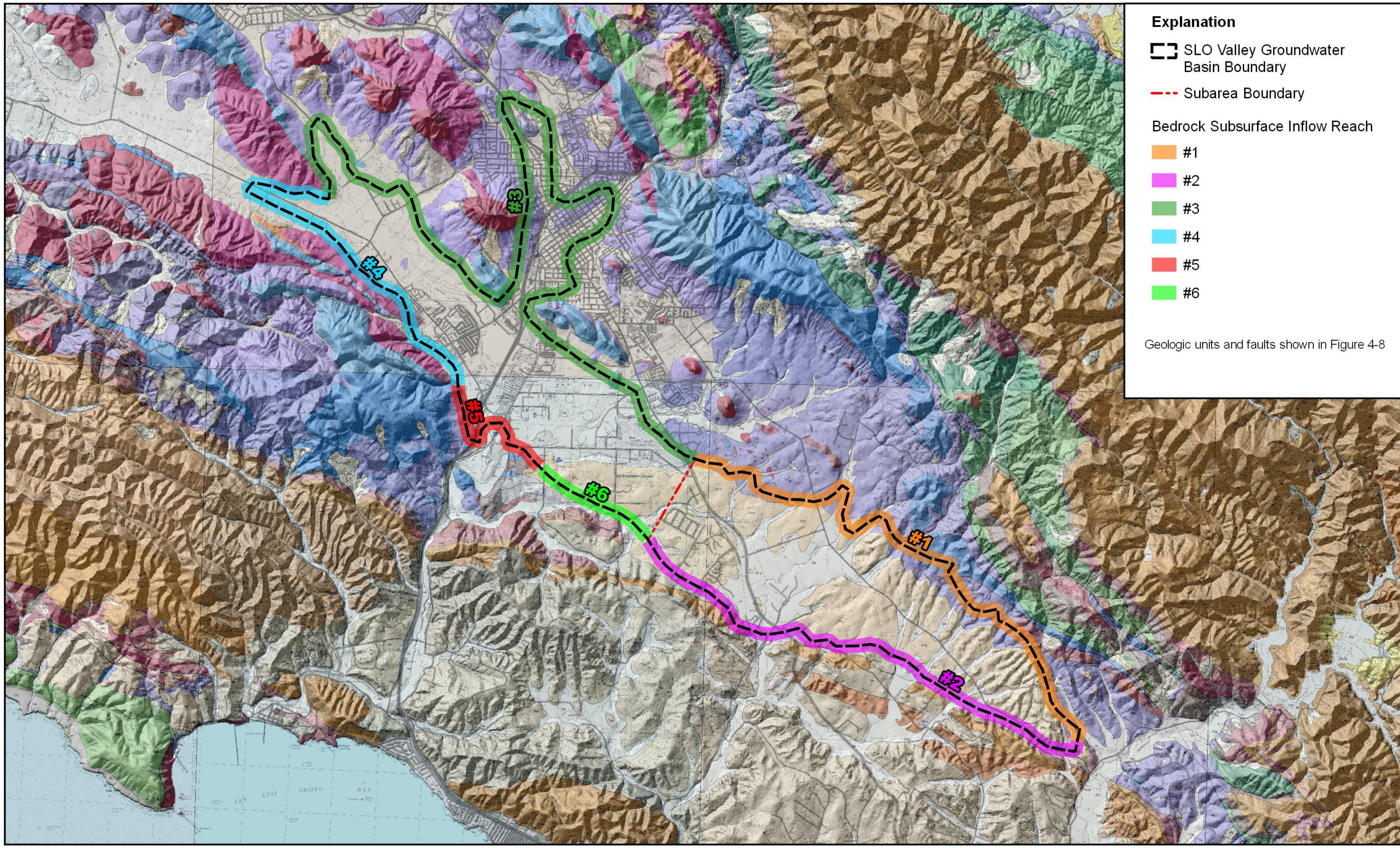
The negative sign denotes that flow is in the direction of decreasing pressure. Since groundwater pressures are greater within the bedrock hills surrounding the Basin than beneath the alluvial valleys, there is subsurface inflow to the Basin from bedrock. Similarly, groundwater elevations in the Edna Valley subarea are greater than in the San Luis Valley subarea and the direction of subsurface flow is from the Edna Valley to the San Luis Valley. The application of Darcy's Law to estimate subsurface inflow from bedrock involves simplification and assumptions of uniformity in the subsurface. The Basin boundary was divided into six reaches, each representing different boundary conditions. Cross-sectional areas for boundary flows were based on the length of each reach times the average thickness of adjacent saturated Basin sediments determined from cross-sections presented in Chapter 4. Hydraulic gradients for each reach were developed by averaging topographic slopes between a line along the Basin boundary and a line drawn at a 5,000-foot setback from the Basin boundary, and assuming the hydraulic gradient paralleled these slopes. Hydraulic conductivity was estimated for each reach based on the bedrock type, a review of pumping test data in the SLO Basin Characterization Report (GSI, 2018), and structural features. Table 6-9 summarizes the results of subsurface inflow estimates. Bedrock subsurface inflow reaches are shown on Figure 6-16.

Table 6-9: Subsurface Inflow Estimates.

Reach	Bedrock Formation	Boundary description	Length	Thickness	Hydraulic gradient	Hydraulic conductivity	Inflow
			ft	ft	ft/ft	ft/day	AFY
1	KJf melange w/serp.	Depositional	43,900	100	0.05	0.05	90
2	Monterey/Lower Pismo	Edna fault	38,100	200	0.01	0.03	30
3	KJf melange w/serp.	Depositional	88,300	20	0.09	0.05	130
4	JKf metavolcanics	Los Osos fault	28,600	40	0.09	0.2	220
5	KJf melange w/serp.	Los Osos fault	12,200	60	0.05	0.05	20
6	Obispo/Rincon w/ serp.	Depositional	9,500	60	0.06	0.05	10
			San Luis Valley subarea				320
			Edna Valley subarea				110
			Basin total				430

Note: KJf - Fransiscan Assemblage
Serp. = serpentinite
AFY = acre-feet per year

Basin boundary types for evaluating subsurface inflow are depositional or fault-bounded. Depositional boundaries occur where Basin sediments gradually thin toward the Basin boundary, while fault boundaries are where Basin sediments are abruptly offset by faulting. Fault boundaries are generally on the south side



Prepared For:

Author: TK
Date: 06/18/2020

SAN LUIS OBISPO VALLEY BASIN GSP

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References:

1. Coordinate System: State Plane California V FIPS 0405 Feet
2. Projection: Lambert Conformal Conic
3. Hirozontal Datum: NAD 83
4. Vertical Datum: NAVD 88
5. Basemap: Dibble (DF-129, DF-130, DF-210, DF-211, DF-212, DF-213, DF-214)

Notes:

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Bedrock Subsurface Inflow Reaches

Figure 6-16

of the Basin, while depositional boundaries are on the north side (see geologic-cross sections in Chapter 4). Thicknesses at the Basin boundary are estimated from Basin cross-sections (Chapter 4).

The hydraulic conductivity of bedrock across the Basin boundary was estimated at a nominal 0.05 feet per day, with two exceptions (Table 6-9). The Franciscan Assemblage metavolcanics are more permeable where fractured along the Los Osos fault zone (southwest Basin boundary; Figure 4-8), and are assigned a greater hydraulic conductivity. The Edna fault (Figure 4-8) offsets sedimentary beds along the Basin boundary and is interpreted to create a barrier to groundwater flow, corresponding to lower permeability.

Subsurface inflow to the San Luis Valley subarea also takes place as Basin cross-flow from the Edna Valley subarea. A subsurface profile of the bedrock high was developed as part of this GSP using geophysical methods (CHG, 2019). Darcy's Law was used to estimate subsurface flow based on a cross-sectional area of 140,000 square feet (approximately 3,500 feet in length and 40 feet saturated depth), a typical hydraulic gradient perpendicular to the boundary of 0.004 feet per foot (average of high and low values from 1986 and 2019 water level contour maps) and an estimated hydraulic conductivity for the sediments of 7 ft/day from local pumping tests listed in the SLO Basin Characterization Report (GSI,2018). The resulting estimated average subsurface cross-flow from the Edna Valley subarea to the San Luis Valley subarea is 30 AFY.

Infiltration of Applied Water (Return Flows)

Estimates for infiltration of applied water include urban return flow and agricultural return flow. Urban return flow comes from water delivered for domestic or commercial/industrial uses that infiltrates to groundwater, mainly through landscape/turf irrigation and septic system discharges (includes suburban/rural residential return flow and recycled water return flow). Urban return flow does not include City wastewater that is discharged to San Luis Obispo Creek, which is accounted for in the surface water budget. Agricultural return flows come from applied irrigation water to crops.

The first step in estimating urban return flows was to separate all delivered water (groundwater pumped from the Basin and imported surface water supplies) into indoor and outdoor use. An estimated 5 percent of indoor use is assumed to be consumptive use (95 percent return flow; EPA, 2008), while 85 percent of outdoor use is consumed (15 percent return flow) based on the typical range of estimates for other local Basins (DWR, 2002; Fugro, 2002). Almost all Indoor water use drains to septic systems or sewer systems. Outdoor water use is generally for irrigation, most of which evapotranspires into the atmosphere.

The distribution of indoor to outdoor water use will vary based on the user. City customers are estimated to average 70 percent indoor use and 30 percent outdoor use, based on approximately 65 percent of delivered water reaching the wastewater treatment plant (with 5 percent indoor consumptive use). Large parcel residential water users outside of City limits tend to use a greater percentage of water for outdoor use than City residents. Businesses served by small water companies can have a wide range of indoor and outdoor distribution, and were assigned values based on the results of a local study on business water use (City of San Luis Obispo, 2000).

The indoor and outdoor water use and associated return flows from water use by City, suburban/rural residential, and small water systems were compiled, together with estimated return flow from recycled water use. Infiltration of Applied Water estimates for urban and agricultural sectors are presented in the historical water budget Table 6-1, Table 6-2, and Table 6-3.

6.3.4.2 Components of Groundwater Outflow

Urban Groundwater Extractions

Groundwater extraction from wells is the primary component of outflow in the groundwater budget. Estimates for historical pumping were derived from various sources, including purveyor records, land use data and water duty factors, and daily soil-moisture budgets. Available purveyor records (meter records) were obtained from the following Basin users:

- City of San Luis Obispo
- Golden State Water Company
- Edna Valley East Mutual Water Company
- Varian Ranch Mutual Water Company

Production records ranged from weekly to quarterly, and were compiled to reflect the water year per GSP requirements. The City used groundwater from wells between 1989 and 2014, with the highest use in water years 1990, 1991, and 1992, averaging 1,830 AFY. Overall City groundwater use averaged 405 AFY between 1989 and 2014. Golden State Water Company averaged 335 AFY over the historical base period (1987-2019), although average water use over the last 5 water years is approximately 210 AFY. Edna Valley East MWC and Varian Ranch MWC have averaged approximately 100 AFY combined since reaching full development in the late 1990s, with 80 AFY combined over the last 5 years.

There are also 42 small water systems, mostly in the San Luis Valley subarea, which use groundwater from wells. Each water system was assigned a use category, and a corresponding water use factor. For example, groundwater use for commercial service connections were assigned water use based on building square footage (from aerial image review), with a 0.06 acre-foot per year per square foot use factor. Water use factors for local use categories were obtained from the results of a study conducted by the City of San Luis Obispo utilities conservation office (SLO City, 2000). The water use estimate was developed for current conditions, as almost all water companies were active throughout the historical base period. The total amount of water used by small water systems in the Basin is estimated at 270 AFY, with the majority of use (260 AFY) in the San Luis Valley subarea. Less than 10 of the 42 small water systems using groundwater are connected to the City sewer.

Urban groundwater extractions have also been used for golf course irrigation (turf). Laguna Lake golf course was served by groundwater wells through 2007, with recycled water use from the City beginning in 2008. San Luis Country Club uses a combination of recycled water use from County Service Area 18 and groundwater. The groundwater extractions and recycled water use components of urban turf irrigation are accounted for separately in the water budget. Estimates for turf irrigation water demand used the same daily soil moisture balance program as crop irrigation (see Agricultural Irrigation).

Rural Residential Groundwater Extractions

Rural residential groundwater use was estimated based on the number of residences identified on aerial images outside of water company service areas. Each rural residence was assigned a water use of 0.8 AFY, consistent with the San Luis Obispo County Master Water Plan (Carollo, 2012). As a comparison, the City study reported residential use for large parcels (>0.26 acres) at 0.6 AFY (City of San Luis Obispo, 2000), which is similar to the average estimated use per service connection in the Golden State Water Company service area over the historical base period. Water use per connection at Varian Ranch MWC and Edna Valley East MWC has ranged from 0.6 to 1.5 AFY, averaging approximately 1 acre-foot per year over the historical base period defined in Section 6.1.1.

Aerial images for 1986, 1994, 2009, and 2018 were reviewed for rural residential development. The estimated number of residences outside of water company service areas was compiled, and resulting computed rural residential water use for these years is presented in Table 6-10.

Table 6-10: Rural Residential Water Use.

Year	SLO subarea	Edna Subarea	Basin Total
	Estimated Number of Residences[1]		
1986	108	54	162
1994	119	61	180
2009	162	145	307
2018	173	158	331
	Estimated Water Use (AFY)[2]		
1986	86	43	130
1994	95	49	144
2009	130	116	246
2018	138	126	265

[1]outside of water company service areas
[2]based on 0.8 AFY per residence

Agricultural Groundwater Extractions

Groundwater use for agricultural irrigation has been estimated using the DWR Consumptive Use Program Plus (CUP+; DWR, 2015) which is a crop water use estimator that uses a daily soil moisture balance. CUP+ was developed as part of the 2013 California Water Plan Update to help growers and agencies estimate the net irrigation water needed to produce a crop.

Daily climate data from CIMIS Station #52 (San Luis Obispo) from 1986 to 2019 were used by the CUP+ program, along with estimates for various crop and soil parameters. The climate data is used to determine local reference evapotranspiration (ETo) on a daily basis. Crop coefficients are then estimated for up to four growth stages (initial, rapid, mid-season, late-season) which determine the crop evapotranspiration (ETc) values. Lastly, the CUP+ program uses variables related to the soil and crop type to determine the estimated applied water demand (ETaw), which is equivalent to the net irrigation requirement. Figure 6-17 shows the annual ETaw for various crops during the historical base period, along with the reference evapotranspiration (ETo) and precipitation at CIMIS Station #52.

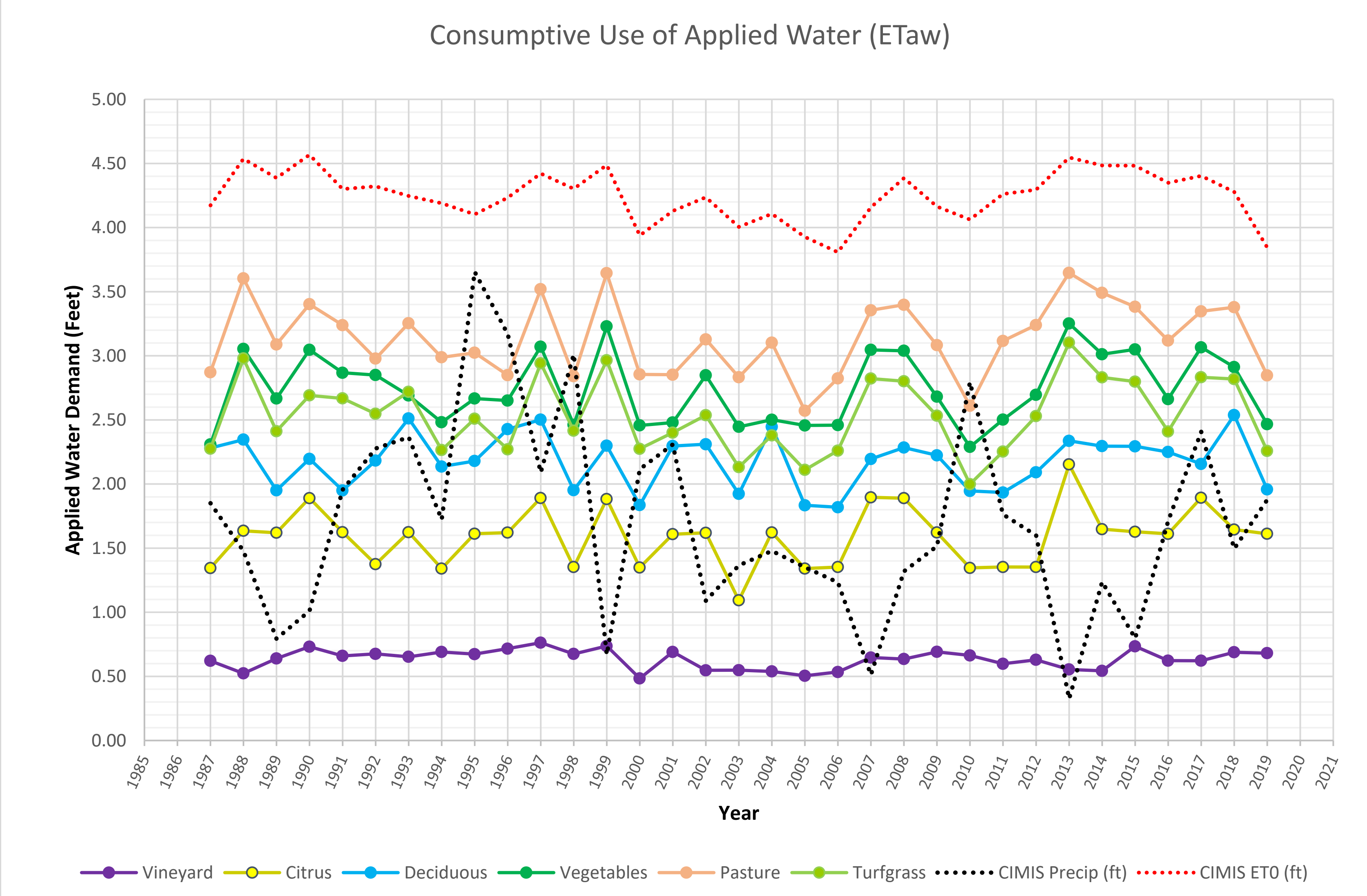


Figure 6-17: Consumptive Use of Applied Water.

Crop types were grouped according to the classification used by County Agricultural Commissioner's Office for crops overlying the Basin. These crop types included citrus, deciduous (non-vineyard), pasture, vegetable, and vineyard. A turf grass classification was added for estimating Urban sector water demand served by groundwater. The CUP+ program provides monthly water demand for each crop type during the hydrologic base period (1987-2019). Low, medium, and high consumptive use of applied irrigation water estimates are presented in Table 6-11. Low and high consumptive use are the respective annual minimum and maximum estimates over the base period, while medium consumptive use is the average. The CUP+ applied water requirement for vegetables was reduced by 40 percent to account for fallow acreage, which is not in production at any given time, based on historical aerial image review.

Table 6-11: Consumptive Use of Applied Water.

Crop Type	Acre-feet per acre per year		
	Low	Med	High
Citrus	1.1	1.6	2.2
Deciduous	1.8	2.2	2.5
Pasture	2.6	3.1	3.7
Vegetables*	1.4	1.6	2.0
Vineyard	0.5	0.6	0.8
Turfgrass	2	2.6	4.1

*60 percent of ETaw to account for fallow fields

As previously discussed in section 6.3.2 (Historical Land Use), the distribution of crop acreage was determined by a review and correlation of DWR and County crop surveys with aerial imagery. Crop acreages were interpolated between the years with data.

Applied water demand volumes were calculated by multiplying the annual acreage for each crop by the average annual applied water demand during each year. The final applied water estimates used for the water budget were adjusted to include efficiency (with system leakage) factors of 80 percent for drip/micro emitter and high-efficiency sprinkler irrigation (citrus, deciduous, vineyard, and turfgrass) and 75 percent for mostly sprinkler with some drip irrigation (pasture and vegetables). The estimated groundwater extractions for agricultural water use are shown in the main water budget Table 6-1, Table 6-2, and Table 6-3.

Wetland Direct ET

There are approximately 570 acres of wetlands and open water in the San Luis Obispo subsurface (Table 6-6), of which approximately 100 acres are open water and 100 acres are wetlands directly connected to Laguna Lake (based on aerial image review) and part of the surface water budget. The remaining 370 acres of wetlands, most of which extend northwest of Laguna Lake into the Los Osos Valley, are assumed to be areas with seasonally shallow groundwater where evapotranspiration by native grasses effectively draws from the groundwater reservoir.

The water demand of wetlands through direct groundwater use is assumed to be equivalent to average consumptive use of irrigated pasture as shown in Table 6-11. Any rainfall over 11.6 inches (Table 6-8) also contributes to meeting wetland water demand. Wetland direct ET estimates are shown in Table 6-1.

Subsurface Outflow

Subsurface outflow from Basin sediments occurs as underflow along the main creek channels (San Luis Obispo Creek and Pismo Creek). Outflow volumes were estimated using Darcy's Law (see Subsurface Inflow in Section 6.3.4.2). Table 6-12 presents the parameters used for subsurface outflow estimates.

Table 6-12: Subsurface Outflow Estimates.

Location	Cross-sectional Area	Hydraulic gradient	Hydraulic conductivity	Outflow
	ft^2	ft/ft	ft/day	AFY
San Luis Obispo Creek	46,800	0.004	65	100
Pismo Creek*	20,600	0.01	20	35

*begins at confluence of West Corral and East Corral de Piedra Creeks (Figure 4-2; Chapter 4)

Cross sectional areas for outflow were based on the estimated width and saturated depth of alluvial deposits in the vicinity of where the creeks exit the groundwater Basin. Hydraulic gradients are the approximate grade of the stream channel, and the hydraulic conductivities are based on pumping tests (GSI, 2018; CHG, 2018). Additional subsurface outflow from the San Luis Valley subarea occurs along Davenport Creek and East Fork Creek, but would be significantly less than San Luis Obispo Creek due to shallower and less permeable alluvial deposits. Total average subsurface outflow from the San Luis Valley subarea is estimated at 100 AFY from San Luis Obispo Creek and a nominal 20 AFY from the smaller tributaries, for a total of 120 AFY. Subsurface outflow from the Edna Valley subarea along the Canada Verde drainage and tributaries is estimated to be similar to Pismo Creek (35 AFY), for a total subsurface outflow from that subarea of 90 AFY (35 AFY each from Pismo Creek and Canada Verde, and 20 AFY cross-flow through the bedrock high; see Subsurface Inflow section above).

6.3.5 Total Groundwater in Storage

Groundwater is stored within the pore space of Basin sediments. The Specific yield is a ratio of the volume of pore water that will drain under the influence of gravity to the total volume of saturated sediments. The specific yield method for estimating groundwater in storage is the product of total saturated Basin volume and average specific yield. Calculation of total groundwater in storage for selected years was performed based on the specific yield method.

Estimates of specific yield for Basin sediments were obtained based on a review of 21 representative well logs. The lithology for each well log was correlated with specific yield values reported for sediment types in San Luis Obispo County (Johnson, 1967). A summary of the correlations is shown in Table 6-13. Locations of well logs used for the specific yield correlations are shown in the referenced cross-sections from the SLO Basin Characterization Report (GSI, 2018).

Groundwater in storage calculations were performed for the Spring conditions of 1986, 1990, 1995, 1998, 2011, 2014, and 2019 using the specific yield method. Water level contours for each year were prepared based on available water level data from various sources, including the County water level monitoring program, Geotracker Groundwater Information System data, groundwater monitoring reports, Stakeholder provided information, and Environmental Impact Reports. Water level contour maps for the Spring 1986 and Spring 2019 are shown in Figure 6-18 and Figure 6-19.

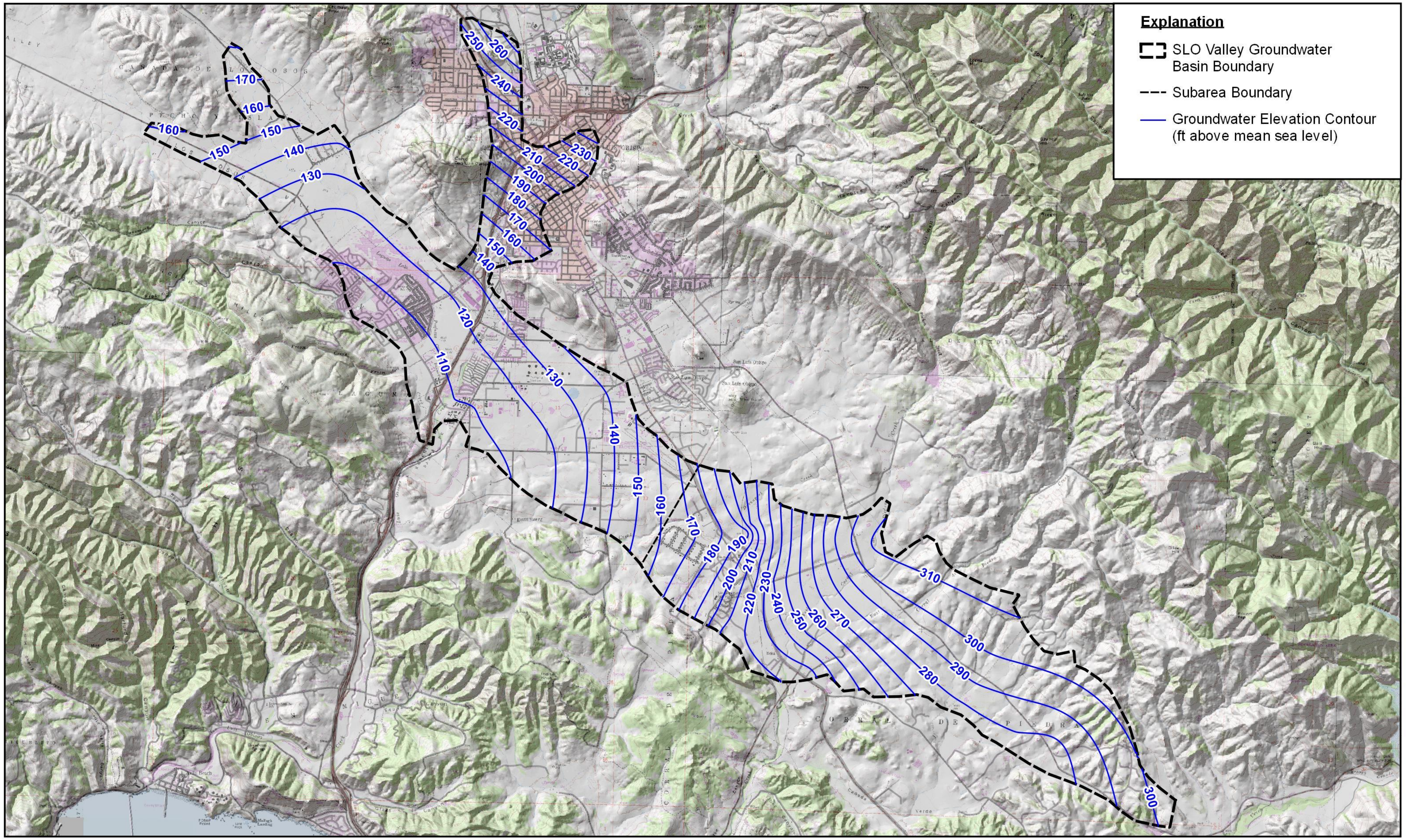
The water level contours for storage calculations extend to the Basin boundaries. Groundwater levels in the San Luis Valley subarea may contour at, or slightly above, ground surface in areas where wetlands are present, and there are no major differences between Spring 1986 and Spring 2019 water levels. In the Edna Valley subarea, water level contours show some notable areas of decline between 1986 and 2019 near the intersection of Edna Road (Highway 227) and Biddle Ranch Road and at the southeast end of the Basin. Declines in these areas are also shown for other time intervals in Figure 5-8 and 5-9 of Chapter 5. Of note, however, is that Spring 2019 water levels shown in Figure 6-18 are lower near the intersection of

Edna and Biddle Ranch Road than for the same period shown in Figure 5-6 (Chapter 5). This is because Figure 5-6 contours pressure in a shallow alluvial aquifer in this area while Figure 6-19 contours pressure in the deeper Pismo Formation aquifer that is the main supply aquifer for irrigation, and more appropriate for water budget storage calculations.

Table 6-13: Specific Yield Averages.

Well ID	Basin Cross-Section	Aquifer Specific Yield (percent)		
		Qal	QTp	Pismo
139405	B-B'	3.0	4.7	
158599	G-G'	6.8	6.9	18.0
279128	C2-C2'	11.0		
279130	A1-A2	8.2	6.5	3.0
287786	C1-C1'	7.2		
319126	C1-C1'	5.5	11.7	
438979	A1-A2	4.4	8.1	
469906	A3-A4		12.0	10.7
529099	E-E'		8.1	11.2
68734	A2-A3		5.9	8.0
710817	G-G'	3.0	5.0	10.8
73143	A1-A2	12.7	5.8	
782309	A2-A3	7.1	10.5	15.8
782656	D-D'	5.0	16.0	
e026022	H-H'		7.4	18.6
e0047435	G-G'	6.6	4.5	17.6
e0115806	offset I-I'		9.1	16.2
e0161526	F-F'		5.4	15.6
e0183287	H-H'	3.0	7.0	
e0225875	A2-A3	3.6	17.3	10.1
TH1	C1-C1'	5.9	8.9	18.0
Average Specific Yield		*6.2*	*8.5*	*13.4*
Basin Average (weighted)		10.5		
San Luis Valley Subarea (weighted)		8.0		
Edna Valley Subarea (weighted)		11.7		

Notes: Cross-sections shown in SLO Basin Characterization Report (GS1, 2018)
Qal = alluvium; QTp = Paso Robles Formation; Pismo = Pismo Formation
Weighted averages based on penetrated thicknesses of aquifer type.



Prepared For:

Author: TK
Date: 06/18/2020

SAN LUIS OBISPO VALLEY BASIN GSP

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0 0.25 0.5 0.75 1 mi
0 0.5 1 km

References:

1. Coordinate System: State Plane California V FIPS 0405 Feet
2. Projection: Lambert Conformal Conic
3. Hirozontal Datum: NAD 83
4. Vertical Datum: NAVD 88
5. Basemap: USGS 7.5' Topographic Map

Notes:

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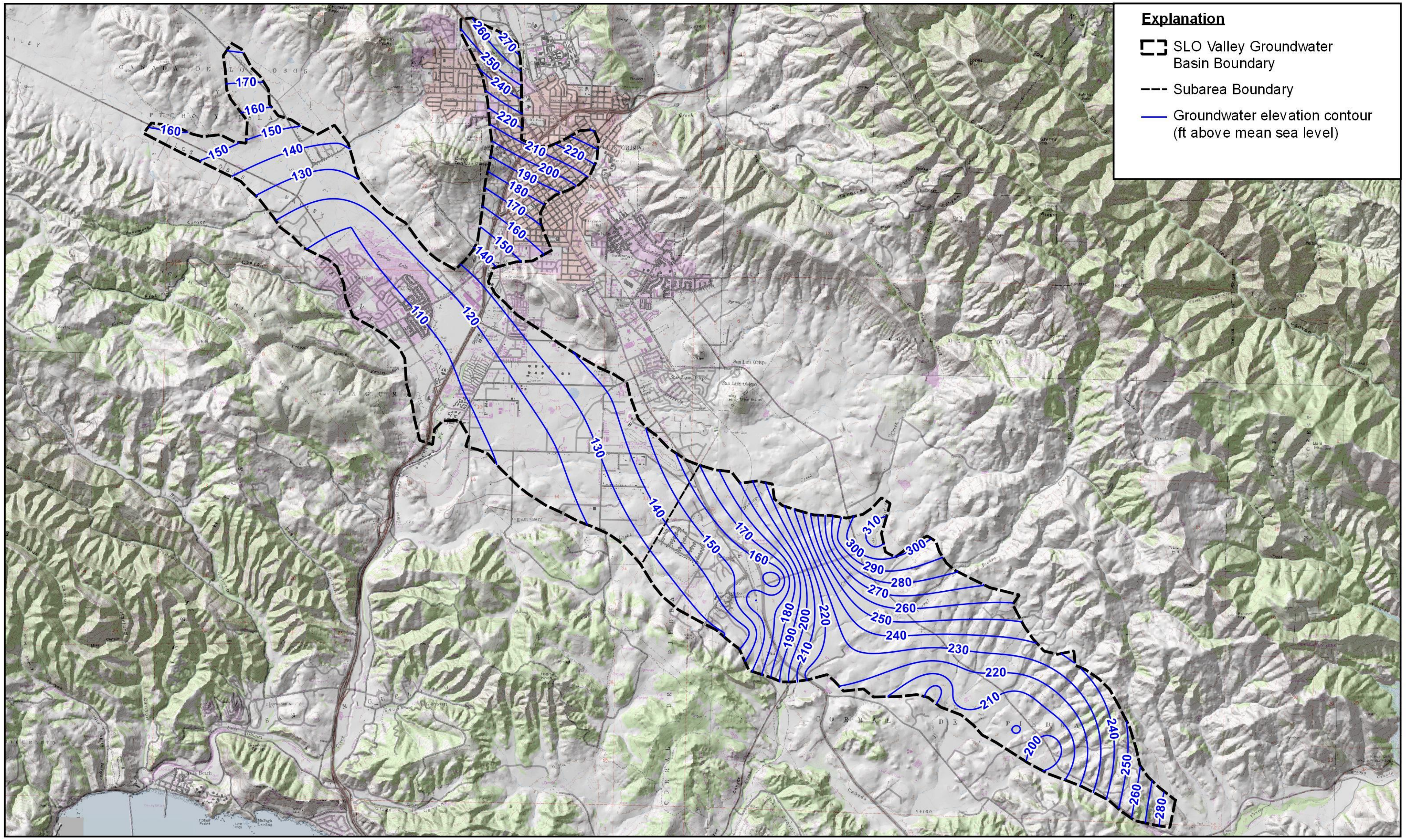
Groundwater Elevation Contours
Spring 1986

Figure 6-18



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Author: TK
Date: 06/18/2020

SAN LUIS OBISPO VALLEY BASIN GSP

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0 0.25 0.5 0.75 1 mi
0 0.5 1 km

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1. Coordinate System: State Plane California V FIPS 0405 Feet
2. Projection: Lambert Conformal Conic
3. Hirozontal Datum: NAD 83
4. Vertical Datum: NAVD 88
5. Basemap: USGS 7.5' Topographic Map

Notes:

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Groundwater Elevation Contours
Spring 2019

Figure 6-19

The water level contour maps and the base of permeable sediments were processed for volume calculation using Surfer, a grid-based mapping and graphic program. The methodology consisted of gridding and trimming surfaces to the Basin subarea boundaries, followed by volume calculation between surfaces. The gross volumes obtained were then multiplied by the representative specific yield for each subarea. An example of the methodology showing gridded surfaces for Spring 2019 water levels and the base of permeable sediments is presented in Figure 6-20. Estimated total storage volumes for selected years using the specific yield method are listed in Table 6-14.

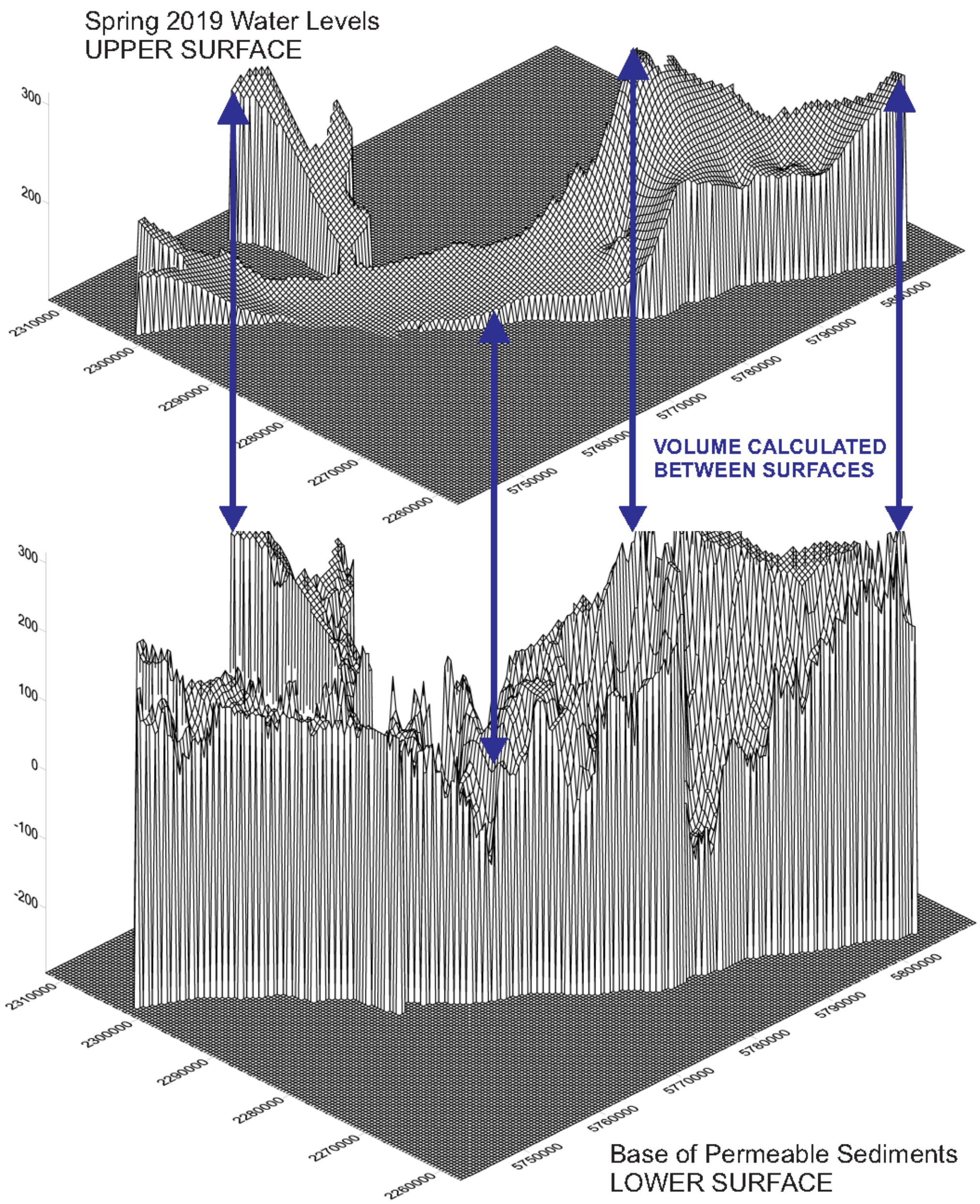

Figure 6-20: Storage Volume Grids.

Table 6-14: Spring Groundwater Storage Estimates.

Year	SLO Subarea	Edna Subarea	Basin Total
	Acre-Feet		
1986	36,310	132,840	169,150
1990	31,560	119,950	151,510
1995	36,750	131,020	167,770
1998	36,990	133,010	170,000
2005	38,080	126,210	164,290
2011	35,910	120,220	156,130
2014	34,280	104,950	139,230
2019	34,940	105,630	140,570

The groundwater storage estimates are much greater than previously reported, which was 23,300 acre-feet for the San Luis Valley subarea and 46,000 acre-feet for the Edna Valley subarea (Groundwater Basin Evaluation, Boyle Engineering, 1991). The Draft DWR study estimated an average storage of 16,000 acre-feet for the San Luis Valley subarea and 34,000 acre-feet for the Edna valley subarea (DWR, 1997). The increases are due primarily to improvements in characterizing Basin saturated thicknesses, specific yield, and methodology.

For example, the average saturated thickness of Basin sediments in the Edna Valley is listed as 102.9 feet by Boyle (1991). For Spring 1990, the average thickness of saturated sediments in the Edna Valley subarea using the base of permeable sediments in the SLO Basin Characterization Report (GSI, 2018) and Surfer gridding methodology is estimated to be approximately 150 feet, an increase of 50 percent. The estimated average specific yield value for the Edna Valley subarea is also close to 30 percent greater for GSP storage calculations (11.7 percent) than the prior estimate (9.1 percent). An additional 30-35 percent decrease in Basin storage areas was also incorporated into the prior methodology through the application of a subsurface configuration factor, which was not clearly described. (Boyle, 1991).

Increases in total groundwater in storage between prior work and current estimates does not imply an increase in sustainable yield or basin recharge rate. The purpose of total storage estimates for the water budget is to provide an independent calculation of change in storage over time, which is a critical part of the water budget equation.

6.3.6 Change in Storage

Balancing the water budget final step in water budget development. As previously mentioned, the water budget equation is as follows:

INFLOW – OUTFLOW = CHANGE IN STORAGE

The annual change in storage for the surface water budget is assumed to be zero, as surface flow moves quickly through the basin and any differences in storage are minor compared to the total budget. Therefore, the surface water balance equation can be simplified as INFLOW = OUTFLOW, and was used to estimate the stream outflow component of the surface water budget.

For the groundwater budget, groundwater-surface water interaction (as stream flow seepage) was adjusted to approximate the change in storage calculated using the specific yield method discussed above. The difference between the estimated change in storage shown in the water budget and the measured change in storage using the specific yield method is the mass balance error. Change in storage is reported between seasonal high (Spring) conditions per GSP regulations.

Change in storage and mass balance error for the groundwater budget is shown in Table 6-15. Figure 6-21 shows total storage using the water budget and specific yield method.

Table 6-15: Change in Storage Comparison – Historical Base Period 1987 – 2019.

Subarea	Water Budget	Specific Yield Method	Mass Balance Error		
	Change in Storage (acre-feet)		acre-feet	AFY	Percent*
San Luis Valley subarea	690	-1,370	2,060	62	6
Edna Valley Subarea	-27,440	-27,210	-230	-7	0

*Percent of total subarea water budget

The difference in change in storage estimates between the water budget and the specific yield method is approximately 60 AFY for the San Luis Valley subarea over the historical base. The water budget estimates a 690 acre-foot gain in storage, compared to a 1,370 acre-foot decline in storage using the specific yield method. A review of the contour maps indicates that the decline in San Luis Valley subarea storage shown by the specific yield method is due to the effects of groundwater level declines in the Edna Valley subarea being contoured across the bedrock high into the San Luis Valley subarea (Figure 6-18 and Figure 6-19). There are no hydrographs for water levels in the bedrock high area, and the extent to which water level declines in the Edna Valley subarea have influenced water levels in the eastern portion of the San Luis Valley subarea is uncertain. Available water level hydrographs do not show overall water level declines west of the bedrock high (Figure 5-11; Chapter 5).

The difference in change in storage estimates between the water budget and the specific yield method is less than 10 AFY for the Edna Valley subarea over the historical base period. The water budget estimates a 27,440 acre-foot decline in storage, compared to a 27,210 acre-foot decline in storage using the specific yield method. The change in storage mass balance error for the Basin historical groundwater budget is less than 100 acre-feet per year, which is reasonable for the purposes of preliminary sustainable yield estimates.

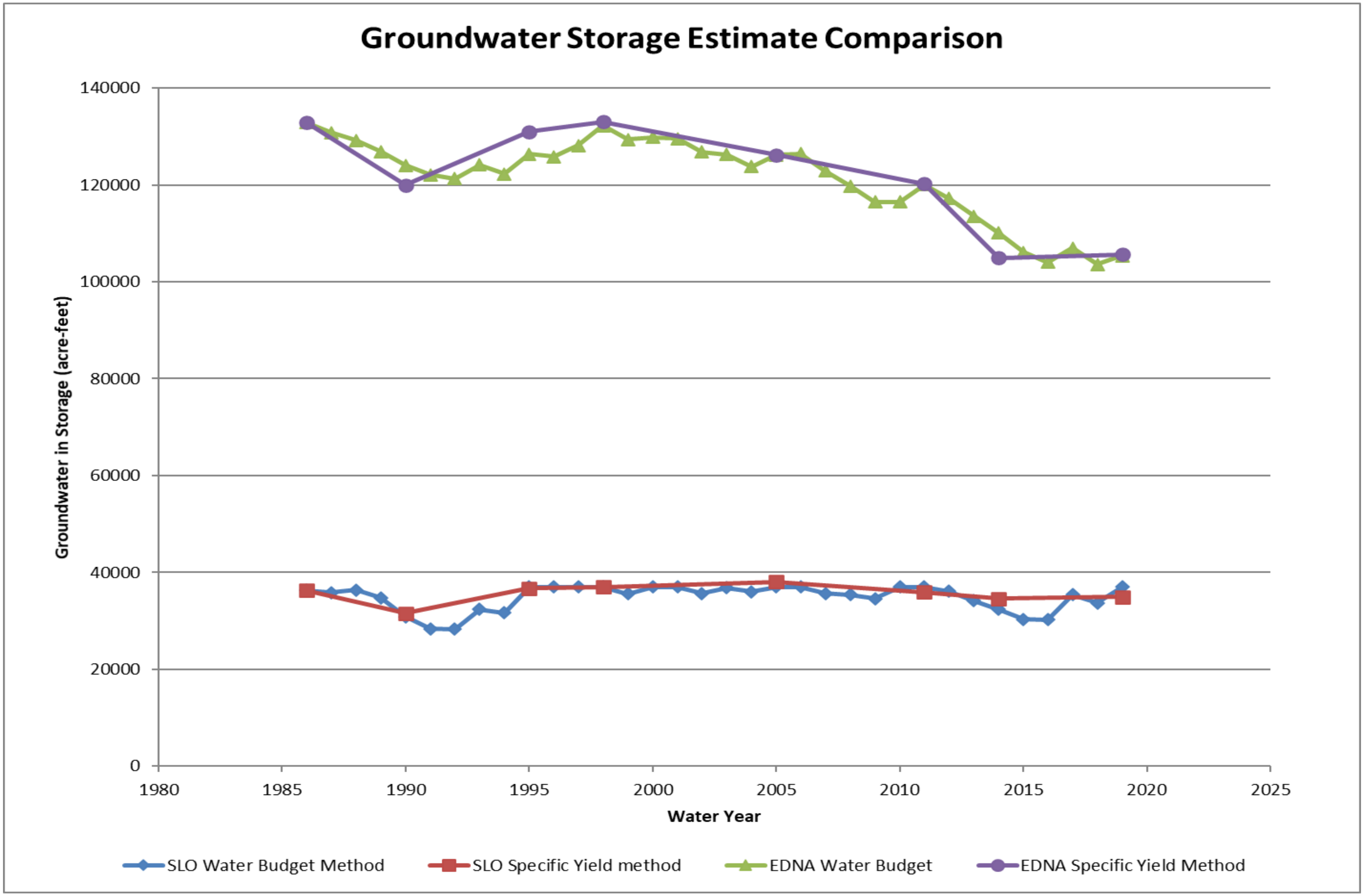

Figure 6-21: Groundwater Storage Estimate Comparison for Basin Subareas.

6.3.7 Preliminary Sustainable Yield Estimate

The sustainable yield is 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. Temporary surplus is the amount of water that may be pumped from an aquifer to make room to store future water that would otherwise be wasted and unavailable for use. Undesirable results will be defined for six sustainable management criteria in Chapter 7. Examples of potential undesirable results are related to long-term declines in water levels and associated loss in groundwater in storage.

Estimating sustainable yield includes evaluating historical, current, and projected water budget conditions. The analytical water budget method utilized in this analysis evaluates historical and current conditions, and provides a preliminary estimate for the Basin sustainable yield. The projected water budget will be evaluated using the Basin numerical model presented later in the projected water budget section of the chapter, at which time the minimum thresholds for the sustainable management criteria can be incorporated and the final sustainable yield will be determined. The preliminary sustainability estimate can be used for planning potential projects and management action scenarios for the Basin numerical model.

The preliminary sustainable yield of the San Luis Obispo groundwater Basin has been estimated separately for each of the subareas. The Edna Valley subarea has experienced cumulative storage declines since 1998, while the San Luis Valley subarea experiences storage declines during drought, but recovers and is typically close to full storage capacity (Figure 6-21).

For the Edna Valley subarea, sustainable yield is estimated as the amount of long-term recharge (groundwater inflow) to the Basin over the historical base period (3,400 AFY) minus subsurface outflow (100 AFY). The resulting preliminary sustainable yield is estimated at a 3,300 AFY.

The San Luis Valley subarea has not experienced cumulative and persistent storage declines. Long-term average recharge to groundwater in the San Luis Valley subarea is estimated to be 3,700 AFY, of which an estimated 1,200 AFY is used by wetlands, leaving 2,500 AFY for withdrawal without long-term declines in storage (subsurface outflow is supported by wastewater discharges). The historical recharge to the subarea may be less than the sustainable yield, however, because average annual recharge can increase with storage declines, particularly in a Basin that is at or near storage capacity.

The San Luis Valley subarea did experience significant undesirable results due to land subsidence during the period of high groundwater use and associated storage decline toward the end of the 1987-91 drought. Average groundwater production from 1990-1992 was 3,960 AFY. Land subsidence is not necessarily a risk over the entire subarea, and would generally require historical storage declines to be exceeded in affected areas for addition subsidence to occur. However, without mitigation for land subsidence or specific projects that increase recharge during dry periods, the preliminary sustainable yield of the San Luis Valley subarea is estimated at 2,500 AFY, based on the long-term average recharge of 3,700 AFY minus 1,200 AFY used by wetlands. Table 6-15 summarizes the preliminary sustainable yield estimates.

Table 6-16: Preliminary Sustainable Yield Estimate (AFY).

San Luis Valley Subarea	2,500
Edna Valley Subarea	3,300
Basin Total	5,800

The above values are lower overall than historical estimates by Boyle (1991) and DWR (1997 Draft). Boyle estimated 5,900 AFY of sustainable yield for the Basin while DWR estimated 2,000-2,500 for the San Luis Valley subarea and 4,000-4,500 for the Edna Valley Subarea.

6.3.8 Quantification of Overdraft

Overdraft is the condition of a groundwater Basin or subbasin where the amount of water withdrawn by pumping exceeds the amount of water that recharges a Basin over a period of years, during which the water supply conditions approximate average conditions.

While the 33-year historical base period is representative of the long-term climatic conditions needed for estimating sustainable yield, a shorter period is appropriate for characterizing water supply conditions with respect to Basin withdrawals and overdraft. Over the last 10 years the City has introduced recycled water reuse at Laguna golf course (historically irrigated by groundwater) and has stopped pumping groundwater from the San Luis Valley subarea, while total irrigated agriculture in the Edna Valley subarea has leveled off, after increasing from the beginning of the historical base period through the mid-2000's (Table 6-5). Overdraft for GSP planning purposes has been estimated as the difference between sustainable yield and average groundwater withdrawals over the last 10 years (2010-2019), with an adjustment in the San Luis Valley subarea to account for reductions in agricultural acreage due to recent development.

Groundwater extractions in the San Luis Valley subarea (adjusted for recent development) have averaged 1,800 AFY since 2010, which is 700 AFY less than the average recharge of 2,500 AFY over the same representative period, indicating a surplus of groundwater for the subarea. In the Edna Valley subarea, groundwater pumping has averaged 4,400 AFY since 2010, which is 1,100 AFY more than the sustainable yield of 3,300 AFY for the subarea. The Edna Valley subarea is an estimated 1,100 AFY in overdraft. Total Basin overdraft is estimated at 400 AFY. Table 6-16 summarizes the overdraft estimates.

Table 6-17: Estimated Overdraft (AFY).

San Luis Valley Subarea	-700*
Edna Valley Subarea	1,100
Basin Total	400

*surplus

In comparison, prior work by Boyle (1991) concluded that there was short-term overdraft in the Basin and that withdrawals in excess of sustainable yield was a common occurrence. However, during the period from 1978-1990, the Basin was not considered in a state of sustained overdraft. The Draft 1997 DWR study does not address overdraft, although there is a net deficit in the basin water budget for the 1969-1977 base period, a surplus for the 1983 water budget, and a deficit for the 1990 water budget. The draft DWR report concluded that additional water beyond the long-term dependable yield could be extracted from the Basin, but that there could be adverse impacts.

6.4 CURRENT WATER BUDGET

The current water budget quantifies inflows and outflows for the Basin based on the last four years of the historical water budget, from 2016 to 2019. These years provide the most recent population, land use, and hydrologic conditions. Recent Basin conditions have been characterized by above average rainfall, along with a decrease in urban extractions and imported surface water supplies assumed to be associated with greater conservation awareness by the public during the 2012-2016 drought. There have also been declines in agricultural acreage and associated groundwater extractions in the San Luis Valley subarea associated with urban development.

Comparisons of the current water budget to the 1987-2019 historical surface water budget used for the preliminary sustainable yield estimates for the two subareas and total Basin are shown in Table 6-17 through Table 6-19. Bar graphs are shown in Figure 6-22 through Figure 6-27. As expected, the average annual water budget inflows and outflows are greater under current conditions than the historical base period, primarily due to greater rainfall. There has been more groundwater inflow than outflow under the current water budget in the San Luis Valley subarea, leading to increased groundwater in storage. In the Edna valley subarea, the outflow has been slightly greater than inflow under the current water budget, with relatively little change to groundwater in storage since the end of the recent drought (Figure 6-21). As noted above, groundwater extractions for agriculture in the San Luis Valley subarea have declined between the historical and current water budgets.

Table 6-18: Current Water Budget - San Luis Valley Subarea.

SAN LUIS VALLEY SUBAREA		
SURFACE WATER BUDGET	**Historical Average (1987-2019)**	**Current (2016-2019)**
Inflow	**AFY**	
Precipitation	10,580	12,280
Groundwater extractions (Urban)	740	400
Groundwater extractions (Ag)	1,630	1,370
Stream Inflow at Basin Boundaries	10,720	10,570
Wastewater discharge to streams	4,080	3,910
Local Imported Supplies	5,820	5,430
TOTAL IN	33,580	33,960
Outflow		
ET of precipitation	7,770	8,220
ET of Applied Water (Urban)	2,050	1,510
ET of Applied Water (Ag)	1,310	1,100
ET of Lake/Wetland/Riparian	650	690
Surface Water Delivery Offset	4,080	3,910
Infiltration of Precipitation	1,610	3,190
Infiltration of Applied Water (Urban)	440	440
Infiltration of Applied Water (ag)	320	260
GW-SW interaction (net)	970	510
Stream outflow at Basin boundary	14,390	14,120
TOTAL OUT	33,580	33,960
GROUNDWATER BUDGET	**Historical Average (1987-2019)**	**Current (2016-2019)**
Inflow	**AFY**	
Infiltration of precipitation	1,610	3,190
Urban water return flow	440	440
Agricultural return flow	320	260
GW-SW interaction (net)	970	510
Subsurface from bedrock	340	340
TOTAL IN	3,670	4,750
Outflow		
Groundwater extractions (Urban)	740	400
Groundwater extractions (Ag)	1,630	1,370
Wetland direct ET	1,160	1,190
Subsurface outflow	120	120
TOTAL OUT	3,650	3,080

Table 6-19: Current Water Budget - Edna Valley Subarea.

EDNA VALLEY SUBAREA		
SURFACE WATER BUDGET	**Historical (1987-2019)**	**Current (2016-2019)**
Inflow	**AFY**	
Precipitation	9,300	10,780
Groundwater extractions (Urban)	880	820
Groundwater extractions (Ag)	3,210	3,440
Stream Inflow at Basin Boundaries	3,630	3,480
TOTAL IN	17,020	18,520
Outflow		
ET of precipitation	6,910	7,200
ET of Applied Water (Urban)	600	610
ET of Applied Water (Ag)	2,650	2,870
ET of Riparian	40	40
Infiltration of Precipitation	1,890	2,800
Infiltration of Applied Water (Urban)	280	210
Infiltration of Applied Water (ag)	560	570
GW-SW interaction (net)	510	490
Stream outflow at Basin boundary	3,580	3,750
TOTAL OUT	17,020	18,520
GROUNDWATER BUDGET	**Historical Average (1987-2019)**	**Current (2016-2019)**
Inflow	**AFY**	
Infiltration of precipitation	1,890	2,800
Urban water return flow	290	220
Agricultural return flow	560	570
GW-SW interaction (net)	510	490
Subsurface from bedrock	110	110
TOTAL IN	3,360	4,180
Outflow		
Groundwater extractions (Urban)	880	820
Groundwater extractions (Ag)	3,210	3,440
Subsurface outflow	100	100
TOTAL OUT	4,190	4,360

Table 6-20: Current Water Budget - Basin Total.

BASIN TOTAL		
SURFACE WATER BUDGET	**Historical Average (1987-2019)**	**Current (2016-2019)**
Inflow	**AFY**	
Precipitation	19,880	23,060
Groundwater extractions (Urban)	1,620	1,220
Groundwater extractions (Ag)	4,840	4,810
Stream Inflow at Basin Boundaries	14,350	14,050
Wastewater discharge to streams	4,080	3,910
Local Imported Supplies	5,820	5,430
TOTAL IN	50,600	52,480
Outflow		
ET of precipitation	14,680	15,420
ET of Applied Water (Urban)	2,650	2,120
ET of Applied Water (Ag)	3,960	3,970
ET of Lake/Wetland/Riparian	690	730
Surface Water Delivery Offset	4,080	3,910
Infiltration of Precipitation	3,500	5,990
Infiltration of Applied Water (Urban)	720	650
Infiltration of Applied Water (ag)	880	830
GW-SW interaction (net)	1,480	1,000
Stream outflow at Basin boundary	17,970	17,870
TOTAL OUT	50,600	52,480
GROUNDWATER BUDGET	**Historical Average (1987-2019)**	**Current (2016-2019)**
Inflow	**AFY**	
Infiltration of precipitation	3,500	5,990
Urban water return flow	730	660
Agricultural return flow	880	830
GW-SW interaction (net)	1,480	1,000
Subsurface from bedrock	450	450
TOTAL IN	7,030	8,930
Outflow		
Groundwater extractions (Urban)	1,620	1,220
Groundwater extractions (Ag)	4,840	4,810
Wetland direct ET	1,160	1,190
Subsurface outflow	220	220
TOTAL OUT	7,840	7,440

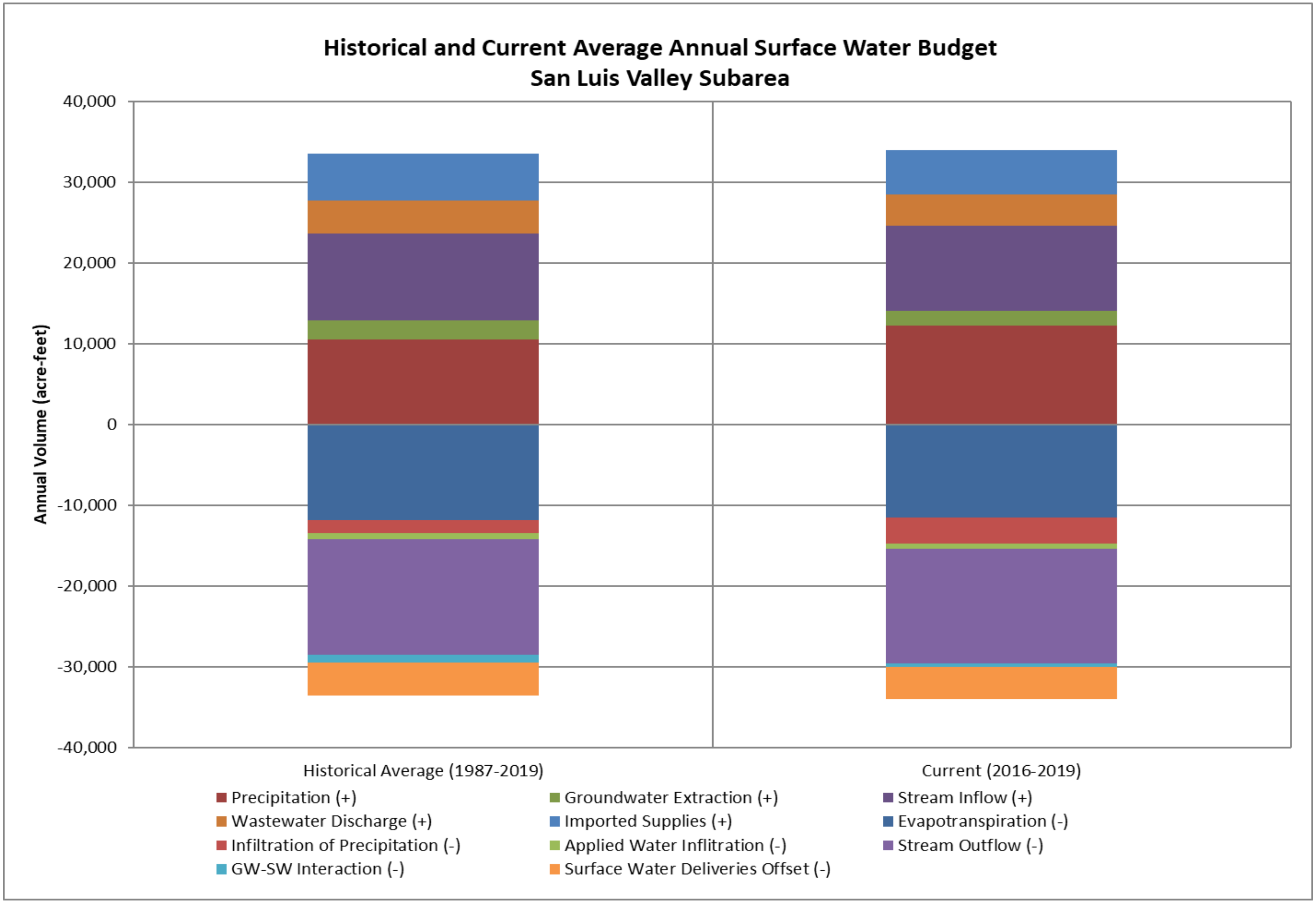

Figure 6-22: Historical and Current Average Annual Surface Water Budget – San Luis Valley Subarea.

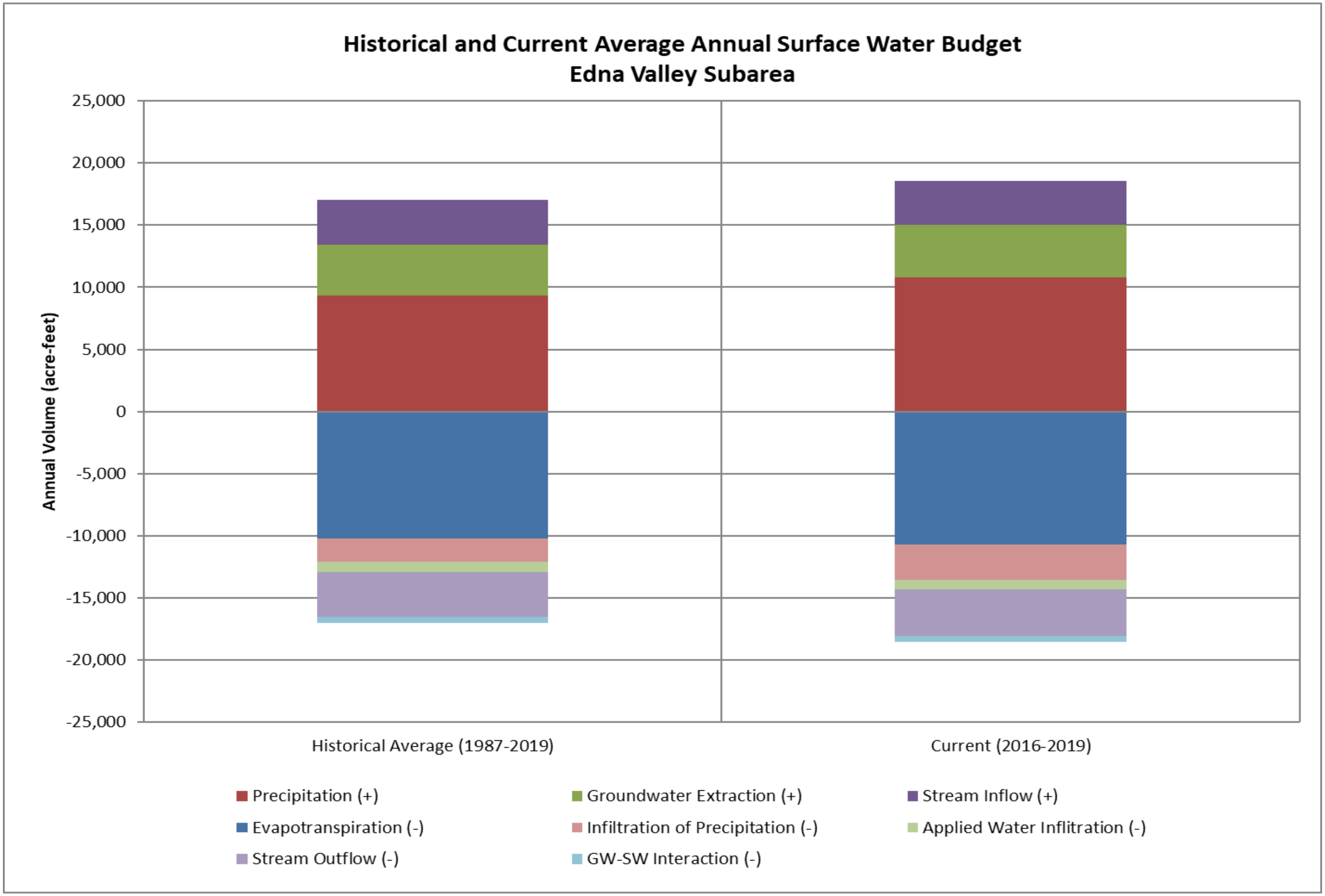

Figure 6-23: Historical and Current Average Annual Surface Water Budget – Edna Valley Subarea.

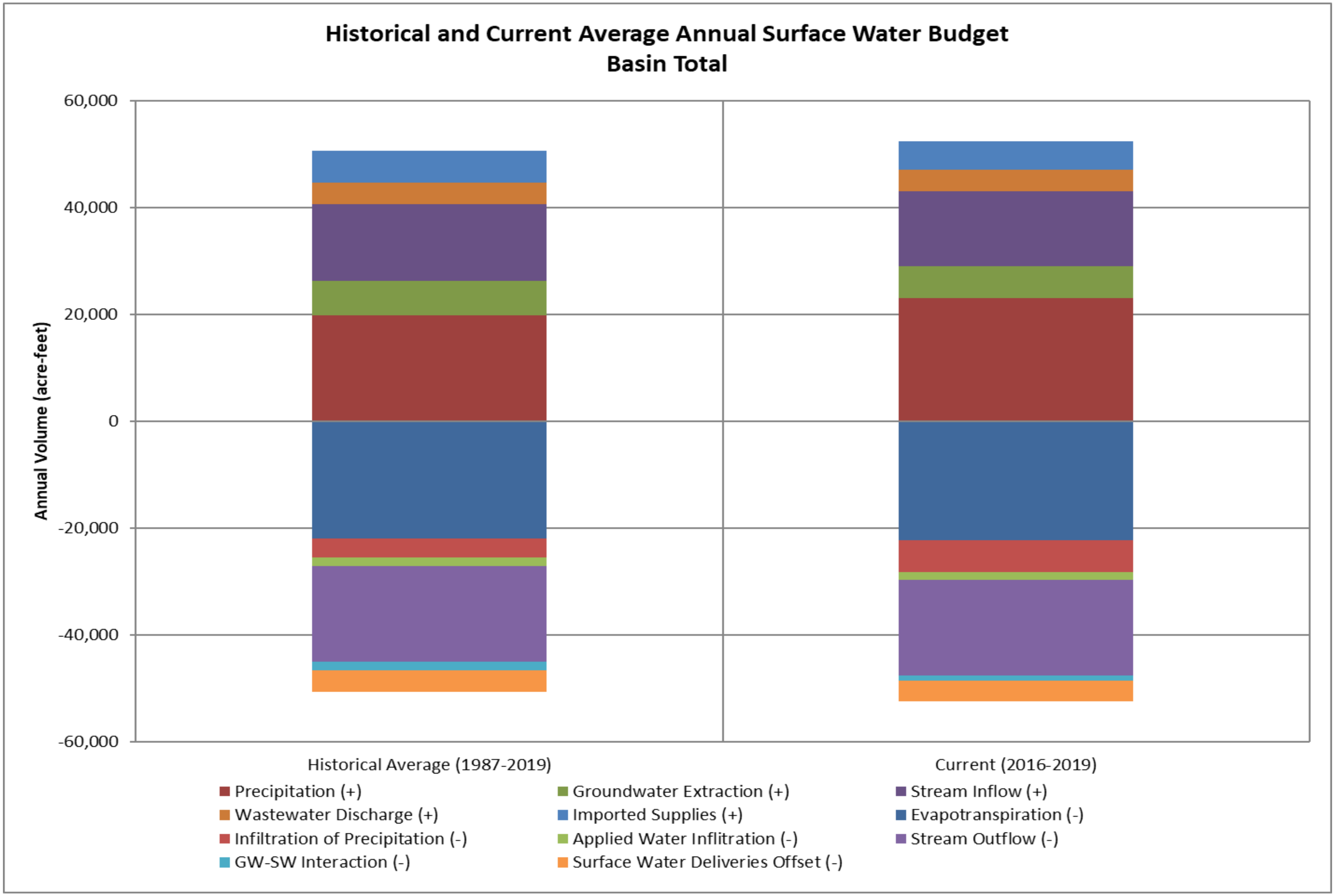

Figure 6-24: Historical and Current Average Annual Surface Water Budget – Basin Total.

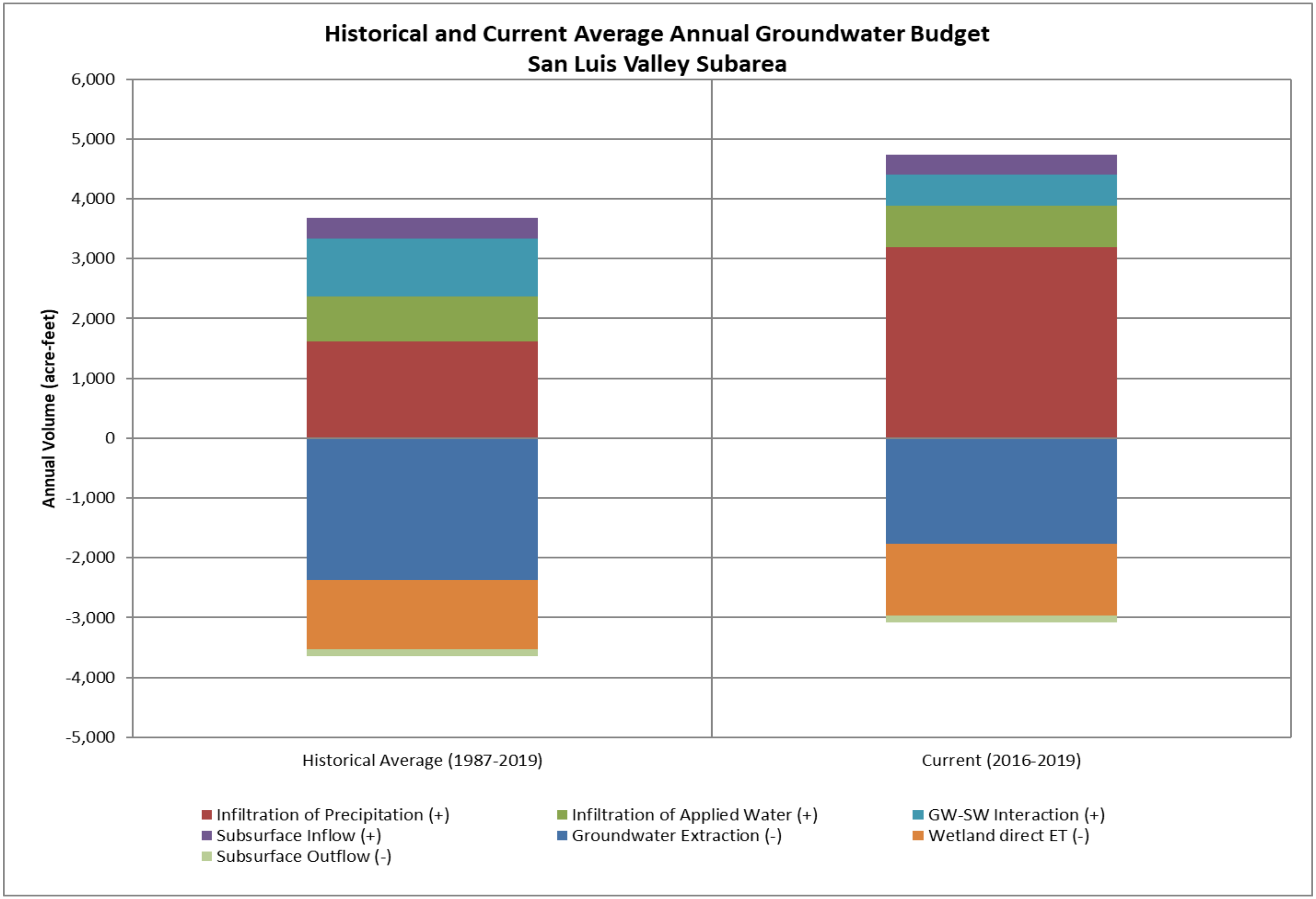

Figure 6-25: Historical and Current Average Annual Groundwater Budget – San Luis Valley Subarea.

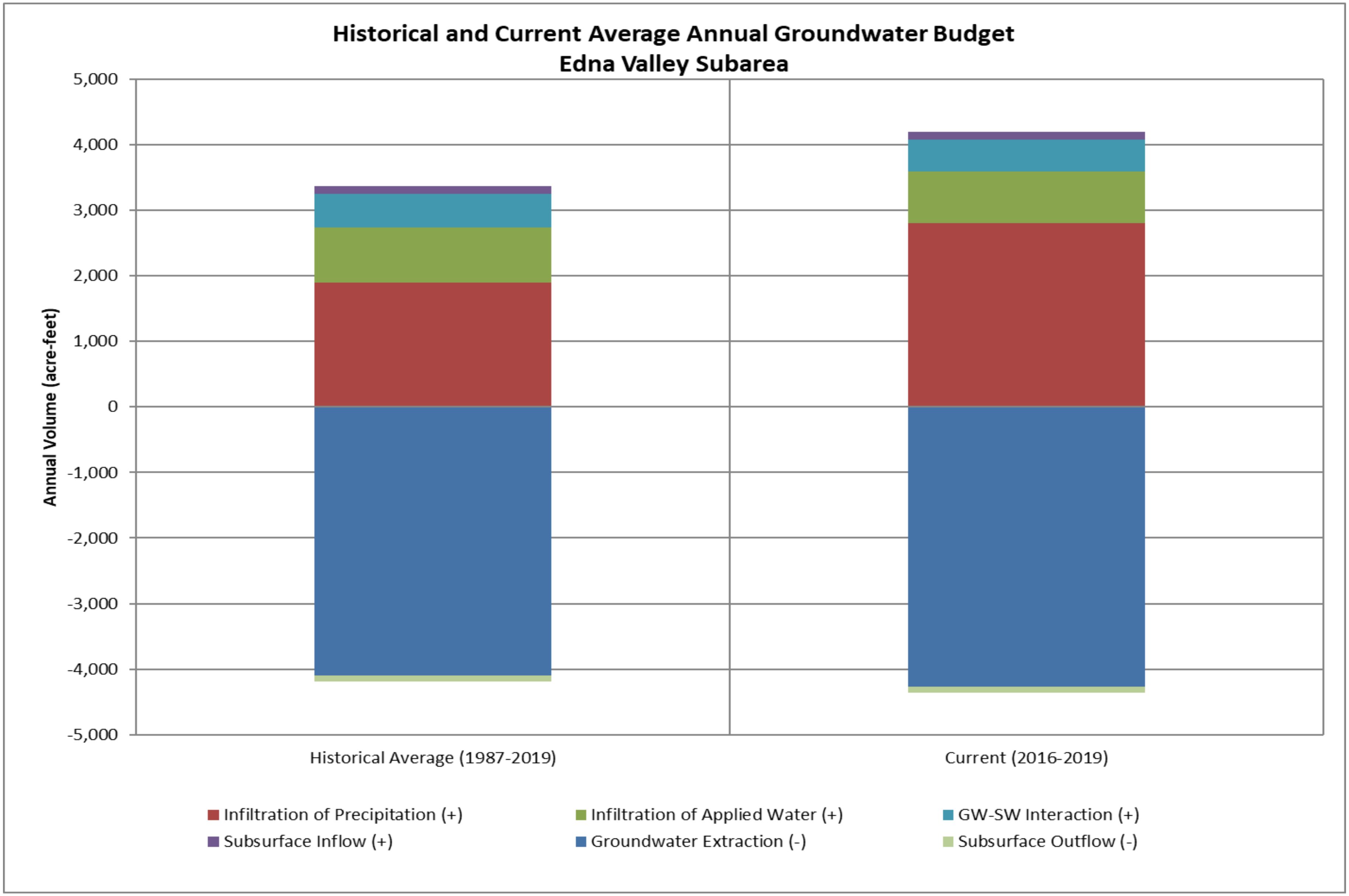

Figure 6-26: Historical and Current Average Annual Groundwater Budget – Edna Valley Subarea.

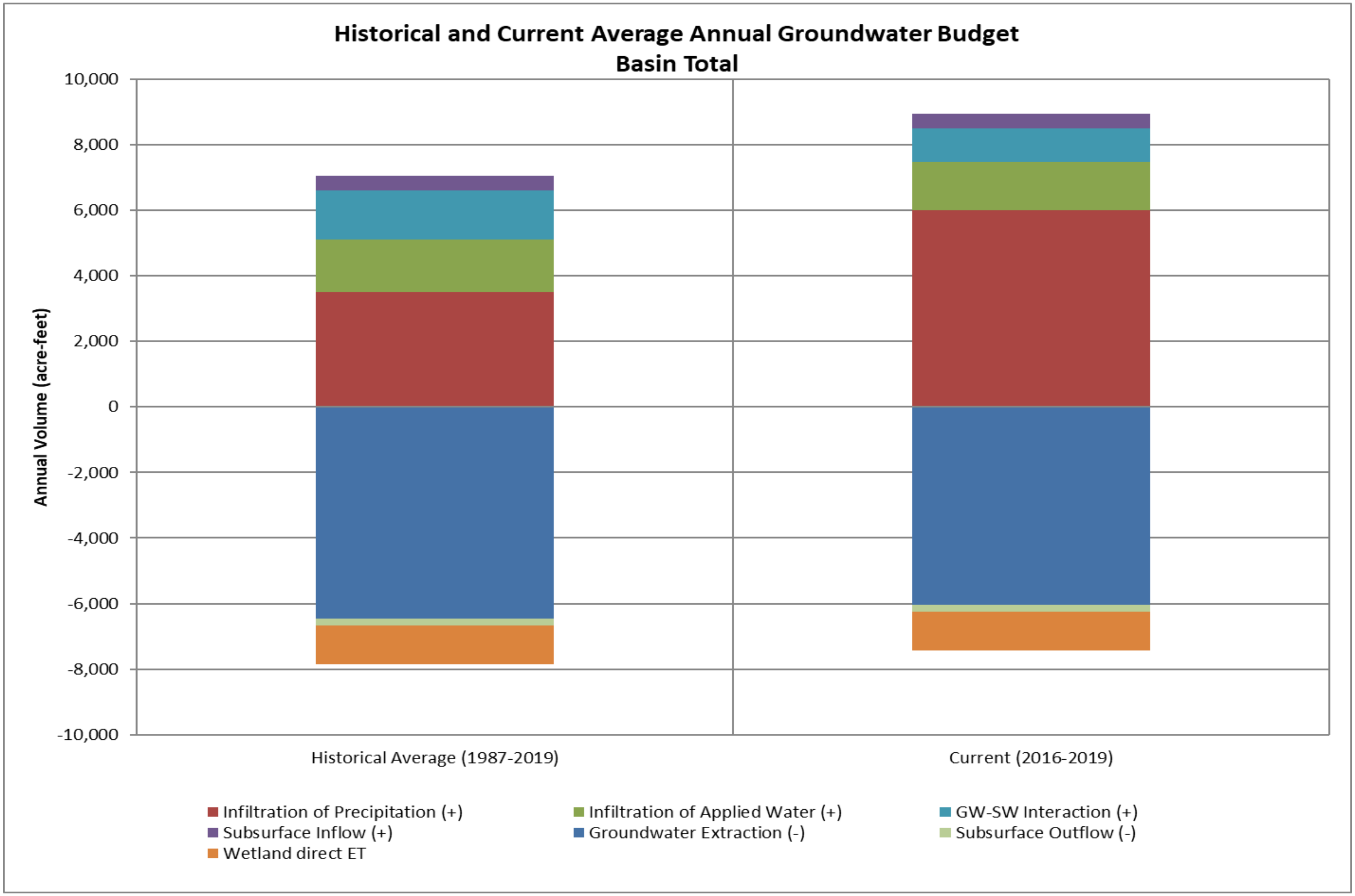

Figure 6-27: Historical and Current Average Annual Groundwater Budget – Basin Total.

6.5 PROJECTED WATER BUDGET

6.5.1 Assumptions

6.5.2 Inflows

6.5.3 Outflows

6.5.4 Change In Storage

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