APPENDIX F. Basin Evaluation – Water Balances for IAZs

F.1 BASELINE CONDITIONS

This Appendix summarizes water balance results for the 22 IAZs that comprise the Central Valley Floor (see complete analysis in: *Initial Conceptual Model [ICM] Final Report: Task 7 and 8 - Salt and Nitrate Analysis for the Central Valley Floor and a Focused Analysis of Modesto and Kings Subregions*. LWA et al. 2013). The summaries for each IAZ are grouped by geographic location within the Central Valley floor.

Results presented here are only available for the 20-year travel zone (upper portion of the aquifer, deemed "shallow" for the ICM study) for conditions simulated by Central Valley Hydrologic Model (CVHM) on a quarterly basis between 1983 and 2003. The presentation of water budget results for each IAZ shows potential horizontal and vertical water movement as shown in **Figure F-1**. Positive budget values indicate volumes contributing to or flowing into the IAZ (e.g., see Table F-1); negative budget values indicate volume amounts leaving or flowing out of the IAZ.

Water balance components in this analysis include:

- Groundwater pumping
- Stream leakage (from gaining stream conditions or losing stream conditions)
- Net recharge (deep percolation out of the root zone)
- Horizontal groundwater inflow and outflow to/from neighboring areas
- Vertical groundwater inflow and outflow to/from the aquifer below the starting unit volume (here, the "lower aquifer" refers to the part of the aquifer system below the 20-year travel zone)
- Groundwater storage (water is allowed to enter storage during years of surplus, and allowed to leave storage via storage depletion during years of deficit)

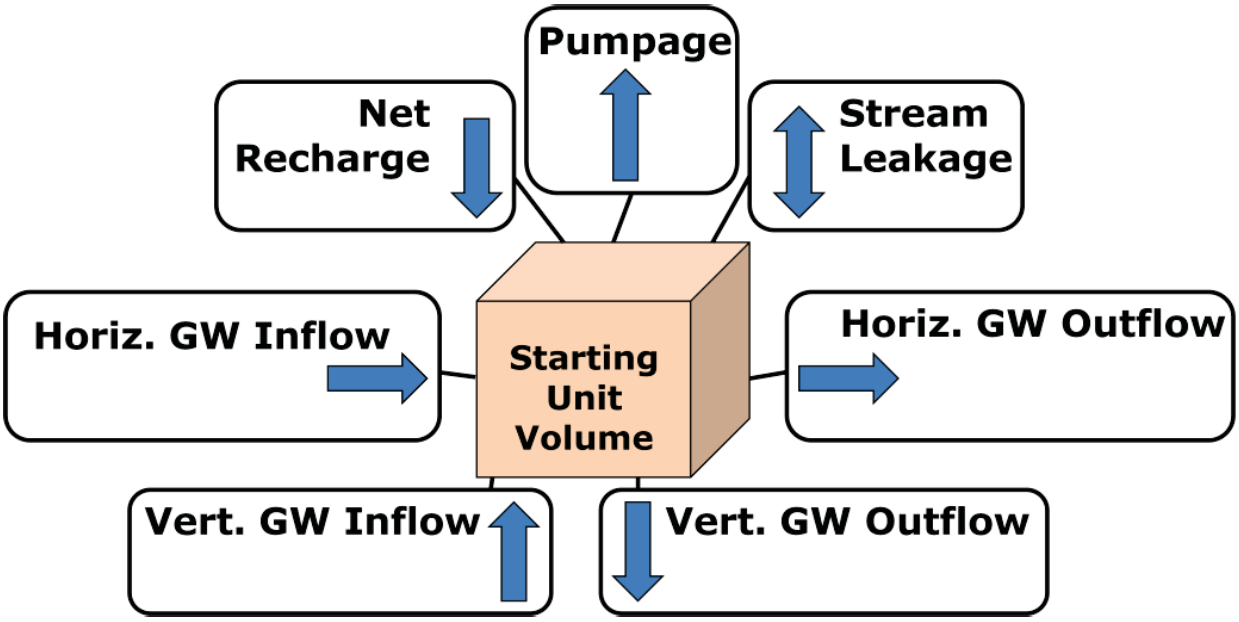

Figure F-1. Water Balance Components and Movement

The summaries below provide tables and figures that detail water balance information for each IAZ in the three areas of the Central Valley (Northern, Middle, and Southern) during the ICM study period (1983-2003) with depths according to their 20-year travel zone as follows:

1) Time-series plots showing quarterly and annual patterns of each water balance component over time,

2) Details about the average water balance components described above,

3) Pie charts showing the different water balance components, and

4) A summary of the water balance conditions for each IAZ over the 20-year study period.

This **Appendix F** is provided in order to present local entities the water balance details they could use for developing the basis of their own local SNMP. The subsections below are summarized in the main SNMP document.

The tables and figures in this Appendix use the following signage:

- Negative numbers indicate that these water balance components are leaving the IAZ
    - o negative storage values indicate water leaving the IAZ to enter storage (via storage replenishment during times of surplus)
    - o negative values for pumping indicate water being removed from the IAZ through wells;
    - o negative stream leakage values indicate water leaving the IAZ groundwater body to enter streams (during gaining stream conditions)

    - negative groundwater recharge values are rare, but indicate groundwater leaving the IAZ's water table through evapotranspiration
    - negative vertical flow values indicate water leaving the IAZ to travel downwards towards the "lower aquifer" below the 20-year travel zone
    - negative horizontal flow values indicate water leaving the IAZ horizontally to travel into neighboring IAZs.
- Positive numbers indicate that these water balance components are entering the IAZ
    - positive storage values indicate water entering the IAZ from storage (via storage depletion during times of deficit)
    - positive groundwater pumping values do not occur
    - positive stream leakage values indicate water entering the IAZ groundwater body from losing stream conditions
    - positive groundwater recharge values indicate water entering the IAZ via deep percolation through the root zone
    - positive vertical flow values are rare, but indicate water entering the IAZ from the "lower aquifer" (this can occur in areas of groundwater discharge, where lower portions of the groundwater aquifer are actually pushing water upwards into the 20-year travel zone)
    - positive horizontal flow values indicate water entering the IAZ horizontally from neighboring IAZs.

F.1.1 Water Balance Conditions for IAZs within the Northern Central Valley

Water balance calculations for the upper aquifer representing the 20-year travel zone from the water table are presented here for IAZs 1 through 7.

F.1.1.1 IAZ 1 Sacramento River above Red Bluff

The water balance components that play a role in the 20-year travel zone for IAZ 1 include: storage, groundwater pumping, stream leakage, groundwater recharge, vertical flow to/from the lower aquifer (deeper than the 20-year travel zone), and horizontal flow to/from the adjacent IAZ 2. Time-series plots for these components are available on a quarterly basis between 1983-2003 (**Figure F-2**). The average annual volumetric water budget summary is presented in tabular format below (**Table F-1**) and in a pie chart (**Figure F-3**).

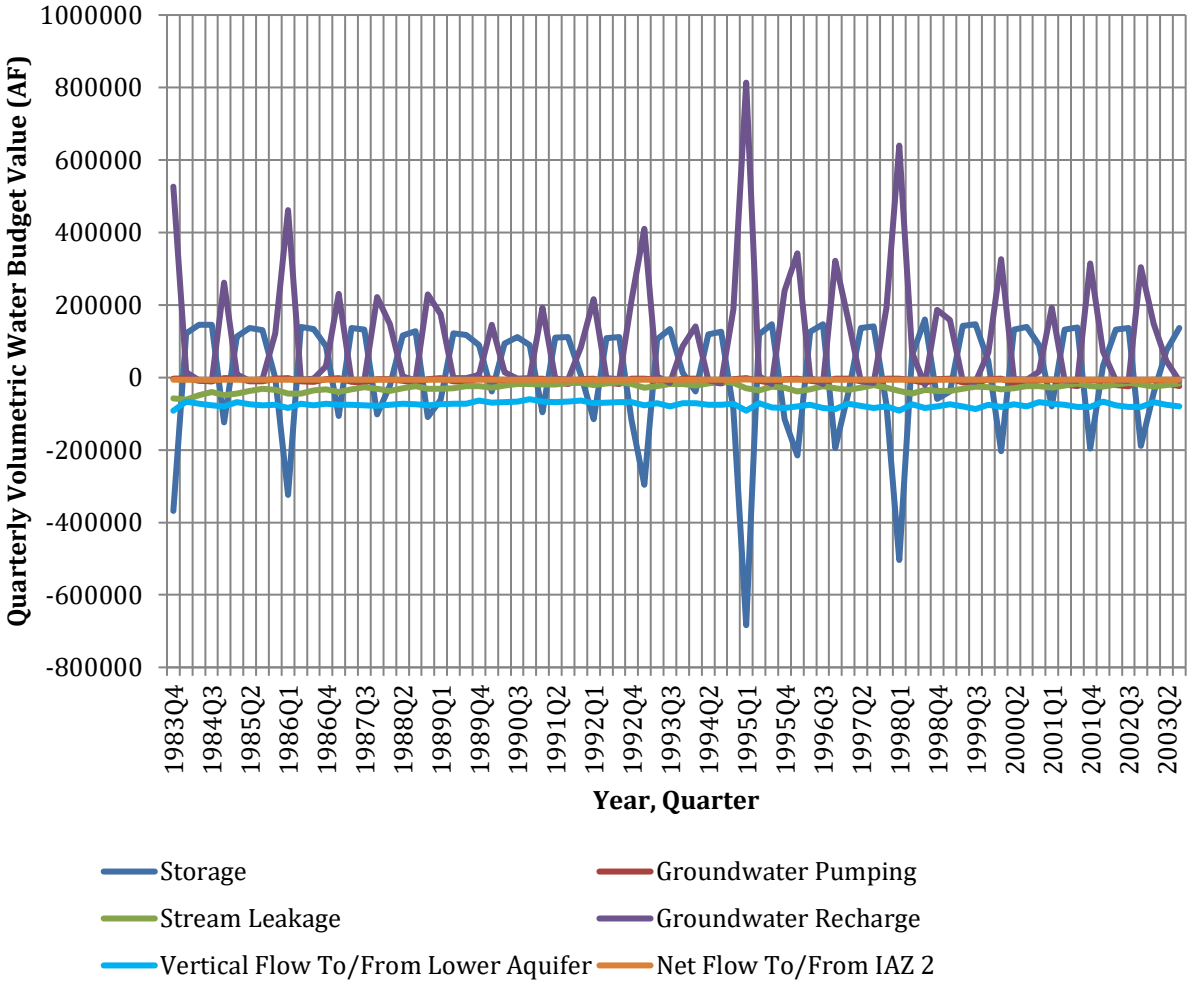

Figure F-2. Quarterly Volumetric Water Budget Time Series Plot for IAZ 1

Table F-1. Average Annual Volumetric Water Budget Components for IAZ 1

Volumetric Water Budget Component	Annual Average Volume* (AF)
Avg Water Volume Present in IAZ 1	***5,582,818***
Storage	**51,882**
GW Pumping	**-34,415**
Stream Leakage	**-108,719**
GW Recharge	**402,626**
Vertical Flow to/from Lower Aquifer	**-287,127**
Net Horizontal Flow to/From IAZ 2	**-24,254**

See explanation of signage at beginning of **Appendix F*

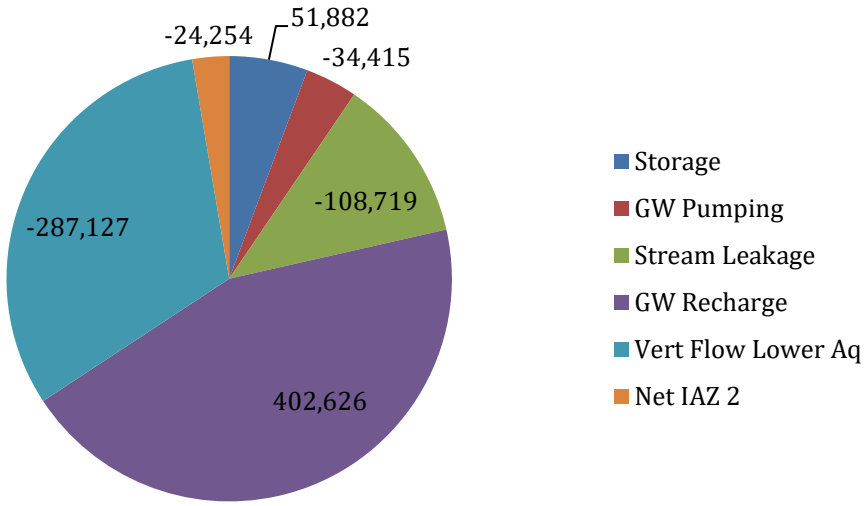

Figure F-3. Average Annual Volumetric Water Budget Components for IAZ 1 (AFY)

The time-series plots and pie chart of volumetric movement in and out of the 20-year travel zone of IAZ 1 indicate the following:

- Groundwater recharge provides the greatest influx of water to the IAZ.
- Vertical flow downward out of the shallow 20-year travel zone combined with groundwater contributing to surface water bodies (via gaining stream conditions, indicated by the Stream Leakage component) make up the greatest outflux components of water leaving the IAZ.
- Groundwater pumping is a small proportion of the volumetric budget components leaving the 20-year travel zone (it is assumed that the majority of groundwater production occurs in deeper aquifer zones below the 20-year travel zone).
- IAZ 1 contributes a small proportion of water volume to adjacent IAZ 2.
- Although the net annual average storage component represents a small proportion of water volume on an average yearly basis, the quarterly fluctuations indicate water going into storage during quarters when groundwater recharge is high.
- The net storage component provides the 20-year travel zone of IAZ 1 with a modest amount of water each year.

F.1.1.2 IAZ 2 Red Bluff to Chico Landing

The water balance components that play a role in the 20-year travel zone for IAZ 2 include: storage, groundwater pumping, stream leakage, groundwater recharge, vertical flow to/from the lower aquifer (deeper than the 20-year travel zone), and horizontal flow to/from the adjacent IAZs (IAZ 1, 3, 4, and 5). Time-series plots for these components are available on a quarterly basis between 1983-2003 (**Figure F-4**). The average annual volumetric water budget summary is presented in tabular format below (**Table F-2**) and in a pie chart (**Figure F-5**).

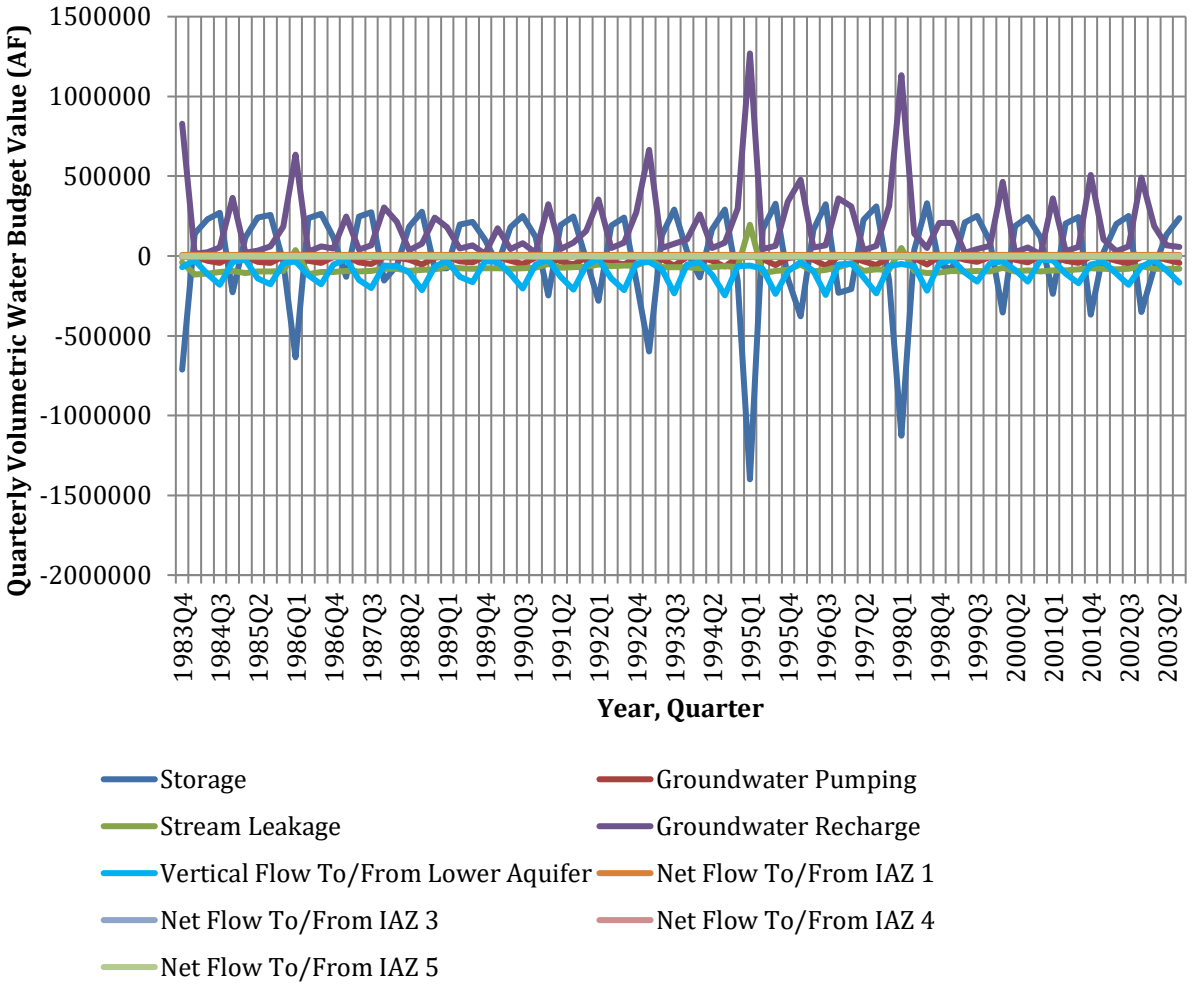

Figure F-4. Quarterly Volumetric Water Budget Time Series Plot for IAZ 2

Table F-2. Average Annual Volumetric Water Budget Components for IAZ 2

Volumetric Water Budget Component	Annual Average Volume* (AF)
Avg Water Volume Present in IAZ 2	**10,470,433**
Storage	**50,531**
GW Pumping	**-82,784**
Stream Leakage	**-289,070**
GW Recharge	**710,340**
Vertical Flow to/from Lower Aquifer	**-381,495**
Net Horizontal Flow to/From IAZ 1	**24,254**
Net Horizontal Flow to/From IAZ 3	**-7,192**
Net Horizontal Flow to/From IAZ 4	**-22,853**
Net Horizontal Flow to/From IAZ 5	**-1,698**

** See explanation of signage at beginning of **Appendix F***

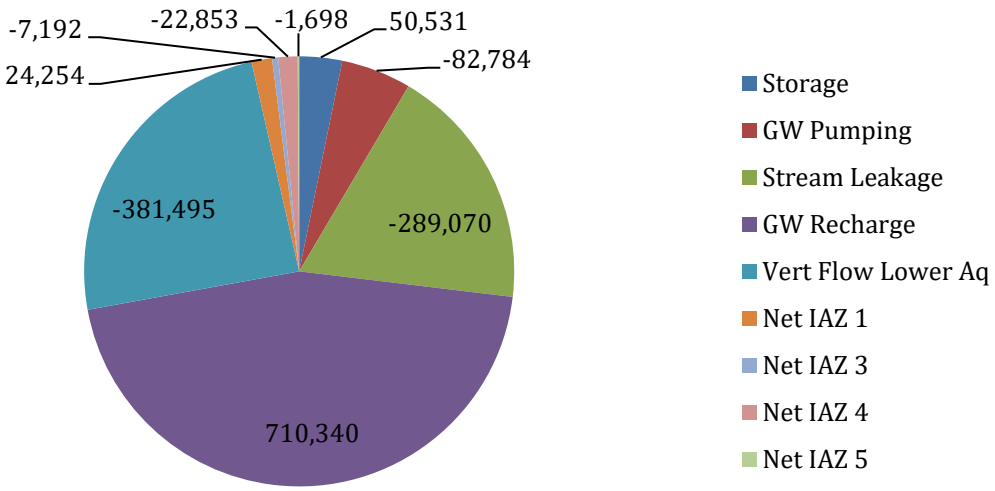

Figure F-5. Average Annual Volumetric Water Budget Components for IAZ 2 (AFY)

The time-series plots and pie chart of volumetric movement in and out of the 20-year travel zone of IAZ 2 indicate the following:

- Groundwater recharge provides the greatest influx of water to the IAZ.
- Vertical flow downward out of the shallow 20-year travel zone combined with groundwater contributing to surface water bodies (via gaining stream conditions, indicated by the Stream Leakage component) make up the greatest outflux components of water leaving the IAZ.
- Groundwater pumping is a small proportion of the volumetric budget components leaving the 20-year travel zone (it is assumed that the majority of groundwater production occurs in deeper aquifer zones below the 20-year travel zone).
- IAZ 2 contributes a small proportion of water volume to adjacent IAZs 3, 4, and 5, and IAZ 2 receives horizontal flow from IAZ 1.
- Although the net storage component represents a small proportion of water volume on an average yearly basis, the quarterly fluctuations indicate water going into storage during quarters when groundwater recharge is high; the net storage component provides the 20-year travel zone of IAZ 2 with a modest amount of water each year.

F.1.1.3 IAZ 3 Colusa Trough

The water balance components that play a role in the 20-year travel zone for IAZ 3 include: storage, groundwater pumping, stream leakage, groundwater recharge, vertical flow to/from the lower aquifer (deeper than the 20-year travel zone), and horizontal flow to/from the adjacent IAZs (IAZs 2, 4, and 6). Time-series plots for these components are available on a quarterly basis between 1983-2003 (**Figure F-6**). The average annual volumetric water budget summary is presented in tabular format below (**Table F-3**) and in a pie chart (**Figure F-7**).

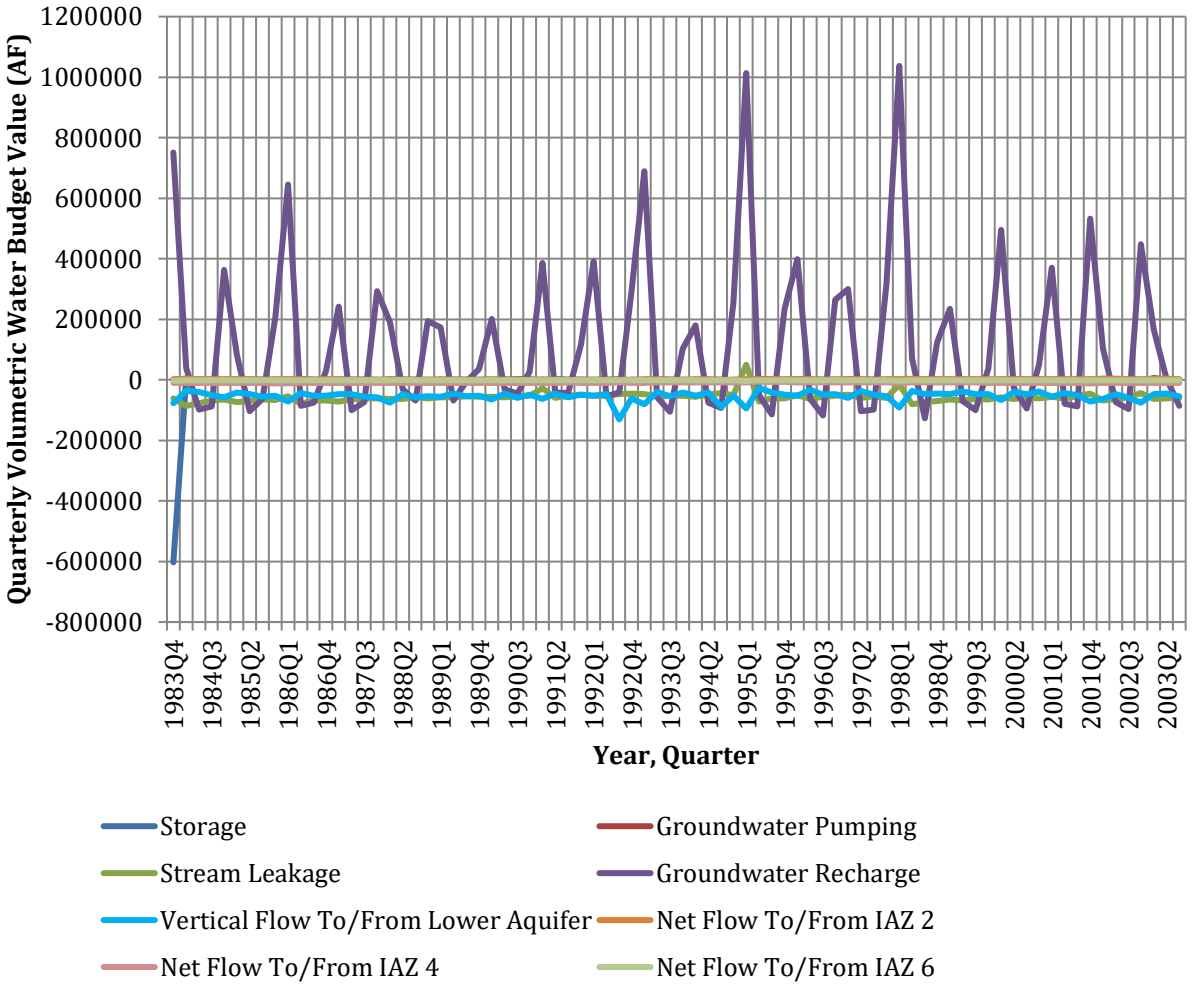

Figure F-6. Quarterly Volumetric Water Budget Time Series Plot for IAZ 3

Table F-3. Average Annual Volumetric Water Budget Components for IAZ 3

Volumetric Water Budget Component	Annual Average Volume* (AF)
Avg Water Volume Present in IAZ 3	**7,909,706**
Storage	**18,281**
GW Pumping	**-1,088**
Stream Leakage	**-218,880**
GW Recharge	**440,506**
Vertical Flow to/from Lower Aquifer	**-204,957**
Net Horizontal Flow to/From IAZ 2	**7,192**
Net Horizontal Flow to/From IAZ 4	**-36,178**
Net Horizontal Flow to/From IAZ 6	**-4,820**

** See explanation of signage at beginning of **Appendix F***

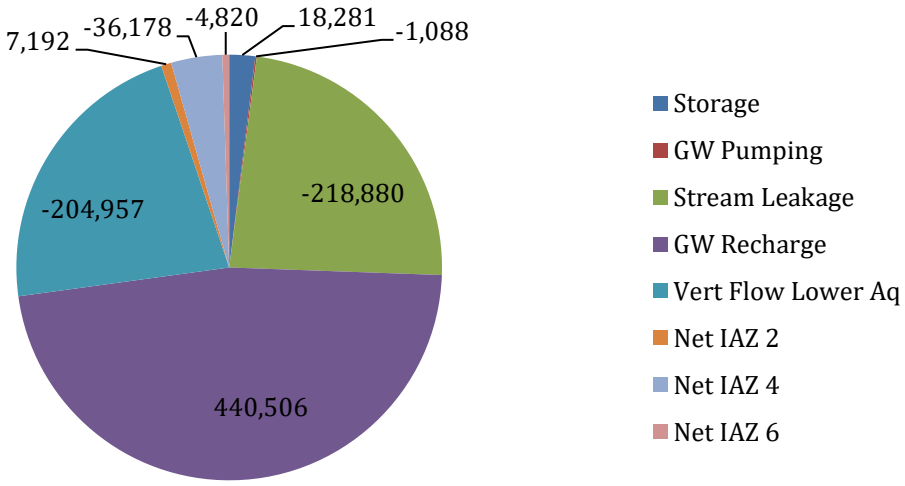

Figure F-7. Average Annual Volumetric Water Budget Components for IAZ 3 (AFY)

The time-series plots and pie chart of volumetric movement in and out of the 20-year travel zone of IAZ 3 indicate the following:

- Groundwater recharge provides the greatest influx of water to the IAZ.
- Vertical flow downward out of the shallow 20-year travel zone combined with groundwater contributing to surface water bodies (via gaining stream conditions, indicated by the Stream Leakage component) make up the greatest outflux components of water leaving the IAZ.
- Groundwater pumping is a small proportion of the volumetric budget components leaving the 20-year travel zone (it is assumed that the majority of groundwater production occurs in deeper aquifer zones below the 20-year travel zone).
- The horizontal flow components of IAZ 3 indicate most horizontal flow going to IAZ 4, with some more horizontal flow going to IAZ 6, and receiving a small amount of water from IAZ 2.

F.1.1.4 IAZ 4 Chico Landing to Knights Landing proximal to the Sacramento River

The water balance components that play a role in the 20-year travel zone for IAZ 4 include: storage, groundwater pumping, stream leakage, groundwater recharge, vertical flow to/from the lower aquifer (deeper than the 20-year travel zone), and horizontal flow to/from the adjacent IAZs (IAZs 2, 3, 5, and 6). Time-series plots for these components are available on a quarterly basis between 1983-2003 (**Figure F-8**). The average annual volumetric water budget summary is presented in tabular format below (**Table F-4**) and in a pie chart (**Figure F-9**).

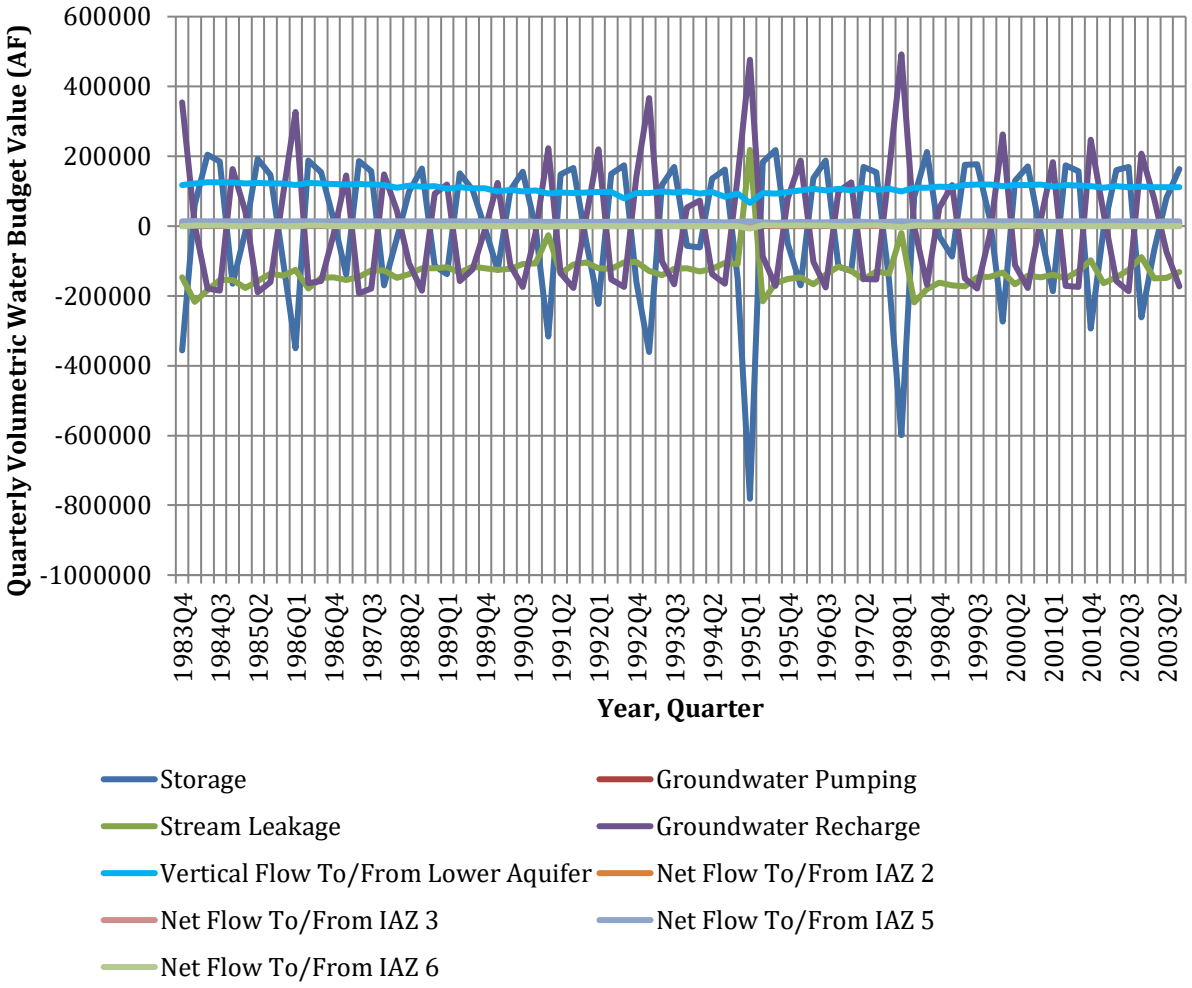

Figure F-8. Quarterly Volumetric Water Budget Time Series Plot for IAZ 4

Table F-4. Average Annual Volumetric Water Budget Components for IAZ 4

Volumetric Water Budget Component	Annual Average Volume* (AF)
Avg Water Volume Present in IAZ 4	**3,641,869**
Storage	**4,451**
GW Pumping	**-15**
Stream Leakage	**-505,577**
GW Recharge	**-19,256**
Vertical Flow to/from Lower Aquifer	**412,415**
Net Horizontal Flow to/From IAZ 2	**22,853**
Net Horizontal Flow to/From IAZ 3	**36,178**
Net Horizontal Flow to/From IAZ 5	**48,038**
Net Horizontal Flow to/From IAZ 6	**1,044**

** See explanation of signage at beginning of **Appendix F***

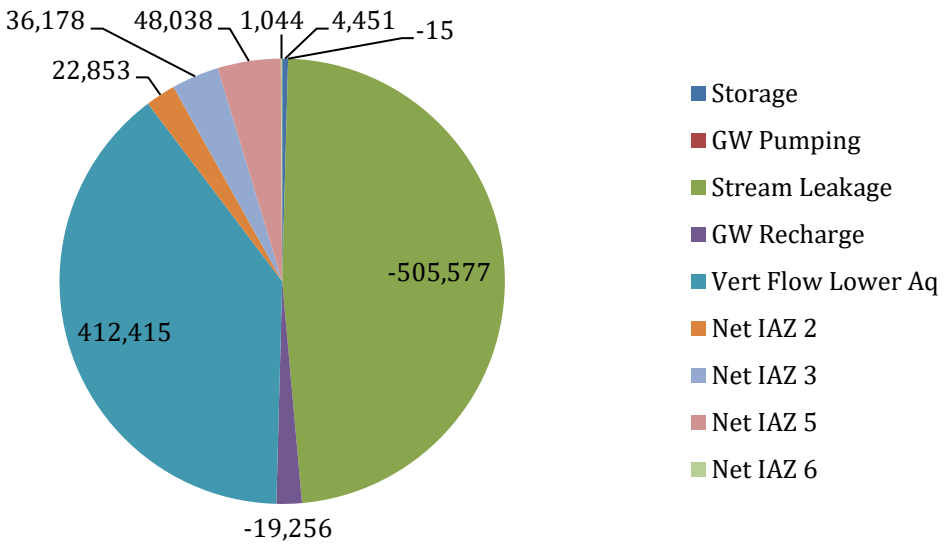

Figure F-9. Average Annual Volumetric Water Budget Components for IAZ 4 (AFY)

The time-series plots and pie chart of volumetric movement in and out of the 20-year travel zone of IAZ 4 indicate the following:

- Upward movement of deeper groundwater provides the greatest influx of water to the IAZ.
- Flow to surface water bodies (via gaining stream conditions, indicated by the Stream Leakage component) and negative groundwater recharge (evapotranspiration and uptake of groundwater) make up the greatest outflux components of water leaving the IAZ.
- Average annual groundwater pumping is minimal in the 20-year travel zone of this IAZ (it is assumed that the majority of groundwater production occurs in deeper aquifer zones below the 20-year travel zone).
- IAZ 4 receives water from all of its adjacent IAZs 2, 3, 5, and 6.
- Although the net storage component represents a small proportion of water volume on an average yearly basis, the quarterly fluctuations indicate water going into storage during quarters when groundwater recharge is high; the net storage component provides the 20-year travel zone of IAZ 4 with a small amount of water each year.

F.1.1.5 IAZ 5 Eastern Sacramento Valley foothills near Sutter Buttes

The water balance components that play a role in the 20-year travel zone for IAZ 5 include: storage, groundwater pumping, stream leakage, groundwater recharge, vertical flow to/from the lower aquifer (deeper than the 20-year travel zone), and horizontal flow to/from the adjacent IAZs (IAZs 2, 4, 6, and 7). Time-series plots for these components are available on a quarterly basis between 1983-2003 (**Figure F-10**). The average annual volumetric water budget summary is presented in tabular format below (**Table F-5**) and in a pie chart (**Figure F-11**).

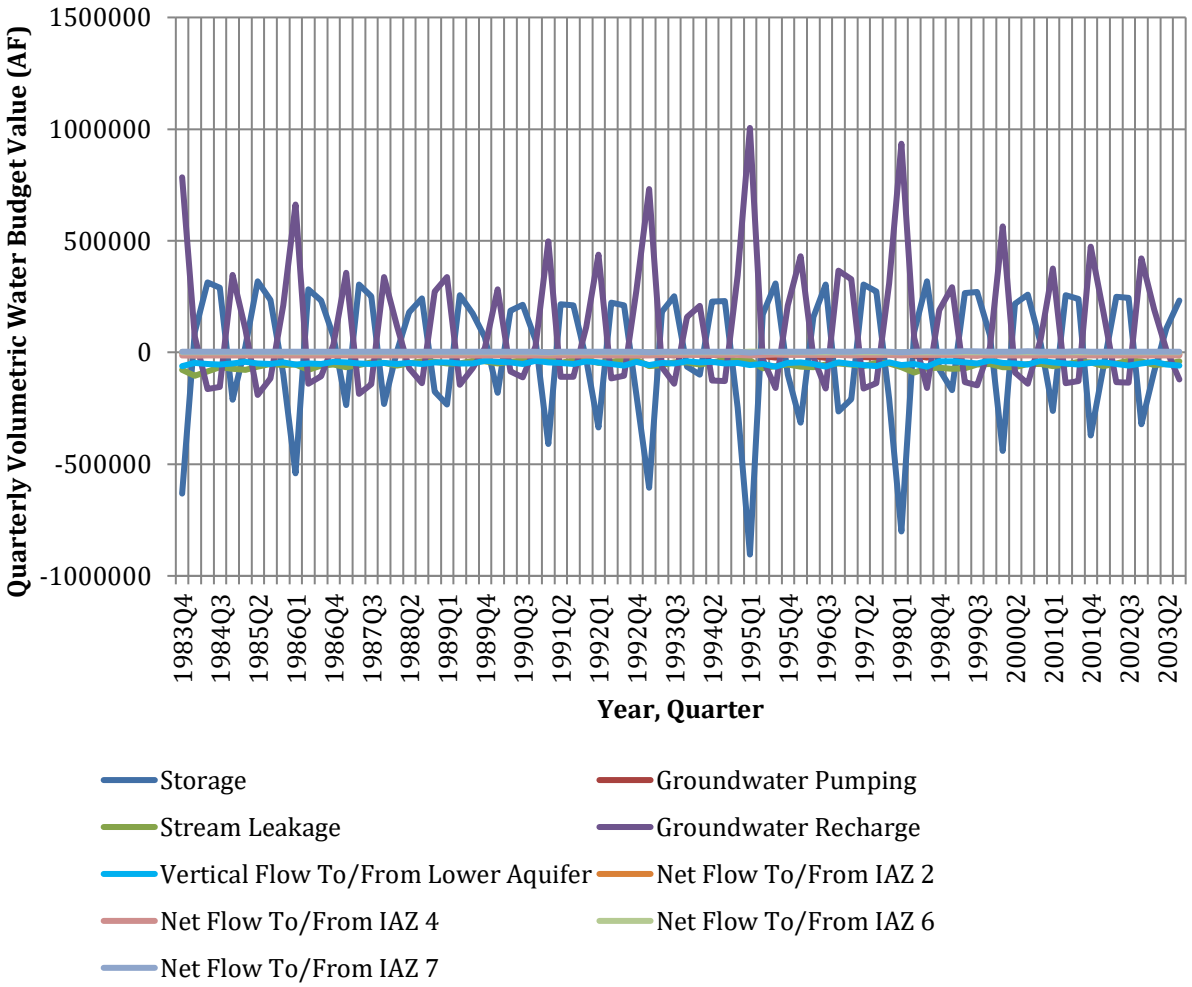

Figure F-10. Quarterly Volumetric Water Budget Time Series Plot for IAZ 5

Table F-5. Average Annual Volumetric Water Budget Components for IAZ 5

Volumetric Water Budget Component	Annual Average Volume* (AF)
Avg Water Volume Present in IAZ 5	**6,489,565**
Storage	**40,940**
GW Pumping	**-24,053**
Stream Leakage	**-203,690**
GW Recharge	**403,073**
Vertical Flow to/from Lower Aquifer	**-185,209**
Net Horizontal Flow to/From IAZ 2	**1,698**
Net Horizontal Flow to/From IAZ 4	**-48,038**
Net Horizontal Flow to/From IAZ 6	**1,299**
Net Horizontal Flow to/From IAZ 7	**13,997**

** See explanation of signage at beginning of **Appendix F***

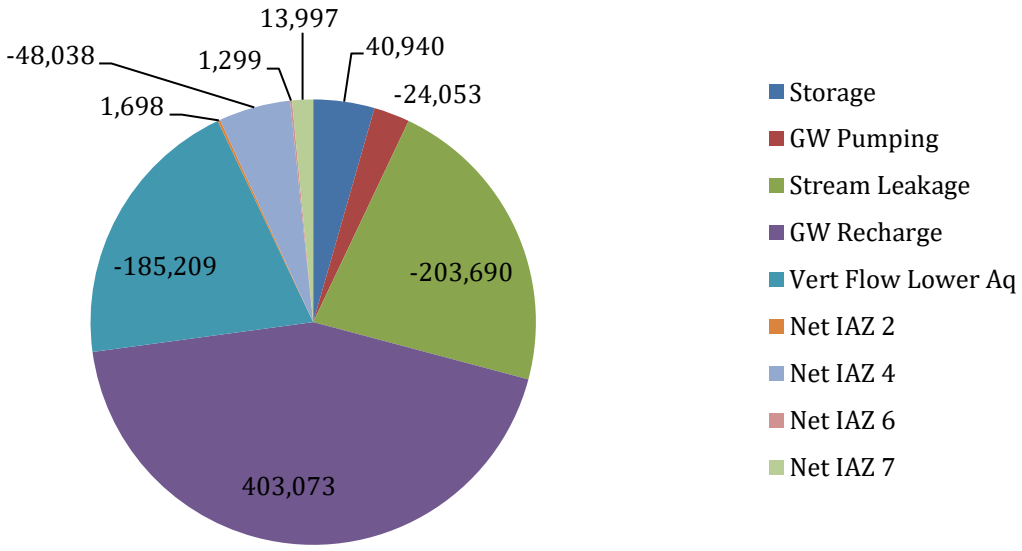

Figure F-11. Average Annual Volumetric Water Budget Components for IAZ 5 (AFY)

The time-series plots and pie chart of volumetric movement in and out of the 20-year travel zone of IAZ 5 indicate the following:

- Groundwater recharge provides the greatest influx of water to the IAZ.
- Vertical flow downward out of the shallow 20-year travel zone combined with groundwater contributing to surface water bodies (via gaining stream conditions, indicated by the Stream Leakage component) make up the greatest outflux components of water leaving the IAZ.
- Groundwater pumping is a small proportion of the volumetric budget components leaving the 20-year travel zone (it is assumed that the majority of groundwater production occurs in deeper aquifer zones below the 20-year travel zone).
- IAZ 5 contributes a small proportion of water volume to adjacent IAZ 4, and IAZ 5 receives horizontal flow from IAZs 2, 6, and 7.
- Although the net storage component represents a small proportion of water volume on an average yearly basis, the quarterly fluctuations indicate water going into storage during quarters when groundwater recharge is high; the net storage component provides the 20-year travel zone of IAZ 5 with a modest amount of water each year.

F.1.1.6 IAZ 6 Cache-Putah area

The water balance components that play a role in the 20-year travel zone for IAZ 6 include: storage, groundwater pumping, stream leakage, groundwater recharge, vertical flow to/from the lower aquifer (deeper than the 20-year travel zone), and horizontal flow to/from the adjacent IAZs (IAZs 3, 4, 5, 7, and 9). Time-series plots for these components are available on a quarterly basis between 1983-2003 (**Figure F-12**). The average annual volumetric water budget summary is presented in tabular format below (**Table F-6**) and in a pie chart (**Figure F-13**).

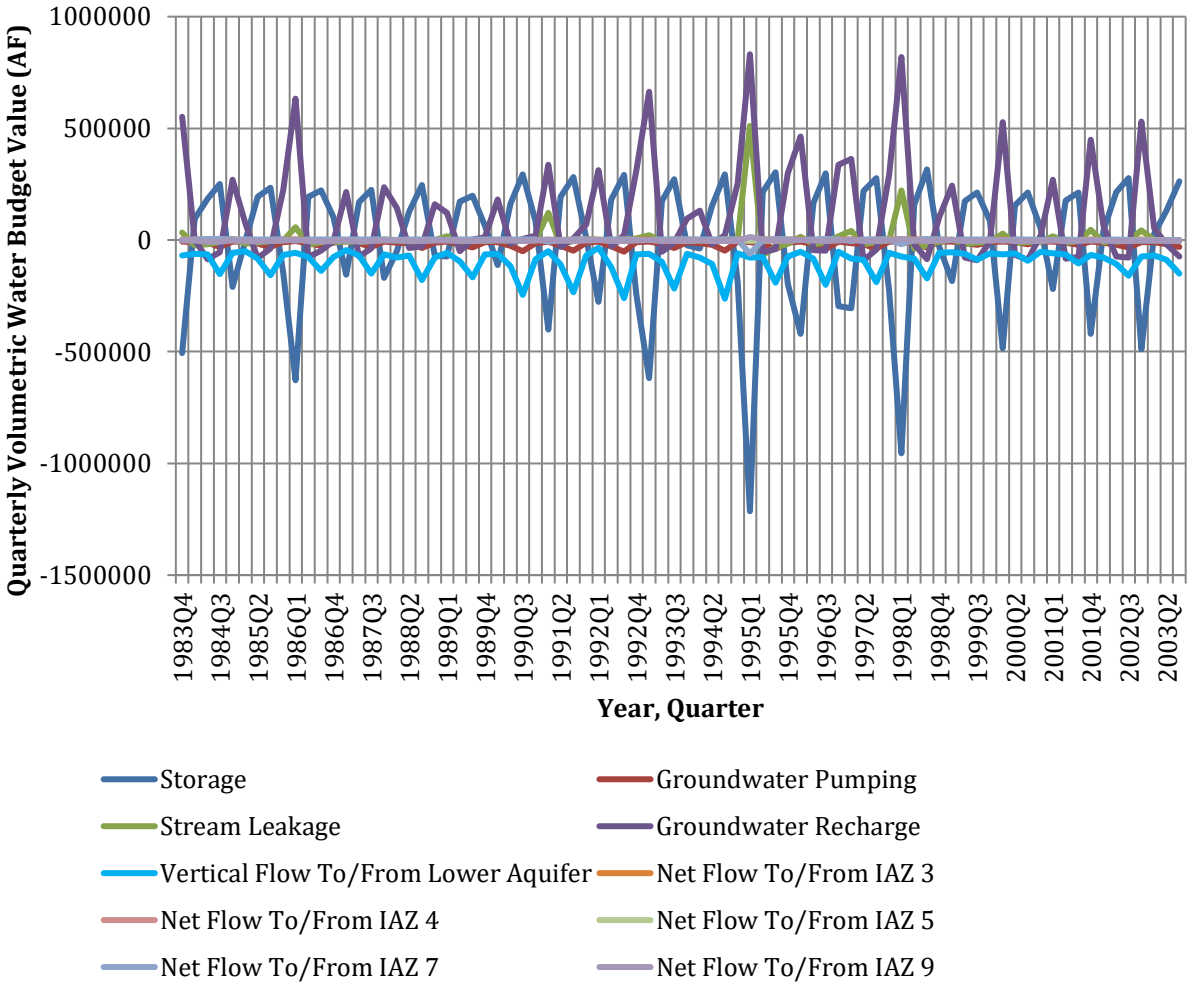

Figure F-12. Quarterly Volumetric Water Budget Time Series Plot for IAZ 6

Table F-6. Average Annual Volumetric Water Budget Components for IAZ 6

Volumetric Water Budget Component	Annual Average Volume* (AF)
Avg Water Volume Present in IAZ 6	**5,600,119**
Storage	**-4,003**
GW Pumping	**-67,239**
Stream Leakage	**30,145**
GW Recharge	**419,131**
Vertical Flow to/from Lower Aquifer	**-371,315**
Net Horizontal Flow to/From IAZ 3	**4,820**
Net Horizontal Flow to/From IAZ 4	**-1,044**
Net Horizontal Flow to/From IAZ 5	**-1,299**
Net Horizontal Flow to/From IAZ 7	**1,710**
Net Horizontal Flow to/From IAZ 9	**-10,688**

** See explanation of signage at beginning of **Appendix F***

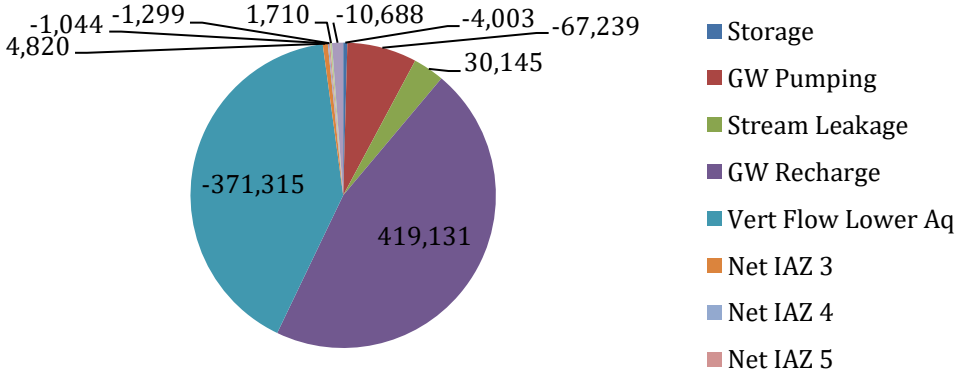

Figure F-13. Average Annual Volumetric Water Budget Components for IAZ 6 (AFY)

The time-series plots and pie chart of volumetric movement in and out of the 20-year travel zone of IAZ 6 indicate the following:

- Groundwater recharge provides the greatest influx of water to the IAZ.
- Vertical flow downward out of the shallow 20-year travel zone combined with groundwater pumping make up the greatest outflux components of water leaving the IAZ.
- IAZ 6 receives surface water via losing stream conditions.
- IAZ 6 provides a small proportion of water volume to adjacent IAZs 4, 5, and 9, and receives horizontal flow from IAZs 3 and 7.
- Although the net storage component represents a small proportion of water volume on an average yearly basis, the quarterly fluctuations indicate water going into storage during quarters when groundwater recharge is high; the net storage component in the 20-year travel zone of this IAZ indicates a modest amount of water replenishing storage each year.

F.1.1.7 IAZ 7 East of Feather and South of Yuba Rivers

The water balance components that play a role in the 20-year travel zone for IAZ 7 include: storage, groundwater pumping, stream leakage, groundwater recharge, vertical flow to/from the lower aquifer (deeper than the 20-year travel zone), and horizontal flow to/from the adjacent IAZs (IAZs 5, 6, and 8). Time-series plots for these components are available on a quarterly basis between 1983-2003 (**Figure F-14**). The average annual volumetric water budget summary is presented in tabular format below (**Table F-7**) and in a pie chart (**Figure F-15**).

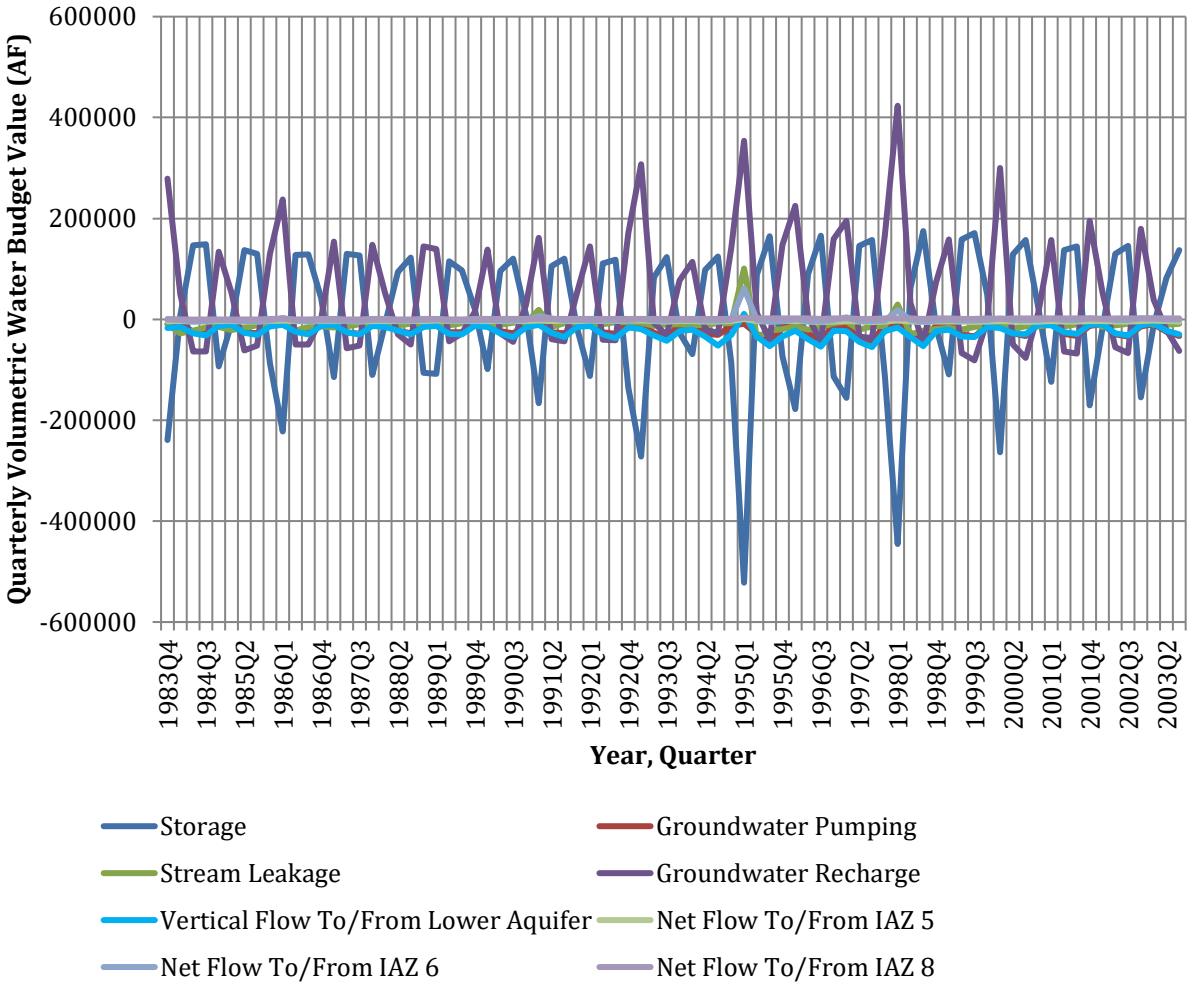

Figure F-14. Quarterly Volumetric Water Budget Time Series Plot for IAZ 7

Table F-7. Average Annual Volumetric Water Budget Components for IAZ 7

Volumetric Water Budget Component	Annual Average Volume* (AF)
Avg Water Volume Present in IAZ 7	**3,183,125**
Storage	**30,830**
GW Pumping	**-76,187**
Stream Leakage	**-39,676**
GW Recharge	**191,457**
Vertical Flow to/from Lower Aquifer	**-94,221**
Net Horizontal Flow to/From IAZ 5	**-13,997**
Net Horizontal Flow to/From IAZ 6	**-1,710**
Net Horizontal Flow to/From IAZ 8	**3,551**

** See explanation of signage at beginning of **Appendix F***

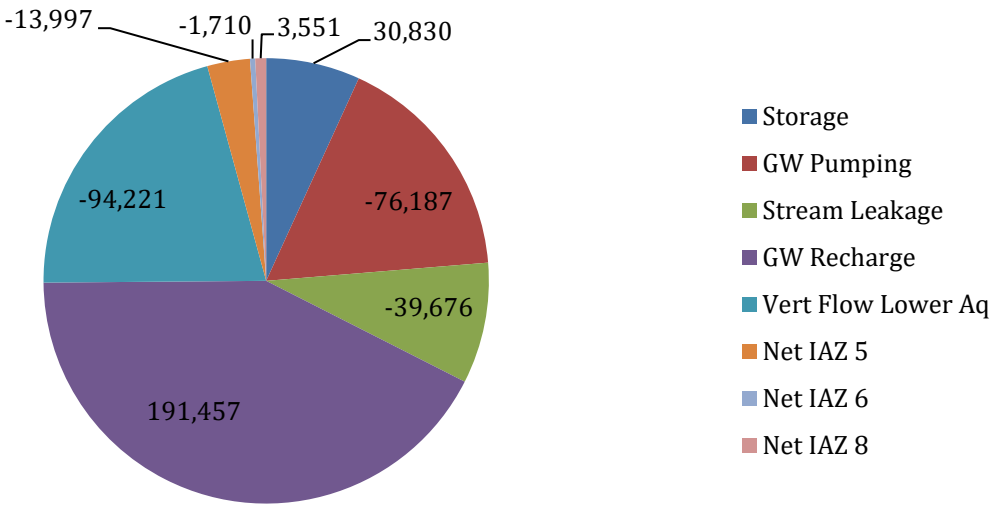

Figure F-15. Average Annual Volumetric Water Budget Components for IAZ 7 (AFY)

The time-series plots and pie chart of volumetric movement in and out of the 20-year travel zone of IAZ 7 indicate the following:

- Groundwater recharge provides the greatest influx of water to the IAZ.
- Vertical flow downward out of the shallow 20-year travel zone combined with groundwater pumping and groundwater contributing to surface water bodies (via gaining stream conditions, indicated by the Stream Leakage component) make up the greatest outflux components of water leaving the IAZ.
- IAZ 7 contributes a small proportion of water volume to adjacent IAZs 5 and 6, and receives horizontal flow from IAZ 8.
- Although the net storage component represents a small proportion of water volume on an average yearly basis, the quarterly fluctuations indicate water going into storage during quarters when groundwater recharge is high; the net storage component provides the 20-year travel zone of IAZ 7 with a modest amount of water each year.

F.1.1.8 Summary of Northern Central Valley IAZs

IAZs in the Northern Central Valley (IAZs 1 through 7) represent the Sacramento Valley Groundwater Basin, where gaining streams are prevalent and groundwater recharge is high. According to the ICM, the 20-year travel zones for IAZs 1 through 7 represent an average range of water volumes between about 3 million AF to about 10.5 million AF (**Figure F-16**). A comparison of average annual water budget components (between 1983 and 2003) gives insight to the differences between the IAZs in the Northern Central Valley IAZs and also some similarities (**Table F-8** and **Figure F-17**). IAZ 4 stands out as behaving differently from the other IAZs in that vertical flow from groundwater deeper than the 20-year travel zone (from the "lower aquifer") is upward instead of downward; IAZ 4 is also a sink with respect to horizontal flow, receiving more groundwater from adjacent IAZs compared to all others; also IAZ 4 is the only IAZ with an average annual negative groundwater recharge component indicating high amounts of uptake and evapotranspiration.

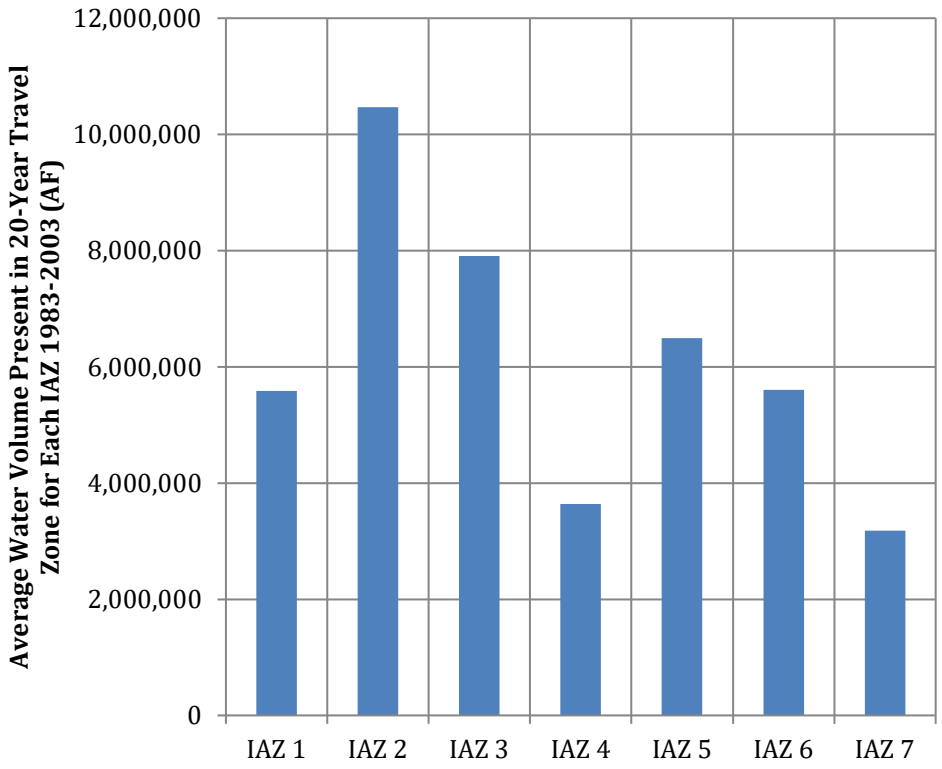

Figure F-16. Average Water Volume Present in 20-Year Travel Zone for Northern Central Valley IAZs (1983-2003)

Table F-8. Annual Average Water Budget Components for the 20-Year Travel Zone of Each IAZ in the Northern Central Valley (1983-2003) (TAFY)

Component	IAZ 1	IAZ 2	IAZ 3	IAZ 4	IAZ 5	IAZ 6	IAZ 7
Average Groundwater Volume present in IAZ (TAF)	5,583	10,470	7,910	3,642	6,490	5,600	3,183
Flow Into/Out of Storage (TAFY)	52	51	18	4.5	41	-4.0	31
Groundwater Pumping (TAFY)	-34	-83	-1.1	0	-24	-67	-76
Flow Into/Out through Stream Leakage (TAFY)	-109	-289	-219	-506	-204	30	-40
Groundwater Recharge (TAFY)	403	710	441	-19	403	419	191
Vertical Flow to/from the Lower Aquifer (below the 20-year travel zone) (TAFY)	-287	-381	-205	412	-185	-371	-94
Horizontal Flow to/from Adjacent IAZs (TAFY)	-24	-7.5	-34	108	-31	-6.5	-12

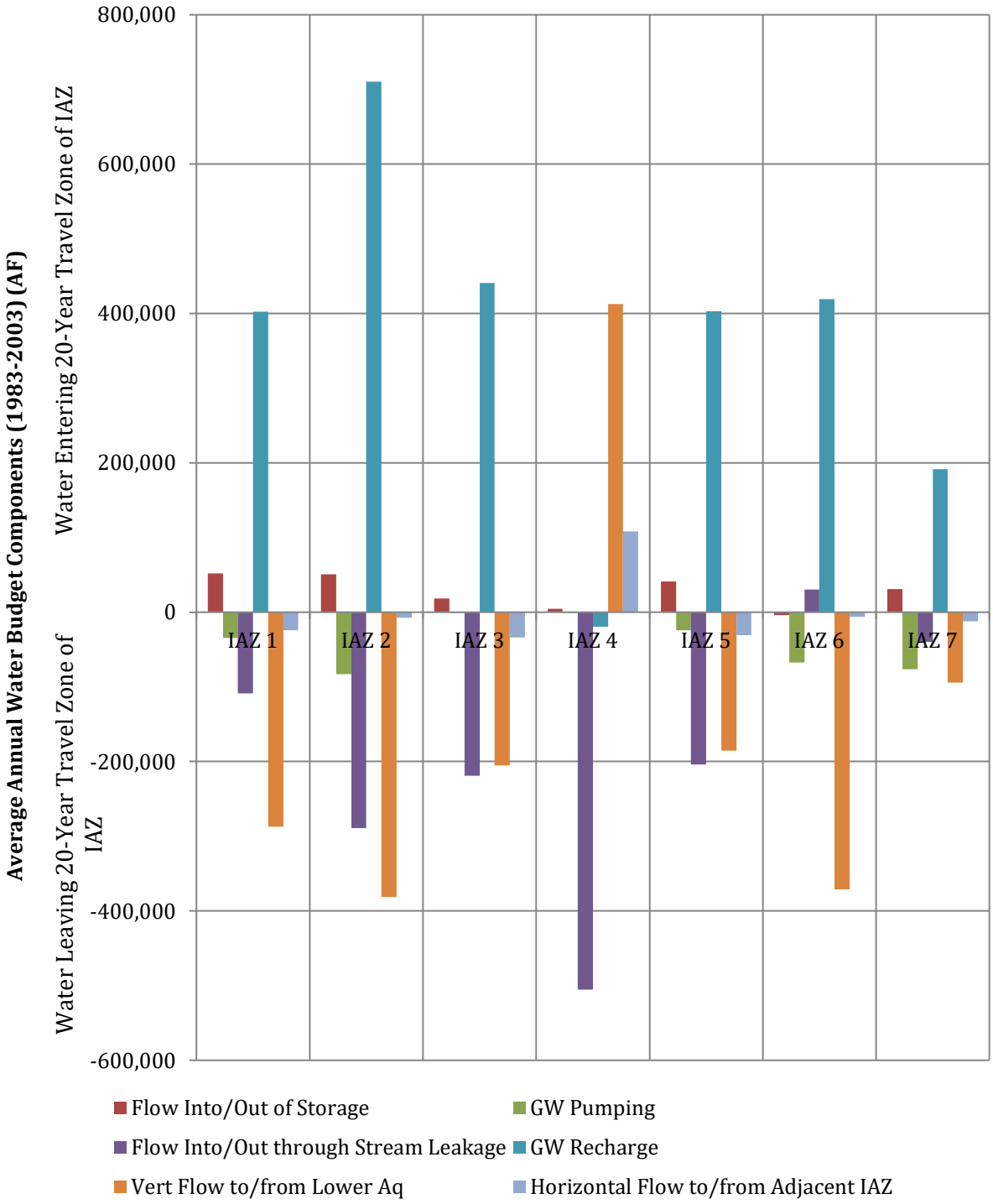

Figure F-17 Average Annual Water Budget Components for the 20-Year Travel Zone for IAZs in the Northern Central Valley (1983-2003)

F.1.2 Water Balance Conditions for IAZs within the Middle Central Valley

Water balance calculations for the upper aquifer representing the 20-year travel zone from the water table are presented here for IAZs 8 through 13 plus 22 individually.

F.1.2.1 IAZ 8 Valley floor east of the Delta

The water balance components that play a role in the 20-year travel zone for IAZ 8 include: storage, groundwater pumping, stream leakage, groundwater recharge, vertical flow to/from the lower aquifer (deeper than the 20-year travel zone), and horizontal flow to/from the adjacent IAZs (IAZs 7, 9, and 11). Time-series plots for these components are available on a quarterly basis between 1983-2003 (**Figure F-18**). The average annual volumetric water budget summary is presented in tabular format below (**Table F-9**) and in a pie chart (**Figure F-19**).

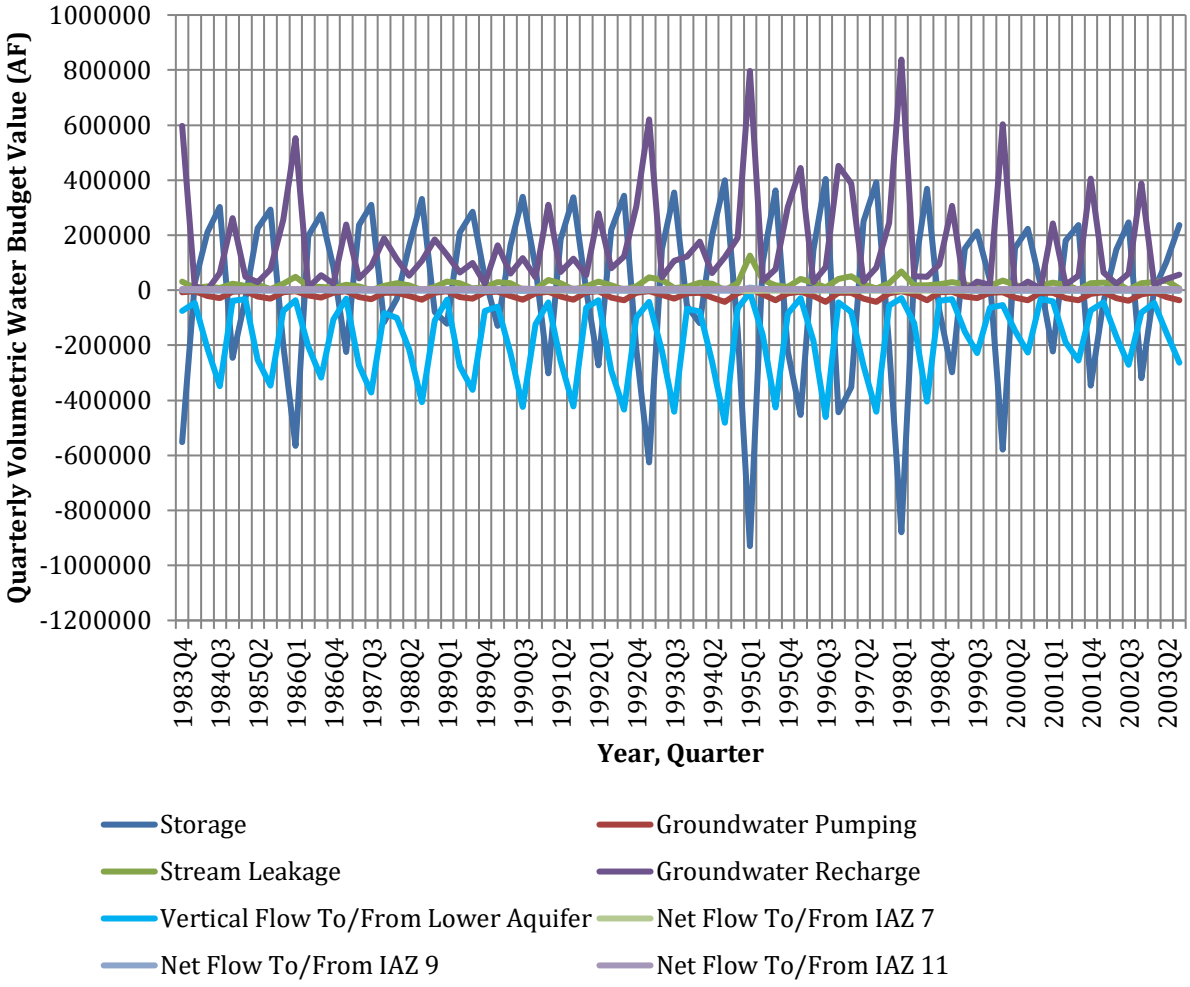

Figure F-18. Quarterly Volumetric Water Budget Time Series Plot for IAZ 8

Table F-9. Average Annual Volumetric Water Budget Components for IAZ 8

Volumetric Water Budget Component	Annual Average Volume* (AF)
Avg Water Volume Present in IAZ 8	**11,643,508**
Storage	**28,959**
GW Pumping	**-69,914**
Stream Leakage	**82,360**
GW Recharge	**611,972**
Vertical Flow to/from Lower Aquifer	**-663,942**
Net Horizontal Flow to/From IAZ 7	**-3,551**
Net Horizontal Flow to/From IAZ 9	**-2,455**
Net Horizontal Flow to/From IAZ 11	**16,601**

** See explanation of signage at beginning of **Appendix F***

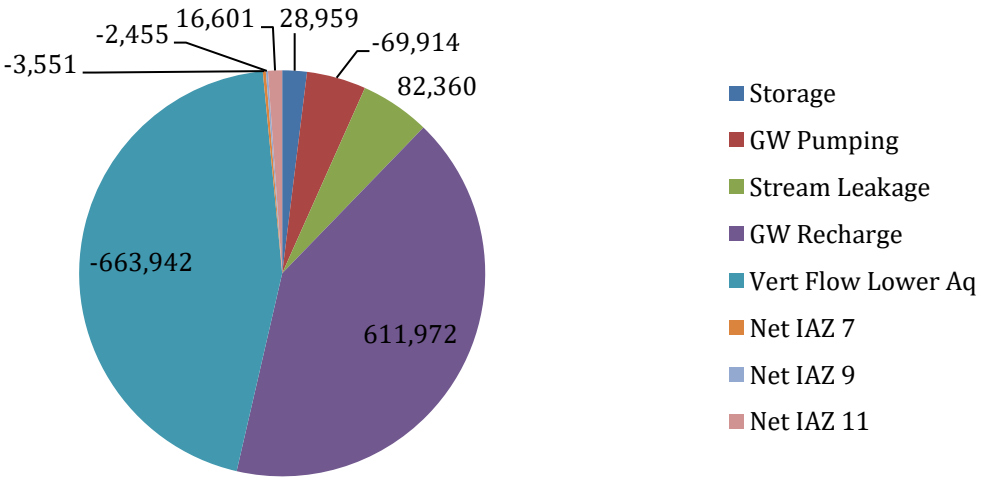

Figure F-19. Average Annual Volumetric Water Budget Components for IAZ 8 (AFY)

The time-series plots and pie chart of volumetric movement in and out of the 20-year travel zone of IAZ 8 indicate the following:

- Groundwater recharge provides the greatest influx of water to the IAZ.
- Vertical flow downward out of the shallow 20-year travel zone combined with groundwater pumping make up the greatest outflux components of water leaving the IAZ.
- IAZ 8 receives surface water via losing stream conditions.
- IAZ 8 contributes a small proportion of water volume to adjacent IAZs 7 and 9, and receives horizontal flow from IAZ 11.
- Although the net storage component represents a small proportion of water volume on an average yearly basis, the quarterly fluctuations indicate water going into storage during quarters when groundwater recharge is high; the net storage component provides the 20-year travel zone of IAZ 8 with a modest amount of water each year.

F.1.2.2 IAZ 9 Delta

The water balance components that play a role in the 20-year travel zone for IAZ 9 include: storage, groundwater pumping, stream leakage, groundwater recharge, vertical flow to/from the lower aquifer (deeper than the 20-year travel zone), horizontal flow to/from the adjacent IAZs (IAZs 6, 8, 10, and 11), and flow in/out of the Delta. Time-series plots for these components are available on a quarterly basis between 1983-2003 (**Figure F-20**). The average annual volumetric water budget summary is presented in tabular format below (**Table F-10**) and in a pie chart (**Figure F-21**).

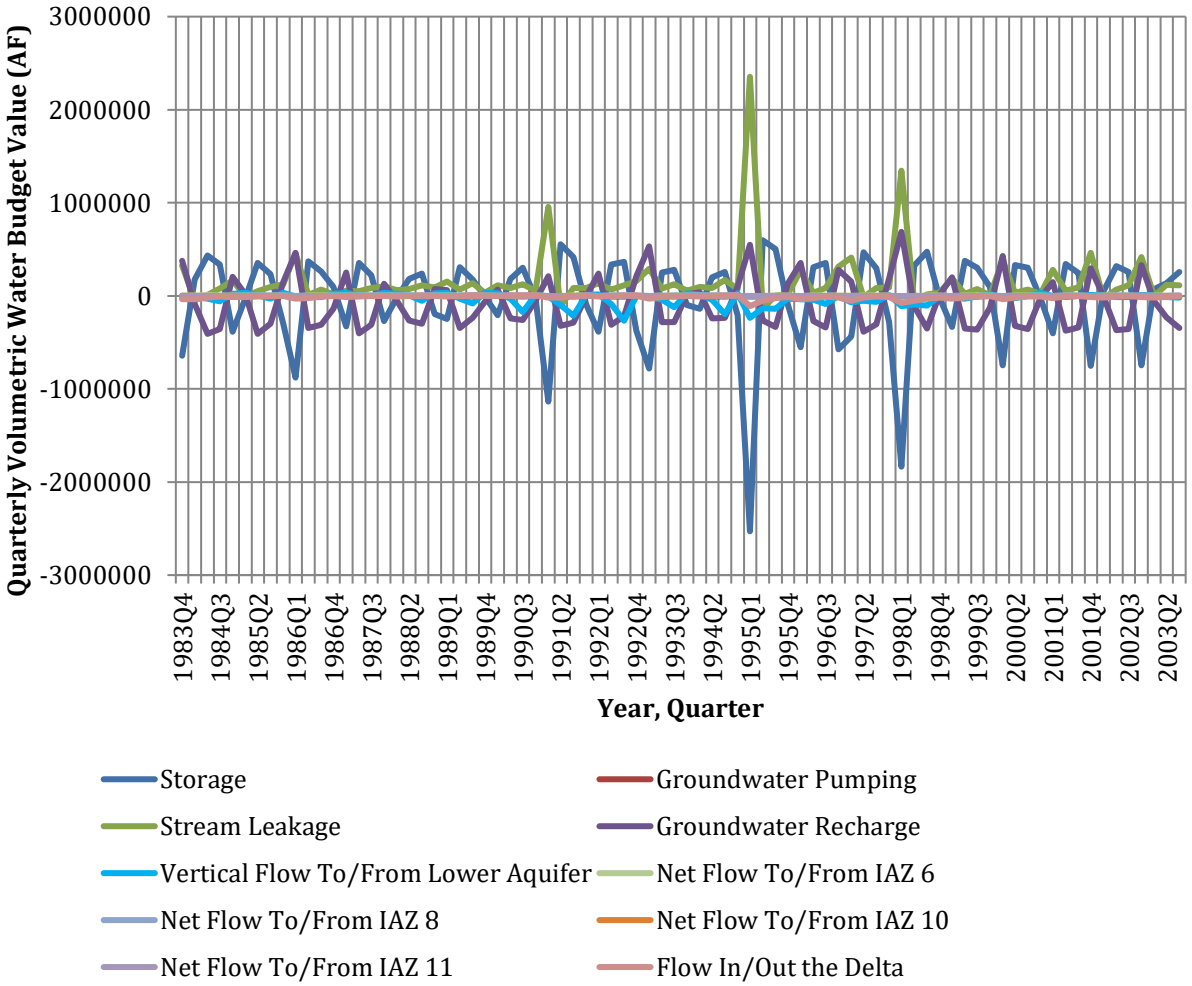

Figure F-20. Quarterly Volumetric Water Budget Time Series Plot for IAZ 9

Table F-10. Average Annual Volumetric Water Budget Components for IAZ 9

Volumetric Water Budget Component	Annual Average Volume* (AF)
Avg Water Volume Present in IAZ 9	**8,585,082**
Storage	**-131,689**
GW Pumping	**-11,302**
Stream Leakage	**596,112**
GW Recharge	**-293,837**
Vertical Flow to/from Lower Aquifer	**-120,090**
Flow In/Out Delta	**-52,278**
Net Horizontal Flow to/From IAZ 6	**10,688**
Net Horizontal Flow to/From IAZ 8	**2,455**
Net Horizontal Flow to/From IAZ 10	**3,459**
Net Horizontal Flow to/From IAZ 11	**3,413**

** See explanation of signage at beginning of **Appendix F***

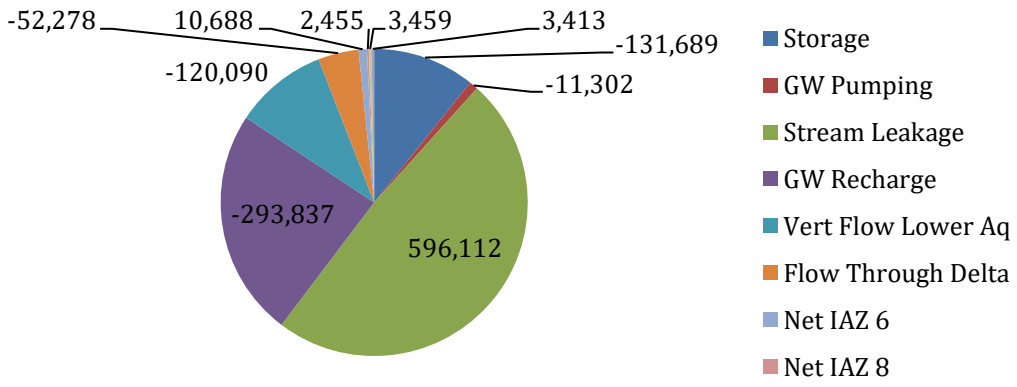

Figure F-21. Average Annual Volumetric Water Budget Components for IAZ 9 (AFY)

The time-series plots and pie chart of volumetric movement in and out of the 20-year travel zone of IAZ 9 indicate the following:

- Stream leakage provides the greatest influx of water to the IAZ.
- Negative groundwater recharge (indicative of high levels of evapotranspiration), groundwater entering storage, and vertical flow downward out of the shallow 20-year travel zone make up the greatest outflux components of water leaving the IAZ.
- IAZ 9 contributes groundwater to the Delta.
- IAZ 9 receives horizontal flow from all adjacent IAZs: 6, 8, 10, and 11.

F.1.2.3 IAZ 10 Delta-Mendota Basin – Northwest Side

The water balance components that play a role in the 20-year travel zone for IAZ 10 include: storage, groundwater pumping, stream leakage, groundwater recharge, vertical flow to/from the lower aquifer (deeper than the 20-year travel zone), and horizontal flow to/from the adjacent IAZs (IAZs 9, 11, 12, and 22). Time-series plots for these components are available on a quarterly basis between 1983-2003 (**Figure F-22**). The average annual volumetric water budget summary is presented in tabular format below (**Table F-11**) and in a pie chart (**Figure F-23**).

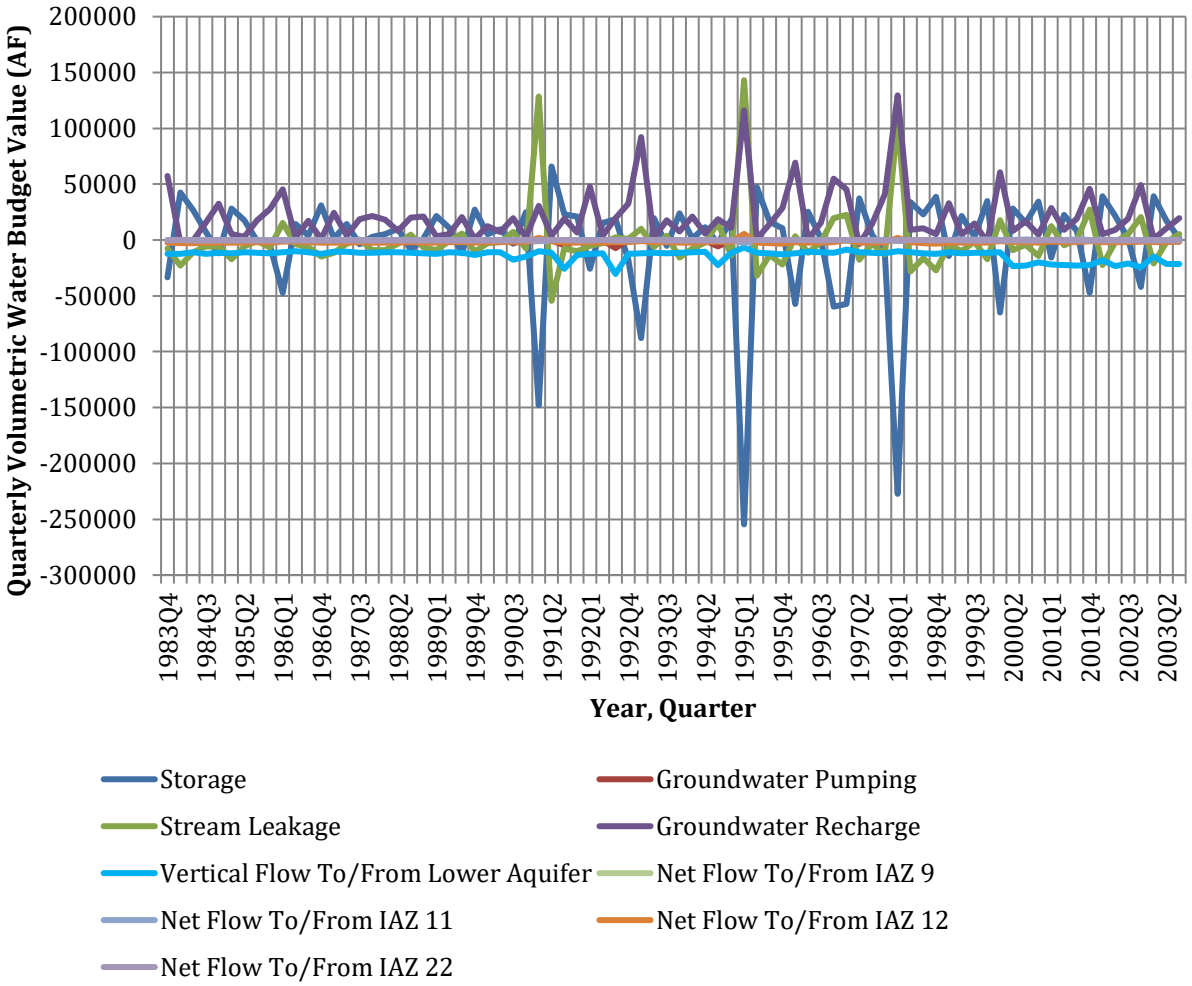

Figure F-22. Quarterly Volumetric Water Budget Time Series Plot for IAZ 10

Table F-11. Average Annual Volumetric Water Budget Components for IAZ 10

Volumetric Water Budget Component	Annual Average Volume* (AF)
Avg Water Volume Present in IAZ 10	**2,121,228**
Storage	**-10,225**
GW Pumping	**-3,098**
Stream Leakage	**-1,327**
GW Recharge	**80,025**
Vertical Flow to/from Lower Aquifer	**-52,587**
Net Horizontal Flow to/From IAZ 9	**-3,459**
Net Horizontal Flow to/From IAZ 11	**-217**
Net Horizontal Flow to/From IAZ 12	**-7,051**
Net Horizontal Flow to/From IAZ 22	**-942**

** See explanation of signage at beginning of **Appendix F***

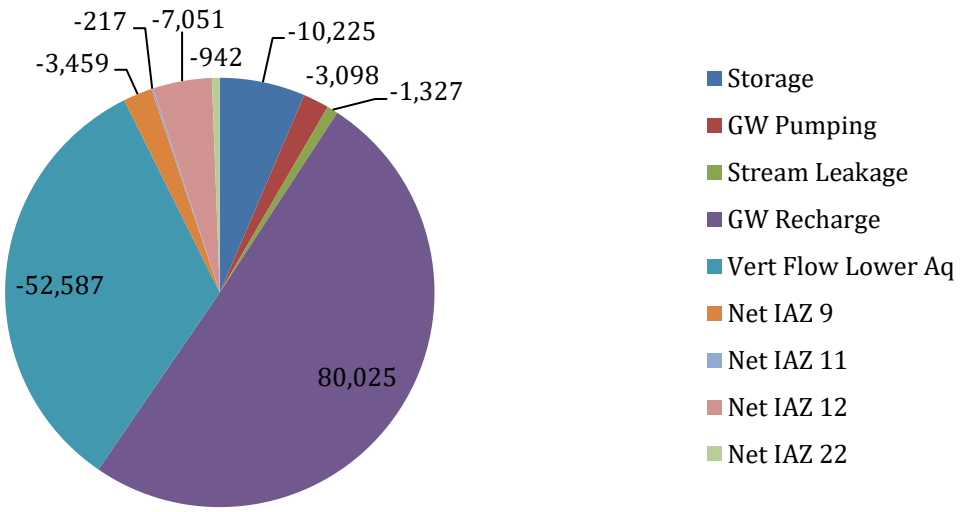

Figure F-23. Average Annual Volumetric Water Budget Components for IAZ 10 (AFY)

The time-series plots and pie chart of volumetric movement in and out of the 20-year travel zone of IAZ 10 indicate the following:

- Groundwater recharge provides the greatest influx of water to the IAZ.
- Vertical flow downward out of the shallow 20-year travel zone combined with groundwater entering storage make up the greatest outflux components of water leaving the IAZ.
- IAZ 10 provides a small amount of water to surface water bodies via gaining stream conditions.
- Groundwater pumping is a small proportion of the volumetric budget components leaving the 20-year travel zone (it is assumed that the majority of groundwater production occurs in deeper aquifer zones below the 20-year travel zone).
- IAZ 10 contributes groundwater to all adjacent IAZs 9, 11, 12, and 22.
- Although the net storage component represents a small proportion of water volume on an average yearly basis, the quarterly fluctuations indicate water going into storage during quarters when groundwater recharge is high.

F.1.2.4 IAZ 11 Modesto and southern Eastern San Joaquin Basin

The water balance components that play a role in the 20-year travel zone for IAZ 11 include: storage, groundwater pumping, stream leakage, groundwater recharge, vertical flow to/from the lower aquifer (deeper than the 20-year travel zone), and horizontal flow to/from the adjacent IAZs (IAZs 8, 9, 10, and 12). Time-series plots for these components are available on a quarterly basis between 1983-2003 (**Figure F-24**). The average annual volumetric water budget summary is presented in tabular format below (**Table F-12**) and in a pie chart (**Figure F-25**).

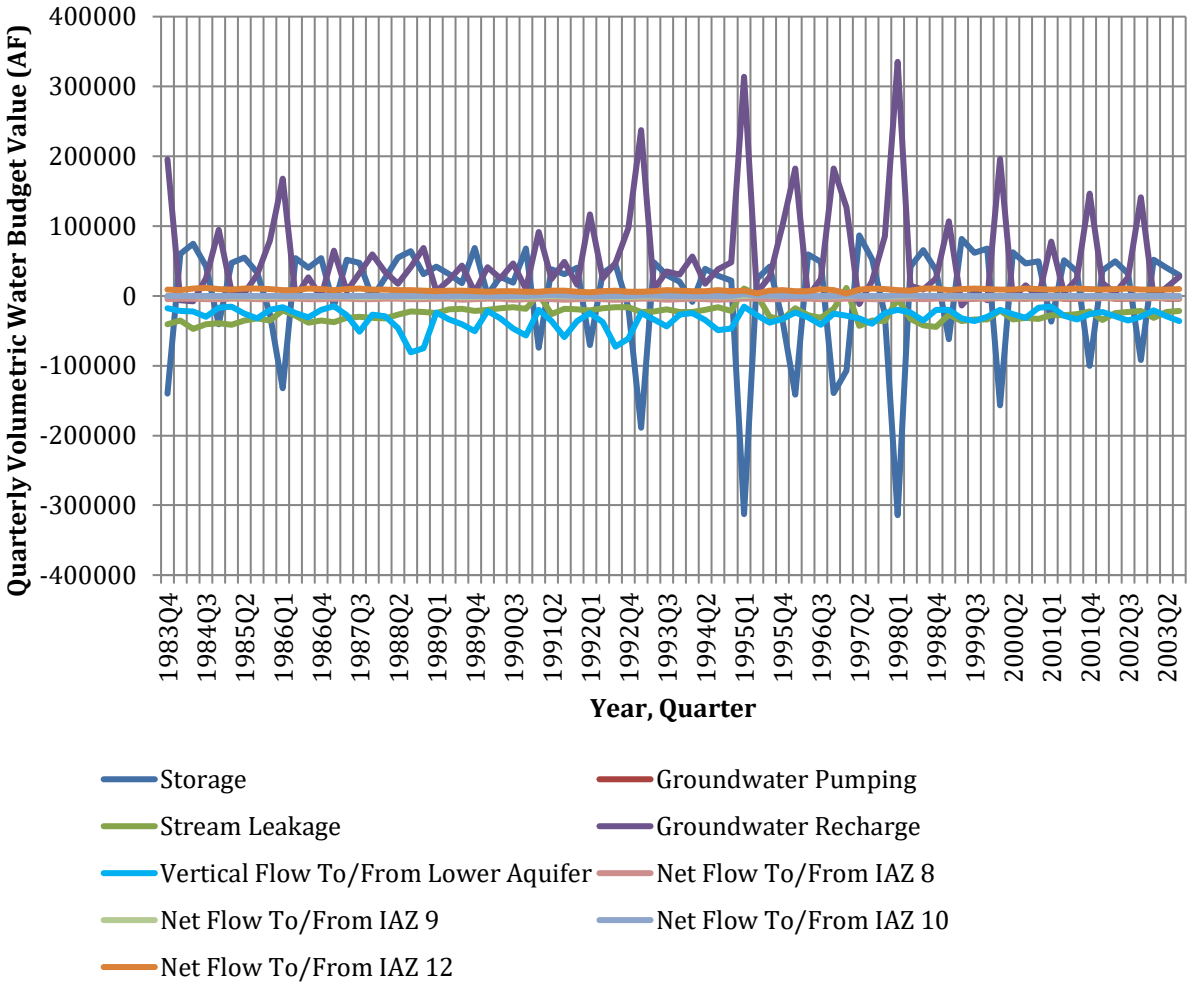

Figure F-24. Quarterly Volumetric Water Budget Time Series Plot for IAZ 11

Table F-12. Average Annual Volumetric Water Budget Components for IAZ 11

Volumetric Water Budget Component	Annual Average Volume* (AF)
Avg Water Volume Present in IAZ 11	**5,580,103**
Storage	**14,226**
GW Pumping	**-9,389**
Stream Leakage	**-98,727**
GW Recharge	**204,351**
Vertical Flow to/from Lower Aquifer	**-122,047**
Net Horizontal Flow to/From IAZ 8	**-16,601**
Net Horizontal Flow to/From IAZ 9	**-3,413**
Net Horizontal Flow to/From IAZ 10	**217**
Net Horizontal Flow to/From IAZ 12	**31,646**

** See explanation of signage at beginning of **Appendix F***

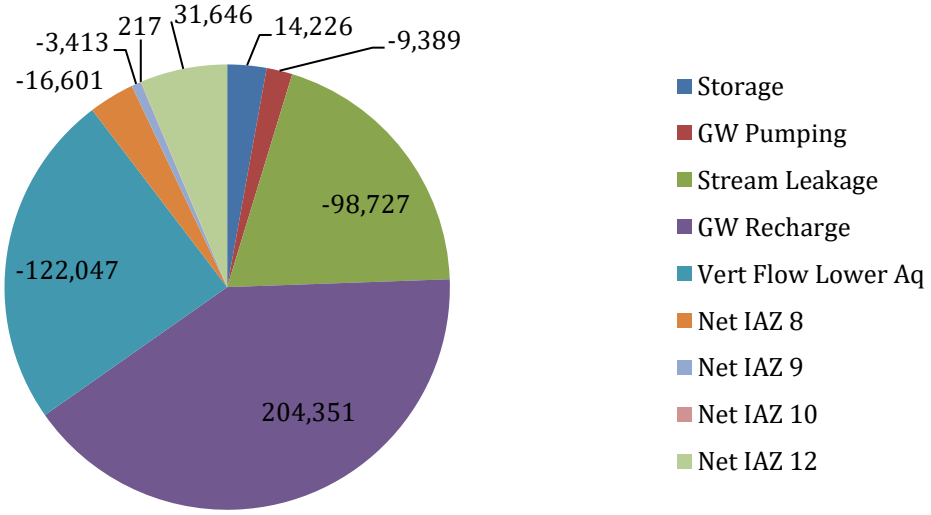

Figure F-25. Average Annual Volumetric Water Budget Components for IAZ 11 (AFY)

The time-series plots and pie chart of volumetric movement in and out of the 20-year travel zone of IAZ 11 indicate the following:

- Groundwater recharge provides the greatest influx of water to the IAZ.
- Vertical flow downward out of the shallow 20-year travel zone combined with stream leakage from gaining stream conditions make up the greatest outflux components of water leaving the IAZ.
- Groundwater pumping is a small proportion of the volumetric budget components leaving the 20-year travel zone (it is assumed that the majority of groundwater production occurs in deeper aquifer zones below the 20-year travel zone).
- IAZ 11 contributes groundwater to adjacent IAZs 8 and 9, and receives water from IAZs 10 and 12.
- Although the net storage component represents a small proportion of water volume on an average yearly basis, the quarterly fluctuations indicate water going into storage during quarters when groundwater recharge is high.

F.1.2.5 IAZ 12 Turlock Basin

The water balance components that play a role in the 20-year travel zone for IAZ 12 include: storage, groundwater pumping, stream leakage, groundwater recharge, vertical flow to/from the lower aquifer (deeper than the 20-year travel zone), and horizontal flow to/from the adjacent IAZs (IAZs 10, 11, and 13). Time-series plots for these components are available on a quarterly basis between 1983-2003 (**Figure F-26**). The average annual volumetric water budget summary is presented in tabular format below (**Table F-13**) and in a pie chart (**Figure F-27**).

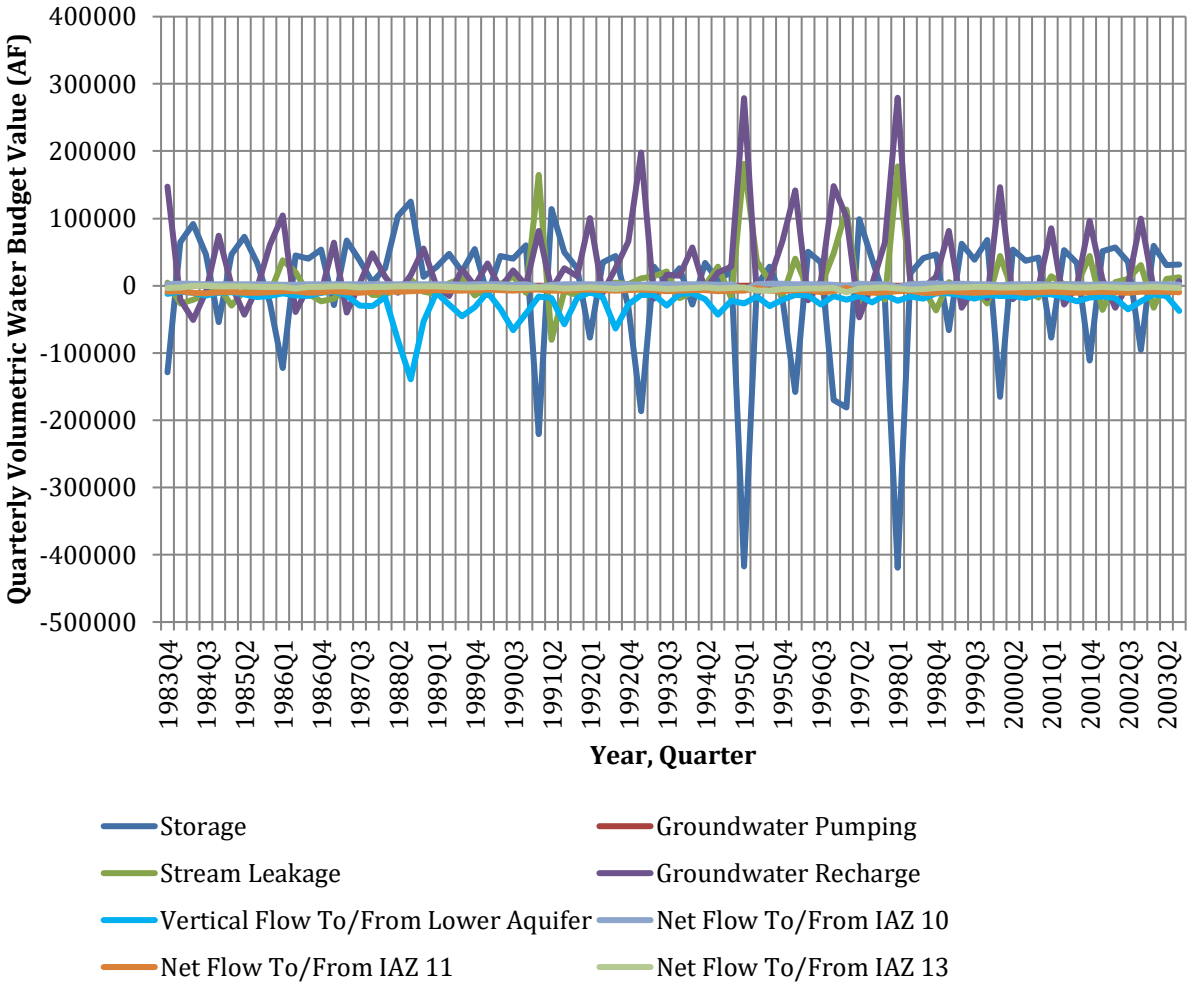

Figure F-26. Quarterly Volumetric Water Budget Time Series Plot for IAZ 12

Table F-13. Average Annual Volumetric Water Budget Components for IAZ 12

Volumetric Water Budget Component	Annual Average Volume* (AF)
Avg Water Volume Present in IAZ 12	**4,768,628**
Storage	**-11,957**
GW Pumping	**-571**
Stream Leakage	**22,978**
GW Recharge	**115,579**
Vertical Flow to/from Lower Aquifer	**-88,312**
Net Horizontal Flow to/From IAZ 10	**7,051**
Net Horizontal Flow to/From IAZ 11	**-31,646**
Net Horizontal Flow to/From IAZ 13	**-11,063**

** See explanation of signage at beginning of **Appendix F***

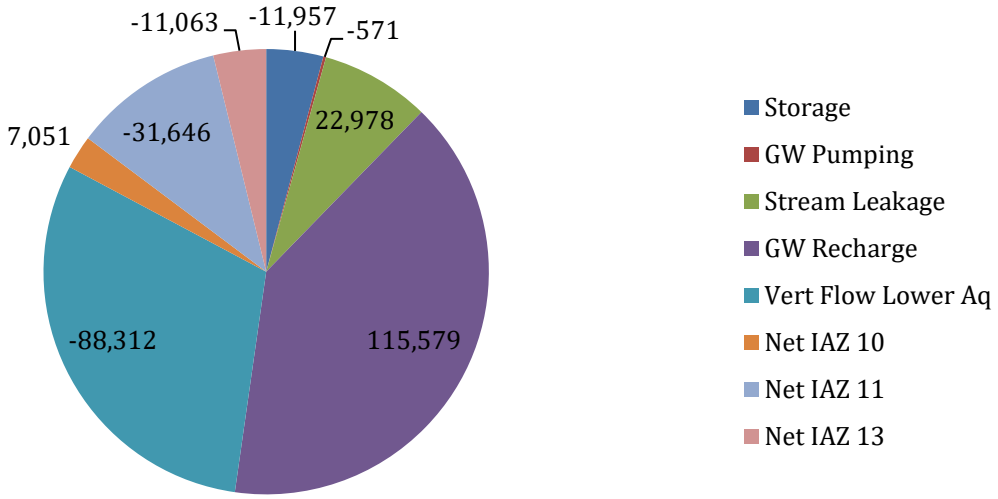

Figure F-27. Average Annual Volumetric Water Budget Components for IAZ 12 (AFY)

The time-series plots and pie chart of volumetric movement in and out of the 20-year travel zone of IAZ 12 indicate the following:

- Groundwater recharge provides the greatest influx of water to the IAZ.
- Vertical flow downward out of the shallow 20-year travel zone is the greatest outflux component of water leaving the IAZ.
- Stream leakage provides IAZ 12 with some water through losing stream conditions.
- Groundwater pumping is a small proportion of the volumetric budget components leaving the 20-year travel zone (it is assumed that the majority of groundwater production occurs in deeper aquifer zones below the 20-year travel zone).
- IAZ 12 contributes groundwater to adjacent IAZs 11 and 13, and receives water from IAZ 10.
- Although the net storage component represents a small proportion of water volume on an average yearly basis, the quarterly fluctuations indicate water going into storage during quarters when groundwater recharge is high.

F.1.2.6 IAZ 13 Merced, Chowchilla, and Madera Basins

The water balance components that play a role in the 20-year travel zone for IAZ 13 include: storage, groundwater pumping, stream leakage, groundwater recharge, vertical flow to/from the lower aquifer (deeper than the 20-year travel zone), and horizontal flow to/from the adjacent IAZs (IAZs 12, 15, 16, and 22). Time-series plots for these components are available on a quarterly basis between 1983-2003 (**Figure F-28**). The average annual volumetric water budget summary is presented in tabular format below (**Table F-14**) and in a pie chart (**Figure F-29**).

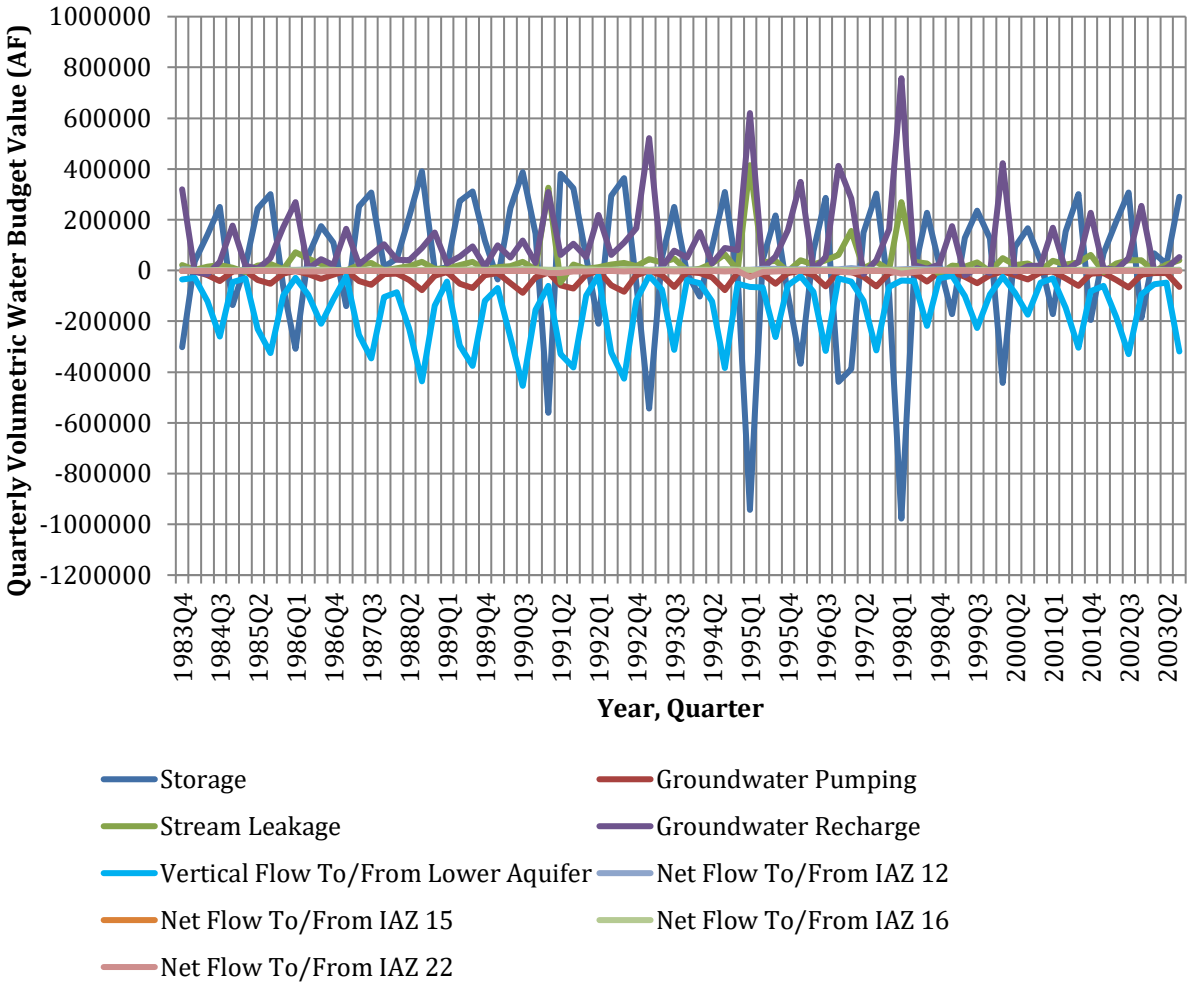

Figure F-28. Quarterly Volumetric Water Budget Time Series Plot for IAZ 13

Table F-14. Average Annual Volumetric Water Budget Components for IAZ 13

Volumetric Water Budget Component	Annual Average Volume* (AF)
Avg Water Volume Present in IAZ 13	**10,116,655**
Storage	**129,128**
GW Pumping	**-103,586**
Stream Leakage	**131,242**
GW Recharge	**414,558**
Vertical Flow to/from Lower Aquifer	**-573,927**
Net Horizontal Flow to/From IAZ 12	**11,063**
Net Horizontal Flow to/From IAZ 15	**-3,333**
Net Horizontal Flow to/From IAZ 16	**7,480**
Net Horizontal Flow to/From IAZ 22	**-10,686**

** See explanation of signage at beginning of **Appendix F***

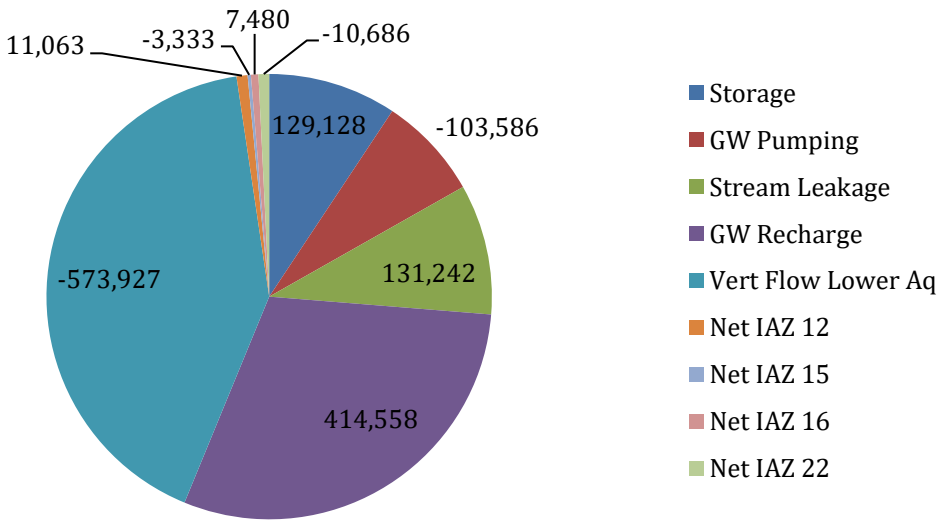

Figure F-29. Average Annual Volumetric Water Budget Components for IAZ 13 (AFY)

The time-series plots and pie chart of volumetric movement in and out of the 20-year travel zone of IAZ 13 indicate the following:

- Groundwater recharge provides the greatest influx of water to the IAZ.
- Vertical flow downward out of the shallow 20-year travel zone is the greatest outflux component of water leaving the IAZ.
- Stream leakage provides IAZ 13 with some water through losing stream conditions.
- Groundwater pumping is a small proportion of the volumetric budget components leaving the 20-year travel zone (it is assumed that the majority of groundwater production occurs in deeper aquifer zones below the 20-year travel zone).
- IAZ 13 contributes groundwater to adjacent IAZs 15 and 22, and receives water from IAZs 12 and 16.
- Although the net storage component represents a small proportion of water volume on an average yearly basis, the quarterly fluctuations indicate water going into storage during quarters when groundwater recharge is high.

F.1.2.7 IAZ 22 Delta-Mendota Basin – Grassland

The water balance components that play a role in the 20-year travel zone for IAZ 22 include: storage, groundwater pumping, stream leakage, groundwater recharge, vertical flow to/from the lower aquifer (deeper than the 20-year travel zone), and horizontal flow to/from the adjacent IAZs (IAZs 10, 13, 14, and 15). Time-series plots for these components are available on a quarterly basis between 1983-2003 (**Figure F-30**). The average annual volumetric water budget summary is presented in tabular format below (**Table F-15**) and in a pie chart (**Figure F-31**).

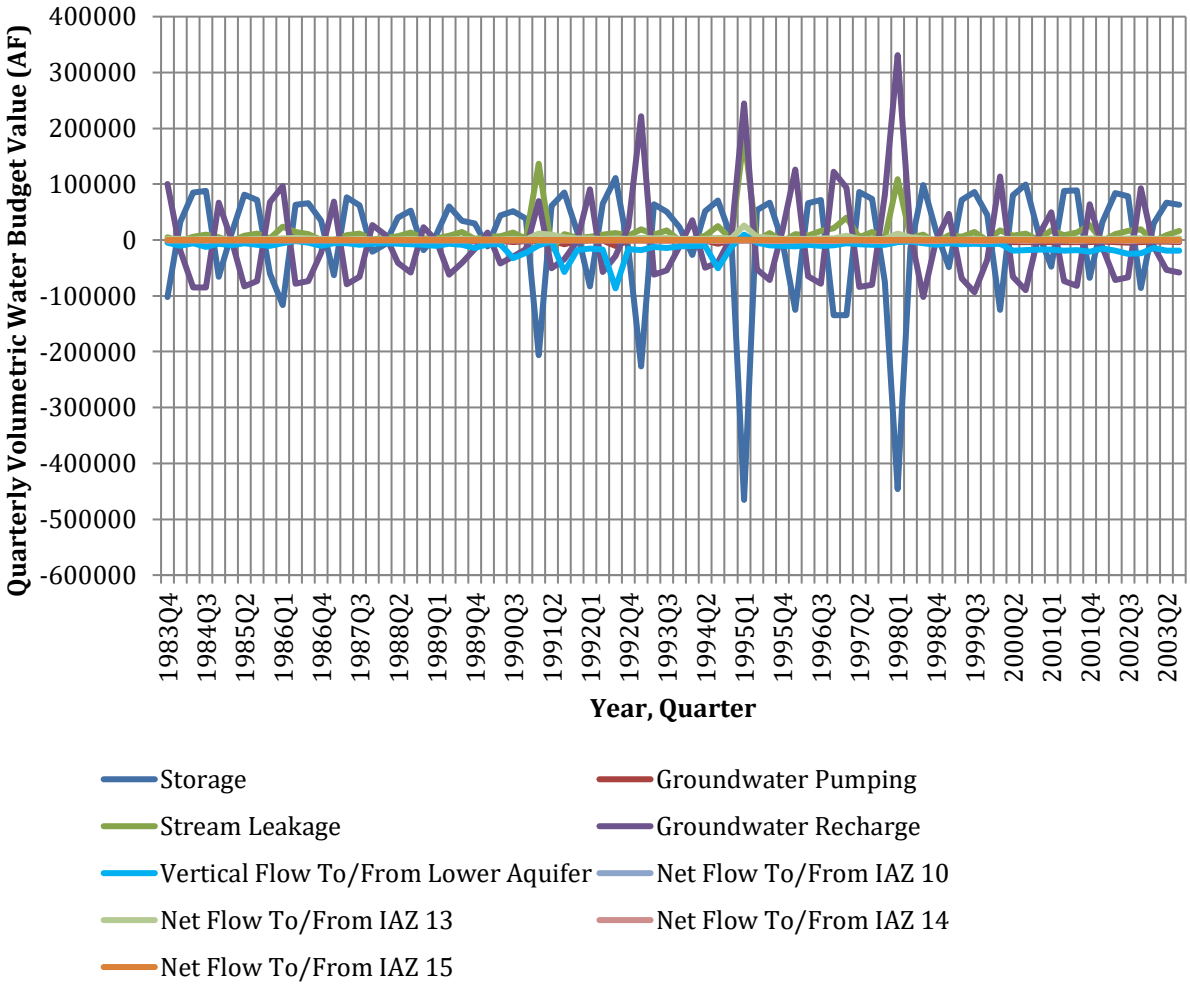

Figure F-30. Quarterly Volumetric Water Budget Time Series Plot for IAZ 22

Table F-15. Average Annual Volumetric Water Budget Components for IAZ 22

Volumetric Water Budget Component	Annual Average Volume* (AF)
Avg Water Volume Present in IAZ 22	**5,659,846**
Storage	**14,052**
GW Pumping	**-5,854**
Stream Leakage	**51,194**
GW Recharge	**-17,020**
Vertical Flow to/from Lower Aquifer	**-49,172**
Net Horizontal Flow to/From IAZ 10	**942**
Net Horizontal Flow to/From IAZ 13	**10,686**
Net Horizontal Flow to/From IAZ 14	**-4,171**
Net Horizontal Flow to/From IAZ 15	**177**

** See explanation of signage at beginning of **Appendix F***

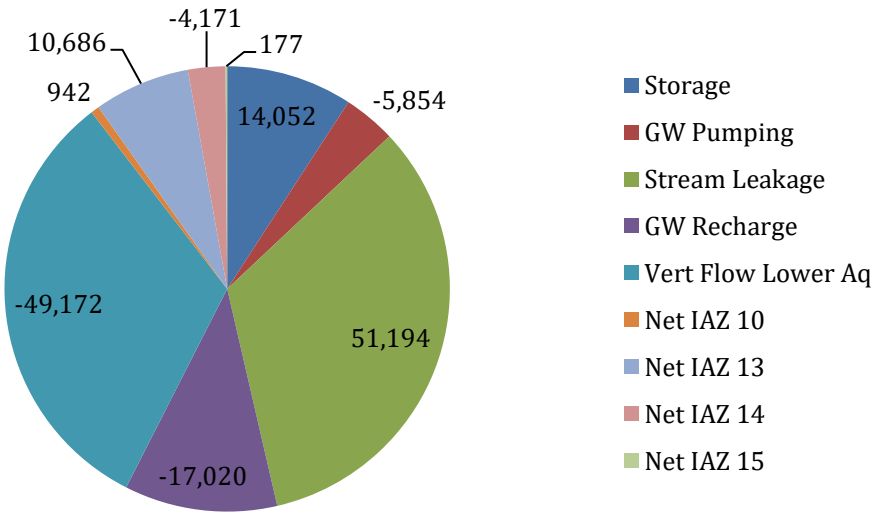

Figure F-31. Average Annual Volumetric Water Budget Components for IAZ 22 (AFY)

The time-series plots and pie chart of volumetric movement in and out of the 20-year travel zone of IAZ 22 indicate the following:

- Stream leakage provides the greatest influx of water to the IAZ.
- Vertical flow downward out of the shallow 20-year travel zone, combined with negative groundwater recharge (due to high levels of uptake and evapotranspiration) are the greatest outflux components of water leaving the IAZ.
- Groundwater pumping is a small proportion of the volumetric budget components leaving the 20-year travel zone (it is assumed that the majority of groundwater production occurs in deeper aquifer zones below the 20-year travel zone).
- IAZ 22 receives groundwater from adjacent IAZs 10, 13, and 15, and contributes water to IAZ 14.
- Although the net storage component represents a small proportion of water volume on an average yearly basis, the quarterly fluctuations indicate water going into storage during quarters when groundwater recharge is high.

F.1.2.8 Summary of Middle Central Valley IAZs

IAZs in the Middle Central Valley (IAZs 8 through 13 plus 22) represent the central portion of the Central Valley, including the Delta, where vertical flow downward to the saturated sediments below the 20-year travel zone is prevalent. According to the ICM, the 20-year travel zones for IAZs 8 through 13 plus 22 represent an average range of water volumes between about 2 million AF to almost 12 million AF (**Figure F-32**). A comparison of average annual water budget components (between 1983 and 2003) gives insight to the differences between the IAZs in the Middle Central Valley IAZs and also some similarities (**Table F-16** and **Figure F-33**). IAZ 9 stands out as behaving different from the other IAZs in that stream leakage dominates the inflow into the IAZ, and it is the only IAZ connected to the Delta and providing groundwater from the 20-year travel zone to the Delta. IAZ 9 also has a relatively high amount of outflux from negative recharge, indicating shallow water table conditions allowing for evapotranspiration to occur and shallow groundwater leaving the IAZ instead of deep percolating. IAZ 8 and IAZ 13 have similarly high amounts of vertical flow leaving the 20-year travel zone to flow downward, as well as higher amounts of groundwater recharge compared to the other IAZs in the Middle Central Valley.

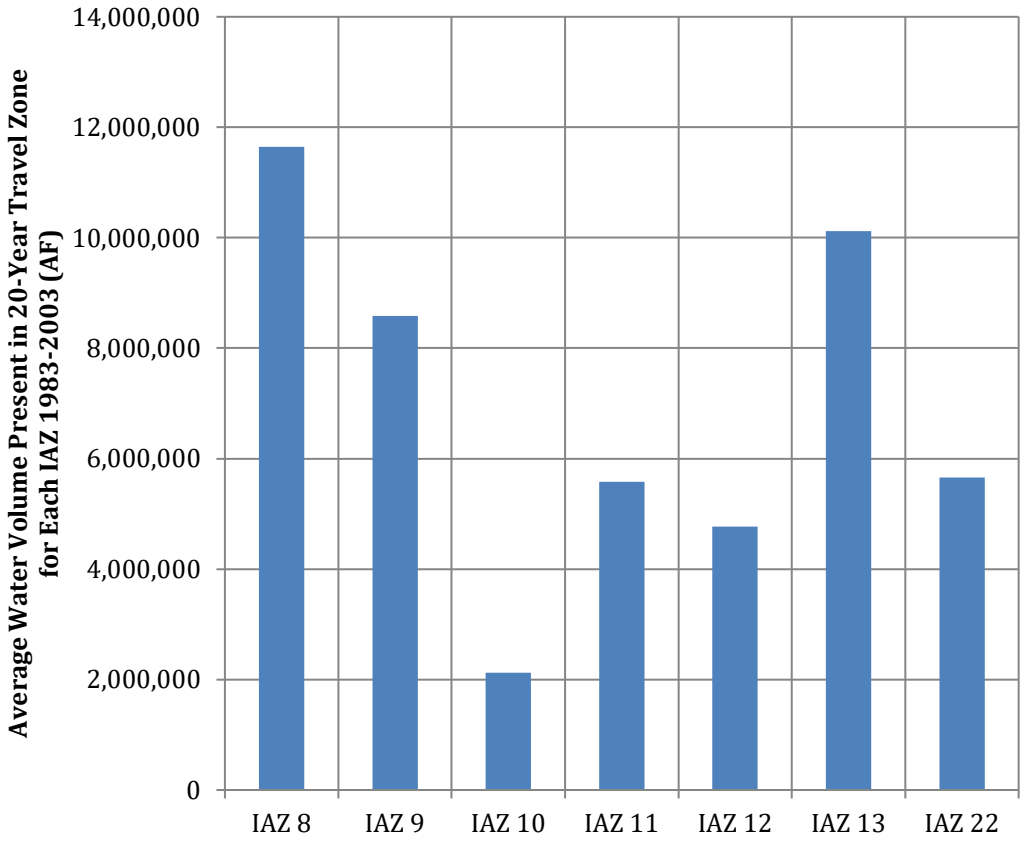

Figure F-32. Average Water Volume Present in 20-Year Travel Zone for Middle Central Valley IAZs (1983-2003)

Table F-16. Annual Average Water Budget Components for the 20-Year Travel Zone of Each IAZ in the Middle Central Valley (1983-2003) (TAFY)

Component	IAZ 8	IAZ 9	IAZ 10	IAZ 11	IAZ 12	IAZ 13	IAZ 22
Average Groundwater Volume present in IAZ (TAF)	11,644	8,585	2,121	5,580	4,769	10,117	5,660
Flow Into/Out of Storage (TAFY)	29	-132	-10	14	-12	129	14
Groundwater Pumping (TAFY)	-70	-11	-3.1	-9.4	-0.6	-104	-5.9
Flow Into/Out through Stream Leakage (TAFY)	82	596	-1.3	-99	23	131	51
Groundwater Recharge (TAFY)	612	-294	80	204	116	415	-17
Vertical Flow to/from the Lower Aquifer (below the 20-year travel zone) (TAFY)	-664	-120	-53	-122	-88	-574	-49
Horizontal Flow to/from Adjacent IAZs (TAFY)	-6.0	13	-8.2	32	-36	4.5	7.6
Flow Through the Delta (TAFY)	-	-52	-	-	-	-	-

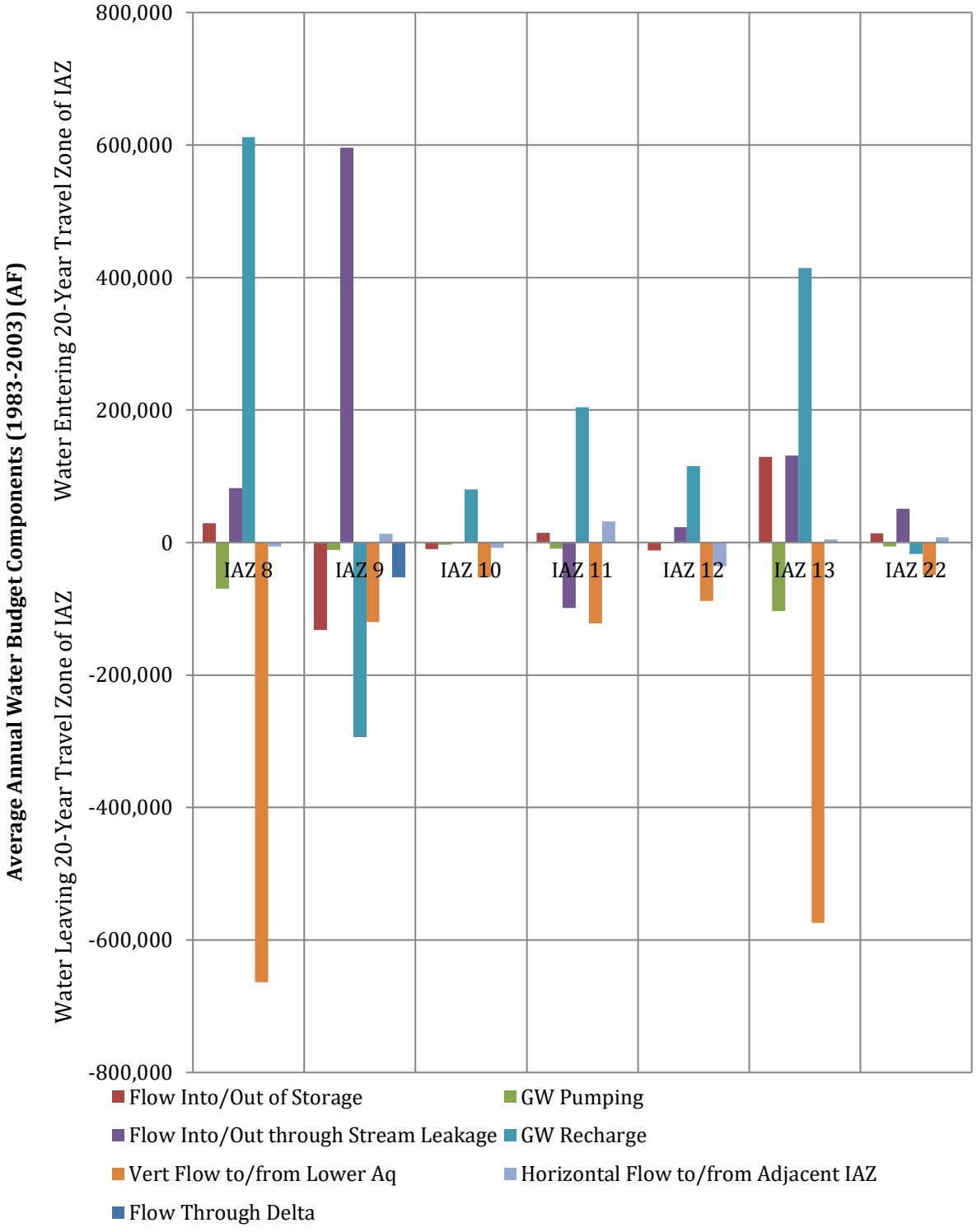

Figure F-33. Average Annual Water Budget Components for the 20-Year Travel Zone for IAZs in the Middle Central Valley (1983-2003)

F.1.3 Water Balance Conditions for IAZs within the Southern Central Valley

Water balance calculations for the upper aquifer representing the 20-year travel zone from the water table are presented here for IAZs 14 through 21 individually.

F.1.3.1 IAZ 14 Westside and Northern Pleasant Valley Basins

The water balance components that play a role in the 20-year travel zone for IAZ 14 include: storage, groundwater pumping, stream leakage, groundwater recharge, vertical flow to/from the lower aquifer (deeper than the 20-year travel zone), and horizontal flow to/from the adjacent IAZs 15, 19, and 22. Time-series plots for these components are available on a quarterly basis between 1983-2003 (**Figure F-34**). The average annual volumetric water budget summary is presented in tabular format below (**Table F-17**) and in a pie chart (**Figure F-35**).

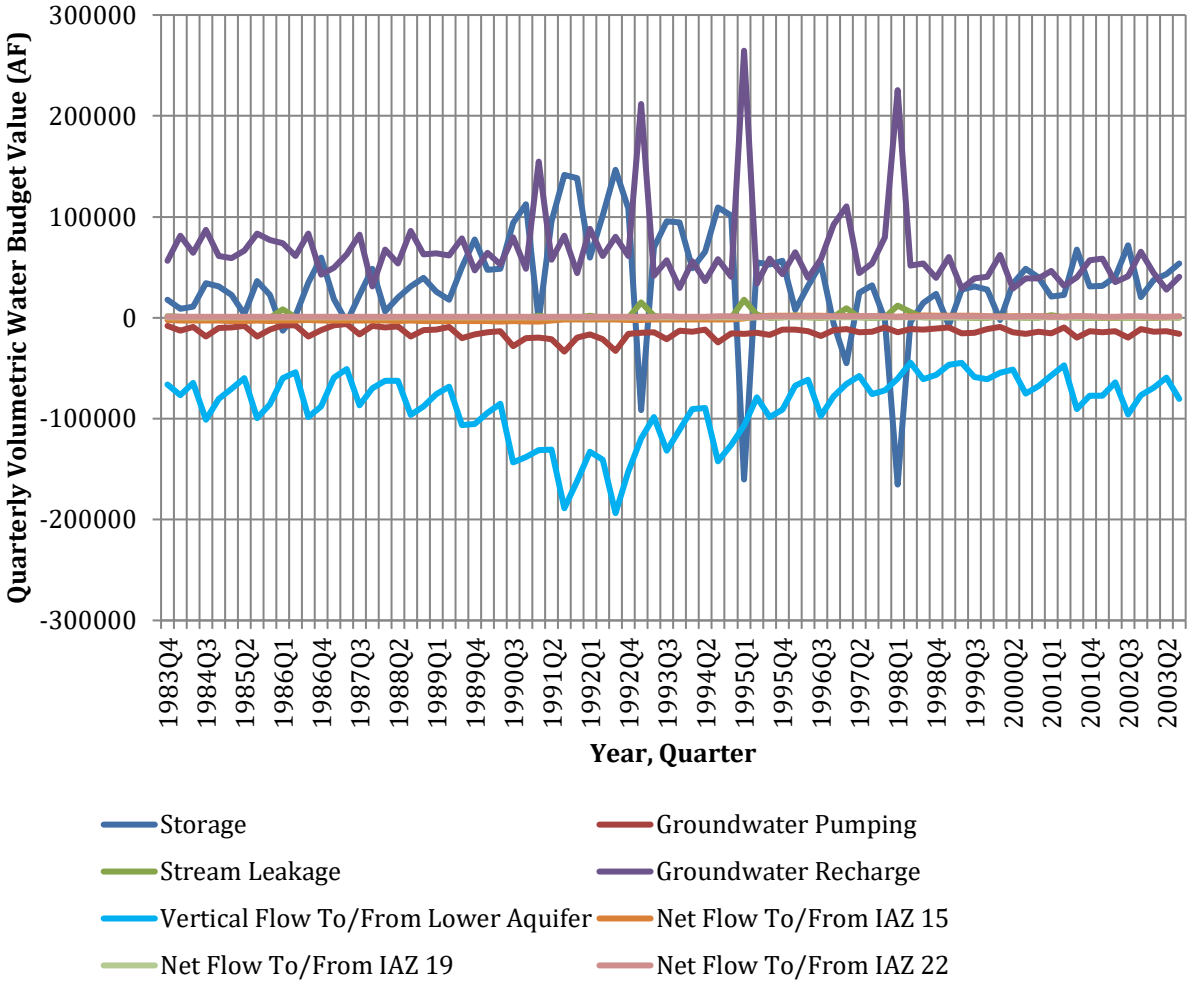

Figure F-34. Quarterly Volumetric Water Budget Time Series Plot for IAZ 14

Table F-17. Average Annual Volumetric Water Budget Components for IAZ 14

Volumetric Water Budget Component	Annual Average Volume* (AF)
Avg Water Volume Present in IAZ 14	**16,730,916**
Storage	**134,221**
GW Pumping	**-55,213**
Stream Leakage	**4,468**
GW Recharge	**246,998**
Vertical Flow to/from Lower Aquifer	**-331,815**
Net Horizontal Flow to/From IAZ 15	**-3,524**
Net Horizontal Flow to/From IAZ 19	**694**
Net Horizontal Flow to/From IAZ 22	**4,171**

** See explanation of signage at beginning of **Appendix F***

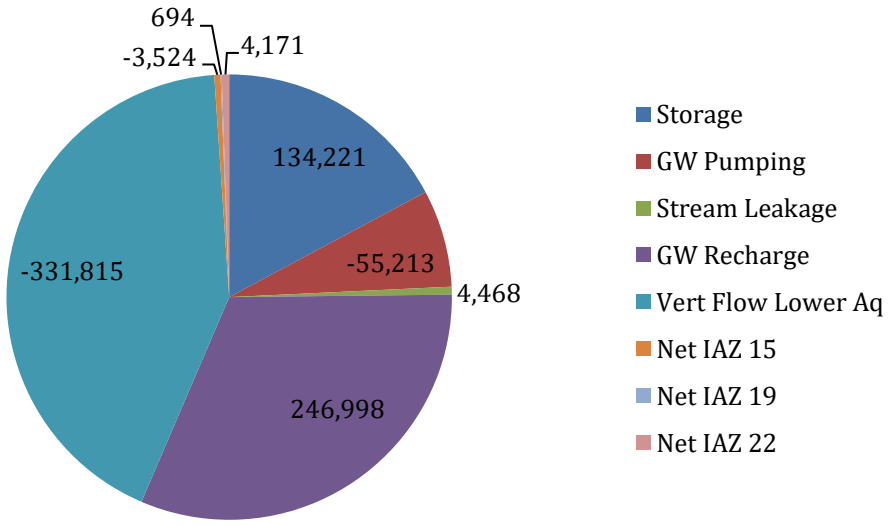

Figure F-35. Average Annual Volumetric Water Budget Components for IAZ 14 (AFY)

The time-series plots and pie chart of volumetric movement in and out of the 20-year travel zone of IAZ 14 indicate the following:

- Groundwater recharge combined with inflow from storage (storage depletion) provide the greatest influx of water to the IAZ.
- Vertical flow downward out of the shallow 20-year travel zone, combined with groundwater pumping are the greatest outflux components of water leaving the IAZ.
- IAZ 14 receives groundwater from adjacent IAZs 19 and 22, and contributes water to IAZ 15.
- The quarterly fluctuations of storage and groundwater recharge indicate water going into storage only during quarters when groundwater recharge is high. The quarterly fluctuations indicate that vertical flow downward out of the 20-year travel zone is associated with a similar pattern of storage depletion (storage contributing water to the 20-year travel zone when flows out of the 20-year travel zone downward are greatest).

F.1.3.2 IAZ 15 Tulare Lake and Western Kings Basin

The water balance components that play a role in the 20-year travel zone for IAZ 15 include: storage, groundwater pumping, stream leakage, groundwater recharge, vertical flow to/from the lower aquifer (deeper than the 20-year travel zone), and horizontal flow to/from the adjacent IAZs (IAZs 13, 14, 16, 17, 18, 19, and 22). Time-series plots for these components are available on a quarterly basis between 1983-2003 (**Figure F-36**). The average annual volumetric water budget summary is presented in tabular format below (**Table F-18**) and in a pie chart (**Figure F-37**).

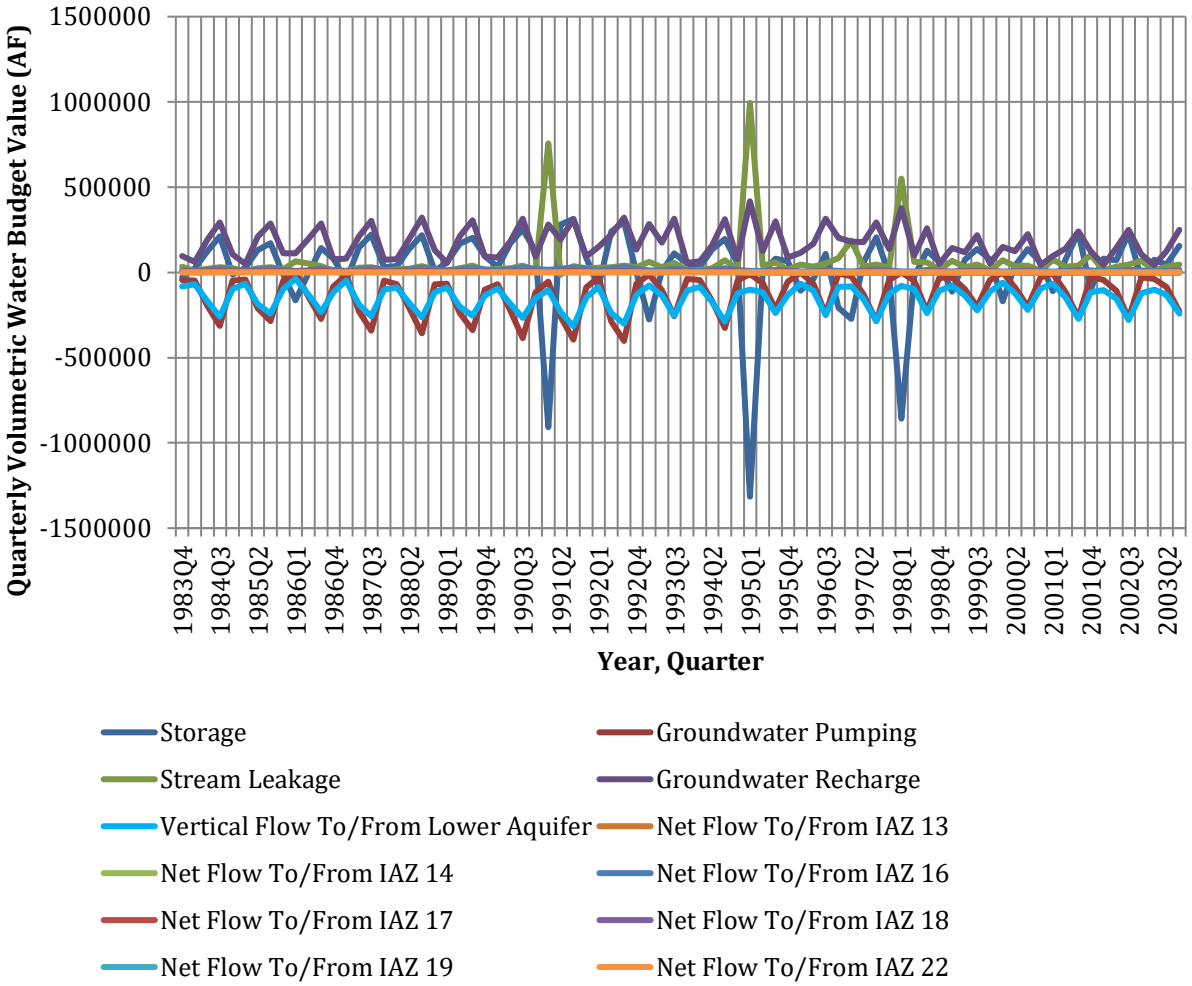

Figure F-36. Quarterly Volumetric Water Budget Time Series Plot for IAZ 15

Table F-18. Average Annual Volumetric Water Budget Components for IAZ 15

Volumetric Water Budget Component	Annual Average Volume* (AF)
Avg Water Volume Present in IAZ 15	**14,263,181**
Storage	**90,830**
GW Pumping	**-502,308**
Stream Leakage	**240,529**
GW Recharge	**662,387**
Vertical Flow to/from Lower Aquifer	**-583,858**
Net Horizontal Flow to/From IAZ 13	**3,333**
Net Horizontal Flow to/From IAZ 14	**3,524**
Net Horizontal Flow to/From IAZ 16	**54,186**
Net Horizontal Flow to/From IAZ 17	**18,481**
Net Horizontal Flow to/From IAZ 18	**5,488**
Net Horizontal Flow to/From IAZ 19	**9,097**
Net Horizontal Flow to/From IAZ 22	**-177**

** See explanation of signage at beginning of **Appendix F***

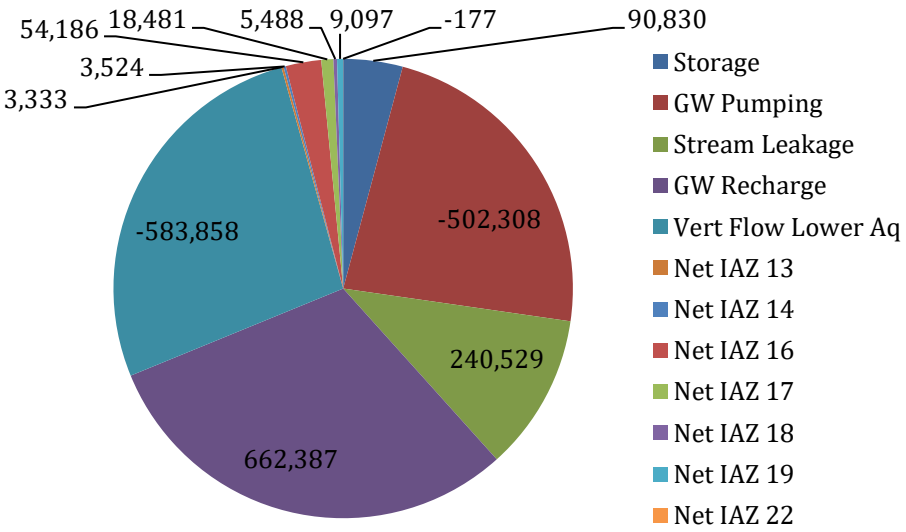

Figure F-37. Average Annual Volumetric Water Budget Components for IAZ 15 (AFY)

The time-series plots and pie chart of volumetric movement in and out of the 20-year travel zone of IAZ 15 indicate the following:

- Groundwater recharge combined with contributions from streams though stream leakage (losing stream conditions) provide the greatest influx of water to the IAZ.
- Vertical flow downward out of the shallow 20-year travel zone, combined with groundwater pumping are the greatest outflux components of water leaving the IAZ.
- IAZ 15 borders 7 different IAZs, and receives groundwater from all but one adjacent IAZs: 13, 14, 16, 17, 18, and 19; while contributing a very small amount of water to IAZ 22.
- The quarterly fluctuations of storage and stream leakage indicate water going into storage only during quarters when stream leakage (losing stream conditions) is high.

F.1.3.3 IAZ 16 Northern Kings Basin

The water balance components that play a role in the 20-year travel zone for IAZ 16 include: storage, groundwater pumping, stream leakage, groundwater recharge, vertical flow to/from the lower aquifer (deeper than the 20-year travel zone), and horizontal flow to/from the adjacent IAZs (IAZs 13, 15, and 17). Time-series plots for these components are available on a quarterly basis between 1983-2003 (**Figure F-38**). The average annual volumetric water budget summary is presented in tabular format below (**Table F-19**) and in a pie chart (**Figure F-39**).

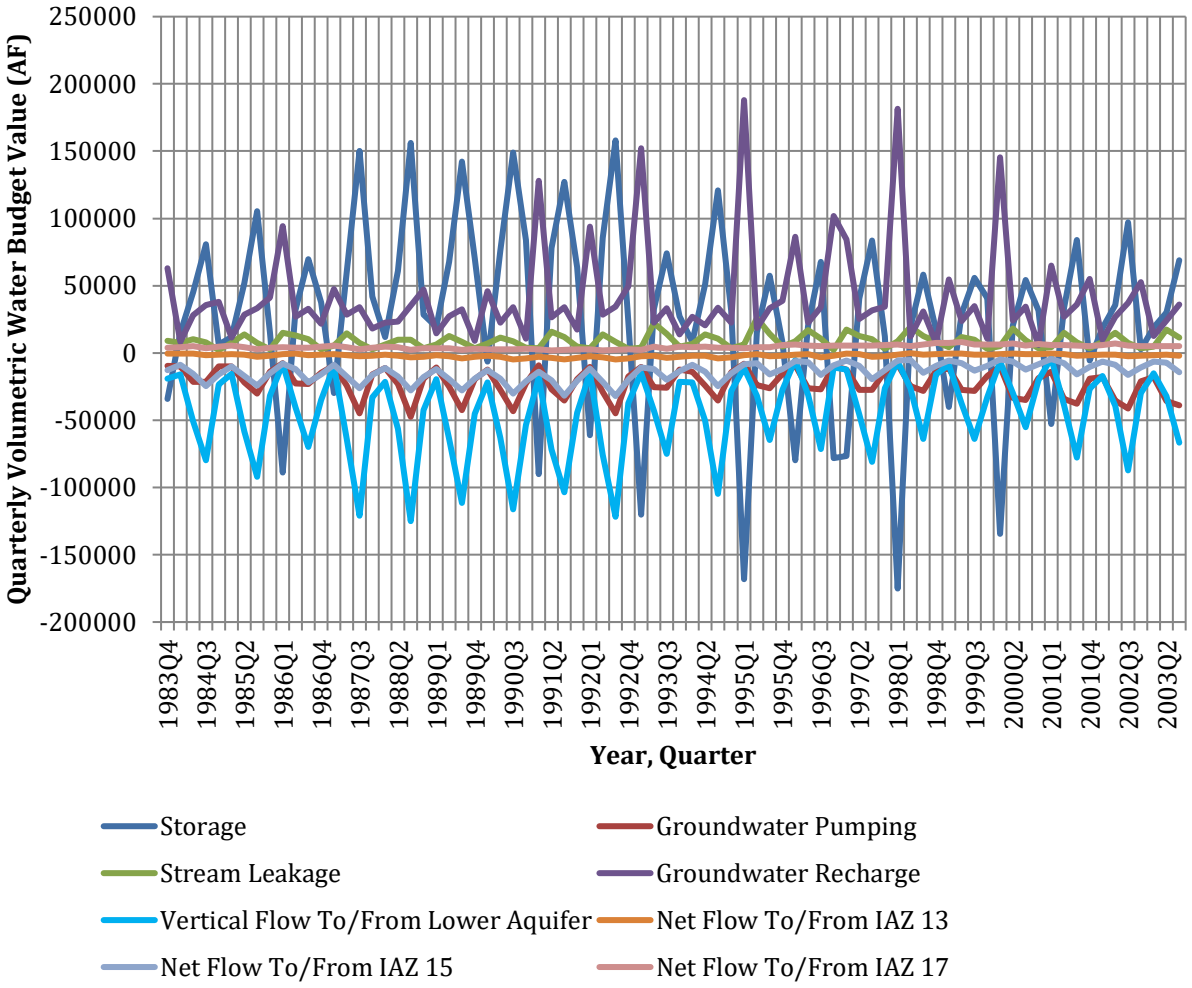

Figure F-38. Quarterly Volumetric Water Budget Time Series Plot for IAZ 16

Table F-19. Average Annual Volumetric Water Budget Components for IAZ 16

Volumetric Water Budget Component	Annual Average Volume* (AF)
Avg Water Volume Present in IAZ 16	**3,020,329**
Storage	**107,074**
GW Pumping	**-84,023**
Stream Leakage	**34,351**
GW Recharge	**157,182**
Vertical Flow to/from Lower Aquifer	**-170,201**
Net Horizontal Flow to/From IAZ 13	**-7,480**
Net Horizontal Flow to/From IAZ 15	**-54,186**
Net Horizontal Flow to/From IAZ 17	**17,313**

** See explanation of signage at beginning of **Appendix F***

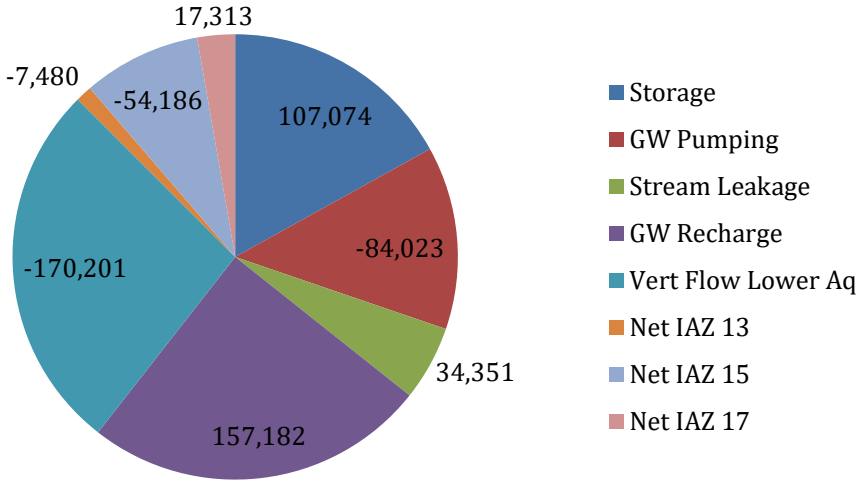

Figure F-39. Average Annual Volumetric Water Budget Components for IAZ 16 (AFY)

The time-series plots and pie chart of volumetric movement in and out of the 20-year travel zone of IAZ 16 indicate the following:

- Groundwater recharge provides the greatest influx of water to the IAZ.
- Vertical flow downward out of the shallow 20-year travel zone combined with groundwater pumping make up the greatest outflux components of water leaving the IAZ.
- IAZ 16 receives water from storage (via storage depletion) and through stream leakage (losing stream conditions).
- IAZ 16 contributes groundwater to adjacent IAZs 13 and 15; and receives water from IAZ 17.
- The only quarters when groundwater storage is replenished is during times when groundwater recharge is high.
- The quarterly fluctuations indicate that vertical flow downward out of the 20-year travel zone is associated with a similar pattern of storage depletion (storage contributing water to the 20-year travel zone when flows out of the 20-year travel zone downward are greatest).

F.1.3.4 IAZ 17 Southern Kings Basin

The water balance components that play a role in the 20-year travel zone for IAZ 17 include: storage, groundwater pumping, stream leakage, groundwater recharge, vertical flow to/from the lower aquifer (deeper than the 20-year travel zone), and horizontal flow to/from the adjacent IAZs (IAZs 15, 16, and 18). Time-series plots for these components are available on a quarterly basis between 1983-2003 (**Figure F-40**). The average annual volumetric water budget summary is presented in tabular format below (**Table F-20**) and in a pie chart (**Figure F-41**).

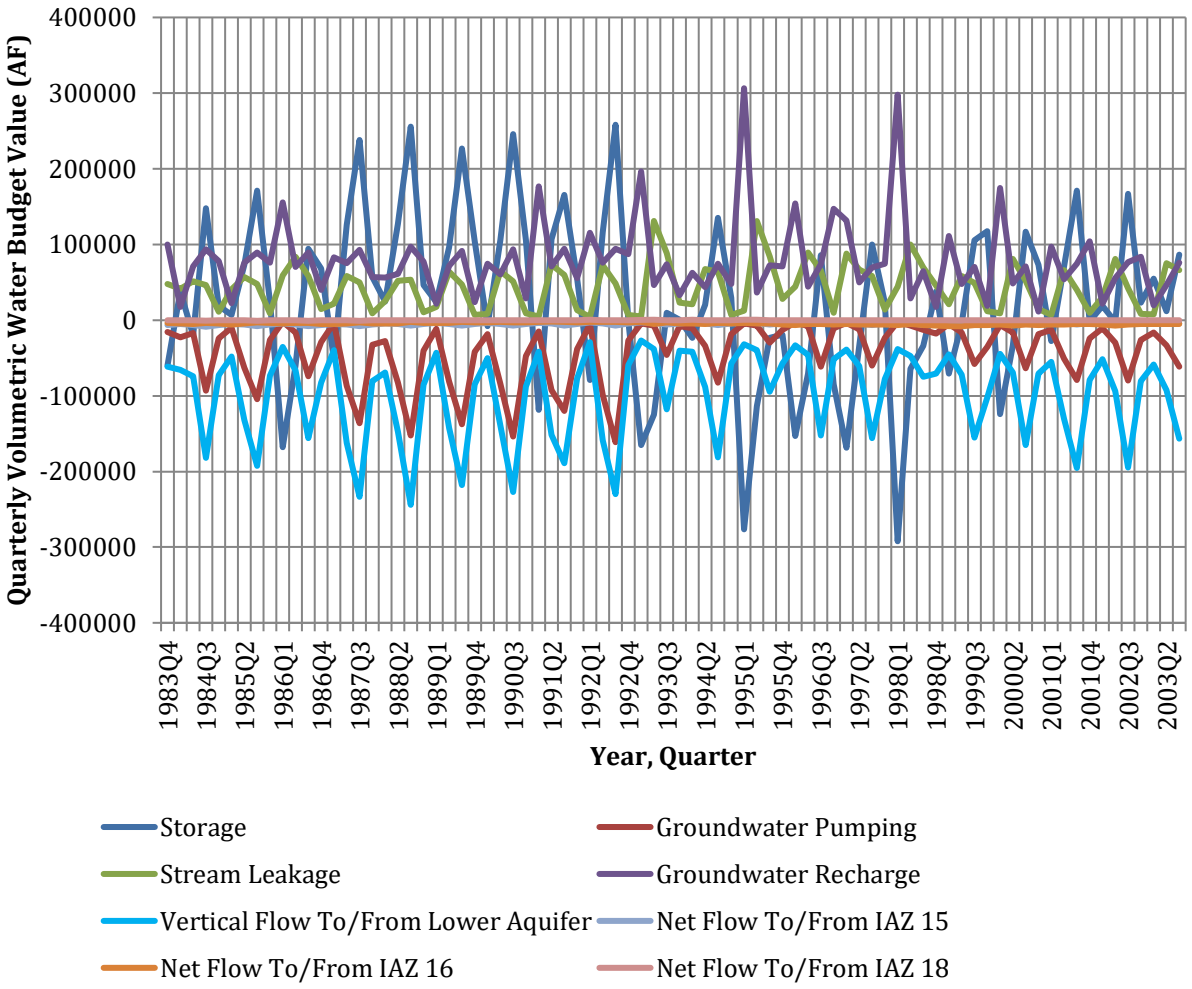

Figure F-40. Quarterly Volumetric Water Budget Time Series Plot for IAZ 17

Table F-20. Average Annual Volumetric Water Budget Components for IAZ 17

Volumetric Water Budget Component	Annual Average Volume* (AF)
Avg Water Volume Present in IAZ 17	**4,704,297**
Storage	**100,477**
GW Pumping	**-158,350**
Stream Leakage	**166,177**
GW Recharge	**300,022**
Vertical Flow to/from Lower Aquifer	**-371,814**
Net Horizontal Flow to/From IAZ 15	**-18,481**
Net Horizontal Flow to/From IAZ 16	**-17,313**
Net Horizontal Flow to/From IAZ 18	**-534**

** See explanation of signage at beginning of **Appendix F***

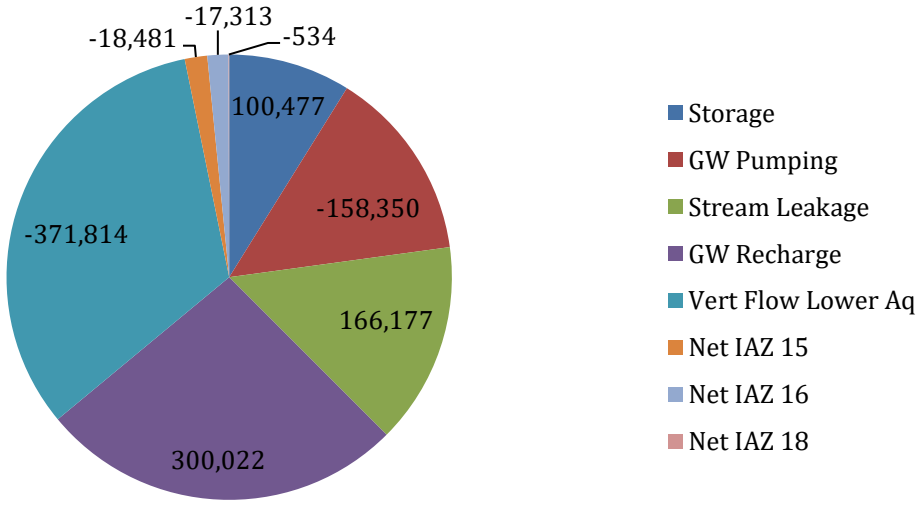

Figure F-41. Average Annual Volumetric Water Budget Components for IAZ 17 (AFY)

The time-series plots and pie chart of volumetric movement in and out of the 20-year travel zone of IAZ 17 indicate the following:

- Groundwater recharge provides the greatest influx of water to the IAZ.
- Vertical flow downward out of the shallow 20-year travel zone combined with groundwater pumping make up the greatest outflux components of water leaving the IAZ.
- IAZ 17 receives water from storage (via storage depletion) and through stream leakage (losing stream conditions).
- IAZ 17 contributes groundwater to all three adjacent IAZs 15, 16, and 18.
- The only quarters when groundwater storage is replenished is during times when groundwater recharge is high.
- The quarterly fluctuations indicate that vertical flow downward out of the 20-year travel zone is associated with a similar pattern of storage depletion (storage contributing water to the 20-year travel zone when flows out of the 20-year travel zone downward are greatest).

F.1.3.5 IAZ 18 Kaweah and Tule Basins

The water balance components that play a role in the 20-year travel zone for IAZ 18 include: storage, groundwater pumping, stream leakage, groundwater recharge, vertical flow to/from the lower aquifer (deeper than the 20-year travel zone), and horizontal flow to/from the adjacent IAZs (IAZs 15, 17, 19, and 20). Time-series plots for these components are available on a quarterly basis between 1983-2003 (**Figure F-42**). The average annual volumetric water budget summary is presented in tabular format below (**Table F-21**) and in a pie chart (**Figure F-43**).

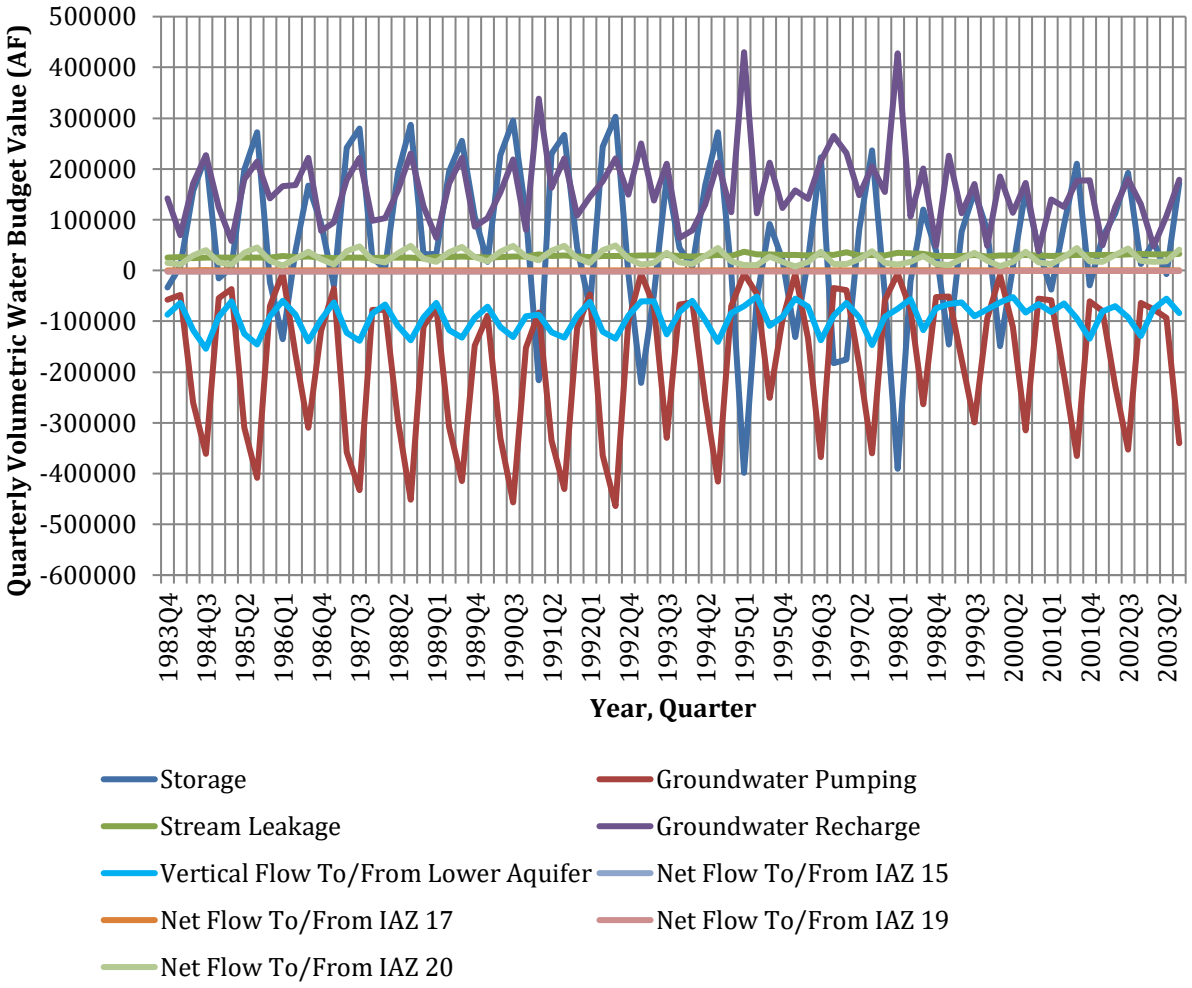

Figure F-42 Quarterly Volumetric Water Budget Time Series Plot for IAZ 18

Table F-21. Average Annual Volumetric Water Budget Components for IAZ 18

Volumetric Water Budget Component	Annual Average Volume* (AF)
Avg Water Volume Present in IAZ 18	**8,249,450**
Storage	**234,602**
GW Pumping	**-678,595**
Stream Leakage	**109,552**
GW Recharge	**603,236**
Vertical Flow to/from Lower Aquifer	**-352,497**
Net Horizontal Flow to/From IAZ 15	**-5,488**
Net Horizontal Flow to/From IAZ 17	**534**
Net Horizontal Flow to/From IAZ 19	**-6,722**
Net Horizontal Flow to/From IAZ 20	**95,470**

** See explanation of signage at beginning of **Appendix F***

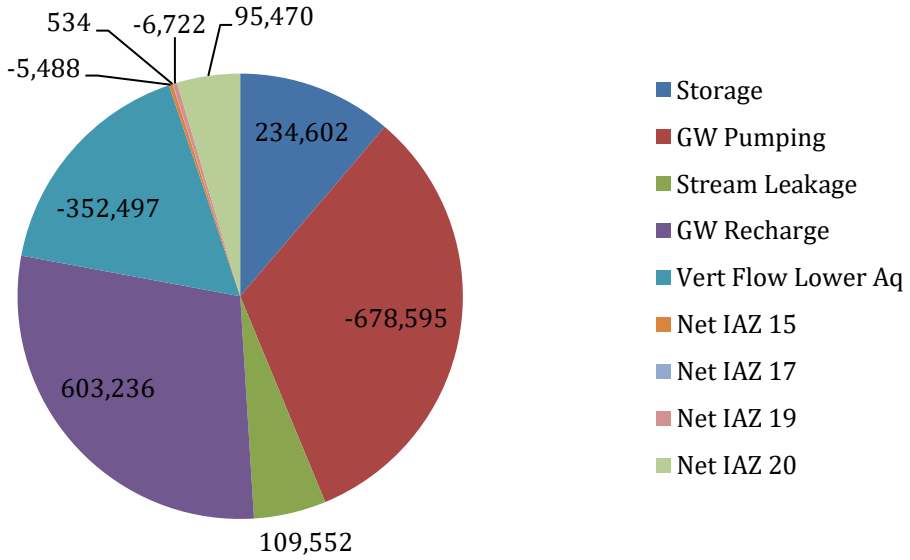

Figure F-43. Average Annual Volumetric Water Budget Components for IAZ 18 (AFY)

The time-series plots and pie chart of volumetric movement in and out of the 20-year travel zone of IAZ 18 indicate the following:

- Groundwater recharge provides the greatest influx of water to the IAZ.
- Groundwater pumping combined with vertical flow downward out of the shallow 20-year travel zone make up the greatest outflux components of water leaving the IAZ.
- IAZ 18 receives water from storage (via storage depletion) and through stream leakage (losing stream conditions).
- IAZ 18 receives groundwater from adjacent IAZs 17 and 20, while contributing groundwater to adjacent IAZs 15 and 19.
- The only quarters when groundwater storage is replenished is during times when groundwater recharge is high.
- Groundwater pumping out of the 20-year travel zone in this IAZ has a slightly higher average yearly value compared to groundwater recharge via deep percolation.

F.1.3.6 IAZ 19 Western Kern County and Southern Pleasant Valley Basin

The water balance components that play a role in the 20-year travel zone for IAZ 19 include: storage, groundwater pumping, stream leakage, groundwater recharge, vertical flow to/from the lower aquifer (deeper than the 20-year travel zone), and horizontal flow to/from the adjacent IAZs (IAZs 14, 15, 18, 20, and 21). Time-series plots for these components are available on a quarterly basis between 1983-2003 (**Figure F-44**). The average annual volumetric water budget summary is presented in tabular format below (**Table F-22**) and in a pie chart (**Figure F-45**).

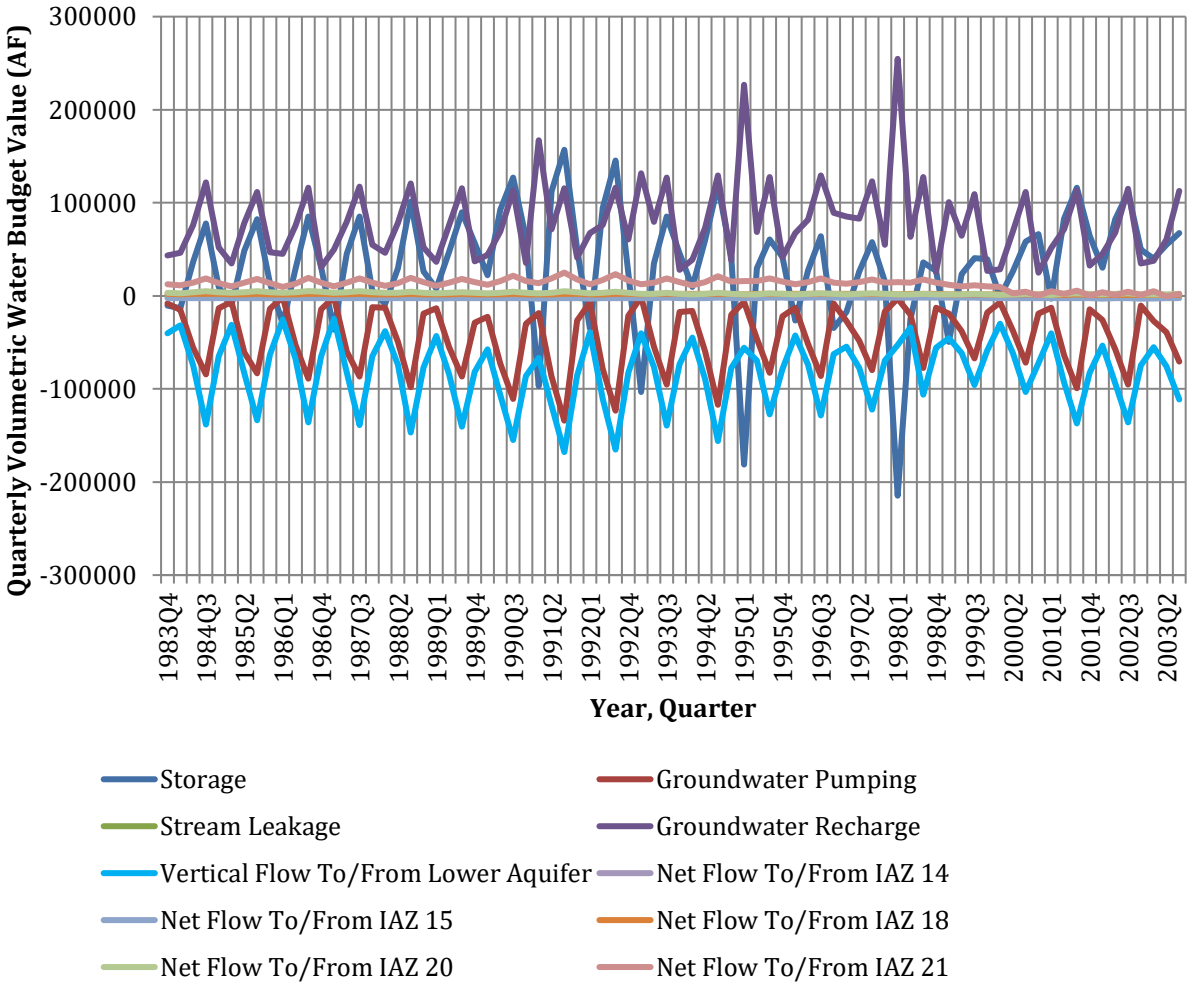

Figure F-44. Quarterly Volumetric Water Budget Time Series Plot for IAZ 19

Table F-22. Average Annual Volumetric Water Budget Components for IAZ 19

Volumetric Water Budget Component	Annual Average Volume* (AF)
Avg Water Volume Present in IAZ 19	**17,342,300**
Storage	**125,471**
GW Pumping	**-168,198**
Stream Leakage	**0**
GW Recharge	**299,792**
Vertical Flow to/from Lower Aquifer	**-313,408**
Net Horizontal Flow to/From IAZ 14	**-694**
Net Horizontal Flow to/From IAZ 15	**-9,097**
Net Horizontal Flow to/From IAZ 18	**6,722**
Net Horizontal Flow to/From IAZ 20	**10,585**
Net Horizontal Flow to/From IAZ 21	**48,835**

** See explanation of signage at beginning of **Appendix F***

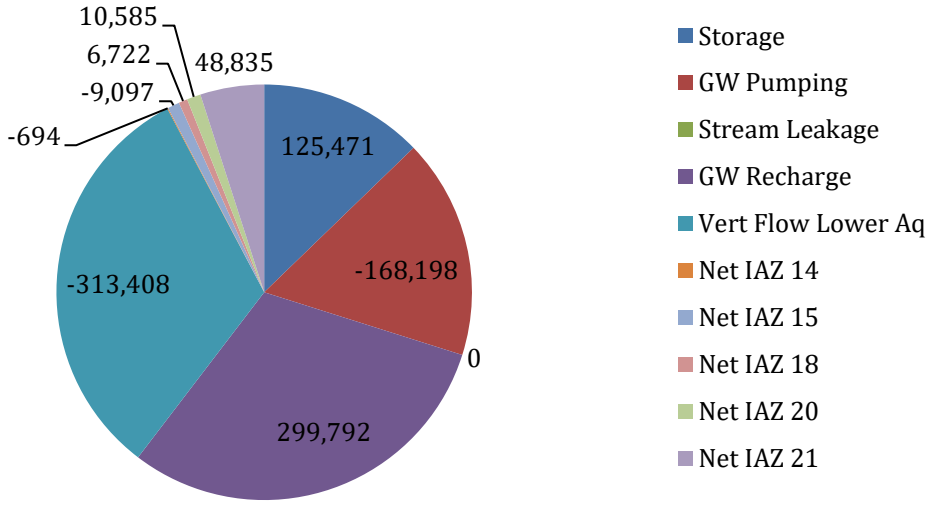

Figure F-45. Average Annual Volumetric Water Budget Components for IAZ 19 (AFY)

The time-series plots and pie chart of volumetric movement in and out of the 20-year travel zone of IAZ 19 indicate the following:

- Groundwater recharge provides the greatest influx of water to the IAZ.
- Groundwater pumping combined with vertical flow downward out of the shallow 20-year travel zone make up the greatest outflux components of water leaving the IAZ.
- IAZ 19 receives water from storage via storage depletion.
- There is zero stream leakage in this IAZ.
- IAZ 19 receives groundwater from adjacent IAZs 18, 20, and 21, while contributing groundwater to adjacent IAZs 14 and 15.
- The only quarters when groundwater storage is replenished is during times when groundwater recharge is high.

F.1.3.7 IAZ 20 Northeastern Kern County Basin

The water balance components that play a role in the 20-year travel zone for IAZ 19 include: storage, groundwater pumping, stream leakage, groundwater recharge, vertical flow to/from the lower aquifer (deeper than the 20-year travel zone), and horizontal flow to/from the adjacent IAZs (IAZs 18, 19, and 21). Time-series plots for these components are available on a quarterly basis between 1983-2003 (**Figure F-46**). The average annual volumetric water budget summary is presented in tabular format below (**Table F-23**) and in a pie chart (**Figure F-47**).

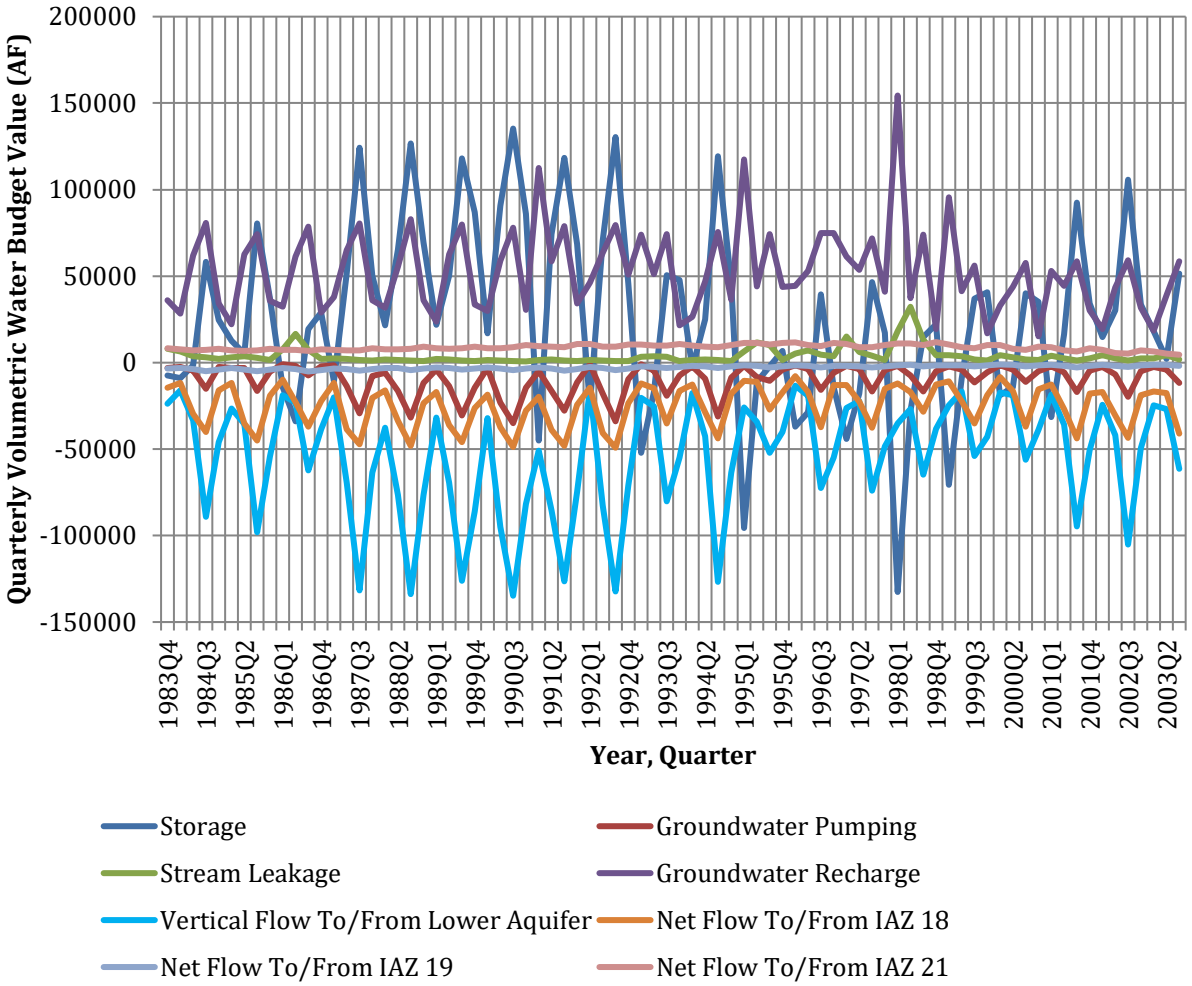

Figure F-46. Quarterly Volumetric Water Budget Time Series Plot for IAZ 20

Table F-23. Average Annual Volumetric Water Budget Components for IAZ 20

Volumetric Water Budget Component	Annual Average Volume* (AF)
Avg Water Volume Present in IAZ 20	**7,269,452**
Storage	**99,970**
GW Pumping	**-36,695**
Stream Leakage	**14,822**
GW Recharge	**202,069**
Vertical Flow to/from Lower Aquifer	**-207,317**
Net Horizontal Flow to/From IAZ 18	**-95,470**
Net Horizontal Flow to/From IAZ 19	**-10,585**
Net Horizontal Flow to/From IAZ 21	**33,197**

** See explanation of signage at beginning of **Appendix F***

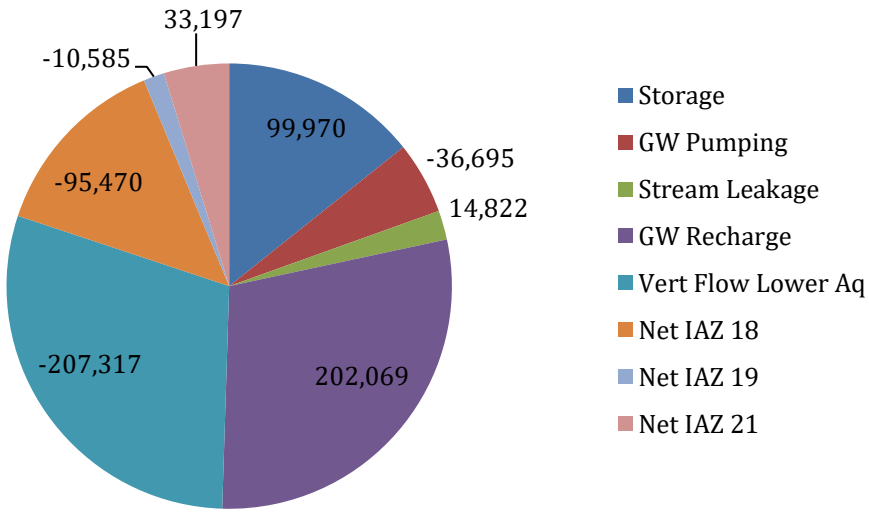

Figure F-47. Average Annual Volumetric Water Budget Components for IAZ 20 (AFY)

The time-series plots and pie chart of volumetric movement in and out of the 20-year travel zone of IAZ 20 indicate the following:

- Groundwater recharge provides the greatest influx of water to the IAZ.
- Vertical flow downward out of the shallow 20-year travel zone makes up the greatest outflux component of water leaving the IAZ.
- Groundwater pumping is a small proportion of the volumetric budget components leaving the 20-year travel zone (it is assumed that the majority of groundwater production occurs in deeper aquifer zones below the 20-year travel zone).
- IAZ 20 receives water from storage via storage depletion.
- Stream leakage provides a small contribution to this IAZ via losing stream conditions.
- IAZ 20 receives groundwater from one adjacent IAZ, IAZ 21, while contributing a significant amount of groundwater to adjacent IAZ 18 and a lesser amount to IAZ 19.
- The only quarters when groundwater storage is replenished is during times when groundwater recharge is high.
- Slightly more water travels downward out of the 20-year travel zone than is recharged via deep percolation on an average annual basis.

F.1.3.8 IAZ 21 Southeastern Kern County Basin

The water balance components that play a role in the 20-year travel zone for IAZ 19 include: storage, groundwater pumping, stream leakage, groundwater recharge, vertical flow to/from the lower aquifer (deeper than the 20-year travel zone), and horizontal flow to/from the adjacent IAZs (IAZs 19 and 20). Time-series plots for these components are available on a quarterly basis between 1983-2003 (**Figure F-48**). The average annual volumetric water budget summary is presented in tabular format below (**Table F-24**) and in a pie chart (**Figure F-49**).

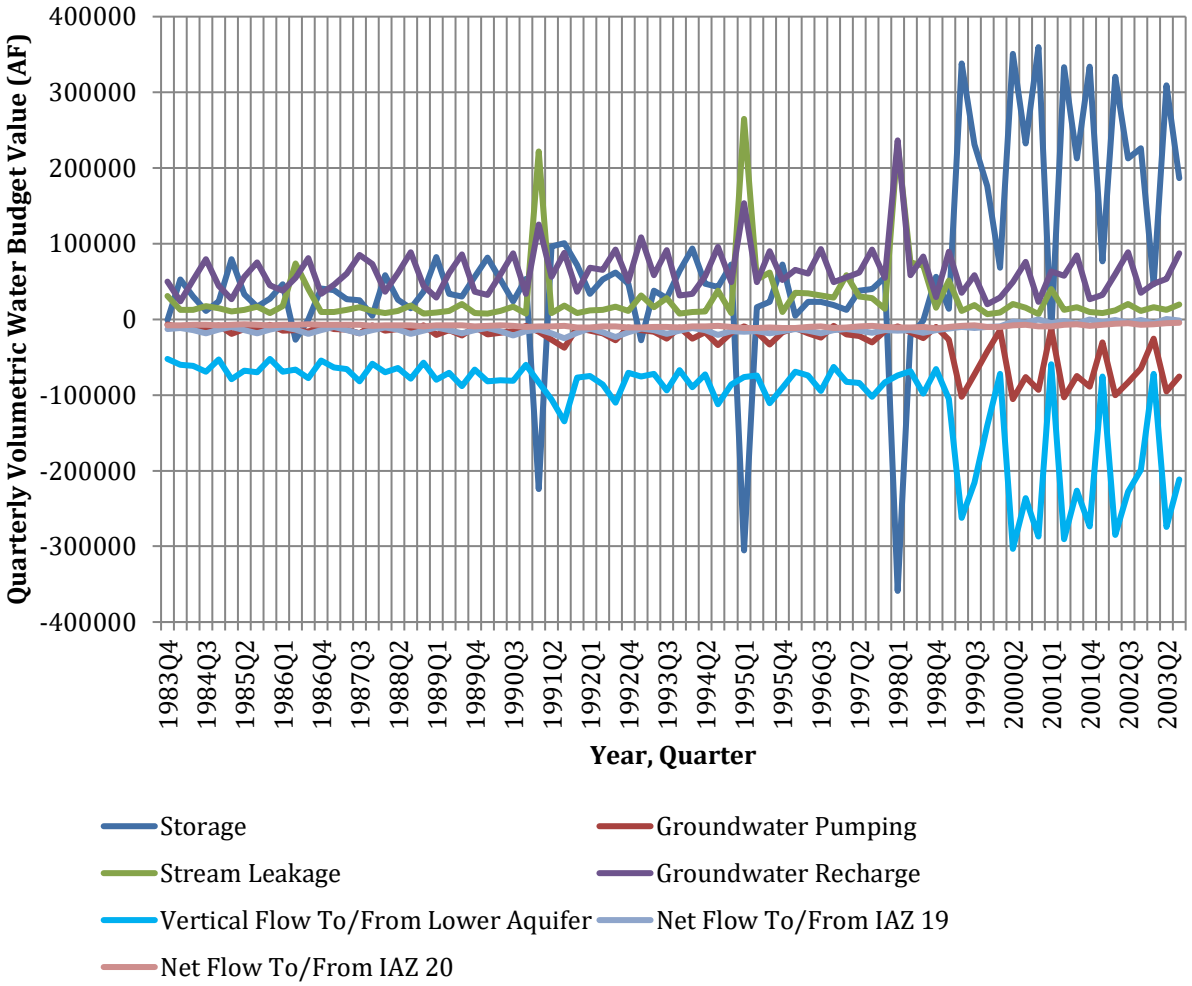

Figure F-48. Quarterly Volumetric Water Budget Time Series Plot for IAZ 21

Table F-24. Average Annual Volumetric Water Budget Components for IAZ 21

Volumetric Water Budget Component	Annual Average Volume* (AF)
Avg Water Volume Present in IAZ 21	**19,703,965**
Storage	**251,667**
GW Pumping	**-109,121**
Stream Leakage	**108,732**
GW Recharge	**237,419**
Vertical Flow to/from Lower Aquifer	**-405,830**
Net Horizontal Flow to/From IAZ 19	**-48,835**
Net Horizontal Flow to/From IAZ 20	**-33,197**

** See explanation of signage at beginning of **Appendix F***

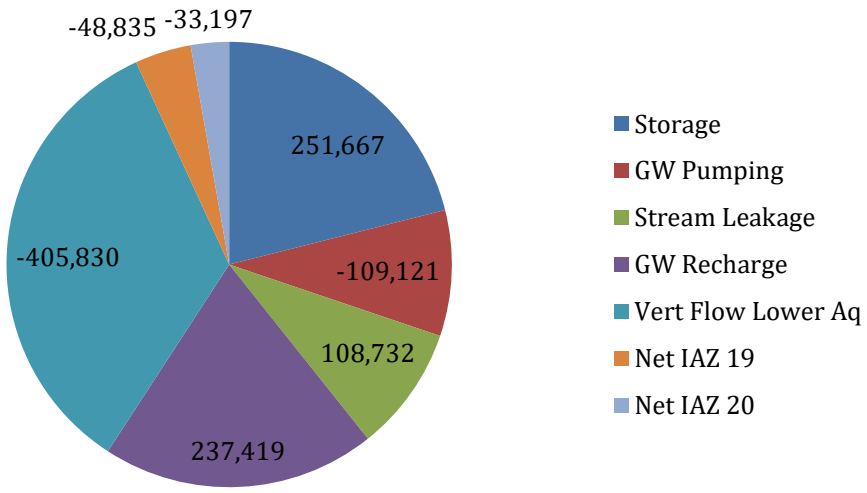

Figure F-49. Average Annual Volumetric Water Budget Components for IAZ 21 (AFY)

The time-series plots and pie chart of volumetric movement in and out of the 20-year travel zone of IAZ 21 indicate the following:

- Groundwater storage and groundwater recharge provide the greatest influx of water to the IAZ via storage depletion out of the 20-year travel zone and deep percolation.
- Vertical flow downward out of the shallow 20-year travel zone makes up the greatest outflux component of water leaving the IAZ.
- IAZ 21 loses water from groundwater pumpage out of the 20-year travel zone.
- Stream leakage (via losing stream conditions) provides a similar amount of water as the amount of groundwater pumped out of this IAZ.
- IAZ 21 receives groundwater from one adjacent IAZ, IAZ 21, while contributing a significant amount of groundwater to adjacent IAZ 18 and a lesser amount to IAZ 19.
- The only quarters when groundwater storage is replenished is during times when groundwater recharge is high.
- The quarterly fluctuations indicate that vertical flow downward out of the 20-year travel zone is associated with a similar pattern of storage depletion (storage contributing water to the 20-year travel zone when flows out of the 20-year travel zone downward are greatest).
- There is a shift in the magnitude of several water budget components (as seen in the quarterly fluctuations) during the late 1990s until 2003, exemplified by increased groundwater pumping, increased downward vertical flow out of the 20-year travel zone, and increased contribution of water from storage. This shift is likely due to a change in land use patterns and/or water demands.

F.1.3.9 Summary of Southern Central Valley IAZs

IAZs in the Middle Central Valley (IAZs 14 through 21) represent the southern portion of the Central Valley, including portions of the San Joaquin Valley and the Tulare Basin, where major outflow components are usually vertical flow downward to the saturated sediments below the 20-year travel zone is prevalent and groundwater pumping. The greatest inflow components are typically groundwater recharge, water from storage depletion, and stream leakage via losing stream conditions. According to the ICM, the 20-year travel zones for IAZs 14 through 21 represent an average range of water volumes between about 3 million AF to almost 20 million AF (**Figure F-50**). A comparison of average annual water budget components (between 1983 and 2003) gives insight to the differences between the IAZs in the Middle Central Valley IAZs and also some similarities (**Table F-25** and **Figure F-51**). IAZ 15 and 18 show the greatest amounts of groundwater recharge and groundwater pumping out of the 20-year travel zone. IAZ 19 has no stream leakage components, whereas all of the other IAZs in this region have a somewhat small proportion of surface water contributing to the 20-year travel zone.

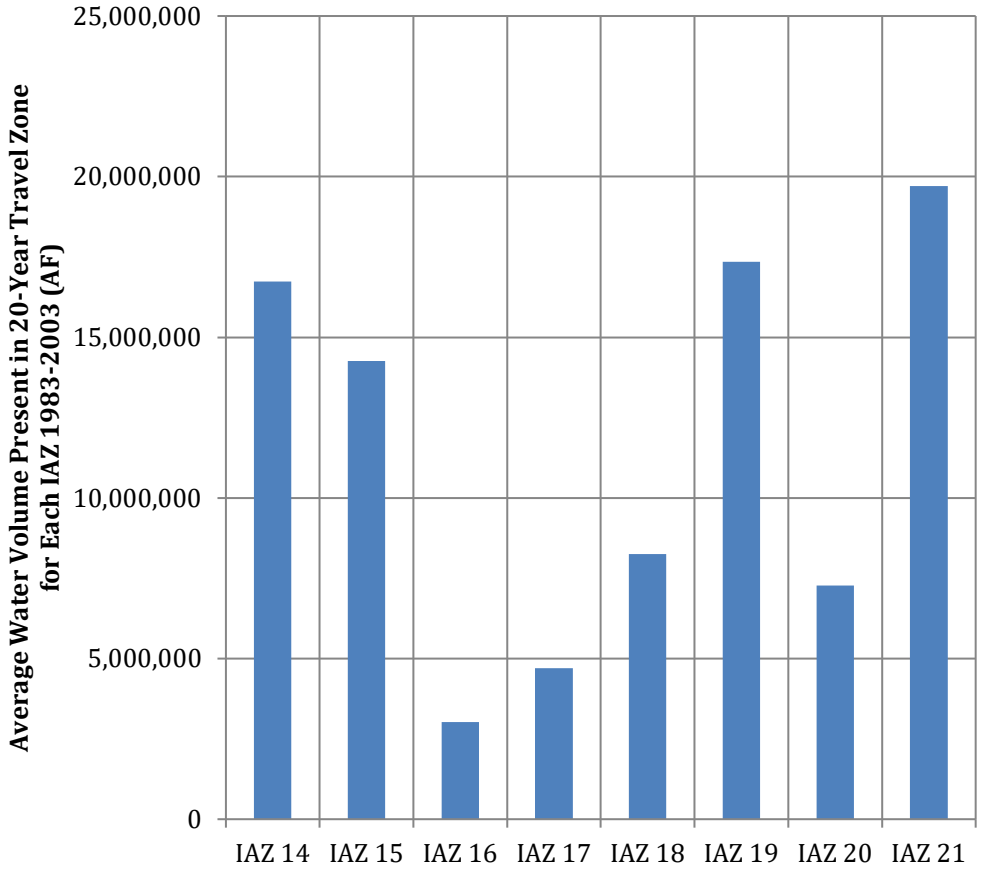

Figure F-50. Average Water Volume Present in 20-Year Travel Zone for Southern Central Valley IAZs (1983-2003)

Table F-25. Annual Average Water Budget Components for the 20-Year Travel Zone of Each IAZ in the Southern Central Valley (1983-2003) (TAFY)

Component	IAZ 14	IAZ 15	IAZ 16	IAZ 17	IAZ 18	IAZ 19	IAZ 20	IAZ 21
Average Groundwater Volume present in IAZ (TAF)	16,731	14,263	3,020	4,704	8,249	17,342	7,269	19,704
Flow Into/Out of Storage (TAFY)	134	91	107	100	235	125	100	252
Groundwater Pumping (TAFY)	-55	-502	-84	-158	-679	-168	-37	-109
Flow Into/Out through Stream Leakage (TAFY)	4.5	241	34	166	110	0	15	109
Groundwater Recharge (TAFY)	247	662	157	300	603	300	202	237
Vertical Flow to/from the Lower Aquifer (below the 20-year travel zone) (TAFY)	-332	-584	-170	-372	-352	-313	-207	-406
Horizontal Flow to/from Adjacent IAZs (TAFY)	1.3	94	-44	-36	84	56	-73	-82

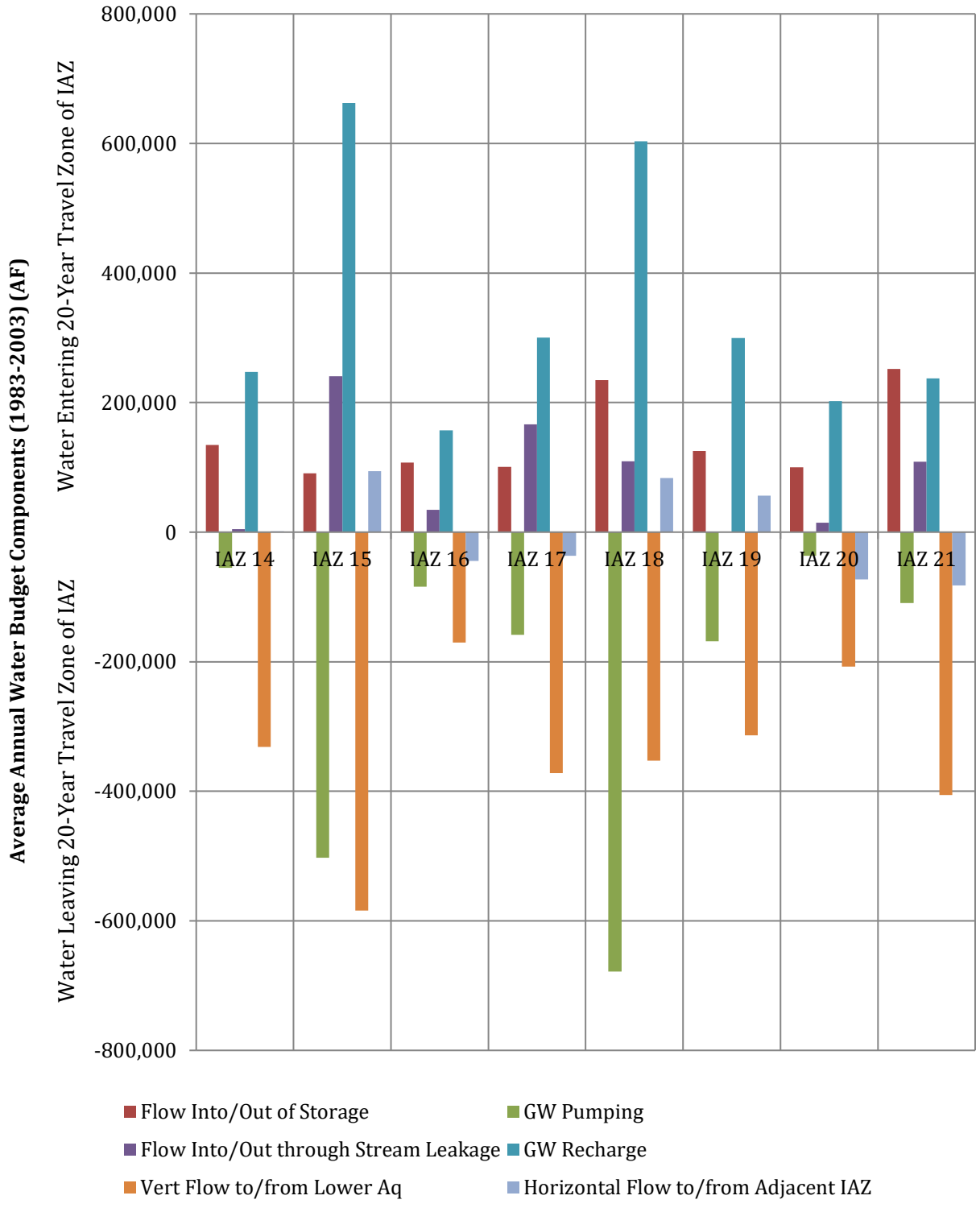

Figure F-51. Average Annual Water Budget Components for the 20-Year Travel Zone for IAZs in the Southern Central Valley (1983-2003)