APPENDIX 2.F. WATER BUDGET INFORMATION

2.F.e. Surface Water System Water Budget: Triangle T Water District GSA

Prepared as part of the

Groundwater Sustainability Plan
Chowchilla Subbasin

January 2020

GSP Team:

Davids Engineering, Inc
Luhdorff & Scalmanini
ERA Economics
Stillwater Sciences and
California State University, Sacramento

TABLE OF CONTENTS

1 INTRODUCTION 1

2 WATER BUDGET CONCEPTUAL MODEL 1

3 WATER BUDGET ANALYSIS 4

3.1 Land Use 5

3.2 Surface Water System Water Budget 9

3.2.1 Inflows 9

3.2.1.1 Surface Water Inflow by Water Source Type 9

3.2.1.2 Precipitation 11

3.2.1.3 Groundwater Extraction by Water Use Sector 11

3.2.1.4 Groundwater Discharge to Surface Water Sources 14

3.2.2 Outflows 15

3.2.2.1 Evapotranspiration by Water Use Sector 15

3.2.2.2 Surface Water Outflow by Water Source Type 20

3.2.2.3 Infiltration of Precipitation 22

3.2.2.4 Infiltration of Surface Water 23

3.2.2.5 Infiltration of Applied Water 25

3.2.3 Change in Surface Water System Storage 26

3.3 Historical Water Budget Summary 28

3.4 Current Water Budget Summary 31

3.5 Net Recharge from SWS 33

3.6 Uncertainties in Water Budget Components 3534

1 INTRODUCTION 1

2 WATER BUDGET CONCEPTUAL MODEL 1

3 WATER BUDGET ANALYSIS 4

3.1 Land Use 5

3.2 Surface Water System Water Budget 9

Formatted: Default Paragraph Font
Formatted: Default Paragraph Font
Formatted: Default Paragraph Font
Formatted: Default Paragraph Font
Formatted: Default Paragraph Font
Formatted: Default Paragraph Font
Formatted: Default Paragraph Font
Formatted: Default Paragraph Font
Formatted: Default Paragraph Font
Formatted: Default Paragraph Font

3.2.1 Inflows 9
3.2.1.1 Surface Water Inflow by Water Source Type 9
3.2.1.2 Precipitation 11
3.2.1.3 Groundwater Extraction by Water Use Sector 11
3.2.1.4 Groundwater Discharge to Surface Water Sources 14
3.2.2 Outflows 15
3.2.2.1 Evapotranspiration by Water Use Sector 15
3.2.2.2 Surface Water Outflow by Water Source Type 20
3.2.2.3 Infiltration of Precipitation 22
3.2.2.4 Infiltration of Surface Water 23
3.2.2.5 Infiltration of Applied Water 25
3.2.3 Change in Surface Water System Storage 26
3.3 Historical Water Budget Summary 28
3.4 Current Water Budget Summary 31
3.5 Net Recharge from SWS 33
3.6 Sustainable Yield 34
3.7 Uncertainties in Water Budget Components 35

Formatted: Default Paragraph Font

LIST OF TABLES

Table 1. Triangle T Water District GSA Land Use Areas (Acres).

Table 2. Triangle T Water District GSA Agricultural Land Use Areas.

Table 3. Triangle T Water District GSA Surface Water Inflows by Water Source Type (Acre-Feet).

Table 4. Triangle T Water District GSA Precipitation by Water Use Sector (Acre-Feet).

Table 5. Triangle T Water District GSA Groundwater Extraction by Water Use Sector (Acre-Feet).

Table 6. Triangle T Water District GSA Evapotranspiration by Water Use Sector (Acre-Feet).

Table 7. Triangle T Water District GSA Evapotranspiration of Applied Water by Water Use Sector (Acre-Feet).

Table 8. Triangle T Water District GSA Evapotranspiration of Precipitation by Water Use Sector (Acre-Feet).

Table 9. Triangle T Water District GSA Evaporation from the Surface Water System (Acre-Feet).

Table 10. Triangle T Water District GSA Surface Outflows by Water Source Type (Acre-Feet).

Table 11. Triangle T Water District GSA Infiltration of Precipitation by Water Use Sector (Acre-Feet).

Table 12. Triangle T Water District GSA Infiltration of Surface Water (Acre-Feet).

Table 13. Triangle T Water District GSA Infiltration of Applied Water by Water Use Sector (Acre-Feet).

Table 14. Triangle T Water District GSA Change in Surface Water System Storage (Acre-Feet).

Table 15. Triangle T Water District GSA Surface Water System Historical Water Budget, 1989-2014 (Acre-Feet).

Table 16. Triangle T Water District GSA Surface Water System Current Water Budget (Acre-Feet).

Table 17. Historical Water Budget: Average Net Recharge from SWS by Water Year Type, 1989-2014 (Acre-Feet).

Table 18. Current Water Budget: Average Net Recharge from SWS by Water Year Type (Acre-Feet).

Table 19. ~~Summary of Sustainable Yield Estimates from Projected With Projects Water Budget.~~

~~Table 20.~~ Estimated Uncertainty of GSA Water Budget Components.

Formatted: Space After: 8 pt, Line spacing: Multiple 1.08 li, Tab stops: Not at 0.25"

LIST OF FIGURES

Figure 1. Chowchilla Subbasin Water Budget Subregion Map.

Figure 2. Triangle T Water District GSA Water Budget Structure.

Figure 3. Triangle T Water District GSA Land Use Areas.

Figure 4. Triangle T Water District GSA Agricultural Land Use Areas.

Figure 5. Triangle T Water District GSA Surface Water Inflows by Water Source Type.

Figure 6. Triangle T Water District GSA Precipitation by Water Use Sector.

Figure 7. Triangle T Water District GSA Groundwater Extraction by Water Use Sector.

Figure 8. Triangle T Water District GSA Evapotranspiration by Water Use Sector.

Figure 9. Triangle T Water District GSA Evapotranspiration of Applied Water by Water Use Sector.

Figure 10. Triangle T Water District GSA Evapotranspiration of Precipitation by Water Use Sector.

Figure 11. Triangle T Water District GSA Evaporation from the Surface Water System.

Figure 12. Triangle T Water District GSA Surface Outflows by Water Source Type.

Figure 13. Triangle T Water District GSA Infiltration of Precipitation by Water Use Sector.

Figure 14. Triangle T Water District GSA Infiltration of Surface Water.

Figure 15. Triangle T Water District GSA Infiltration of Applied Water by Water Use Sector.

Figure 16. Triangle T Water District GSA Change in Surface Water System Storage.

Figure 17. Triangle T Water District GSA Surface Water System Historical Water Budget, 1989-2014.

Figure 18. Triangle T Water District GSA Surface Water System Current Water Budget.

1 INTRODUCTION

To ensure sustainable groundwater management throughout California's groundwater basins, the Sustainable Groundwater Management Act of 2014 (SGMA) requires Groundwater Sustainability Agencies (GSAs) to prepare and adopt Groundwater Sustainability Plans (GSPs) with strategies to achieve subbasin groundwater sustainability within 20 years of plan adoption. Integral to each GSP is a water budget used to quantify the subbasin's groundwater overdraft (if applicable) and sustainable yield.

In 2017, Triangle T Water District (TTWD) GSA formed to manage approximately 14,700 acres of the Chowchilla Subbasin. This document presents results of the surface water system (SWS) water budgets developed for historical and current land use conditions in TTWD GSA. The TTWD GSA water budgets were integrated with separate water budgets developed for four (4) other subregions covering the remainder of the Chowchilla Subbasin. Together, these water budgets provide the boundary water budget for the Chowchilla Subbasin SWS. Results of the subbasin boundary water budget are reported in the Chowchilla Subbasin GSP Section 2.2.3 and were integrated with a subbasin groundwater model (GSP Appendix 6.E) to estimate subbasin sustainable yield (GSP Section 2.2.3).

2 WATER BUDGET CONCEPTUAL MODEL

A water budget is defined as a complete accounting of all water flowing into and out of a defined volume (e.g., a subbasin or a GSA) over a specified period of time. The conceptual model (or structure) of the TTWD GSA water budget developed for this investigation is consistent with the GSP Regulations defined under Title 23 of California Code of Regulations[1] (CCR) and adheres to sound water budget principles and practices defined by California Department of Water Resources (DWR) in the Water Budget Best Management Practice (BMP) guidelines (DWR, 2016).

The lateral extent of TTWD GSA is defined by the boundaries indicated in Figure 1. The vertical extent of TTWD GSA is the land surface (top) and the base of fresh water at the bottom of the basin (bottom), as described in the hydrogeologic conceptual model (HCM) developed in GSP Section 2.2.1. The vertical extent of Chowchilla Subbasin and its GSAs is subdivided into a surface water system (SWS) and the underlying groundwater system (GWS), with separate but related water budgets prepared for each that together represent the overall subbasin water budget.

A conceptual representation of the TTWD GSA water budget is represented in Figure 2. This document details only the SWS portion of the TTWD GSA water budget. The SWS is divided into two primary accounting centers: the Land Surface System and the Rivers and Streams System. The Land Surface System is further divided into three accounting centers representing the subregion water use sectors: Agricultural Land, Native Vegetation Land, and Urban Land (urban, industrial, and semi-agricultural).

[1] California Code of Regulations Title 23. Waters, Division 2. Department of Water Resources, Chapter 1.5. Groundwater Management, Subchapter 2. Groundwater Sustainability Plans.

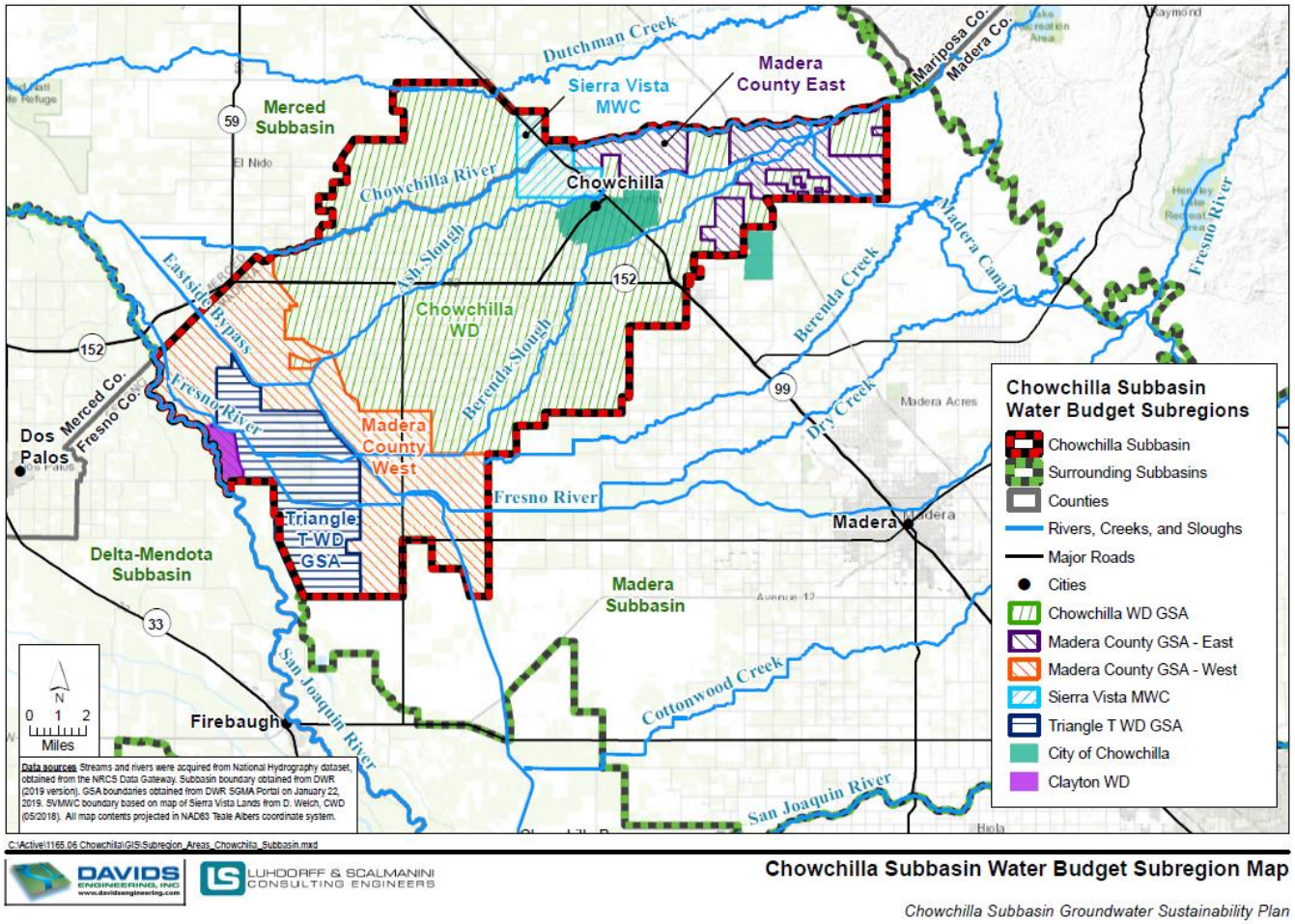

Figure 1. Chowchilla Subbasin Water Budget Subregion Map

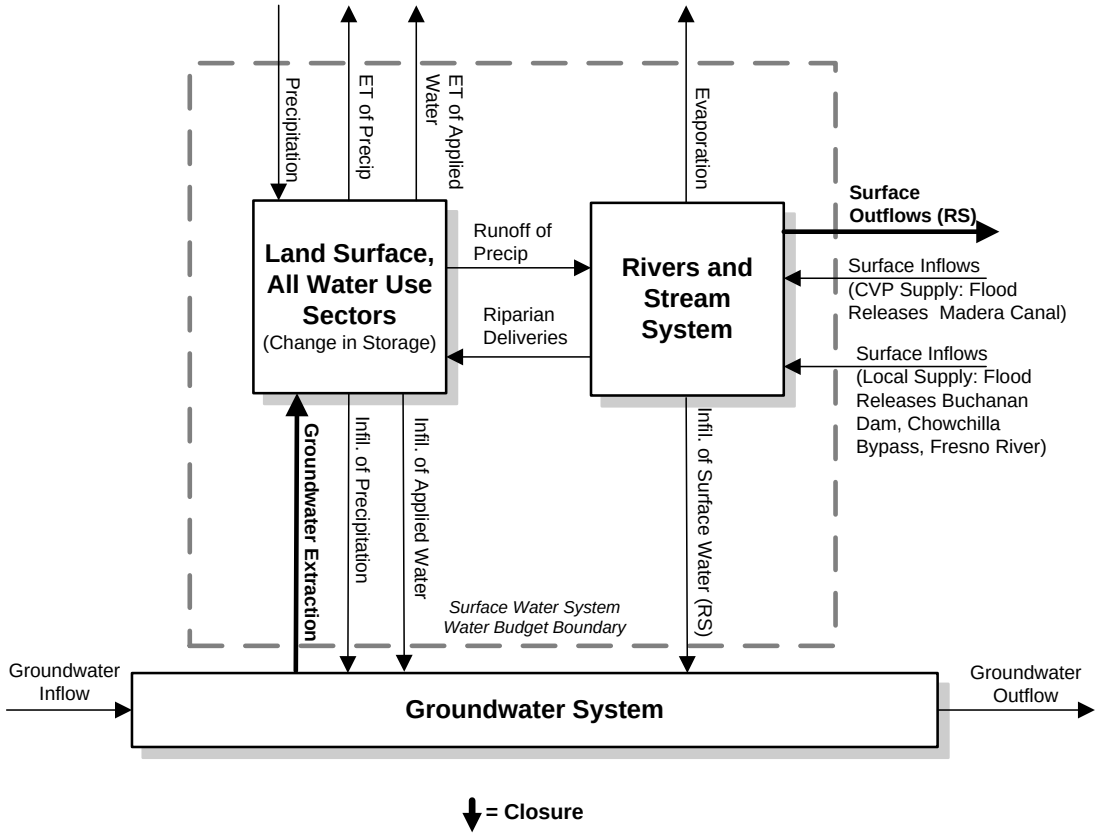

Figure 2. Triangle T Water District GSA Water Budget Structure

Water budget components, or directional flow of water between accounting centers and across the SWS boundary, are indicated by arrows. Inflows and outflows were calculated using measurements and other historical data or were calculated as the water budget closure term – the difference between all other estimated or measured inflows and outflows from each accounting center or water use sector (bold arrows).

Inflows to the SWS include precipitation, surface water inflows (in various canals and streams), and groundwater extraction. Outflows from the SWS include evapotranspiration (ET), surface water outflows (in various canals and streams), and infiltration to the groundwater system (seepage and deep percolation). Also represented in Figure 2 are inflows and outflows from the GWS, which are discussed and quantified at the subbasin level in the GWS water budget in GSP Section 2.2.3. Subsurface GWS inflows and outflows are not quantified on the water budget subregion scale.

Inflows and outflows were quantified following the process described in GSP Section 2.2.3 on a monthly time step for water years in the historical water budget base period (1989-2014 hydrologic and land use conditions), the current water budget (2015 land use using 1989-2014 average hydrologic conditions), and projected water budget. Four projected water budgets were prepared for the years 2019 through 2090 based on 1965 through 2015 hydrologic conditions, projected water supplies, and 2017 land use adjusted for urban area projected growth from 2017-2070 (areas were held constant from 2071-2090):

1. Historical hydrologic conditions and water supply data, with adjustment for projected alteration of available Friant releases by the San Joaquin River Restoration Program (SJRRP)[2]
    a. Without projects and management actions, and
    b. With projects and management actions
2. Historical hydrologic conditions and water supply data, with adjustment for projected alteration of available Friant releases by the SJRRP and adjustment for anticipated climate change per DWR-provided 2030 climate change factors
    a. Without projects and management actions, and
    b. With projects and management actions.

Information regarding the data sources and adjustments used to prepare the historical, current, and projected water budgets are described in GSP Section 2.2.3.

3 WATER BUDGET ANALYSIS

The historical water budget and current land use water budget for TTWD GSA are presented below following a summary of land use data relevant to water budget development. Land use data is provided for the 1989-2014 historical water budget period and for 2015, the current land use water budget period.

[2] Adjustments were based on the Friant Report ("Estimate of Future Friant Division Supplies for use in Groundwater Sustainability Plans, California," Friant Water Authority, 2018). Although the Friant Report accounts for climate change, it is considered the best available estimate of projected Friant releases under SJRRP. For comparison, projected Madera Canal deliveries under SJRRP were also estimated without account for climate change from the Kondolf Hydrographs (in "Effects to Water Supply and Friant Operations Resulting From Plaintiffs' Friant Release Requirements," Steiner, 2005). These estimates were approximately equal to the Friant Report 2030 climate change adjusted deliveries. Thus, the Friant Report projections were used instead to maintain consistent assumptions in estimating Madera Canal deliveries across all projected simulations.

3.1 Land Use

Land use estimates for 1989 through 2015 corresponding to water use sectors (as defined by the GSP Regulations) are summarized in Figure 3 and Table 1 for the TTWD GSA. According to GSP Regulations (23 CCR § 351(al)):

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

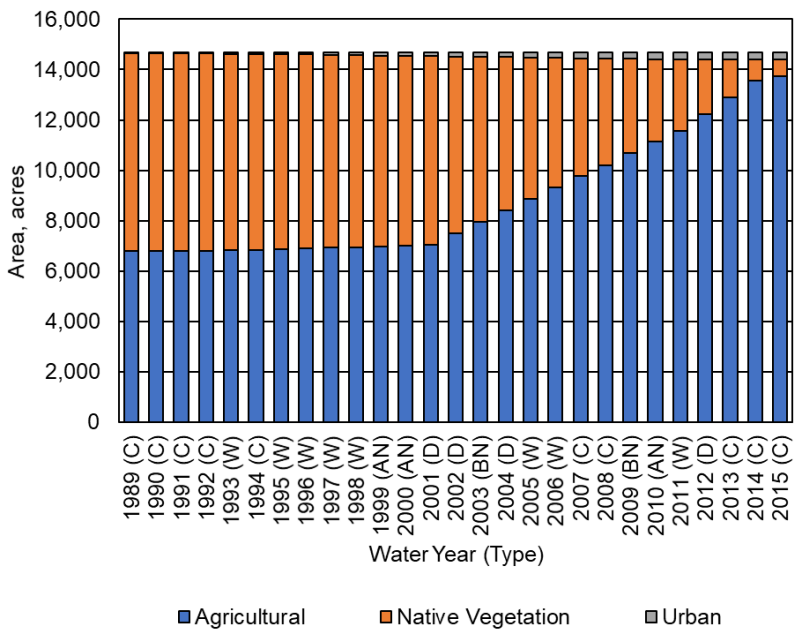

Figure 3. Triangle T Water District GSA Land Use Areas

Table 1. Triangle T Water District GSA Land Use Areas, acres

Water Year (Type)	Agricultural	Native Vegetation[1]	Urban[2]	Total
1989 (C)	6,792	7,844	55	14,691
1990 (C)	6,809	7,825	56	14,691
1991 (C)	6,813	7,819	58	14,691
1992 (C)	6,815	7,814	61	14,691
1993 (W)	6,825	7,801	64	14,691
1994 (C)	6,842	7,780	69	14,691
1995 (W)	6,872	7,745	74	14,691

Water Year (Type)	Agricultural	Native Vegetation[1]	Urban[2]	Total
1996 (W)	6,898	7,704	89	14,691
1997 (W)	6,924	7,663	104	14,691
1998 (W)	6,950	7,622	119	14,691
1999 (AN)	6,976	7,580	134	14,691
2000 (AN)	7,002	7,539	149	14,691
2001 (D)	7,029	7,498	164	14,691
2002 (D)	7,484	7,030	177	14,691
2003 (BN)	7,938	6,563	190	14,691
2004 (D)	8,393	6,095	202	14,691
2005 (W)	8,849	5,626	215	14,691
2006 (W)	9,304	5,159	228	14,691
2007 (C)	9,759	4,691	241	14,691
2008 (C)	10,214	4,223	253	14,691
2009 (BN)	10,670	3,754	266	14,691
2010 (AN)	11,125	3,287	279	14,691
2011 (W)	11,580	2,819	292	14,691
2012 (D)	12,243	2,159	288	14,691
2013 (C)	12,908	1,498	285	14,691
2014 (C)	13,571	838	281	14,691
2015 (C)	13,746	671	273	14,691
Average (1989-2014)	8,600	5,922	169	14,691

[1] Area includes land classified as native vegetation and water surfaces.
[2] Area includes land classified as urban, industrial, and semi-agricultural.

In TTWD GSA, water use sectors include agricultural, native vegetation, and urban land use. The urban land use category includes urban and semi-agricultural[3] lands as well as industrial land, which covers only a small area in the subbasin.

As indicated, the majority of land in TTWD GSA is currently used for agriculture, covering approximately 13,700 acres in 2015. Much of this land has gone into agricultural production since the early 2000s, largely replacing native vegetation in the GSA.

Agricultural land uses are further detailed in Figure 4 and Table 2. In the 1990s, a majority of the agricultural area in TTWD GSA was used to cultivate alfalfa, mixed pasture, and miscellaneous field crops. In recent years, these crops have been increasingly replaced by orchard crops, which expanded from less than 100 acres in 1989 to over 11,000 acres in 2015.

[3] As defined in the DWR county land use surveys, semi-agricultural land use subclasses include farmsteads, livestock feed lot operations, dairies, poultry farms, and miscellaneous semi-agricultural land use incidental to agriculture (small roads, ditches, non-planted areas of cropped fields (DWR, 2009).

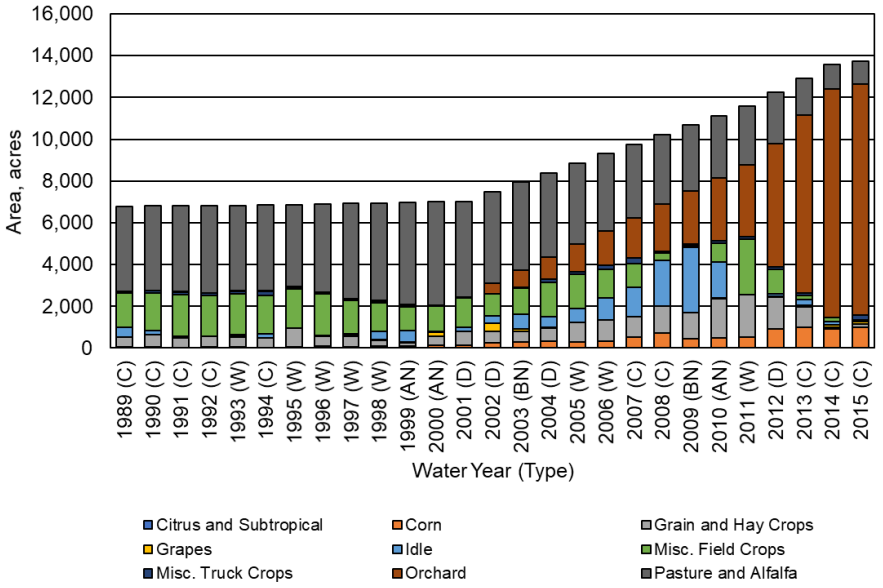

Figure 4. Triangle T Water District GSA Agricultural Land Use Areas

Table 2. Triangle T Water District GSA Agricultural Land Use Areas

Water Year (Type)	Citrus and Subtropical	Corn	Grain and Hay Crops	Grapes	Idle	Misc. Field Crops	Misc. Truck Crops	Orchard	Pasture and Alfalfa	Total
1989 (C)	0	45	463	5	473	1,643	65	16	4,083	6,792
1990 (C)	0	38	593	5	220	1,767	124	17	4,044	6,809
1991 (C)	0	35	439	5	96	1,989	116	21	4,111	6,813
1992 (C)	0	38	514	6	24	1,925	129	16	4,162	6,815
1993 (W)	0	40	500	6	89	1,964	127	16	4,082	6,825
1994 (C)	0	37	456	6	166	1,872	183	16	4,105	6,842
1995 (W)	0	38	905	7	12	1,886	72	16	3,935	6,872
1996 (W)	0	77	502	7	26	1,976	64	20	4,225	6,898
1997 (W)	5	59	509	16	75	1,616	78	24	4,543	6,924
1998 (W)	0	86	301	7	396	1,369	82	28	4,682	6,950
1999 (AN)	0	104	131	75	509	1,172	66	32	4,888	6,976
2000 (AN)	4	127	426	214	14	1,207	12	44	4,954	7,002
2001 (D)	0	118	677	7	201	1,410	1	39	4,576	7,029
2002 (D)	9	247	545	397	325	1,069	18	477	4,398	7,484
2003 (BN)	0	278	532	124	683	1,253	53	795	4,220	7,938
2004 (D)	0	313	643	37	508	1,623	183	1,043	4,043	8,393
2005 (W)	0	295	920	13	661	1,631	139	1,326	3,865	8,849
2006 (W)	0	350	985	3	1,052	1,386	206	1,635	3,687	9,304
2007 (C)	0	545	943	3	1,421	1,117	287	1,932	3,510	9,759
2008 (C)	0	730	1,279	12	2,194	349	54	2,263	3,332	10,214
2009 (BN)	0	452	1,248	2	3,125	57	104	2,528	3,155	10,670
2010 (AN)	0	499	1,879	11	1,746	898	121	2,994	2,977	11,125
2011 (W)	0	532	2,043	0	1	2,643	130	3,431	2,799	11,580
2012 (D)	0	921	1,505	36	137	1,167	128	5,888	2,461	12,243
2013 (C)	0	993	979	72	271	221	115	8,490	1,767	12,908
2014 (C)	0	900	108	108	155	189	11	10,925	1,174	13,571
2015 (C)	0	1,004	136	126	70	3	232	11,051	1,126	13,746
Average (1989-2014)	1	304	770	46	561	1,362	103	1,694	3,761	8,600

3.2 Surface Water System Water Budget

This section presents surface water system water budget components within TTWD GSA as per GSP regulations. These are followed by a summary of the water budget results by accounting center.

3.2.1 Inflows

3.2.1.1 Surface Water Inflow by Water Source Type

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

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

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

Local Supplies

Local supply inflows to TTWD GSA include inflows along Fresno River and Chowchilla Bypass.

CVP Supplies

CVP supply inflows to TTWD GSA include flood releases from Buchanan Dam and Millerton Reservoir that enter the subregion along Berenda Slough.

Recycling and Reuse

Recycling and reuse are not a significant source of supply within TTWD GSA.

Other Surface Inflows

For the water budgets presented herein, precipitation runoff from outside the subregion is considered relatively minimal and is expected to pass through the waterways accounted above following relatively large storm events. Precipitation runoff from lands inside the subregion is internal to the surface water system and is thus not considered as surface inflows to the subregion boundary.

Summary of Surface Inflows

The surface water inflows described above are summarized by water source type in Figure 5 and Table 3. During the study period, total surface water inflows vary by water year type, averaging 747 thousand acre-feet (taf) per wet year.

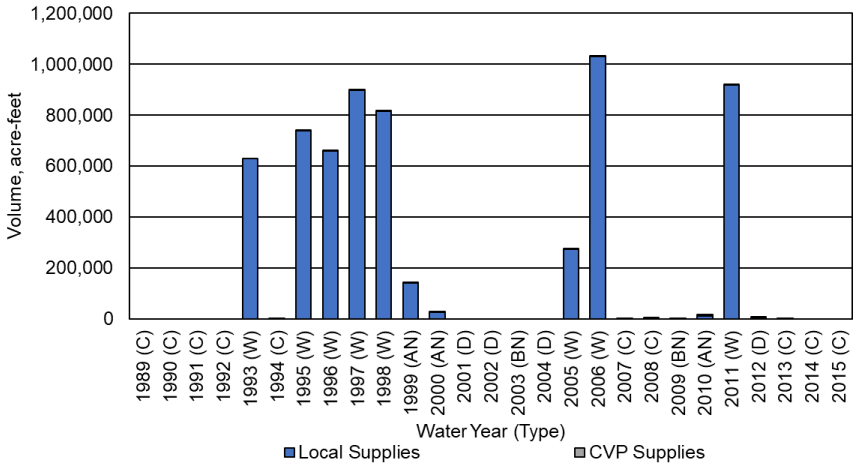

Figure 5. Triangle T Water District GSA Surface Water Inflows by Water Source Type.

Table 3. Triangle T Water District GSA Surface Water Inflows by Water Source Type (Acre-Feet).

Water Year (Type)	Local Supply	CVP Supply	Total
1989 (C)	0	0	0
1990 (C)	0	0	0
1991 (C)	0	0	0
1992 (C)	0	0	0
1993 (W)	630,140	0	630,140
1994 (C)	0	870	870
1995 (W)	739,540	1,320	740,860
1996 (W)	660,590	900	661,490
1997 (W)	897,730	1,920	899,650
1998 (W)	815,570	2,820	818,390
1999 (AN)	141,120	660	141,780
2000 (AN)	27,460	270	27,730
2001 (D)	0	0	0
2002 (D)	0	0	0
2003 (BN)	0	0	0
2004 (D)	0	0	0
2005 (W)	274,160	360	274,520
2006 (W)	1,030,340	1,320	1,031,660
2007 (C)	3,380	0	3,380
2008 (C)	2,320	20	2,330
2009 (BN)	620	500	1,120

Water Year (Type)	Local Supply	CVP Supply	Total
2010 (AN)	10,710	6,160	16,870
2011 (W)	916,970	2,620	919,590
2012 (D)	5,960	850	6,810
2013 (C)	1,040	510	1,550
2014 (C)	0	0	0
2015 (C)	0	0	0
Average (1989-2014)	236,830	810	237,640
Average (1989-2014) W	745,630	1,410	747,040
Average (1989-2014) AN	59,760	2,360	62,130
Average (1989-2014) BN	310	250	560
Average (1989-2014) D	1,490	210	1,700
Average (1989-2014) C	750	150	900

3.2.1.2 Precipitation

Precipitation estimates for TTWD GSA are provided in Figure 6 and Table 4. Precipitation estimates are reported by water use sector.

Total precipitation is highly variable between years in the study area, ranging from approximately 9 taf (7 inches) during average dry years to 17 taf (14 inches) during average wet years.

3.2.1.3 Groundwater Extraction by Water Use Sector

Estimates of groundwater extraction by water use sector are provided in Figure 7 and Table 5. For agricultural and urban (urban, semi-agricultural, industrial) lands, groundwater extraction represents pumping, while for native lands, groundwater extraction by riparian vegetation was considered to be negligible. In all water use sector water budgets, groundwater extraction served as the water budget closure term. Groundwater extraction is dominated by irrigated agriculture and increases over time, following the trend of increasing orchard acreage in the subregion. The consumptive water use of orchards is higher than most other crops grown in the subbasin, and groundwater serves as a major source of supply for the pressurized irrigation systems typical of orchards. During wet years, groundwater extraction is reduced in months when surface water is available to water rights users.

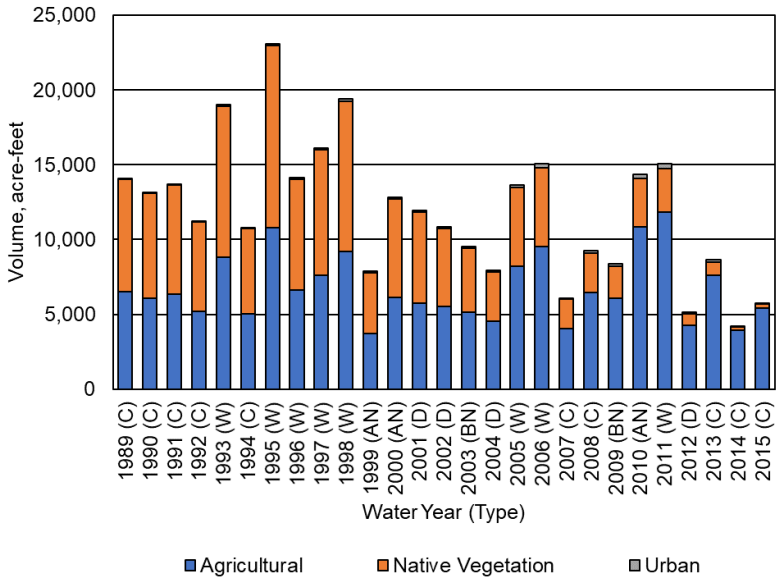

Figure 6. Triangle T Water District GSA Precipitation by Water Use Sector.

Table 4. Triangle T Water District GSA Precipitation by Water Use Sector (Acre-Feet).

Water Year (Type)	Agricultural	Native Vegetation	Urban	Total
1989 (C)	6,510	7,530	50	14,090
1990 (C)	6,090	7,000	50	13,140
1991 (C)	6,370	7,310	60	13,730
1992 (C)	5,200	5,970	50	11,210
1993 (W)	8,830	10,100	80	19,010
1994 (C)	5,010	5,710	50	10,770
1995 (W)	10,810	12,190	120	23,110
1996 (W)	6,630	7,410	90	14,130
1997 (W)	7,610	8,420	110	16,140
1998 (W)	9,180	10,070	160	19,410
1999 (AN)	3,740	4,060	70	7,870
2000 (AN)	6,110	6,590	130	12,830
2001 (D)	5,730	6,110	130	11,970
2002 (D)	5,530	5,200	130	10,860
2003 (BN)	5,150	4,260	120	9,540
2004 (D)	4,530	3,290	110	7,930
2005 (W)	8,230	5,240	200	13,670
2006 (W)	9,530	5,290	230	15,060
2007 (C)	4,050	1,950	100	6,100
2008 (C)	6,440	2,670	160	9,260

Water Year (Type)	Agricultural	Native Vegetation	Urban	Total
2009 (BN)	6,070	2,140	150	8,360
2010 (AN)	10,880	3,220	270	14,370
2011 (W)	11,860	2,890	300	15,050
2012 (D)	4,270	750	100	5,120
2013 (C)	7,610	880	170	8,660
2014 (C)	3,910	240	80	4,230
2015 (C)	5,400	260	110	5,770
Average (1989-2014)	6,760	5,250	130	12,140
Average (1989-2014) W	9,080	7,700	160	16,950
Average (1989-2014) AN	6,910	4,620	160	11,690
Average (1989-2014) BN	5,610	3,200	140	8,950
Average (1989-2014) D	5,010	3,840	120	8,970
Average (1989-2014) C	5,690	4,360	80	10,130

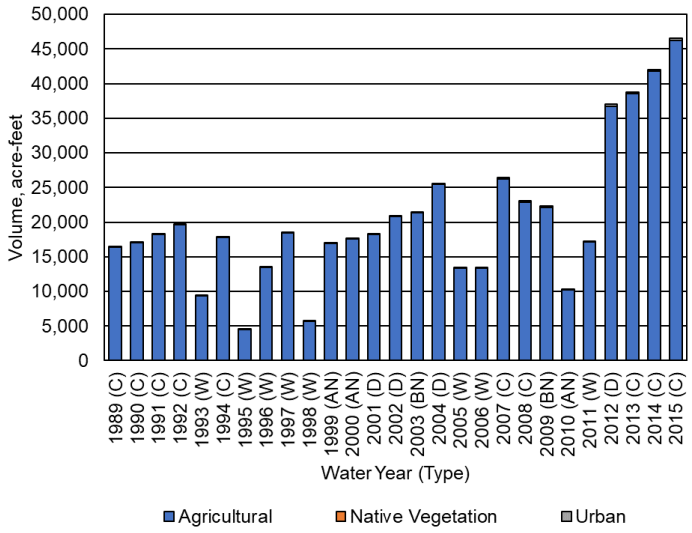

Figure 7. Triangle T Water District GSA Groundwater Extraction by Water Use Sector.

Table 5. Triangle T Water District GSA Groundwater Extraction by Water Use Sector (Acre-Feet).

Water Year (Type)	Agricultural	Native Vegetation	Urban	Total
1989 (C)	16,394	0	31	16,425
1990 (C)	17,065	0	33	17,098
1991 (C)	18,175	0	39	18,214
1992 (C)	19,632	0	47	19,679
1993 (W)	9,383	0	36	9,419
1994 (C)	17,755	0	48	17,803
1995 (W)	4,526	0	24	4,550
1996 (W)	13,425	0	50	13,475
1997 (W)	18,475	0	92	18,567
1998 (W)	5,703	0	50	5,753
1999 (AN)	16,940	0	97	17,037
2000 (AN)	17,613	0	91	17,704
2001 (D)	18,213	0	98	18,311
2002 (D)	20,786	0	135	20,921
2003 (BN)	21,344	0	137	21,481
2004 (D)	25,414	0	190	25,604
2005 (W)	13,324	0	119	13,443
2006 (W)	13,319	0	120	13,439
2007 (C)	26,217	0	212	26,429
2008 (C)	22,910	0	211	23,121
2009 (BN)	22,076	0	215	22,291
2010 (AN)	10,222	0	120	10,342
2011 (W)	17,120	0	134	17,254
2012 (D)	36,765	0	252	37,017
2013 (C)	38,526	0	243	38,769
2014 (C)	41,814	0	239	42,053
2015 (C)	46,248	0	264	46,512
Average (1989-2014)	19,351	0	118	19,469
Average (1989-2014) W	11,909	0	78	11,988
Average (1989-2014) AN	14,925	0	103	15,027
Average (1989-2014) BN	21,710	0	176	21,886
Average (1989-2014) D	25,295	0	169	25,463
Average (1989-2014) C	24,276	0	123	24,399

3.2.1.4 Groundwater Discharge to Surface Water Sources

The depth to groundwater is greater than 100-200 ft across much of the Chowchilla Subbasin. Given the depth to the water table in the Chowchilla Subbasin, groundwater discharge to surface water sources is negligible.

3.2.2 Outflows

3.2.2.1 Evapotranspiration by Water Use Sector

Evapotranspiration (ET) by water use sector is reported in Figures 8 to 10 and Tables 6 to 8. First, total ET is reported, followed by ET from applied water and ET from precipitation.

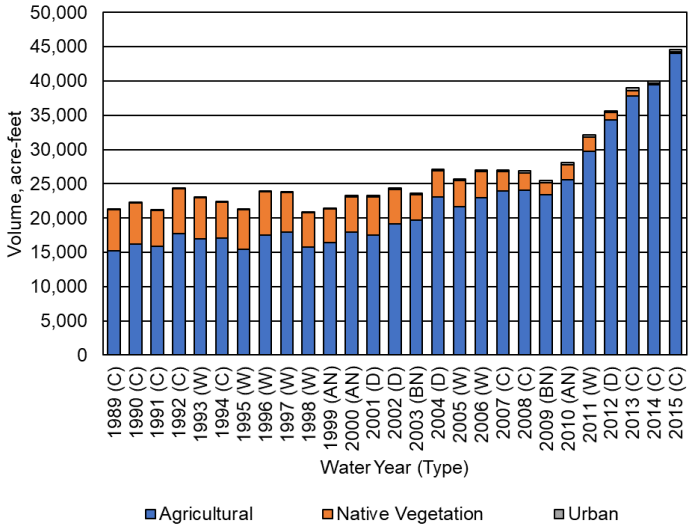

Figure 8. Triangle T Water District GSA Evapotranspiration by Water Use Sector.

Table 6. Triangle T Water District GSA Evapotranspiration by Water Use Sector (Acre-Feet).

Water Year (Type)	Agricultural	Native Vegetation	Urban	Total
1989 (C)	15,240	5,940	70	21,250
1990 (C)	16,200	5,980	70	22,250
1991 (C)	15,850	5,320	70	21,240
1992 (C)	17,770	6,560	80	24,410
1993 (W)	16,930	6,090	80	23,100
1994 (C)	17,050	5,240	80	22,370
1995 (W)	15,480	5,790	80	21,350
1996 (W)	17,510	6,320	100	23,930
1997 (W)	17,970	5,720	120	23,810
1998 (W)	15,720	5,030	120	20,870
1999 (AN)	16,460	4,850	140	21,450
2000 (AN)	17,950	5,180	170	23,300
2001 (D)	17,480	5,590	190	23,260
2002 (D)	19,130	5,010	210	24,350
2003 (BN)	19,700	3,710	220	23,630
2004 (D)	23,050	3,800	260	27,110

Water Year (Type)	Agricultural	Native Vegetation	Urban	Total
2005 (W)	21,690	3,790	240	25,720
2006 (W)	22,940	3,850	260	27,050
2007 (C)	23,960	2,810	270	27,040
2008 (C)	24,070	2,480	310	26,860
2009 (BN)	23,360	1,800	310	25,470
2010 (AN)	25,550	2,210	300	28,060
2011 (W)	29,700	2,110	310	32,120
2012 (D)	34,350	1,020	290	35,660
2013 (C)	37,800	830	340	38,970
2014 (C)	39,430	250	280	39,960
2015 (C)	44,010	230	310	44,550
Average (1989-2014)	21,630	4,130	190	25,950
Average (1989-2014) W	19,740	4,840	170	24,750
Average (1989-2014) AN	19,990	4,080	200	24,270
Average (1989-2014) BN	21,540	2,750	270	24,560
Average (1989-2014) D	23,500	3,850	230	27,580
Average (1989-2014) C	23,040	3,930	180	27,150

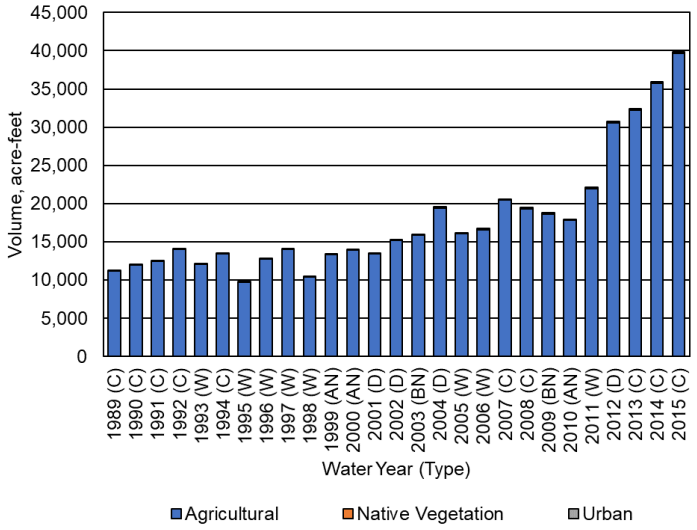

Figure 9. Triangle T Water District GSA Evapotranspiration of Applied Water by Water Use Sector.

Table 7. Triangle T Water District GSA Evapotranspiration of Applied Water by Water Use Sector (Acre-Feet).

Water Year (Type)	Agricultural	Native Vegetation	Urban	Total
1989 (C)	11,200	0	30	11,230
1990 (C)	11,960	0	30	11,990
1991 (C)	12,450	0	30	12,480
1992 (C)	14,060	0	40	14,100
1993 (W)	12,050	0	30	12,080
1994 (C)	13,470	0	40	13,510
1995 (W)	9,690	0	20	9,710
1996 (W)	12,730	0	30	12,760
1997 (W)	14,020	0	50	14,070
1998 (W)	10,400	0	50	10,450
1999 (AN)	13,360	0	60	13,420
2000 (AN)	13,900	0	80	13,980
2001 (D)	13,390	0	80	13,470
2002 (D)	15,180	0	100	15,280
2003 (BN)	15,850	0	120	15,970
2004 (D)	19,440	0	150	19,590
2005 (W)	16,040	0	110	16,150
2006 (W)	16,610	0	110	16,720
2007 (C)	20,470	0	140	20,610
2008 (C)	19,350	0	180	19,530
2009 (BN)	18,580	0	190	18,770
2010 (AN)	17,830	0	130	17,960
2011 (W)	21,990	0	110	22,100
2012 (D)	30,550	0	160	30,710
2013 (C)	32,260	0	200	32,460
2014 (C)	35,700	0	200	35,900
2015 (C)	39,670	0	220	39,890
Average (1989-2014)	17,020	0	90	17,110
Average (1989-2014) W	14,190	0	70	14,260
Average (1989-2014) AN	15,030	0	90	15,120
Average (1989-2014) BN	17,220	0	160	17,380
Average (1989-2014) D	19,640	0	120	19,760
Average (1989-2014) C	18,990	0	100	19,090

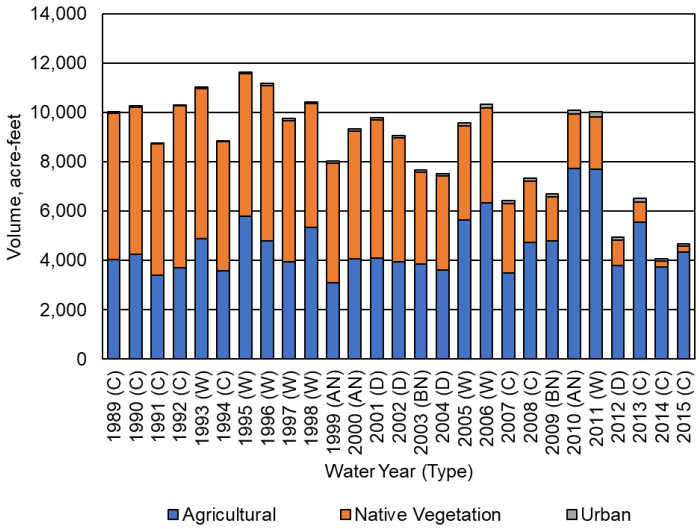

Figure 10. Triangle T Water District GSA Evapotranspiration of Precipitation by Water Use Sector.

Table 8. Triangle T Water District GSA Evapotranspiration of Precipitation by Water Use Sector (Acre-Feet).

Water Year (Type)	Agricultural	Native Vegetation	Urban	Total
1989 (C)	4,040	5,940	40	10,020
1990 (C)	4,240	5,980	40	10,260
1991 (C)	3,400	5,320	40	8,760
1992 (C)	3,710	6,560	40	10,310
1993 (W)	4,880	6,090	50	11,020
1994 (C)	3,580	5,240	40	8,860
1995 (W)	5,790	5,790	60	11,640
1996 (W)	4,780	6,320	70	11,170
1997 (W)	3,950	5,720	70	9,740
1998 (W)	5,320	5,030	70	10,420
1999 (AN)	3,100	4,850	80	8,030
2000 (AN)	4,050	5,180	90	9,320
2001 (D)	4,090	5,590	110	9,790
2002 (D)	3,950	5,010	110	9,070
2003 (BN)	3,850	3,710	100	7,660
2004 (D)	3,610	3,800	110	7,520
2005 (W)	5,650	3,790	130	9,570
2006 (W)	6,330	3,850	150	10,330
2007 (C)	3,490	2,810	130	6,430
2008 (C)	4,720	2,480	130	7,330
2009 (BN)	4,780	1,800	120	6,700
2010 (AN)	7,720	2,210	170	10,100

Water Year (Type)	Agricultural	Native Vegetation	Urban	Total
2011 (W)	7,710	2,110	200	10,020
2012 (D)	3,800	1,020	130	4,950
2013 (C)	5,540	830	140	6,510
2014 (C)	3,730	250	80	4,060
2015 (C)	4,340	230	90	4,660
Average (1989-2014)	4,610	4,130	100	8,840
Average (1989-2014) W	5,550	4,840	100	10,490
Average (1989-2014) AN	4,960	4,080	110	9,150
Average (1989-2014) BN	4,320	2,750	110	7,180
Average (1989-2014) D	3,860	3,850	110	7,820
Average (1989-2014) C	4,050	3,930	80	8,060

Total ET varies between years, with the lowest observed in 1998, at less than 21 taf, and greatest in 2015, at approximately 45 taf. Total ET generally increases over time, again following the trend of increasing orchard acreage.

In addition to ET from land surfaces, estimates of evaporation from TTWD GSA rivers and streams are reported in Figure 11 and Table 9. Evaporation from the Rivers and Streams System includes evaporation of both surface inflows and of precipitation runoff within local sloughs and depressions. Total evaporation from all sources averaged less than 1 taf per year between 1989 and 2014.

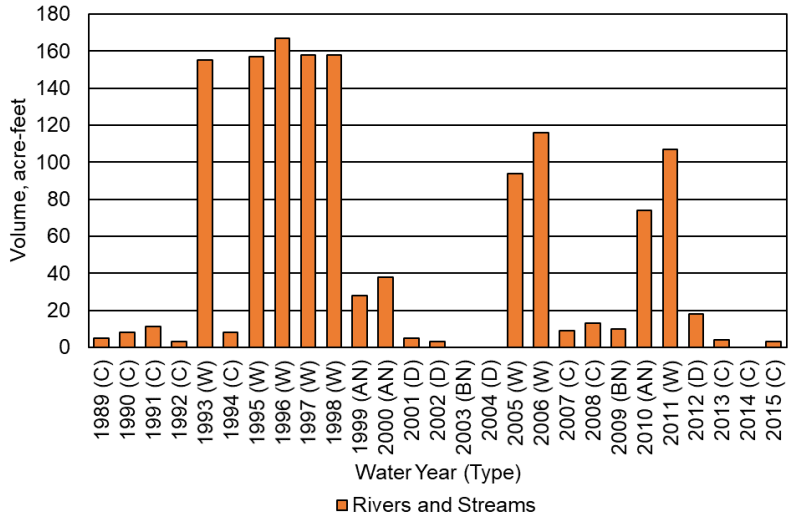

Figure 11. Triangle T Water District GSA Evaporation from the Surface Water System.

Table 9. Triangle T Water District GSA Evaporation from the Surface Water System (Acre-Feet).

Water Year (Type)	Rivers and Streams[1]
1989 (C)	10
1990 (C)	10
1991 (C)	10
1992 (C)	0
1993 (W)	160
1994 (C)	10
1995 (W)	160
1996 (W)	170
1997 (W)	160
1998 (W)	160
1999 (AN)	30
2000 (AN)	40
2001 (D)	10
2002 (D)	0
2003 (BN)	0
2004 (D)	0
2005 (W)	90
2006 (W)	120
2007 (C)	10
2008 (C)	10
2009 (BN)	10
2010 (AN)	70
2011 (W)	110
2012 (D)	20
2013 (C)	0
2014 (C)	0
2015 (C)	0
Average (1989-2014)	50
Average (1989-2014) W	140
Average (1989-2014) AN	50
Average (1989-2014) BN	10
Average (1989-2014) D	10
Average (1989-2014) C	10

[1] Includes evaporation of surface inflows and of precipitation runoff.

3.2.2.2 Surface Water Outflow by Water Source Type

Surface water outflows by water source type are summarized in Figure 12 and Table 10. In TTWD GSA, runoff of applied water is assumed negligible and runoff of precipitation is collected in waterways within TTWD GSA, with most infiltrating to the groundwater system except following the largest storm events. Thus, surface outflows from the GSA are expected to be a mixture of local supplies and CVP supplies along Eastside Bypass and Fresno River. Between 1989 and 2014, these combined outflows averaged approximately 726 taf during wet years.

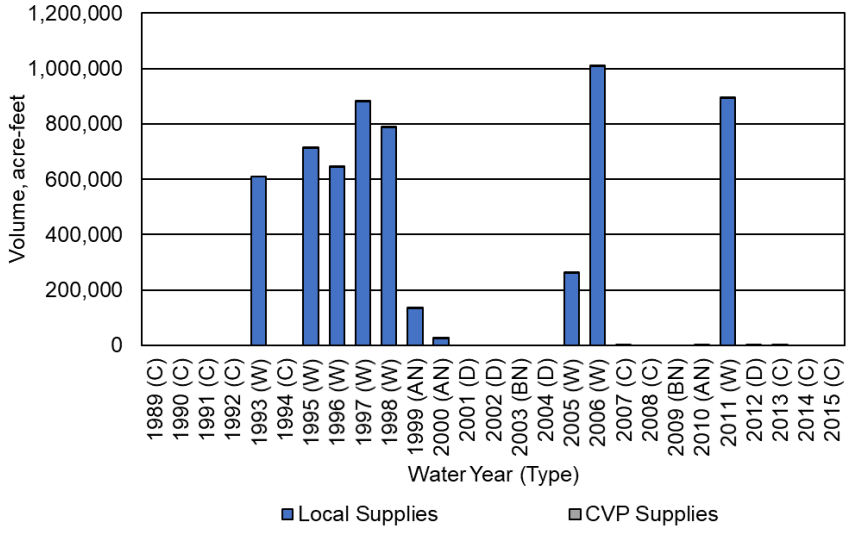

Figure 12. Triangle T Water District GSA Surface Outflows by Water Source Type.

Table 10. Triangle T Water District GSA Surface Outflows by Water Source Type (Acre-Feet).

Water Year (Type)	Local Supplies	CVP Supplies	Total
1989 (C)	0	0	0
1990 (C)	0	0	0
1991 (C)	0	0	0
1992 (C)	0	0	0
1993 (W)	609,400	0	609,400
1994 (C)	0	0	0
1995 (W)	712,830	1,280	714,110
1996 (W)	642,890	840	643,730
1997 (W)	882,030	1,870	883,900
1998 (W)	786,740	2,690	789,430
1999 (AN)	134,560	640	135,200
2000 (AN)	23,670	250	23,920
2001 (D)	0	0	0
2002 (D)	0	0	0
2003 (BN)	0	0	0
2004 (D)	0	0	0
2005 (W)	260,810	350	261,160
2006 (W)	1,009,250	1,260	1,010,510
2007 (C)	1,740	0	1,740
2008 (C)	0	0	0
2009 (BN)	0	0	0
2010 (AN)	370	0	370
2011 (W)	892,570	740	893,310

Water Year (Type)	Local Supplies	CVP Supplies	Total
2012 (D)	3,900	0	3,900
2013 (C)	270	0	270
2014 (C)	0	0	0
2015 (C)	0	0	0
Average (1989-2014)	229,270	380	229,650
Average (1989-2014) W	724,570	1,130	725,690
Average (1989-2014) AN	52,870	300	53,160
Average (1989-2014) BN	0	0	0
Average (1989-2014) D	980	0	980
Average (1989-2014) C	220	0	220

3.2.2.3 Infiltration of Precipitation

Estimated infiltration of precipitation (deep percolation of precipitation) by water use sector is provided in Figure 13 and Table 11. Infiltration of precipitation to the groundwater system is highly variable from year to year due to variation in the timing and amount of precipitation, ranging from less than 2 taf annually during some critical and dry years to over 8 taf during 1995.

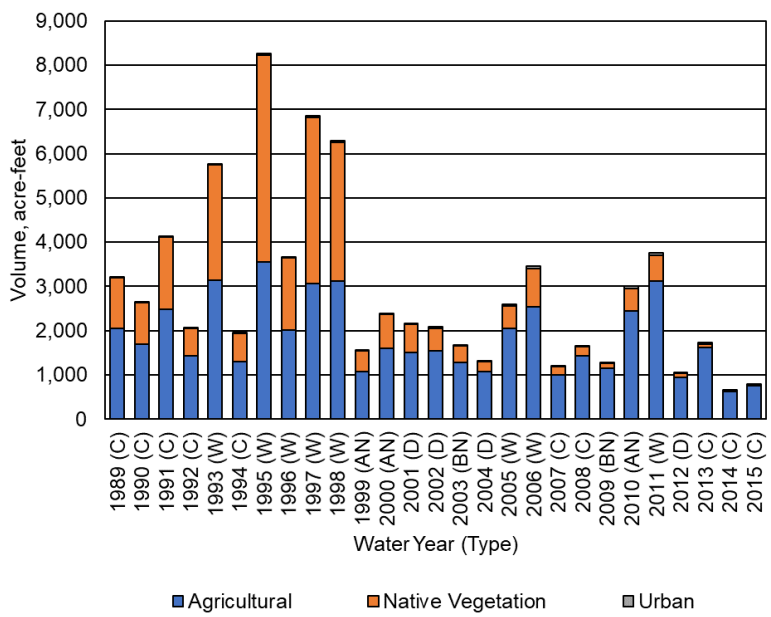

Figure 13. Triangle T Water District GSA Infiltration of Precipitation by Water Use Sector.

Table 11. Triangle T Water District GSA Infiltration of Precipitation by Water Use Sector (Acre-Feet).

Water Year (Type)	Agricultural	Native Vegetation	Urban	Total
1989 (C)	2,050	1,150	10	3,210
1990 (C)	1,690	940	10	2,640
1991 (C)	2,490	1,630	20	4,140
1992 (C)	1,430	620	10	2,060
1993 (W)	3,130	2,610	20	5,760
1994 (C)	1,310	630	10	1,950
1995 (W)	3,560	4,660	40	8,260
1996 (W)	2,010	1,640	20	3,670
1997 (W)	3,070	3,750	40	6,860
1998 (W)	3,120	3,130	50	6,300
1999 (AN)	1,080	460	10	1,550
2000 (AN)	1,600	770	20	2,390
2001 (D)	1,510	630	20	2,160
2002 (D)	1,540	520	20	2,080
2003 (BN)	1,280	370	20	1,670
2004 (D)	1,080	220	20	1,320
2005 (W)	2,050	510	30	2,590
2006 (W)	2,530	870	50	3,450
2007 (C)	1,010	180	20	1,210
2008 (C)	1,430	210	20	1,660
2009 (BN)	1,150	120	20	1,290
2010 (AN)	2,450	500	60	3,010
2011 (W)	3,120	580	60	3,760
2012 (D)	940	90	20	1,050
2013 (C)	1,620	80	30	1,730
2014 (C)	630	10	10	650
2015 (C)	760	20	10	790
Average (1989-2014)	1,880	1,030	30	2,940
Average (1989-2014) W	2,820	2,220	40	5,080
Average (1989-2014) AN	1,710	580	30	2,320
Average (1989-2014) BN	1,220	250	20	1,490
Average (1989-2014) D	1,270	370	20	1,660
Average (1989-2014) C	1,520	610	20	2,150

3.2.2.4 Infiltration of Surface Water

Estimated infiltration of surface water (seepage) by source is provided in Figure 14 and Table 12. Seepage from the Rivers and Streams System includes seepage of both surface inflows and of precipitation runoff into local sloughs and depressions. Seepage from rivers and streams follows the pattern of surface water inflows, averaging approximately 10 taf per wet year between 1989 and 2014.

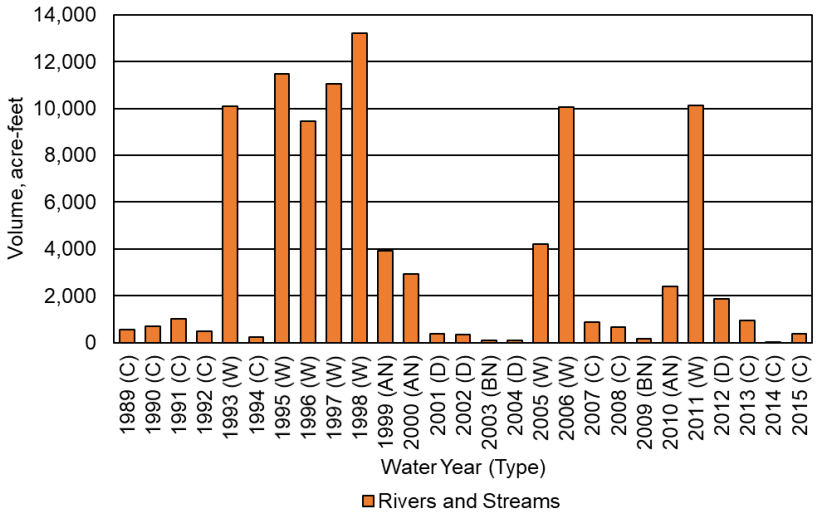

Figure 14. Triangle T Water District GSA Infiltration of Surface Water.

Table 12. Triangle T Water District GSA Infiltration of Surface Water (Acre-Feet).

Water Year (Type)	Rivers and Streams[1]
1989 (C)	540
1990 (C)	690
1991 (C)	1,010
1992 (C)	480
1993 (W)	10,110
1994 (C)	240
1995 (W)	11,470
1996 (W)	9,440
1997 (W)	11,040
1998 (W)	13,210
1999 (AN)	3,910
2000 (AN)	2,920
2001 (D)	370
2002 (D)	330
2003 (BN)	100
2004 (D)	80
2005 (W)	4,210
2006 (W)	10,070
2007 (C)	890
2008 (C)	660
2009 (BN)	150
2010 (AN)	2,390
2011 (W)	10,140

Water Year (Type)	Rivers and Streams[1]
2012 (D)	1,880
2013 (C)	940
2014 (C)	30
2015 (C)	390
Average (1989-2014)	3,740
Average (1989-2014) W	9,960
Average (1989-2014) AN	3,070
Average (1989-2014) BN	130
Average (1989-2014) D	670
Average (1989-2014) C	610

[1] Includes infiltration of surface inflows and of precipitation runoff within the subregion. To calculate Net Recharge from SWS below, Rivers and Streams System seepage is summed across the subbasin and redistributed to each subregion in proportion to gross area.

3.2.2.5 Infiltration of Applied Water

Estimated infiltration of applied water (deep percolation of applied water) by water use sector is provided in Figure 15 and Table 13. Infiltration of applied water is dominated by agricultural irrigation and has increased over time due to the expansion of agriculture land in the GSA.

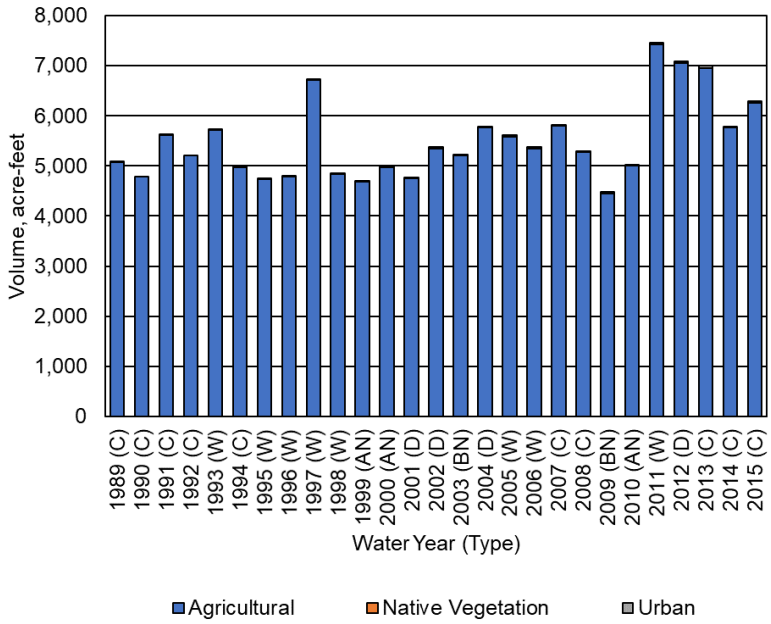

Figure 15. Triangle T Water District GSA Infiltration of Applied Water by Water Use Sector.

Table 13. Triangle T Water District GSA Infiltration of Applied Water by Water Use Sector (Acre-Feet).

Water Year (Type)	Agricultural	Native Vegetation	Urban	Total
1989 (C)	5,080	0	10	5,090
1990 (C)	4,790	0	0	4,790
1991 (C)	5,620	0	10	5,630
1992 (C)	5,210	0	0	5,210
1993 (W)	5,710	0	10	5,720
1994 (C)	4,980	0	10	4,990
1995 (W)	4,730	0	10	4,740
1996 (W)	4,790	0	10	4,800
1997 (W)	6,720	0	20	6,740
1998 (W)	4,830	0	20	4,850
1999 (AN)	4,690	0	10	4,700
2000 (AN)	4,970	0	20	4,990
2001 (D)	4,750	0	20	4,770
2002 (D)	5,350	0	20	5,370
2003 (BN)	5,210	0	20	5,230
2004 (D)	5,760	0	20	5,780
2005 (W)	5,580	0	30	5,610
2006 (W)	5,350	0	30	5,380
2007 (C)	5,800	0	20	5,820
2008 (C)	5,270	0	30	5,300
2009 (BN)	4,450	0	30	4,480
2010 (AN)	5,000	0	30	5,030
2011 (W)	7,430	0	30	7,460
2012 (D)	7,050	0	30	7,080
2013 (C)	6,960	0	40	7,000
2014 (C)	5,760	0	30	5,790
2015 (C)	6,260	0	30	6,290
Average (1989-2014)	5,460	0	20	5,480
Average (1989-2014) W	5,640	0	20	5,660
Average (1989-2014) AN	4,890	0	20	4,910
Average (1989-2014) BN	4,830	0	30	4,860
Average (1989-2014) D	5,730	0	20	5,750
Average (1989-2014) C	5,500	0	20	5,520

3.2.3 Change in Surface Water System Storage

Estimates of change in SWS storage are provided in Figure 16 and Table 14. Inter-annual changes in storage within the surface water system consist primarily of root zone soil moisture storage changes, are relatively small, and tend to average near zero over many years. During wet years, change in SWS storage is estimated as higher during some months when estimated riparian deliveries satisfy much of the crop water demand, substantially reducing groundwater pumping estimates.

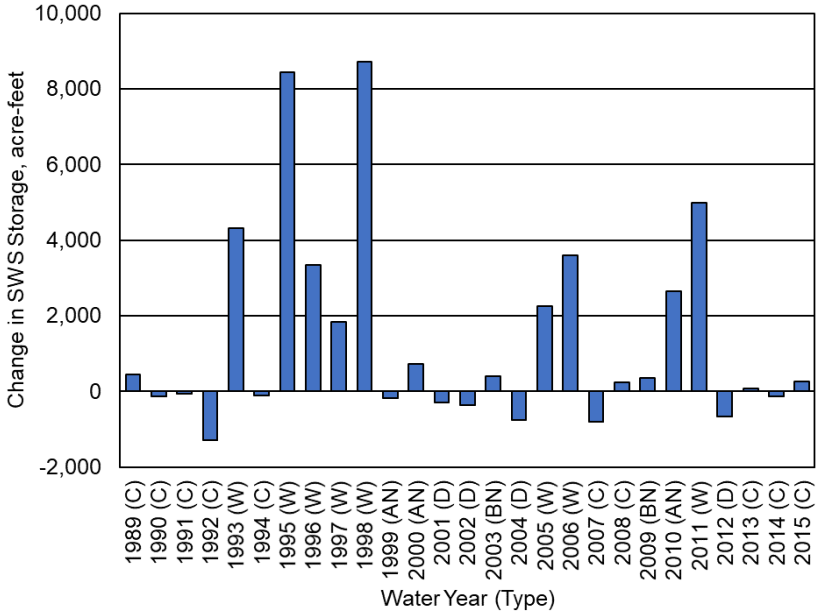

Figure 16. Triangle T Water District GSA Change in Surface Water System Storage.

Table 14. Triangle T Water District GSA Change in Surface Water System Storage (Acre-Feet).

Water Year (Type)	Change in SWS Storage
1989 (C)	440
1990 (C)	-140
1991 (C)	-60
1992 (C)	-1,280
1993 (W)	4,320
1994 (C)	-100
1995 (W)	8,440
1996 (W)	3,350
1997 (W)	1,840
1998 (W)	8,730
1999 (AN)	-170
2000 (AN)	720
2001 (D)	-280
2002 (D)	-350
2003 (BN)	410
2004 (D)	-760
2005 (W)	2,250
2006 (W)	3,590
2007 (C)	-790

Water Year (Type)	Change in SWS Storage
2008 (C)	250
2009 (BN)	360
2010 (AN)	2,650
2011 (W)	5,000
2012 (D)	-650
2013 (C)	70
2014 (C)	-140
2015 (C)	270
Average (1989-2014)	1,450
Average (1989-2014) W	4,690
Average (1989-2014) AN	1,070
Average (1989-2014) BN	390
Average (1989-2014) D	-510
Average (1989-2014) C	-190

3.3 Historical Water Budget Summary

Annual inflows, outflows, and change in SWS storage during the historical water budget period (1989-2014) are summarized in Figure 17 and Table 15. Inflows are shown as positive values, while outflows and change in SWS storage are shown as negative values. During wet years, boundary surface inflow and outflow volumes are substantially higher than other components. Figure 17 thus only shows the difference between the surface inflows and surface outflows after seepage and evaporation are accounted within TTWD GSA. Review of the variability in component volumes across years provides insight into the impacts of hydrology on the surface water system water budget.

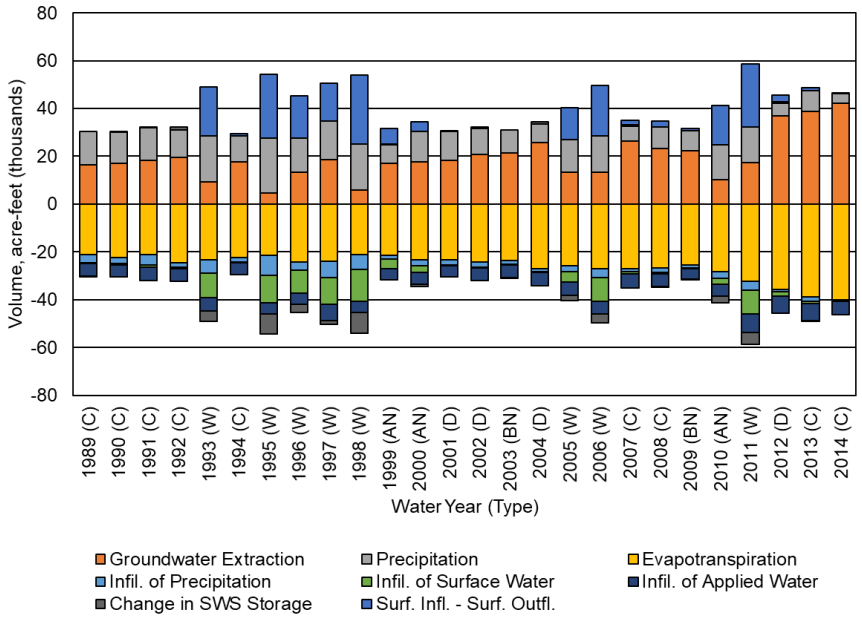

Figure 17. Triangle T Water District GSA Surface Water System Historical Water Budget, 1989-2014.

Table 15. Triangle T Water District GSA Surface Water System Historical Water Budget, 1989-2014 (Acre-Feet).

Water Year	Boundary Surface Inflows	Groundwater Extraction	Precipitation	Evapo-transpiration[1]	Infil. of Precipitation	Infil. of Surface Water[2]	Infil. of Applied Water	Boundary Surface Outflows	Change in SWS Storage
1989 (C)	0	16,430	14,090	-21,240	-3,210	-540	-5,090	0	-440
1990 (C)	0	17,100	13,140	-22,250	-2,640	-690	-4,790	0	140
1991 (C)	0	18,210	13,730	-21,230	-4,140	-1,010	-5,620	0	60
1992 (C)	0	19,680	11,210	-24,420	-2,060	-480	-5,210	0	1,280
1993 (W)	630,140	9,420	19,010	-23,260	-5,760	-10,110	-5,720	-609,400	-4,320
1994 (C)	870	17,800	10,770	-22,370	-1,940	-240	-4,990	0	100
1995 (W)	740,860	4,550	23,110	-21,510	-8,260	-11,470	-4,740	-714,110	-8,440
1996 (W)	661,490	13,480	14,130	-24,100	-3,670	-9,440	-4,800	-643,730	-3,350
1997 (W)	899,650	18,570	16,140	-23,970	-6,860	-11,040	-6,740	-883,900	-1,840
1998 (W)	818,390	5,750	19,410	-21,030	-6,300	-13,210	-4,850	-789,430	-8,730
1999 (AN)	141,780	17,040	7,870	-21,480	-1,560	-3,910	-4,710	-135,200	170
2000 (AN)	27,730	17,700	12,830	-23,340	-2,390	-2,920	-4,980	-23,920	-720
2001 (D)	0	18,310	11,970	-23,270	-2,160	-370	-4,760	0	280
2002 (D)	0	20,920	10,860	-24,350	-2,080	-330	-5,370	0	350
2003 (BN)	0	21,480	9,540	-23,630	-1,670	-100	-5,230	0	-410
2004 (D)	0	25,600	7,930	-27,100	-1,320	-80	-5,790	0	760
2005 (W)	274,520	13,440	13,670	-25,810	-2,590	-4,210	-5,620	-261,160	-2,250
2006 (W)	1,031,670	13,440	15,060	-27,170	-3,450	-10,070	-5,370	-1,010,510	-3,590
2007 (C)	3,380	26,430	6,100	-27,060	-1,200	-890	-5,820	-1,740	790
2008 (C)	2,330	23,120	9,260	-26,860	-1,660	-660	-5,290	0	-250
2009 (BN)	1,120	22,290	8,360	-25,490	-1,290	-150	-4,480	0	-360
2010 (AN)	16,870	10,340	14,370	-28,130	-3,000	-2,390	-5,030	-370	-2,650
2011 (W)	919,590	17,250	15,050	-32,230	-3,760	-10,140	-7,460	-893,310	-5,000
2012 (D)	6,810	37,020	5,120	-35,680	-1,060	-1,880	-7,080	-3,900	650
2013 (C)	1,560	38,770	8,660	-38,970	-1,730	-940	-7,010	-270	-70
2014 (C)	0	42,050	4,230	-39,950	-650	-30	-5,800	0	140
Average (1989-2014)	237,640	19,470	12,140	-26,000	-2,940	-3,740	-5,470	-229,650	-1,450
W	747,040	11,990	16,950	-24,890	-5,080	-9,960	-5,660	-725,690	-4,690
AN	62,130	15,030	11,690	-24,320	-2,320	-3,070	-4,910	-53,160	-1,070
BN	560	21,890	8,950	-24,560	-1,480	-120	-4,850	0	-390
D	1,700	25,460	8,970	-27,600	-1,650	-670	-5,750	-980	510
C	900	24,400	10,130	-27,150	-2,140	-610	-5,510	-220	190

[1]Includes ET of applied water, ET of precipitation, and evaporation from the Rivers and Streams System.
[2]Includes infiltration from the Rivers and Streams System within the subregion. To calculate Net Recharge from SWS below, Rivers and Streams System seepage is summed across the subbasin and redistributed to each subregion in proportion to gross area.

3.4 Current Water Budget Summary

The current water budget was developed following a similar process to the historical water budget using the 2015 land use in Table 1 and the same 1989-2014 average hydrologic conditions of the historical base period, including surface water flows, precipitation, and weather parameters. This allowed quantification of groundwater inflows and outflows for current consumptive use in the context of average water supply conditions.

Annual inflows, outflows, and change in SWS storage from the current water budget are summarized in Figure 18 and Table 16. Inflows are shown as positive values, while outflows and change in SWS storage are shown as negative values. Similar to Figure 17, Figure 18 only shows the difference between the surface inflows and surface outflows after seepage and evaporation are accounted within TTWD GSA.

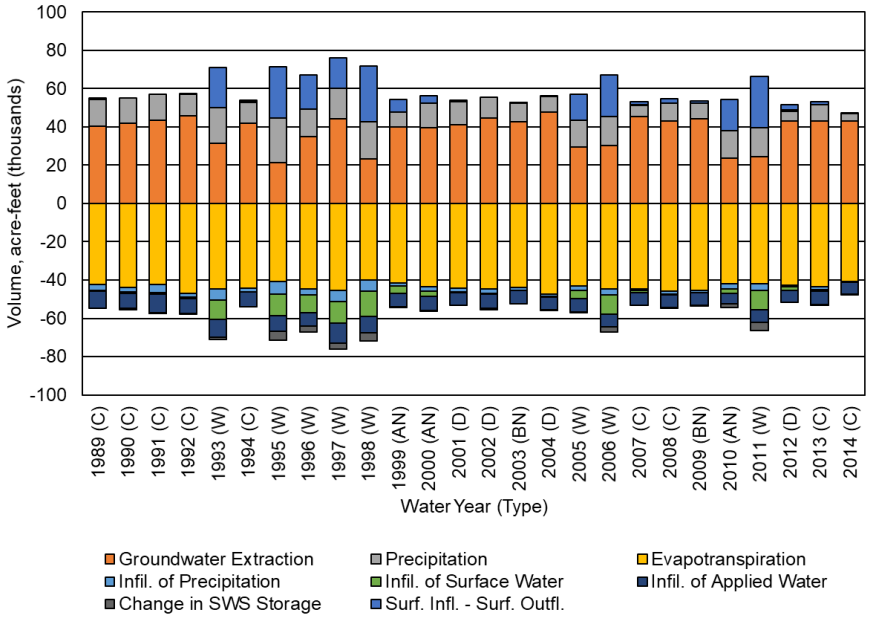

Figure 18. Triangle T Water District GSA Surface Water System Current Water Budget.

Table 16. Triangle T Water District GSA Surface Water System Current Water Budget (Acre-Feet).

Water Year	Boundary Surface Inflows	Groundwater Extraction	Precipitation	Evapo-transpiration[1]	Infil. of Precipitation	Infil. of Surface Water[2]	Infil. of Applied Water	Boundary Surface Outflows	Change in SWS Storage
1989 (C)	0	40,210	14,090	-42,260	-3,270	-480	-8,800	0	510
1990 (C)	0	42,010	13,140	-43,690	-2,590	-670	-7,850	-20	-330
1991 (C)	0	43,380	13,730	-42,260	-4,260	-1,010	-9,380	-90	-110
1992 (C)	0	45,860	11,220	-46,960	-2,110	-480	-7,860	-10	340
1993 (W)	630,140	31,210	19,010	-44,760	-5,660	-10,110	-9,460	-609,200	-1,160
1994 (C)	870	41,960	10,770	-44,300	-1,860	-220	-7,560	0	350
1995 (W)	740,860	21,320	23,120	-40,770	-6,520	-11,470	-8,130	-713,860	-4,550
1996 (W)	661,490	34,970	14,130	-44,620	-3,120	-9,440	-7,010	-643,460	-2,940
1997 (W)	899,650	44,110	16,140	-45,440	-5,840	-11,040	-10,680	-883,760	-3,140
1998 (W)	818,390	23,240	19,410	-40,070	-5,690	-13,210	-8,410	-789,240	-4,420
1999 (AN)	141,780	39,890	7,870	-41,670	-1,490	-3,900	-7,000	-135,160	-330
2000 (AN)	27,730	39,590	12,830	-43,370	-2,410	-2,920	-7,030	-24,010	-420
2001 (D)	0	41,010	11,970	-44,310	-2,040	-350	-6,670	0	390
2002 (D)	0	44,440	10,860	-44,770	-2,190	-320	-7,560	-20	-430
2003 (BN)	0	42,730	9,550	-43,880	-1,610	-40	-7,000	0	260
2004 (D)	0	47,750	7,930	-47,470	-1,240	-30	-6,770	0	-160
2005 (W)	274,520	29,650	13,680	-42,980	-2,500	-4,160	-7,100	-260,950	-140
2006 (W)	1,031,660	30,290	15,070	-44,490	-3,120	-10,070	-6,880	-1,010,030	-2,430
2007 (C)	3,380	45,210	6,100	-44,660	-970	-860	-6,590	-1,700	70
2008 (C)	2,330	43,160	9,270	-45,630	-1,600	-370	-6,660	-10	-500
2009 (BN)	1,120	44,030	8,380	-45,560	-1,230	30	-6,420	-10	-350
2010 (AN)	16,870	23,540	14,390	-42,020	-2,680	-2,120	-5,680	-310	-1,990
2011 (W)	919,590	24,580	15,060	-42,090	-3,170	-10,130	-6,760	-892,750	-4,330
2012 (D)	6,810	43,090	5,130	-42,830	-830	-1,830	-6,140	-3,900	500
2013 (C)	1,560	43,020	8,660	-43,300	-1,660	-910	-6,930	-260	-170
2014 (C)	0	42,860	4,230	-40,660	-660	-30	-5,940	0	190
Average (1989-2014)	237,640	38,200	12,140	-43,650	-2,710	-3,700	-7,400	-229,570	-970
W	747,040	29,920	16,950	-43,150	-4,450	-9,950	-8,060	-725,410	-2,890
AN	62,130	34,340	11,700	-42,350	-2,190	-2,980	-6,570	-53,160	-910
BN	560	43,380	8,960	-44,720	-1,420	0	-6,710	0	-40
D	1,700	44,070	8,970	-44,850	-1,580	-630	-6,790	-980	70
C	900	43,070	10,140	-43,750	-2,110	-560	-7,510	-230	40

[1]Includes ET of applied water, ET of precipitation, and evaporation from the Rivers and Streams System.
[2]Includes infiltration from the Rivers and Streams System within the subregion. To calculate Net Recharge from SWS below, Rivers and Streams System seepage is summed across the subbasin and redistributed to each subregion in proportion to gross area.

3.5 Net Recharge from SWS

Overdraft is defined in DWR Bulletin 118 as "the condition of a groundwater basin or subbasin in which the amount of water withdrawn by pumping exceeds the amount of water that recharges the basin over a period of years, during which the water supply conditions approximate average conditions" (DWR 2003). The Chowchilla Subbasin water budget indicates that overdraft conditions occurred during the 1989-2014 historical base period. Per 23 CCR Section 354.18(b)(5), the subbasin overdraft has been quantified for this base period. The evaluation of overdraft conditions includes estimates of recharge from subsurface flows. However, estimates of recharge from subsurface flows are less accurate when estimated for areas less that an entire subbasin. Thus, for estimates of GSA level contribution to overdraft, the term net recharge from the SWS is defined as groundwater recharge minus groundwater extraction. Net recharge from the SWS is useful for understanding and analyzing the combined effects of land surface processes on the underlying GWS.

When calculated from the historical water budget, average net recharge from the SWS represents the average recharge (when positive) or shortage of recharge (when negative) based on historical cropping, land use practices, and average hydrologic conditions. When calculated from the current land use water budget, average net recharge represents the average recharge based on current cropping, land use practices, and average hydrologic conditions.

Average net recharge from the SWS is presented below for the TTWD GSA portion of the Chowchilla Subbasin. Table 17 shows the average net recharge from the SWS for 1989-2014 based on the historical water budget, and Table 18 shows the same for the current water budget. Historically, the average net recharge in TTWD GSA was approximately -8.9 taf per year between 1989 and 2014. Under current land use conditions, the average net recharge in TTWD GSA is approximately -26 taf, indicating shortage conditions.

Table 17. Historical Water Budget: Average Net Recharge from SWS by Water Year Type, 1989-2014 (Acre-Feet).

Year Type	Number of Years	Infiltration of Applied Water (a)	Infiltration of Precipitation (b)	Infiltration of Surface Water[1] (c)	Groundwater Extraction (d)	Net Recharge from SWS (a+b+c-d)
W	8	5,660	5,080	5,610	11,990	4,360
AN	3	4,910	2,320	1,280	15,030	-6,520
BN	2	4,850	1,480	170	21,890	-15,390
D	4	5,750	1,650	430	25,460	-17,630
C	9	5,510	2,140	660	24,400	-16,090
Annual Average (1989-2014)	26	5,470	2,940	2,180	19,470	-8,880

[1] Calculated from the total subbasin Rivers and Streams System seepage summed and redistributed to each subregion in proportion to gross area.

Table 18. Current Water Budget: Average Net Recharge from SWS by Water Year Type (Acre-Feet).

Year Type	Number of Years	Infiltration of Applied Water (a)	Infiltration of Precipitation (b)	Infiltration of Surface Water[1] (c)	Groundwater Extraction (d)	Net Recharge from SWS (a+b+c-d)
W	8	8,060	4,450	5,490	29,920	-11,920
AN	3	6,570	2,190	1,230	34,340	-24,350
BN	2	6,710	1,420	110	43,380	-35,140
D	4	6,790	1,580	380	44,070	-35,320
C	9	7,510	2,110	510	43,070	-32,940
Annual Average (1989-2014)	26	7,400	2,710	2,080	38,200	-26,010

[1] Calculated from the total subbasin Rivers and Streams System seepage summed and redistributed to each subregion in proportion to gross area.

~~3.6 Sustainable Yield~~

~~GSP Regulations require the water budget to quantify the sustainable yield for the subbasin. Sustainable yield is defined as "the maximum quantity of water, calculated over a base period representative of long-term conditions in the basin and including any temporary surplus, that can be withdrawn annually from a groundwater supply without causing an undesirable result" (CWC Section 10721(w)). The sustainability goal for the Chowchilla Subbasin is to implement a package of projects and management actions that will, by 2040, balance long-term groundwater system inflows with outflows based on a 50-year period representative of average historical hydrologic conditions.~~

~~In alignment with GSP Regulations and DWR's Sustainable Management Criteria BMP (DWR, 2017), sustainable yield has been estimated as part of the subbasin historical water budget (1989-2014) and the subbasin projected with projects water budget (2040-2090). A single value of sustainable yield has been estimated for the subbasin as a whole during each of these analysis periods, which have been shown to be representative of long-term average hydrologic conditions (DWR, 2017). The subbasin sustainable yield estimates are provided in Section 2 of the GSP.~~

~~In addition to the subbasin-level estimates, subregion-level sustainable yield estimates have been prepared as support for GSA efforts to achieve the subbasin sustainability goal. Sustainable yield was calculated for each subregion across the projected period, with a specific focus on the 2040-2090 evaluation period following implementation of GSP projects and management actions. Sustainable yield is dependent upon conditions in existence at the time, and therefore changes during implementation of projects that increase recharge or lead to reductions in demand. As such, sustainable yield was not calculated for the 2020-2040 GSP implementation period because each time a recharge or "in lieu" project is completed, the sustainable yield will increase. For the 2040-2090 period, model results show that the schedule for project implementation together with the mitigation program for domestic wells results in MOs and related values for the sustainability indicators that avoid MTs and associated undesirable results. Thus, the sustainable yield for this 2040-2090 projected period ensures this is a quantity of water "…that can be withdrawn annually from a groundwater supply without causing an undesirable result" (CWC Section 10721(w)).~~

~~Sustainable yield was calculated for the 2040-2090 projected period using two methods (Table 19). The first method estimates sustainable yield as the average annual groundwater extraction minus the average~~

~~annual change in groundwater storage during the projected 2040-2090 period. Since average groundwater inflows approximately equal outflows during the 2040-2090 period, the average annual change in the groundwater storage was assumed to be zero over this 50-year period. The second method calculates sustainable yield as the sum of the average projected annual inflows to the groundwater system (infiltration of applied water, infiltration of precipitation, infiltration of surface water, and subsurface inflows). Inflows from the surface water system were calculated for each subregion individually, while subsurface inflows were calculated at the subbasin boundary and distributed to each subregion in proportion to their total area in the subbasin. After the Chowchilla and neighboring basins reach sustainability, subsurface groundwater inflows are expected to decrease as the groundwater system reaches new equilibrium levels.~~

~~*Table 19. Summary of Sustainable Yield Estimates from Projected With Projects Water Budget.*~~

~~Quantification Method~~	~~Average Volume, 2040-2090 (AF)~~	~~Estimated Confidence Interval (percent)~~	~~Confidence Interval Source~~	~~Average minus CI (AF)~~	~~Average plus CI (AF)~~
~~Groundwater Extraction and GWS Change in Storage~~	~~33,700~~	~~25%~~	~~Professional judgment based on historical calculations.~~	~~25,300~~	~~42,100~~
~~Total Inflows to GWS~~	~~37,100~~	~~25%~~	~~Professional judgment based on historical calculations.~~	~~27,800~~	~~46,400~~

~~3.7~~3.6 Uncertainties in Water Budget Components

Uncertainties associated with each water budget component were estimated as a percentage representing approximately a 95% confidence interval following the procedure described by Clemmens and Burt (1997). Uncertainties for all independently measured or estimated water budget components were estimated based on the measurement accuracy, typical values reported in technical literature, typical values calculated in other water budgets, and professional judgement.

Table 19~~20~~ provides a summary of typical uncertainty values associated with major SWS inflow and outflow components. These uncertainties provide a basis for evaluating confidence in water budget results and help to identify data needs that may be addressed during GSP implementation.

Table 19~~20~~. Estimated Uncertainty of GSA Water Budget Components.

Flowpath Direction (SWS Boundary)	Water Budget Component	Data Source	Estimated Uncertainty (%)	Source
Inflows	Surface Water Inflows	Measurement	20%	Estimated streamflow measurement accuracy and adjustment for losses.
	Riparian Deliveries	Measurement	10%	Estimated measurement accuracy.
	Precipitation	Calculation	30%	Clemmens, A.J. and C.M. Burt, 1997.
	Groundwater Extraction	Closure	20%	Typical uncertainty calculated for Land Surface System water balance closure.
Outflows	Surface Water Outflows	Closure	20%	Typical uncertainty calculated for Rivers and Streams System water balance closure.
	Evaporation	Calculation	20%	Estimated accuracy of calculation based on CIMIS reference ET and free water surface evaporation coefficient.
	ET of Applied Water	Calculation	10%	Estimated accuracy of daily IDC root zone water budget component based on CIMIS reference ET, estimated crop coefficients from SEBAL energy balance, and annual land use.
	ET of Precipitation	Calculation	10%	Estimated accuracy of daily IDC root zone water budget component based on CIMIS reference ET, precipitation, estimated crop coefficients from SEBAL energy balance, and annual land use.
	Infiltration of Applied Water	Calculation	20%	Estimated accuracy of daily IDC root zone water budget component based on annual land use and NRCS soils characteristics.
	Infiltration of Precipitation	Calculation	20%	Estimated accuracy of daily IDC root zone water budget component based on annual land use, NRCS soils characteristics, and CIMIS precipitation.
	Infiltration of Surface Water	Calculation	15%	Estimated accuracy of daily seepage calculation using NRCS soils characteristics and calculated runoff of precipitation.
	Change in SWS Storage	Calculation	50%	Professional Judgment.
Net Recharge from SWS		Calculation	25%	Estimated water budget accuracy; typical value calculated for GSA-level net recharge from SWS.