Water Resource Availability for the Tucson Metropolitan Area

July 2006

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Executive Summary

Groundwater has long been a significant water source for many areas in Arizona. In 1980 Arizona adopted the Groundwater Management Act (Act) to address the serious groundwater overdraft that was occurring in Tucson and several other regions of the state by the municipal, industrial and agricultural sectors. The Groundwater Management Act, through the goal of "safe-yield," has forced the municipal sector within the Tucson Active Management Areas (AMA) to utilize alternative, renewable sources of water. This report focuses on the municipal sector of the Tucson AMA and explains how water management is accomplished and the manner in which municipal water providers – the suppliers of water to the Tucson region's residents and businesses – are likely to meet the future water demands of their service areas.

The institutions that are used to carry out water management in the Tucson AMA are complex. A key set of rules in the water management universe are the Assured Water Supply Rules (AWS Rules). These rules establish that new municipal growth must utilize renewable water supplies. The Rules provide flexibility; they do allow new growth to be served with groundwater, should sufficient groundwater be available for pumping, but most groundwater use must be replenished with other water supplies, such as Central Arizona Project (CAP) water or effluent. Not all water providers in the AMAs, however, have access to CAP water or effluent. To ensure that these water providers could continue to grow, yet meet the standards of the AWS rules, the Central Arizona Groundwater Replenishment District (CAGRD) was created. Current laws allow areas to continue to grow through contracts where the CAGRD agrees to replenish groundwater used by new subdivisions in excess of that allowed per the provisions of the AWS Rules. The projections provided by the CAGRD show rapid growth in the agency's replenishment obligations, even though they are based on projected membership only through 2015.

Each agency or city that plans for water demands must consider important questions such as: What are the region's dependable (or "firm") water supplies? Where might the region find other sources of water? How many people can those supplies support? Will sufficient supplies be available to support future population growth?

There have been efforts to quantify the population that can be served by the Tucson AMA's renewable water supplies. This is a challenging exercise in that it depends on many assumptions, as well as the complex interaction of rules, regulations and institutions. Arriving at a population figure that current supplies can support is complicated by a number of factors. For example, the rate at which effluent will be utilized has significant uncertainties. Membership in the CAGRD allows growth in some areas based on the expectation that it will find the water supplies needed for replenishment rather than a guarantee based on water supplies under contract for the full 100 years. The rate of water consumption is a key determinant, and there are many complexities associated with forecasting water use on a per capita basis.

The report provides a worksheet with several illustrative "Scenario Populations" for the year 2030. For each scenario, The Scenario Population is the number of people that can be served by the Total Annual Supply, based on the assumptions. The scenarios show that the water supplies identified are more than sufficient to accommodate growth as projected by the Pima Association of Governments. How robust this finding is clearly depends on the assumptions. Should the population projections be too low, water use rates per capita too low, or water supply assumptions too high, additional water supplies will have to be identified sooner. In addition, the scenario analysis does not quantify the public investments required to actually utilize the identified water sources.

The scenarios are for 2030 and only consider municipal water needs. They do not tell us how close we are to meeting the Groundwater Management Act's safe-yield goal. How close or far away we are from achieving a balance between groundwater withdrawals and natural and artificial recharge depends primarily on the water use of the agricultural and industrial sectors. The Act set a 2025 date for meeting the safe-yield goal. In 1980, 2025 was 45 years away; now it is less than 20 years away. The Act called for the development of Fourth and Fifth Management Plans. It will likely be through the development of these regulatory documents, as well as the next CAGRD Plan of Operation, that the Tucson region will begin to consider collectively what its future water picture is likely to look like.

Given the rapid growth of Tucson, the rest of Central Arizona and the State, the following is recommended to the Tucson Business Community:

- Monitor growth in the CAGRD and consider the implications of that growth on the future availability and cost of water for the Tucson region.
- Participate in the development of a common set of facts on which to base regional water supply decisions.
- Monitor and/or participate in development of future water legislation and regulations, including conservation ordinances and conservation plans, for local jurisdictions, water providers, the Tucson AMA and the state.

- Monitor the development of drought plans, which requires some understanding the implications of shortages on the Colorado River on the cost and availability of CAP water.
- Support continued efforts to meet the safe-yield water management goal established in statute.
- Encourage regional efforts to explore innovative approaches to water supply treatment, development, and acquisition and participate in evaluation of policy and infrastructure investment options that may enhance the region's ability to secure additional water supplies.

Many of the suggested actions are associated with participation in collaborative, broad-based efforts. Understanding of the nature of the region's water supply challenges requires looking toward the long-term. Water management is not just the concern of water managers. The coalition of business interests that participated in the development of this report should continue to work with the public sector and others in the private sector to ensure that the Tucson region continues to have sufficient water supplies.

Author's Note: Preparation of this report relied on documents publicly available at the time of preparation. Funding was provided by Metropolitan Pima Alliance, Southern Arizona Leadership Council, Tucson Association of REALTORS, Southern Arizona Homebuilders Association, Marana Chamber of Commerce, Tucson Metropolitan Chamber of Commerce, and Tucson Regional Water Council. Several individuals were given the opportunity to review this report before its finalization. However, the content of this report reflects the author's interpretations and viewpoints only.

Introduction

It is well known that much of Arizona, which receives little rainfall annually, has historically relied on groundwater to meet a significant portion of its water needs. The reliance on groundwater as the exclusive source of water for the heavily populated metropolitan area of Pima County has resulted in overdraft (groundwater use in excess of natural replenishment of underground aquifers) of regional aquifers. In 1980 Arizona adopted the Groundwater Management Act (Act) to address the serious groundwater overdraft – or mining – that was occurring in several regions of the state, including Tucson. The Arizona Department of Water Resources (ADWR) was established as the state agency responsible for implementing and enforcing the laws regulating groundwater use.[1] Since 1993, Colorado River water has been delivered to the Tucson region through the Central Arizona Project (CAP) canal. In addition, treated wastewater, or effluent, has been increasingly recognized as a source of water for meeting community needs. The question, where does our region's water come from, no longer has a simple answer. More importantly, the question, where will we find our future water supplies has an even less obvious answer.

People may recognize political boundaries, but natural resources, such as water, do not. The state's approach to groundwater management focuses on groundwater basins rather than political subdivisions of the state. Active Management Areas (AMAs), the areas of regulatory oversight, were delineated on the basis of hydrologic considerations, not political boundaries. The Tucson Active Management Area (Tucson AMA), shown in Figure 1, includes the majority of Pima County's population, a portion of Pinal County and a very small part of Santa Cruz County. When established in 1980, the Tucson AMA included a substantial portion of Santa Cruz County, but in 1994 the Santa Cruz AMA was separated from the Tucson AMA. Although there are common elements to the regulations governing groundwater use in the state's five AMAs, the intent of the Act was to allow regulations to be differentiated to recognize the different circumstances of the respective AMAs. Each AMA has a satellite ADWR office, with staff whose focus is on the AMA in which they reside. The Management Plans, which include specific conservation regulations, are developed at the AMA level, with significant stakeholder input, prior to being submitted to the ADWR Director for approval.[2]

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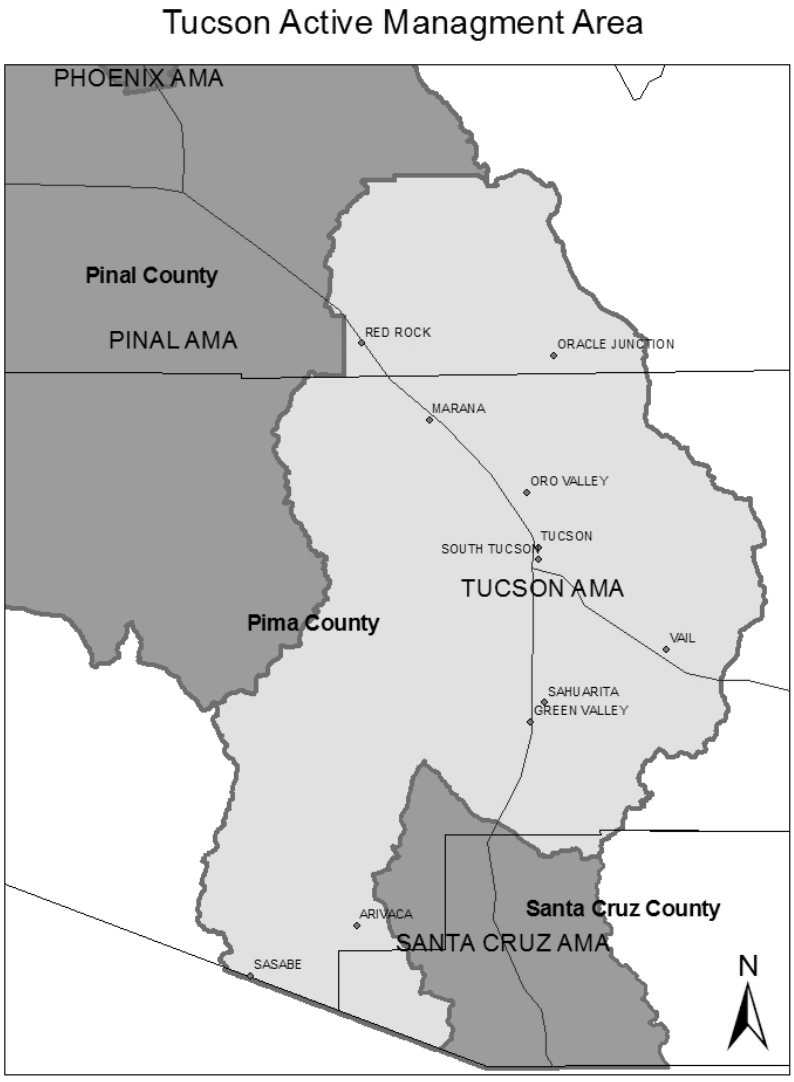
[1] See Arizona Revised Statutes (ARS), Title 45, for the full text of the Groundwater Management Act and related statutes. Arizona Revised Statues can be accessed on line through the Arizona Legislature's online service, www.azleg.state.az.us. General information about water management in Arizona can be found in the *Arizona's Water Future: Challenges and Opportunities*, Background Report for the 85th Arizona Town Hall, Fall 2004, available online at www.cals.arizona.edu/azwater/.

[2] The Third Management Plan for the Tucson AMA is in effect through 2010. Work will begin in the near future on the Fourth Management Plan, which will cover the period 2011 through 2020. The Management Plans, which include much background information on the AMA and the Groundwater Management Act, are available online through the web site of the Arizona Department of Water Resources, www.azwater.gov.

Figure 1: Tucson Active Management Area

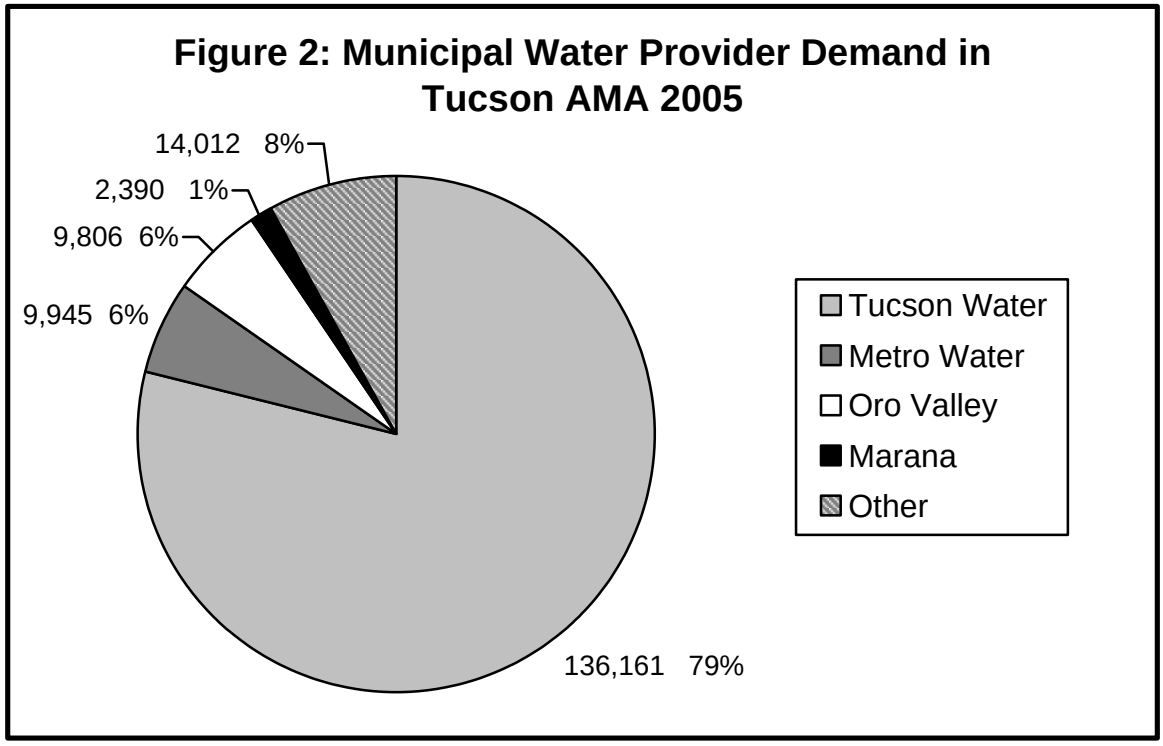


The water management goal for the Tucson AMA is safe-yield. As defined by Arizona Revised Statute (ARS § 45- 561) safe-yield "means a groundwater management goal which attempts to achieve and thereafter maintain a long-term balance between the annual amount of groundwater withdrawn in an active management area and the annual amount of natural and artificial recharge in the active management area." This critically important goal by 2025 drives water management activities of the region.

The main water users in the Tucson AMA are categorized as municipal, agricultural and industrial. The Groundwater Management Act regulates the groundwater use of these sectors differently. Numerous water companies, called "municipal water providers" by ADWR, provide water to citizens of the Tucson AMA. Tucson Water, operated by the City of Tucson, is by far the largest, see Figure 2.[3] Although called municipal water providers, these water companies may be owned and operated by cities and towns, water districts, cooperatives, or private individuals/companies. Examples of other municipal water providers in the Tucson AMA are the Marana Water Utility, operated by the Town of Marana, Metro Water, a domestic water improvement district, and Vail Water Company, a privately owned water company.[4] In addition, many individual land owners are not part of the municipal water system and supply their own water through individually owned and operated wells.

[3] CAGRD Plan of Operation, November 2004

[4] The complete list of large water providers in the Tucson AMA can be found in Chapter 5 of the Tucson AMA Third Management Plan.



Total water demanded in 2005 was 172,314 AF. (Figures for Marana, Metro Water and Other are projections for 2005) Figures for Tucson Water and Oro Valley are actual use.
Source: CAGRD Plan of Operation November 2004 and Communication with Tucson Water and Oro Valley.

The state's innovative approach to groundwater regulation is full of complexities. The focus of this report is the municipal sector. This report explains how water management is accomplished and the manner in which municipal water providers – the suppliers of water to the Tucson region's residents and businesses – are likely to meet the future water demands of their service areas. As will be explained in the next section, the Act placed a significant amount of the burden of achieving safe-yield on the municipal sector.

Growing Demands and Achieving the Water Management Goal – The Assured Water Supply Rules

The Groundwater Management Act mandated that new residential growth not depend on groundwater mining. An important set of rules, known as the Assured Water Supply Rules (AWS Rules), was adopted in 1995.[5] For the first time, it was established by rule that new municipal growth would have to depend substantially on water sources other than mined groundwater. That is, renewable supplies would be used to meet new residential water demands. This requirement was crucial for moving the region to less reliance on groundwater in favor of alternative supplies. The Rules provide flexibility; they

[5] The Assured and Adequate Water Supply Rules can be found in Title 12, Natural Resources, of the Arizona Administrative Code and can be accessed from the web site of the Arizona Secretary of State, www.azsos.gov.

do allow new growth to be served with groundwater, should sufficient groundwater be available for pumping, but – and this is an important "but" – most groundwater use must be replenished with other water supplies, such as Central Arizona Project (CAP) water or effluent.

The AWS Rules themselves are complex and are currently undergoing revision, although the fundamental provisions are expected to remain the same. There are two ways in which an assured water supply can be demonstrated. Either a developer of land applies for a Certificate of assured water supply, or a municipal water provider applies for a Designation of assured water supply. In either case, the applicant must show ADWR that a series of conditions are met. The key distinction between the two is that a Certificate is connected to a particular subdivision plat, while a Designation covers the entire service area of a water provider.

This distinction has significance when considering the extent to which a water provider must rely on renewable water supplies. A designated provider must show that renewable water supplies will be used to serve pre-1995 demand as well as new demand. Certification only requires new developments to engage in replenishment, leaving existing subdivisions to rely on groundwater mining to meet their demands. This effectively means that some residents bear a portion of the region's burden of achieving safe-yield while others do not.[6]

Figure 3 shows the water providers in the Tucson AMA that hold a Designation of Assured Water Supply.[7] While the group of seven includes the largest providers, it does not include all large water providers in the AMA. For example, Community Water Company of Green Valley and Flowing Wells Irrigation District are not designated water providers.

How do applicants for Assured Water Supply Certificates or Designations show they can meet the requirements of the Assured Water Supply Rules? ADWR considers five primary criteria:

1. The water supply is physically, legally, and continuously available for the next 100 years.
2. The water meets water quality standards or is of sufficient quality.
3. The proposed water use is consistent with the management goal of the AMA.
4. The proposed water use is consistent with the management plan of the AMA in force at the time of application.
5. The applicant has the financial capability to construct any necessary water storage, treatment, and delivery systems.

[6] Owners of what are called exempt wells, which are wells below a pump capacity of 35 GPM also do not face any requirement to use renewable supplies. They are called exempt because they are not subject to regulatory oversight by ADWR. In addition, subdividers of land into five parcels or less are exempt from the AWS Rules. These small subdivisions are often called wildcat subdivisions.

[7] Shown for the Town of Marana is the service area as defined by the Arizona Department of Water Resources, which includes only the areas where the utility is currently serving. Marana intends to serve customers in its Town limits.

In general, to meet requirement 3, applicants have to show that the development will draw a substantial proportion of its water from renewable supplies, even if criterion one is met; that is, even if groundwater is physically, legally and continuously available for 100 years.

A promise to use renewable supplies will not pass muster when an AWS application is undergoing review. ADWR staff must see evidence that the renewable water supply will in fact be available for use by the applicant. How can an applicant demonstrate it will use water supplies other than mined groundwater? There are several ways:

A. A renewable water supply for which the water provider has a contract, such as CAP water, may be treated and then delivered directly to customers. While this is a mechanism utilized in many Phoenix area cities, it is not currently being utilized in the Tucson AMA. ADWR staff examines the nature of the contracts for water to determine if the contract can reasonably be expected to be in effect for 100 years. It also looks to see if the facilities are available to treat the surface water. Direct utilization of effluent for turf irrigation and other uses is also a substitute for mined groundwater.

B. A renewable water supply, such as CAP water or effluent, may be recharged at an ADWR permitted location within the AMA and a credit accrued for that storage. The credit may be "redeemed" when the water is recovered through a permitted recovery well. This is often considered "indirect" use of the renewable supply. The use of the renewable supply is through storage and recovery rather than through a treatment plant. The location of the recovery of the stored water may be distant from the location of storage, or the recovery and storage locations may be in close proximity. The storage and recovery option for use of CAP water is being utilized by several water providers in the Tucson AMA. Storage and recovery activities must follow highly complex laws, regulations and rules, the details of which are beyond the scope of this report.[8] In reviewing an application for a certificate or designation of Assured Water Supply, ADWR staff examines the plans for storage and recovery carefully to determine if the facilities to be used are in fact permitted and available for use.

C. Through membership in the Central Arizona Groundwater Replenishment District (CAGRD), the CAGRD assumes the responsibility to replenish groundwater use that is in excess of allowable use per the groundwater allocations established by the AWS Rules. The CAGRD must replenish the groundwater within the AMA from which it was withdrawn within three years of use. The CAGRD must submit a Plan of Operation to ADWR every 10 years to demonstrate that it has

[8] For a summary of Arizona's Storage and Recovery programs, see "The Importance of Water Storage and Recovery in Arizona," by Sharon B. Megdal, *Arizona Review*, Vol. 3, Issue 1, Spring 2005, pp. 10-12, available online at www.cals.arizona.edu/azwater/.

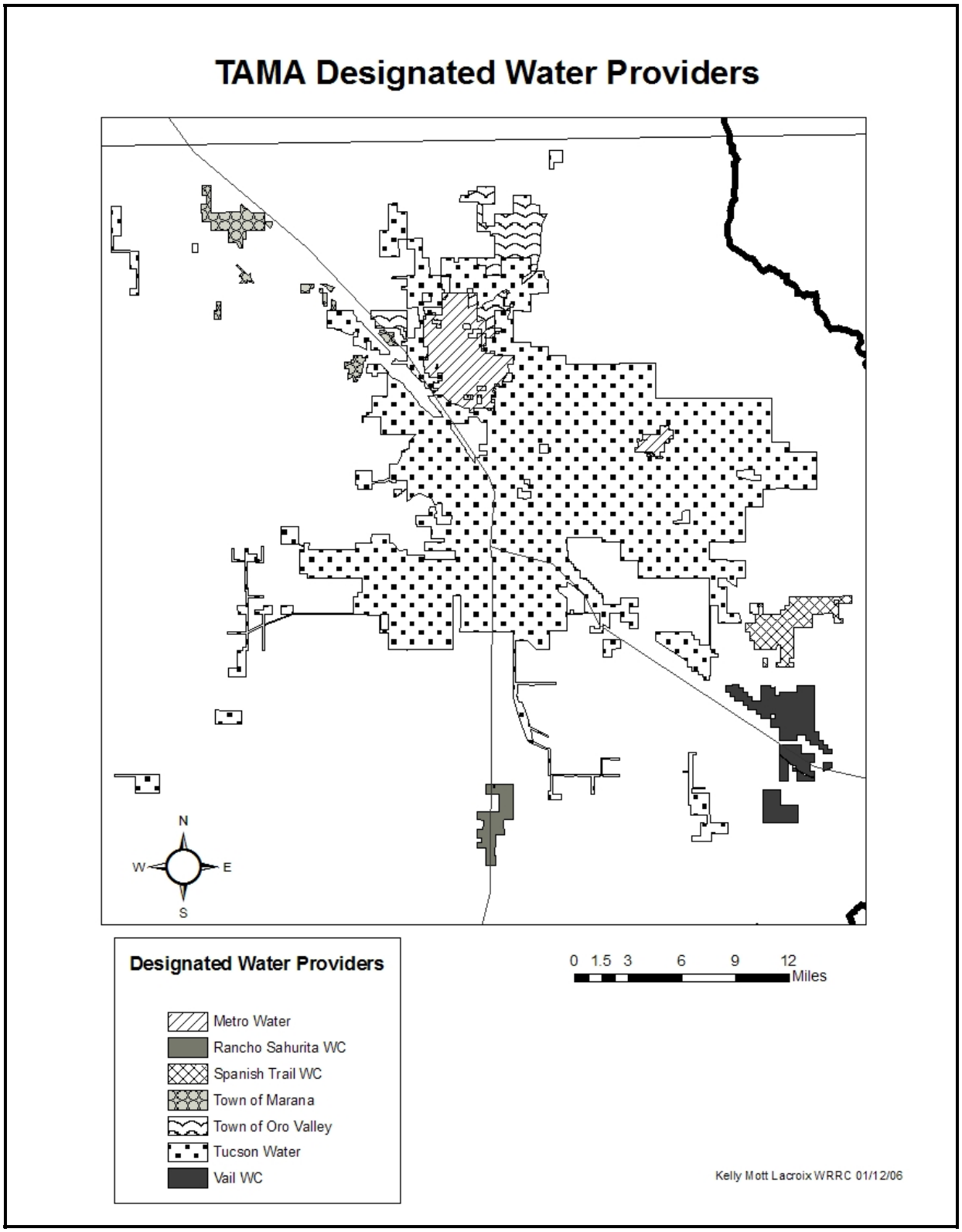
water supplies available over the next 20 years to meet replenishment obligations and that it can reasonably expect to have water available over the 80 years beyond that. The 2004 CAGRD Plan of Operation, the second prepared since formation of the CAGRD, was approved by the ADWR Director in the Fall of 2005. Unlike a water provider requesting a designation, the CAGRD does not have to demonstrate it has firm contracts to water for 100 years.

D. Extinguishment of grandfathered water rights can enable the water supplier to utilize an amount of groundwater, which will not be subject to replenishment. The formula is less generous as time passes, making this an increasingly limited option going forward.[9]

E. Special sources of groundwater, such as remediated groundwater, may be quantified.

[9] Grandfathered irrigation rights were provided to anyone who owns land that was legally irrigated with groundwater from Jan 1, 1975 to Jan 1, 1980 and was issued a Certificate of Irrigation Grandfathered Rights by ADWR. Extinguishment of grandfathered irrigation rights differs from conversion to non-irrigation rights. Type 1 non-irrigation rights are associated with land permanently retired from farming and converted to a non-irrigation use. Type 2 non-irrigation rights are associated with groundwater withdrawn for any non-irrigation purpose. (Arizona Town Hall Report) When these rights are sold to municipalities for the sake of AWS designation they are not transferred on an acre-foot to acre-foot basis. Under the AWS Rules, an assured water supply credit for extinguishing a grandfathered right can be purchased according to the following guidelines: the amount of credit is equal to 1.5 acre-feet per acre of irrigation acres for Type I and 1 acre-foot per acre for Type II associated with the extinguished right; this amount is multiplied by the difference between the calendar year in which the right was extinguished and 2025. This amount is then distributed over the 100 year period for an Assured Water Supply. For example: a city buys 100 acres of land in 2005, this provides them with 150 acre-feet per year (100 x 1.5) for 20 years (2025 – 2005) for a total of 3,000 acre feet. The 3,000 acre feet spread over 100 years therefore provides them with an additional groundwater credit of 30 acre feet per year. This amount of water can then be used without any associated requirement to replenish.

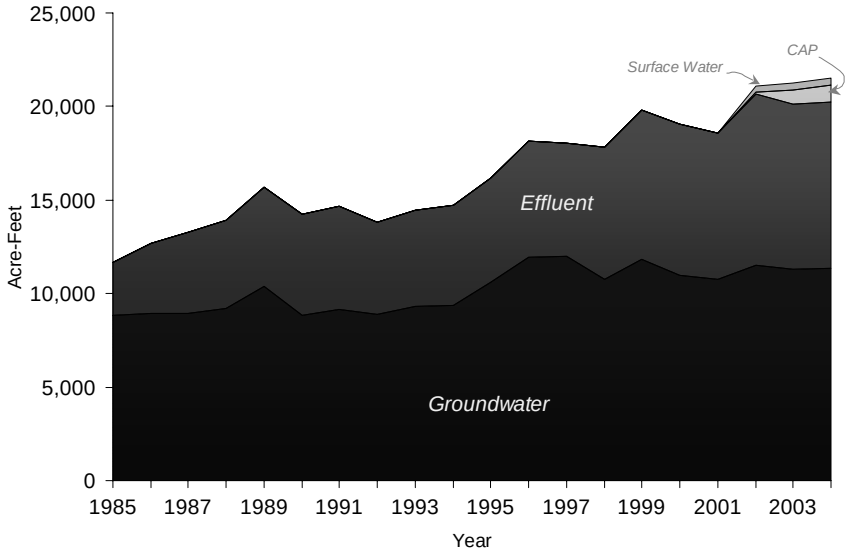
Figure 3: Designated Water Providers in the Tucson AMA



The AWS Rules do allow some utilization of groundwater through the establishment of a groundwater allocation account. Groundwater use can be charged against this account according to the water provider's own schedule. It can be used in the early years or saved for later years. The account cannot be overdrawn. In addition, each year four percent of the water supplied by the water provider to their service area is added to the groundwater allocation. This amount, called incidental recharge, represents an estimate of the amount of water that has recharged into the aquifer each from uses associated with the provider.

The AWS Rules place a significant responsibility on the municipal water sector. Of the three major water using sectors specified in the law, it alone faces a requirement to utilize renewable water supplies in place of groundwater. Other sectors may choose to use water supplies other than groundwater due to economic or other considerations. So long as other regulatory requirements are met, state law does not require the agricultural and industrial sectors to use renewable water supplies. The industrial sector includes sand and gravel operations and some turf facilities, which often rely on their own wells and water rights to meet their water needs. Golf courses may use only groundwater, however, the ADWR Management Plan contains provisions limiting the quantity of water used by golf courses. Additionally, many local governments have also enacted ordinances governing the type of water used by golf courses. The current types of water used by golf courses is indicated in Figure 4.

Figure 4: Golf Course Use by Water Type and Year in the Tucson AMA



Source: Arizona Department of Water Resources. 2004. 2004 Water Use Summary. Accessed at: http://www.azwater.gov/WaterManagement_2005/Content/AMAs/TucsonAMA

The Central Arizona Project

The Central Arizona Project (CAP) makes it feasible to substitute a renewable water supply for groundwater use. In fact, according to legend, it was the promise that this substitution would be incorporated into the Groundwater Management Act that enabled Governor Bruce Babbitt of Arizona to convince Secretary of the Interior Cecil Andrus that federal investment in the Central Arizona Project was warranted. Completed in 1992, the CAP was built to deliver over 1.5 million acre feet of Colorado River water annually to Central Arizona.[10] The 336 mile system cost the federal government approximately $4 billion to build. The Central Arizona Water Conservation District (CAWCD) was initially established to develop and execute CAP water delivery subcontracts and repay the federal government the reimbursable costs of building the CAP. Subsequently, CAWCD was given the authority and responsibility to operate the CAP canal. The CAWCD is a political subdivision of the state; its territory covers the three central Arizona counties, Maricopa, Pima and Pinal. Although the CAP system was not expected to reach all parts of the three named counties, its boundaries do in fact coincide with county boundaries. Today the CAP serves over 80 customers in three principal groups: municipal and industrial, agricultural and Indian users. The highest priority users of CAP water are Indian and municipal/industrial subcontractors. Therefore, should scheduled deliveries be cut or reduced for a period of time, the first deliveries cut would be to non-Indian agriculture. [11]

CAP primarily relies on revenues from property taxes, which are used to repay its portion of the federal investment, and user fees. It also has obtained revenues from the sale of power. The CAP is governed by a 15-person elected board, four of which are elected at large by Pima County residents every six years. Because the canal begins at close to sea level at the Colorado River near Lake Havasu City and reaches an elevation of approximately 2,800 feet near its terminus several miles south of Tucson, water transportation relies on a series of pumping stations.

Although it actually costs more to deliver water to Tucson because of the higher elevation than that of Maricopa and Pinal counties, the CAP has always employed “postage stamp” water rates. That is, the same amount per acre foot of water delivered through the CAP canal is charged to customers regardless of where they are located in the three-county CAWCD service area. This approach to rate setting, which is used by all Federal water projects, is very important to Tucson. Like other utilities, the CAWCD does charge different rates to different classes of subcontractors. For example, the rates paid by agricultural customers differ from those paid by holders of Municipal & Industrial (M&I) subcontracts,

[10] An acre foot is 325,851 gallons of water and represents the amount of water that covers one acre of land with one foot of water. How many households can be served by an acre foot of water obviously depends on the water use per household for indoor and outdoor use.

[11] Water Resources Research Center. 1999. *Water Resources in the Tucson Area: Seeking Sustainability.* p. 99.

which differ from rates charged to purchasers of excess water (water that would otherwise have gone unused in Arizona) on an annual basis. In the Tucson AMA there are thirteen municipal long-term subcontracts. In 2005 these subcontractors paid $79 per acre foot of water delivered. In 2006 they will pay $82 per acre foot of water, exclusive of capital charges, plus $28 per acre foot capital charge for their entire subcontract volume.

Tucson AMA CAP subcontract holder's current and pending allocations are listed in Table 1.[12]

Table 1: CAP Current and Pending Allocations in the Tucson AMA

Allocation Holder	Current Allocation[13]	Pending Allocation[14]	Total
City of Tucson	135,966	8,206	144,172
Avra Cooperative	0	808	808
Community Water Company (GV)	1,337	1,521	2,858
Flowing Wells Irrigation District	4,354	0	4,354
Green Valley Domestic Water Improvement District	1,900	0	1,900
Town of Marana	47	0	47
Metro Water	8,858	4,602	13,460
Town of Oro Valley	6,748	3,557	10,305
Spanish Trail Water Company	3,037	0	3,037
Arizona State Land Dept.	14,000	0	14,000
Vail Water Company	786	1,071	1,857
Total Non-Indian Water	**177,033**	**19,765**	**196,798**
San Xavier District	27,000	23,000	50,000
Schuk Toak District	10,800	5,200	16,000
Pasqua Yaqui Tribe	500	0	500
Total Indian Water	**38,300**	**28,200**	**66,500**
Total	**215,333**	**47,965**	**263,298**

Source: Tucson Water Plan: 2000 – 2050 and PL 108-451 sec 104 b.1

[12] The pending allocations to the Tohono O'odham Nation are part of the Arizona Water Settlements Act passed in December 2004. (PL 108-451 sec 104 b.1) They have not yet been finalized; however, it is likely that each entity will receive the amount of allocation listed in Table 1. The others are likely to be confirmed once the related pieces of the Arizona Settlements Act are finalized.

[13] These figures are current as of Oct. 3, 2005. Information taken from CAP website http://www.cap-az.com/about/index.cfm?action=allocations&subSection=7

[14] Information on pending allocations was taken from Tucson Water's Water Plan 2000 – 2050.

Table 1 shows that, in addition to municipal water providers and the Arizona State Land Department, two Indian Nations hold rights to use CAP water. The Tohono O'odham hold a total of 37,800 acre feet in Indian priority CAP water, with an additional 28,200 acre feet of lower priority water allocated to the Nation through the Arizona Water Settlements Act of 2004. This allocation is divided between the San Xavier and Schuk Toak Districts. In addition, the Pasqua Yaqui Tribe has rights to 500 acre feet of CAP water.

The problems associated with introducing CAP water into the Tucson Water delivery system in the early 1990s resulted in discontinuation of direct deliveries, shutdown of the plant built specifically for treating CAP water, and voter enactment of limitations on the ways in which Tucson Water can deliver CAP water. The fiasco led Tucson Water and others to favor a utilization approach that relies on Arizona's storage and recovery statutes. Several water providers have engaged in what is called annual storage and recovery, where water is stored and recovered in the same year. Tucson's Central Avra Valley Storage and Recovery Project serves primarily as an annual storage and recovery project. Tucson and many others store for the long-term as well. Table 2 shows the long-term storage account balances of various entities in the Tucson AMA. Credits in this table are calculated based on how much water was stored for each entity minus a five percent cut to the aquifer. Water is stored in a variety of locations. As of 2004 there were 15 permitted water storage facilities in the Tucson AMA. [15] These are the credits that have been accrued but not yet utilized by the storer. Through storage activity by individual water providers and through the replenishment program carried out by the Central Arizona Groundwater Replenishment District, which is discussed in the following section, the Tucson AMA municipal sector is at this time relying completely on storage and recovery as the means of utilizing CAP water.

[15] Arizona Department of Water Resources, 2004 ADWR Semi-annual Status Report: Underground water storage, savings and replenishment (recharge) program, p 26-27

Table 2: Long-Term Storage Account Balances by Storer Tucson AMA	
Last updated by ADWR: 11-22-05 (2003 Credit calculations are not yet complete and totals are subject to revision.)	
STORER	2003 (AF)
Tucson Water	86,434.1
Central AZ Water Conservation District	1,805.0
Central AZ Groundwater Replenishment District	4,543.7
Metro Water	15,252.0
Comm. Water Comp. of Green Valley	1,429.0
AZ Water Banking Authority	227,119.3
Oro Valley	14,124.0
Spanish Trail Water Company	29,678.0
Fidelity Trail #10773	*6838.0
US Bureau of Reclamation	2,178.0
Vail Water Company	2,554.8
Marana	5,403.6
AZ State Land Department	*2033.4
Robson Quail Cr	100.6
SLF-Agua, LLC	*1750.0
Del Lago Golf	115.0
Robson Ranch Mts, LLC	3,500.0
Green Valley DWID	705.4
TOTAL:	**394,942.5**
*Totals are from a date earlier than Dec. 31, 2003.	

Source: Communication with ADWR 11/22/05

The Central Arizona Groundwater Replenishment District

The CAGRD was authorized by the Arizona Legislature in 1993.[16] It covers the same geographic region as the CAP and is governed by the same board. It was created to facilitate indirect use of renewable water supplies for those without long-term contracts to CAP water and/or proximity to the CAP canal. For many, its formation meant that compliance with the AWS Rules' requirement that the water use be consistent with the respective AMA management goal was in fact feasible. Enrollment in the CAGRD has exceeded expectations. What is unique about the Tucson AMA is that all the region's designated water providers belong to the CAGRD. This is not the case in the Phoenix AMA. Water companies who join are called Member Service Areas (MSAs). Member Lands (MLs) are those members for which a Certificate of Assured Water Supply is the goal. There are some key differences in the

[16] See ARS 48- 3771

manner in which replenishment charges are assessed to MSAs versus MLs. MSAs are assessed a replenishment tax based on the acre foot volume to be replenished, and it is up to the MSA water providers to recoup the CAGRD's charges from their customers. The residents of Member Lands are individually assessed replenishment fees based on their yearly use through their property tax bills. The CAGRD certifies the assessment to the county board of supervisors. Table 3 provides information on Tucson membership in the CAGRD. [17]

Table 3: CAGRD Annual Projected Replenishment Obligations for the Tucson AMA (AF) [18] (For members enrolled through 2015)

Member Service Areas				
	2005	**2025**	**2030**	**2035**
Vail	27	925	1,396	1,868
Marana	645	8,766	8,766	8,766
Metro	161	0	0	0
Tucson	5,000	0	0	0
Oro Valley	2,105	0	0	1,935
Spanish Trail	0	0	0	835
Rancho Sahuarita	55	0	1,430	1,669
Member Lands				
Current and Future MLs (Enrollment through 2015)	2,000	11,000	11,500	11,600
TOTAL	10,000	20,800	23,100	26,700

Source: CAGRD Plan of Operation, November 2004

The CAGRD is required to replenish all groundwater use by its members that is in excess of that allowed per the provisions of the AWS Rules. The obligation of the CAGRD to perform replenishment is effectively uncapped and continues in perpetuity. Some CAGRD members, however, have special contracts that limit the obligation of the CAGRD. Tucson Water is one example. Its contract effectively caps the CAGRD's replenishment obligation at 12,500 acre feet per year. This cap was put in place

[17] See the CAGRD Plan of Operation, submitted November 2004, available www.cap-az.com, for detailed information on the CAGRD and its membership. See also, Ferris, Megdal and Eden, "An Introduction to the Central Arizona Groundwater Replenishment District," January 2006, www.cals.arizona.edu/azwater.

[18] This table comes directly from the CAGRD plan of operation. The CAGRD determined replenishment obligations based on what each water provider indicated as their projected replenishment needs. In the case of Tucson Water they did not indicate at the time that they would need to use the CAGRD. It is likely, however, that Tucson Water will have to use their allocation of 12,500 af of groundwater replenishment through the CAGRD in 2025 and 2035 in order to satisfy the conditions of their new Assured Water Supply designation, which has not been finalized as of April 2006.

because of Tucson's large size and its large subcontract for CAP water. The CAGRD was not expected to obtain the water supplies needed for very large water providers, especially one with the largest municipal CAP allocation in the state, to meet the renewable water utilization requirement of the Rules. Tucson Water joined the CAGRD after its difficulties with delivery of CAP water and passage of the voter initiative, when it appeared that it would have difficulty satisfying the requirements of the AWS Rules. Other Tucson AMA members have standard contracts with the CAGRD, which do not include a cap.

The formation of the CAGRD is considered a key innovation in Arizona groundwater management in that it provides a mechanism to utilize renewable water supplies for many who had no access. For others, it provides a back-up means of utilizing renewable water supplies should other approaches fail. In Tucson's case, their direct delivery approach failed, and a back-up mechanism was needed while Tucson developed its own recharge facilities. Current law does not allow the CAGRD to turn away members nor cancel contracts, provided that replenishment and other fees are paid. The law does allow MSAs to request to de-enroll.[19] This change was made upon a recommendation included in the 2001 Final Report of the Governor's Water Management Commission. Tucson was an advocate of this change.

While its formation is considered a significant water management innovation, there are concerns about how the CAGRD will meet its projected long-term replenishment obligations. The rate of growth in membership has exceeded expectations. Based on membership projections through 2015, the period covered in the recently approved 10-year CAGRD Plan of Operation, replenishment obligations for 2035 for all three counties are projected to be 226,800 acre feet. Just under 12% of that obligation, or approximately 26,700 acre feet, is projected as 2035 Tucson AMA replenishment. Although these projections are based on numerous assumptions and actual numbers are likely to differ substantially from these projections, there is no question that future CAGRD replenishment obligations are large.

Because the CAGRD does not itself have access at this time to many firm or long-term water supplies, it identified in its Plan of Operation "potentially available sources of water". They include obtaining CAP water through acquisition of some Municipal & Industrial priority subcontract water as well as short-term and longer term contracts with Indians. They also cite short-term and long-term lease agreements for effluent and for Colorado River water from Arizona rights holders along the main stem of the Colorado River. Finally, they show the possibility of acquiring rights to imported groundwater. All of these sources are listed in the Plan of Operation, but no arrangements or contracts for these likely

[19] Under ARS 48-3780 (B) a member service area can terminate its relationship with the CAGRD if ADWR approves a modification to that MSA's AWS designation because: 1) the water provider has obtained a substitute supply of water, other than groundwater, that is consistent with assured water supply rules, 2) the MSA has provided adequate public notice of its intentions to de-enroll, and 3) has paid all amounts owed to the CAGRD (both capital and replenishment).

sources of water are in place. There are two related concerns. First, ADWR has granted numerous designations and certificates of AWS based on membership in the CAGRD, but the CAGRD does not hold title to firm supplies of water to meet its replenishment obligations. Secondly, the sources of water to meet future replenishment obligations are largely the same sources of water targeted by municipal water providers throughout the state as they consider their options for meeting future water demands. Whereas the CAGRD provides the replenishment insurance or guarantee municipal water providers need, the water companies are developing their own plans for meeting their future water needs. They are looking to meet their future demands in the most economical manner. CAGRD replenishment services represent a two-edged sword. It is important to the members that CAGRD replenishment services must be provided. On the other hand, the cost of future replenishment services is not under the control of CAGRD members and has significant uncertainties associated with it. Moreover, the CAGRD will likely be competing with some of its own members for water sources to meet future demands.

Planning for Future Water Demands

Providing water to communities requires considerable planning. Since the 1980 enactment of the Groundwater Management Act, ADWR has developed a series of Management Plans for the Tucson AMA. The Third Management Plan (TMP) is currently in effect. It was developed in the late 1990s and was based on best information at that time. It has been almost 10 years since the early work on the TMP was done. Many of the TMP projections are stale. Yet, for many indicators, the TMP provides the best AMA-wide information available. An example of an ADWR water budget similar to that in the TMP is included as Table 4.

Table 4: Water Scenarios Based on Third Management Plan			
	1998	2003	2025
Municipal Sector (Includes Exempt Wells)			
Total Demand	163,198	185,199	247,100
Total Supply	163,198	185,199	247,100
Groundwater	153,535	124,113	63,000
CAP	200	50,998	146,400
Effluent	9,463	9,811	37,700
Surface Water	0	277	0
Agricultural Sector			
Total Demand	94,809	102,959	54,200
Total Supply	94,809	102,959	54,200
Groundwater	70,882	85,617	41,200
Groundwater (in lieu)	22,947	17,342	10,000
CAP	0	0	0
Effluent	980	0	3,000
Industrial Sector			
Total Demand	57,544	47,430	75,400
Total Supply	57,544	47,430	75,400
Groundwater	56,844	45,721	70,700
CAP	0	160	0
Effluent	700	1,549	4,700
Indian			
Total Demand	100	14,196	16,000
Total Supply	100	14,196	16,000
Groundwater	100	788	200
CAP	0	13,408	15,800
Effluent	0	0	0
Other Demand Riparian	3,705	3,705	3,705
Total Demand	**315,651**	**349,784**	**392,700**
Total Groundwater Use	**308,013**	**277,286**	**188,805**
(Less) Net Natural Recharge	62,045	62,045	62,045
(Less) Net Incidental Recharge	81,972	43,257	32,516
(Less) Cuts to the Aquifer	2,341	8,362	45,200
Total Overdraft	**161,655**	**163,622**	**49,044**
Net Artificial Recharge	22,688	56,919	13,500

The Management Plan is both more and less than a typical, regional government plan. It is more in that it is regulatory. It includes detailed conservation program regulations for each major water sector. The municipal conservation regulations, including the Gallons Per Capita Per Day (GPCD) Program, are included in Chapter 5 of the TMP. GPCD figures provide insight into relative water consumption throughout the region and across regions. However, when comparing GPCD rates, it is important to know what is or is not included in the figure. A recently issued report by the United States Geological Survey, provides a figure showing GPCD rates of cities in the western U.S. The data from that figure are

reproduced here as Table 5. It is not clear from the text of the report, however, whether these figures are directly comparable to the GPCD rates regulated by ADWR.

For regulatory purposes in Arizona, a water company's overall GPCD rate provides an indication of total water provided for all users divided by the population. More golf course use of groundwater within a provider's service area or a higher rate of use by commercial customers translates into a higher GPCD. But golf course or other use of effluent is not included in the GPCD rate that is regulated by ADWR. A service area that is mostly residential tends to have a lower GPCD than an area with more of a mix of customers. Target figures for overall GPCD and that for the residential portion of a service area are a focus of the regulations. However, because the GPCD was subject to a court challenge, which did not get resolved until 2004, this program has not received a lot of attention of late. Although the court challenge has been resolved, the future impact of this program will not be understood until the development of the Fourth Management Plan, when ADWR staff is expected to look at this program with an eye toward revising it. It is possible ADWR staff will not wait until the Fourth Management Plan and address the residential conservation program as a modification to the Third Management Plan.

The Management Plan is less than what one might expect in a regional plan in that it is not an operational plan that can be implemented by water companies. The Management Plans, along with statutes and rules, provide the regulatory context and framework, but the water providers themselves determine how they will satisfy the regulations through their own plans. The Groundwater Management Act and associated management plans and rules provide the "rules of engagement"; the water companies determine how they meet these rules. Therefore, although there is a regional approach to specification of the regulations, the individual water companies can act independently and often do.

As would be expected, the manner in which water companies go about developing and sharing their water resource and water infrastructure financing plans varies according to their circumstances. Except for Tucson Water, plans for water providers in the Tucson AMA typically are relatively brief documents outlining infrastructure needs and demand estimates. The planning horizon for these plans is usually 5 years, 10 years and ultimate build out.

Table 5: Per Capita Water Use for Selected Western Cities	
City	**GPCD Water Use**
Portland, OR	88
Seattle, WA	120
Salt Lake City, UT	138
Bozeman, MT	139
Aspen, CO	140
Los Angeles, CA	141
Santa Fe, NM	143
Albuquerque, NM	144
Denver, CO	151
El Paso, TX	154
Casper, WY	173
San Diego, CA	176
Boise, ID	190
Phoenix, AZ	218
Las Vegas, NV	245
Source: Anderson, Mark T. and Lloyd H. Woosley, Jr. 2005. Water Availability for the Western United States – Key scientific challenges: U.S. Geological Survey Circular 1261. Author Note: These figures are as reported in the USGS Circular and could not be verified.	

The most detailed, recent plan available in the Tucson AMA is Tucson Water's *Water Plan: 2000-2050* (Tucson Water Plan). Released in November 2004, it has been the subject of numerous presentations and public forums. The Tucson Water Plan is an indicator of the issues being faced by most water providers in the region. The Tucson Water Plan identifies the important and complex issues facing the region as it attempts to accommodate the water needs of a growing population. Water budget information for Tucson Water and the other water providers in the Tucson AMA can be found in Appendix A.

The Tucson Water Plan is predicated on a number of factors and assumptions. First, it represents predictions for the entire Tucson Water service area, which includes a considerable number of customers living outside of the Tucson City limits. Because its geographic boundaries differ from those of the City, the population figures are unique. The plan relies on an amount of water usage per person per day and calls it the GPCD rate. However, this GPCD rate is not necessarily the same as the GPCD rate ADWR looks at under their regulatory conservation program. The Tucson Water Plan assumes a fixed GPCD rate of 177 for the 50 years. The Plan states that a GPCD of 177 was assumed because the Tucson

Service area has maintained a relatively constant 177 GPCD for the past 20 years.[20] As noted below, when some scenarios are presented, it is reasonable to assume some decrease in the region's water use per capita, especially over a long period of time. However, the purpose of this discussion is to report on what is in the Tucson Water Plan rather than critique it.

The breakdown of the different components of the GPCD rate used by Tucson is shown in Table 6. Included in the figure is the direct use of reclaimed water, which is excluded from consumption when ADWR looks at compliance with conservation targets for their GPCD program. This distinction is not important in the context of Tucson Water's planning exercise. Because the utility is looking at the overall demand for water resources, it must consider all uses of water, including direct use of reclaimed water.

By assuming the overall GPCD rate stays constant at 177 over the 50 years, the plan therefore assumes that conservation will not increase in any measurable way, the utilization of reclaimed water will remain at eight percent of overall water deliveries, and the mix of residential and non-residential water use will remain fixed. In addition, it assumes the lost and unaccounted for water will remain at about 11 percent of water delivered to customers. While the validity of these assumptions could be questioned, the large size of Tucson Water means it takes considerable change in the underlying numbers to produce noticeable change in any of the averages.

Table 6: Breakdown of Tucson Water GPCD	
Residential [21]	**110**
Reclaimed Water	**14**
Commercial and Industrial Water	**35**
Lost and Unaccounted for Water	**18**
Total Water Use	**177**

Source: Tucson Water Plan 2000 — 2050

The Recommended Plan in the Tucson Water Plan, reproduced below as Figure 5, shows the utilization of different water resources over time. It includes Tucson's current allocation of CAP water (135,966), but it does not include the additional 8,206 acre feet Tucson has been slated to get, pending

[20] Tucson Water Plan p. 3-6

[21] The residential figure can be broken down into figures for indoor and outdoor usage. According to the ADWR TAMA Third Management Plan a new single family housing unit will use 57 GPCD interior and 118 Gallons per Household per Day (GPHD) for exterior. The estimate for a multifamily housing unit is 57 GPCD interior and 21 GPCD exterior. This is a model rate. Average multifamily exterior rate is 26 GPCD. [21] If we assume an average 2.8 people per single family household this would mean that outdoor water consumption is about 42 GPCD.

official approval, of additional Municipal & Industrial priority CAP water. Although the Tucson Water Plan: 2000 - 2050 does not include this additional allocation, Tucson Water indicates that they have begun to use the additional allocation in their resource projections because almost all of the legal hurdles to its use have been cleared.[22] It also does not appear to include explicit reliance on the CAGRD for the 12,500 acre feet of replenishment. This is a source of renewable water supplies for Tucson. The discussion in the Tucson Water Plan suggests that this replenishment may not be included because of the Plan's focus on locating recharge close to recovery. Because Tucson Water cannot control the location of CAGRD storage, the utility cannot be certain that the storage would occur at locations that satisfy Tucson Water's own criteria for location of groundwater replenishment. This issue could be addressed through an agreement with the CAGRD to perform what is called "contract replenishment", that is, replenishment that is on behalf of a specific CAGRD member. Another reason for omission of the 12,500 acre feet in renewable supplies through the CAGRD could be the CAGRD's lack of firm sources of water to meet this replenishment obligation. As noted, the CAGRD is likely to look to the same sources of supply as other water users in the region to obtain water to meet its replenishment obligation. Finally, Tucson Water has no control over the charges assessed by the CAGRD, although CAGRD is a non-profit government entity and its charges must be cost based.

Figure 5: Tucson Water Recommended Plan

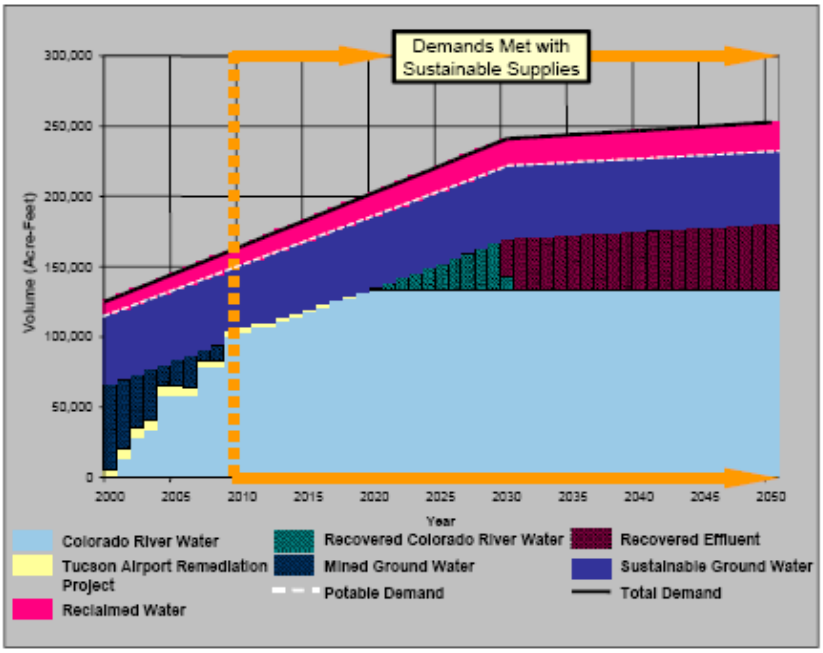


Figure 7-1: Projected Total Demand and Use of Resources for the Recommended Plan.

Source: Tucson Water Plan 2000 - 2050

[22] Modeer, David. (2006). Personal Communication with Author.

The Tucson Water Plan includes 50,000 acre feet annually of what is called "Renewable Ground Water", that is, use of groundwater that the plan calls "hydrologically sustainable".[23] This is groundwater use that the utility believes is consistent with establishing a balance of groundwater withdrawals with groundwater use in its service area. However, there is no utility-specific calculation of renewable groundwater in the AMA water budget or in the AWS Rules determination of Tucson Water's groundwater allocation, and the Plan acknowledges this. Tucson Water was given a groundwater allocation at the time of its AWS Designation of 1.68 million acre feet. It also is entitled to use two million acre feet of groundwater as a result of its purchase of Avra Valley farmland. Since acquiring its Designation of Assured Water Supply, Tucson has used some of its groundwater allocation.[24,25]

Another important source of water for Tucson Water is effluent. The recommended plan includes use of recovered effluent beginning in 2030. The increased use of effluent indirectly through recharge has received much attention locally, as it has nationally. Effluent is being recognized throughout the state and nation as an important water supply. Tucson has ownership of a considerable quantity of effluent. In 2003 the City of Tucson used 13,121 acre feet directly as reclaimed water, about half of their 30,739 acre foot effluent allocation. Tucson's reclaimed water is sold to golf courses, schools and parks at a rate of $610 per acre foot.[26] The majority of the remaining effluent in the City's allocation is discharged into the Santa Cruz River. Tucson Water's plans for increased effluent utilization will be closely scrutinized, not only because of water quality concerns but because the effluent flows in the Santa Cruz River maintain valuable riparian habitat.

The Tucson Water Plan acknowledges that the utility must seek additional supplies to serve future demands. Certain assumptions can be argued, but doing so would only change the timing of the need for additional supplies. Obtaining additional supplies is not only a focus of Tucson. It is a concern of other Tucson area providers who are serving growing communities, such as Marana and Oro Valley. Oro Valley, for example has recently completed the first phase of its Reclaimed Water System that will reduce

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[23] See page 7-10 of the Tucson Water Plan for a discussion of Renewable Ground Water and "hydrological sustainable" groundwater pumping. It should be noted that on February 14, 2006, Tucson Water Director David Modeer gave a presentation to the Tucson Mayor and Council on "Drought on the Colorado River and Tucson's Near-Term Water Resource Needs." He provided some slides showing Tucson Water's resources. The Groundwater slide did not reference "renewable ground water" but noted that groundwater is a non-renewable, interim supply source.

[24] At the end of 2004 Tucson Water had 1,407,016 AF of their original groundwater allocation remaining. This number does not include the 2 million AF from Avra Valley farmland.

[25] Appendix C of the Tucson Water Plan discusses the water supplies incorporated in Tucson's current Assured Water Supply designation. Approval of an update to the designation is pending. In order to increase the water deliveries that are consistent with a 100-year water supply, Tucson has to again satisfy the criteria discussed above.

[26] 14 golf courses, 32 parks, 40 schools, Univ. of Arizona and Pima Comm. College have purchase agreements for reclaimed water with city of Tucson. Price per acre foot taken from Tucson Water webpage http://www.tucsonaz.gov/water/faqs_on_reclaim.htm

groundwater withdrawals by approximately 1500 af per year. Phase 2 of their system will be completed in 2007 and will reduce groundwater pumping by an additional 1000 acre-feet. The rapidly growing Town of Marana, which has only 47 acre feet of CAP water under contract, is actively seeking additional renewable water supplies. Additional water supplies may also be necessary to fulfill the habitat requirements of the Sonoran Desert Conservation Plan.[27] These common concerns have led to a renewed call for regional cooperation.

Regional Approaches to Water Management

Calls for meaningful regional cooperation in the Tucson AMA are part of the region's history, as are failed attempts at cooperation. The City of Tucson and Pima County have a long history of difficulties associated with water and wastewater issues. The 1979 Intergovernmental Agreement (IGA) related to water and sewer assets and operations was updated with a 2000 supplemental IGA. At the time of the initial CAP allocations, Tucson Water received allocations based on the expectation that it would be the regional water provider. Tucson Water and some water companies in the northwest part of the metropolitan region entered into contractual arrangements for the direct delivery of treated CAP water. Subsequently, the private water companies that entered these agreements were acquired by new publicly owned water providers (Metro and Oro Valley). Tucson's retreat from a program of direct delivery meant its ability to provide CAP water regionally was in doubt. The dissolution of the Northwest Area agreements was the result. Eventually, a portion of Tucson's CAP allocation, which had been 148,420 acre feet, was transferred to Oro Valley and Metro.[28] Similarly, ownership of some of the region's effluent has also been transferred to Metro and Oro Valley.

In the early 1990s, a regional water district, the Santa Cruz Valley Water District (SCVWD) was formed. This statutorily authorized district was given 30 months to approve an augmentation plan for the Tucson AMA, to develop a plan of operation, and to vote on permanent formation of the district. The seven member initial board, which was appointed by the Governor, had representatives from the major water using sectors and large political jurisdictions. The City of Tucson board member and the Pima County board member each had veto authority over the permanent formation of the district. After a trial

[27] The water needs under the Sonoran Desert Conservation Plan have not yet been finalized. As a result, this report has not expressly taken into account water needs under the SDCP.

[28] Note that Metro Water and Oro Valley are both in control of their own CAP allocations. This is the result of two separate settlements with the City of Tucson. In 1997 Metro Water agreed to pay the City of Tucson 12.3 million over a 21 year period for lost revenue and for previously expanded capitol costs incurred. As a result Metro Water is no longer required to take or pay for treated CAP water from Tucson and will receive its own 9,500 acre foot allocation of untreated CAP water. A similar settlement occurred in 2001 between Oro Valley and Tucson whereby Oro Valley will receive 4,454 af of CAP water and will pay Tucson $3.8 million to annul their agreement with Tucson and compensate Tucson for damages it incurred for Central Arizona Project water purchases and CAP water distribution system costs in behalf of Oro Valley.

period of operation, which included successful sponsorship of the first turnout to deliver CAP water to agriculture in Pima County, the late 1993 vote on permanent formation failed. The vote was five in favor of permanent formation and two opposed, with the City of Tucson board member voting in opposition. The other member who voted in opposition was, surprisingly, the board member representing the agricultural district that benefited from the SCVWD's investment.[29]

It is worth noting that in early 1993, when the CAGRD was authorized to perform replenishment services in the Tucson AMA, the SCVWD was also given this authority. Had the SCVWD been formed, the Tucson AMA would have had a local entity authorized to perform replenishment. The SCVWD was not authorized to be a municipal water provider, however, concerns were voiced that perhaps that is what some had in mind for it. It was established to provide a mechanism for voluntary collaboration in investment in infrastructure, regional recharge projects and other projects. The approaches to governing and financing the permanent entity, had it been formed, were changed legislatively during the SCVWD's short existence. The argument for an elected board with taxing authority, subject to approval by the citizens of the AMA, was led by the City of Tucson representative to the SCVWD board. With a change in leadership at the City, it ironically may have been the strengthening of the authorities of the SCVWD that led to Tucson's disapproval of permanent formation of the district.[30]

Regionalization of water planning in the Tucson metropolitan area has been the focus of several efforts. The Southern Arizona Water Resources Association, (SAWARA) a community-based water resources organization no longer operating, studied the issue. Approaches of other regions have been examined. Although the SCVWD effort failed, water providers in the region have worked together effectively. The northwest water providers have been working on a plan to deliver CAP water to the northwest portion of the Tucson metropolitan area. This project was conceived of during the development of the SCVWD augmentation plan, and included in the official SCVWD Augmentation Plan. Pima County, Tucson Water, the U. S. Bureau of Reclamation and others have jointly developed an effluent managed recharge project in the Santa Cruz River.[31] The Southern Arizona Water Users Association (SAWUA) formed as a private organization to serve as a forum for large water providers and users to address issues of common interest. The Water Conservation Alliance of Southern Arizona (Water CASA) has for many years served as a vehicle for water company cooperation focused on

[29] It may be because of this experience that there was resistance to granting veto authority to any board members on the Regional Transportation Authority.

[30] It was during the legislative session immediately following the vote on permanent formation failed that the Santa Cruz AMA obtained legislative approve to secede from the Tucson AMA.

[31] Managed recharge involves leaving the effluent in the river and gaining credits for effluent water that infiltrates and recharges the aquifer. This is in contrast to constructed recharge, where basins are typically used. State law allows credit for only 50% of effluent recharged at a managed recharge site. The remaining amount recharged is counted as natural recharge in the water budget calculations.

conservation efforts.[32] There are also efforts underway to form a regional organization for the purpose of obtaining additional water supplies. Most recently, on February 14, 2006, the Pima County Administrator requested that the City of Tucson participate with the county on a study of the feasibility of forming a Regional Water and Wastewater Authority. The region is going to have to compete with others in the state looking at the same supplies. Competition within the region is likely to put the entire region at a disadvantage relative to the Phoenix AMA water interests.

In summary, regional cooperation on specific projects and issues has occurred and is likely to continue. Formation of a regional entity responsible for water provision and sewer services, as some have advocated, however, is a very complex undertaking. It will require considerable examination and debate. Broad institutional and citizen support will be essential. Based on the experience of the Santa Cruz Valley Water District, governance and financial arrangements will be key to determining the acceptability of any new regional entity.

Water Resource Availability for the Tucson Metropolitan Area

Water planning is complex. The connection between growth and water is undeniable. However, land use planning and water planning tend to be done separately. Regardless, the water planners have to plan for more people. Exactly where the additional people will locate and at what rate the population will grow are uncertain. But the region will continue to grow. A number of questions arise in this context. What are the region's dependable (or "firm") water supplies? Where might the region find other sources of water? How many people can those supplies support? Will sufficient supplies be available to support future population growth?

While it may seem counterintuitive, one can be confident that water supplies will be sufficient to support platted development, while at the same time be uncertain of to the "identity" and cost of these future water supplies. The confidence factor directly relates to the implementation of the Assured Water Supply Rules. The uncertainty reflects the complicated nature of current-day water supply portfolios, where arrangements are not in place today to meet all of the demands of current platted developments, let alone future developments. Water is physically present to meet demands, but all of the water required to replenish groundwater pumping by members of the CAGRD has not been identified. The CAGRD has been a key enabling mechanism for those in the Tucson AMA desiring an AWS Designation or Certificate. But associated with the CAGRD are significant uncertainties.

It must be noted that the Tucson Water Plan is not the same as an Assured Water Supply demonstration. First, the AWS Rules require 100 years worth of Assured Water Supply. That requires

[32] This organization was formed by water providers that did not have the resources individually to operate conservation offices. Tucson Water, which does have its own conservation office, is not a member.

the five criteria be met to the satisfaction of ADWR. An amount of water is quantified as being available to provide the service area's customers, and Tucson Water can serve new customers provided their projected use, when added to projected current demands, does not exceed the certified level. Tucson Water is revising its Assured Water Supply designation. When complete, the community will have an idea of the growth that can be accommodated with the water resources identified in the designation. The purpose of the Tucson Water Plan is to determine how certain water resources, such as effluent and CAP water, will be utilized in the future so that the necessary investments can be put in place for future utilization of those supplies. For example, if the utility wishes to show ADWR it will utilize more of its effluent through off-river recharge and recovery, it will have to implement a program to accomplish that.

There have been efforts to quantify the population that can be served by the Tucson AMA's water supplies. In the Fall of 2000, the Southern Arizona Water Resources Association issued a publication entitled "How Much Population Growth Can Be Supported By Our Water Supply?"[33] The short publication looked at some alternative regional water budgets and, based on varying assumptions, concluded that the Tucson region could support as many as 2.28 million people if *all* metal mining and agriculture use of water ceased in the Tucson AMA. They assumed 200,000 acre feet of CAP water would be available to the region; the amount of net natural recharge was 60,800 acre feet; that 40 percent of municipal use flowed into the effluent/reclaimed water system, and that 4 percent of municipal water and 12 percent of industrial use returned to the aquifer as incidental recharge. Further, SAWARA assumed the municipal use of water per person per day was 175 gallons, which is very close to the 177 assumed by Tucson Water in its plan. To that, SAWARA added another 10 gallons per day per person to represent non-metal mining plus other industrial demand.

As noted in this report, the industrial and agricultural sectors are not required to use renewable water supplies. SAWARA's study assumed that these sectors continued to rely on groundwater for what water they did use. SAWARA's study also assumed that, should mining and agricultural use of water decline sufficiently, municipal water providers would gain the rights to use the groundwater not used by those sectors, provided the overall amount of groundwater used was consistent with achieving safe-yield.

The current AWS Rules do not directly allow groundwater use by the municipal sector to increase on an acre foot by acre foot basis if agricultural or mining use declines. That is, the amount of groundwater that can be used without incurring a replenishment obligation does not change, unless water rights are purchased and extinguished. The value of extinguishing agricultural water rights is in fact quite limited. However, it is true that less groundwater use by agriculture and industry translates into more physically available groundwater, which could figure into hydrological studies of 100 years worth of physical water availability (see criterion 1 under the discussion of the AWS Rules). However, use of

[33] *Water Words*, Volume 18, Number 2, Autumn 2000.

groundwater made available by reduced agricultural/mining would have to be replenished under criterion 3 of the AWS Rules.

Scenario development is further complicated by several other factors. Membership in the CAGRD allows member service areas to grow based on the expectation that the CAGRD will find the water supplies needed for replenishment rather than a guarantee based on water supplies under contract for the full 100 years.[34] There is some constraint to the system in that designations have to be renewed periodically. If replenishment is to be relied upon, the water provider must show that the groundwater it uses is physically available. This requires hydrologic modeling, which must be done to the satisfaction of ADWR. According to ADWR, developers and water providers have been able to demonstrate physical availability for AWS purposes throughout much of the Tucson AMA. [35] Fundamentally, and not surprisingly, future growth depends on the physical availability of groundwater, which must be replenished, and/or direct utilization of renewable supplies. If the groundwater is physically available, membership in the CAGRD is accomplished, and the CAGRD Plan of Operation is approved by ADWR, it must be assumed that renewable supplies will be obtained to replenish the groundwater use. To assume otherwise would be at odds with all official determinations regarding assured water supplies. The uncertainty is associated with the type of water used for replenishment and its costs.

The Tucson region had 177,033 acre feet of CAP water available and 43,742 acre feet of effluent available in 2005, excluding water specifically allocated for use by Indian Nations. The CAGRD Plan of Operation and Tucson Water Plan estimated that the Region used 73,858 acre feet of CAP water and approximately 13,121 acre feet of reclaimed water in 2005.[36] Should pending reallocations be approved, there will be an additional 18,777 acre feet of non-Indian CAP water available to the region. As the Tucson Water Plan shows, it is relying on its AWS groundwater allocation in the early years, with a phase-in of greater use of CAP through storage and recovery. Therefore, some of the unutilized CAP water is targeted for use and not available to serve additional people beyond those already planned for. The timing for utilization of some CAP water, on the other hand, is unknown. For example, the manner in which the 14,000 acre feet of CAP water held by the Arizona State Land Department will be utilized is unknown at this time. Plans for utilization of CAP allocations by undesignated providers with CAP allocations, such as Flowing Wells Irrigation District and Community Water Company of Green Valley,

[34] Note that membership in the CAGRD is used to satisfy criteria 4 under the AWS rules ("The proposed use is consistent with water management goals") by providing a "renewable" water resource option. Membership in the CAGRD cannot be used to prove a 100 year physically-available water supply.
[35] Communication with Ken Seasholes, ADWR, Tucson AMA, April 10, 2006.
[36] The CAGRD Plan of Operation indicates that only Tucson Water and Metro Water will use their CAP allocations in 2005. 2005 effluent use is based on Tucson Water's 2003 reclaimed water use. Only Tucson's reclaimed water use is considered for the region for 2005 because although Oro Valley began reclaimed water use in 2005, use information was not available.

are also unclear at this time. Therefore, actual figures on CAP availability versus use demonstrate only that the region is not yet fully utilizing its renewable resources. The Tucson Water Plan has been discussed here in some detail. For more detailed discussion of water budgets for Tucson Water, Marana, Oro Valley and Metro Water, see Appendix A.

The rate at which effluent will be utilized has significant uncertainties as well. If the effluent is removed from the Santa Cruz River prior to recharge, instead of allowing the effluent to recharge the aquifer as it flows down the River, the rate of accrual of credits increases (from 50 percent to 100 percent (less losses) of the amount of effluent recharged). This increases the rate at which the effluent can be utilized indirectly through recharge. However, plans to remove effluent from the Santa Cruz River are not well developed, nor are recovery plans. There is resistance to both removal of the effluent from the River as well as recovery of the effluent for use. In addition, there is 28,200 acre feet of effluent that is held by the U.S. Secretary of the Interior as part of the Southern Arizona Water Rights Settlement Act. Although this has been the subject of study, the terms under which this effluent will be available to the non-Indian municipal sector over the long-term is not known.

A considerable number of long-term storage credits have been accrued in the Tucson AMA, as shown on Table 2. Over half of the credits, however, are held by the Arizona Water Banking Authority, a government entity established in 1996 to assist the state with utilizing excess CAP water to meet water management and CAP water utilization goals. The credits held by the AWBA will be used to firm up supplies in times of shortage in Colorado River supplies, outage of the CAP canal or fulfillment of Arizona's interstate storage agreement with Nevada. The credits held by individual water providers can be used to meet future water demands. Many have stored in anticipation of tighter supplies of CAP water. It must be remembered that it takes 100 acre feet of credits to achieve one acre foot of assured water supply. Unlike CAP water, which is available on an annual basis, credit use is a one-time occurrence.

As noted, water providers were granted groundwater allocations through the assured water supply designation/certification process. An examination of reports filed with ADWR shows that several of the water providers have reported utilization of a portion of their groundwater allocations in each year since 2000. Although the balance in these accounts is augmented each year by a volume equal to four percent of overall water use, the accounts do provide a constraint on the amount of groundwater that can be pumped by those with AWS Designations or Certificates without incurring a replenishment obligation.[37]

An important part of the exercise to determine how far a given amount of water will go is the rate of consumption. Obviously, how intensively the water is used at the outset will determine how much

[37] As noted, beyond ADWR conservation requirements, there are not limitations on the groundwater pumping by undesignated water providers. Therefore, some municipal sector groundwater pumping may continue in perpetuity. Exempt well pumping will continue. And pumping by the metal mining and agricultural sectors will continue for some indefinite period of time.

growth water supplies can support. Assuming usage at 177 gallons per capita per day, the figure assumed in the Tucson Water Plan, and usable return flows of 40 to 60 percent of the water overall (including residential return flows and incidental recharge), an incremental acre foot of water can serve seven to eight additional residents (and the generated commercial and other activities) for a year. Even this rough calculation requires numerous assumptions and/or pieces of information. How much of each component of the GPCD can be re-used and how many times? If 40 percent of a household's indoor water use returns to the system through the wastewater treatment plan, how is that water used? If used for golf course watering, the resulting water will then be used for turf irrigation, with the associated incidental recharge factor determining how much can be used as a second order return flow. If stored and recovered for eventual use in the potable water system, the rate of use is higher.

On the supply side, the supplies noted in the discussion of the CAGRD will factor into plans for the Tucson AMA. Possibilities for additional water supplies beyond those already discussed in this section include the lease of CAP water from the Tribes, purchase of water from users along the main stem of the Colorado River, and increased actual utilization of effluent.

Demand-side efforts to reduce subcomponents of the existing GPCD will continue. Re-use programs, such as harvesting of rain water and installation of gray water systems, are of increasing interest.[38] Installation of graywater systems can be something of a concern for municipal water providers who have assumed a certain rate of return flows from households. Household reduction of wastewater flows through the use of water from washing machines and other uses means reduced flows into the sewer system. Capture of rainwater to any significant extent would mean reduced flows through drains and reduced runoff into washes and streams. These actions, which are seen as positive from the perspective of re-use of existing water supplies and capture of rainwater, and from the perspective of reduced demand for potable water initially, would have to be reflected in the water provider and regional water budgets.

While additional conservation is always desirable – and the region should strive to do more – there is some question regarding how much motivation there is for additional conservation. The potential to conserve water likely varies across the community. Many consumers in the Tucson AMA have already adopted conservation practices. Economic incentives will affect behavior. The ability to reuse water already paid for or capture rainwater can be economically attractive to the individual consumer. In addition, how much money is saved by reducing water consumption clearly depends on the rate structure. Currently, water is relatively inexpensive both in an absolute sense and relative to income levels. There appear to be many other places households will look to reduce their outflow of funds prior to their water

[38] Little, Val. *Graywater Guidelines.* Water Conservation Alliance of Southern Arizona. This document is available online at http://www.watercasa.org/pubs/Graywater%20Guidelines.pdf

bills. Like everything else about water planning, the economic considerations related to water provision are complex as well.

As the community grows new households, utilizing low use plumbing fixtures, will use less water for indoor purposes, other things equal, than existing households. Conservation ordinances can influence the per capita water use as well. On a per capita basis, average residential water use across the region is expected to decline over time.

With the above discussion in mind, alternative scenarios for 2030 are shown on a worksheet presented in Table 7. This year was chosen because it is close enough to 2025 to make use of ADWR Third Management Plan projections and it is consistent with recent planning efforts by Pima County Wastewater Management. The scenarios are for illustrative purposes only, and are intended to show how many people, the "Scenario Population" toward the bottom of the table, can be served by water supplies known to the region and projected replenishment by the CAGRD in 2030. Caution should be used when considering the numbers. The underlying assumptions are clearly subject to debate; changes could result in higher or lower Scenario Population figures. As just one example, there could be double counting. For example, effluent under the control of the Department of the Interior may eventually be incorporated into a provider's supply portfolio. Or it may be used for replenishment by the CAGRD. But a given acre foot of effluent can be used only once. Another consideration, which would lead to underestimating the Scenario Population, is the omission of numbers showing long-term storage accounts. Because those held by water provides are used on a one-time basis, they have not been included in these illustrations. It is possible their use will reduce future replenishment obligations by the CAGRD.

Table 7 shows multiple scenarios. They depend on how much effluent is used and the assumed gallons per capita per day rate. Although Tucson Water assumed a constant 177 GPCD rate throughout their plan, it is reasonable to consider a decrease in the GPCD rate for several reasons. As previously mentioned, new and remodeled homes will likely utilize less water for indoor purposes. It is not clear that large tracts of turf will be built at the same rate as historically has been the case. The rate of growth in non-residential demand relative to residential demand is unclear. Yet in all sectors, some increase in conservation is likely. Therefore, it is reasonable to assume that, overall, the regional GPCD rate will decline, particularly over a long period of time. By how much is uncertain. Therefore, the scenarios use two different rates, the higher set at 165 and the lower set at 150. These rates are arbitrarily selected, but they show the implications of higher versus lower regional water use rates. It is important to remember that the GPCD figures here are intended to include all sources of water used to serve municipal water needs and are not the same as the figures used by ADWR in the municipal conservation program.

Table 7: Scenarios Worksheet

2030 Scenarios Worksheet*	M&I + DOI Effluent + Higher GPCD	Half (M&I + DOI) Effluent + Higher GPCD		M&I + DOI Effluent + Lower GPCD	Half (M&I + DOI) Effluent + Lower GPCD
See Notes for Assumptions	Year 2030	Year 2030		Year 2030	Year 2030
PAG Pima County Population Projection[1]	1,496,045	1,496,045		1,496,045	1,496,045
Estimated 2005 Population = 916,026					
Water Supplies/Sources in Acre Feet					
CAGRD with Tucson Water[2]	35,600	35,600		35,600	35,600
Allowable GW[3]	41,100	41,100		41,100	41,100
Exempt Well GW[4]	4,000	4,000		4,000	4,000
Undesignated GW[5]	22,000	22,000		22,000	22,000
Effluent[6]	67,409	33,705		67,409	33,705
Effluent DOI[7]	28,200	14,100		28,200	14,100
Municipal & Industrial CAP[8]	195,810	195,810		195,810	195,810
Total Annual Supply in Acre Feet[9]	394,119	346,315		394,119	346,315
Total Annual Supply in Gallons[10]	128,424,070,269	112,846,926,140		128,424,070,269	112,846,926,140
Assumed Total GPCD[11]	165	165		150	150
Water Per Person per annum[12]	60225	60225		54750	54750
Scenario Population[13]	2,132,405	1,873,756		2,345,645	2,061,131
Scenario Population less Projected Population[14]	636,360	377,711		849,600	565,086
Ratio of Scenario Population to Projected Pop[15]	1.43	1.25		1.57	1.38

Notes to Table 7

*These calculations are meant to be illustrative only. They are based on many assumptions and are not intended to be forecasts or projections. The worksheet scenarios do not quantify the public investments required to actually utilize the identified water sources. Additional public investments may be required to utilize the resources.

1. The population projections are for Pima County and are based on Pima Association of Government Projects. PAG estimated population for 2005 was 916,026. The Tucson AMA has different boundaries but includes metropolitan Pima County.

2. The projected replenishment obligations are from the November 2004 CAGRD Plan of Operation, The CAGRD projections do not include replenishment for Tucson, but it is assumed that Tucson will need 12,500 af of replenishment for its AWS. The figure shown has added 12,500 replenishment for Tucson Water added Plan's projection for the Tucson AMA.

3. Allowable groundwater is an estimate of the groundwater pumping that is allowable under the AWS Rules, annualized. (ADWR Est.)

4. Some pumping is going to occur through exempt wells. This is an estimate of the annual pumping based on a 1999 Tucson AMA Task Force Report.

5. Some water providers are undesignated and allowed to pump groundwater to serve pre-AWS Rules population solely using groundwater (ADWR Est.)

6. This figure is based on Brown and Caldwell's 2006 Metropolitan Area Facility Plan Update Pima County Wastewater Management Projection, accessed from http: on March 21, 2006. It includes the projected outputs of the three metropolitan wastewater treatment plants (95,286 af) plus the outputs of the non-metropolitan treatment plants (10,323 af) less the 10,000 af effluent set aside for the conservation pool less the 28,200 af of effluent held in trust for the Tohono O'odham Nation by the Department of the Interior. There are many uncertainties regarding the amount of effluent that will be utilized. They relate to the return flows from municipals uses, the manner in which the effluent is utilized (e.g. managed recharge at 50% credits or constructed recharge or direct utilization through the reclaimed system). The extent of future use of effluent to meet municipal demands may depend on technological innovations as well.

7. The manner in which the 28,200 af of effluent held by the Secretary of the Interior for the benefit of the Tohono O'odham Nation will likely be used by municipal users in the Tucson AMA, but many uncertainties surround this utilization, as indicated in note 6. In addition, the CAGRD may use some of this effluent for its replenishment. So, there could be double counting involved.

8. This figure represents the subcontracts held by Tucson AMA M&I water providers and the Arizona State Land Dept. (14,000 af) and pending M&I reallocations. The Tohono O'odham Nation hold rights to 37,800 af, with another 28,200 non-Indian priority water associated with the recent federal water settlement. The scenarios assume no leasing of Indian CAP water for non-Indian municipal purposes.

9. An acre foot of water is 325,851 gallons.

10. Total Supply times 325,851

11. Gallons per capita per day is an assumed number that includes all customers and all water sources served by municipal water providers. It includes, for example, golf course use of effluent or reclaimed water provided through a municipal water system. The value of this number for the region will depend on the level of conservation across water using sectors, the mix of newer and older housing stock, the amount of outdoor water use, and other factors.

12. Annual water use per year, equal to the assumed GPCD times 365.

13. The Scenario Population is the number of people that can be served by the Total Annual Supply, based on assumptions. It equals "total annual supply in gallons" divided by "water per person per annum".

14. This is the difference between the population that the scenario assumptions show can be supported by the assumed water supplies less the PAG projected population. A positive number demonstrates that the identified water supplies can serve more than the PAG projected population.

15. A ratio greater than one indicates that the scenario population is greater than the projected population.

Table 7 includes detailed notes explaining the assumptions and calculations. All scenarios include significant use of effluent, and, clearly, how far given supplies go depends on the assumed GPCD rate. The scenarios do not show how the CAGRD will meet its replenishment obligations; they only assume that they will be met. The methodology used for the scenario calculations are different from those used by SAWARA. These calculations are not safe-yield calculations. Continued use of groundwater by agriculture, mining and other industries is not considered in our calculations. Instead, we focus on water available, under current laws, rules and regulations, to the municipal sector. The tables assume that the municipal sector overall will rely on about 67,000 of groundwater annually. It is not a coincidence that the reliance on groundwater of the municipal sector is not that far off from estimates of the region's natural recharge plus municipal incidental recharge. The amount of net natural recharge was considered when determining the groundwater allowances for Tucson AMA AWS applicants. That is why the Tucson AMA allowances were more generous than the Phoenix AMA allowances.

The results shown on our scenario worksheet, though developed based on very different assumptions, are similar to SAWARA's. The scenarios show that water supplies are more than sufficient to accommodate growth as projected by the Pima Association of Governments. How robust this finding is clearly depends on the assumptions. Should the population projections be too low or water supply assumptions too high (because the CAGRD contracts for effluent held by the Department of Interior, for example), additional water supplies will have to be identified sooner. There is no water leasing from the Tohono O'odham Nation built into the worksheet. The scenarios shown in Table 7 are for illustrative purposes only.

The scenarios are for 2030 and include for that year the CAGRD's projected replenishment obligations based on membership only through 2015. The CAGRD's need for water for replenishment depends on its overall replenishment obligations, not just the Tucson AMA obligation. Growth in membership is even more rapid in the other AMAs. In this context, it should be noted that it is important that Tucson interests monitor growth in the CAGRD and consider the implications of that growth on the future availability and cost of water for the Tucson region.

When considering future supplies, it should be noted that, assuming a GPCD rate of 150, an incremental acre foot of water initially serves about six people. Remembering that associated with this new water are return flows, which then generate additional return flows. When considering the return flows, a rough rule of thumb is that each incremental acre foot can be used two times. Although this is a gross calculation, and many factors would determine how many people an acre foot of water can supply, this provides some indication of the incremental need for water as the population grows.

It is not difficult to do some sensitivity analysis using the scenario worksheet. For comparison purposes, it is useful to look at the bottom number of Table 7, which shows the ratio of the Scenario

Population to the Projected Population. The more the ratio number is above one, the greater the cushion of water supplies to support additional growth. The illustrative scenarios shown in the worksheet indicate that there is the capacity to supply water to 25 to 57 percent more people than PAG projects to live in Pima County by 2030. (Recall that water supply planning is done on an AMA basis, which differs from the County. But the overlap is considerable and PAG county projections are the most accurate we can obtain at this point.) If we assume a GPCD rate of 175, the figure used by SAWARA and close to the figure used in the Tucson Plan, *and* projected population that exceeds the PAG population projections by 10 percent, *and* use of only half the effluent supplies, the ratio is 1.07. This means that the assumed water supplies, given the rate of use of 175 gallons per person per day, would be just enough to support the higher projected population. There would be very little cushion. As another example, if we were to assume CAP water available to the region does not include the 14,000 acre feet allocated to the State Land Department (or for some reason this amount of allocated CAP water is used by the CAGRD for replenishment), the ratios are reduced by .05 to .06, depending on the column of the base scenario work sheet. See Table 8.

In summary, the worksheet scenarios and some sensitivity analysis suggest that, with reductions in per capita water use associated with new construction and conservation, there are sufficient water supplies to serve more than the population that has been projected for Pima County for 2030. However, where we actually find ourselves in 2030 will depend on several factors, as discussed above.

Table 8: Ratio of Scenario Population to Projected Population	Full Use M&I and DOI Effluent	Half Use M&I and DOI Effluent
Base Scenario with a GPCD of 150 (Taken from Table 7)	1.57	1.38
Base Scenario with a GPCD of 165 (Taken from Table 7)	1.43	1.25
Base Scenario with a GPCD of 175 (All Other Calculations Same as Table 7)	1.34	1.18
10% Increase in PAG 2030 Pop. and a GPCD of 175 (All Other Calculations Same as Table 7)	1.22	1.07
No State Land CAP (14,000 af) with a GPCD of 165 (All Other Calculations Same as Table 7)	1.37	1.20
No State Land CAP (14,000 af) with a GPCD of 150 (All Other Calculations Same as Table 7)	1.51	1.32

The Economics of Water Provision

What is the cost of water going to be? The ADWR Management Plans incorporate little discussion of the economic implications of regulatory practices. The financial analysis included in water plans is often much less extensive than the engineering analysis. Detailed financial feasibility analyses are often lacking, partly because of their difficulty, but also because those doing the analysis tend to think about the technical aspects of the projects. Certain costs, such as the cost of treatment plants and the physical infrastructure to deliver water are routinely estimated. Other costs, such as the costs to the end user or utilization of water of high mineral content, have not been as well explained. The costs of alternatives include these end user costs as well as the costs incurred by the utility.

In addition to the many economic (and other!) questions surrounding integration of CAP water into the region's water supplies, we must add questions regarding effluent utilization to meet long-term municipal demands, and the cost of leasing water. The "next bucket" of water has not been clearly identified.

The cost of water is certain to increase. At what rate we do not know. The spread of the burden of acquiring new supplies is of great interest. As the region considers its options for water supplies and regionalism, it is important that the economic implications of the decisions be well understood.

The State of the Tucson Active Management Area

It has not been that long since the Third Management Plan for the Tucson AMA was developed. Yet much has changed since then. The CAGRD has grown into a significant agency. Tucson Water has implemented a totally different approach to delivery of CAP water. The Southern Arizona Water Rights Settlement Act has been amended, so that the water rights of the Tohono O'odham Nation have been further quantified. ADWR's gallons per capita per day conservation program has withstood legal challenge, but, as a result, the program is expected to be revised. The region is experiencing drought, which is resulting in water tables declining more than expected in parts of the region.

What is the State of the AMA? In the mid-1990s, the Tucson office of ADWR prepared a State of the AMA report, in advance of work on the Third Management Plan. It provided some important region-wide water information. The information in the Third Management Plan is almost ten years old. We do not have a consistent set of readily accessible, current information on the state of the AMA. It is important that the Tucson region, as a whole, make informed water supply decisions. A common set of facts is important to regional decision making. There is considerable water available to the region, yet there are considerable unknowns. Tucson Water has presented a plan to the community in order to assist in making decisions about the future. There are many underlying assumptions and many complexities; it is difficult to simplify water planning. Other water providers are facing similar situations, albeit on a

smaller scale. Despite the complexities, the region should maintain efforts to meet the safe-yield goal established in statute – and maybe more. It has been realized that safe-yield on a broad geographic basis, such as the AMA, may not be sufficient for uniformly ensuring sustainable supplies for all water utilities in the future. It is well recognized that current law can result in localized imbalance of withdrawals and recharge. Sustainability has been defined as the ability of current generations to meet their needs without compromising the ability of future generations to meet their needs.[39] It is a more demanding goal than safe-yield.

Water utilities throughout Arizona are planning for their growing populations. Innovative, often expensive, approaches to water supply treatment, development, and acquisition are being explored. The Tucson region is not alone in needing to identify water supplies to support expected growth. Municipal water providers have recognized that the CAGRD, which is an important tool for them, is also a competitor for water supplies. The CAGRD alone has huge needs for water supplies. The Tucson region is expected to account for less than 30 percent of the future replenishment. And it is not only the communities in Central Arizona that are in need of additional water supplies. For example, the Prescott area is exploring opportunities for importing renewable water supplies.

Sound regional water planning depends on hydrology and finance, and it requires careful, strategic planning. It will involve the weighing of environmental considerations as well. Although the region has had limited success at regional cooperation on water issues, it has had successes upon which it must build. ADWR is about to develop the Fourth Management Plan. This process should be monitored carefully by the business community and others. The business community can assist in long-term water planning. Participation in water planning discussions, however, requires diligence, much like the due diligence associated with business decision making.

It is going to be important that the regional players develop a common understanding of the water challenges and approach resolving them in a collaborative manner. A periodic State of the AMA forum, for which a limited background report is prepared in advance, would assist the region in developing this understanding. The forum should both provide information and the opportunity to question that information. Its goal should be developing a common set of facts and an understanding of the decisions that must be made, including the implications of alternative actions. It should position members of the business community and others to understand the long-term implication of current-day water planning and investment decisions. Holding such a forum on a periodic basis will take time and resources. Some may question its value in the absence of an obvious water crisis. Without sufficient understanding of our water situation the community will not appreciate what the future may look like in terms of future water

[39] This is the most commonly accepted working definition of sustainability. It is found in the Brundtland Report from the World Commission on Environment and Development, 1987.

supply shortages, water rates and water quality. Such a forum would not focus on one provider's plan. No one provider would be in the "hot seat", so to speak. Its focus would be on the entire Tucson AMA. The forum would involve those making water management decisions on a day-to-day basis and those affected by them. The effort would involve the Arizona Department of Water Resources, water providers, government entities, the business community and others. It will take time and resources, but the importance of sound planning for our water future requires the effort. [40]

The Role for the Business Community

We are well over half-way into the 45-year period in which the region was expected to achieve safe-yield. The scenarios presented above were not about achieving safe-yield. They were about how far certain water sources can go in satisfying human demands. Communities are growing and high growth rates are expected to continue. Mining and some agricultural water use are going to continue as well. The needs of the environment are also being recognized more than in the past. We are in a severe drought. Might it be a sustained drought as well? The issues are more complex and challenging than ever.

What needs to be done so that the region can achieve safe-yield? What are the implications if it does not? The deliberations of Governor Hull's Water Management Commission, which met for 18 months during 2000 and 2001, revealed little appetite for increased regulation. The notion of imposing a replenishment obligation on industry was not embraced. Agriculture settled a long-standing dispute with the Arizona Department of Water Resources, the effect of which was to essentially freeze the stringency of efficiency standards.

The development of the fourth management plan will be based on different assumptions than previous plans. Will it be micro focused -- how many toilet flushes per person per household? -- or macro focused – where will the next bucket of water come from? The municipal water conservation program requires rebuilding. The Assured Water Supply program has matured, as has the CAGRD. In the latter case, the growth/maturing process was much quicker than expected. We no longer have the luxury of looking to the Central Arizona Project to meet future demand. Effluent and other sources of water are "the next bucket". Research into desalinization and other treatment technologies is accelerating and

[40] This footnote provides a personal perspective of the author of this report. In the latter half of the 1980s, I had the experience of being a board member of SAWARA, prior to becoming what could be called a full-time water professional. Again, in the early 1990s, I sat on the board, this time as the Executive Director of the Santa Cruz Valley Water District. I noted how difficult it could be for those on the board who did not follow the issues on a day-to-day basis to follow the intricacies of the discussions. There was and still is no intention to obfuscate; the issues are really complex. I observed – maybe projected – that it was difficult for those who were not water professional to always be engaged. Any effort to develop a forum or program like that noted will require an effort to provide the necessary information in a manner that engages the audience and helps them focus on the major water issues before the community and the nature and consequences of the decisions that must be made.

leading to actual implementation. Discussions about mechanisms for water augmentation, including weather modification, are being renewed. Communities outside of AMAs are bumping up against water supply limits. There are debates about whether the adequate water supply standards in non-AMA areas of the state offer sufficient consumer protections. Maricopa County is beginning to explore the development of a huge tract of state land known as Superstition Vistas. How will finding renewable water supplies for this new and very large community affect the Tucson region? How and when is the Arizona State Land Department going to determine how it is going to utilize its CAP allocation? What happens as we near 2025? The development of the Fifth Management Plan will begin in perhaps a dozen years from now. How will the Groundwater Management Act be revised? This last question is an extremely important one for the Tucson region as well as the state.

What role is there for the business community of the Tucson Active Management Area to participate in water policy making and water management decisions? It could be described as undefined because it is potentially so broad. It is extremely important that the business community recognize that water management is not just the concern of water managers. Water managers will say that their job is not to make decisions about growth; their job is to make sure the population has safe and reliable water, that is, sufficient water supplies of good quality. It is up to the public and private sectors together to determine the characteristics of our communities. Addressing Arizona's water needs has historically been approached in a non-partisan manner. The experience financing and building the Central Arizona Project – and finally being able to use CAP water – showed us that focus and persistence are required. The CAP has been built.

The region needs to determine whether enhanced treatment of CAP water is something the community is willing to pay for, when and in what manner effluent will be utilized (including use for the environment), what new conservation programs should be implemented, how extensive regional cooperation can be, and what new water supplies can be identified. Many of these endeavors will require significant citizen/community investment. The options will depend on technology, economics and law/institutions. There will be legislative change within the next 20 years; it will be necessary to look beyond 2025. It will take focused attention on the part of the business community, working with the public sector, to ensure that the Tucson region continues to have sufficient water supplies and remains a place where we want our children and grandchildren to live.

Appendix A: Water Budgets

Tucson Scenarios

To meet its water needs Tucson Water has five principal sources: effluent, reclaimed water, Central Arizona Project (CAP) water, replenishment from the Central Arizona Groundwater Replenishment District (CAGRD) and allowable groundwater credits.

In this water budget **effluent** is defined as treated wastewater that is not re-used by Tucson Water through their reclaimed water system. Effluent can be manually or naturally recharged into the aquifer. If the effluent is manually recharged Tucson Water will accrue either long-term or short-term storage credits, depending on when the water is recovered. If the water is allowed to naturally recharge, Tucson Water will receive "managed" recharge credits, which provide them with a 50% credit for water the infiltrates into the groundwater.

Reclaimed water is the treated wastewater pumped through Tucson Water's system to golf courses and other turf facilities. **Central Arizona Project** water comes from Tucson Water's allocation of CAP water and can be used directly or through recharge and recovery into the aquifer. Like effluent, the recharge and recovery can be short-term or long-term. **CAGRD replenishment** is the amount of water that the CAGRD will recharge on behalf of Tucson Water to compensate for their use of excess groundwater. This amount is contractually limited to 12,500 acre-feet per year.

Finally, Tucson Water can utilize their **allowable groundwater credits.** These credits come from a number of sources. The first is 1,682,070 acre-feet. This number is based on Tucson Water's groundwater use in 1994 multiplied by 15 years. The second source is 314,000 acre-feet of extinguishment credits that Tucson Water acquired by buying and retiring farmland. The third resource is 2,000,000 acre-feet available to Tucson Water also from the extinguishment of water use on farmland in Avra Valley and pursuant to Arizona Revised Statute 45-463 F. The fourth source is 161,418 acre-feet of groundwater available from 2001 to 2019 for the remediation of contaminated groundwater. The fifth, and final resource, is approximately 791,000 acre-feet. This is considered to be the amount of incidental recharge that will occur over 100 years. This amount is calculated as 4% of Tucson Water's total water use. All allowable groundwater credit amounts are firm except for the final source which can change based on water consumption.

Table 1: Tucson Water Firm Water Supplies 2003 - 2025

Year	Reclaimed Water* (AF)	Effluent (AF)	CAP Use (AF)	CAGRD	Total Supply	Demand (177 GPCD)	"Balance"
2003	13,121	8,809	42,597	5,000	69,527	136,948	(67,421)
2005	13,121	9,640	61,300	12,500	96,561	143,150	(46,589)
2010	13,121	8,671	125,000	12,500	159,292	157,599	1,693
2015	13,784	18,617	135,966	12,500	180,867	172,302	8,565
2020	14,960	17,441	142,672	12,500	187,573	187,005	568
2025	16,137	16,264	142,672	12,500	187,573	201,709	(14,136)

Source: Pima County Wastewater Facility Update Plan 2005; CAP delivery schedule, CAP website; CAGRD Plan of Operation November 2004

In 2004 Tucson Water's allowable groundwater was 1,407,016 af (this includes GW used pursuant to ARS 46-463 F but not the sum total of ARS 46-463 F available)

Table 1, Tucson Water Firm Water Supplies 2003 - 2025. This table demonstrates what we have determined to be Tucson Water's most secure and both physically and legally available water resources. In 2003, according to the Tucson Water Plan, actual **reclaimed water** use was 13,121 AF. Thirteen thousand one hundred and twenty-one is assumed for 2005 – 2010 because 8% of demand, Tucson Water's rate of consumption indicated in the Plan, would be less than 13,121 AF. From 2015 – 2025 it is assumed that reclaimed water demand will be 8% of total demand.

All **effluent** use numbers come from the Pima County Wastewater Facility Update Plan 2005. For 2003 – 2010 the amount of reclaimed water is subtracted from the effluent total, and the result is divided by two to account for managed recharge credits. Beginning in 2015, the full amount of effluent is utilized because the Tucson Water Plan indicates that full utilization of effluent will be achieved by 2014.

CAP use for 2003 – 2005 is based on the CAP delivery schedule taken from the CAP website. In 2010 CAP use is assumed to be 125,000 AF because the Tucson Water Plan indicates that SAVSARP (a recharge/recovery facility) will be online by 2007 and recharging 45,000 AF a year and CAVSARP (also a recharge/recovery facility) will be permitted to recharge 80,000 AF. The amount of CAP water use in 2015 increases to 135,966 because the Tucson Water Plan states that full utilization of their CAP allocation will occur on or before 2012. (Note, Tucson Water Plan does not account for their pending new allocation, therefore full utilization is 135,966 AF not 144,172 AF). From 2020 – 2025 the amount of CAP use is taken from the CAGRD Plan of Operation (November 2004) because it is expected that Tucson Water will receive their additional allocation of CAP water.

The amount of reliance on **CAGRD replenishment** for 2003 is the amount that Tucson Water actually used. For 2005 to 2012 12,500 AF is used because this is the maximum amount of water that the CAGRD can recharge on Tucson Water's behalf. (Note, in the Tucson Water Plan they do not indicate that they will use this 12,500 AF allowance).

Supply is the sum of reclaimed, effluent, CAP and CAGRD water resources. Demand estimates are taken from the CAGRD Outlook 2003 study and assume a GPCD of 177. Population figures from the Outlook

Study are based on Pima Association of Governments (PAG) estimates. The balance column is supply minus demand

Table 2: Making Up the Difference 2003 – 2025

Year	"Balance"	Allowable GW - Recharge	Remediation GW	Balance	ARS 46-463.F Use	Allowable GW - AWS Designation	Balance
2003	(67,421)	5,478	6,802	(55,141)	42,330	12,811	0
2005	(46,589)	5,726	8,495	(32,368)			
2010	1,693	6,304	8,495	16,492			
2015	8,565	6,892	8,495	23,952			
2020	568	7,480	0	8,048			
2025	(14,136)	8,068	0	(6,068)			

Source: Tucson Water Report to CAGRD 2003

Table 2, Making Up the Difference 2003 – 2025 In table one there is a negative balance most years, meaning that Tucson Water will have to rely on groundwater or another water resource to meet demand. Table two shows how Tucson Water might make up the difference by first subtracting incidental recharge credits and remediation water credits. Incidental recharge credits are demand for that year from table one multiplied by 4%. Remediation credits for 2003 are the actual number of credits used by Tucson Water in 2003, taken from Tucson Water's 2003 report to the CAGRD. For 2005 – 2015 the amount of remediation credits is the annual amount indicated in the Tucson Water Plan (161,418 divided by 18 years). Remediation credits do not extend past 2015 because Tucson Water can only utilize them between 2001 and 2019. In some years even after incidental recharge and remediation credits are used there is still a deficit. The last three columns here show, for 2003 only, the actual method that Tucson Water used to close the gap. This information comes from Tucson Water's 2003 report to the CAGRD.

Other Firm Water Supply Scenarios

These tables provide water budgets for the rest of the Tucson AMA using a format similar to the Tucson Water Scenarios spreadsheet. The spreadsheet includes water budgets for Town of Marana, Town of Oro Valley, Metro Water and the rest of the Tucson AMA.

For these water budgets all **effluent** figures are taken from the Pima County Wastewater Facility Update Plan 2005. In these budgets reclaimed water is not separated from effluent because projections of reclaimed water use were not available. All **CAP use** and maximum dependence on **CAGRD replenishment** numbers are from the CAGRD Plan of Operation (November 2004). Maximum dependence on the CAGRD for the DAWS figures are based on the current assured water supply designations for each water provider. Unlike the City of Tucson, the amount each water provider can depend on the CAGRD for their DAWS can increase based on their needs. **Incidental recharge** is the amount of demand each year multiplied by 4%. Supply is the sum of effluent, CAP use, CAGRD replenishment and incidental recharge. Balance is supply minus demand. The amount of allowable groundwater for Marana, Oro Valley and Metro Water is the amount of allocation remaining at the end of 2004 and is from each water provider's 2004 annual report to the CAGRD.

Table 1: Town of Marana Firm Water Supplies 2005 -2025

Year	Effluent Flows* (AF per year)	CAP Use (AF per year)	Max DAWS Dependence on CAGRD (AF/Yr)	Incidental Recharge	Total Supply	Demand	"Balance"
2005	0	0	3,700	117	3,796	2,930	1,406
2010	0	0	3,700	179	3,879	4,484	(605)
2015	0	0	3,700	242	3,942	6,049	(2,107)
2020	0	0	3,700	305	4,005	7,615	(3,610)
2025	0	0	3,700	367	4,067	9,181	(5,114)

Source: CAGRD Plan of Operation November 2004

In 2004 Marana had 2,646 af remaining of their allowable groundwater

Table 1: Town of Marana Firm Water Supplies 2005 - 2025 As of 2003 the Town of Marana did not have any dedicated effluent flows. CAP use is indicated as zero because, although Marana has an allocation of 47 AF, CAGRD indicates that they will not be using this allocation. Marana's demand figures are taken from the CAGRD Outlook 2003 report and assume 140 GPCD. Population figures for demand are based on PAG population estimates. The maximum DAWS dependence on the CAGRD is based on Marana's current AWS designation and can increase in subsequent AWS designations.

Table 2: Town of Oro Valley Firm Water Supplies 2005 – 2025

Year	Effluent Flows* (AF per year)	CAP Use (AF per year)	Max DAWS Dependence on CAGRD (AF/Yr)	Incidental Recharge	Total Supply	Demand	"Balance"
2005	2,111	0	10,447	357	12,915	8,926	3,989
2010	1,979	9,541	10,447	382	22,349	9,541	12,808
2015	2,218	10,176	10,447	407	23,248	10,176	13,072
2020	2,535	10,305	10,447	432	23,719	10,812	12,907
2025	2,947	10,305	10,447	458	24,157	11,447	12,710

Source: CAGRD Plan of Operation November 2004; Pima County Wastewater Facility Update Plan 2005

In 2004 Oro Valley had 28,880 af of allowable groundwater remaining

Table 2, Town of Oro Valley Firm Water Supplies 2005 – 2025 Demand assumes 446 Gallons per Housing Unit per Day (GPHUD) and is taken from the CAGRD Outlook 2003 study. It should be noted, however, that in their most recent report to the GRD (2004) Oro Valley shows their GPCD to be 200 with demand in 2005 10,299 AF compared to CAGRD estimate of 8,926 AF in 2005 and 11,871 AF in 2010 compared to CAGRD estimate of 9,541 AF for 2010. The maximum DAWS dependence on the CAGRD is based on Oro Valley's current AWS designation and can increase in subsequent AWS designations.

Table 3: Metro Water Firm Water Supplies 2005 – 2025

Year	Effluent Flows* (AF per year)	CAP Use (AF per year)	Max DAWS Dependence on CAGRD (AF/Yr)	Incidental Recharge	Total Supply	Demand	"Balance"
2005	3146	8,858	11,000	398	23,402	9,945	13,457
2010	2951	10,204	11,000	408	24,563	10,204	14,359
2015	3306	10,496	11,000	420	25,222	10,496	14,726
2020	3779	10,788	11,000	432	25,999	10,788	15,211
2025	4393	11,080	11,000	443	26,916	11,080	15,836

Source: CAGRD Plan of Operation November 2004; Pima County Wastewater Facility Update Plan 2005

In 2004 Metro Water had 121,277 AF of allowable groundwater remaining

Table 3, Metro Water "Real" 2005 – 2025 Demand assumes 399 GPHUD and is taken from CAGRD Outlook 2003 Study. These numbers are very similar to the most recent GRD report (2004) to ADWR. In this report Metro Water assumes a GPCD of 160 in 2004 decreasing every few years to 156 GPCD in 2013. The maximum DAWS dependence on the CAGRD is based on Metro Water's current AWS designation and can increase in subsequent AWS designations.

Table 4: Rest of Tucson AMA Firm Water Supplies 2005 – 2025

Year	Effluent Flows (AF per year)*	CAGRD Projected Excess GW Use	CAP Use (AF per year)	Incidental Recharge	Total Supply	Demand	"Balance"
2005	5,985	2,116	500	560	9,161	14,012	(4,851)
2010	6,488	5,017	500	691	12,696	17,277	(4,581)
2015	7,840	5,292	500	804	14,436	20,099	(5,663)
2020	9,169	9,838	500	908	20,415	22,701	(2,286)
2025	10,721	12,012	500	1,018	24,251	25,452	(1,201)

Source: CAGRD Plan of Operation November 2004; Pima County Wastewater Facility Update Plan 2005

*Data based on projections for Pima County plus projections for WWTP outside of PC with values between 2010 – 2020 interpolated

Table 4, Rest of Tucson AMA Firm Water Supplies 2005 – 2025 For this table projected excess groundwater figures from the CAGRD Plan of Operation were used in lieu of maximum dependence on CAGRD because maximum dependence on CAGRD numbers were not readily accessible. Demand figures were taken from the CAGRD Plan of Operation. The GPCD or GPHUD vary greatly across the many providers included in this table.

Appendix B: Glossary

Acre-foot – A unit of water measurement. One acre-foot of water will cover an acre of land to a depth of one foot. One acre-foot is equivalent to 325,851 gallons.

Allowable Groundwater – The principal source of allowable groundwater comes from the allowance granted by the Assured Water Supply program to each designated water provider based on their water consumption in 1994 multiplied by 15 years. Allowable groundwater can also come from extinguishing grandfathered water rights and, in the case of Tucson Water, from a land purchase in Avra Valley (see ARS 45-463 F).

Assured Water Supply – Any new subdivision developer within an Active Management Area must demonstrate that a 100-year water supply is available before s/he can sell the land. An AWS can be established either through a municipal water provider's Designation of Assured Water Supply (DAWS) for their service area or a developer's Certificate of Assured Water Supply (CAWS). (For further discussion of AWS Rules see pgs. 4 - 8)

Active Management Area – A geographical area which has been designated pursuant to the Groundwater Management Act of 1980 as requiring active management of groundwater. (Defined by ARS 45-402)

Central Arizona Groundwater Replenishment District (CAGRD) – Replenishment authority created by the legislature in 1993 and operated by the Central Arizona Water Conservation District. The CAGRD operates in Pima, Pinal and Maricopa Counties. The CAGRD was created to help municipal providers comply with the Assured Water Supply Rules. (For more information see pgs. 11 - 14)

Central Arizona Water Conservation District (CAWCD) – Originally established to operate and maintain the CAP canal. The CAWCD is a political subdivision of the state and covers Pima, Pinal and Maricopa Counties. In 1993 the CAWCD became the operating entity for the CAGRD as well.

Certificate of Assured Water Supply – A permit issued by the director of ADWR for a development, other than a master-planned community, after the director determines that an assured water supply exists for the development pursuant to A.R.S. 45-576. A Certificate is connected to a particular parcel of land and only new development on that land is prevented from relying on groundwater mining to meet water demands.

Designation of Assured Water Supply – An order issued by the director of ADWR designating a municipal provider as having an assured water supply pursuant to A.R.S. 45-576. Once the municipal provider obtains the designation for their service area any new subdivision within that service area is deemed to have met the AWS Rule. A designation of assured water supply is associated with the entire service area of a water provider. The designated water provider must show that renewable water supplies will be used to serve both pre-1995 demand and any new demand.

Effluent - Treated municipal wastewater. If effluent is re-used it is considered reclaimed water.

Excess Groundwater - The amount of groundwater used that is more than the allowable amount of groundwater according to the AWS Rules.

Exempt well – Well with a maximum pump capacity of less than 35 gallons per minute used for non-irrigation purposes. As of January 1, 2006 exempt wells cannot be drilled in active management areas on

land if any part of the land is within 100 feet of an operating water distribution system of a municipal water provider that has an assured water supply designation.

Gallons per Capita per Day (GPCD) – Amount of water that one person uses in one day. This amount includes commercial/industrial uses, residential indoor/outdoor uses, reclaimed water use, and lost and unaccounted for water.

Gallons per Housing Unit per Day (GPHUD) – Amount of water used by one housing unit in one day. It is generally assumed that each housing unit contains, on average, 2.8 people. This amount includes commercial/industrial uses, residential indoor/outdoor uses, reclaimed water use, and lost and unaccounted for water.

Grandfathered Water Rights – These water rights can be: Type 1, non-irrigation grandfathered rights; Type 2, non-irrigation grandfathered rights and irrigation grandfathered rights. Type 1 non-irrigation rights are associated with land permanently retired from farming and converted to a non-irrigation use. Type 2 non-irrigation rights are based on the maximum amount of water pumped for a non-irrigation use from a non-exempt well in any year between 1975 and 1980.

Graywater – Water from bathtubs, laundry and bathroom sinks. According to Arizona law, water from kitchen sinks and dishwashers is not considered graywater.

Groundwater Allocation – Amount of allowable groundwater designated under the Assured Water Supply rules for a municipal water provider.

Groundwater Mining – The amount of groundwater withdrawn or received by a municipal provider from within an active management area during a calendar year for use in its service area minus incidental recharge.

Incidental Recharge – The percolation of water to an aquifer after the water has been withdrawn, diverted or received for delivery by a municipal provider for use within its service area (ARS 45-651). Each municipal provider is entitled to allowable groundwater credits equal to 4% the amount of water used during each year. These groundwater credits are known as incidental recharge credits.

Industrial Use – Term used in active management areas for a non-irrigation use of water that is not supplied by a city, town or private water company, including animal industry use and expanded animal industry use. (ARS 45-651). Turf areas, including golf courses, are considered industrial uses when the water is not supplied by a city, town or private water company.

Long-term Water Storage – Renewable water manually stored underground which is not recovered in the same calendar year. For long-term storage water a 5% cut to the aquifer is assessed. A cut to the aquifer is a percentage of water that was stored that is not recovered. For example, if 100 acre-feet of water is placed in long-term storage only 95 acre-feet will be available for future use.

Lost and Unaccounted for Water – Part of the calculation of GPCD and GPHUD. It is the comparison of a water user's annual water production to its annual water deliveries. The difference between these two figures is considered lost and unaccounted for water. Sources of lost and unaccounted for water include meter error, leaks and theft.

Managed Recharge Credit – When a renewable water supply is allowed to naturally recharge a managed recharge credit is received. The credit holder receives credit for only 50% of the water the infiltrates into the groundwater.

Member Land (ML) - A term used by CAGRD for an individual subdivision that commits to paying a replenishment assessment and whose water provider agrees to submit the water delivery information necessary to calculate the annual assessment. Once enrolled, the member land cannot change its boundaries without approval of the CAGRD. There are 74 MLs in the Tucson AMA.

Member Service Area (MSA) – Term used by the CAGRD for a city, town, district or water company that submits annual reports to CAGRD indicating the amount of excess groundwater delivered in their service area. The MSA pays a tax to CAGRD based on use to fund replenishment. There are seven MSAs in the Tucson AMA.

Municipal Use –All non-irrigation uses of water supplied by a city, town, private water company or irrigation district. (ARS 45-651)

Municipal Water Provider – A city, town, private water company or irrigation district that supplies water for non-irrigation use. (ARS 45-651)

Overdraft – Groundwater use in excess of natural replenishment of aquifer.

Reclaimed Water – Treated effluent that is used for turf irrigation or other industrial uses.

Renewable Water Supplies – Any water supply other than mined groundwater, e.g., Central Arizona Project Water, effluent, etc.

Safe-yield - A groundwater management goal which attempts to achieve and thereafter maintain a long-term balance between the annual amount of groundwater withdrawn in an active management area and the annual amount of natural and artificial recharge in the active management area. (ARS 45-651)

Short-term Water Storage - Surface water manually stored underground that is recovered in the same calendar year. No cut to the aquifer is assessed.

Water Harvesting – The capture and storage of rainfall to irrigate plants or supply people and animals.

Appendix C: Other Tucson Area Water Supply and Demand Tables and Figures

I. Effluent

Table 1: Effluent Availability							
Calendar Year	2003	2004	2005	2010	2015	2020	2025
SAWRSA	28200	28200	28200	28200	28200	28200	28200
CEP	0	0	1638	8000	10000	10000	10000
Tucson Water	30861	30663	32401	30463	32907	34939	38752
Metro Water	3074	2937	3146	2951	3306	3779	4393
Oro Valley Water	2062	2360	2111	1979	2218	2535	2947
Pima County	4300	3996	4445	3933	4270	4584	5121
Total	68,497	68,156	71,942	75,525	80,901	84,037	89,413

Source: Pima County Wastewater Facility Update 2005

Table 1: Effluent Availability - Pima County Waste Water Management (PCWWM) is the major producer of effluent in the Tucson area. The 1979 Merger IGA dictates that the first 28,200 AF of effluent go to the United States under the Southern Arizona Water Rights Settlement Act (SAWRSA). Tucson Water has rights to 90 percent of the remaining effluent, which was about 36,000 AF in 2004. (Tucson Water shares approximately 8 percent of its allotment with Metro Water, and 5 percent with Oro Valley Water Utility).[41] The remaining 10 percent of available effluent goes PCWWM, about 4,000 AF in 2004. Effluent flows from non-metropolitan facilities such as Avra Valley, Marana, and Corona de Tucson are expected to increase from around 2,789 AF in 2005 to 10,323 AF by 2025.[42]

Environmental restoration projects are projected to use 5,603 AF of effluent annually by 2010 from the Conservation Effluent Pool allocation. The Conservation Effluent Pool, which specifies 10,000 AF of effluent for environmental restoration projects, was identified in the 2000 Supplemental Intergovernmental Agreement. The implementation of the use of this pool requires a separate agreement, which is currently being negotiated with the City of Tucson.[43]

[41] Brown and Caldwell. Spring 2006 *Pima County Wastewater Management Department Metropolitan Area Facility Plan Update.* Revised Draft Tucson: Pima County Wastewater Management Department. p. 6.2
[42] Ibid. p. 6.5
[43] Ibid. 6.4

II. CAP Historic Deliveries to the Tucson AMA

Table 1: CAP Deliveries 1999 - 2005 (through Sept)

	1999	2000	2001	2002	2003	2004	2005 (to Sept)	**Total by Type**
Marana (Incentive)		1,500	2,047	1,047	1,047	1,047	2,271	8,959
City of Tucson	9,240	9,248	19,176	20,433	42,597	56,200	48,717	205,611
City of Tucson (Incentive)	5,906	3,799	4,306	8,533				22,544
Cortaro-Marana ID	1,981	0				2,500	5,750	10,231
AVRP/AWBA	0	1,978	6,311	6,805	3,539	6,084	1,882	26,599
CAVSARP/AWBA	7,365	0				6,000	8,000	21,365
Green Valley						597	400	997
Green Valley (Incentive)	0	0						0
Kai Farms						1,000	1,500	2,500
Kai Farms (Incentive)	0	0						0
Kai Farms/AWBA			1,110	1,722	3,092	1,100		7,024
BKW Farms						3,463	3,620	7,083
BKW Farms/AWBA					1,527			1,527
Metro Water					8,145	8,858	8,445	25,448
Metro Water (Incentive)	4,220	8,000	8,000	7,104				27,324
Oro Valley (Incentive)	2,000	2,500	2,500	2,500	2,500	2,500	2,500	17,000
Pima Mine Rd/AWBA	10,468	7,393	13,174	22,307	17,315	18,265	14,660	103,582
Spanish Trail (Incentive)		8,533						8,533
Vail Water Co (Incentive)		786	786	786	786	1,268	786	5,198
San Xavier Coop. Farm		0	820	1,208	1,516	1,611	2,074	7,229
Tohono O'Odham/Schk Tk		702	8,337	9,899	12,702	11141	10216	52,997
Total by Year	41,180	42,939	64,520	81,297	93,719	120,587	108,550	

Source: Compiled from data on CAP website http://www.cap-az.com/operations/index.cfm?action=deliveries&subSection=15

Table 2: CAP Deliveries 1999 - 2005 (Scheduled)

	1999	2000	2001	2002	2003	2004	2005 (Scheduled)	**Total by Type**
Marana (Incentive)		1,500	2,047	1,047	1,047	1,047	2,547	9,235
City of Tucson	9,240	9,248	19,176	20,433	42,597	56,200	61,300	218,194
City of Tucson (Incentive)	5,906	3,799	4,306	8,533				22,544
Cortaro-Marana ID	1,981	0				2,500	5,750	10,231
AVRP/AWBA	0	1,978	6,311	6,805	3,539	6,084	3,289	28,006
CAVSARP/AWBA	7,365	0				6,000	15,000	28,365
Green Valley						597	604	1,201
Green Valley (Incentive)	0	0						0
Kai Farms						1,000	1,500	2,500
Kai Farms (Incentive)	0	0						0
Kai Farms/AWBA			1,110	1,722	3,092	1,100	1,000	8,024
BKW Farms						3,463	3,620	7,083
BKW Farms/AWBA					1,527			1,527
Metro Water					8,145	8,858	8,858	25,861
Metro Water (Incentive)	4,220	8,000	8,000	7,104				27,324
Oro Valley (Incentive)	2,000	2,500	2,500	2,500	2,500	2,500	2,500	17,000
Pima Mine Rd/AWBA	10,468	7,393	13,174	22,307	17,315	18,265	24,584	113,506
Spanish Trail (Incentive)		8,533						8,533
Vail Water Co (Incentive)		786	786	786	786	1,268	786	5,198
San Xavier Coop. Farm		0	820	1,208	1,516	1,611	19,626	24,781
Tohono O'Odham/Schk Tk		702	8,337	9,899	12,702	11,141		42,781
Total by Year	41,180	42,939	64,520	81,297	93,719	120,587	148,417	

Source: Compiled from data on CAP website http://www.cap-az.com/operations/index.cfm?action=deliveries&subSection=15

Tables 1 and 2: CAP Deliveries – Table 1 shows CAP deliveries to the Tucson AMA from1999 through September 2005. Table 2 shows CAP deliveries to the Tucson AMA from 1999 to the end of 2005, with deliveries for October through December assumed based on scheduled deliveries for the year.

III. Population

Table 1: Population Projections					
	2005	2010	2015	2020	2025
PAG	954,549	1,057,775	1,161,002	1,264,228	1,367,445
TAMA	921,000	1,005,300	1,092,300	1,179,200	1,266,500
DES	943,795	1,031,623	1,119,342	1,206,244	1,290,996

Source: Pima County Wastewater Management Department Metropolitan Area Facility Plan Update (2005); Tucson AMA Third Management Plan (1999) and Department of Economic Security webpage http://www.workforce.az.gov/?PAGEID=67&SUBID=138 (projections were updated in 2005).

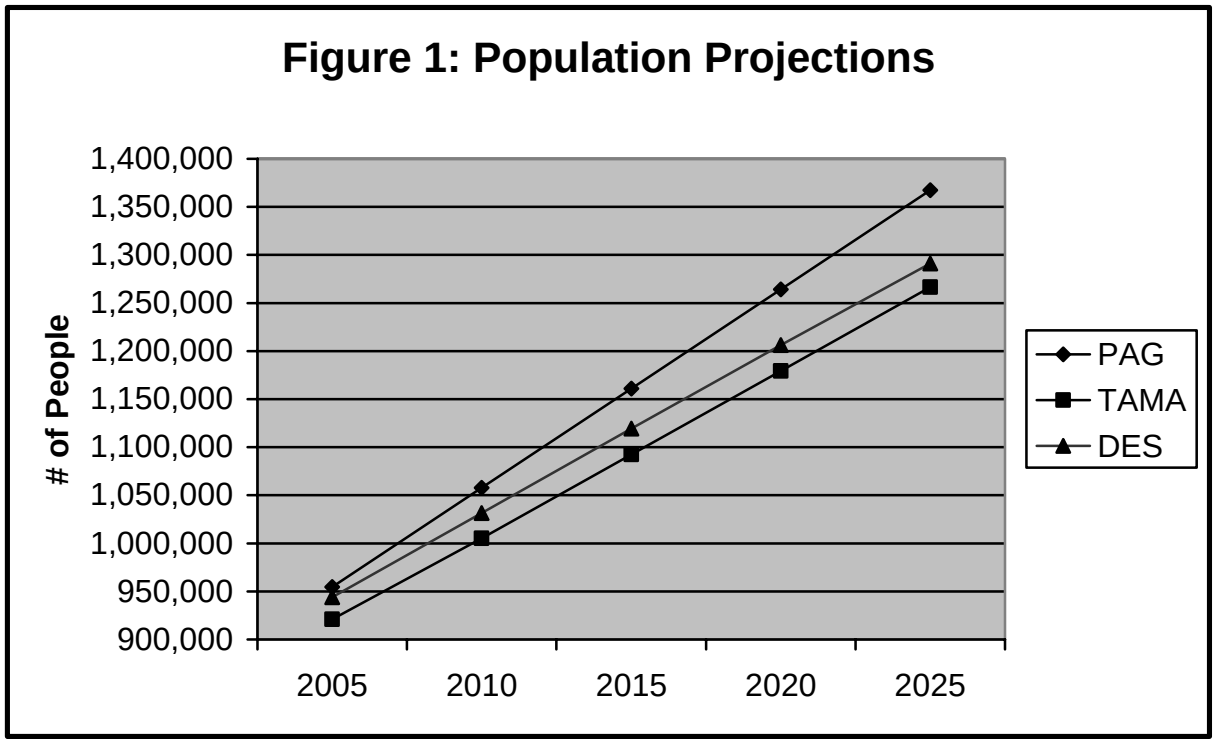

Table 1 and Figure 2: Population Projections - These figures are from: the Pima Association of Governments population projections as reported in the Pima County Wastewater Management Department Metropolitan Area Facility Plan Update (2005); the Tucson AMA Third Management Plan (1999) and the Department of Economic Security webpage on population projections (projections were updated in 2005). Note that the PAG and DES population projections are for Pima County only whereas the TAMA projections include parts of Pinal County, Santa Cruz County and do not include all of Pima County.

IV. Demand

Table 1: Demand, Designated Water Providers (In Acre Feet)					
	2005	2010	2015	2020	2025
City of Tucson	143,150	157,599	172,302	201,709	216,412
Metro Water	9,945	10,204	10,496	10,788	11,080
Rancho Sahuarita WC	246	492	741	991	1,240
Spanish Trail	697	1,250	1,808	2,366	2,924
Town of Marana	2,930	4,484	6,049	7,615	9,181
Town of Oro Valley	8,926	9,541	10,176	10,812	11,447
Vail Water Company	941	1,425	1,916	2,407	2,898
	166,295	184,995	203,488	236,688	255,182

Table 2: Demand, Large Water Providers (In Acre Feet)					
	2005	2010	2015	2020	2025
City of Tucson	143,150	157,599	172,302	201,709	216,412
Metro Water	9,945	10,204	10,496	10,788	11,080
Town of Marana	2,930	4,484	6,049	7,615	9,181
Town of Oro Valley	8,926	9,541	10,176	10,812	11,447
Vail Water Company	941	1,425	1,916	2,407	2,898
Voyager WC	140	144	149	154	159
Ray WC	1,466	1,498	1,538	1,577	1,617
Las Quintas	225	248	276	305	333
Lago del Oro	1,487	1,686	1,894	2,101	2,310
Green Valley WC	714	775	846	917	988
Flowing Wells ID	1,901	1,916	1,938	1,959	1,981
Com WC of GV	2,082	2,246	2,362	2,477	2,592
Avra WC	590	612	637	663	689
	173,957	192,378	210,579	243,484	261,687

Source: CAGRD Plan of Operation Draft Nov, 8 2004 table C-1

Tables 1 and 2: Demand, Designated and Large Water Providers – This information is a summary of information for the Tucson AMA taken from the CAGRD Plan of operation. For each water provider demand was determined using PAG population projections and the GPCD or GPHUD provided by each water provider. In table 2 large water providers University of Arizona, Davis Monthan Air Force Base, and the Arizona State Prison are not included because demand information was not available on them as they are not members of the CAGRD.

Appendix D – References

Source: Anderson, Mark T. and Lloyd H. Woosley, Jr. 2005. Water Availability for the Western United States – Key scientific challenges: U.S. Geological Survey Circular 1261.

Arizona Department of Water Resources. 2003. *AWS No. 2003-001 Assured Water Supply Designation for the Town of Oro Valley.* Phoenix: Arizona Department of Water Resources.

Arizona Department of Water Resources. 1999. *Third Management Plan for Tucson Active Management Area 2000 – 2010.* Tucson: Arizona Department of Water Resources.

Arizona Water Settlements Act. S. 437 sec 304 - 312

Brown and Caldwell. 2005. *Metropolitan Area Facility Plan Update 2005.* Tucson: Pima County Wastewater Management Department.

Central Arizona Groundwater Replenishment District. 2004. C*entral Arizona Groundwater Replenishment District Plan of Operation Submitted Draft November 2004.* Phoenix: Central Arizona Groundwater Replenishment District.

Central Arizona Project and Maricopa Association of Governments Information Center. 2004. *Outlook 2003: Municipal Demand Projections for CAWCD's Service Area Assuming Historic Data through January 2003.* Phoenix: Central Arizona Project.

Central Arizona Project. 2005. *CAP Subcontracting Status Report.* Phoenix: Central Arizona Project. Available at: http://www.cap-az.com/about/ index.cfm?action= allocations&subSection=7

Central Arizona Project. 1999 – 2005. *Water Deliveries.* Accessed on CAP website http://www.cap-az.com/about/index.cfm?action=allocations&subSection=7. 01/17/06

City of Tucson Water Department. 2004. *Water Plan 2000 – 2050.* Tucson: City of Tucson.

City of Tucson Water Department. 1999 – 2004. *Annual Report to Groundwater Replenishment District.* Phoenix: Arizona Department of Water Resources.

CH2MHill. 1989. *Tucson Water Resources Plan 1990 – 2100.* Tucson: CH2MHill.

CH2MHill. 2002. *Town of Oro Valley Reclaimed Water System Master Plan: Revised Draft.* Tempe: CH2MHill.

Little, Val. *Graywater Guidelines.* Tucson: Water Conservation Alliance of Southern Arizona. Available at http://www.watercasa.org/pubs/Graywater%20Guidelines.pdf

Metropolitan Domestic Water Improvement District. 1999 – 2004. *Annual Report to Groundwater Replenishment District.* Phoenix: Arizona Department of Water Resources.

Office of Economic Development and Water Resources Research Center. 2004. *Arizona's Water Future: Challenges and Opportunities.* Tucson: University of Arizona. Available at online at www.cals.arizona.edu/azwater/.

Town of Marana. 1999 – 2004. *Annual Report to Groundwater Replenishment District.* Phoenix: Arizona Department of Water Resources.

Town of Oro Valley. 1999 – 2004. *Annual Report to Groundwater Replenishment District.* Phoenix: Arizona Department of Water Resources.

Water Resources Research Center. 1999. *Water in the Tucson Area: Seeking Sustainability.* Tucson: Water Resources Research Center.

WestLand Resources, Inc. 2003. *Town of Oro Valley Potable Water System Master Plan.* Tucson: WestLand Resources, Inc.

WestLand Resources, Inc 2004. *Town of Marana Potable Water Master Plan – 2004.* Tucson: WestLand Resources, Inc.

Governor's Water Management Commission. 2001. *Final Report of the Governor's Water Management Commission*. Phoenix: Arizona Department of Water Resources. Available at http://www.azwater.gov/dwr/Content/Publications/files/FinalReport.pdf

SAWARA. 2000. "How Much Population Growth Can Be Supported by Our Water Supply?" *Water Words* Volume 18, Number 2, Autumn 2000.

Vanoverbeke, Christina "Water reuse plans become reality: Phase 1 of OV's reclaimed water system complete." Northwest Explorer Aug. 3 2005