7. Water Budget

A water budget is an accounting of the input and output volumes of water for the different components of the hydrologic cycle and for a specified hydrologic system. The hydrologic cycle is a continuous set of processes through which water evaporates from the oceans to the atmosphere, falls on the land, and eventually flows back to the oceans. Components of the cycle include the following:

- Evaporation from open water and transpiration from plants and other living organisms
- Precipitation, part of which is intercepted by vegetation or other surfaces and subsequently evaporated and part of which becomes runoff.
  - Some precipitation seeps (infiltrates) into the ground to become soil moisture, part of which is taken up by plant roots and returned to the atmosphere through the process of transpiration. It is difficult to separate this transpiration from evaporation, so they are typically combined into a single term known as evapotranspiration (ET).
  - Precipitation that is not intercepted or infiltrated flows across the land surface and through channels, from which it may be diverted for various consumptive uses or used to fill reservoirs, where it is stored until used or evaporated.
- When soil moisture storage capacity is exceeded, recharge to groundwater occurs. Groundwater may reside in storage until withdrawn from a well, or where physical conditions allow, it may discharge into streams or lakes.

The hydrologic cycle is thus a complex movement of water through several subsystems. A hydrologic budget is a quantification of the amounts of water moving in and out of a specified subsystem of the overall hydrologic cycle.

For a given region, the overall hydrologic budget can be expressed by the equation (Viessman and Lewis, 1996):

$$P - R - G - E - T = \Delta S$$

Where P = precipitation
R = surface runoff
G = groundwater flow to and from other basins
E = evaporation
T = transpiration
ΔS = change in aquifer storage

Except for precipitation, subsets of these parameters apply differently to budgets computed above or below the surface. For example, losses to infiltration from the surface are realized as an input to the subsurface system, and losses from subsurface discharges are sometimes realized as an input to the surface system. It is therefore convenient to view surface water systems and groundwater systems as separate, interconnected subsystems of the hydrologic cycle.

The Southwest Region covers a very large area based on political (county line) boundaries and contains 3 major stream systems and 12 hydrogeologic groundwater basins. Separate water budgets were developed for each hydrologic system.

7.1 Groundwater Budgets

The water budgets presented in this section provide a broad overview of the supply and demand in each of the basins shown in Figure 5-12; however, they should not be used as an indicator of availability of supply to meet demand in individual localities, as that ability depends on water rights, infrastructure, and adequate local surface water and/or groundwater supplies.

The water budgets for the Southwest Region were developed using data from previous investigations, where available, and supplemented with estimates made by DBS&A. The terms and methodology used to estimate the groundwater budget components are described in Section 7.1.1.

Gaps in understanding of the water budgets exist where data are insufficient to quantify a component of flow. Groundwater budgets for individual systems with hydrologic boundaries can be developed more accurately than those with subsurface groundwater flow between basins. The degree to which the water budget components are understood and areas in which additional studies are necessary to fill the gaps is included in the discussions of each geologic basin in Sections 7.1.2.1 through 7.1.2.12. Surface water budgets for the Gila, San Francisco, and Mimbres Basins are discussed in Section 7.2. Details of each water budget are provided in Appendix F.

7.1.1 Groundwater Budget Terms and Methodology

The groundwater budget components (Figure 7-1) consist of the following inflow and outflow components:

- *Inflow:* Recharge, stream loss, sub-flow from adjacent basins, and return flow from municipal, mining, or irrigation uses

- *Outflow:* Pumping from municipal, commercial, domestic, irrigation, industrial, livestock, mining, and power generation wells, evapotranspiration, discharge to springs, and sub-flow to other basins.

A water budget is the balance between inflow and outflow:

- If the total inflow and outflow components are equal, water levels will not rise or fall.

- If outflow is greater than the inflow, water levels in the aquifer will decline and the volume of water in storage will decrease.

- If inflow is greater than outflow, water levels in the aquifer will rise and the volume of water in storage will increase.

In other words, where the change in storage is negative, water levels in the basin are dropping and where the value is positive, water levels are rising. It is possible for water levels to be dropping in one location and rising in another within the same basin.

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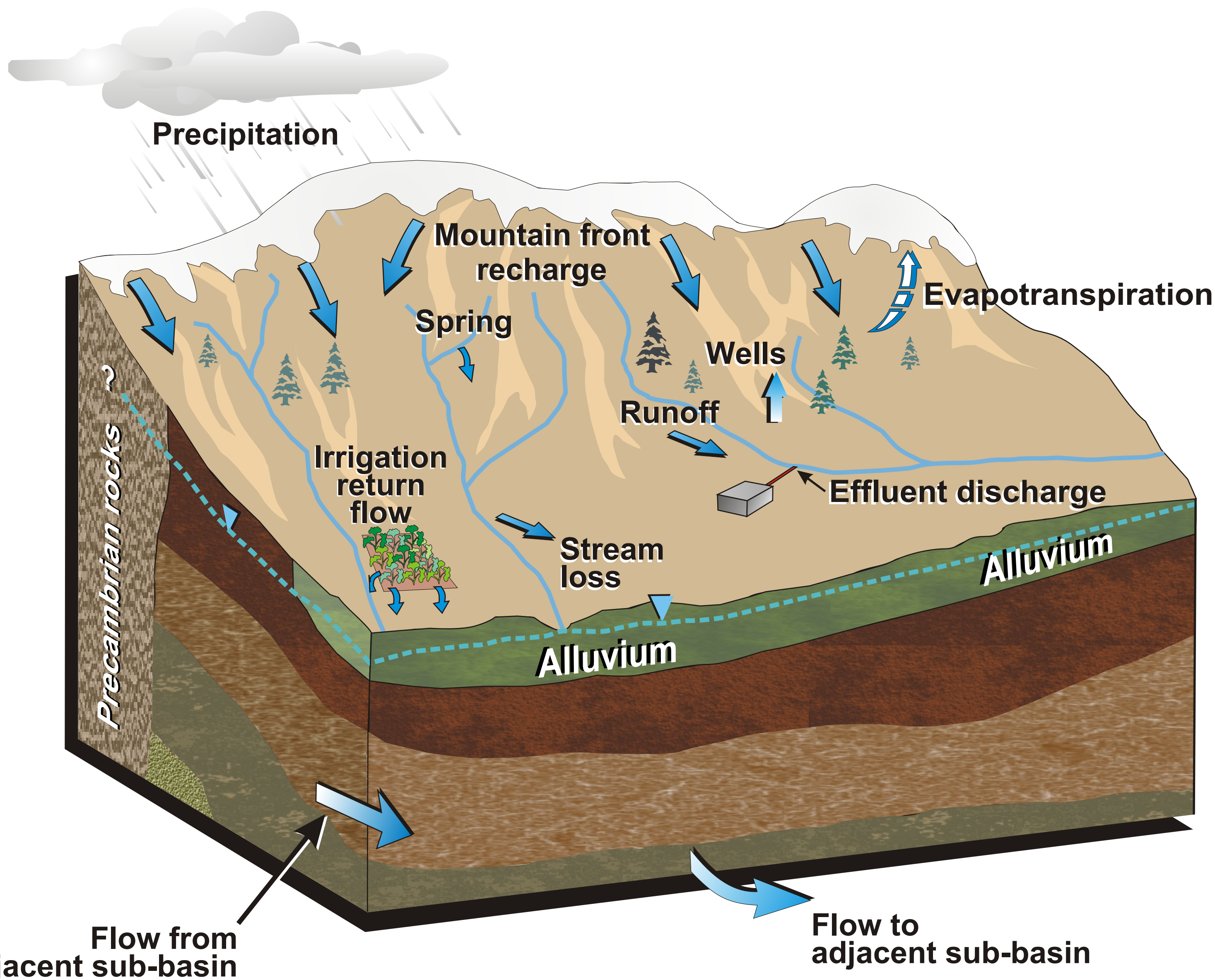

Not to Scale

SOUTHWEST NEW MEXICO REGIONAL WATER PLAN

Water Budget Components

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Figure 7-1

Where the water budget components are poorly understood, the difference between inflow and outflow components may be a result of error in or lack of knowledge of the basin rather than an indication of changes in groundwater storage. Where inflow in the Southwest Region was estimated to be significantly greater than the estimated outflows, DBS&A balanced the water budget by assuming that either the outflow would occur as sub-flow to another basin or as evapotranspiration, depending on the water level flow directions.

The procedures used to estimate the inflow and outflow components for the Southwest Region groundwater budgets are discussed in Sections 7.1.1.1 and 7.1.1.2.

7.1.1.1 Inflow Components

Recharge consists of the addition of water to an aquifer by infiltration, either directly into the aquifer or indirectly by way of another rock formation. Recharge as estimated here is the natural recharge from precipitation that infiltrates to the water table. Artificial recharge, as when water is injected through wells or spread over permeable surfaces for the purpose of recharging an aquifer, is considered part of the "return flow" component described below. The method of estimating recharge is described in Section 5.3.4.

Stream loss represents the recharge to the aquifer from seepage losses that occur from streams. Estimates of stream loss require stream gaging stations in appropriate locations with sufficient periods of record to establish the average annual losses to groundwater in a losing reach. Such losses vary from day to day and year to year depending on the amount of precipitation. Stream losses that result from infiltration of treated effluent that is discharged to an ephemeral stream are considered part of return flow from municipal use, described below. Estimates of stream loss in the Southwest Region are available only for the Mimbres Basin.

Sub-flow from adjacent basins is the water that flows underground across basin boundaries. Estimates of this inflow component from previous investigations are available for about half the basins. Evaluation of water level contours and flow directions combined with balancing the water budget can also provide insight into relative gains or losses between the geologic basins. Where a basin falls only partly within the Southwest Region, flow out of the portion of the basin within the planning region is included in the water budget.

For some uses, a portion of the diverted flow is not consumptively used and returns to a water body; the returned water is called ***return flow***. In general, all commercial uses are assumed to be fully depleted, and return flow from self-supplied domestic wells is not included in the water budgets. The water budgets in Section 7.1.2 include, as applicable, estimates of return flow to groundwater from municipal, mining, and irrigation, based on OSE estimates of return flow and irrigation efficiencies (Wilson et al., 2003):

- The OSE estimate generally assumes that 50 percent of municipal uses are returned to the groundwater system.

- Wilson et al. (2003) estimates that about 20 percent of water diverted for mining returns to the groundwater.

- The estimates of irrigation return flow are based on a combination of conveyance losses and estimated irrigation efficiencies (which differ from basin to basin, ranging in the Southwest Region from 40 percent for flood irrigation to 85 percent for drip irrigation). For example, an irrigation water right of 1,000 ac-ft with a system conveyance efficiency of 60 percent and an on-farm efficiency of 70 percent will lose 400 ac-ft to return flow before it reaches the farm and 30 percent of the remaining 600 ac-ft, or 180 ac-ft, for a total return flow of 580 ac-ft. A portion of the losses may go to evaporation or evapotranspiration and not result in return flow. Such losses are called "incidental depletions." The estimates of return flow based on Wilson et al. (2003) do not identify such losses. All return flow from irrigation, whether from surface water or groundwater diversions, is assumed to be to groundwater. In reality, some of the conveyance losses—for example, from a surface water canal—may return to the stream system relatively immediately.

7.1.1.2 Outflow Components

The estimates of ***well diversions*** for municipal, commercial, irrigation, industrial, livestock, mining, and power uses were all derived from OSE's water use report for 2000 (Wilson et al., 2003) and modified by Engineers Inc., as described in Section 6.1.

The ***evapotranspiration*** component of the water budget is the discharge of groundwater through the roots of trees or other vegetation that taps the aquifer directly. It does not include the evapotranspiration of precipitation that does not recharge the aquifer and it does not include riparian evapotranspiration (which is included in the surface water budgets). Evapotranspiration (as it relates to groundwater budgets) occurs where the depth to water is shallow. The only published estimates of evapotranspiration from groundwater in the Southwest Region are for the Mimbres Basin. For this water plan, DBS&A also estimated evapotranspiration for the Playas and Hachita-Moscos basins based on the water balance and water level contours.

Discharge to springs and streams occurs where the groundwater level intersects the ground surface or the elevation of a stream. Discharge to springs can either be directly measured, where a spring issues at a single location, or can be estimated in the same way that stream losses are estimated, by evaluating the water budget on a stream system using stream gages. The latter method was used in this study, recognizing that the lack of estimates of flow from ungaged tributaries may result in an overestimation of spring flow. Outflow to springs and streams was estimated for the three basins that have stream gages, the Gila, San Francisco, and Mimbres.

Sub-flow out of a basin is the water that flows underground out of a basin boundary. Estimates for this outflow component from previous investigations are available for about half the basins. Evaluation of water level contours and flow directions can also provide insight into relative gains or losses between the geologic basins.

7.1.2 Summary of Basin Groundwater Budgets

Table 7-1 summarizes the groundwater budget for 12 geologic basins in the Southwest Region, and Table 7-2 summarizes the groundwater budgets by county. Additional details on the basin groundwater budgets are provided in Appendix F. (The planning region also includes a small area of the San Bernadino Basin in the southwest corner of Hidalgo County and a small part of the Middle Rio Grande Basin in southeastern Catron County, both of which are not included in the water budget summary due to the lack of water use in these areas and insufficient data.) Sections 7.1.2.1 through 7.1.2.12 briefly discuss the estimates of inflow and outflow to each basin.

Table 7-1. Groundwater Budget Components for the Southwest New Mexico Water Planning Region

Component	Groundwater Flow by Basin (ac-ft/yr)												
	San Simon	Playas-San Basilio	Animas	Hachita-Moscos	Mimbres	Nutt-Hockett	Gila	San Francisco	Little Colorado	San Agustin	Rio Salado	North Plains	Total
Inflow													
Recharge	2,910	8,050	16,130	4,230	24,990	270	72,980	55,950	18,290	18,320	1,800	980	224,900
Stream loss	0	0	0	0	10,000	0	0	0	0	0	0	0	10,000
Flow from adjacent basins	0	0	0	7	0	0	2,700	0	0	0	0	0	2,710
Return flow M&I	8	0	410	0	3,610	0	590	50	20	0	0	0	4,690
Return flow mining	0	220	0	0	3,810	20	470	0	0	0	0	0	4,520
Return flow irrigation	540	890	11,970	0	48,730	5,500	27,020	15,940	1,270	150	0	0	112,010
Total Inflow	3,460	9,160	28,510	4,240	91,140	5,790	103,760	71,940	19,580	18,470	1,800	980	358,830
Outflow													
Municipal wells	16	13	830	0	7,210	0	1,040	110	40	0	0	0	9,260
Commercial [a]	4	0	500	0	200	0	120	20	4	4	0	0	850
Domestic wells [a]	5	20	180	20	1,470	8	100	140	60	60	0.4	3	2,070
Irrigation wells	1,340	1,980	27,810	0	78,290	16,430	3,070	0	0	340	0	0	129,260
Industrial [a]	0	0	0	0	40	0	20	0	0	0	0	0	60
Livestock [a]	0	0	0	60	410	0	350	30	30	50	50	0	980
Mining [a]	0	4,330	0	0	18,720	30	2,740	0	0	0	0	0	25,820
Power [a]	0	0	0	0	280	0	0	0	0	0	0	0	280
Evapotranspiration	0	2,810	0	2,300	13,400	0	0	0	0	18,020	0	0	36,530
Springs/stream gain	0	0	0	0	4,800	0	54,600	59,930	0	0	0	0	119,330
Sub-flow out	2,100	7	2,700	1,860	0	0	41,680	11,720	19,440	0	1,750	980	82,240
Total Outflow	3,470	9,160	32,020	4,240	124,820	16,470	103,720	71,950	19,570	18,470	1,800	980	406,670
Error and/or change in storage [b]	–10	0	–3,510	0	–33,680	–10,680	40	–10	10	0	0	0	–47,840

[a] Self-supplied
[b] Errors of 10 acre feet per year (ac-ft/yr) are due to rounding of the values.

Shaded values represent estimate based on water budget balance and water level contours.
M&I = Municipal and industrial

Table 7-2. Summary of Groundwater Budgets by County

Component	Groundwater Flow by County (ac-ft/yr)				
	Catron	Grant	Hidalgo	Luna	Total
Inflow					
Recharge	122,990	69,870	29,110	3,880	225,850
Stream loss	0	0	0	10,000	10,000
Flow from adjacent sub-basin	0	0	2,710	0	2,710
Return flow municipal	70	2,020	430	2,160	4,680
Return flow mining	20	4,270	220	30	4,520
Return flow irrigation	17,360	24,210	19,690	50,760	112,020
Total Inflow	140,420	100,370	52,160	66,830	359,780
Outflow					
Municipal wells	150	3,910	880	4,320	9,260
Commercial (self-supplied) [a]	30	140	510	180	860
Domestic wells	270	920	200	680	2,070
Irrigation wells	340	4,100	33,140	91,670	129,250
Industrial (self-supplied) [a]	8	11	3	40	61
Livestock (self-supplied)	180	220	260	340	1,000
Mining (self-supplied)	0	21,460	4,330	40	25,830
Power (self-supplied)	0	280	0	0	280
Evapotranspiration	18,020	3,960	4,540	10,000	36,520
Springs/stream gain	59,930	59,400	0	0	119,330
Sub-flow out[b]	22,170	0	5,700	970	28,840
Total Outflow	101,100	94,401	49,560	108,240	353,298
Error and/or change in storage	39,323	5,969	2,600	–41,410	

[a] Outflow for commercial and industrial wells is based on the depletion amount (return flow was not included for the few wells where OSE estimates a small amount of return flow).

B Sub-flow out is only shown for basin contained entirely in one County, thus totals differ from Table 7-1.

Ac-ft/yr = acre feet per year

Figure 7-2, which shows the overall groundwater balance between inflows and outflows for each basin, reveals that inflows are less than outflows in the Animas, Mimbres, and Nutt-Hockett hydrogeologic basins, indicating that groundwater mining is occurring. Groundwater mining may also be occurring locally in the vicinity of well fields in the other basins. As shown in Figure 7-3, the Mimbres Basin has by far the greatest amount of groundwater diversions, approaching 100,000 ac-ft/yr. Additional discussion of each basin is provided in Sections 7.1.2.1 through 7.1.2.12.

7.1.2.1 San Simon Basin

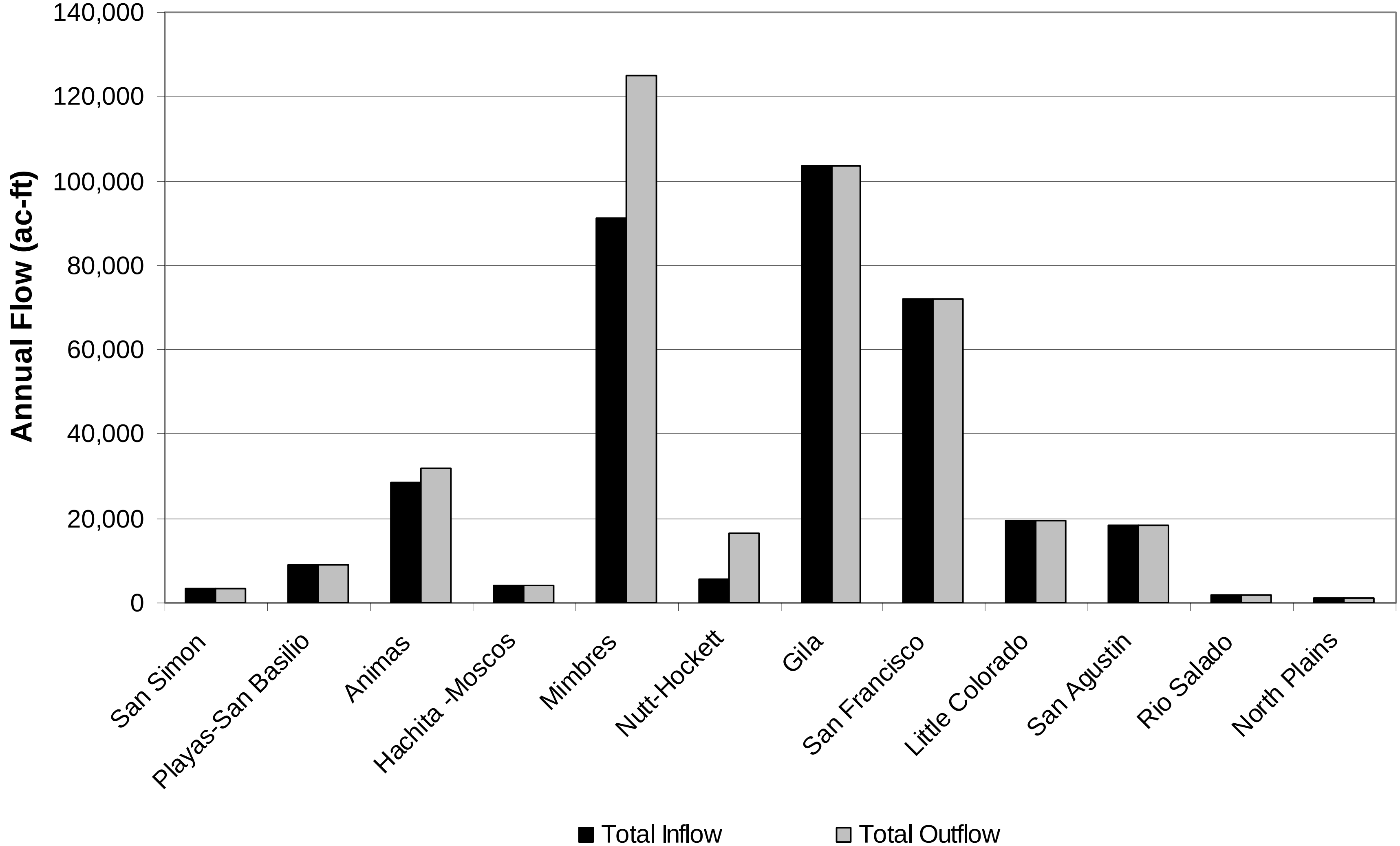
Inflow to the San Simon Basin occurs through recharge and municipal and irrigation return flow, while estimated outflows are due to groundwater pumping from municipal, domestic, commercial, and irrigation wells (Appendix F, Table F-2). The irrigation return flow is based on an irrigation efficiency of 55 percent for flood irrigated lands and 65 percent for sprinkler irrigation from the 1,340 ac-ft/yr of groundwater diversions.

The total estimated outflow from documented sources is approximately 2,100 ac-ft/yr less than the estimated inflows, which may be due to a lack of estimates of the sub-flow out of the basin. Examination of water table contours indicates that groundwater is flowing to the west out of New Mexico, and DBS&A has estimated that sub-flow to be 2,100 ac-ft/yr.

7.1.2.2 Animas Basin

Inflow to the Animas Basin occurs through recharge and municipal and irrigation return flow, while estimated outflows are due to groundwater pumping from municipal, domestic, commercial, industrial, and irrigation wells and to sub-flow to the Gila Basin (Appendix F, Table F-3). The estimated irrigation return flow is based on an irrigation efficiency of 55 percent for flood irrigated lands and 65 percent for sprinkler irrigation from groundwater diversions of almost 28,000 ac-ft/yr.

The total estimated outflow is about 3,500 ac-ft/yr more than the estimated inflows, which may indicate a decrease in the amount of storage in this basin. Examination of water level hydrographs shows a steady decline since the 1950s.



SOUTHWEST NEW MEXICO REGIONAL WATER PLAN

Total Annual Inflow and Outflow for Each Groundwater Basin

Figure 7-2

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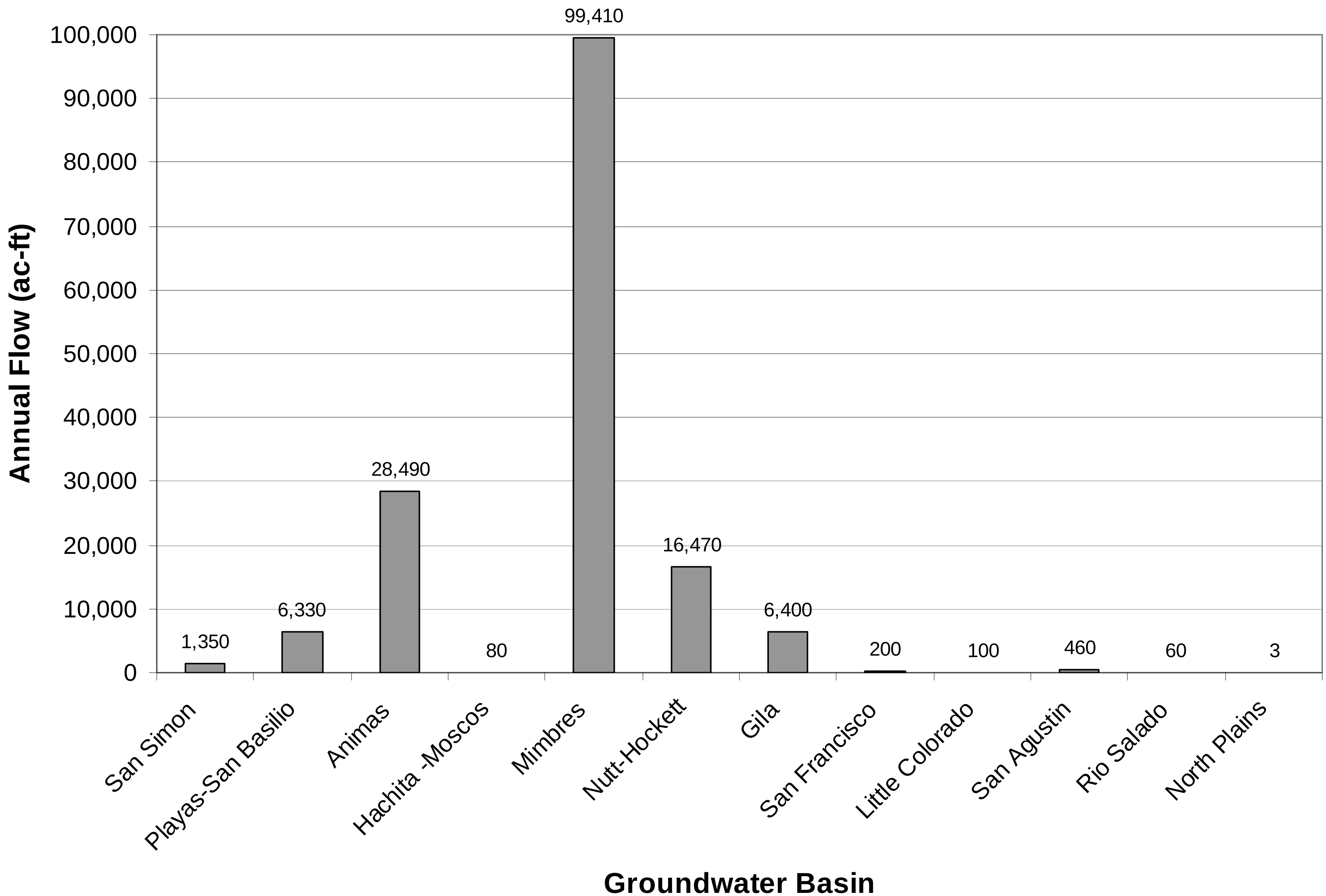

SOUTHWEST NEW MEXICO REGIONAL WATER PLAN

Annual Groundwater Pumping by Basin

Figure 7-3

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7.1.2.3 Playas-San Basilio Basin

Inflow to the Playas-San Basilio Basin occurs through recharge and mining and irrigation return flow, while estimated outflows are due to groundwater pumping from municipal, domestic, irrigation, and mining wells and to sub-flow out of the basin (Appendix F, Table F-4). The irrigation return flow estimate is based on an irrigation efficiency of 55 percent.

The total estimated outflow from documented sources is about 2,800 ac-ft/yr less than the estimated inflows, which may be due to a lack of estimates for the evapotranspiration out of the basin. Examination of water table contours indicates that groundwater flow converges in the center of the basin and may exit through evapotranspiration; therefore, evapotranspiration may be about 2,800 ac-ft/yr.

7.1.2.4 Hachita-Moscos Basin

Inflow to the Hachita-Moscos Basin occurs through recharge (no return flow is calculated for the small amount of diversions from wells), while estimated outflows are due to groundwater pumping from domestic and stock wells and to sub-flow out of the basin (Appendix F, Table F-5). The total estimated outflow is about 2,300 ac-ft/yr less than the estimated inflows, which may be due to a lack of estimates for the evapotranspiration component or to error in estimation of other components. Examination of water table contours indicates that groundwater levels have not changed significantly over a 50-year period.

7.1.2.5 Mimbres Basin

Inflow to the Mimbres Basin, the largest and most heavily used of the basins in the Southwest Region, occurs through recharge and return flow, while estimated outflows are due to groundwater pumping from all types of wells and to springs or stream gain (Appendix F, Table F-6):

- Most of the recharge occurs in the portion of the Mimbres Basin within Grant County, where an average 2.8 percent of the precipitation results in recharge. Although more than half of the area of the basin lies within Luna County, that area receives less than 8 inches of annual precipitation, which does not result in any recharge based on the method applied in this study. In reality, some intense thunderstorms may produce runoff that would result in small amounts of recharge through ephemeral channels within Luna County, but no estimate is available for this analysis.

- The return flow from irrigation is based on both conveyance losses from surface water diversions and on-farm efficiencies of both surface and groundwater diversions.

- The estimate for stream loss is from the Mimbres River in Luna County. The 6,500 ac-ft/yr of sub-flow south to Mexico previously estimated by Hanson et al., 1994 is not included, because Hawley et al., 2000 noted that a reversal in groundwater flow directions at the U.S. border indicates that groundwater is no longer flowing to the south, but may instead be entering the basin.

- Estimated evapotranspiration may range from 0 to 45,000 ac-ft/yr. Hanson et al. (1994) estimated predevelopment evapotranspiration to be 42,000 ac-ft/yr in Luna County and 3,400 ac-ft/yr in Grant County. However, Hawley et al. (2000) suggest that the irrigation wells are capturing most of the water that was previously discharged through evapotranspiration. Their study shows a value of 10,000 ac-ft/yr for the evapotranspiration within Luna County, but recognizes that this value may range from 0 to more than 10,000 ac-ft/yr. The total evapotranspiration of 13,400 ac-ft used in DBS&A’s water budget for the Southwest Region represents 10,000 ac-ft in Luna County and 3,400 ac-ft in Grant County.

- Part of the municipal supply for the Mimbres basin is derived from the Silver City Frank’s well field in the Gila Basin. Return flow from all of the municipal diversion for Silver City returns to the Mimbres Basin.

The total estimated outflow is about 34,000 ac-ft/yr more than the estimated inflows, which may be due to an overestimation of evapotranspiration or an underestimation of recharge in Luna County. However, at least some of the difference likely reflects a change in the amount of water in storage, as evidenced by water level hydrographs, which show that the water table has dropped about 50 feet over the past 50 years.

7.1.2.6 Nutt-Hockett Basin

Inflow to the Nutt-Hockett Basin occurs through recharge and mining and irrigation return flow, while estimated outflows are due to groundwater pumping from domestic, mining, and irrigation wells (Appendix F, Table F-7). Return flow from irrigation is the largest inflow component (5,500 ac-ft/yr) and is based on an irrigation efficiency of 60 percent for flood irrigated lands, 65 percent for sprinkler irrigation, and 85 percent for drip irrigation from the 16,430 ac-ft/yr pumped from irrigation wells.

The total estimated outflow is about 10,700 ac-ft/yr more than the estimated inflows, which may represent a change in storage. Examination of one water level hydrograph available for the Nutt-Hockett Basin shows a decline of almost 150 feet over a 40-year period. Examination of recent USGS water level elevations indicates that the water levels are higher than those in the Rio Grande Basin to the east and higher than the water levels in the Mimbres Basin to the west; therefore, it is unlikely that sub-flow from other basins is recharging the Nutt-Hockett Basin significantly. Thus the change in storage suggested by the water budget is likely fairly accurate.

7.1.2.7 Gila Basin

Inflow to the Gila Basin occurs mostly through recharge and irrigation return flow, with municipal and mining return flow and sub-flow from the Animas Basin contributing lesser amounts (Appendix F, Table F-8). The irrigation return flow estimate is based on conveyance losses and an on-farm irrigation efficiency ranging from 40 to 55 percent for surface water diversions of 31,200 ac-ft/yr and groundwater diversions of 3,070 ac-ft/yr.

Some of the estimated outflows occur due to groundwater pumping from municipal, commercial, domestic, irrigation, industrial, livestock, and mining wells (Appendix F, Table F-8); however, the largest component of estimated outflows is springs and stream gain. Discharge of groundwater to the Gila River is estimated to be 54,600 ac-ft/yr based on the median flows at two stream gages: the Gila River near Gila and the Gila River below Blue Creek, near Virden. The gain to the Gila River on this reach is 28,130 ac-ft/yr which, when adjusted to account for the irrigation diversions along this reach of 22,460 ac-ft/yr and riparian evapotranspiration of 4,010 ac-ft, results in a total gain of 54,600 ac-ft/yr. Tributary inflow from ungaged perennial tributaries in this reach, if known, would lower the estimated flow from groundwater to surface water.

Additional gains may occur in the Virden Valley downstream of this reach. The gain between the Gila River near Redrock and the Gila River near Virden, where no perennial streams contribute to the flow of the Gila, is about 8,000 ac-ft/yr, confirming a significant groundwater contribution to the Gila River.

The total estimated outflow is more than 41,680 ac-ft/yr less than the estimated inflows, which may be due to a lack of estimate for the sub-flow out of the basin. Examination of water table contours indicates that groundwater is flowing to the west out of New Mexico. Accordingly, the water budget was balanced by adjusting the value for sub-flow out of the basin to be 41,680.

7.1.2.8 San Francisco Basin

Inflows to the San Francisco Basin are due to recharge and to return flow from municipal and irrigation use (Appendix F, Table F-9). The irrigation return flow estimate is based on conveyance losses of 13,500 ac-ft/yr and 2,460 ac-ft from on-farm returns (an irrigation efficiency of 40 percent for the 4,100 ac-ft/yr of surface water delivered to the farms). The bulk of outflows are due to springs and stream gain, with lesser amounts due to groundwater pumping from municipal, industrial, commercial, domestic, and livestock wells (Appendix F, Table F-9).

The irrigation return flow is assumed to recharge the aquifer, which will ultimately result in groundwater discharge to the San Francisco River, or part of the 59,930 ac-ft/yr estimated as spring flow from the groundwater. The discharge to the river from groundwater was calculated by subtracting the median flows at the San Francisco River near Reserve (12,160 ac-ft/yr) from those at the gage near Glenwood (50,030 ac-ft/yr) and adjusting for the surface water diversions of 17,600 ac-ft/yr and calculated riparian evapotranspiration of 4,490 ac-ft/yr. This method does not account for the inflow from ungaged tributaries to the San Francisco River within this reach.

The total estimated outflow is more than 11,720 ac-ft/yr less than the estimated inflows, which may be due to a lack of estimate for the sub-flow out of the basin. Examination of water table contours indicates that groundwater is flowing to the west out of New Mexico, and therefore, the water budget was balanced by showing 11,720 ac-ft/yr as sub-flow to the west.

7.1.2.9 San Agustin Basin

Estimated inflows to the San Agustin Basin are due to recharge and irrigation return flow, while documented outflows are due to pumping from commercial, domestic, irrigation, and livestock wells (Appendix F, Table F-10). The irrigation return flow estimate is based on an irrigation efficiency of 55 percent.

The total estimated outflow is about 18,000 ac-ft/yr less than the estimated inflows (Appendix F, Table F-10), which may be due to a lack of estimate for evapotranspiration from Lake San Agustin Playa. The detailed water level maps of the complex aquifer system in this basin (Myers et al., 1994) do not show sub-flow to adjacent basins, but rather indicate a convergence of flow directions toward the center of the basin in both the San Agustin bolson-fill aquifer and the deeper Datil aquifer. Based on the available water level and water budget data, the water budget was adjusted to show evapotranspiration of about 18,000 ac-ft/yr.

7.1.2.10 Little Colorado Basin

Estimated inflows to the Little Colorado Basin are due to recharge and municipal and irrigation return flow, while outflows are due to pumping from municipal, commercial, domestic, and livestock wells (Appendix F, Table F-11). Return flow from irrigation is based on an irrigation efficiency of 45 percent for surface water diversions in the vicinity of Quemado and conveyance losses of 620 ac-ft/yr.

The total estimated outflow is about 19,400 ac-ft/yr less than the estimated inflows, which may be due to a lack of estimate for the sub-flow out of the basin. Examination of water table contours indicates that groundwater is flowing to the west out of New Mexico, and therefore, sub-flow to the west is estimated to be 19,400 ac-ft/yr.

7.1.2.11 North Plains Basin

Estimated inflows to the North Plains Basin are due solely to recharge, and the only withdrawals of groundwater in the North Plains Basin are from domestic wells serving the 30 people living in this basin (Appendix F, Table F-12). The total estimated outflow is about 980 ac-ft/yr less than the estimated inflows, which may be due to a lack of estimate for the sub-flow out of the basin. Examination of water table contours indicates that groundwater is flowing to the west toward the

Little Colorado Basin, and therefore the water budget was balanced by assuming a sub-flow out of 980 ac-ft/yr.

7.1.2.12 Rio Salado Basin

Estimated inflows to the Rio Salado Basin are due solely to recharge, and the only withdrawals of groundwater are from livestock and a minimal amount from domestic wells serving the tiny population in this basin (Appendix F, Table F-13). The total estimated outflow is about 1,750 ac-ft/yr less than the estimated inflows, which may be due to a lack of estimate for the sub-flow out of the basin. Examination of water table contours indicates that a groundwater mound occurs in the center of the basin, resulting in groundwater flow to the east toward the Rio Grande and to the west toward the North Plains Basin. Therefore, to balance the water budget, sub-flow to other basins is estimated to be about 1,750 ac-ft/yr.

7.1.2.13 Groundwater Budget Data Gaps

As suggested by the discussions in Sections 7.1.2.1 through 7.1.2.12, more information on the amount of evapotranspiration and sub-flow in and out of each basin is needed to obtain a better understanding of the water budgets. Return flow estimates could be improved by measuring surface diversions and canal losses. Detailed water level maps could help define the flow regimes in each basin. However, despite the uncertainty in quantifying the water budget components, groundwater mining does appear to be occurring in the Animas, Mimbres, and Nutt-Hockett Basins.

7.2 Surface Water Budget

Surface water budgets were prepared for the three principal perennial streams in the region: San Francisco, Gila, and Mimbres Rivers.

7.2.1 Surface Water Budget Terms and Methodologies

As with groundwater budgets, surface water budget analyses rely heavily on estimates (based on prior studies and expert judgment) instead of actual measurements. Although precipitation and streamflow are measurable water sources, they are typically measured at only a few locations. By comparison, evaporation, evapotranspiration by plants, infiltration, return flows, spring and seep discharges are usually estimated. Consequently, surface water budget calculations generally have a high degree of uncertainty and should be used with considerable caution.

7.2.1.1 Inflow components

Inflow sources for surface water include surface inflow, stream/spring gain, and return flow.

Runoff from rain and snowmelt provides ***surface inflow*** to a stream, that is, the volume of water that flows in the streams from the precipitation that has not been intercepted or evaporated from non-riparian vegetation.

The estimated precipitation volume for the entire planning region is 12,200,000 acre-feet (based on the precipitation contours in Figure A2-4), but the vast majority of this inflow does not show up as streamflow, due to upland ET and other factors. About 10 to 20 percent of precipitation wets and adheres to aboveground objects (generally vegetation) and is subsequently returned to the atmosphere through evaporation. However, interception in areas with dense forests may be as much as 25 percent of total annual precipitation (Viessman and Lewis, 1996). In addition, non-riparian ET can exceed 90 percent of precipitation in some watersheds (Brooks et al., 1991). Measurements of non-riparian ET in the Los Alamos, New Mexico area showed that ET losses were between 75 and 87 percent of total precipitation (Gray, 1997).

Therefore, the water budget discussed herein is based on the amount of surface water available in the three main drainages in the planning region, rather than the precipitation volume. Inflows, as calculated here, are comprised of gaged streamflow volumes measured at USGS gages on these three drainages. The streamflows used in the water budget are the median values for the period 1950 through 2002, as presented in Section 5.2.1, with the annual yields corrected for the number of irrigated acres upstream of the gage site.

Inflow from springs and seeps is the ***spring/stream gain, which is*** estimated by the increased flow volume between an upstream and downstream gage. The spring/stream gain used in the water budget for the Southwest Region was based on values cited in the literature or on the stream gain along a reach between two gages, adjusted for irrigation diversions and riparian evapotranspiration for the reach. The spring/stream gain reflects the amount of water that is discharged from the aquifer and inflow from ungaged tributaries.

Return flow from irrigation with surface water is assumed to recharge groundwater and ultimately return to the stream through spring/stream gain. The return flow is calculated using the procedures by Wilson et al. (2003) described in Section 7.1.1.1.

Return flow from municipal, mining, and industrial users discharged directly to streams was estimated to be zero based on Wilson et al. (2003).

7.2.1.2 Outflow components

Outflows are comprised of surface water depletions and flow past the state line. The depletions were determined as follows:

- Estimates of ***irrigation diversion*** are from OSE annual water use report for 2000 (Wilson et al., 2003).

- Water diverted for ***municipal/commercial*** and ***mining*** water supplies are from New Mexico OSE annual water use report (Wilson et al., 2003).

- Stream ***seepage*** into the groundwater is the amount of water that is lost from the stream and recharges the aquifer. Although the Gila and the San Francisco Rivers appear to be gaining through most of the planning region, it is possible that reaches within these stream systems are losing; however, data on seepage losses were not available to make reliable estimates of these quantities for most of the basins in the Southwest Region. Estimates of stream seepage are included in the water budget only for the Mimbres River.

- Since 1990, the OSE has reported ***reservoir evaporation*** only for reservoirs with 5,000 or more acre-feet of storage. Therefore, estimates of reservoir evaporation are based on the OSE reservoir and stock pond evaporation data for 1985, which more accurately reflect the total evaporation in each river basin.

- ***Evapotranspiration*** (water lost from plants, such as transpiration through tree leaves, and direct evaporation from surface water) is based on the riparian acreage within the reaches between gages. As discussed in Section 5.1.3, DBS&A estimated riparian ET to be 19,900 ac-ft/yr based on an estimated riparian acreage of approximately 6,700 acres and average riparian ET rates in New Mexico. The estimated depletions for the reaches between the stream gages on the three rivers total 12,090 ac-ft/yr.

- ***Surface outflow*** from the region is based on values cited in the literature or stream gage data for the downstream reach.

7.2.2 Summary of Surface Water Budgets by Stream Basin

Surface water budgets for the San Francisco, Gila, and Mimbres basins were prepared based on the surface water inflow and outflow terms presented above. The major input—runoff from rain and snowmelt—was quantified based on gaged streamflows for average conditions as well as for drought conditions, the latter of which were based on 10th-percentile streamflows (flows at a level that 10 percent of all flows fall below and 90 percent above).

The available information available on surface water budget components is presented in Table 7-3. The results of the surface water budgets showed that inflows were greater than outflows in the San Francisco and Gila systems for both average and drought conditions (Table 7-3). However, due to legal restrictions on the use of surface water (Section 4), no excess surface water is available to meet new demands in these systems. In the Mimbres system, inflows were greater than outflows under average conditions and approximately equal to outflows in drought conditions (Table 7-3), but again, no excess surface water is available to meet new demands in the Mimbres due to legal restrictions.

Table 7-3. Surface Water Budgets

Sub-Basin	San Francisco River				Gila River						Mimbres River			
	Catron County (Reserve to Glenwood)		Grant County		Catron County		Grant County (Gila to Virden)		Hidalgo County (Virden to Stateline)		Grant County (Mimbres to Faywood)		Luna County (Faywood to Deming)	
	Amount (ac-ft/yr)	Reference	Amount (ac-ft/yr)	Reference	Amount (ac-ft/yr)	Reference	Amount (ac-ft/yr)	Reference	Amount (ac-ft/yr)	Reference	Amount (ac-ft/yr)	Reference	Amount (ac-ft/yr)	Reference
Inflow														
Average surface inflow [a]	12,160	USGS stream gage San Francisco River near Reserve median flow (1950–2002)	NA	No gages	NA	No gages	102,660	USGS Gage Gila near Gila median flow (1950–2002)	NA	No gages	7,510	Median, Mimbres near Mimbres	10,000	Hawley et al., 2000
Springs/stream gain	59,930	See Table F-9	NA		NA		54,600	See Table F-8	NA		4,800	Hanson et al., 1994	0	Hanson et al., 1994
Return flow of irrigation from surface water only [b]	*15,940*	Wilson et al., 2003, applied to groundwater	0	Wilson et al., 2003	0	Wilson et al., 2003	*20,190*	Wilson et al., 2003, applied to groundwater	*5,380*	Wilson et al., 2003, applied to groundwater	*2,130*	Wilson et al., 2003, applied to groundwater	*12,740*	Wilson et al., 2003, applied to groundwater
Return flow from municipal uses [c]	0	Wilson et al., 2003	0	Wilson et al., 2003	0	Wilson et al., 2003	0	Wilson et al., 2003	0	Wilson et al., 2003	0	Wilson et al., 2003	0	Wilson et al., 2003
Outflow														
Irrigation diversion (depletion)	17,560 (1,620)	Wilson et al., 2003, San Francisco River	0	Wilson et al., 2003	0	Wilson et al., 2003	22,460 (2,270)	Wilson et al., 2003, Gila	8,740 (3,365)	Wilson et al., 2003, Virden Valley	3,310 (1,180)	Wilson et al., 2003, Mimbres Basin	22,510 (9,775)	Wilson et al., 2003, Mimbres Basin
Livestock (depletion = diversion)	0	Wilson et al., 2003	0	Wilson et al., 2003	0	Wilson et al., 2003	140	Wilson et al., 2003	50	Wilson et al., 2003	60	Wilson et al., 2003	80	Wilson et al., 2003
Municipal/commercial diversion (depletion)	1	Wilson et al., 2003, Glenwood Fish Hatchery	0	Wilson et al., 2003	0	Wilson et al., 2003	150 (75)	Tyrone Water System and Fort Bayard Medical Center	0	Wilson et al., 2003	26 (13)	Wilson et al., 2003, Santa Clara Village	0	Wilson et al., 2003
Mining	0	Wilson et al., 2003	0	Wilson et al., 2003	0	Wilson et al., 2003	0	Wilson et al., 2003	0	Wilson et al., 2003	0	Wilson et al., 2003	0	Wilson et al., 2003
Seepage	NA		NA		NA		NA		NA		NA		10,000	Hawley et al., 2000
Reservoir evaporation	0	Wilson et al., 2003	0	Wilson et al., 2003	140	Wilson et al., 2003, Snow Lake and Wall Lake	390	Wilson et al., 2003, Bill Evans Dam and Lake Roberts	0	Wilson et al., 2003	55	Bear Canyon	205	King Reservoir and stock ponds (Wilson, 1985)
Riparian evapotranspiration	4,490	DBS&A Calc.	0	DBS&A Calc.	410	DBS&A Calc.	4,010	DBS&A Calc.	1,620	DBS&A Calc.	1,130	DBS&A Calc.	430	DBS&A Calc.
Average surface outflow	50,030	USGS stream gage San Francisco River near Glenwood median flow (1950–2002)	0	San Francisco River does not enter Grant County	NA	No gages	130,790	USGS stream gages Gila below Blue Creek, near Virden, median flow (1950–2002)	NA	No gages	10,000	Hawley et al., 2000	0	Hanson et al., 1994

[a] Use of surface water in Gila, San Francisco, and Mimbres Rivers is restricted by water rights adjudication; therefore, surface inflow does not represent water available for use in the region.

[b] Applied to groundwater that ultimately becomes stream gain if not intercepted by wells; therefore, italicized numbers not included in total inflow.

[c] 941 acre-feet per year of treated effluent that is discharged from Silver City wastewater treatment plant to San Vicente Arroyo is treated as return flow to the groundwater.

ac-ft/yr = Acre-feet per year
NA = Not available
USGS = U.S. Geological Survey