

Water Use Characteristics



3.1 INTRODUCTION

This chapter describes current and historical water use by each of the three water demand sectors in the Tucson Active Management Area (AMA): municipal, industrial, and agricultural users. It also briefly describes demographic and economic characteristics that influence water use. Water use patterns for each sector are discussed, including past trends in water use and anticipated growth patterns. Sources of water supply, trends in the use of these supplies and anticipated future supply utilization are discussed. The projections discussed in this chapter are based on the “Third Management Plan Scenario” in Chapter 11, the Water Budgets and Projections Chapter of this Plan, which assumes implementation of Third Management Plan programs. Finally, a water budget of past and current demand and supply conditions relative to safe-yield is presented that illustrates the need for continued conservation and augmentation efforts during the third management period in order to reach the AMA safe-yield goal.

The Tucson AMA includes portions of Pima, Santa Cruz, and Pinal Counties. Incorporated cities and their 1995 populations include Tucson (455,299), South Tucson (5,570), Marana (5,309), Oro Valley (19,657), and Sahuarita (2,159). The AMA population within unincorporated areas of the three counties totaled approximately 280,482 in 1995. Part of the Schuk Toak District and the entire San Xavier District of the Tohono O’odham Nation are located within the AMA boundaries, as are the Pascua Yaqui tribal lands. However, these lands are not under the jurisdiction of the Arizona Department of Water Resources (Department). The population on the Tohono O’odham District lands within AMA boundaries was approximately 1,500 in 1995. The population on Pascua Yaqui tribal lands was approximately 3,810 in 1995. Over 95 percent of the region's population resides within the northern part of the Upper Santa Cruz Valley subbasin which includes the Tucson metropolitan area, Oro Valley, the eastern portion of Marana, Green Valley and Sahuarita. The remaining population is centered in the Avra Valley subbasin communities of Three Points (Robles Junction) and Arivaca, and the western portion of Marana. According to Department of Economic Security estimates and projections, the 1995 population of approximately 768,017 within the current borders of the Tucson AMA is projected to reach about 1,005,400 by 2010 and 1,266,500 by 2025. The majority (78 percent) of the population in the Tucson AMA is served by Tucson Water, the water utility operated by the City of Tucson. The Tucson AMA contains one consolidated irrigation distribution system that serves over 80 farms and is operated by the Cortaro Marana Irrigation District. The area's economy is based on a variety of industries including government, education, aviation and aerospace industries, retail trade, tourism, medical and health care, telecommunications, real estate development, construction, agriculture, and copper mining.

Each water demand sector has unique water use characteristics that influence the sector’s ability to contribute to meeting the AMA management goal of achieving safe-yield. Agricultural use includes water used for crop irrigation by irrigation grandfathered right holders. Municipal use includes water supplied by cities, towns, private water companies and irrigation districts for domestic, industrial and commercial purposes. Industrial use includes groundwater withdrawn pursuant to non-irrigation grandfathered rights or permits for industrial purposes. Table 3-1 illustrates that municipal water use has increased since 1985 and agricultural use has declined. Industrial water use has remained at approximately 19 percent of the total AMA demand.

Table 3-2 shows the volume of each source of water used by each regulated sector in the years 1985, 1990 and 1995. Historically, water users in the Tucson AMA have been groundwater dependent. This has continued to be the case although effluent use has increased and Central Arizona Project (CAP) water is now available within the AMA but is not being directly used for potable purposes. Delivery of CAP water to a number of farms in the AMA began in 1993 under the Department’s groundwater savings program (see Chapter 8). At groundwater savings facilities, recipients (typically farms) use CAP water supplied by a water storer with an excess supply, in-lieu of pumping groundwater. Water storers (typically municipal providers, Central Arizona Water Conservation District (CAWCD), or the Arizona Water Banking Authority) accrue CAP water storage credits that can be recovered in the future by pumping groundwater.

The CAP water used on the groundwater savings facility is considered to be groundwater for water accounting purposes and so is not shown as CAP water in Table 3-2. When the water storer recovers the storage credits, the water will be considered CAP water for water accounting purposes. No recovery had occurred through 1995. Effluent and CAP water use is expected to increase in the future, especially in the municipal sector as water storers begin to recover their credits.

**TABLE 3-1
WATER USE BY SECTOR
1985, 1990, AND 1995
TUCSON ACTIVE MANAGEMENT AREA**

Sector	1985		1990		1995	
	Total Use (Acre-feet)	% of AMA	Total Use (Acre-feet)	% of AMA	Total Use (Acre-feet)	% of AMA
Agricultural	114,450	40	93,801	34	97,180 ¹	31
Municipal	115,735	40	129,444	48	154,894	50
Industrial	55,744	20	48,743	18	60,204	19
TOTAL	285,929	100	271,988	100	312,278	100

¹ 1995 agricultural data do not include the water usage of exempt small rights; rights <10 acres in size were deregulated in 1994.

NOTE: Municipal water use associated with exempt wells (wells that pump less than 35 gallons per minute) is not shown.

NOTE: Agricultural use includes canal losses.

**TABLE 3-2
WATER USE BY SOURCE
1985, 1990, AND 1995
TUCSON ACTIVE MANAGEMENT AREA**

Year	Municipal Use (Acre-feet)	Agricultural Use (Acre-feet)	Industrial Use (Acre-feet)	Total Use (Acre-feet)
1985 TOTALS	115,735	114,450	55,744	285,929
CAP Water	0	0	0	0
Effluent	3,080	3,446	356	6,882
Groundwater	112,655	111,004	55,388	279,047
1990 TOTALS	129,444	93,801	48,743	271,988
CAP Water	0	0	0	0
Effluent	6,279	3,986	769	11,034
Groundwater	123,165	89,815	47,974	260,954
1995 TOTALS	154,894	97,180 ²	60,204	312,278
CAP Water	103 ¹	0	0	103 ¹
Effluent	7,711	1,801	782	10,294
Groundwater	147,080	95,379	59,422	301,881

¹In 1995, Tucson Water used 103 AF of CAP water for treatment plant maintenance.

²1995 agricultural data do not include the water usage of exempt small rights; rights <10 acres in size were deregulated in 1994.

NOTE: Municipal water use associated with exempt wells is not shown.

NOTE: Agricultural use includes canal losses.

In this chapter, the following topics are discussed in the order listed:

- Agricultural Water Use Characteristics
- Municipal Water Use Characteristics
- Industrial Water Use Characteristics
- Current Water Budget
- Conclusions

3.2 AGRICULTURAL WATER USE CHARACTERISTICS

This section describes agricultural water users, trends in agricultural water use, agricultural water demand and supplies, the status of flexibility account credits, and some factors that influence agricultural water use.

Certificates of Irrigation Grandfathered Rights (IGFRs) were issued to farmers in the early 1980s if two or more acres of land were irrigated between 1975 and 1980. In 1994, legislation removed the conservation requirements for IGFRs that were ten acres or less in size, provided they were not part of an integrated farming operation. Certificates of IGFRs designate the number of irrigation acres allowed to be irrigated. A water duty and a maximum annual groundwater allotment are established by the management plan for each IGFR (see Chapter 4). With few exceptions, no new land greater than two acres in size can be irrigated within an AMA.

The total amount of water currently allotted annually under the Second Management Plan to all IGFRs in the Tucson AMA is approximately 153,000 acre-feet. If the holder of an IGFR uses less than the total annual water allotment for his acreage, the unused portion is credited in an irrigation flexibility account for that IGFR. The balance in this account is cumulative. Flexibility accounts may be debited if more than the annual water allotment is used. The total amount of flexibility account (flex) credits accumulated by the end of 1995 for all Tucson AMA IGFRs was about 673,000 acre-feet. Most IGFRs have accumulated many credits while some have accumulated very few.

It is probable that most of the accumulated agricultural flex credits will not be used since they can only be used pursuant to an IGFR. Accumulated credits may be used on some IGFRs as conservation requirements become more stringent and in cases where farms irrigate full acreage or multiple crops. Also, under certain conditions, farmers may transfer flex credits accumulated during the preceding calendar year from one IGFR to another. This provision provides flexibility in the types of crops and amount of acreage that farmers may choose to irrigate and to avoid being in a flex debit or noncompliance situation. Currently there are no IGFRs with a debit flex account balance in the Tucson AMA.

Cotton is the predominant crop grown in the Tucson AMA and is usually rotated with winter wheat or barley. Pecan trees grown by Farmers Investment Company (FICO) are the major crop grown in the Green Valley and Sahuarita area south of Tucson. Other crops grown in the Tucson AMA include grain sorghum, alfalfa, pasture grasses, and vegetables. Pasture grass predominates the crops grown in the southern portion of the Tucson AMA. Cropping patterns have not changed significantly in the Tucson AMA since the verification of crops grown during the historic period of 1975 to 1980. Some fluctuations in cropped acreage since this historic period have been observed primarily due to market demands and federal programs.

Most on-farm irrigation systems within the Tucson AMA are flood irrigated and consist of sloped fields served by siphon tube application from a concrete ditch to the field. Some field applications are made through turnouts and gate structures. Many fields have been converted to modified slope, which involves leveling the lower portion of the field to contain runoff. Some farms have installed level basin irrigation systems that are typically more water efficient systems if properly managed. Other irrigation systems

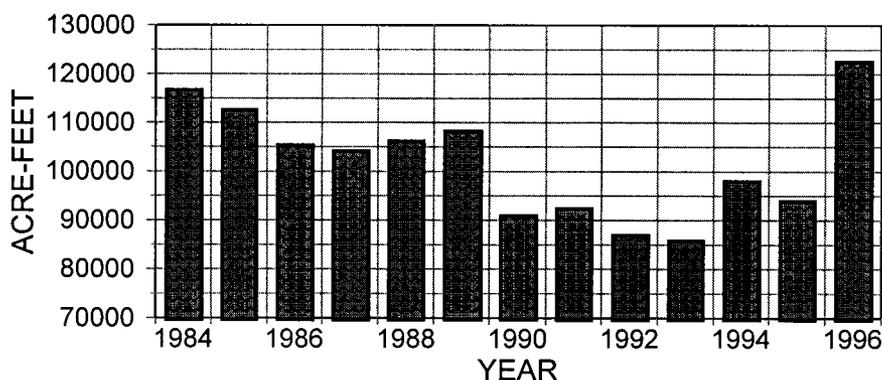
found in the Tucson AMA, but utilized to a much lesser extent, include sprinkler and trickle (drip) application methods.

3.2.1 Agricultural Water Demand

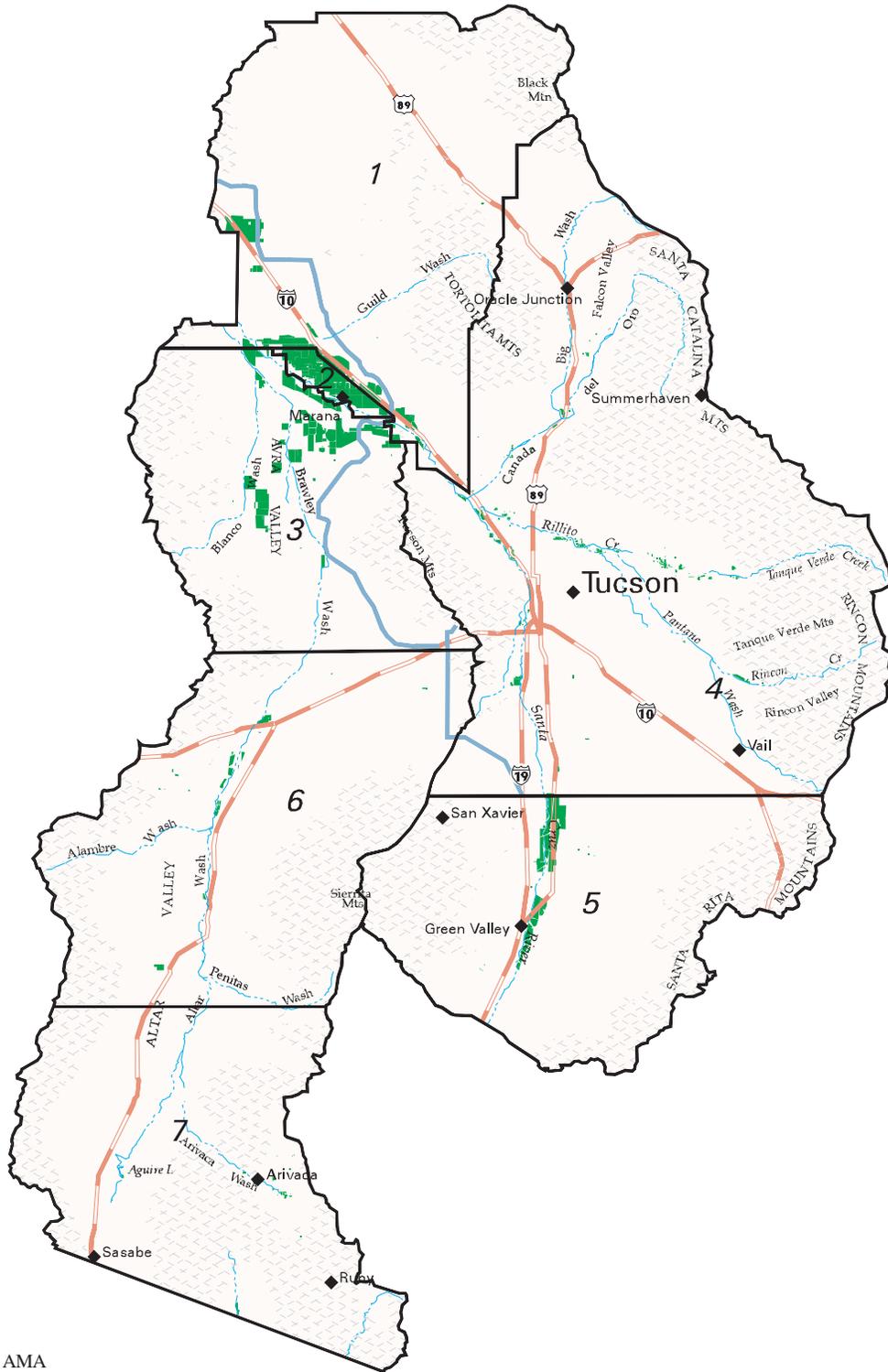
There is currently a total of 205 IGFRs over ten acres in size (or less than ten acres in size but part of an integrated farming operation) in the Tucson AMA. The irrigation acres associated with these rights total about 35,000 acres with a maximum annual groundwater allotment of 153,258 acre-feet. Agricultural water use currently accounts for about one-third of the total annual water use in the Tucson AMA. Generally, water demand for irrigated agriculture decreased from 1985 through 1995 although it fluctuated during this period. Water demand is influenced by many factors that vary annually, including weather. A total of 93,816 acre-feet of water use was reported by regulated IGFRs in 1995. In 1996, agricultural water use increased by more than 20 percent; however, it is difficult to predict if this trend will continue. Recent agricultural water use increases are thought to be a result of the Federal Agriculture Improvement and Reform Act of 1996 and improved market conditions. Figure 3-1 graphically shows agricultural water use from the years 1984 to 1996.

During the second management period, seven Areas of Similar Farming Conditions (ASFCs) were established in the Tucson AMA for the purpose of evaluating irrigation water use characteristics and conservation potential. These areas were designated based on specific criteria related to farming conditions located throughout the AMA. Figure 3-2 displays the boundaries of these seven ASFCs and the location of irrigation acreage. Table 3-3 displays 1995 water use by ASFCs.

**FIGURE 3-1
HISTORIC AGRICULTURAL WATER USE
1984-1996
TUCSON ACTIVE MANAGEMENT AREA**



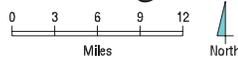
There are three irrigation districts in the Tucson AMA: Cortaro Marana Irrigation District (CMID), Avra Valley Irrigation District (AVID), and Flowing Wells Irrigation District (FWID). FWID is primarily a municipal water provider and can serve only 76 irrigation acres. There are also two IGFRs in the Pinal County portion of the Tucson AMA that receive water from the Central Arizona Irrigation and Drainage District (CAIDD). The CAIDD delivers water primarily to farms in the Pinal AMA. Farms within the CMID, AVID, and FICO make up the majority of the agricultural land in the Tucson AMA. A description of these areas follows.



- Tucson AMA
- Irrigated Acreage
- Hardrock
- Areas Of Similar Farming Conditions
- Streets and Highways
- CAP Canal
- Rivers and Streams
- Cities

Figure 3- 2

Irrigation Acreage Within Areas Of Similar Farming Conditions



ORIGINAL SOURCE
Arizona Department of Water Resources
Geographic Information System

**TABLE 3-3
REGULATED IRRIGATED GRANDFATHERED RIGHT CHARACTERISTICS BY
AREAS OF SIMILAR FARMING CONDITIONS FOR 1995
TUCSON ACTIVE MANAGEMENT AREA**

ASFC	IGFRS	Irrigation Acres	Annual Allotment (AF)	Water Use (AF)	Percent Use	Flex Account Credits (AF)
1	12	3,843	18,209	2,382	3	140,438
2	63	10,543	41,789	28,483	30	138,950
3	41	11,360	45,693	29,693	31	227,053
4	54	1,914	7,450	1,230	1	58,448
5	9	5,909	34,763	30,681	33	64,126
6	13	1,103	4,305	1,279	1	34,443
7	13	282	1,049	68	<1	9,223
Total	205	34,954	153,258	93,816	100	672,681

ASFC = Areas of Similar Farming Conditions

IGFRs = Irrigation Grandfathered Rights

AF = Acre-feet

3.2.1.1 Cortaro-Marana Irrigation District

CMID (ASFC 2) is the only agricultural irrigation district in the Tucson AMA with a consolidated irrigation delivery system. It provides water to 63 regulated IGFRs and 10 exempt IGFRs less than 10 acres in size, totaling about 11,000 acres of farmland the majority of which is in the Avra Valley subbasin. Cotton makes up about 70 percent of the total cropped acres, grains (wheat, barley, and sorghum) make up about 25 percent, and the remaining 5 percent is made up of alfalfa hay, vegetables, and nuts. Irrigation water use in CMID has annually averaged approximately 35,000 acre-feet from the years 1987 through 1995. Only four IGFRs within CMID have consistently reported zero annual water use.

CMID's delivery system consists of about 54 miles of concrete lined canals and eight miles of pipeline. There are currently 27 irrigation wells in the Cortaro area (southern end of CMID's distribution system of pipelines and canals) that pump from water levels that average 115 feet below land surface. An additional 18 irrigation wells in the Marana area (northern end of CMID's distribution system) pump groundwater from a depth that currently averages 263 feet.

CMID declined to sign a contract for CAP water. However, as a groundwater savings facility, CMID does receive CAP water, which it uses in-lieu of pumping a portion of its groundwater. In addition, an average of about 3,000 acre-feet of effluent is purchased annually from Pima County and delivered to CMID via a ditch from the Ina Road Water Pollution Control Facility (wastewater treatment plant). The effluent is blended with groundwater prior to delivery for irrigation.

3.2.1.2 Avra-Valley Irrigation District

AVID (ASFC 3) is located in the northern part of the Avra Valley subbasin, predominantly west of the Santa Cruz River. AVID contains about 11,000 acres of farmland that is associated with 41 regulated IGFRs and 15 exempt IGFRs less than 10 acres in size. Cropping patterns in AVID consist of about 80 percent cotton, 12 percent grains (wheat, barley, and sorghum), 3 percent alfalfa, 1 percent millet, 1 percent lettuce, and the remaining 3 percent is made up of miscellaneous crops. Irrigation water use in AVID has annually averaged approximately 27,000 acre-feet from the years 1987 through 1995. Only two IGFRs within AVID have consistently reported zero annual water use. Farmers within AVID operate their irrigation systems independently using groundwater wells and on-farm irrigation distribution systems.

AVID was initially formed to obtain CAP water, however, the district declined to sign a CAP water contract. A groundwater savings facility that utilizes CAP water includes several of the farming operations in AVID.

3.2.1.3 Farmers Investment Company

The IGFRs associated with FICO (within ASFC 5) are divided into two separate operating areas with pecans being the predominant crop grown in both areas. The southern part of FICO includes about 1,800 acres and is referred to as the Continental Farm. The northern section is known as the Sahuarita Farm and has approximately 4,000 acres. Annual water use at FICO has averaged approximately 28,000 acre-feet from the years 1987 through 1995. All of the water used at FICO for irrigation comes from privately owned wells and is predominantly applied using flood irrigation techniques. Most of the farm fields are basin leveled and are irrigated using efficient water management techniques. FICO has also begun researching the potential use of drip irrigation systems on established orchards. FICO currently uses groundwater for irrigation, but use of CAP water and/or effluent is being explored.

3.2.1.4 Red Rock Area

ASFC 1 has 12 regulated IGFRs covering nearly 4,000 acres. Only 1 IGFR in this area is an exempt IGFR less than 10 acres in size. Four of the 12 IGFRs have consistently reported zero annual water use. One large IGFR, consisting of 2,022 irrigation acres was not irrigated from 1990 through 1996, which contributed to the relatively large accumulation of flex account credits in this area. Since this time, the farm has been converted from pecan trees to row crops. In 1997, this IGFR entered into a groundwater savings project arrangement with the Department and was irrigated with CAP water.

3.2.1.5 Other Agricultural Areas

Other agricultural areas within the Tucson AMA include the Tucson area (ASFC 4), the Altar Valley (ASFC 6), and farmland in the Arivaca area (ASFC 7). Cropping patterns and annual water use from 1987 through 1995 have remained relatively constant in each of these areas. In 1995, the total water use in these areas made up less than 3 percent of the total agricultural water use in the Tucson AMA.

ASFC 4 has 54 regulated IGFRs and 145 exempt IGFRs less than 10 acres in size. Twenty two of the 54 regulated IGFRs have consistently reported zero annual water use. Many of the IGFRs that irrigate in this area grow bermuda grass or alfalfa hay for pasture.

ASFC 6 has 13 regulated IGFRs and two exempt IGFRs less than 10 acres in size. Five of the 13 regulated IGFRs have consistently reported zero annual water use. Pasture grass is the predominant crop in this area.

ASFC 7 has 13 regulated IGFRs and six exempt IGFRs less than 10 acres in size. Six of the 13 regulated IGFRs have consistently reported zero annual water use. Irrigated pasture consisting of bermuda grass and alfalfa is the primary crop grown in this area.

3.2.2 Agricultural Water Supplies

Most agricultural water demand in the Tucson AMA is supplied by groundwater. Effluent is used to a lesser extent. No agricultural entities in the Tucson AMA have contracted for CAP allocations. However, CAP water is used on some farms through groundwater savings facilities as described previously.

Table 3-4 displays the amount of reported annual agricultural water use by source and the percent of agricultural use to the total water use in the Tucson AMA for the years 1987 to 1996. Groundwater values include all of the water used on IGFRs including in-lieu use on groundwater savings facilities and CMID's water use, which is reported as surface water. The effluent column is primarily the effluent delivered to CMID.

**TABLE 3-4
AGRICULTURAL WATER DEMAND BY WATER SOURCE
1987 THROUGH 1995
TUCSON ACTIVE MANAGEMENT AREA**

Year	Groundwater (Acre-feet)¹	Effluent (Acre-feet)	Total Water Use (Acre-feet)	Percent of Total AMA Use
1987	100,700	3,375	104,075	38
1988	102,645	3,527	106,172	38
1989	103,846	4,277	108,123	36
1990	86,863	3,986	90,849	34
1991	89,663	2,698	92,361	33
1992	84,803	2,077	86,880	32
1993	83,750	2,015	85,765	31
1994 ²	95,152	2,793	97,945	32
1995 ²	92,015	1,801	93,816	30
1996 ²	119,862	2,676	122,538	35

¹ CAP water delivered to Groundwater Savings Facilities is shown as groundwater. Also, the water reported by CMID as surface water is considered to be groundwater by the Department pending adjudication of surface water rights; it is included as groundwater in this table.

² 1994, 1995 and 1996 data do not include the water usage of exempt small rights; rights <10 acres in size were deregulated in 1994.

NOTE: Canal losses are not included in demand numbers.

CMID reported 12,910 acre-feet of "surface water" use in 1995. This water is withdrawn from wells and is considered by the Department to be groundwater pending adjudication of surface water rights. A total of 10,100 acre-feet of CAP water was used by groundwater savings facilities in 1995. For purposes of water budget accounting, in-lieu water delivered to groundwater savings facilities is considered groundwater. In addition, about 1,801 acre-feet of effluent use was reported by CMID in 1995.

3.2.3 Indian Agriculture

Indian agricultural water use is expected to increase within the Tohono O'odham Nation during the third management period. However, the Nation is not subject to the regulations of the 1980 Groundwater Management Act. CAP allocations to the San Xavier and Schuk Toak Districts are listed in Table 8-1 of Chapter 8. The San Xavier District has the potential to rebuild their irrigated farmland and develop additional agricultural land with water and funds available through the Southern Arizona Water Rights Settlement Act. Department projections show that about 5,000 acre-feet of agricultural water from CAP sources may be used on the San Xavier District by the year 2005. The Schuk Toak District is currently developing a farm that is expected to utilize 10,800 acre-feet of CAP water per year by the year 2010.

3.3 MUNICIPAL WATER USE CHARACTERISTICS

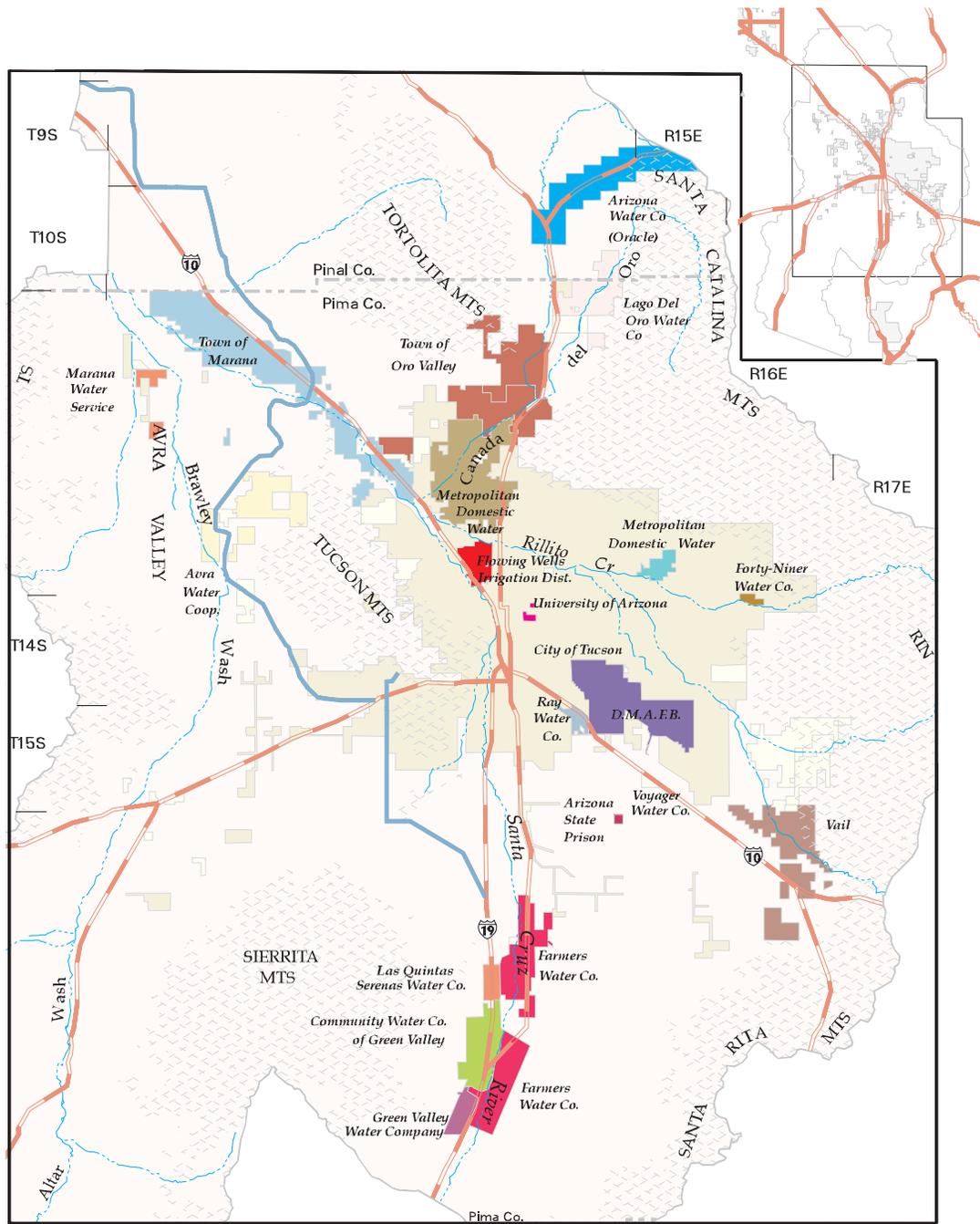
This section describes the categories of municipal water users and the usage patterns of specific water users. It also describes the available water supplies in the Tucson AMA and reports trends in the usage of those supplies.

The Groundwater Code (Code) defines municipal use as "all non-irrigation uses of water supplied by a city, town, private water company or irrigation district..." A.R.S. § 45-561.11. Municipal water providers serve water pursuant to service area rights, and may be operated by incorporated cities and towns or by private water companies. A private water company may be a member-owned or corporately-owned entity that distributes or sells water and is regulated by the Arizona Corporation Commission. There are also quasimunicipal providers that are governed by an elected board of directors. These include domestic water improvement districts, irrigation districts and water user's associations. The Department also regulates the following entities as water providers if they pump water from one or more non-exempt wells (wells that pump over 35 gallons per minute): large institutional facilities such as schools, prisons and military installations; mobile home parks; homeowner's associations; and well cooperatives. By definition, large municipal providers serve over 250 acre-feet of water (about 81 million gallons) per year and small municipal providers annually serve 250 acre-feet of water or less. There are 151 water providers in the Tucson AMA regulated under the municipal conservation program. The 19 large provider service areas and some small provider service areas are located on Figure 3-3.

Municipal water use is analyzed volumetrically and in terms of the average gallons per capita per day (GPCD) rate of the water users. This form of analysis allows a comparison of the relative water use per customer of each water provider to its GPCD conservation requirement and is used to assess conservation potential. The GPCD conservation requirement for water providers is an allocation tool that has the effect of quantifying the service area right based on population served.

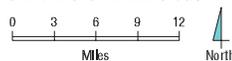
3.3.1 Municipal Water Demand

Municipal water demand has increased with population growth. Municipal providers are required to meet water conservation requirements, as described in Chapter 5. Water use by the municipal sector is expected to continue to increase during the third management period, although an increase in renewable supply utilization is also anticipated due to provisions of the Assured Water Supply Rules (AWS Rules) (also described in Chapter 5). These rules require use of renewable water supplies in the demonstration of an assured water supply. This is expected to result in a significant decline in groundwater use by this sector.



- Tucson AMA
- Hardrock
- Rivers and Streams
- Streets and Highways
- Counties
- CAP Canal

Figure 3-3
**Water Provider
Service Areas**



ORIGINAL SOURCE
Arizona Department of Water Resources
Geographic Information System

Table 3-5 shows historic municipal demand in the Tucson AMA from all sources (groundwater, effluent and CAP water), by year from 1985 through 1996, and the percent of total AMA demand served by these sources each year. In general, the proportion of municipal water use compared to other sectors has increased since 1985. However, because agricultural use increased in 1996, the municipal proportion of water use in the AMA decreased that year. Small providers historically represent 2 to 3 percent of municipal demand.

**TABLE 3-5
TOTAL MUNICIPAL WATER DEMAND ¹
1985 THROUGH 1996
TUCSON ACTIVE MANAGEMENT AREA**

Year	Large Providers (Acre-feet)	Small Providers (Acre-feet)	Municipal Use (Acre-feet)	Total Population²	Percent of Total AMA Use
1985	113,007	2,728	115,735	569,863	40 %
1986	120,977	2,702	123,679	595,982	46 %
1987	126,745	2,847	129,592	623,232	47 %
1988	129,161	2,963	132,124	631,282	47%
1989	138,196	2,992	141,188	642,433	47%
1990	126,744	2,700	129,444	650,043	48%
1991	129,310	2,591	131,901	657,611	47%
1992	133,996	2,574	136,570	688,781	50%
1993	136,823	2,581	139,404	709,120	50%
1994	142,513	5,946 ³	148,459	742,074	48%
1995	149,454	5,440	154,894	764,026	50%
1996	157,352	5,362	162,714	768,854	47%

¹ Total Municipal Demand includes all sources of water, including effluent; does not include exempt well demand.

² Total Population includes only the population served by large and small providers. This is not the total population of the AMA.

³ In 1994, a change to the definition of large providers resulted in 20 large providers being reclassified as small providers. As a result, water use by small providers increased significantly in 1994 over previous years.

In 1995, the 19 large providers in the Tucson AMA supplied 149,454 acre-feet of groundwater and effluent, or 96 percent of total municipal demand. Tucson Water supplied 117,083 acre-feet of groundwater and effluent or about 76 percent of total municipal demand. Small municipal providers used 5,440 acre-feet or 4 percent of the municipal demand. Altogether, municipal water users used 154,894 acre-feet in 1995, or approximately 50 percent of the AMA's total water use. Five percent, or 7,711 acre-feet, of the total use was supplied with effluent, primarily to turf-related facilities.

Table 3-6 summarizes large municipal provider population, water use, and the total, residential, non-residential, and lost and unaccounted for water GPCD rates for 1985, 1990 and 1995 (lost and unaccounted for water is water that was withdrawn, diverted and/or received by the provider but that was not delivered to a customer). In 1985, the average total GPCD for large providers was estimated at 176 GPCD. By 1990 the rate had dropped to 169 GPCD and in 1995 it increased slightly to 172 GPCD.

Residential rates have remained fairly constant while non-residential water use rates have declined due to increased effluent use by turf-related facilities.

TABLE 3-6
LARGE MUNICIPAL PROVIDER GALLONS PER CAPITA PER DAY RATES
1985, 1990, AND 1995
TUCSON ACTIVE MANAGEMENT AREA

Year	Population	Total GPCD	Residential GPCD	Non-Residential GPCD	Lost GPCD
1985	556,850	176	113	45	18
1990	635,076	169	113	43	13
1995	736,326	172	113	41	18

GPCD = Gallons per capita per day

Figure 3-4 compares the total GPCD rates of Tucson Water to the average total GPCD rate of the other large water providers from 1985 to 1996. The GPCD rate calculation includes all water used except direct use effluent and effluent recovered within the area of impact, as defined in Chapter 5 section 5-101 (7). The total GPCD rate is lower overall for Tucson Water and declined from 171 to 164 GPCD between 1985 and 1995 while the average of the other providers' use was about 205 GPCD in both 1985 and 1995. Between 1985 and 1995, Tucson Water's residential rate averaged about 110 GPCD, about 11 GPCD lower than the average residential rate for the other large providers in 1995. Non-residential use declined by 6 GPCD for Tucson Water but increased by 11 GPCD for other large providers during the same period. Contributing to the increase is golf course construction and lack of reclaimed water use outside the Tucson Water service area. Tucson Water is the only provider that has a reclaimed water distribution system. In 1996, water use increased in both the Tucson Water service area and the service areas of other large providers. Higher GPCD rates have coincided with years of hot and dry weather and late or below average summer rainfall.

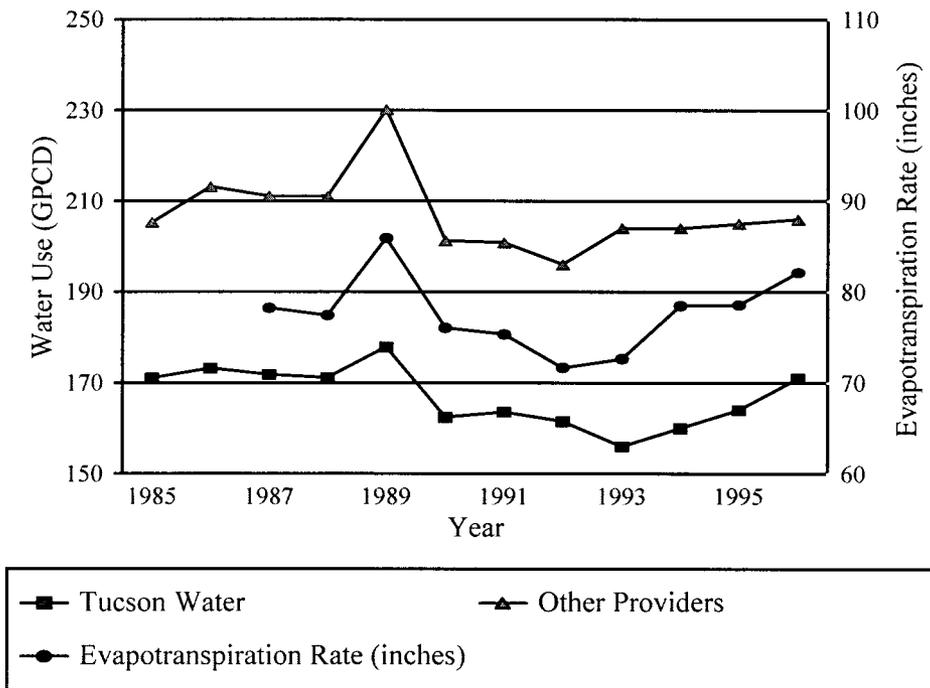
Total GPCD rates for individual large water providers range from about 80 GPCD to over 800 GPCD. Changes in GPCD rates are attributable to several variables, including disproportionate non-residential growth, conservation programs, economic factors, weather, inaccurate data and other variables. Residential GPCD rates range from around 65 GPCD to about 300 GPCD, but only two large providers have residential GPCD rates over 170. Residential GPCD use is strongly correlated to the age of the housing units, the type of landscaping, the number of persons per household, water rates in the service area, and the income level.

Figure 3-4 also compares the evapotranspiration rate (ET_o) to the GPCD rate. ET_o is an indication of the amount of water lost by a well-watered reference crop through transpiration by plants and through evaporation from the soil surface. The ET_o value is based on temperature, relative humidity, wind speed, precipitation, soil temperature and incident solar radiation. Comparison of ET_o with GPCD demonstrates the close correlation between water use and weather. From 1987 through 1997, the average ET_o measured at the University of Arizona Campbell Avenue Farm was 77.57 inches and ranged from 71.67 inches in 1992 to 85.93 inches in 1989. GPCD rates peaked in 1989 as a result of a record hot, dry year. For the Third Management Plan, municipal water use was analyzed for conservation potential using a four-year average (1992 through 1995) rather than a single year to account for weather variations. The four-year average includes two cool, wet weather years and two hot, dry weather years, thus reducing under or over estimation of conservation potential.

3.3.1.1 Large Providers

Figure 3-5 depicts 1995 water use and GPCD rates for municipal providers separated into the following categories: (1) municipalities and districts, (2) private water companies, and (3) institutional providers. Municipalities and districts use the largest volume of water and have relatively low per capita rates. Tucson Water's high volume of water use is so much larger than any other provider that its water use characteristics dominate the "municipalities and districts" category. Private water companies and providers that serve institutional facilities generally have higher per capita rates because they have relatively small populations compared to the amount of their non-residential use. Also shown in Figure 3-5 are small municipal water providers. Small municipal water providers include a wide variety of water users (discussed in section 3.2.1.3). They represent about 5,000 acre-feet of annual municipal use and have an average per capita rate comparable to that for municipalities and districts.

**FIGURE 3-4
LARGE PROVIDER GPCD AND EVAPOTRANSPIRATION
1985-1996
TUCSON ACTIVE MANAGEMENT AREA**

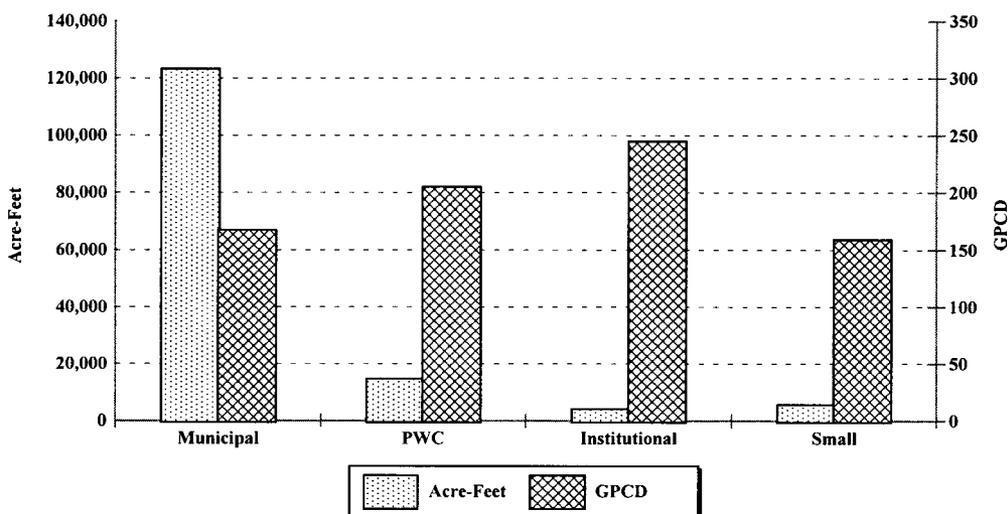


In addition to Tucson Water, which served 109,927 acre-feet of groundwater in 1995 to almost 600,000 people, the two largest water suppliers to municipal users in the AMA are the Metropolitan Domestic Water Improvement District (MDWID) and the Town of Oro Valley. In 1995, MDWID served 8,557 acre-feet of groundwater to a population of almost 41,000, and the Town of Oro Valley served 5,707 acre-feet of groundwater to about 23,500 water users. Table 8-A1 in Chapter 8 shows the Assured Water Supply status of all of the designated providers in the Tucson AMA.

3.3.1.1.1 Municipalities and Districts

Three municipalities serve water in the Tucson AMA: the City of Tucson, the Town of Oro Valley, and the Town of Marana. In 1995, these municipalities served approximately 84 percent of the AMA population and provided 82 percent of the water served by water providers. There are two districts that function as quasimunicipal providers: MDWID and FWID. These two providers served about 8 percent of the population and 8 percent of the water used in 1995. Table 3-7 shows percentages of water use and population for municipalities and districts in 1995. The single family residential water use category includes detached dwelling units. The multifamily residential water use category includes apartments, duplexes, triplexes, townhouses, condominiums and mobile home parks. Typically, a multifamily housing unit uses less water than a single family housing unit because exterior water demand is less per unit.

**FIGURE 3-5
1995 MUNICIPAL WATER USE
TUCSON ACTIVE MANAGEMENT AREA**



Note: The "Municipal" category includes special districts that function as municipal providers.

Tucson Water

While Tucson Water serves a large portion of the Tucson metropolitan area both inside and outside of the city limits, it is operated by the City of Tucson and water rates and policy are set by the Tucson Mayor and City Council. Approximately 40 percent of the population served by Tucson Water is located outside the city limits. Approximately 55 percent of the housing units in the service area are single family, which represents 75 percent of the residential demand and more than half of the total demand in the service area. Non-residential water service comprises about a quarter of Tucson Water's deliveries and includes schools, hospitals, shopping centers, manufacturing, offices, stores, restaurants and turf-related facilities such as golf courses and parks. Only about one percent of Tucson Water's potable water deliveries were to turf-related facilities in 1995. Most turf customers receive effluent through Tucson Water's reclaimed water system.

The Town of Oro Valley Water Utility

The Town of Oro Valley Water Utility was created in 1996 when the town purchased Rancho Vistoso and Cañada Hills water companies. Oro Valley Water Utility serves about 3 percent of the AMA large provider population and supplies 4 percent of total municipal water use. About half of the deliveries in

Oro Valley are to residential customers, primarily single family residences. About 19 percent of the households served by Oro Valley Water Utility in 1996 were within age-restricted communities. Oro Valley has a high percentage of non-residential use (48 percent), including groundwater deliveries to five golf courses, which constituted 38 percent of total deliveries in the service area in 1996.

The Town of Marana

From 1992 through 1997, the Town of Marana acquired several water systems within the town boundaries, including Honea Water Company, Cortaro Water Users Association and portions of Marana-Picture Rocks Water Service and IM Water Company. The population and water use numbers displayed in Table 3-7 include portions of the service area not actually acquired until 1996 or 1997; these are included for purposes of presenting data that reflects more current patterns of use. Ninety-three percent of Marana Municipal deliveries are to residential customers, primarily single family homes. Seven percent of the water service is to mixed commercial and government office customers. Many residences are mobile or manufactured homes on individual lots. The greater frequency of gardens, evaporative cooling, pasture and livestock in rural residential areas like Marana tends to cause GPCD rates to be higher than those for urban areas. In 1995, Marana Municipal served less than 1 percent of the AMA large provider population.

**TABLE 3-7
1995 MUNICIPALITY AND DISTRICT WATER USE
TUCSON ACTIVE MANAGEMENT AREA**

	Providers				
	City of Tucson	Town of Oro Valley	Town of Marana	MDWID	FWID
Population	597,017	22,479	3,277	40,870	14,951
Total Use ¹ (Acre-feet)	109,927	5,707	518	8,557	2,842
Residential Use (Acre-feet)	74,396	2,857	451	6,770	2,135
Residential Use as a % of Total Use	75%	52%	93%	84%	82%
% Single Family Residential	70%	97%	89%	89%	45%
% Multifamily Residential	30%	3%	4%	11%	55%
Non-residential Use (Acre-feet)	24,580	2,599	32	1,258	480
Non-residential Use as a % of Total Use	25%	48%	7%	16%	18%

¹ Includes residential, non-residential, and lost and unaccounted for water use.

Metropolitan Domestic Water Improvement District

Metropolitan Domestic Water Improvement District (MDWID) serves much of the northwest portion of the Tucson metropolitan area. The MDWID service area consists partly of unincorporated areas and partly of areas within the town limits of Oro Valley. MDWID served about 6 percent of the AMA large provider population and 6 percent of the water used in 1995. Deliveries are primarily to single family residential

customers. Multifamily residential deliveries, primarily apartments, comprise about 13 percent of MDWID's residential service. Non-residential customers include schools, medical facilities, shopping areas, offices, restaurants and a park.

Flowing Wells Irrigation District

Flowing Wells Irrigation District serves a former agricultural area south of the Rillito River and east of Interstate 10. The District is nearly built out and very little additional development is projected within the service area. FWID serves areas within the City of Tucson as well as unincorporated areas in Pima County. FWID provides water for about 2 percent of the AMA large provider population and water uses. Most deliveries are to residential customers. About 62 percent of residential housing units are mobile or manufactured homes in mobile home parks, 23 percent are site-built single family residences and 15 percent are multifamily units. Non-residential customers include schools, shopping areas, offices, restaurants and light manufacturing and account for approximately 18 percent of the service area demand.

3.3.1.1.2 Private Water Companies

There are 11 private water companies in the Tucson AMA that are large providers. They serve a range of development from relatively small, slow-growing areas to rapidly growing areas northwest of Tucson and in the Green Valley/Sahuarita area south of Tucson. Development in these areas typically consists of either urban or rural single family residences or golf-centered retirement communities. In 1995, private water companies served about 6 percent of the AMA's large provider population and 7 percent of the water use. During the second management period growth within the service areas of small private water companies has caused several to become large providers, while other existing large private water companies have been acquired by municipalities or reorganized as domestic water improvement districts.

Residential deliveries comprise the majority of the water served by private water companies in the Tucson AMA. Farmers Water Company is a notable exception, with about 60 percent of its water deliveries going to non-residential uses, primarily pecan processing. Also, about 60 percent of deliveries made by private water companies that serve golf-centered residential communities, such as Forty-Niner Water Company and Green Valley Water Company, serve turf-related facilities. Per capita use varies widely among the private water companies, not only because of the huge impact of golf course water service, but also because of the impact of larger lots and higher income levels.

3.3.1.1.3 Institutional Providers

There are three large providers in the Tucson AMA with institutional characteristics as defined in the Institutional Provider Program (IPP) in the Second Management Plan. To qualify for the IPP, providers must serve over 90 percent of their water to non-residential uses. Only one large provider, the Arizona State Prison Complex - Tucson, is currently in the IPP. In addition to personal water use by inmates, the prison uses water for institutional food service, laundry, and landscape watering. The other two providers with institutional water use patterns are the University of Arizona and Davis-Monthan Air Force Base (DMAFB). Arizona State Prison Complex -Tucson, University of Arizona, and Davis-Monthan Air Force Base served about 3 percent of the water use and large provider population in the AMA in 1995.

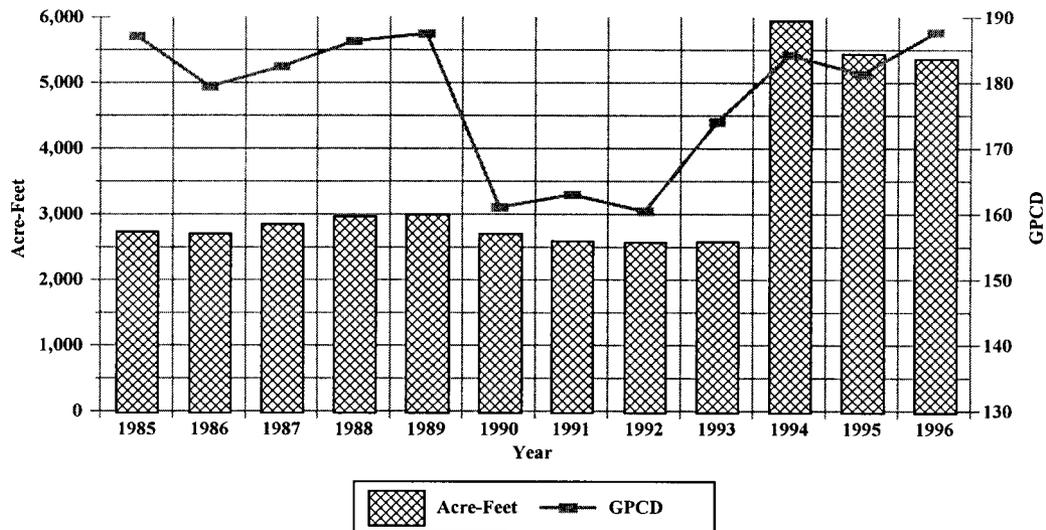
About 20 percent of University of Arizona water deliveries are to campus student housing, 2 percent to student union facilities and 25 percent for heating and cooling. The remaining 53 percent includes landscape watering and uses in classroom and laboratory buildings. Effluent use for landscape watering, installation of more efficient plumbing fixtures, and reduction of turfed area has contributed to reductions in volumetric water use and GPCD rates since 1987.

DMAFB is a federal facility that has made many water conserving changes over the past ten years in exterior irrigation practices and through the metering of buildings. Deliveries include about 42 percent to base housing and 14 percent to the base golf course. These deliveries are metered. The remainder of deliveries are unmetered and are used for commercial and recreational facilities, dormitories, non-residential landscape watering, and aircraft maintenance.

3.3.1.2 Small Providers

There are currently 127 active small municipal providers in the Tucson AMA. Figure 3-6 shows the average GPCD rate and volume of groundwater used by small municipal providers between 1985 and 1996. The average GPCD rate has fluctuated from 187 GPCD in 1985 to 161 GPCD in 1990, and 188 in 1996. A large decline in GPCD rates from the late 1980s to the early 1990s was likely the result of higher than average rainfall and lower than average evapotranspiration rates in the early 1990s compared to low rainfall and high evapotranspiration rates in the late 1980s. In 1994, a legislative change to the large provider definition resulted in 20 of the large providers being reclassified as small providers, resulting in an increase in the volume accounted for as small provider water use (see Table 3-5). The average per capita rate of the reclassified providers was 186, which resulted in increasing the total small provider average GPCD rate. In addition, between 1994 and 1996, low amounts of summer rainfall and higher than average evapotranspiration rates impacted per capita use.

**FIGURE 3-6
SMALL PROVIDER WATER USE
1985-1996
TUCSON ACTIVE MANAGEMENT AREA**



The 127 small providers are divided into five general categories as follows: 40 well cooperatives, 33 mobile home parks, 32 private water companies regulated by the Arizona Corporation Commission (ACC), five institutional-type providers (small providers are not eligible for the Institutional Provider Program), and 17 miscellaneous providers. Miscellaneous small providers include apartment complexes, motels and group housing that operate non-exempt wells. Small providers serve a wide range of residential developments in urban, suburban and rural areas. While the majority of small provider water deliveries are made to residential customers, per capita usage is highly variable due to differences in water rates, household income and lifestyle. In 1996, small providers delivered less than 3 percent of the municipal water used in the Tucson AMA.

3.3.2 Municipal Water Supplies

Groundwater is the predominant water supply served to municipal users. Effluent is served to turf-related facilities, landscaped medians, schools, and parks for irrigation. CAP water is not currently served directly to municipal users but in 1996, 2,800 acre-feet of CAP water were stored in underground storage facilities and almost 17,000 acre-feet were stored at groundwater savings facilities for later recovery by municipal providers. Tucson Water is currently prohibited from directly serving CAP water to its potable customers by a citizen's initiative passed in 1995 called the Water Consumers Protection Act (WCPA). Further discussion of the CAP delivery problems experienced by Tucson Water and the WCPA can be found in Chapter 8, section 8.2.2.1.2. Table 3-2 shows water use by source for 1985, 1990, and 1995. A small volume of CAP water was used in 1995 to maintain Tucson Water's Hayden-Udall CAP Water Treatment Plant.

3.3.2.1 Groundwater

In 1985, municipal groundwater use was 112,655 acre-feet or 97 percent of municipal supply. By 1995, it had increased to 147,080 acre-feet, or 95 percent of the total municipal water supply. Effluent use makes up the balance of water supply, increasing from 3 percent in 1985 to 5 percent in 1995. By the year 2010, municipal demand could be as much as 200,000 acre-feet even if municipal water providers meet the Third Management Plan conservation requirements. However, if use of renewable supplies increases from current levels, groundwater use could decrease substantially.

Providers designated as having an assured water supply are limited in the amount of mined groundwater they can use. As of May 1998, six providers had received Designations of Assured Water Supply. As provided for in the AWS Rules, these providers will need to replenish any mined groundwater used to serve both current and projected new demands in excess of their "groundwater allotment" (see Chapter 5, section 5.3). New subdivisions within the service area of nondesignated providers must independently obtain a Certificate of Assured Water Supply. While these new subdivisions are subject to a groundwater replenishment obligation, the current demand of undesignated providers (about 21,000 acre-feet) is not subject to groundwater replenishment and they can continue to use groundwater to meet this demand. This on-going groundwater mining is contrary to the Department's efforts to encourage the use of renewable supplies.

3.3.2.2 Effluent

Effluent has been used on a limited basis for golf course watering since the late 1970s. In 1984, the City of Tucson began operation of a reclaimed water distribution system to deliver effluent throughout its service area. In 1985, 3,080 acre-feet of reclaimed water and secondary effluent were used by the municipal sector. In 1990, the municipal sector used 6,279 acre-feet of reclaimed water and secondary effluent. A total of 7,711 acre-feet of reclaimed water and secondary effluent was accounted for as municipal use. Effluent use is projected to reach 18,800 acre-feet by 2010, or 9 percent of municipal water demand. Turf-related facilities served by municipal providers have an incentive to convert to effluent due to the City of Tucson's delivery policies and the favorable cost of effluent delivered through the City's reclaimed system as compared to the cost of potable groundwater delivered by the City.

While effluent use has increased since 1980, actual use is falling short of the assumptions in the Second Management Plan water budget of utilization of 40 percent of the region's effluent by the year 2000. Due to cost constraints, ownership issues, and location of treatment plants and delivery systems in relation to potential users, direct use of effluent has been slower to develop than was anticipated. In 1995, about 85 percent of the treated wastewater generated at the two regional wastewater treatment plants was discharged into the Santa Cruz River. However, improvements in treatment technologies, changing attitudes, and

increasing permitting and monitoring costs associated with discharging effluent into public waterways have facilitated efforts to utilize effluent as a water supply.

3.3.2.3 Central Arizona Project Water

Ten water providers in the Tucson AMA hold subcontracts for 163,033 acre-feet of CAP water (as shown in Chapter 8, Table 8-1). Six water providers held water storage permits for CAP water as of May, 1998. These permits allow the providers to store water at underground storage facilities or groundwater savings facilities and to earn long-term storage credits that may be accumulated for future use and recovered in a different location than where the water was stored. Recovered water retains the legal character of the originally stored water regardless of the hydrologic connection between the points of storage and recovery. Storage and recovery of CAP water helps to mitigate some of the water quality and access problems that have frustrated efforts to utilize CAP water as a directly delivered potable supply in the Tucson AMA. Tucson Water directly delivered more than 46,000 acre-feet of CAP water to potable customers in 1993 and more than 22,000 acre-feet in 1994. However, since that time CAP water has not been delivered for direct potable use due to water quality problems that are discussed in detail in Chapter 8.

3.4 INDUSTRIAL WATER USE CHARACTERISTICS

This section discusses the types of industrial water users and the water use patterns that are particular to each industrial subsector. It also includes an explanation of the water supplies available to industrial users and the constraints on utilizing renewable supplies. Industrial water users pump groundwater from their own wells pursuant to a Type 1 or Type 2 non-irrigation grandfathered right or a groundwater withdrawal permit. These rights and permits have annual volumetric allotments. Industrial users are subject to annual conservation requirements described in Chapter 6. All industrial users have general conservation requirements. In addition, the following industrial user groups in the Tucson AMA have specific conservation requirements:

- Turf-Related Facilities (≥ 10 acres)
- Sand and Gravel Facilities (>100 acre-feet/year)
- Metal Mining Facilities (>500 acre-feet/year)
- Large-Scale Power Plants (>25 megawatts)
- Large-Scale Cooling Facilities (>1000 tons)
- Dairy Operations (monthly average ≥ 100 lactating cows/year)
- New Large Landscape Users ($>10,000$ square feet)
- New Large Industrial Users (>100 acre-feet/year)

3.4.1 Industrial Water Demand

Water demand fluctuates for the industrial sector depending on market conditions, weather patterns, population, and industry-specific variables. While industrial water use is limited by the total volume of grandfathered rights and permits, some new permits can be issued to support industrial uses. Demand by most industrial use sectors has been relatively constant since 1987 with the exception of metal mine use which has fluctuated due to changes in the worldwide demand for copper.

With urban growth comes construction of golf courses, schools, parks, shopping centers, and other industrial facilities. It is anticipated that most future general industrial development will be served by municipal providers, although existing industrial right holders are also expected to increase their use in the future. Urban expansion into previously rural areas may also impact the operations of some industrial users. For example, encroaching urbanization may result in complaints about dust and noise generated by sand and gravel facilities and may affect the location of future sites.

3.4.1.1 Historic and Current Demand

Beginning in 1987, the reporting requirements of the First Management Plan went into effect, and the data reported by industries to the Department improved. As a proportion of overall AMA demand, industrial use has fluctuated between 15 to 20 percent since 1987 as shown in Table 3-8. The Tucson AMA has the largest industrial sector as a percentage of total AMA water use when compared to the other AMAs. Because of this, water conservation efforts and efforts to promote use of renewable supplies by industrial users is a focus of Tucson AMA water management activities.

Table 3-9 contains detailed water use information for 1995, including the number of industrial facilities by category, associated water rights and permits, and the volume used in 1995. Industrial users currently use considerably less water than they are entitled to use pursuant to their grandfathered water right and permit allotments. The actual allotment associated with the industrial sector is 192,462 acre-feet per year not including emergency dewatering and hydrologic testing permits. The difference between the allotment volume and actual use is partially explained by the process used to establish grandfathered water rights. Type 2 non-irrigation grandfathered right allotments for industrial users were based on the highest pumpage year from 1975 to 1980. Industrial water use is associated with production levels that in some cases were high during this period; production levels and annual water use can fluctuate widely in response to varying economic conditions. In addition, some industrial users have ceased operations entirely, although they have retained their water rights.

**TABLE 3-8
WATER USE BY INDUSTRIAL USERS 1987-1995
TUCSON ACTIVE MANAGEMENT AREA**

User Category	Total Industrial Water Use Per Year (acre-feet)								
	1987	1988	1989	1990	1991	1992	1993	1994	1995
Metal Mining	22,309	23,899	31,606	32,443	39,605	36,536	38,721	43,523	41,359
Turf-Related ¹	6,315	6,857	7,287	7,059	7,118	6,782	6,858	7,204	7,961
Sand & Gravel	4,386	3,383	3,408	3,296	2,323	2,869	3,847	4,458	5,176
Electric Power	1,679	2,728	2,766	1,942	1,325	1,772	1,835	2,521	1,609
Dairies	70	72	51	53	62	46	48	70	73
Other Indus. >100 AFA	3,021	2,719	2,443	2,154	2,318	2,457	2,618	2,852	2,754
Other Indus. <100 AFA	3,093	2,995	2,703	1,796	2,574	1,575	1,407	1,531	1,272
Total Indus.	40,872	42,654	50,263	48,743	55,325	52,036	55,334	63,159	60,204
% of Total AMA Demand	15%	15%	17%	18%	20%	19%	20%	20%	19%

¹ Industrial Turf-related facilities pump groundwater from their own wells pursuant to a Type 1 or Type 2 non-irrigation grandfathered right or a groundwater withdrawal permit. Water served to turf-related facilities by municipal providers is included in the municipal providers' water use in section 3.2.

TABLE 3-9
INDUSTRIAL GROUNDWATER RIGHTS AND WITHDRAWAL SUMMARY
1995
TUCSON ACTIVE MANAGEMENT AREA

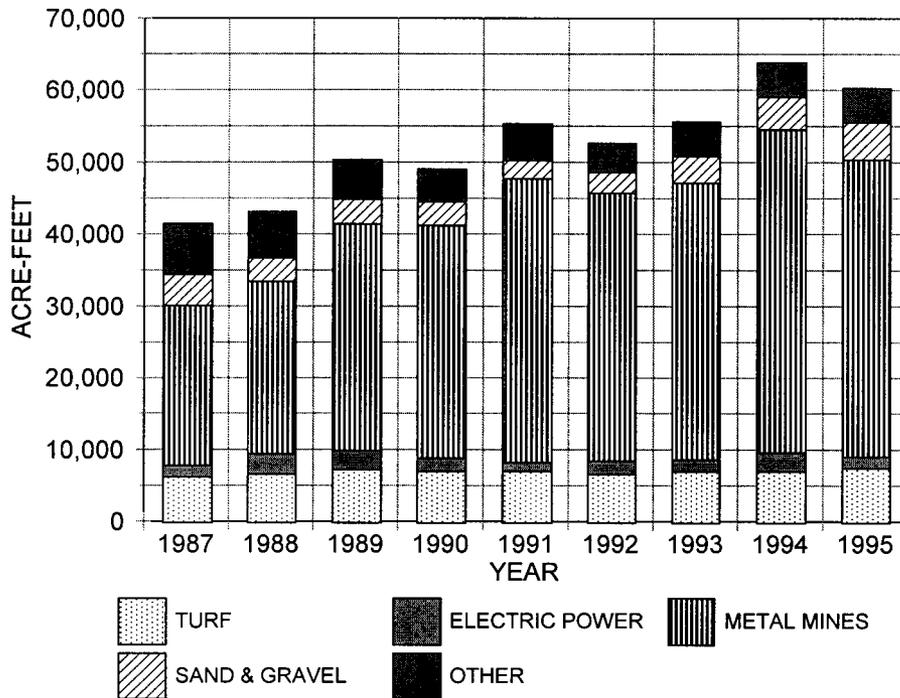
User Category	1995 Groundwater Use (AF)	1995 Total Water Use (AF)	Right or Permit Allotments¹ (AF)	Type of Right or Permit	Number of Facilities
Metal Mines	41,359 ²	41,359 ²	63,098	Type 1 non-irrigation rights Type 2 mineral extraction rights Mineral extraction permits	4
Turf-Related	7,179	7,961	11,034	Type 1 non-irrigation rights Type 2 non-irrigation rights Industrial use permits	28
Sand and Gravel	5,176	5,176	17,194	Type 1 non-irrigation rights Type 2 non-irrigation rights Type 2 mineral extraction rights General industrial use permits Mineral extraction permits	15
Other Industrial	4,026	4,026	90,855	Type 1 non-irrigation rights Type 2 non-irrigation rights Industrial use permits ¹	340 ^{1,3}
Electric Power	1,609	1,609	10,071	Type 2 electrical generation rights	2
Dairies	73	73	210	Type 2 non-irrigation rights	1
TOTAL	59,422	60,204	192,462		390

¹ Does not include emergency dewatering, temporary dewatering or hydrologic testing permits.

² Includes 2,982 acre-feet withdrawn from San Xavier District by ASARCO not pursuant to groundwater rights and permits.

³ Number of groundwater rights and permits

**FIGURE 3-7
TRENDS IN INDUSTRIAL WATER USE
1987 THROUGH 1995
TUCSON ACTIVE MANAGEMENT AREA**



3.4.1.2 Water Demand by Industrial Subsector

3.4.1.2.1 Metal Mines

Metal mining is by far the largest water using industrial category in the Tucson AMA, using 41,359 acre-feet in 1995 (Table 3-9). Four metal mines are currently operating in the Tucson AMA: Cyprus Sierrita, Cyprus Twin Buttes, ASARCO Mission Complex and ASARCO Silver Bell. In 1995, the activities of the Cyprus Sierrita and Twin Buttes mines consumed 27,389 acre-feet. ASARCO Mission Complex withdrew 10,771 acre-feet pursuant to their groundwater allocation in 1995, plus an additional 2,982 acre-feet of groundwater pumped from the San Xavier District by agreement with the District, for a total of 13,753 acre-feet of groundwater use. Groundwater withdrawn from the District is not subject to state reporting and management requirements for groundwater. ASARCO Silver Bell Mine used only 217 acre-feet of groundwater in 1995, but has constructed a new solvent extraction/electrowinning plant at the site that will lead to increased copper production and water use. Metal mining is anticipated to maintain current water use rates through 2025. Metal mines are projected to use approximately 47,000 acre-feet in 2010.

3.4.1.2.2 Turf-Related Facilities

Turf-related facilities constitute the next largest industrial user category in the Tucson AMA and include 12 golf courses, four parks, four cemeteries, and eight schools served by their own industrial groundwater rights rather than by a water provider. Other turf facilities are served by municipal providers and are included in the discussions of municipal water use in section 3.2. In 1995, 7,961 acre-feet of water was served to industrial turf-related facilities for watering turf grass and other landscaping, and for filling lakes and ponds. Ninety percent, or 7,179 acre-feet, of the total water used was groundwater. The 782 acre-feet

of effluent used by two golf courses and one cemetery was the only effluent used by industrial users in 1995. Most of these turf-related facilities predate the Code and are served by Type 2 non-irrigation grandfathered rights. These facilities are located in the Tucson metropolitan area, Marana and Green Valley. At the time of development, the facilities tended to be on the outskirts of the urbanized area or in newly developed rural areas. Industrial user golf courses developed after 1980 are situated on lands with Type 1 non-irrigation grandfathered rights. One school is served by a general industrial use permit. Most future industrial user turf-related facilities are anticipated to be developed on lands with Type 1 rights. A small number of Type 2 rights may become available to serve new facilities as older industrial facilities in urbanized areas are converted to effluent use.

3.4.1.2.3 Sand and Gravel Facilities

Sand and gravel facilities used 5,176 acre-feet of groundwater in 1995. In the Tucson AMA, 15 sand and gravel facilities are clustered along the banks of the Santa Cruz River or along sand and gravel deposits in the Tucson, Green Valley and Marana areas. These sand and gravel facilities are served by Type 1 non-irrigation grandfathered rights, Type 2 non-irrigation grandfathered rights, and Type 2 mineral extraction rights or general industrial use permits that allow them to withdraw up to approximately 17,000 acre-feet of groundwater annually. Sand and gravel use is expected to expand to meet increased materials needs from the construction industry.

3.4.1.2.4 Other Subsectors

In 1995, the electric power industry used 1,609 acre-feet and the one remaining dairy in the AMA used 73 acre-feet. Groundwater demand by electric power is not projected to parallel population growth because the electric power needed to meet increasing demand is likely to be imported, rather than generated within the AMA. The one dairy currently operating in the AMA is expanding the size of the dairy herd and water use is expected to increase. It is not anticipated that any additional dairies will be constructed in the AMA. Miscellaneous industrial users that do not fit into the definitions of the specific regulatory categories constitute the "other" industrial user category. Some of the largest users included in this category are cement manufacturing plants, hospitals, bottling plants, electronics plants, aerospace facilities, shopping centers, and resorts. This group used 4,026 acre-feet of groundwater in 1995. There are currently no feedlot operations in the AMA. The number and water use of new large landscape users, new large industrial users, and large-scale cooling facilities have not yet been identified in the AMA. Cooling tower use, however, is expected to increase with time as the number of offices, shopping centers, schools, hospitals, and other large facilities increase along with population growth.

3.4.2 Industrial Water Supplies

The industrial sector in the Tucson AMA is almost entirely groundwater dependent and uses less renewable water supplies than either the agricultural or municipal sectors. Effluent is used only by turf-related facilities and constitutes about one percent of overall industrial water use. Water supply sources and volumes from 1987 to 1995 are shown in Table 3-10.

Because industrial users have the legal authority to withdraw groundwater up to the annual allotment of their rights and permits, subject to conservation requirements, they have no economic incentive to use more costly renewable water supplies. In addition, physical access to renewable supplies is often limited because potential users are far from conveyance facilities. No industrial user in the AMA holds a CAP subcontract. Use of effluent supplies must be negotiated with the entities who control this supply: the City of Tucson, Pima County, and the United States Secretary of the Interior. Some industrial users also have water quality requirements depending on the industrial process involved and may need to treat water or remove salts or other constituents from renewable supplies prior to their use, which can add to the expense of alternative water supplies. Some industrial users could use non-groundwater supplies if cost,

availability, and water quality conditions were met. Potential users include metal mines, sand and gravel operations, large-scale electric power plants, and large-scale cooling facilities as discussed in Chapter 6. Opportunities for use of renewable supplies by the industrial sector will be explored in the third management period.

TABLE 3-10
WATER SUPPLY SOURCES SERVING INDUSTRIAL USES
1987 THROUGH 1995
TUCSON ACTIVE MANAGEMENT AREA

Year	Groundwater		Effluent		Total Water Use (AF)
	Volume (AF)	Percent of Total Water Use	Volume (AF)	Percent of Total Water Use	
1987	40,323	99%	549	1%	40,872
1988	41,987	98%	667	2%	42,654
1989	49,619	99%	644	1%	50,263
1990	47,974	98%	769	2%	48,743
1991	54,654	99%	671	1%	55,325
1992	51,475	99%	561	1%	52,036
1993	54,684	99%	650	1%	55,334
1994	62,371	99%	788	1%	63,159
1995	59,422	99%	782	1%	60,204

AF = Acre-feet

3.5 CURRENT WATER BUDGET

The water budget shown in Table 3-11 contains information on water use within each demand sector in 1990 and 1995, as well as hydrologic components described in Chapter 2. This water budget reflects actual conditions in 1990 and 1995, except where factors are averaged over time as is the case with net natural recharge. The budget contains more municipal groundwater use than is shown in previous sections of this chapter because it includes estimates of water use by owners of exempt wells and Indian water use. The water budget indicates more agricultural water use in 1995 than shown in previous sections because it includes an estimate of water use for exempt small irrigation rights.

Mined groundwater constituted over half of the total water supply in 1995, leaving the AMA far from reaching its safe-yield goal. Demand for groundwater consistently exceeds water supplied through natural and incidental recharge. While around 10,100 acre-feet of CAP water was recharged in 1995, this volume does not appear in the water budget because the associated CAP recharge credits were not recovered to meet sector demands in 1995. Approximately 100 acre-feet of CAP water was used for treatment plant maintenance in 1995, and this volume does appear in the budget. Demand in all sectors increased between 1990 and 1995 resulting in a corresponding increase in groundwater overdraft between these years. Water budget projections of demand and supply through 2025 are described in depth in Chapter 11.

**TABLE 3-11
WATER BUDGET
1990 AND 1995
TUCSON ACTIVE MANAGEMENT AREA**

	1990	1995
Municipal Sector		
Demand - TOTAL	130,100	155,500
Non-Indian ¹	130,000	155,400
Indian ²	100	100
Supply - TOTAL	130,100	155,500
CAP Water ³	0	100
Effluent	6,300	7,700
Groundwater	123,800	147,700
Agricultural Sector		
Demand - TOTAL	93,800	98,000
Non-Indian ¹	93,800	98,000
Indian ²	0	0
Supply - TOTAL	93,800	98,000
CAP Water ³	0	0
Effluent	4,000	1,800
Groundwater	89,800	96,200
Industrial Sector		
Demand - TOTAL	48,800	60,200
Supply - TOTAL	48,800	60,200
CAP Water ³	0	0
Effluent	800	800
Groundwater	48,000	59,400
Other Demand		
Demand - Evapotranspiration	3,700	3,700
Supply - Groundwater	3,700	3,700
TOTAL DEMAND	276,400	317,400
Total Groundwater Use	265,300	307,000
(Less) Net Natural Recharge ⁴	60,800	60,800
(Less) Incidental Recharge	70,300	82,300
Groundwater Overdraft	134,200	163,900

¹ Non-Indian demand indicates demand for uses off Tohono O'odham Indian Reservation lands and includes exempt wells and water served to the Pascua Yaqui tribal lands by Tucson Water

² Indian Demand comprises demand on the San Xavier and Schuk Toak Districts of the Tohono O'odham Reservation.

³ CAP water use is shown in the water budget only if CAP water recharge credits have been recovered or CAP water was used directly

⁴ Net Natural Recharge is composed of the following components: mountain front and stream channel recharge, and groundwater inflow less groundwater outflow.

3.6 CONCLUSIONS

Water use by the municipal and industrial sectors has increased since 1985 and recent agricultural water use is at levels comparable to the mid-1980s following reductions in use in the early 1990s. All sectors continue to use predominantly groundwater although effluent use and use of CAP water through in-lieu arrangements and direct recharge are increasing. These water supply and demand trends illustrate that considerable water conservation and renewable water use efforts are needed to achieve the Tucson AMA safe-yield goal by 2025.

The Third Management Plan programs in Section II of this plan discuss in detail the Department's conservation and augmentation strategies for the third management period. These programs are designed to result in progress toward meeting the AMA safe-yield goal.