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. The part of the hydrologic cycle that is of most relevance to water planning is the fate of precipitation, which will partition to the following components:

- Some precipitation that falls on land seeps (infiltrates) into the ground to become soil moisture, some 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 off land surfaces, so they are typically combined into a single term known as evapotranspiration.

- 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 Groundwater may reside in storage until withdrawn from a well, or where physical conditions allow, it may discharge into springs, streams, or lakes or flow to other groundwater basins.

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 following 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 (groundwater) 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.

Water budgets can be developed more accurately for individual systems with hydrologic boundaries as compared to locations based on political boundaries. In the Taos region, separate surface water and groundwater budgets were developed for each of the four subregions described in Section 3 and shown in Figure 3-1.

The boundaries of the four subregions are drawn along watershed boundaries, and hence represent distinct areas for surface water budgets. However, the subregions do not represent distinct groundwater basins, and the potential for error in determining sub-flow terms of the groundwater budgets is thus greater. Although the water budgets provide a broad overview of the supply and demand in each of the subregions, 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 proximity to surface water and/or groundwater supplies.

7.1 Surface Water Budget

Surface water budgets were prepared for the two principal perennial streams in the planning region, the Rio Grande and Costilla Creek, and were further subdivided based on the subregions. Costilla Creek was assessed separately from the other Rio Grande tributaries because it is managed under a separate interstate compact (Section 4.5.2).

7.1.1 Surface Water Budget Terms and Methodologies

Surface water budget analyses rely heavily on estimates of components instead of actual measurements. Although precipitation and streamflow are measurable, they are typically measured at only a few locations. Evaporation, evapotranspiration by plants, infiltration, return flows, and spring and seep discharges generally are estimated rather than measured directly. Consequently, surface water budget calculations often have a high degree of uncertainty and should be used with considerable caution.

The inflow and outflow components used in the Taos Region surface water budgets are described in Sections 7.1.1.1 and 7.1.1.2. Figure 7-1 is a schematic showing the water budget components.

7.1.1.1 Inflow Components

Inflow sources for surface water include surface inflow, spring or stream gain, and return flow from municipal and irrigation uses.

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

The estimated average annual precipitation volume for the entire planning region is 1,900,000 ac-ft/yr (based on the precipitation contours in Figure 5-3), but the vast majority of this inflow does not become streamflow due to upland evapotranspiration and other factors. Non-riparian evapotranspiration, which is likely the largest output component of the water budget, can exceed 90 percent of precipitation in some watersheds (Brooks et al., 1991), and measurements in the Los Alamos, New Mexico area showed that non-riparian evapotranspiration losses were between 75 and 87 percent of total precipitation (Gray, 1997). In addition, about 10 to 20 percent of precipitation is intercepted such that it wets and adheres to aboveground objects (generally vegetation) and is subsequently returned to the atmosphere through evaporation. In areas with dense forests, such evaporation may be as much as 25 percent of total annual precipitation (Viessman and Lewis, 1996).

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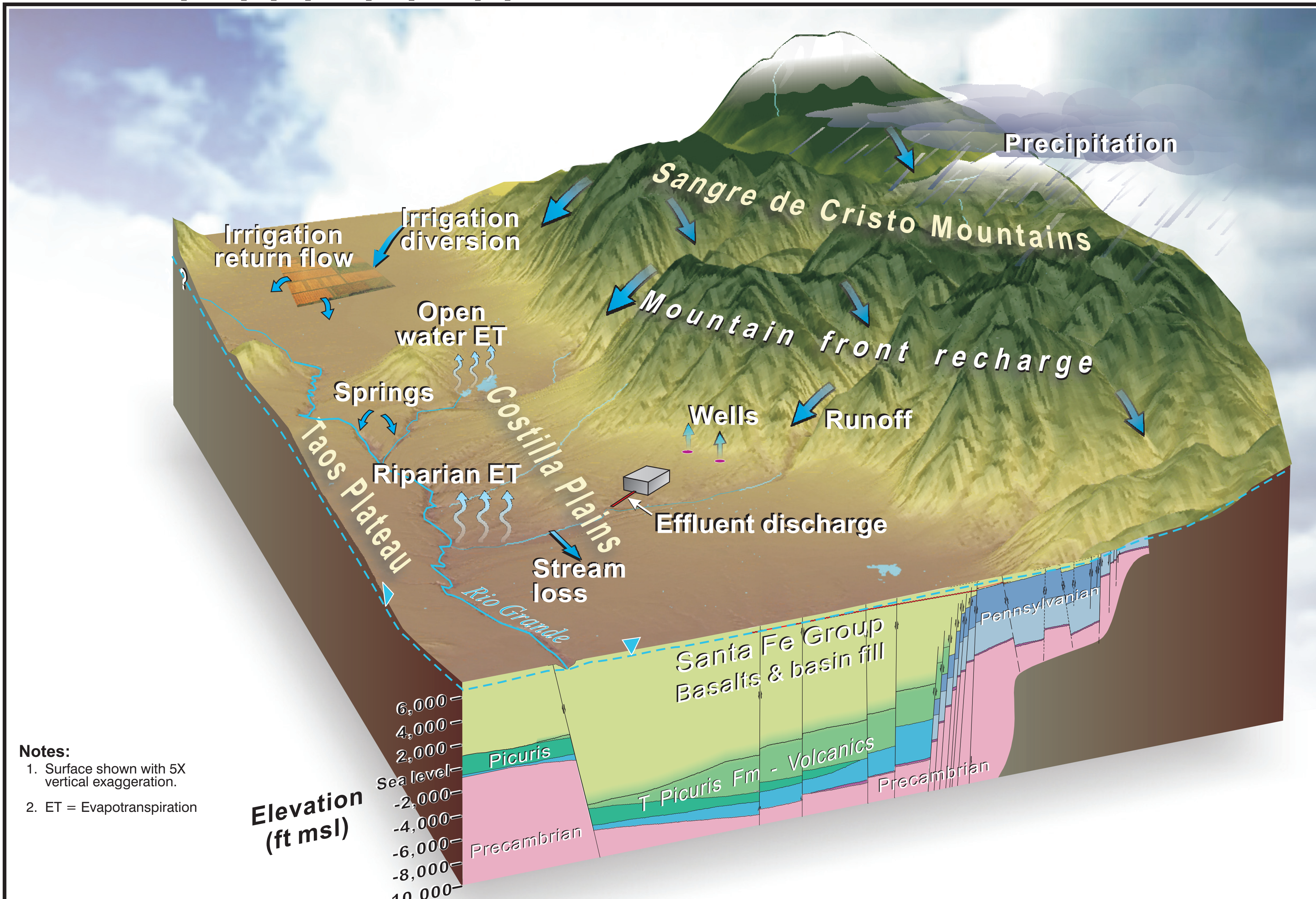

Notes:

1. Surface shown with 5X vertical exaggeration.
2. ET = Evapotranspiration

TAOS REGIONAL WATER PLAN

Water Budget Components

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Figure 7-1

Accordingly, the water budget discussed herein does not include precipitation, but rather is based solely on the amount of surface water that flows into the planning region. In the Taos water budgets, this inflow component is comprised of gaged stream discharges from Costilla Creek and the other tributaries to the Rio Grande, specifically, the median discharges for the period 1990 through 2004 (Table 7-1), the period for which the most relevant gages have consistent data. All of the irrigated lands are below gages that provide the annual inflow. The inflow for the Rio Embudo was estimated from the balance of the water budget in the South subregion.

Spring/stream gain is inflow from springs and seeps and ungaged tributaries and was assumed to be equivalent to the balance of the water budget. Thus, the estimated inflows minus irrigation diversions, reservoir evaporation, and riparian evapotranspiration for the tributary are estimated as stream gain from springs or ungaged tributaries. In the South subregion, the stream gain was estimated from the groundwater budget and reflects (1) water that is discharged from the aquifer and (2) inflow from ungaged tributaries.

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***. Return flow from irrigation with surface water is assumed to return directly to the stream, except in the Central subregion (in which case they were divided between surface water and groundwater based on the results of a modeling effort [Burck et al., 2004]), and is calculated using the procedures of Wilson et al. (2003), which are described in Section 7.2.1.1. Return flow from municipal users discharged directly to streams was estimated to be about 50 percent of diversions for the Town of Taos (Wilson et al., 2003).

The surface water budgets developed for the Taos region do not consider instream flow, as development of instream flow requirements was beyond the scope of this plan. However, identification an appropriate instream flow regime, although requiring considerable biological and hydrological study, could be valuable for future planning efforts. Analysis of the effects of instream flow policy on water rights and San Juan-Chama exchanges, which was also beyond the scope of this plan, could also be worthwhile.

7.1.1.2 Outflow Components

Outflows are comprised of surface water depletions and flow past the subregion boundary or the confluence with another stream. Outflows due to ***surface water diversions*** include:

Table 7-1. Stream Statistics for Taos Water Budgets

USGS Site Name	USGS Site Number	Period of Record	Water Yield (acre-feet)			
			Period of Record		Median 1990-2004	Drought Year [a]
			Median	Average		
North subregion						
Rio Grande at Lobatos	8251500	1900-2004	323,618	404,027	239,637	57,267
Rio Grande CO-NM Stateline	8252000	1953-1982	202,349	249,836	---	56,397
Costilla Creek above Costilla Dam	8252500	1938-2004	6,645	8,004	8,018	1,651
Casias Creek near Costilla	8253000	1938-2004	10,806	11,446	11,756	2,557
Santistevan Creek near Costilla	8253500	1938-2004	1,854	1,918	2,021	436
Costilla Creek below Costilla Dam	8254000	1938-2004	16,603	20,565	29,704	15,406
Costilla Creek near Costilla	8255500	1937-2004	31,286	35,655	30,718	11,243
Acequia Madre at Costilla	8256000	1967-1990	3,451	3,654	---	2,446
Cerro Canal at Costilla	8258000	1965-1991	17,097	17,056	---	6,873
Latir Creek	8263000	1946-1969	3,660	3,879	---	1,919
Cabrestro Creek	8266000	1944-1995	6,885	8,001	---	3,765
Rio Grande near Cerro	8263500	1949-2004	271,850	322,959	275,107	95,564
Red River near Questa	8265000	1925-2004	30,696	32,796	28,380	6,856
Red River below Fish Hatchery near Questa	8266820	1979-2004	56,361	56,382	48,651	23,312
Central subregion						
Rio Hondo near Valdez	8267500	1935-2004	22,696	25,064	22,877	6,617
Rio Hondo near Arroyo Hondo	8268500	1913-1985	14,624	19,728	---	6,704
Rio Grande near Arroyo Hondo	8268700	1964-2004	434,018	472,429	380,006	132,782
Rio Pueblo de Taos near Taos	8269000	1913-2004	16,941	20,435	16,724	3,526
Rio Lucero near Arroyo Seco	8271000	1913-2004	14,841	15,508	15,131	3,620
Rio Fernando	8275000	1963-1980	2,353	3,701	---	760
Rio Grande del Rancho near Talpa	8275500	1953-2004	12,850	14,519	12,959	2,114

[a] 2002 or minimum on record

--- = Not applicable (period of record does not include 1990 through 2004)

Table 7-1. Stream Statistics for Taos Water Budgets

USGS Site Name	USGS Site Number	Period of Record	Water Yield (acre-feet)				Drought Year [a]
			Period of Record		Median 1990-2004		
			Median	Average			
Central subregion (cont.)							
Rio Pueblo de Taos below Los Cordovas	8276300	1957-2004	30,045	44,605	32,940		6,646
Rio Grande blw Taos Junct. Bridge nr Taos	8276500	1926-2004	473,474	538,345	474,922		200,539
South subregion							
Rio Pueblo near Peñasco	8277470	1992-2004	38,008	37,064	38,008 [b]		4,959
Rio Santa Barbara near Peñasco	8278500	1953-1957 1992-2004	21,719	22,105	25,795 [b]		7,384
Embudo Creek at Dixon	8279000	1924-2004	51,619	60,487	76,740		9,050
Rio Grande at Embudo	8279500	1900-2004	618,992	660,307	515,464		201,263

[a] 2002 or minimum on record
[b] Period of record used in water budgets is 1992 through 2004.

- *Public and domestic use.* Diversions from surface water and return flows for public and domestic use are estimated for the town of Red River and the community of San Cristobal for the year 2000 (Wilson et al., 2003).

- *Commercial use.* Commercial water use was based on the diversions for 2000 (Wilson et al., 2003), which reflect current commercial uses.

- *Livestock use.* Livestock diversions are based on year 2000 estimates (Wilson et al., 2003).

- *Industrial and power uses.* Essentially no surface water is used for these purposes in the planning region, and they were therefore not included in the surface water budget.

- *Mining.* The use of surface water for mining occurs only in the North subregion, for the Molycorp's molybdenum mine, as reported by Wilson et al. (2003).

- *Irrigation use:* Estimates of the amount of surface water diverted for irrigation for the Central subregion were derived from Bellinger (2004). For the North, West and South subregions, surface diversions for irrigation were based on the agricultural use by location for 1999 from the 2000 OSE water use report (Wilson et al., 2003). OSE reports irrigation by location within the county, which allows for the subdivision of irrigation diversions by subregion. The North subregion includes all irrigation for Cerro-Questa and Costilla, the South subregion includes Embudo and vicinity (with portions of Rio Arriba County), and the West subregion includes Pilar and Ojo Caliente.

Average annual ***reservoir evaporation*** for Costilla Reservoir and other open water was calculated using the National Hydrography Dataset (USGS, 2005a) for the area of open water between or below stream gages. The open water evaporation rates were obtained from the OSE water use report for 1990 (Wilson, 1992) and are essentially the gross evaporation rate minus the annual rainfall. The OSE water use report for 1990 was used because it contained more evaporation rates for reservoirs than the OSE report for 2000, which contains information for only one reservoir (Wilson et al., 2003). The resulting net evaporation rate was multiplied by the area of open water in each subregion, as determined from the National Hydrography Dataset (USGS, 2005a), to obtain a total amount of evaporation in the Taos Region (Table 7-2).

Table 7-2. Area of Open Water Between Gages to Apply to Surface Water Budgets

Gage	Area [a] (acres)	Gross Evaporation Rate [b] (ft/yr)	Rainfall [b] (ft/yr)	Net Evaporation Rate [b] (ft/yr)	Evaporation [c] (ac-ft/yr)
North subregion					
Costilla Creek above Costilla Dam, NM to Costilla Creek below Costilla Dam, NM	333	2.50	2.08	0.42	139.7
Red River below Zwergle Damsite near Red River, NM to Red River near Questa, NM	1.0	2.92	2.08	0.84	0.8
Red River near Questa, NM to Red River below Fish Hatchery, near Questa, NM	0.6	2.92	1.33	1.59	1.0
Central subregion					
Rio Lucero near Arroyo Seco, NM to confluence with Rio Pueblo de Taos	201	3.75	1.00	2.75	552.8
Rio Pueblo de Taos near Taos, NM to confluence with Rio Fernando de Taos	1.4	3.75	1.00	2.75	3.8

[a] Waterbody acreage calculated using:
National Hydrography Dataset (NHD), High-resolution *(generally developed at a 1:24,000/1:12,000 scale)* (USGS, 2005a)
Source website: http://nhd.usgs.gov

[b] Wilson et al., 2003

[c] Evaporation = Net evaporation rate times area in acres

Evapotranspiration (water lost from plants, such as transpiration through tree leaves) is based on the riparian acreage on the reaches between stream gages. The riparian acreage for the reaches between and below gages is based on the hydric soils acreage that is not irrigated, as obtained from Natural Resources Conservation Service (NRCS) Soil Survey Geographic database (SSURGO) (USDA, 2005). The area of irrigated land was obtained from the USGS National Gap Analysis Program (2004a), and the portion of that land on each tributary was estimated (Table 7-3). A riparian evapotranspiration rate of 2.21 acre-feet per acre is the average of the weighted CIR for phreatophytes using the modified Blaney Criddle method from 1935 to 1988 developed for the OSE Taos Groundwater Model (Bellinger, 2004). Because this evapotranspiration is based on estimated rather than measured rates, there is considerable uncertainty in the estimate.

Evapotranspiration also takes place in the reaches above the gages where no hydric soils are present, but those depletions occur prior to the inflow as measured at each upstream gage and thus are not part of the surface water budgets presented here.

Stream loss into the groundwater is the amount of water that is lost from a stream and recharges the aquifer. In the groundwater budget this recharge is included in the total recharge estimate; however in the surface water budgets, stream loss was only estimated in the Central subregion, through a modeling effort by the OSE. Stream loss likely occurs in the West subregion, but no stream gages are available on the ephemeral streams in that area. Stream loss may also occur in some reaches of streams in the North and South subregions, but overall the streams are gaining, as indicated by the water level contours (which show groundwater flowing toward the streams) illustrated in Figure 5-14.

Surface outflow from the planning region was based on the 1990 through 2004 median flow rate at downstream stream gages in each subregion (Table 7-1). On Costilla Creek, the most downstream gage for estimating outflow is above a portion of the irrigated lands, and therefore, the outflow for this stream was adjusted for the median discharge to two canals that were measured from 1965 to 1992.

Table 7-3. Riparian Evaporation for Surface Water Budgets

Gage	Area [a] (acres)	Evapotranspiration (ac-ft/yr)
Per acre rate [b]		*2.21*
North		
Cabresto Creek near Questa, NM to confluence with Red River	44	98
Red River near Questa, NM to Red River below Fish Hatchery, near Questa, NM	313	692
Costilla Creek below diversion at Costilla, NM to Costilla Creek near Amalia, NM	439	971
Central		
Rio Hondo at Damsite, at Valdez, NM to Arroyo Hondo at Arroyo Hondo, NM	80	177
Rio Hondo near Valdez, NM to Rio Hondo at Damsite, at Valdez, NM	15	33
Rio Lucero near Arroyo Seco, NM to confluence with Rio Pueblo de Taos	28	62
Rio Pueblo de Taos near Taos, NM to confluence with Rio Fernando de Taos	46	102
Rio Fernando de Taos near Taos, NM to Rio Pueblo de Taos near Ranchito, NM	8	18
Rio Grande del Rancho near Talpa, NM to confluence with Rio Fernando de Taos	128	283
Rio Pueblo de Taos near Ranchito, NM to Rio Pueblo de Taos at Los Cordovas, NM	9	20
Rio Pueblo de Taos at Los Cordovas, NM to Rio Pueblo de Taos below Los Cordovas, NM	26	57
South		
Rio Pueblo near Peñasco, NM to Embudo Creek at Dixon, NM	8	18
Rio Santa Barbara near Peñasco, NM to confluence w/ Rio Pueblo	272	601

[a] Estimated using Soil Survey Geographic (SSURGO) database for Taos County and parts of Rio Arriba and Mora Counties, New Mexico (USDA, 2005) Source website: http://SoilDataMart.nrcs.usda.gov/

[b] Bellinger, 2004

7.1.2 Summary of Surface Water Budgets

The DBS&A team prepared surface water budgets based on the amount of surface water available in Costilla Creek (which falls only within the North subregion) and the Rio Grande and its other tributaries within the planning region. (As noted above, Costilla Creek was separated because it is administered under a separate interstate compact [Section 4.5.2]). Annual water budgets for each subregion were prepared for both the median water supply and a drought year, as discussed in Sections 7.1.2.1 and 7.1.2.2. While the supply components in these budgets are based on the median or drought supply, the diversions for both median and drought budgets are based on current demands to illustrate shortfalls during drought years. For the drought budgets, only the stream inflow component is reduced, where in reality the component of spring flow/stream gains may also be reduced; however, but it is not possible to quantify these variations without surface water/groundwater models.

These water budgets serve to illustrate in a general sense the available supply as compared to demand. A detailed numerical model of all of the surface water and groundwater systems would be needed to more accurately assess the water budget components.

7.1.2.1 Median Surface Water Budget

The surface water budget under median conditions for each subregion is presented in Table 7-4. Inflows are comprised primarily of gaged stream discharges from main drainages and inflows from gaged tributaries. The stream discharges are the median annual water yields for the period from 1990 through 2004 or, if the record for 1990 to 2004 was not available, the median for the period of record (Table 7-1).

As discussed in Section 4, several apportionment actions (i.e., the Costilla Creek Compact and the Rio Grande Compact) limit the amount of irrigated acreage and consumptive use in the Rio Grande and Costilla Basins, with the remaining flows intended for downstream users. Consequently, the result of inflows minus depletions shown for the surface water budgets (Table 7-4) does not represent excess water for the planning region, but rather the average amount of water that flows downstream to other users.

7.1.2.2 Representative Drought Year Surface Water Budget

The annual surface water budget for a representative drought year is presented in Table 7-5. Inflows in the drought year water budget are composed of the water yields recorded by regional gaging stations in the year in which the minimum recorded flow at that station occurred, which in most cases was in 2002. Outflows are comprised of surface water depletions reported by the OSE (Wilson et al., 2003):

Table 7-4. Surface Water Budgets Under Median Conditions for the Taos Water Planning Region

Component	Amount (ac-ft/yr)						
	Costilla	Other Rio Grande Tributaries					Rio Grande Main Stem
	North	North	Central	South	West	Total	Taos County
Inflow							
Surface inflow	21,796	38,924	71,532	66,646	699	177,801	239,637
Inflow from gaged tributaries	---	---	---	---	---	---	173,000
Stream gain	8,088	15,463	19,256	16,488	0	51,207	102,827
Return flow commercial	0	4	180	0	0	184	---
Return flow mining	0	427	0	0	0	427	---
Return flow irrigation	8,519	10,984	11,291	10,815	113	33,203	---
Total inflow	38,403	65,802	102,259	93,949	813	262,822	515,464
Outflow							
Diversions							
Municipal	0	91	0	0	0	91	0
Commercial	0	5	201	0	0	206	0
Domestic	0	0	---	0	0	0	0
Irrigation	12,170	15,692	41,054	16,638	206	73,590	0
Industrial	0	0	0	0	0	0	0
Livestock	0	12	12	12	4	40	0
Mining	0	515	0	0	0	515	0
Power	0	0	0	0	0	0	0
Riparian evapotranspiration	971	790	751	620	0	2,161	0
Open water evaporation	140	1	557	0	603	1,161	0
Stream loss	0	0	12,119	0	0	12,119	---
Surface outflow	25,122	48,695	47,565	76,740	0	173,000	515,464
Total outflow	38,403	65,802	102,259	94,010	813	262,883	515,464
Balance	0	0	0	–62	0	–61	0

ac-ft/yr = Acre-feet per year   --- = Not applicable

Table 7-5. Stream Water Budgets Under Drought Conditions for the Taos Water Planning Region

Component	Amount (ac-ft/yr)						
	Costilla	Other Rio Grande Tributaries					Rio Grande Main Stem
	North	North	Central	South	West	Total	Taos County
Inflow							
Surface inflow	4,644	12,539	18,125	12,894	97	43,655	57,267
Inflow from gaged tributaries	---	---	---	---	---	---	45,712
Stream gain	8,088	15,463	19,256	16,488	0	51,207	98,284
Return flow commercial	0	4	180	0	0	184	0
Return flow mining	0	427	0	0	0	427	0
Return flow irrigation	2,596	4,920	3,036	1,927	113	9,996	0
Total inflow	15,328	33,353	40,597	31,309	210	105,469	201,263
Outflow							
Diversions							
Municipal	0	91	0	0	0	91	0
Commercial	0	5	201	0	0	206	0
Domestic	0	0	0	0	0	0	0
Irrigation	12,170	15,692	41,054	16,638	206	73,590	0
Industrial	0	0	0	0	0	0	0
Livestock	0	12	12	12	4	40	0
Mining	0	515	0	0	0	515	0
Power	0	0	0	0	0	0	0
Riparian evapotranspiration	971	790	751	620	0	2,161	0
Open water evaporation	140	1	557	0	603	1,161	0
Stream loss	0	0	12,119	0	0	12,119	
Surface outflow	8,447	23,312	13,350	9,050	0	45,711	201,263
Total outflow	21,728	40,418	68,044	26,319	813	135,595	201,263
Balance	–6,400	–7,065	–27,447	4,989	–603	–30,126	0

ac-ft/yr = Acre-feet per year --- = Not applicable

- Depletions for public, domestic, livestock, and commercial use were based on OSE-reported depletions for those categories in the year 2000. As with the median surface water budget, industrial and power uses were not included in the water budget because no water use was reported by the OSE in the planning region for these categories from 1975 through 2000.

- The median irrigation diversions were used for the drought water budget to show the true shortfall between normal demand and low supply. (As noted in Section 6.1.2, the OSE-reported irrigation diversions for the year 2000 are based on 1999 data because 2000 was a drought year and OSE water use reports are meant to represent normal conditions.) Though median diversions were used to provide an independent estimate of demand that has not been forced to be lowered due to drought, actual return flows during drought conditions were used so that supply would not be overestimated. The return flow from irrigation was reduced for each locale based on the percent inflow in a drought year as compared to the median inflow:

  – On Costilla Creek, the drought supply (minimum for the period of record) is about 21 percent of the median flow in the gaged streams.

  – On the Rio Grande tributaries in the North subregion, the drought supply is 32 percent of the median flow.

  – In the Central subregion, the drought supply (minimum for the period of record) is 29 percent of the median supply for the Rio Hondo, 21 percent for the Rio Pueblo de Taos, 24 percent for the Rio Lucero, 32 percent for the Rio Fernando and 16 percent for the Rio Grande del Rancho near Talpa.

- Annual reservoir evaporation for the drought year was estimated to be the same as in the median year. Evaporation rates may be slightly higher during hot, dry years, but the total evaporation is more likely controlled by reservoir surface area, which may be lower during extended droughts.

- Riparian evapotranspiration was estimated to be the same volume in the drought year as in the median year. This value may decrease in a drought year due to plants shutting down or dying back from lack of available water; however, available data are insufficient to accurately estimate drought year riparian evapotranspiration.

Again, because of the various apportionment actions on the Rio Grande and Costilla Creek (Sections 4.5.1 and 4.5.2), the total of inflows minus depletions shown on the drought year budget (Table 7-5) does not represent excess water for the planning region, but rather the average amount of water that flows to users downstream.

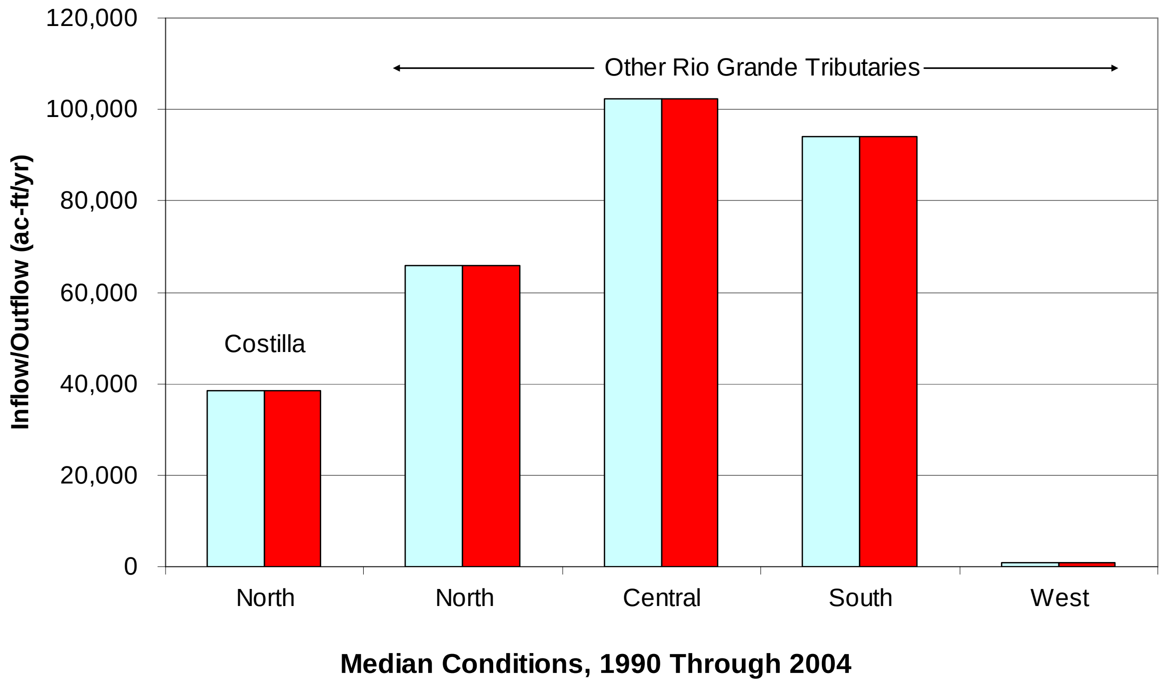
7.1.3 Discussion of Surface Water Budgets

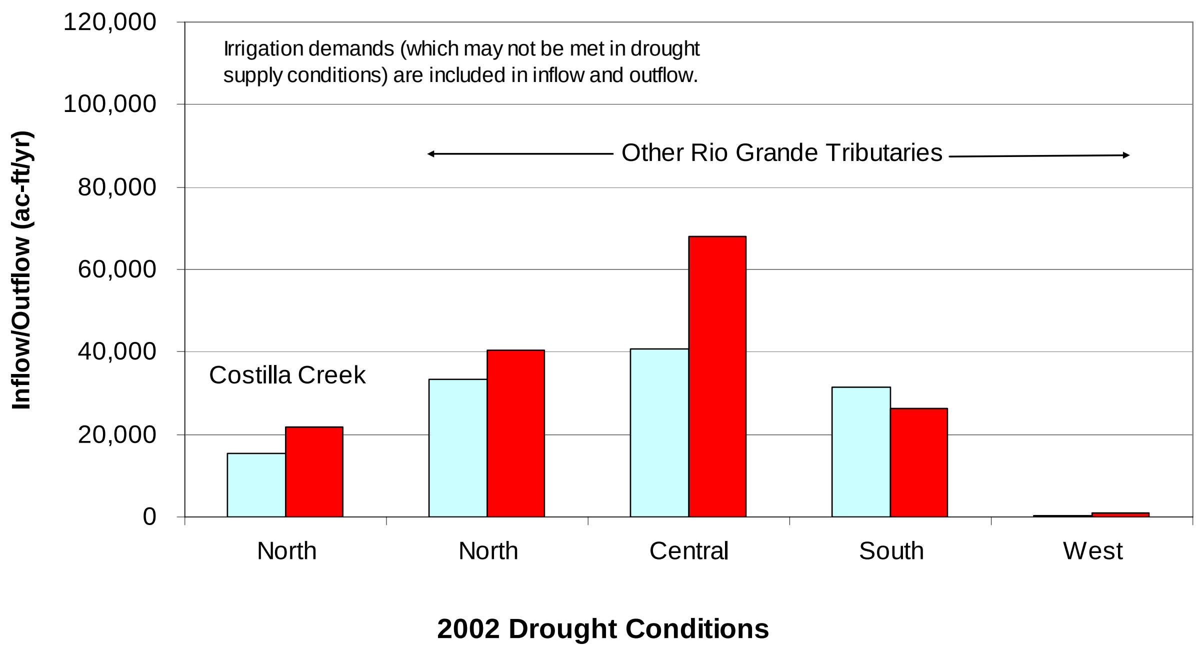
Figure 7-2 shows the total magnitude of estimated inflow and outflows on each of the tributaries under median conditions and drought conditions. While the surface water inflows must equal outflows, Figure 7-2 shows the median demand (outflow) versus the actual supply (inflow), which in some subregions results in more outflows than inflows. The balance in each gaged reach in each of the subregions, as well as the assumptions and methods for developing the water budgets, are shown on Tables G-1 through G-7 (Appendix G). The surface water budgets do not take into account the variability of supply during the year, that is, that most of the flow occurs during March, April and May and stream flows diminish in summer when the water is needed most. Therefore, for practical purposes, these budgets may represent an optimistic assessment of supply versus demand.

Figure 7-3 shows the water budget on the main stem of the Rio Grande under median and drought conditions. The estimates for direct diversions or demands on the Rio Grande are zero, as irrigation directly from the Rio Grande does not occur in the planning region due to the geography of the steep canyon in which the Rio Grande flows. Riparian evaporation likely occurs, but because of the narrow canyon, the area is small and the rate of evaporation is low.

7.1.3.1 North Subregion

As shown in Tables G-1 and G-2 the North subregion includes streams in two drainages: the Costilla and the Rio Grande.





□ Total Inflow
■ Total Outflow

TAOS REGIONAL WATER PLAN

Surface Water Budgets for Tributaries in the Taos Region

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Figure 7-2

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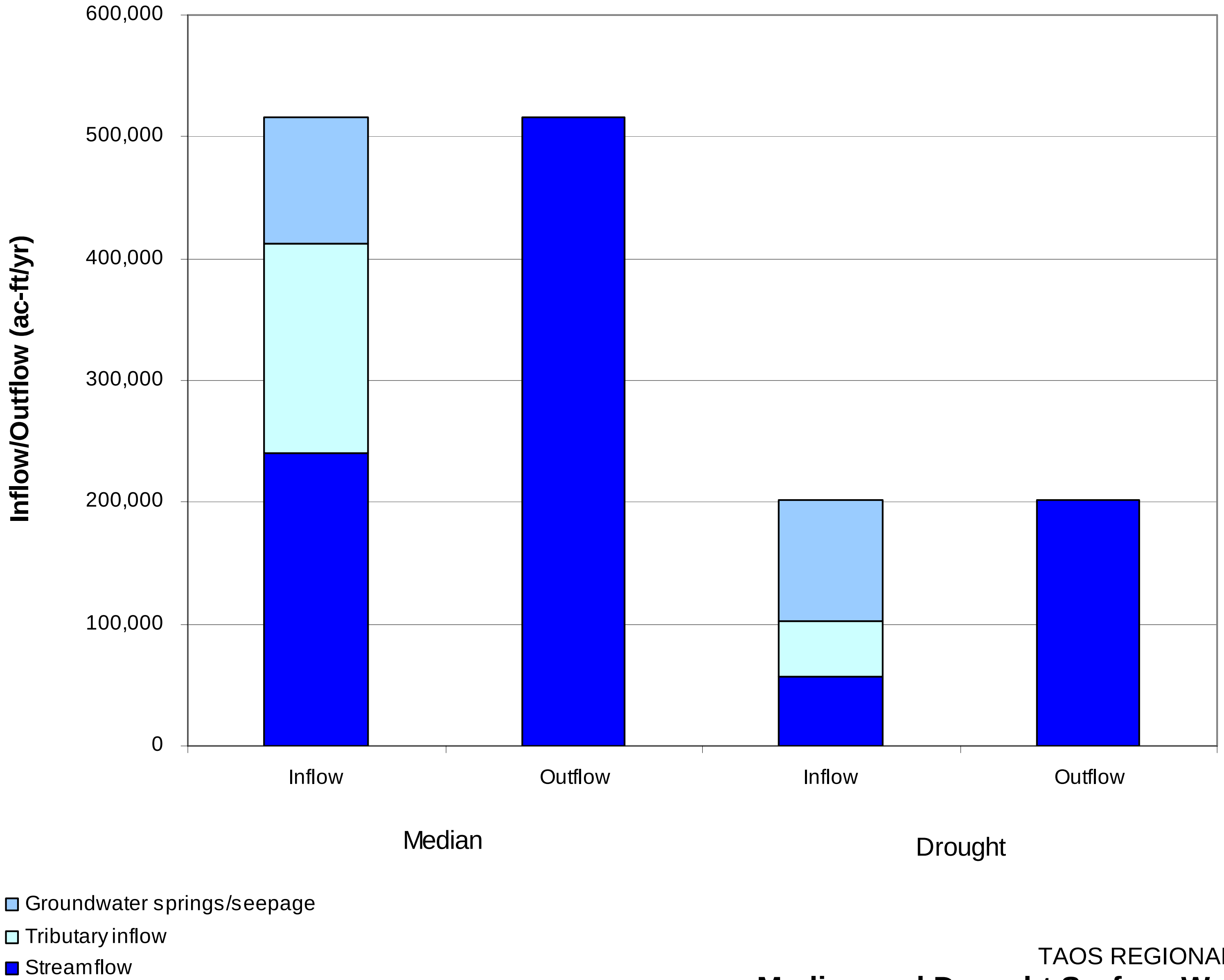

TAOS REGIONAL WATER PLAN

Median and Drought Surface Water Budgets
Main Stem of the Rio Grande

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Figure 7-3

Figure 7-4 shows the overall surface water budget for Costilla Creek under median conditions for 1990 through 2004 and under the drought conditions of 2002 (irrigation demands for the drought water budget are equal to those under median conditions to illustrate drought year shortfalls). Costilla Creek is a gaining stream overall from Costilla Reservoir to near the town of Costilla, although portions may be losing or gaining throughout the reach (Tribble, 2006). The estimated gains are about 8,000 ac-ft/yr.

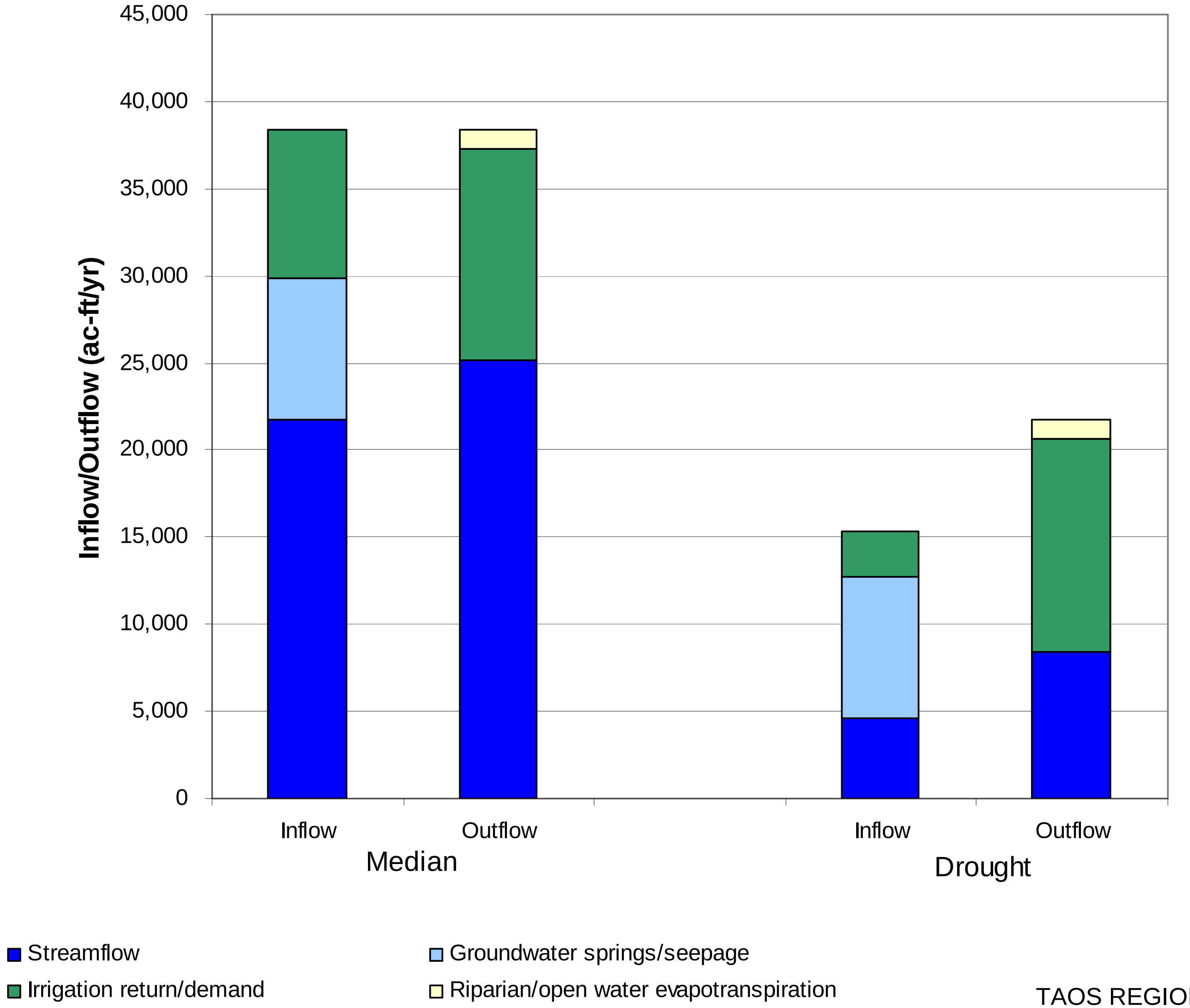
Irrigation demands as estimated in the Costilla Creek water budgets (based on Wilson et al., 2003) include diversions of 12,170 ac-ft/yr in 1999 and return flows of 8,500 ac-ft/yr. However, the median of measured diversions from the Acéquia Madre at Costilla and the Cerro Canal from 1967 to 1990 was 20,500 ac-ft/yr. Whether irrigation diversions have decreased or diversions in 1999 were underestimated is not clear. Further, Landsat satellite imagery for 2002 shows fewer acres under irrigation than the OSE does (7,300 versus 10,500 acres), yet USGS GIS coverage of all acres currently or previously irrigated shows 15,500 acres, about 50 percent more acreage than reported by the OSE.

As shown in Figure 7-4, OSE-estimated water demands on Costilla Creek appear to be met under median conditions, but inflows do not meet demands under drought conditions, during which the shortfall is about 6,400 acre-feet.

Within the Rio Grande Basin, Red River and Cabresto Creeks are both gaining. Irrigation diversions of 15,700 ac-ft/yr (and return flows of 11,000 ac-ft/yr) are met from stream inflow of almost 39,000 ac-ft/yr and spring flow of 15,500 ac-ft/yr. Surface water is also used for mining at Molycorp's molybdenum mine near Questa. Figure 7-5 shows the surface water budgets under median and drought conditions for Rio Grande tributaries in the North subregion. As shown in this figure, water demands appear to be met under median conditions, but inflows do not meet demands under drought conditions, where the shortfall is about 7,100 acre-feet.

7.1.3.2 Central Subregion

The surface water budget components for the Central subregion are better understood than for the other three subregions in the Taos Region because OSE, in collaboration with the Bureau of Reclamation, has developed a numerical groundwater model (Burck et al., 2004; Barroll and Burck, 2006; Bellinger, 2004) to support ongoing adjudications of water rights. Values used for key components of the Central subregion water budgets are:



TAOS REGIONAL WATER PLAN

Median and Drought Surface Water Budgets for Costilla Creek

Figure 7-4

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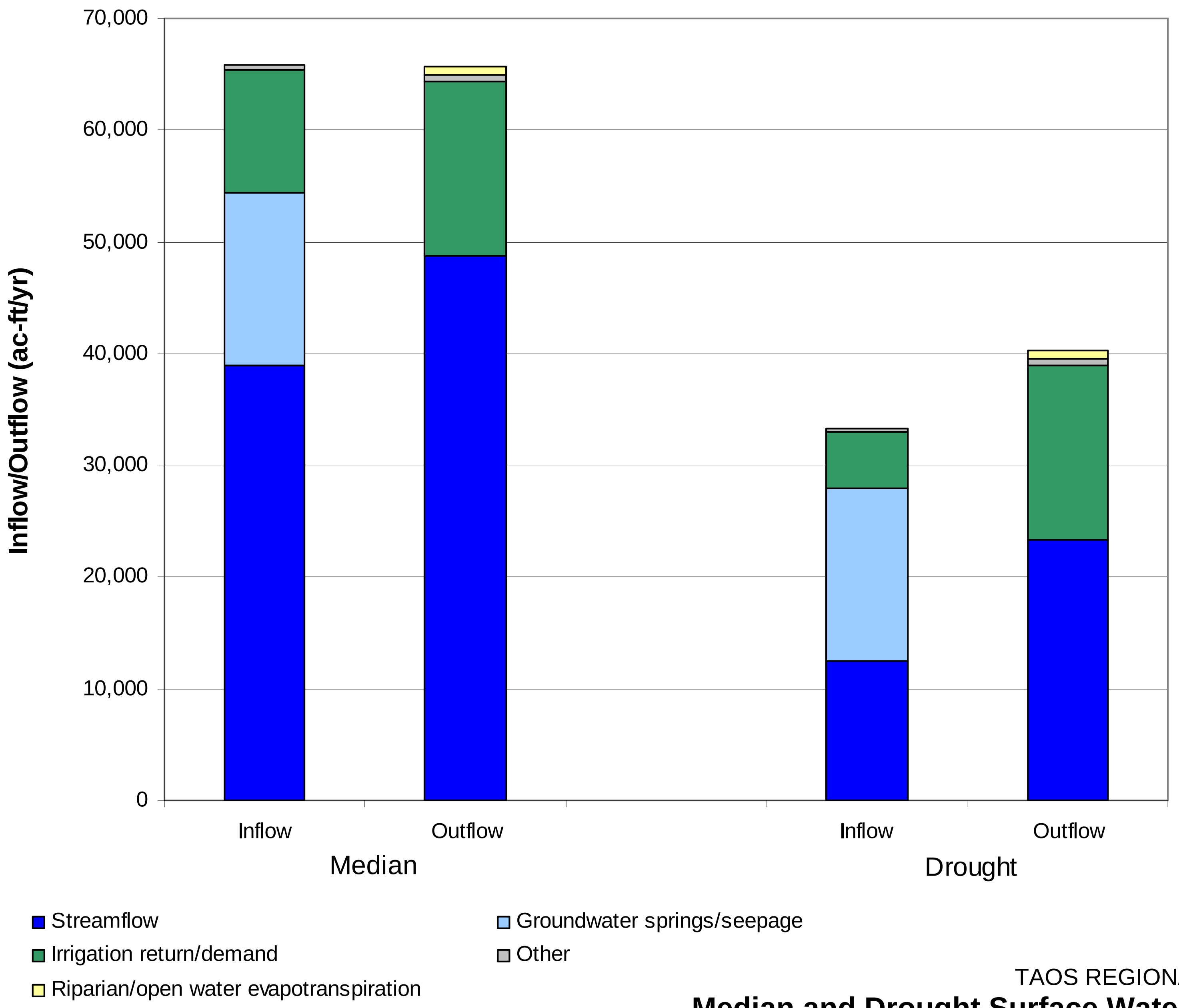

TAOS REGIONAL WATER PLAN

Median and Drought Surface Water Budgets for Tributaries to the Rio Grande, North Subregion

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- The irrigation diversions from the six tributaries in the Central subregion (Rio Hondo, Arroyo Seco, Rio Lucero, Rio Fernando, Rio Pueblo de Taos, and the Rio Grande del Rancho) total 41,000 ac-ft/yr (Bellinger, 2004).

- Irrigation return flows return to both surface water and groundwater; Burck et al. (2004) estimates that 27.5 percent of irrigation diversions return to surface water and 29.5 percent recharge groundwater.

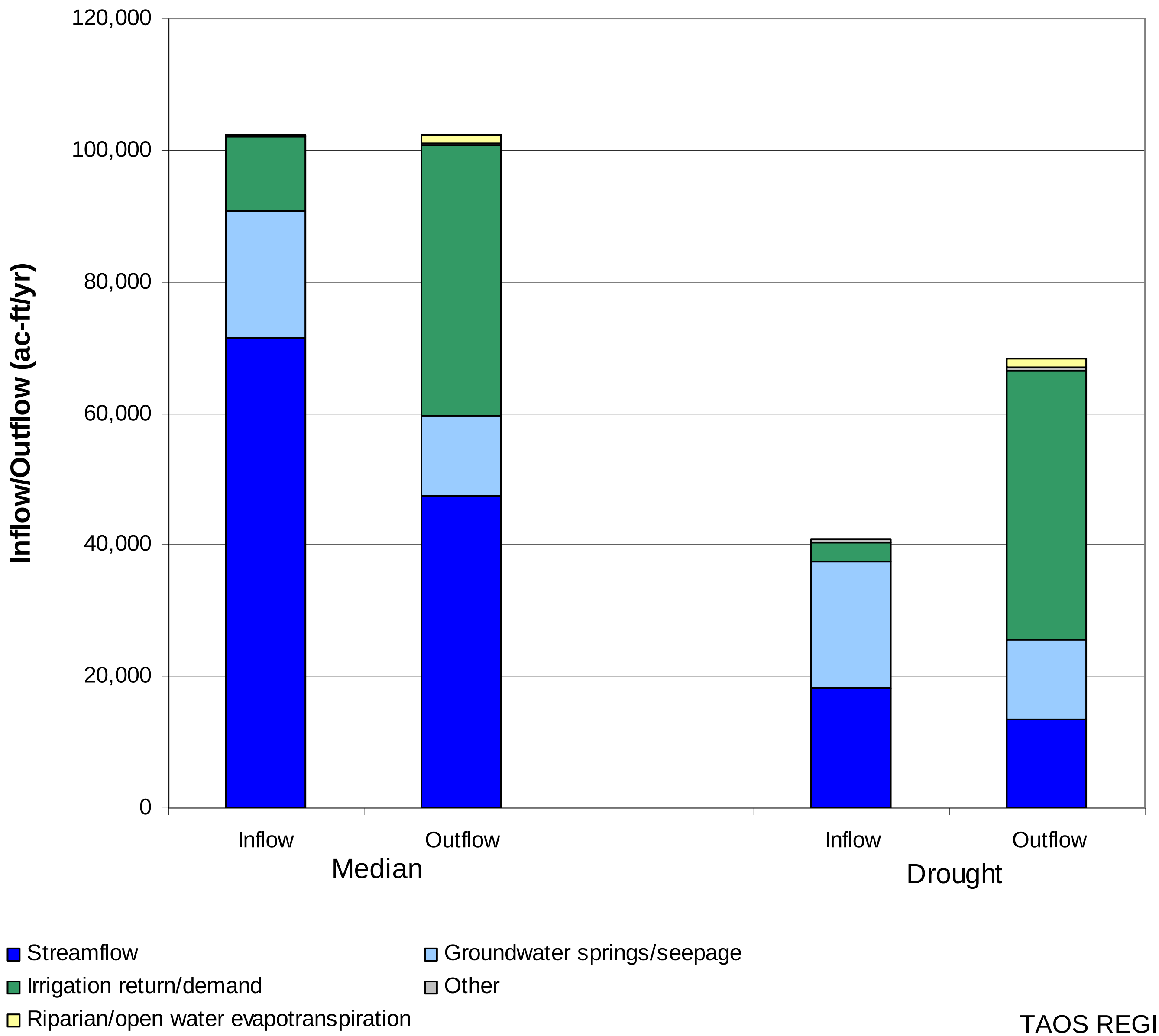
- Riparian evapotranspiration impacting streamflow directly is estimated to be 751 ac-ft/yr using the acreage of hydric soils that do not overlap with irrigation. Another almost 3,600 ac-ft/yr of riparian evapotranspiration is applied to the groundwater budget based on the location of hydric soils distant from the streams. The total riparian evapotranspiration rate of 4,344 ac-ft/yr is less than the total 5,370 acre-feet simulated in OSE's groundwater model (Barroll and Burck, 2006). Although they also used the acreage of hydric soils, they may not have subtracted the acreage of irrigated lands that overlap with the hydric soil acreage.

Figure 7-6 shows the surface water budgets under both median and drought conditions for the Central subregion. The irrigation demands (which were based on the 1996, 1999 and 2000 irrigation seasons as estimated by Bellinger [2004]) cannot be met by the water supply under the drought conditions of 2002, estimated to be about 27,000 acre-feet short of demand (Figure 7-6). Thus, the actual irrigation diversions would be much less than shown in this figure.

7.1.3.3 South Subregion

Surface water inflows in the three streams in the South subregion (Rio Santa Barbara, Rio Pueblo and Rio Embudo) include an estimated 67,000 ac-ft/yr of streamflow under median conditions, 16,500 ac-ft/yr of groundwater inflow (springs), and almost 11,000 ac-ft/yr of irrigation return flow (Tables G-5 and G-6). Irrigation diversions are estimated to be about 16,600 ac-ft/yr, and the median measured outflow of Embudo Creek from 1990 through 2004 was 76,700 ac-ft/yr, indicating that sufficient water is available for irrigation demands.

Figure 7-7 shows the surface water budgets for the South subregion under both median and drought conditions. Even in drought conditions, it appears that sufficient water is available to



TAOS REGIONAL WATER PLAN

Median and Drought Surface Water Budgets for Tributaries to the Rio Grande, Central Subregion

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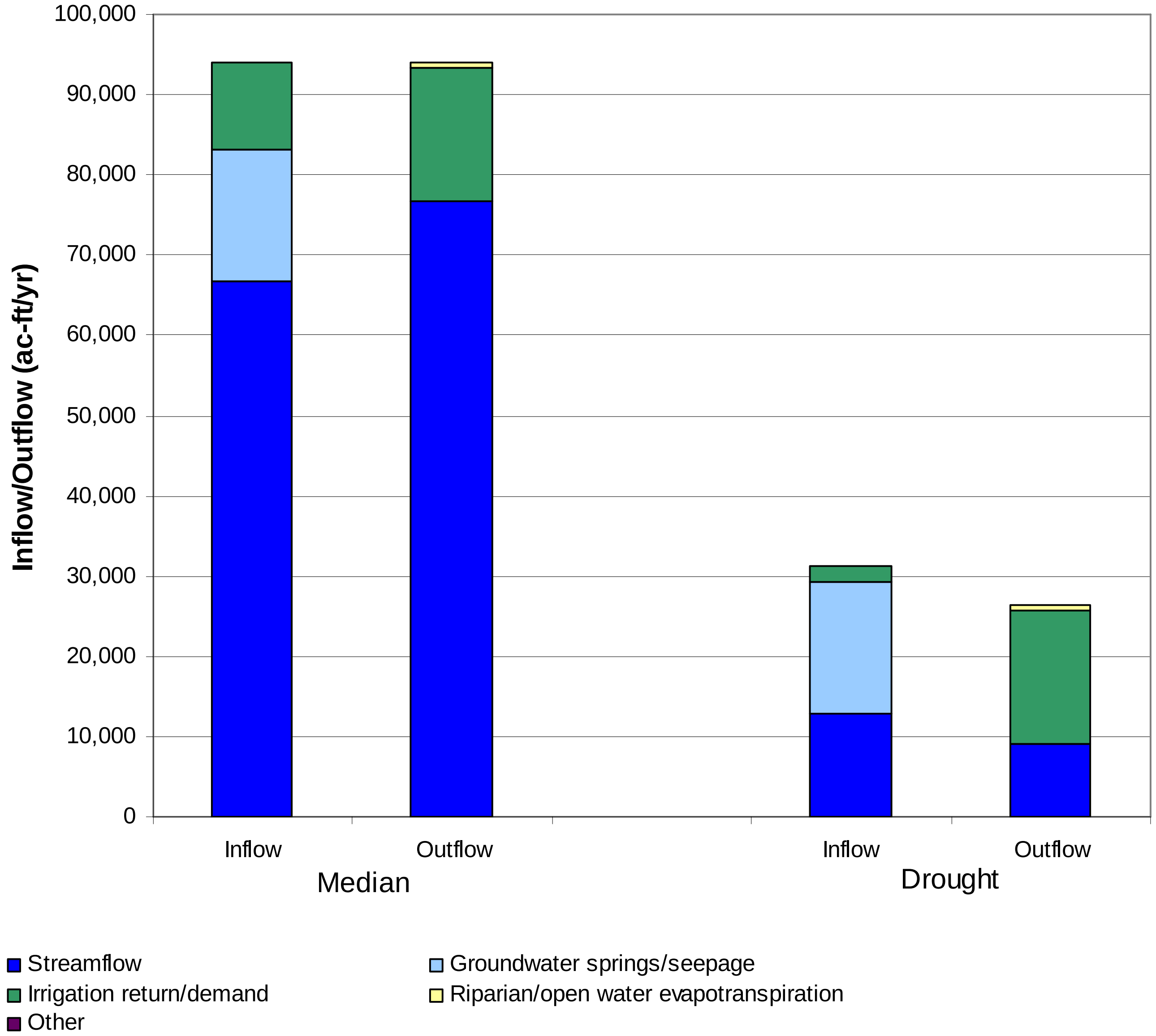
Figure 7-6



TAOS REGIONAL WATER PLAN

Median and Drought Surface Water Budgets for Tributaries to the Rio Grande, South Subregion

Figure 7-7

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meet demands; however, because this budget does not take into account season variability, the availability of supply during the growing season may be insufficient to meet demands. Also, even when the subregion totals show sufficient water, there may be shortfalls in specific locations, particularly in areas that are downstream of major diverters.

7.1.3.4 West Subregion

Little is known about the magnitude of flows in the ephemeral surface water drainages in the West subregion. Evaporation from Carson Reservoir, which intermittently retains water on the Arroyo Aguaje de la Petaca, is estimated to be about 600 ac-ft/yr (Table 7-6). Irrigation of 80 acres in the vicinity of Pilar and Ojo Caliente is supplied by the ungaged Rio Tusas, which receives perennial flow from the warm springs at Ojo Caliente. Ojo Caliente has an estimated flow rate of 60 gpm (Geo-Heat Center, 2005), which equates to 97 ac-ft/yr. The estimated water diversions for irrigation of 206 ac-ft/yr minus the return flow (113 ac-ft/yr) result in a depletion rate of 93 ac-ft/yr, roughly equal to the flow rate from Ojo Caliente.

7.2 Groundwater Budget

Historically, groundwater has provided most of the domestic, public water system, and livestock water supply needs throughout the Taos Region, about half of the commercial water supply, and 4 percent of the irrigation depletions. While the demands on groundwater have been estimated by the OSE (Wilson et al., 2003), the natural components of groundwater flow are not well understood for the planning region. DBS&A has calculated recharge as described in Section 5.3.3, but little else is known. Although the groundwater budgets are thus incomplete, they do clarify areas for which data are needed.

7.2.1 Groundwater Budget Terms and Methodology

The groundwater budget components consist of the inflow components of recharge, stream loss, sub-flow from adjacent basins, and return flow from municipal, mining, and irrigation uses. The outflow components consist of pumping from municipal, commercial, domestic, irrigation, industrial, livestock, mining, and power generation wells, evapotranspiration, springs, and sub-flow to other basins. Figure 7-1 shows the components of the Taos Region water budgets.

Table 7-6. Total Open Water Evaporation in Taos Water Planning Region
Page 1 of 2

GIS Coverage [a]	Area [b] (acres)	Evaporation Rate [c] (feet)	Evaporation (ac-ft/yr)	
			Total	Groundwater Only
North subregion				
Lake/pond: hydrographic category = intermittent	96.4	1.59	153	---
Lake/pond: hydrographic category = perennial	595.9	1.59	947	---
Lake/pond: hydrographic category = perennial; stage = average water elevation	406.0	1.59	646	---
Reservoir: reservoir type = sewage treatment pond	6.6	1.59	10	---
Reservoir: reservoir type = water storage; construction material = non-earthen	0.7	1.59	1	---
Swamp/marsh	3.8	1.59	6	---
Total North	1,109		1,764	1,622 [d]
Central subregion				
Lake/pond: hydrographic category = intermittent	55.6	2.75	153	---
Lake/pond: hydrographic category = perennial	59.2	2.75	163	---
Lake/pond: hydrographic category = perennial; stage = average water elevation	31.5	2.75	87	---
Reservoir: reservoir type = water storage; construction material = non-earthen	0.3	2.75	1	---
Swamp/marsh	201.2	2.75	553	---
Total Central	348		956	399 [d]
South subregion				
Lake/pond: hydrographic category = intermittent	8.4	2.75	23	---
Lake/pond: hydrographic category = perennial	49.3	2.75	136	---
Lake/pond: hydrographic category = perennial; stage = Average water elevation	4.6	2.75	13	---
Reservoir: reservoir type = sewage treatment pond	0.4	2.75	1	---
Swamp/marsh	28.7	2.75	79	---
Total South	91	---	251	251

[a] Lake/pond category shows separate water bodies
Swamp/marsh not duplicated with riparian areas
[b] Acreage estimated using water bodies included in National Hydrography Dataset (NHD) (USGS, 2005a)
[c] Wilson et al., 2003
[d] Total minus open water evaporation shown in Table 7-2
[e] Intermittent only

Table 7-6. Total Open Water Evaporation in Taos Water Planning Region

GIS Coverage [a]	Area [b] (acres)	Evaporation Rate [c] (feet)	Evaporation (ac-ft/yr)	
			Total	Groundwater Only
West subregion				
Lake/pond: hydrographic category = intermittent	383.6	2.75	1,055	---
Lake/pond: hydrographic category = perennial	219.1	2.75	603	---
Total West	602.7		1,657	1,055 [e]

[a] Lake/pond category shows separate water bodies
Swamp/marsh not duplicated with riparian areas

[b] Acreage estimated using water bodies included in National Hydrography Dataset (NHD) (USGS, 2005a)

[c] Wilson et al., 2003

[d] Total minus open water evaporation shown in Table 7-2

[e] Intermittent only

A groundwater budget is the balance between inflow and outflow:

- If the total inflow and outflow components are equal, groundwater levels will not rise or fall.
- If outflow is greater than the inflow, groundwater levels will decline and the volume of water in storage will decrease.
- If inflow is greater than outflow, groundwater levels 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.

To understand the groundwater inflows and outflows, regular measurement of groundwater levels is needed. Unfortunately, the USGS, which is the primary agency that monitors groundwater levels, has few wells in the planning region, one of which is in the Central subregion and the remainder in the North subregion (none are in the South or West subregions) (Section 5.3.5).

The procedures used to estimate the inflow and outflow components for the Taos groundwater budgets are discussed in Sections 7.2.1.1 and 7.2.1.2. Estimates for those components are detailed in Appendix G.

7.2.1.1 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 herein is the natural recharge from precipitation that infiltrates to the water table, including mountain front and areal recharge, and stream loss that recharges groundwater. The method of estimating recharge is described in Section 5.3.3.

The recharge estimates for the numerical model developed by the OSE for the Central subregion were used to calibrate to the precipitation contours for the other subregions. Recharge rates vary from 0 percent for areas that receive less than 11 inches of precipitation to 8 percent for areas that receive more than 19 inches of precipitation. Overall, recharge ranges from 1 percent in the West subregion to 5 percent in the Central subregion and 6 percent in the North and South subregions (Table 7-7). The percentage of precipitation that results in recharge is lower in the Taos Region than in other parts of the state with similar elevations, primarily because area groundwater discharges to streams and marshy areas, indicating a lack of storage capacity to accept more recharge.

Stream loss represents the recharge to the aquifer by seepage from streams and is calculated as described in Section 7.1.1.2. Establishing the median annual losses to groundwater in a losing reach requires records from stream gaging stations in appropriate locations with sufficient periods of record. Such losses vary from day to day and year to year depending on the amount of precipitation. For the groundwater budget, stream losses were estimated as part of the overall recharge amount.

Sub-flow from adjacent basins is the water that flows underground across basin boundaries. No estimates of this inflow component are available for any of the basins in the planning region; however, this component is likely to be very small. Groundwater flow is generally parallel to basin boundaries, where water moves along the slope of the water table, which in general follows the topographic slope. Groundwater is highest beneath the Sangre de Cristo Mountains and flows westward to the Rio Grande in the North, Central, and South subregions. In the West subregion, groundwater flows to the east and discharges to the Rio Grande (Figure 5-14).

As discussed in Section 7.1.1.1, ***return flow*** is that portion of diversions that is not consumptively used and returns to a water body. In general, all commercial and livestock uses are assumed to be fully depleted, and return flow from self-supplied commercial and livestock wells is not included in the water budgets. The water budgets do include, as applicable, estimates of return flow to groundwater from municipal, domestic, mining, and irrigation uses, based on OSE estimates of return flow and irrigation efficiencies (Wilson et al., 2003):

Table 7-7. Recharge Estimates for the Taos Water Planning Region

Subregion	Precipitation (inches) Range	Precipitation (inches) Average	Area Within Precipitation Range [a] (acres)	Total Precipitation [b] (acre-feet)	Percent of Precipitation to Recharge [c]	Recharge [d] (acre-feet)	Percent of Total [e]
North	<11	10	101,676	84,730	0	0	---
	11 - 15	13	49,009	53,094	1	531	---
	15 - 19	17	27,209	38,547	3	1,156	---
	>19	20	252,683	421,138	8	33,691	---
Total	---	---	430,578	597,508	---	35,378	6
Central	11 - 15	13	121,726	131,870	1	1,319	---
	15 - 19	17	42,415	60,088	3	1,803	---
	>19	20	171,019	285,031	8	22,802	---
Total	---	---	335,160	476,989	---	25,924	5.4
South	<11	10	7,722	6,435	0	0	---
	11 - 15	13	78,962	85,542	1	855	---
	15 - 19	17	22,488	31,858	3	956	---
	>19	20	123,392	205,653	8	16,452	---
Total	---	---	232,564	329,488	---	18,263	6
West	<11	10	174,728	145,606	0	0	---
	11 - 15	13	296,172	320,853	1	3,209	---
	15 - 19	17	3,948	5,593	3	168	---
Total	---	---	474,848	472,053	---	3,376	1
Region Total	---	---	1,473,149	1,876,038	---	82,942	4

[a] Precipitation contours from World Climatic Center
[b] Average precipitation multiplied by area within precipitation range
[c] Calibrated to OSE-modeled recharge (Burck et al., 2004) in the Central subregion, with same percentages applied to other subregions
[d] Percent of precipitation multiplied by total precipitation
[e] Total recharge in subregion divided by total precipitation in subregion

- The OSE estimate generally assumes that 50 percent of municipal/domestic uses are returned to the groundwater system unless metered (Wilson et al., 2003).

- Return flow from mining at the Molycorp molybdenum mine near Questa is estimated by OSE to be about 83 percent of diversions (Wilson et al., 2003), though Molycorp has indicated that they believe their return flow rate is 88 percent (Molycorp Inc., 2007).

- The estimates of irrigation return flow are based on a combination of conveyance losses and estimated irrigation efficiencies, as described by Wilson et al. (2003). These differ from basin to basin, but in the planning region, return flow from projects varies from 35 percent for lands irrigated with groundwater to 70 percent for projects irrigated with surface water. For example, an irrigation water right of 1,000 acre-feet with a system conveyance efficiency of 60 percent and an on-farm efficiency of 70 percent will lose 400 acre-feet before it reaches the farm and 30 percent of the remaining 600 acre-feet (180 acre-feet), for a total return flow of 580 acre-feet. All return flow from irrigation with groundwater diversions is assumed to return to groundwater.

7.2.1.2 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), as described in Section 6.1. Diversions from domestic wells were estimated by subtracting the population served by public water systems from the total county population and multiplying the remainder by an average per capita demand (Section 6.1.1.2).

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; therefore, evapotranspiration of groundwater occurs only where the depth to water is shallow. For groundwater, this outflow component includes water evaporated from hydric soils not adjacent to streams; it does not include the evapotranspiration of precipitation that does not recharge the aquifer and riparian evapotranspiration from areas of hydric soils and open water adjacent to streams. Table 7-8 shows the total amount of estimated riparian evapotranspiration that was applied to groundwater. Direct evaporation from open water not associated directly with a stream reach (e.g., marshy areas and lakes) was also estimated as a depletion to the groundwater budgets (Table 7-9).

Table 7-8. Estimates of Riparian Evapotranspiration Applied to Groundwater Budgets

	Hydric Soils Area (acres)			ET From Hydric Soils (ac-ft/yr)		
Subregion	Total [a]	Overlapping Irrigated [b]	Non-Irrigated Land	Total [c]	Applied to SW Budgets	Applied to GW Budgets
North	2,726	951	1,774	3,921	1,762	2,160
Central	4,662	2,696	1,966	4,344	751	3,593
South	2,527	1,830	697	1,541	620	921
West	698	0	698	1,543	0	1,543

[a] Estimated using Soil Survey Geographic (SSURGO) database for Taos County and parts of Rio Arriba and Mora Counties, New Mexico (USDA, 2005)
[b] Gap Analysis Program (USGS, 2004a)
[c] Calculated by multiplying the consumptive irrigation requirement of 2.21 acre-feet per acre (Bellinger, 2004) by hydric soil acreage in non-irrigated lands

ac-ft/yr = Acre-feet per year
SW = Surface water
GW = Groundwater

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 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; to lessen such overestimation, the spring and stream gain categories are combined. Discharges to springs and streams were estimated for Costilla Creek, Red River, and the other tributaries of the Rio Grande in the Central and South subregions.

Sub-flow out of a basin is the water that flows underground out of a basin boundary. No estimates of sub-flow out of the basins in the planning region were available; however, in the North, Central and West subregions, sub-flow out of the basin (and discharge to the Rio Grande directly) was estimated to balance the groundwater budgets.

7.2.2 Summary of Basin Groundwater Budgets

Table 7-9 and Figure 7-8 summarize the groundwater budgets for the four subregions in the planning region. Most of the man-induced components (such as groundwater pumping) are metered, but many of the natural components (such as evapotranspiration, sub-flow out of the basins, and spring and stream gain) are estimated indirectly from GIS coverage and balancing

Table 7-9. Groundwater Budgets for the Taos Water Planning Region

Component	Amount (ac-ft/yr)			
	North	Central	South	West
Inflow				
Recharge	35,378	25,924	18,263	3,376
Return flow M&I	409	780	154	26
Return flow commercial	5	21	3	9
Return flow domestic	98	568	111	42
Return flow mining	2,140	0	0	0
Return flow irrigation	448	12,269	163	0
Total inflow	38,478	39,562	18,695	3,454
Outflow				
Diversions				
Municipal wells	802	1,560	308	53
Commercial	36	148	19	28
Domestic wells	195	1,135	223	85
Irrigation wells	1,280	350	466	0
Industrial	0	3	0	0
Livestock	18	18	18	6
Mining	2,579	0	0	0
Power	0	0	0	0
Open water evaporation	1,623	399	251	1,055
Riparian evapotranspiration	2,160	3,593	921	1,543
Springs/stream gain	23,551	17,455	16,488	0
Sub-flow out	6,234	14,900	0	685
Total outflow	38,478	39,562	18,694	3,454
Balance	0	0	0	0

ac-ft/yr = Acre-feet per year M&I = Municipal and industrial

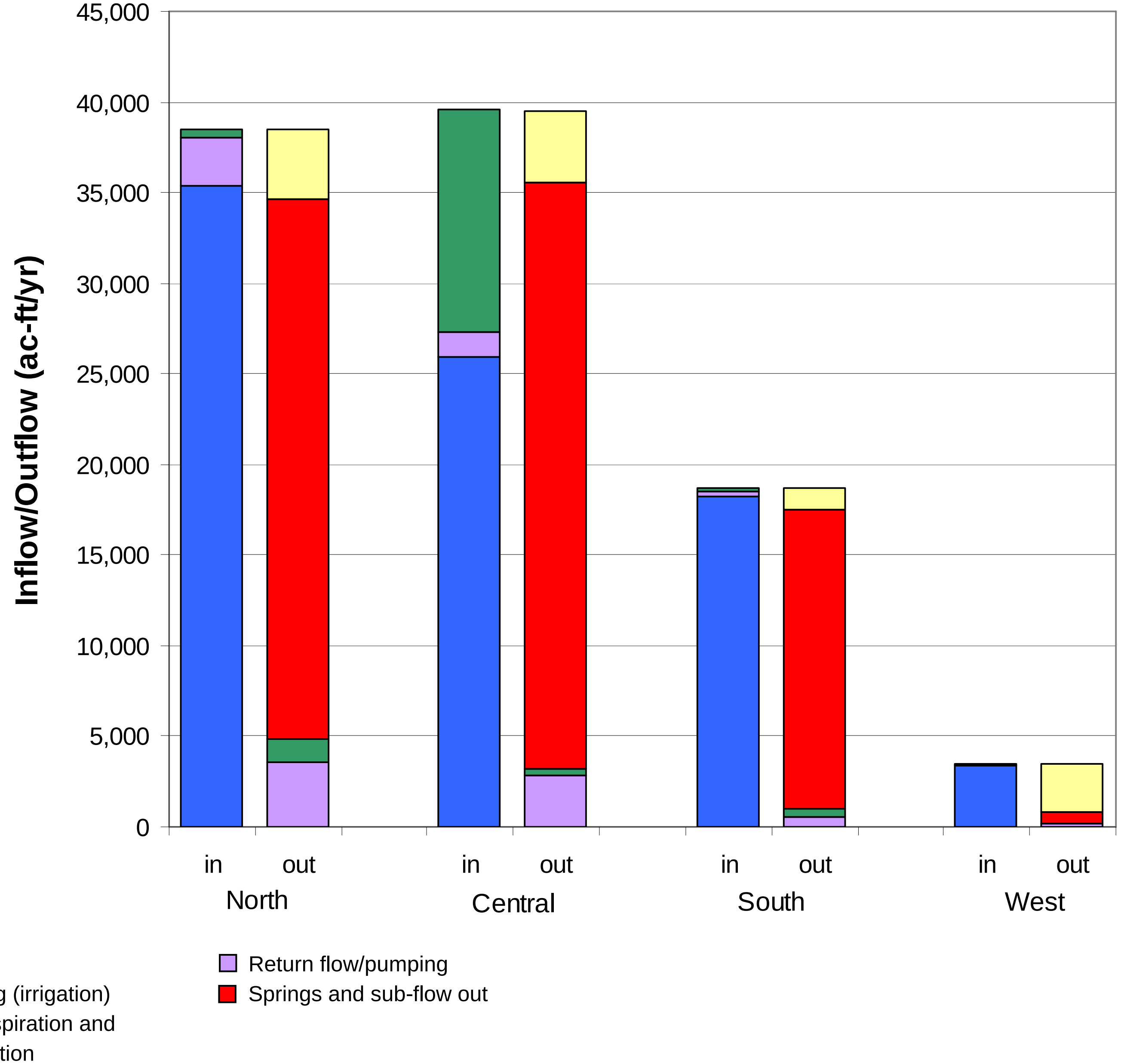

Figure 7-8

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TAOS REGIONAL WATER PLAN

Groundwater Budgets for Subregions

the water budget. Because all of the water budgets for the planning region are based on available data, which is limited, the difference between inflow and outflow components may be a result of error in the knowledge of the basin rather than an indication of changes in groundwater storage. Therefore, the net differences between calculated inflows and outflows are not presented in Table 7-9.

The primary input component of the groundwater budget is recharge. As discussed in Section 5.3.3, the recharge estimate based on modified Maxey-Eakin calculations ranges from 0 to 8 percent of average annual precipitation. The estimated average recharge for the groundwater basins within the planning region is about 83,000 ac-ft/yr, or about 4 percent of the total amount of precipitation falling on the region each year.

Although not estimated, recharge rates will be reduced during drought years, when lower snowpack yields and lessened rainfall produce reduced amounts of runoff available for recharge.

The primary output components of the simple groundwater budget constructed here are diversions from pumping wells for the year 2000 for the aforementioned uses (Section 7.2.1.2), summarized in Table 6-1 and briefly described below:

- In the year 2000, all of the domestic water supply (diversions of 1,600 acre-feet) and almost all of the public water supply were from groundwater (2,800 acre-feet versus 9 acre-feet from surface water). Together, these two uses made up 47 percent of groundwater diversions.

- Also in 2000, groundwater supplied 60 acre-feet, or 60 percent of the total livestock needs. This 60 acre-feet comprised less than 1 percent of the total estimated groundwater diversions.

- Mining diversions included 2,580 acre-feet from groundwater (28 percent of all groundwater diversions and 83 percent of the water used for mining). After accounting for return flows, the estimated depletion of groundwater totals 440 acre-feet.

- Irrigation accounted for 23 percent of all groundwater diversions in the planning region. However, groundwater supplied only 2 percent of all irrigation diversions (surface and groundwater) in the same year.

- The remaining 3 percent of tabulated groundwater diversions in 2000 were for commercial and industrial uses.

Figure 7-9 shows the total amount of pumping from each subregion. The North and Central subregions have by far the greatest amount of groundwater diversions, totaling just above 8,000 ac-ft/yr; the total combined pumping in the South and West subregions is only about 1,200 ac-ft/yr.

Based on a review of water level hydrographs and water table contour maps, the water budgets appear to reasonably represent median conditions in the aquifers. The budgets indicate that water levels are not declining in response to pumping. However, few hydrographs with long-term records are available for an adequate assessment of the aquifers. Furthermore, even if the region as a whole is not experiencing significant groundwater level declines, there may be declines in local areas that are affected by pumping. Additional monitoring to evaluate changes in water levels is warranted.

7.3 Comparison of Water Supply, Water Rights and Diversions

The water budgets discussed thus far are based on annual flows and depletions. However, a couple of factors affect the practical availability of supply to meet demands, particularly for agriculture:

- Only a small fraction of irrigation in the region currently uses groundwater, and with the exception of Costilla Creek (which can use the storage capacity of Costilla Reservoir), irrigation in the Taos Region depends almost entirely on the flow in the streams during the growing season. Therefore, the surface water supply available in each subregion during the growing season was compared to the projected demand.

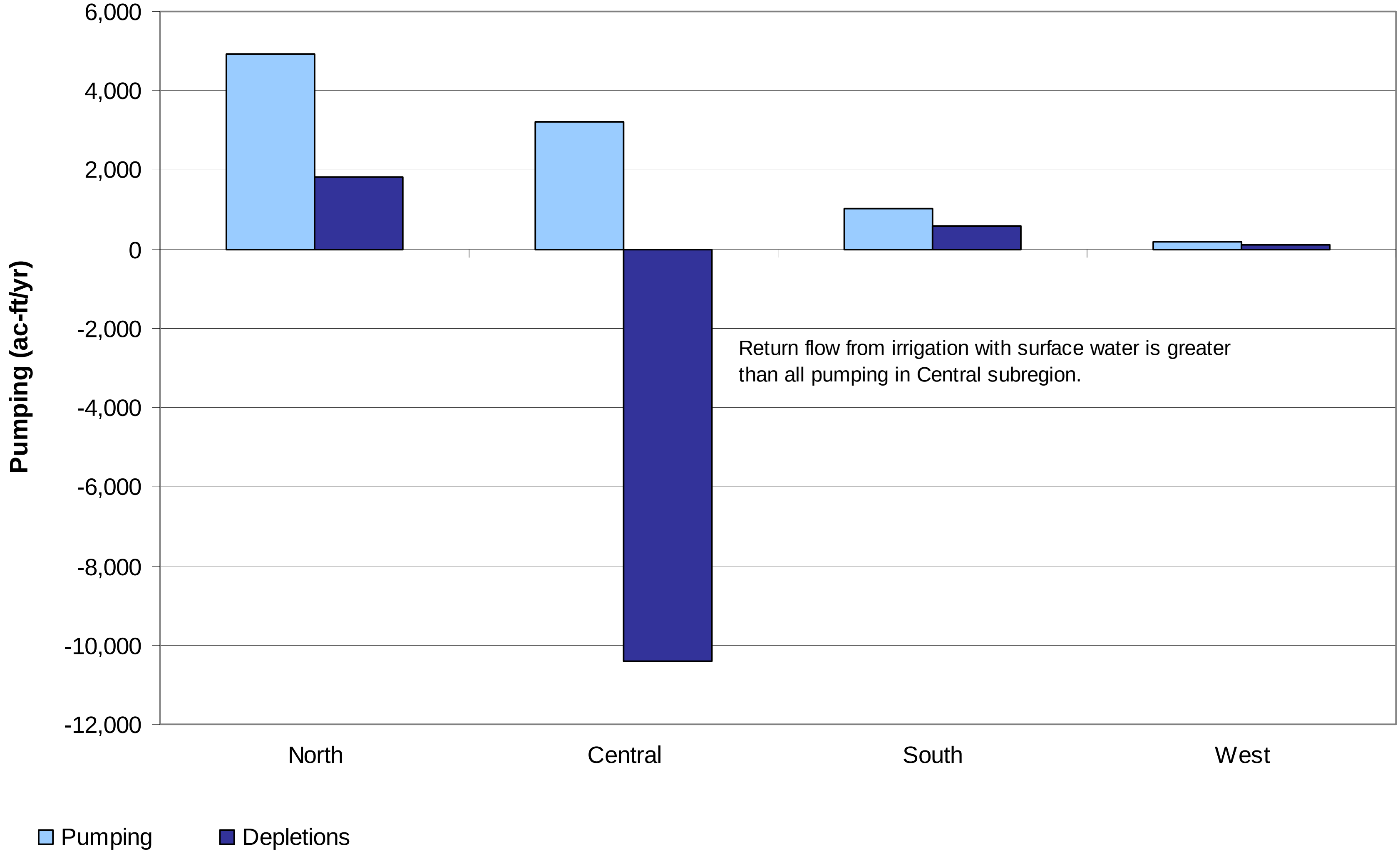

Figure 7-9

TAOS REGIONAL WATER PLAN

Groundwater Pumping in Subregions

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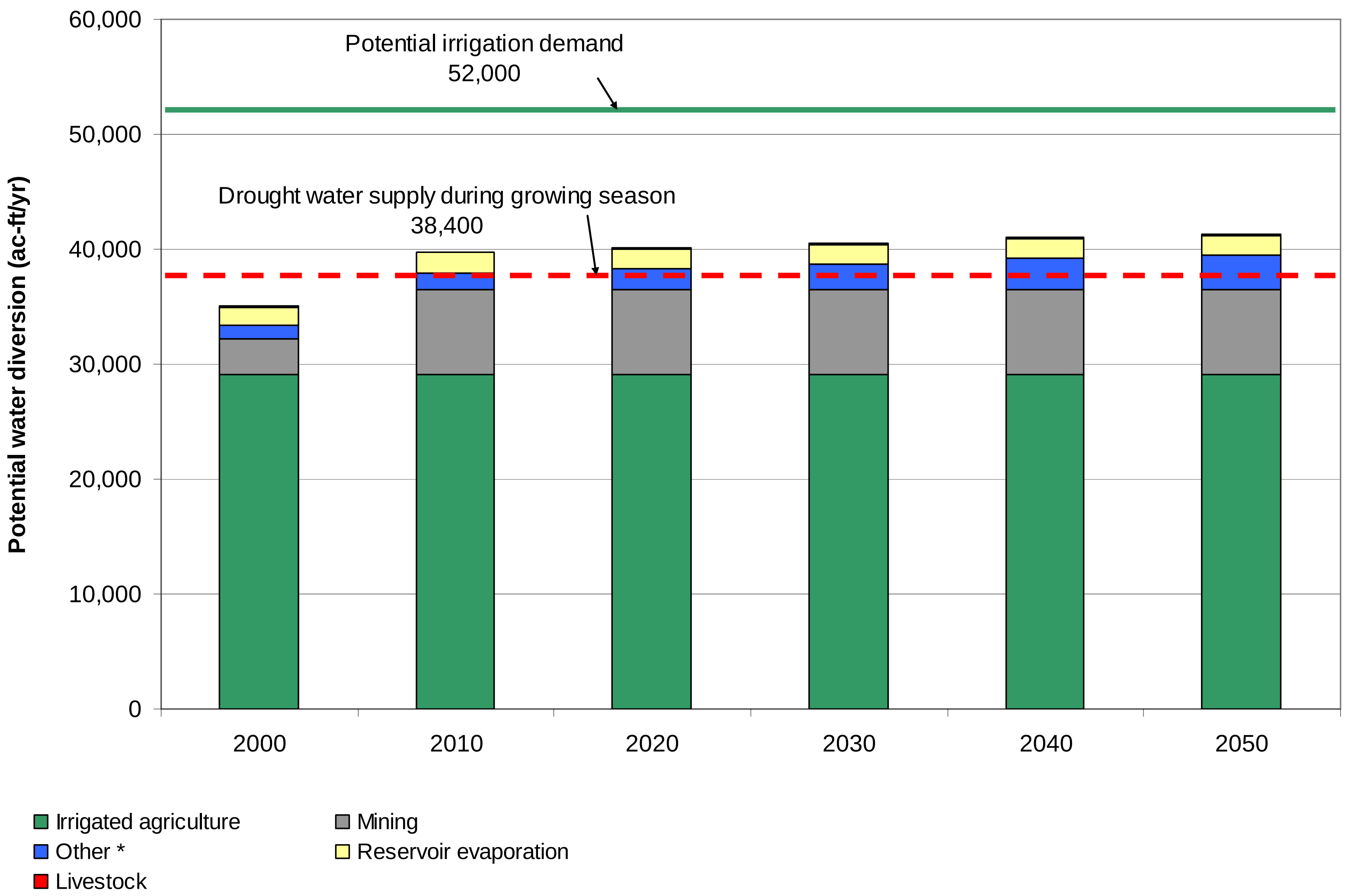
- The potential diversion was also compared to the total irrigation water rights in each subregion. Because not all areas have been adjudicated, the water right estimates (Appendix F1, Table F1-3) may not be complete, but the estimates are based on the best information currently available.

The growing season in the Taos Region is primarily five months out of the year (May through September). Although some irrigation may begin in April and continue into October, 91 percent of the CIR is estimated to be used during the months of May through September (Bellinger, 2004).

Ideally, the growing season supply, current diversions, and water rights on each stream system should be examined independently to plan for future diversions and potential drought. Because a complete analysis of every stream system in the planning region was outside the scope of this study, a general overview of projected diversions and available supply was developed by analyzing the centrally located Rio Hondo to obtain an average ratio of growing season to annual supply that was then applied to all streams in the planning region. On the Rio Hondo the available supply during the growing season is about 75 percent of the annual supply, based on USGS streamflow records for the Rio Hondo near Valdez gaging station from 1935 to 2001. Accordingly, the growing season supply for all streams in the region was estimated as 75 percent of all inflows plus 100 percent of surface water irrigation return flow.

7.3.1 North Subregion

In the North subregion, the projected demand for all uses (including those that rely on groundwater and open water evaporation that occurs upstream of the surface water gages) is presented in Figure 7-10. The potential irrigation diversion could be about 42,000 ac-ft/yr for surface water only or 52,500 ac-ft/yr, including groundwater rights, based on the water right information compiled from the Red River Adjudication (no groundwater rights are listed in the Costilla Decree). The growing season surface supply is 83,000 (median) and 38,400 (drought) including return flow. Given these amounts, total demands (including those supplied by groundwater) slightly exceed the available surface water supply in drought years. Should water rights be applied to their full extent (only about 12 percent of the irrigation groundwater rights in the Red River Adjudication are currently used [Wilson et al., 2003; U.S. District Court, 2000]), more shortages could occur.



* Other includes commercial, domestic, public water supply, industrial, and power

TAOS REGIONAL WATER PLAN

Potential Demand vs. Growing Season Supply
High-Growth Projection, North Subregion

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Figure 7-10

7.3.2 Central Subregion

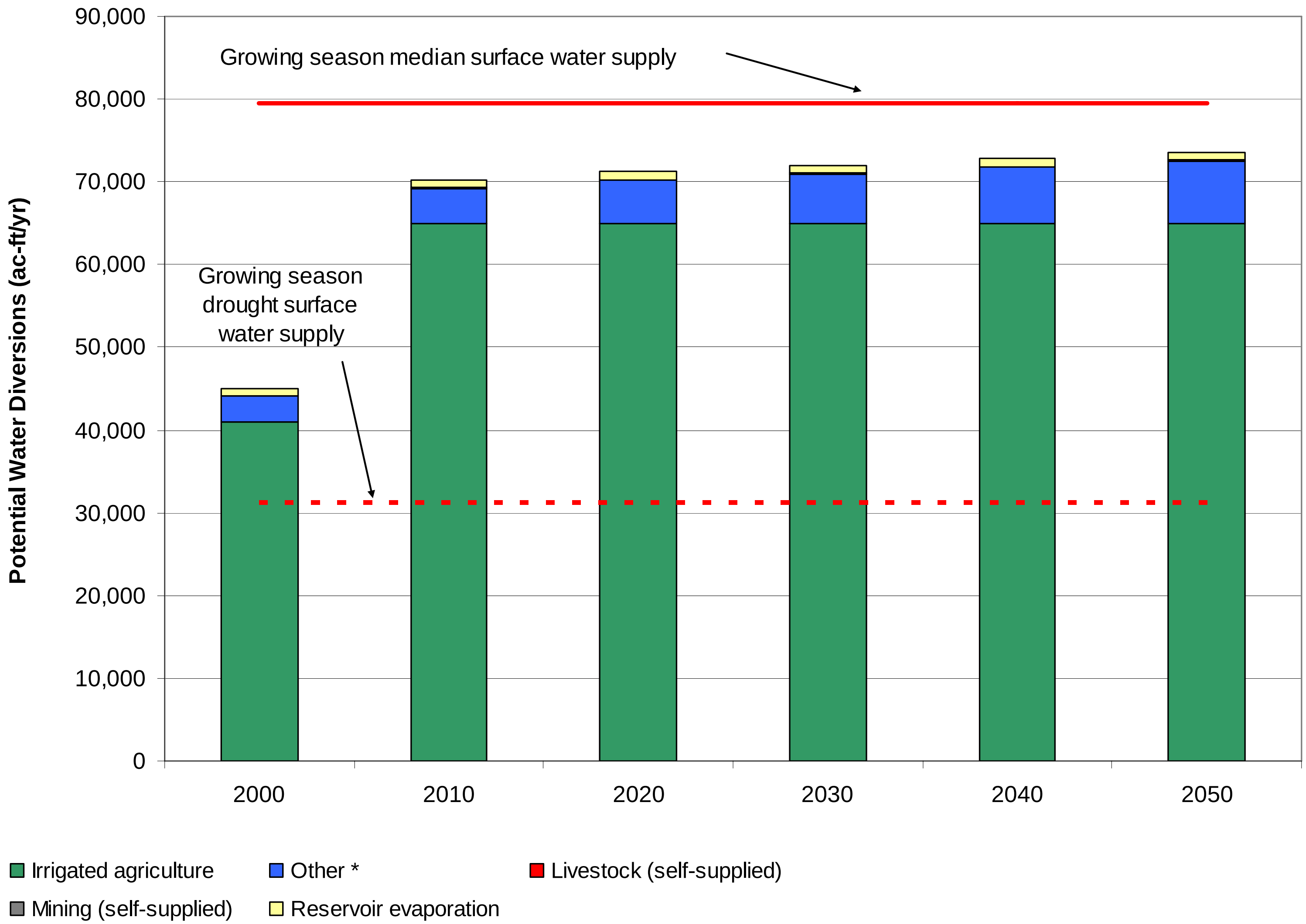
The potential projected water diversions in the Central subregion are based on the full exercise of all water rights rather than the estimated diversion in 1999 (as was done for the other subregions). As part of the OSE modeling effort, Bellinger (2004) estimated that 41,100 ac-ft/yr was diverted for irrigation, 24,000 ac-ft/yr less than the estimated water rights in the Central subregion.

Under this scenario, water demands (diversions) appear to be met by the median surface water supply (Figure 7-11) although, if the projected irrigation demands increase as proposed in the Draft Abeyta Settlement Agreement (Section 4.5.3.1), the water supply is barely sufficient in median conditions. Under the dry conditions of 2002, surface water demands are more than twice the drought supply (Figure 7-11). The public, commercial, and domestic demands are met with groundwater supplies, which appear to be sufficient to meet those demands. Even when the subregion totals show sufficient water, however, there may be shortfalls in specific locations, particularly in areas that are downstream of major diverters.

Measures implemented to meet growing demand, such as significant groundwater development or changes in upstream surface water use, should be considered carefully, on a case by case basis.

7.3.3 South Subregion

The total demand (diversions) for the South subregion (including about 500 ac-ft/yr of irrigation with groundwater) is well below even the drought surface water supply during the growing season (Figure 7-12). The total diversions in the South subregion are only projected to increase by about 360 ac-ft/yr to 18,300 ac-ft/yr under the high-growth scenario, well below the drought supply of 24,000 ac-ft/yr during the growing season. Even if all the water rights are fully exercised, diversions would total about 23,600 under the high-growth scenario, still less than the drought supply observed in 2002 during the growing season.



* Other includes commercial, domestic, public water supply, industrial, and power

TAOS REGIONAL WATER PLAN

Potential Demand vs. Growing Season Supply
High-Growth Projection, Central Subregion

Figure 7-11

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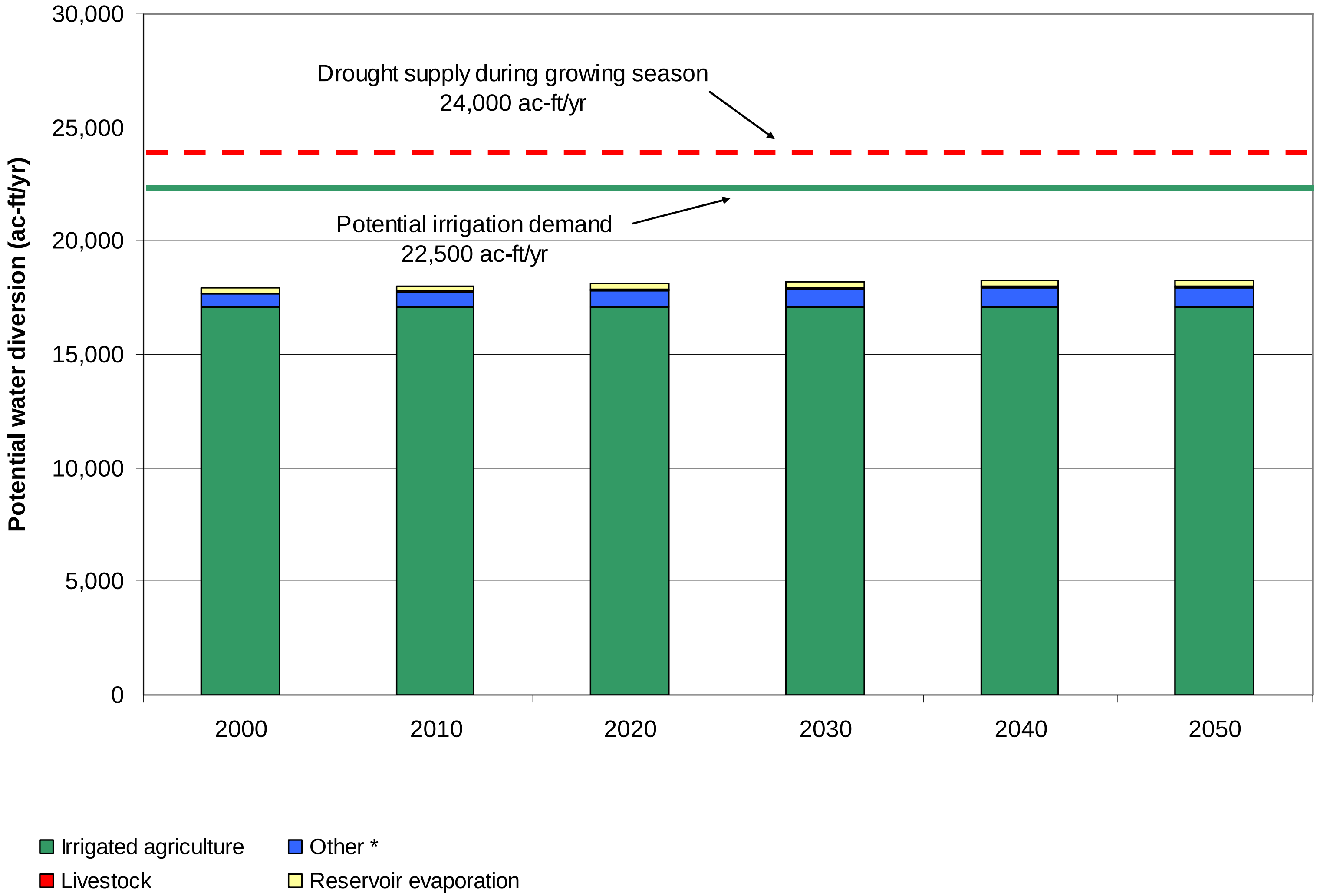
11/27/07



* Other includes commercial, domestic, public water supply, industrial, and power

TAOS REGIONAL WATER PLAN

Potential Demand vs. Growing Season Supply
High-Growth Projection, South Subregion

Figure 7-12

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Even in drought conditions, it appears that sufficient water is available to meet demands; however, though the subregion totals show sufficient water, there may be shortfalls in specific locations, particularly in areas that are downstream of major diverters.

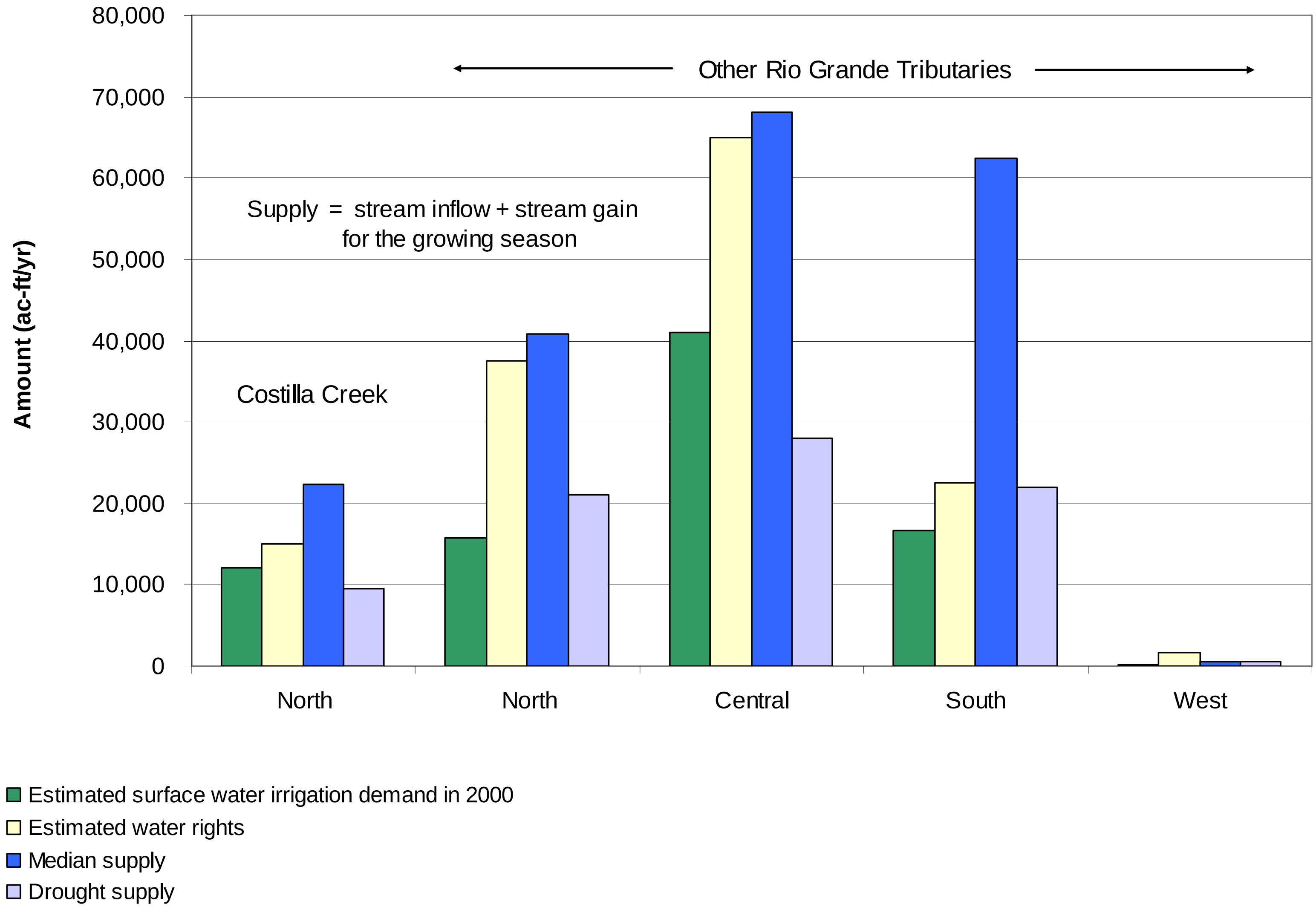
7.3.4 West Subregion

The West subregion relies almost entirely on groundwater. The surface water diversion of about 200 ac-ft/yr for irrigation is supplied by the flow from hot springs and is unlikely to be impacted by drought. The reservoir evaporation that occurs in the West subregion is primarily the evaporation of flood flows that are temporarily stored in Carson Reservoir. Groundwater should be able to meet the projected demands for commercial, public, and domestic uses.

7.3.5 Summary

The gap between supply and demand in the Taos Region occurs in the portion of the irrigation sector that depends on surface water. The demands on groundwater by the public, commercial and domestic sectors can be met with the available groundwater; however, each public or commercial water supply system must retain sufficient water rights to meet those demands. The ability to transfer water rights to new groundwater uses is contingent on the demonstration that such a transfer would not cause impairment or be contrary to public welfare or conservation (Section 4). While sufficient groundwater is physically available in the region, local water right impairment issues may affect the ability to develop groundwater in specific locations. There may also be market competition for the limited water rights that are for sale.

Figure 7-13 shows the irrigation diversions for surface water only, the water rights associated with surface water irrigation, and the stream inflow and stream gain during the growing season (return flows not included) for the median and drought years. As shown in this graph, the North, Central and South subregions appear to have sufficient supply to meet the water rights under median conditions, but during a drought, such as the one in 2002, current diversions cannot be met on the Costilla Creek and the other Rio Grande tributaries in the Central subregion, and estimated water rights can be fully supplied only in the South subregion.



TAOS REGIONAL WATER PLAN

Irrigation Demand, Water Rights, and Growing Season Supply

Figure 7-13

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4/21/08