WATER AND GROWTH: FUTURE WATER SUPPLIES FOR CENTRAL ARIZONA[1]

Global Institute of Sustainability
Discussion Paper #1

Background paper for June 21, 2006 workshop on
Future Water Supplies for Central Arizona,

Sponsored by Arizona State University's Global Institute of Sustainability

in coordination with the

University of Arizona's Water Resources Research Center's Conference:
Providing Water to Arizona's Growing Population: How Will We Meet the Obligation?[1]

(draft 6/13/2006)

Jim Holway
Peter Newell
Terri Sue Rossi[2]

[1] This paper, additional appendices, background information for the June 21 workshop, and a link for providing comments on the paper are posted at: http://sustainability.asu.edu/gios/waterworkshop.htm.

TABLE OF CONTENTS

FIGURES, TABLES AND APPENDICES

- Overview of Arizona Water Management Programs
  - Managing for sustainability in an urban climate: Lessons learned from 20 years of groundwater management in Arizona, US
- AMA Water Budgets
- Assured Water Supply Rules Summary
- Sample Water Efficiency Practices
- Arizona Department of Water Resources
  - Arizona Water Settlements Act
  - Assured Water Supply Rules
  - Updated AMA Water Budgets
- Central Arizona Project (CAP)
  - Central Arizona Water Conservation District (CAWCD)
  - CAP Allocations
- Central Arizona Groundwater Replenishment District (CAGRD)
  - University of Arizona Water Resources Research Center background paper on CAGRD
- Bureau of Reclamation - Lower Colorado Region
  - Colorado River Allocations

I. INTRODUCTION

Does central Arizona have enough water to continue growing? How many people can live here? Where will the water come from….and for how long is this water use sustainable? Nearly all discussions of growth in our region and throughout the state eventually turn to questions about the adequacy of our water supplies. The purpose of this paper is to consider future municipal[3] water supplies for our region and to advance discussions on the issues involved in putting those supplies to use in central Arizona.

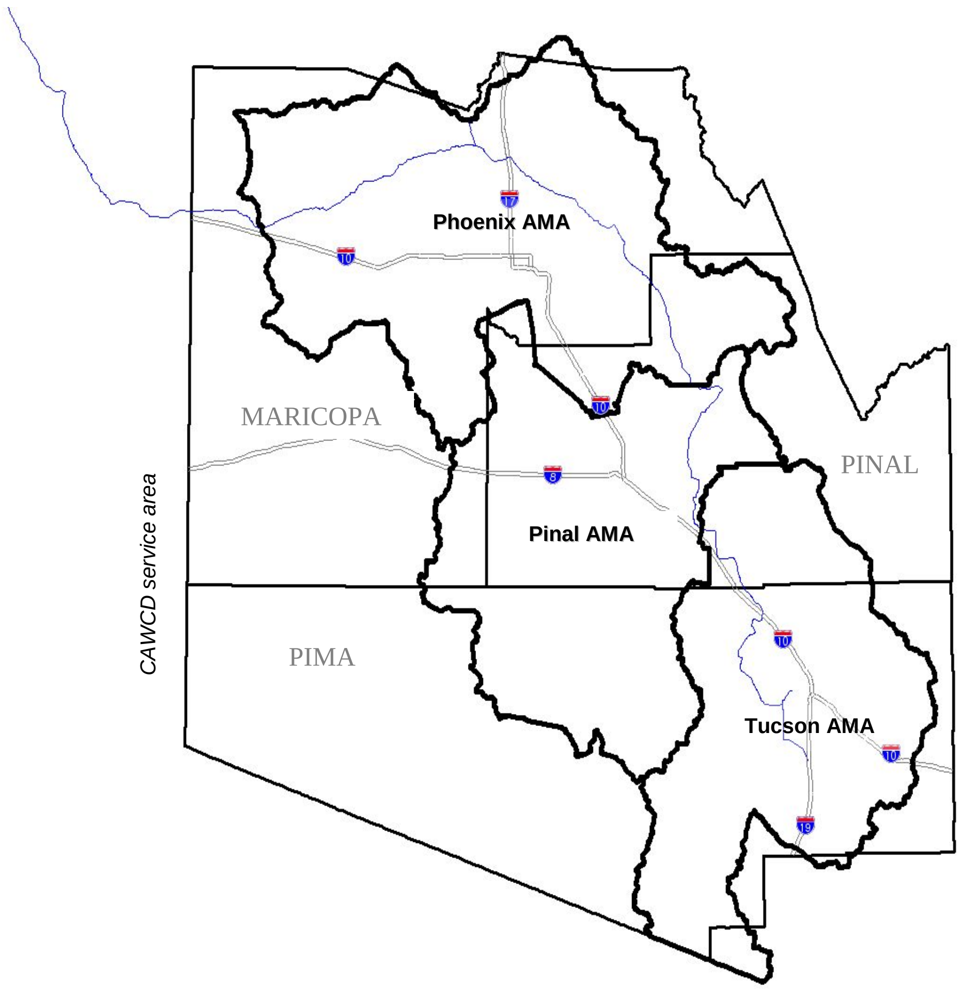
This paper looks at growth, water needs, and water-supply issues for the Phoenix, Pinal, and Tucson Active Management Areas (AMAs[4]) over the next 50–100 years. These three central Arizona AMAs encompass the vast majority of the population within Maricopa, Pinal, and Pima counties. We use this timeframe and regional area for three principal reasons. First, major water-supply investments typically take several decades to plan and build so that water-supply planning must occur years in advance of meeting water demands. Second, by looking at the longer term, we see potential impacts and major infrastructure needs that are not clear if we only look out 20–30 years[5]. Third, new supplies, at least for the next several decades, will be transported primarily through the Central Arizona Project (CAP). Because these supplies can be used in any of the three AMAs, a regional perspective that includes all three AMAs is essential. Figure 1 shows the CAWCD service area, the three AMAs, and the respective counties.

Based on the available information presented in this paper, sufficient water supplies could likely be made available for continued development in central Arizona for some time to come. However, few, if any, unallocated renewable water supplies remain in the Southwest. Increasing the water supplies for growing urban areas, at some point, will require either transfers of water from other uses and users or new, creative mechanisms to exchange or transfer treated seawater. For such transfers to occur a number of legal, political, infrastructure and environmental issues will have to be resolved.

This paper is intended to inform ongoing discussions among water managers, land-development interests, planners, interested citizens and decision makers. As rapid urbanization continues, we will face significant questions about water use and supply. The water-management choices we make will impact regional development, water costs, the institutions and programs established to manage water, and the environmental and social impacts of future water transfers. Political, legal, and economic factors will also shape and constrain these choices. We hope that this paper and ensuing discussions will illuminate the choices available and dispel some of the mystery, confusion, and uncertainty surrounding water issues and their relation to growth in our region.

This "Draft for Discussion" represents a preliminary paper to inform the June 21 workshop sponsored by the Global Institute of Sustainability at Arizona State University. This draft focuses on a single illustrative scenario of future water demand and potential supplies to meet the demand. We have intentionally not provided a comprehensive treatment of the many related issues and challenges to transferring new water supplies into central Arizona, preferring to leave this to the workshop and subsequent discussions. The Institute will, if comments and discussion indicate sufficient interest, revise this paper, incorporate additional community input, discuss the critical issues raised, and produce a final paper for both decision makers and the general public.

Figure 1. Central Arizona AMAs, counties, and CAWCD service area.



II. POPULATION PROJECTIONS

Approximately 4.8 million people reside within the three AMAs. Population for the three counties (Maricopa, Pinal and Pima) is slightly larger, at 5 million. To project future population, we use the three counties as a proxy for the AMAs[6]. By 2055, according to official state projections[7], population in these counties will increase to over 11.1 million. Extrapolating this data beyond 2055, the population is estimated to increase by 92,000 people per year, reaching 12.9 million people by 2075 and 15.2 million by 2100.[8] Figure 2 illustrates both the historic and projected growth for central Arizona. Projections for the three counties and the rest of the state are seen in Table 1[9].

This paper focuses upon the central Arizona AMAs. However, interactions among different regions in the state are likely to increase as the entire state continues to grow and water transfers between areas are explored to meet increasing demand. Figure 3 illustrates the regions in question. A major source of potential future supplies will be water rights used along the Colorado River; therefore, we briefly examine population growth and potential water demands in the western Arizona counties along the river. In addition, northern Arizona communities, through the Northern Arizona Municipal Water Users Association (NAMWUA) have petitioned for an allocation of CAP water[10]. The Navajo Nation has also filed claims for Colorado River water supplies. Finally, local and federal water managers have also considered the potential of extending the CAP canal further south and east to the Sierra Vista area and Fort Huachuca. Except for the river communities, the other identified areas lack the infrastructure that could be used to import water.

It is beyond the scope of this discussion to determine which communities within these counties might compete for Colorado River water or other supplies being considered by central Arizona water providers. In addition, we have not tried to determine what local supplies will be available

Figure 2. Historic and projected growth for Maricopa, Pima, and Pinal counties (from Table 1)

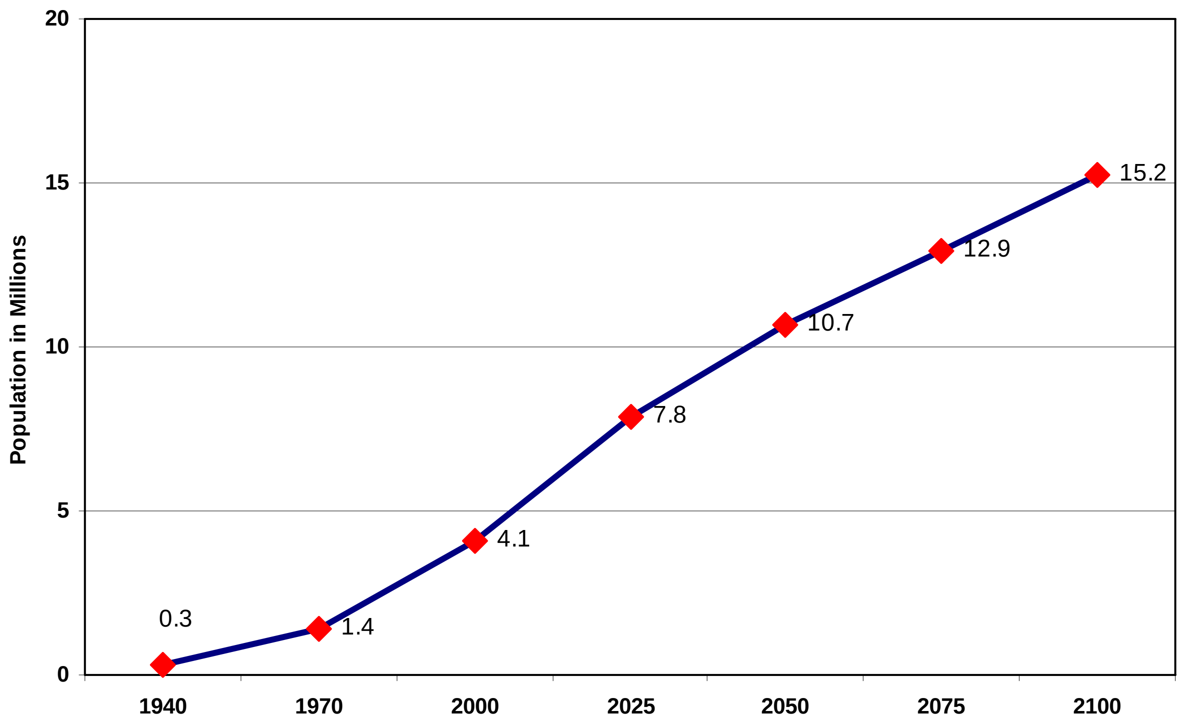
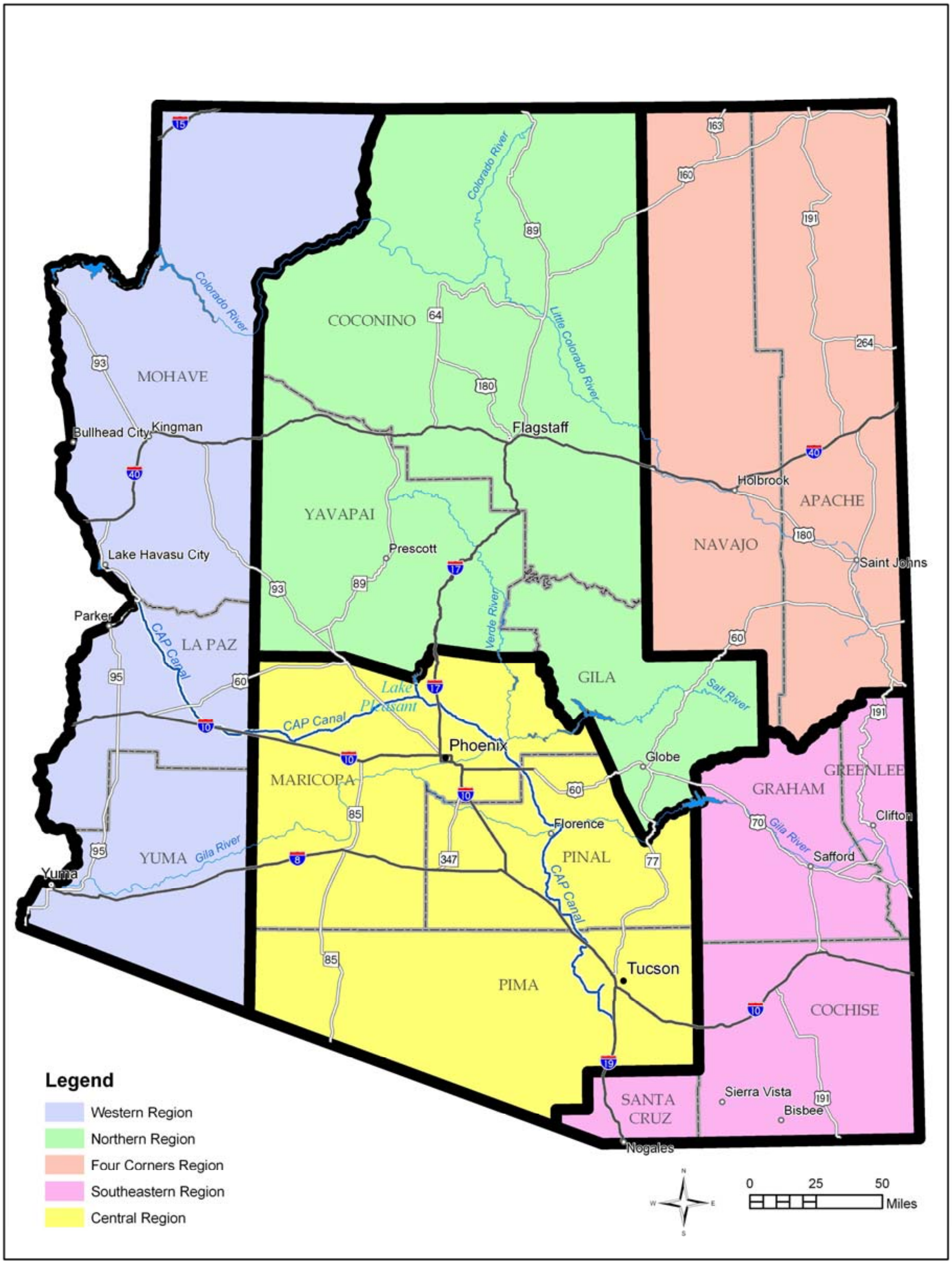


Table 1

Population Projections by County and Region
DES Projections for 2010–2050
Authors Projections[8] for 2060–2100

	2000	2010	2020	2030	2040	2050	2060	2070	2080	2090	2100
Maricopa	3,072,149	4,217,427	5,276,074	6,207,980	7,009,664	7,661,423	8,209,097	8,778,107	9,347,117	9,916,127	10,485,137
Pima	843,746	1,070,723	1,271,912	1,442,420	1,585,983	1,709,026	1,831,622	1,953,646	2,075,670	2,197,694	2,319,718
Pinal	179,727	364,587	609,720	852,463	1,081,737	1,302,950	1,529,581	1,754,566	1,979,551	2,204,536	2,429,521
Central AZ	4,095,622	5,652,737	7,157,706	8,502,863	9,677,384	10,673,399	11,570,300	12,486,319	13,402,338	14,318,357	15,234,376
La Paz	19,715	22,632	25,487	28,074	29,715	30,909	32,382	33,781	35,180	36,579	37,978
Mohave	155,032	221,443	281,668	330,581	367,952	400,695	434,082	467,249	500,416	533,583	566,750
Yuma	160,026	218,810	271,361	316,158	351,299	377,598	403,258	428,769	454,280	479,791	505,302
Western AZ	334,773	462,885	578,516	674,813	748,966	809,202	869,721	929,798	989,875	1,049,952	1,110,029
Apache	69,423	78,229	86,533	93,447	99,190	104,248	109,163	114,093	119,023	123,953	128,883
Navajo	97,470	123,172	147,045	165,647	180,054	192,360	204,644	216,833	229,022	241,211	253,400
Four Corners	166,893	201,401	233,578	259,094	279,244	296,608	313,807	330,926	348,045	365,164	382,283
Coconino	116,320	141,457	159,345	173,829	186,871	198,149	208,076	218,284	228,492	238,700	248,908
Gila	51,335	57,766	64,396	69,879	74,195	78,274	82,750	87,119	91,488	95,857	100,226
Yavapai	167,517	241,667	305,343	355,462	390,954	418,671	446,814	474,640	502,466	530,292	558,118
Northern AZ	335,172	440,890	529,084	599,170	652,020	695,094	737,640	780,043	822,446	864,849	907,252
Santa Cruz	38,381	50,210	61,658	71,033	78,526	84,708	90,776	96,829	102,882	108,935	114,988
Graham	33,489	37,441	41,119	44,556	47,623	49,929	51,544	53,308	55,072	56,836	58,600
Greenlee	8,547	8,209	8,189	8,289	8,611	9,067	9,614	10,148	10,682	11,216	11,750
Cochise	117,755	146,037	169,717	187,725	201,179	212,822	225,372	237,654	249,936	262,218	274,500
Southeast AZ	198,172	241,897	280,683	311,603	335,939	356,526	377,306	397,939	418,572	439,205	459,838
Arizona Total	5,130,632	6,999,810	8,779,567	10,347,543	11,693,553	12,830,829	13,868,772	14,925,023	15,981,274	17,037,525	18,093,776

Figure 3. Map of Arizona regions and counties.



to these communities. However, the rough estimates below do convey the magnitude of potential demands. Table 2 provides population estimates for the areas outside central Arizona, and Table 4 projects their water demands.

Table 2. Population Projections for Selected Areas Outside of Central Arizona

	2000	2050	2100
Western Counties - Totals	334,773	809,202	1,110,030
LaPaz	19,715	30,909	37,978
Yuma	160,026	377,598	505,302
Mohave	155,032	400,695	566,750
Northern Arizona[10]		798,875	
Navajo Claims			
Southeastern[11]	58,523	105,006	135,685

III. CURRENT AND PROJECTED WATER DEMAND

Current Uses

According to 1998 AMA water-budget data[12], current water demand for central Arizona is 3.6 million AF[13]. Municipal uses, the focus of this paper, account for 28% of this demand, agriculture 53%, industrial water uses with their own water rights 6%, and Native American[14] uses 11% (primarily Gila River Indian Community agricultural uses) (Figure 4a). Renewable water supplies are used to meet 59% of the demand, with CAP supplying 23%, other surface water (primarily Salt River Project supplies) 31% and effluent 5% (Figure 4b). In addition to this CAP usage (835,000 AF in 1998 and 1.28 MAF in 2005), CAP water is also used for groundwater recharge. Groundwater use supplies 41% of the total demand, with much of this demand being met through groundwater mining. The AMAs have significantly reduced their dependence on groundwater from 63% in 1985[15] to 41% in 1998. Table 3 shows the generalized water budget for the three combined AMAs. In addition, significant quantities of CAP water and treated effluent are also being recharged into the groundwater for future use. Approximately 4 MAF of recharge water was stored through the end of 2002, with annual recharge volumes between 200,000 and 400,000 AF. In 2005, 149,000 AF of CAP water was delivered to underground storage facilities and another 223,000, as part of groundwater savings facilities, was delivered to agricultural users in lieu of groundwater.

How we use our water can be important for determining the types of supplies, water treatment, and delivery infrastructure we need for the future. Figure 4c uses the example of the City of Phoenix water system to illustrate how our region uses municipal water supplies. In larger urban areas with significant commercial and employment activities, households use about two-thirds of municipal supplies. In developing areas and bedroom communities, residential use can exceed 90%. Within both residential and nonresidential sectors, nearly two-thirds of the water used is applied for landscaping and other exterior uses such as pools.

Figure 4a. Demand by sector for Phoenix, Pinal and Tucson AMAs in 1998[12].

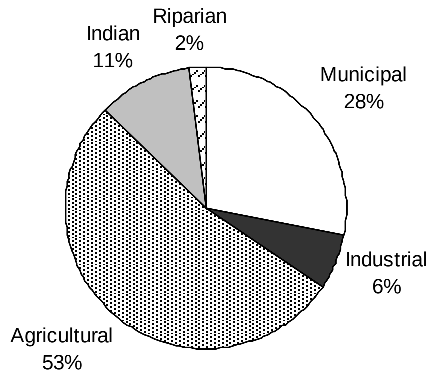


Figure 4b. Supply mix[16] for Phoenix, Pinal and Tucson AMAs in 1998[12].

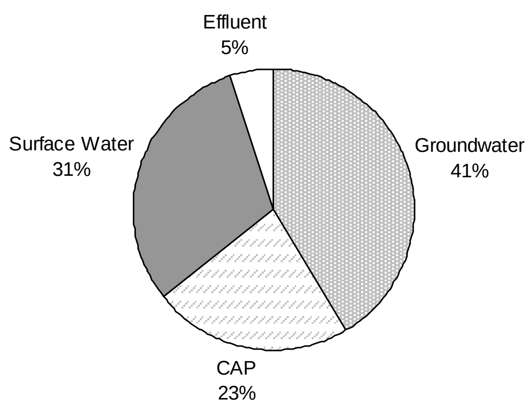


Figure 4c. Residential vs nonresidential municipal water uses for the City of Phoenix[17]

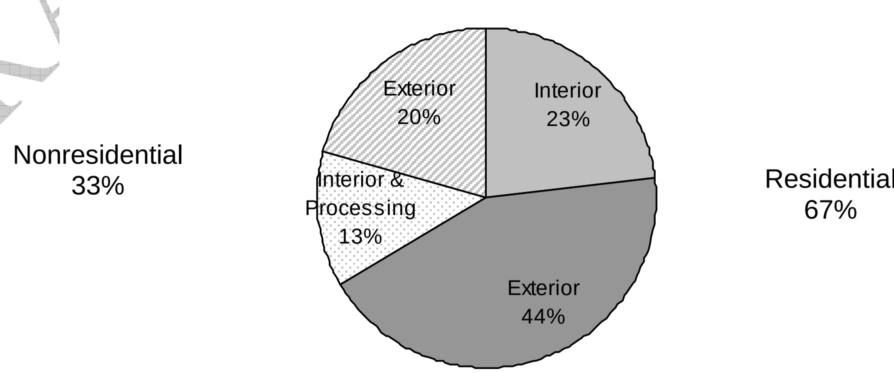


Table 3. Central Arizona AMA Water Budget in 1998[12] (data from Governor's Water Management Commission Final Report, 2004)

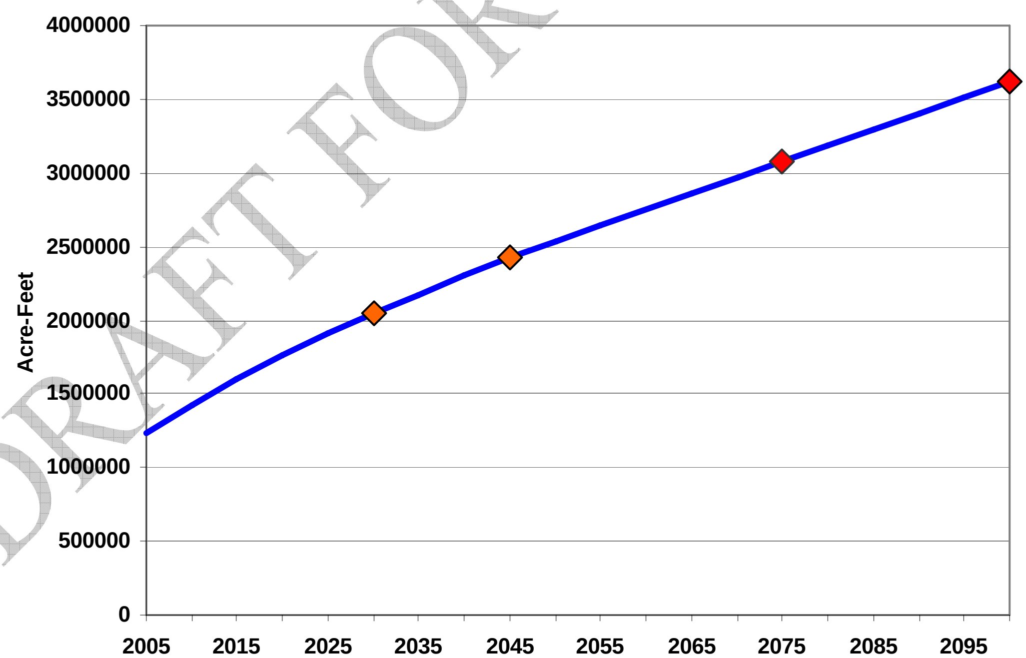
	Tucson	Pinal	Phoenix	TOTALS
	ac -ft / yr			
Municipal				
Demand	163,198	19,779	850,483	1,033,460
Supply				
Groundwater	150,835	18,700	207,112	376,647
CAP (direct use and credit recovery)	200	512	171,081	171,793
Other surface water	0	534	456,831	457,365
Effluent	9,463	33	15,459	24,955
Industrial				
Demand	57,544	8,292	163,641	229,477
Supply				
Groundwater	56,844	7,088	78,937	142,869
CAP (direct use)	0	0	2,227	2,227
Other surface water	0	0	9,102	9,102
Effluent	700	1,204	73,374	75,278
Agricultural				
Demand	94,809	834,959	1,013,022	1,942,790
Supply				
Groundwater	70,882	371,351	402,378	844,611
Groundwater (in lieu)	22,947	77,753	106,999	207,699
CAP (direct use, no in lieu)	0	266,367	99,046	365,413
Other surface water	0	114,958	340,934	455,892
Effluent	980	4,530	63,765	69,275
Indian				
Demand	100	165,352	231,755	397,207
Supply				
Groundwater	100	28,928	96,879	125,907
CAP (direct use, no in lieu)	0	87,672	0	87,672
Other surface water	0	43,521	134,889	178,410
Effluent	0	5,231	2,325	7,556
Other				
Demand (Riparian)	3,700	15,400	48,000	67,100
TOTALS (except for "other")				
Demand	315,651	1,028,382	2,258,901	3,602,934
Supply				
Groundwater	278,661	426,067	785,306	1,490,034
CAP (direct, recovery and in lieu AG)	23,147	432,304	379,353	834,804
Other surface water	0	159,013	941,756	1,100,769
Effluent	11,143	10,998	154,923	177,064

Projected Use

To develop long-term projections for water demand, we make a number of simplifying assumptions. Revisions to this paper could alter those assumptions and develop additional water demand scenarios. Of particular note is our focus on the growth of municipal demand. Municipal water demand is both the sector experiencing the most growth and the only user required to secure renewable supplies. Agriculture use, at least outside of the Native American communities[18] is projected by the Arizona Department of Water Resources (ADWR) and local water managers, to decline significantly in central Arizona. Although non-Indian agriculture will remain a significant water user in the Pinal AMA, we assume the surface water used by agriculture will eventually be available for transfer to municipal providers. We also assumed that any major industrial water users not served by local municipal providers would have their own rights to use groundwater, and therefore will not receive water from municipal providers nor compete for renewable supplies[19].

Based on the forecasted population growth, municipal water demand in the central Arizona AMAs is expected to increase from today's levels of 1 MAF to around 2.1 MAF in 2030, 2.4 MAF in 2045, 3.1 MAF in 2075 and 3.6 MAF in 2100. Figure 5 and Appendix A depict these regional demands.

Figure 5. Water-demand projection for central Arizona.



These water-demand projections are based on the population projections in Table 1 and the assumed per capita water-use rates from Column 2 of Appendix A. These per capita use levels assume that the urban development pattern and levels of water use will remain similar to today, which results in a slightly decreasing GPCD (gallons of water used per capita per day) due to the higher efficiency of new development[20].

Changes in urban-development patterns, living standards, water-use efficiency, conservation practices, and landscaping could all significantly alter the municipal water-use patterns shown in Figure 4c and reflected in the current municipal GPCD. For simplicity's sake, we have continued current trends well into the future. Revisions of this paper may examine the impact of changing consumption patterns and analyze the implications of different per capita demand scenarios.

Table 4 estimates potential water demands from the other regions of Arizona discussed in Section II and shown in Figure 3. We do not attempt to determine what portion of this demand might be met through acquisition of Colorado or CAP water rights, but it seems reasonable to assume that a significant portion of the about 300,000 AF of demand projected for the western Arizona counties bordering the Colorado River, and perhaps some portion of the demand shown for other areas of the state, will receive Colorado River supplies.

Table 4. Projected Water Demands for Selected Areas Outside of Central Arizona

	2000	2050	2100
		(ac-ft/yr)	
Western Counties[21] - Totals	93,748	226,606	310,848
LaPaz	5,521	8,656	10,635
Yuma	44,813	105,741	141,503
Mohave	43,415	112,209	158,710
Northern Counties[10]		68,702	
Navajo Claims[22]			
Southeastern Counties[23]	11,013	19,760	25,534

IV. GROUNDWATER MANAGEMENT, ASSURED WATER-SUPPLY RULES, AND THE CENTRAL ARIZONA GROUNDWATER REPLENISHMENT DISTRICT

The water-supply choices made by water providers in the Active Management Areas are influenced by the Groundwater Management Act (GMA) and its Assured Water Supply (AWS) requirements. In addition, many new developments and water providers join the Central Arizona Groundwater Replenishment District (CAGRD) to meet the AWS rules. Therefore, before considering current and future water supplies, we provide background on the GMA, the AWS rules, and the CAGRD.

Groundwater Management Act and Assured Water Supply Rules

Arizona's GMA, adopted in 1980, was widely heralded as the nation's most comprehensive and forward-looking groundwater-management program. The principal purposes of the act were to allocate scarce water resources, install a water-management structure to help secure federal approval of the CAP, and halt the overuse of groundwater and the lowering of groundwater levels. The GMA created Active Management Areas (AMAs) and established a management goal for each one. The goal of the Phoenix and Tucson AMAs is to achieve safe-yield by 2025 (safe-yield means that groundwater use equals groundwater recharge), resulting in stable water levels. The Pinal AMA has a different goal, designed to preserve the agricultural economy for as long as feasible while preserving sufficient supplies for future municipal and industrial growth. A key component of the GMA was a requirement to adopt rules requiring that new growth have an assured water supply by 1995.

Before any land can be subdivided[24] in the Phoenix, Pinal, and Tucson AMAs, state regulations adopted in 1995, known as the assured water-supply rules, require demonstration of a 100-year water supply consistent with the water-management goals of each AMA[25]. Generally speaking, in the Phoenix and Tucson AMAs this means that little or no groundwater can be used to for new subdivisions unless the groundwater is replaced. The Pinal AMA, due to its different goal and historically minor municipal and industrial use (until recently <3% of overall water use in the AMA), has assured water-supply rules that allow significant groundwater use for new development. However, these rules are under review, and AMA water users are proposing to revise the rules and greatly increase the use of renewable supplies to serve new development[26].

There are two ways to obtain an assured water supply:

1. Certificate-Based Approach

   Under this approach, individual developers or builders obtain a certificate of assured water supply from the ADWR.

2. Designation-Based Approach

   Under this approach, a water provider decides to obtain a designation of assured water supply that acts as an umbrella assured water-supply status. In this case, the developer/builder would not need to obtain a certificate, but would simply obtain service from the designated provider. A designated provider must meet the AWS rules for all of their demand, whereas within undesignated providers, only subdivisions approved after 1995 must meet AWS requirements.

Key to the AWS rules is the requirement that providers demonstrate legal and physical availability of the water supply for 100 years. For renewable supplies, such as CAP water, surface water, or effluent, a designated provider or certificate applicant is required to have a permanent right or a 100-year contract. When groundwater is used for some or all of the actual physical water supply, the water provider must demonstrate sufficient groundwater in storage to meet the necessary demand for 100 years without causing levels to drop lower than 1,000 feet below the surface (1,100 feet in the Pinal AMA). If any of the groundwater use for the subdivision will be above the volumes allowed by the AWS rules, regardless of whether the supply was obtained through a certificate or designation approach, this “excess” use must be replenished.

Arizona’s AWS rules mainly determine the water supplies required for new development in the AMAs. Of particular note, these rules require most groundwater use to be replenished, at least in the Phoenix and Tucson AMAs. The impact of the AWS rules on water-resource development varies among AMAs. In general, large, city-owned water providers chose to obtain a designation of AWS that is an umbrella status that allows individual developers to bypass certification. Smaller utilities and private water companies generally avoid putting together the portfolios of renewable supplies needed to obtain a designation, thus requiring developers to obtain AWS certificates directly from the state. This is particularly true in new developed areas at the urban edge, where infrastructure to treat and deliver renewable supplies may be absent. Generally CAGRD membership is less expensive because pumping and replenishment groundwater costs less than building surface water treatment plants and infrastructure to deliver water to the treatment plants.

The Central Arizona Groundwater Replenishment District (CAGRD)[27]

Many new master-planned communities, and even a number of cities in central Arizona, have secured their assured water supply, at least in part, by joining the CAGRD. The CAGRD does not deliver a physical supply of water to a community’s treatment plant or distribution system. The CAGRD is a mechanism to replenish excess groundwater (in excess of that allowed by the AWS rules) for developments that have enough groundwater in storage to supply all or part of their demand. When a CAGRD member reports the volume of its excess groundwater pumping to the CAGRD, the CAGRD then has a period of up to three years to secure supplies (or use recharge credits already earned) and recharge them into the ground to replenish the “excess” groundwater use. The CAGRD’s replenishment of members’ excess groundwater use need not take place within the area of hydrologic impact of the groundwater pumping but can occur anywhere within the AMA. The CAGRD was designed primarily to ease development on the urban fringe, where infrastructure (such as canals and treatment plants) did not exist to deliver or treat water.

The decision of whether or not to join the CAGRD is largely a factor of supply accessibility and timing. Water providers with established rights to renewable supplies and sufficient financial resources typically obtain an AWS designation and are independent of the CAGRD. Generally, water providers with limited rights to renewable supplies and/or insufficient financial resources to invest in acquiring and treating renewable supplies join the CAGRD and may or may not choose to be designated as having an assured water supply. Some water providers with sufficient water rights and financial resources still join the CAGRD for several possible reasons: 1) needed infrastructure is not yet complete; 2) legal and political matters are preventing the use of the renewable supplies; and 3) groundwater supplies are plentiful and the provider wants to protect the supply from other users. In addition, a number of water providers who have sufficient infrastructure and the resources to acquire renewable water supplies are still joining the CAGRD because many of the water supplies they can obtain on their own do not meet the 100-year requirement of the state's AWS rules.

The CAGRD is required to produce a plan of operation that must be approved by the ADWR[28]. The standards the CAGRD has to meet for reliability and security of its water portfolio are different than the AWS standards for individual water providers or developers[29].

V. WATER SUPPLY APPROACHES AND EVALUATION CRITERIA

Water-Supply Approaches

For illustrative purposes, we outline three approaches to developing an assured water-supply portfolio:

- groundwater dependent
- renewable water dependent
- combination approach

Groundwater-Dependent Approach
This approach represents the usual method of development on the urban fringe or outside the larger cities. Under this approach, the utility or utilities serving the area would develop wells and developers/builders would obtain AWS certificates from the ADWR and enroll the lands in the Central Arizona CAGRD as "member lands." Alternatively, the utility might decide to obtain an umbrella AWS status (referred to as a designation) and become a "member service area" of the CAGRD. Either way, the subdivisions would be served groundwater, and groundwater would be replenished by the CAGRD at some location in the AMA. The only difference among these CAGRD membership alternatives is how the retail water user would pay for the cost of replenishing the groundwater. In the first instance as "member lands," payment would be made through property tax bills. In the second case, for "member service areas," payment would be made through water bills. Under the groundwater-dependent approach, the physical availability would limit groundwater development.

Renewable-Water and Imported-Groundwater Approach
Under this second approach, the utility or utilities serving an area would acquire sufficient renewable water supplies or imported groundwater to meet the needs of its customers and AWS requirements. These supplies would likely be acquired from the supplies described in Section VI below. Like in the first alternative, the utility could rely on a certificate-based approach for assured water supply, or the utility could obtain an AWS designation. Either way, the utility would be independent of the CAGRD.

Combination Approach
Under this final approach, the utility or utilities serving an area could acquire renewable supplies for a portion of their needs and rely on the CAGRD for the remainder. Reasons a developer or water provider may take this approach include: first, the only way significant quantities of

groundwater can be secured for AWS purposes is to join the CAGRD[30]. By doing this, the groundwater beneath the property would be "allocated" and not available for assured water supply use by others. Second, CAGRD membership could serve as a bridge in the early years before a water-supply portfolio could be acquired. Finally, over the long term, CAGRD membership could act as a stabilizer should anticipated acquisitions prove difficult to realize or as regulations and laws change. The utility or utilities serving an area could decide to use a certificate-based approach or a designation approach to assured water supply.

The remainder of the paper considers current and potential water supplies, a few of the issues likely to impact supply availability, and implications of different supplies for building water-supply portfolios.

Criteria for Evaluating Water-Supply Approaches

The five evaluation criteria described below can be used to consider the advantages and disadvantages of different types of water supplies and approaches to building water-supply portfolios. Evaluations of the different supplies on these, and perhaps additional, criteria are expected to be a topic of conversation in the June 21 water and growth workshop. Based on these discussions this section may be expanded.

Cost

Cost is typically evaluated relative to other supply alternatives. Costs considered include treatment, quality, infrastructure improvements (e.g. pipes, pumps, wells), acquisition, mitigation (e.g. subsidence and environmental impacts), transportation, and other related costs. Alternatives with lower costs rate better against this criterion.

Accessibility

Accessibility is defined as how quickly and easily water providers obtain control of the supplies for their portfolio. Alternatives including supplies over which providers, landowners, or developers have immediate control, or can expect to have control, rate better on this criterion.

Reliability

Reliability is defined to include two parameters: 1) how well the alternative responds to shortages and droughts (diverse alternatives with redundancy rate better on this criterion); and 2) permanence (supplies available in perpetuity or with longer-term leases rate higher.

Legal and Administrative Feasibility

We define legal and administrative feasibility as how well the alternatives work within existing regulatory structures and contractual arrangements. Administratively burdensome alternatives or those that require legislative or regulatory change would rate poorly. This criterion evaluates how difficult acquiring the supply will be in terms of institutional constraints. Recognizing that laws and rules will evolve, this criterion also considers potential changes and the resiliency of the supply alternatives to potential legal changes. Legal changes could include modifications to: environmental protection standards such as the Federal Endangered Species Act and the Safe Drinking Water and Clean Water Acts; Arizona's Assured Water Supply Rules, Well Spacing and Well Impact Rules, Recharge and Recovery programs and Fourth Management Plan requirements; CAP operating procedures: and procedures for developing State Trust Land.

Public Acceptance
Public acceptance is defined as how well the alternatives would fare under public scrutiny. Because issues of political and public acceptance change over time this criteria is highly subjective and variable. Alternatives that would be well received rate better on this criterion.

VI. CURRENT AND POTENTIAL MUNICIPAL WATER SUPPLIES

The major sources of water for central Arizona include the Colorado River, the Salt, Verde and Gila rivers, groundwater, and effluent (see Table 3 and Figures 4 a-c above). We discuss each water supply below and their potential to supply new growth in central Arizona.

Colorado River Water

The Colorado River watershed extends from the mountains of Wyoming and Colorado through the Grand Canyon and deserts of Arizona into Mexico and the Gulf of California. The Colorado River is the largest river and a major source of water supply and power for the Southwest. An extensive body of treaties, interstate compacts, federal legislation, court decrees, and operating agreements make up the "Law of the River" that lays out the allocation of water and rules for managing the river. In general, the upper basin states of Wyoming, Colorado, Utah and New Mexico are allocated 7.5 MAF, as are the lower basin states of Arizona, California and Nevada, with another 1.5 MAF allocated to Mexico. However, recent research on historic climate and Colorado River flows indicates the actual long-term supply available from the Colorado River is likely less than the 16.5 MAF allocated[31].

California's allocation is the largest, at 4.4 MAF. Arizona is entitled to 2.8 MAF and Nevada 300,000. Arizona's entitlement is divided between the 1.3 MAF used along the Colorado River and 1.5 MAF used in central Arizona by CAP water users. In order to secure Congressional funding for the CAP canal, Arizona had to agree to make Arizona's CAP water allocation a lower priority than California's 4.4 MAF entitlement. Practically speaking this means that whenever there is a shortage on the Colorado River, the water supply to the CAP canal will be cut back before any deliveries to California are reduced.

Colorado River – On River Uses

The major water users along the Colorado River are several agricultural water projects in the Yuma area and the Colorado River Indian Tribes. The Fort Mojave Indian Tribe and the Cibola Valley Irrigation District hold other significant entitlements. Current use averages about 1.2 million out of the 1.3 MAF in entitlements. Some portion of these entitlements may be available for acquisition by central Arizona water users. Municipal users along the river (e.g. Lake Havasu City, Mohave County Water Authority, City of Yuma) hold additional smaller entitlements, however these supplies are assumed to be needed for the current and future demands of river communities and unavailable for acquisition by central Arizona water users[32]. Along the Colorado River, Indian and agricultural water project users are the most senior and most of the mainstem Colorado River rights are senior to the Central Arizona Project.

A previous report estimated 475,000 AF[33] of Colorado River supplies may be available to be purchased and could be moved to central Arizona if senior water-right holders are willing to lease or sell either a portion or all of their rights. Water rights could be acquired through lease or sale by: 1) fallowing currently irrigated lands, 2) investing in conservation improvements on currently irrigated lands or for irrigation district conveyance structures and then leasing or purchasing the "conserved" water; and 3) purchasing lands that come with water rights. These water supplies could be made available permanently, for specified lease periods,[34] or only for shortage years as a backup supply. To date, no contracts have been negotiated by municipal providers to move Colorado River water by any of these mechanisms in Arizona[35]. Should the water rights be acquired, in some cases, the legal right to sever the water right from the land[36] may have to be secured and for some districts transferring water to central Arizona would require Federal Congressional action as well.

Colorado River – CAP Water

Construction of the Central Arizona Project was authorized by Congress in 1968 to facilitate Arizona's use of its entitlement to 2.8 million acre-feet of Colorado River water in order to replace the use of mined groundwater in central Arizona and to maintain as much as possible of Arizona's irrigated farm land while providing an additional source of water for future municipal and industrial needs. Water was first delivered through the CAP in 1985 and the canal was considered substantially complete in 1993.

The 1.5 million acre-feet CAP supply can be divided into two categories: Indian and non-Indian supplies. Today, the Indians hold approximately 32% of the CAP supply. Non-Indians hold the remaining roughly 68% of the CAP supply. After the Arizona Water Settlements Act is fully effective, Arizona Indian tribes will hold nearly 46% of the CAP supply, and the remaining supply or 54% of the CAP supply will be held by non-Indians.

The Indian supply is made up of four different priorities. Some of the Indian supply delivered through the CAP is the result of Indian settlements. This water holds a higher priority than the CAP itself. The remaining Indian supply includes municipal and industrial (M&I) and Indian priorities. These priorities share equal standing. The Indian supply also includes a non-Indian agricultural (NIA) priority that holds a lower priority. In times of shortage, the NIA priority would be cut first. The non-Indian supply is made up of two of these priorities: the M&I priority and the NIA priority. Specifically regarding the NIA priority water, up to 96,295 AF will be available for future non-Indian M&I use in central Arizona.

CAP M&I Subcontracts
A subcontract for CAP M&I water is considered desirable due to its higher-priority status on the CAP system, as well as its cost and acceptable water quality. While the approximately 670,000[37] AF supply is fully allocated, new developments could have access to a portion of these supplies by developing within the service areas of jurisdictions with an allocation or on state land through the limited allocations held by the Arizona State Land Department[38]. Finally, to the extent others decide to relinquish their CAP allocations, new communities or water providers could compete to acquire those relinquished supplies.

Indian Leases and Non-Indian Agricultural Priority CAP Water
Two other methods of securing CAP water are possible in central Arizona: leasing an Indian supply and securing a future allocation of non-Indian agricultural priority water (NIA water). As a result the original allocation of CAP supplies and applicable Indian water-rights settlements, certain Arizona tribes have significant CAP allocations that, if the tribe chooses to, can be leased for up to 100 years. In the analysis presented in Appendix A, an estimated 40,000 AF of additional CAP Indian water is assumed to be available for lease[39] beyond the 154,000 AF committed through current leases.

In addition to the M&I and Indian supplies discussed above, nearly 100,000 AF of water previously allocated to non-Indian agriculture (NIA) will be re-allocated for municipal purposes. This NIA water will be allocated over time, with an initial allocation phase likely occurring in 2010. NIA water holds a lower priority than M&I water, making NIA water a less reliable supply. Use of NIA water might require a back-up supply to make it reliable for long-term municipal use. If stored underground, NIA water could also be used as a back-up supply itself for future use.

Recharge and Recovery of CAP Water
The Colorado River and CAP supplies outlined above can be used directly or stored in the aquifer through groundwater recharge projects and recovered for later use. Although the vast majority of recharge credits in Arizona are earned through the storage of excess CAP water, other supplies including effluent can also be stored for later recovery. Seventy-nine recharge facilities with the capacity to store nearly 2 MAF of water per year are permitted in Arizona[40].

Surface Water – Other Than Colorado River

Salt and Verde River Water

The vast majority of rights to Salt and Verde river waters are held by the Salt River Project for use on project lands. Based on an AWS analysis produced by SRP in 1996, the available municipal supply is estimated at 520,000 AF[41]. Smaller rights to Salt and Verde waters are also held by Roosevelt Water Conservation District (on average 35,000 AF)[42]. These supplies are tied to project lands and are therefore only available for demands within those areas[43].

Agua Fria River Water

The Maricopa Water District and the CAWCD hold rights to Agua Fria water stored in Lake Pleasant. The average supply available from the Agua Fria is 35,000 AF per year[44].

Gila River Water

Rights to Gila River water in central Arizona are held by both the Gila River Indian Community (GRIC) and by the San Carlos Irrigation and Drainage District (SCIDD). The GRIC water rights are considered to be unavailable for sale or lease. The agricultural water rights held by SCIDD are legally tied to the agricultural lands within the District, however, these supplies could be available through sever and transfer for future municipal development within the boundaries of the District. The volume of available Gila River water is highly variable; however, staff of the Pinal AMA previously estimated that approximately 100,000 AF could likely be firmed for municipal water supplies through storage during wet periods and recovery during dry periods[45].

Other Surface Water

Among other surface-water rights held by water providers in central Arizona, the only one of significance outside the AMAs is the Bill Williams River water rights held by the City of Scottsdale through its ownership of Planet Ranch. Scottsdale purchased this ranch in the 1980s when AMA cities were looking for water farms. Planet Ranch would provide up to 15,000 AF of surface water that could be imported into central Arizona.

<u>Local Groundwater</u>

Large reserves of groundwater are available throughout much of central Arizona. However, historic overuse of these supplies was one of the factors leading to adoption of the GMA in 1980 and the resulting restrictions on groundwater use. The availability and feasibility of using local groundwater supplies is influenced by the GMA as well as other factors such as drought, land use, subsidence, recharge, and water quality.

Under the assured water-supply rules, five different types of groundwater may be used to serve development.

1. Pre-rules groundwater used for developments that were approved before the assured water-supply rules, and groundwater used for non-residential demands which are not affected by the rules,
2. An incidental recharge factor which varies by AMA[46]
3. An allowable groundwater balance based on a percentage of the total water use and when the subdivision was approved or a percentage of the 1994 use of designated providers[47].
4. AMA water farms (The City of Mesa's Pinal County Farm and the City of Tucson's retired agricultural lands in the Avra Valley)
5. Imported groundwater, discussed further below.

Although groundwater in excess of this amount could be used, it would have to be replaced through recharge somewhere in the AMA.

The degree to which new developments can rely on CAGRD membership and replenishment is limited by the physical availability of groundwater. CAGRD membership can only provide access to the groundwater in storage down to 1,000 feet below land surface (1,100 feet in the Pinal AMA) which is physically recoverable by a water provider's well field[48].

Groundwater Imported From Outside of AMAs and AMA Water Farms

After the passage of the GMA, cities within central Arizona began looking to purchase farms with access to groundwater supplies outside the AMAs. The cities of Phoenix and Mesa bought farms for access to groundwater and the City of Scottsdale purchased land with senior surface water rights. These purchases caused concerns throughout rural Arizona and led to legislative efforts to restrict the practice of purchasing water farms in other regions of the state. In 1991, the Groundwater Transportation Act restricted the ability to transfer groundwater into AMAs, but investments already made were granted a grandfathered ability to transfer groundwater stored in certain aquifers of remote groundwater basins to the AMAs[49]. There are three remote groundwater basins that function as water farms: Butler Valley, Harquahala Valley and McMullen Valley. The Arizona State Land Department owns much of the land in Butler Valley and some lands in Harquahala Valley. Private parties and the City of Scottsdale own other parts of Harquahala Valley. Lands within McMullen Valley are owned by the City of Phoenix. The volume of water that can be exported from these farms is approximately 18.1 MAF. For this analysis we assumed these groundwater withdrawals would be spread across a 200 year period for an annual importation averaging 90,500 AF per year. Water pumped from these water farms could be conveyed through the CAP canal if wheeling agreements are negotiated. In addition to these water farms, Arizona law authorizes the withdrawal and transportation of up to 200,000 AF of Yuma area groundwater to AMAs due to waterlogging in the Yuma area[50]. We did not include the use of this water in the analysis.

In addition to these water farms located outside AMAs, there are two farms located inside AMAs also authorized by State statute. One is located in the Pinal AMA, and one in the Tucson AMA. We also spread the allowable groundwater withdrawals from these farms over a 200-year period for this analysis, resulting in an available supply of 22,500 AF per year. The land in the Pinal AMA farm, owned by the City of Mesa, may have acquisition potential if Mesa's future demands are sufficiently met. The Pinal AMA farm may also be sold off to developers and no longer qualify as a water farm under state law. The Tucson AMA farm, owned by the City of Tucson, would not be a potential acquisition supply for other areas.

Reclaimed Water

As people use water, a wastewater stream is produced. Once cleaned to acceptable standards, this supply becomes a resource called reclaimed water or effluent. Except for areas dependent upon septic tanks, most wastewater produced in central Arizona is treated in centralized wastewater treatment plants and is available as reclaimed water.

New growth in central Arizona will produce significant quantities of effluent. Larger developments and wastewater systems are likely to be designed so that effluent can be captured, treated and reused or recharged within the development project. Through appropriate landscape design, infrastructure siting and wastewater treatment, outdoor water use and irrigation of parks and golf courses can be met largely through effluent use. During winter months, when effluent production often exceeds non-potable water demands, effluent can be recharged into the groundwater and later recovered as part of the water supply.

In this regional analysis, 30% of municipal water demand is assumed to return for wastewater treatment[51]. Of the reclaimed water produced, 30% is assumed available to meet the projected demand of municipal water providers until 2050. After 2050, this analysis assumes that 70% of the reclaimed water will be available for municipal use.

<u>**Desalinization**</u>

Desalinization of Brackish Local Groundwater

Highly saline groundwater, too high in total dissolved solids (TDS) for any use without treatment to lower salinity levels, exists in large quantity in several areas of central Arizona. The southwest portion of the Phoenix AMA, in the area of Goodyear and Buckeye, is one such location. No estimates of available supply are provided in this paper, however in areas with high groundwater levels, significant quantities of water may be available that could be used without creating damaging water-level declines. Treatment to reduce TDS is expensive and also produces a highly concentrated brine reject stream of wastewater for disposal.

Importation or Exchange of Desalinization Water

Some view desalinization of seawater as a source of supply for additional growth after we have maximized the potential to re-allocate existing supplies or increase water-use efficiency. Desalinated water could expand our supply in one of two ways. First, by building the treatment plants[52] and canals to directly treat and import supplies from locations such as the Pacific Ocean or the Gulf of California. Second, by treating and delivering the water to coastal California or Mexico, in exchange for diverting their allocations from the Colorado River into central Arizona.

VII FUTURE SUPPLY USE AND TIMING: AN ILLUSTRATIVE SCENARIO

The water supplies developed to serve central Arizona will be the result of the decisions made by multiple different water providers, water users, regulatory and planning agencies, water-right holders, land owners and elected officials. The purpose of this section is to illustrate the types of supplies potentially available. We categorize these potential water supplies based on illustrative assumptions about the ability to secure them. Table 5[53] and Figure 6 illustrate 5 categories of future supply certainty:

1. "Currently Secured Supply" is comprised of both:
    a. "Currently used or allocated" municipal supplies (i.e. SRP rights and CAP allocations that may not be fully used today) and

b. “Virtually certain” additional supplies that are already secured through ownership, contract or law for central Arizona water users (e.g. current leases for Indian CAP water). In addition, sufficient infrastructure exists to import all of these supplies. These supplies include groundwater farms in western and central Arizona.

2. “Likely Available Supply” includes additional supplies which could be secured for importation through excess canal capacity in the CAP without changing current operating conditions or making infrastructure improvements. These supplies could include approximately 275,000 AF of Colorado River rights or limited conversion of San Carlos Irrigation District’s Gila River irrigation rights to municipal use.

3. “Possibly Available Supply” includes additional supplies that may be able to be secured for importation through CAP as a result of changing current operating conditions and making some infrastructure improvements. These supplies would be comprised of additional purchase or lease of another approximately 200,000 AF of Colorado River rights and other potential sources. Up to another approximately 400,000 AF of reclaimed water is assumed available by raising the percentage of available effluent going to municipal use from 30 to 70%. In addition, further conversion of Gila River supplies from irrigation to municipal use could be pursued.

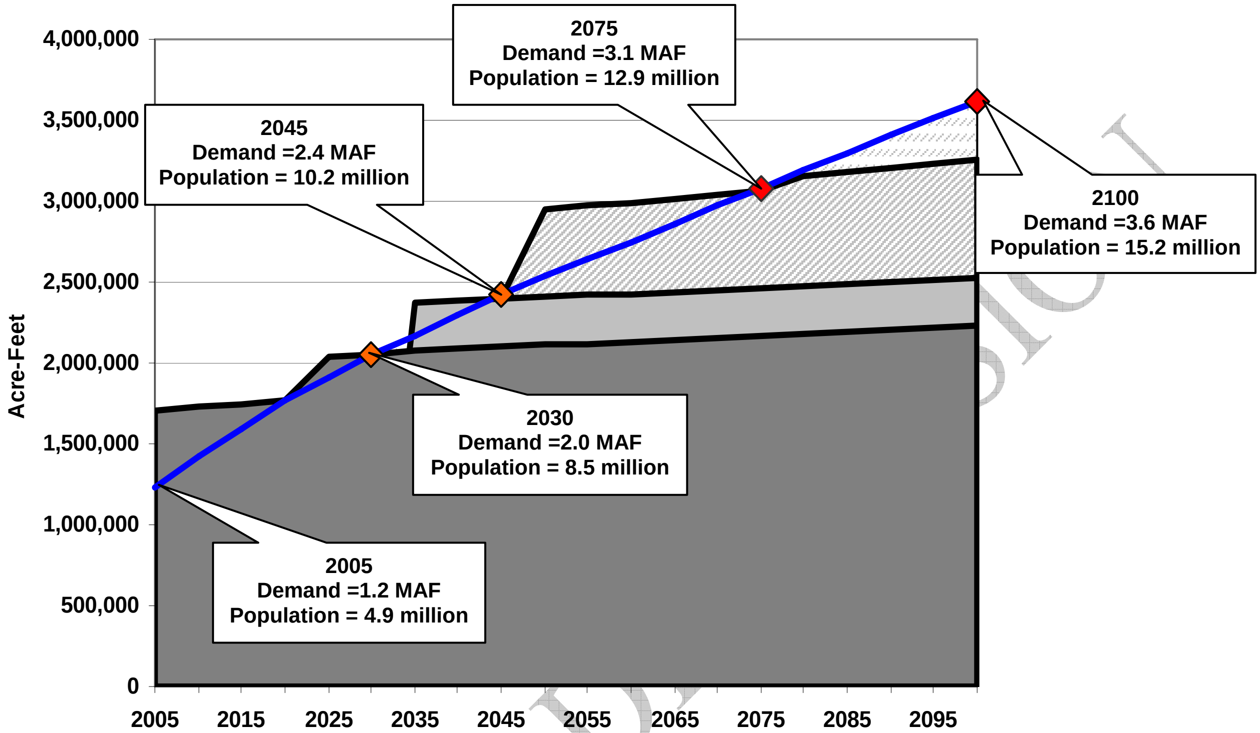
4. “Uncertain Additional Available Supply” includes additional supplies secured from the Colorado River, from potential desalinization imports or exchanges, or from elsewhere. In addition, beyond 2100 some of the groundwater supplies would be depleted, thus requiring additional new supplies. New infrastructure not currently planned would have to be built to import these supplies.

Table 5.
Current and Future Potential Water Supplies for Central Arizona

Degree of Availability	Current or Allocated Today	Virtually Certain 2006 - 2030	Likely 2031 - 2045	Possibly 2046 - 2075	Uncertain 2075 – 2100	Uncertain Beyond 2100
Colorado River Water						
Indian Leases	0	0	117,000	140,000	140,000	? 140,000 ?
Non-Indian Rights	0	0	158,000	335,000	335,000	? 335,000 ?
CAP Water						
CAP M&I Subcontracts	621,000	621,000	668,000	668,000	668,000	668,000
Hohokam Water	47,000	47,000	0	0	0	0
Indian Leases	154,000	193,000	193,000	193,000	193,000	? 193,000 ?
NIA Priority CAP Water	0	96,000	96,000	96,000	96,000	96,000
Surface Water						
SRP (Salt and Verde) Water	520,000	520,000	520,000	520,000	520,000	520,000
Agua Fria River	30,000	35,000	35,000	35,000	35,000	35,000
Gila River			20,000	40,000	100,000	100,000
Planet Ranch– Bill Williams				15,000	15,000	15,000
Other Surface Water Supplies	20,000	20,000	20,000	20,000	20,000	20,000
Groundwater						
Pre-AWS Rules	75,000	75,000	75,000	75,000	75,000	75,000
AWS - Allowable	80,000	80,000	80,000	80,000	80,000	80,000
Incidental Recharge	48,000	72,000	79,000	94,000	109,000	+ 109,000 +
AMA Water Farms	0	22,500	22,500	22,500	22,500	? 22,500 ?
Imported from Water Farms Outside AMAs	0	90,500	90,500	90,500	90,500	? 90,500 ?
Reclaimed	111,000	184,000	218,000	646,000	760,000	+ 760,000 +
Desalinated						
SUPPLY Total	1,706,000	2,056,000	2,392,000	3,070,000	3,259,000	
Supply Deficit	476,000	10,000	-32,000	-7,000	-362,000	
DEMAND Total	1,230,000	2,046,000	2,424,000	3,077,000	3,621,000	

? - indicates potentially expired leased water supplies or finite groundwater resources
+ - as water use increases, incidental recharge and reclaimed water is likely to increase

Figure 6. Comparison of central Arizona supply and demand.



Notes for Figure 6

Currently Secured Supply

Likely Available Supply

Possibly Available Supply

Uncertain Supply

Figure 6 provides a graphical summary of this information. Regionally, there is an estimated 1.7 MAF of water supply in use or currently secured for use by municipal providers in 2005 increasing to approximately 2.4 MAF considered likely available by 2045. According to these projections, demands are projected to exceed "Currently Secured" supplies by approximately 2030 and additional "Likely Available" supplies by 2045 depending on actual population growth and how efficiently the projected growth uses the water. If additional "Possibly Available" supplies are secured, the CAP canal capacity is maximized to increase the ability to import water by an additional 200,000 AF, and a higher percentage of reclaimed water is used; then demands may not exceed these possibly available supplies until 2075. Demands exceeding the estimated

2075 levels would have to be met with additional “Uncertain (but potentially) Available” supplies and new infrastructure not envisioned today.

VIII. WATER-SUPPLY INFRASTRUCTURE DEVELOPMENT AND PLANNING

Water supplies for new growth areas will, in the near term, most likely rely upon existing regional water infrastructure, in particular, the CAP. The CAP canal will be increasingly critical for both direct delivery to surface-water treatment plants and for delivering untreated water to groundwater-recharge projects.

Currently the CAP canal is the only infrastructure in existence that can be used to transport Colorado River water and water from western groundwater basins into central Arizona. The CAP canal has enough capacity to transport all CAP water and approximately 300,000 acre-feet per year of additional, non-CAP supplies[54]. With modifications to existing infrastructure and changes in operations, an additional 200,000 acre-feet of non-CAP supplies could also be transported through the “excess capacity” of the canal[55].

Access to excess capacity in the CAP canal for the purposes of importing non-CAP water is critical in the discussion of future water supplies in central Arizona because legal access to Colorado River water rights are only of use if the water can be transported into central Arizona[56].

New growth areas choosing to rely on groundwater use and replenishment by the CAGRD will also need detailed hydrologic studies to quantify available groundwater. The CAGRD will also need to identify appropriate sites for groundwater-recharge projects. Additionally, many areas throughout central Arizona are subject to land subsidence and fissuring if groundwater is depleted. Efforts to prevent or mitigate these impacts need to be built into the long-range water supply and infrastructure planning. Identifying locations for well fields and for recharge early could allow those sites to be protected and incorporated into both the infrastructure design of new development and land use planning.

Significant investments in infrastructure as well as water management and treatment technologies will be necessary to use potentially available water supplies for population growth in the region. Major infrastructure expansions and other investments that may be needed include:

- Additional groundwater pumping capacity in both existing and new areas for backup supplies during droughts, for recovery of water stored via groundwater recharge projects and for CAGRD members relying on groundwater as their principal source of supply
- Water transportation canals and pipelines for moving water from supply sources to new growth areas within central Arizona
- Water-treatment technology development and new plants for treating surface water and potentially for treating contaminated or brackish groundwater
- Wastewater treatment plants and non-potable distribution systems and technology development for wastewater reuse and recharge

- Groundwater recharge projects and other infrastructure to facilitate conjunctive management of surface water, groundwater and effluent as well as research on how to best use aquifers for storage and recovery
- Canals for importing new water supplies into central Arizona
- Plans for treating brackish groundwater for potable uses or irrigation and industrial purposes, particularly in areas of high groundwater levels
- Significant investments will also be important simply to maintain the existing capacity in groundwater pumping, water importation and distribution systems, water supply reservoirs, water and wastewater treatment and groundwater recharge

IX. CONCLUSIONS

Assembling water supplies for new development and rapidly growing cities will become increasingly complex, controversial, and expensive. Cheaper, more-reliable supplies, with longer-term contracts will likely be exhausted earlier than less-attractive supplies. Building a water-supply portfolio sufficient to provide perpetual water service in the face of increasing competition for supplies and evolving regulatory requirements may require using all types of available supplies: CAP water, mainstem Colorado River water rights, other surface-water supplies, groundwater, reclaimed water, and brackish and sea water. In addition, conjunctive management of all available supplies through mechanisms such as recharge and recovery and regional cooperation on major infrastructure needs will become increasingly important.

A critical issue not considered in this paper is the mechanisms used to allocate water. Should future water supplies be allocated based on an open market, with prices set by supply and demand, by contracts negotiated between willing buyers and sellers, by a government agency or other institution? Will any limitations or rules be established for whatever allocation mechanisms are used? Securing supplies for our growing population will certainly require hard work, creativity, and the resolution of many issues.

A second significant issue we have not examined is the impact of drought and climate change on the validity of the historic estimates of available water supplies. Understanding the vulnerability of water supplies throughout the state will be essential to ensuring we have the water supplies and necessary infrastructure to sustain future growth.

We hope this paper has met its intended purpose: to inform and facilitate discussion. It is our goal to assist with identifying key issues that need to be addressed by water managers and the development community in Arizona. Future drafts of this paper could report on the results of those conversations and highlight short- and long-term policy development agendas, needs for future infrastructure investment, and areas of desired university research. Ideally, this paper and subsequent activities will help our region to develop a consensus blueprint on comprehensive long-term water management strategies for our region and our state.

APPENDICES

APPENDIX A
Regional Water Demands and Supplies - Detail

	Population	Estimated GPCD	Estimated Potable Demand (AF)	Estimated Reclaimed Water (AF)	CAP Water for M&I Uses - Allocations & Leases (AF)	Water Farms (AF)	Colorado River Water (AF)	Other Surface Water (AF)	Grandfathered Groundwater (AF)	Total Potential Supply (AF)	% of Potential Supply Used
	Column 1	*Column 2*	*Column 3*	*Column 4*	*Column 5*	*Column 6*	*Column 7*	*Column 8*	*Column 9*	*Column 10*	*Column 11*
2005	4,874,180	225	1,230,000	111,000	822,000	0	0	570,000	203,000	1,706,000	72%
2010	5,652,737	224	1,418,000	128,000	822,000	113,000	0	575,000	209,000	1,847,000	77%
2015	6,424,803	222	1,596,000	144,000	822,000	113,000	0	575,000	214,000	1,868,000	85%
2020	7,157,706	220	1,764,000	159,000	822,000	113,000	0	575,000	220,000	1,889,000	93%
2025	7,849,129	218	1,914,000	172,000	958,000	113,000	0	575,000	224,000	2,042,000	94%
2030	8,502,863	215	2,046,000	184,000	958,000	113,000	0	575,000	227,000	2,057,000	99%
2035	9,113,036	212	2,166,000	195,000	958,000	113,000	279,500	595,000	230,000	2,371,000	91%
2040	9,677,384	212	2,300,000	207,000	958,000	113,000	279,500	595,000	232,000	2,385,000	96%
2045	10,196,271	212	2,424,000	218,000	958,000	113,000	279,500	595,000	234,000	2,398,000	101%
2050	10,673,399	212	2,537,000	533,000	958,000	113,000	479,500	630,000	236,000	2,950,000	86%
2055	11,112,290	212	2,642,000	555,000	958,000	113,000	479,500	630,000	238,000	2,974,000	89%
2060	11,570,300	212	2,750,000	578,000	958,000	113,000	479,500	630,000	240,000	2,999,000	92%
2065	12,028,309	212	2,859,000	600,000	958,000	113,000	479,500	630,000	243,000	3,024,000	95%
2070	12,486,319	212	2,968,000	623,000	958,000	113,000	479,500	630,000	246,000	3,050,000	97%
2075	12,944,328	212	3,077,000	646,000	958,000	113,000	479,500	630,000	249,000	3,076,000	100%
2080	13,402,338	212	3,186,000	669,000	958,000	113,000	479,500	690,000	252,000	3,162,000	101%
2085	13,860,347	212	3,295,000	692,000	958,000	113,000	479,500	690,000	255,000	3,188,000	103%
2090	14,318,357	212	3,404,000	715,000	958,000	113,000	479,500	690,000	258,000	3,214,000	106%
2095	14,776,366	212	3,513,000	738,000	958,000	113,000	479,500	690,000	261,000	3,240,000	108%
2100	15,234,376	212	3,621,000	760,000	958,000	113,000	479,500	690,000	264,000	3,265,000	111%

30% % of potable demand assumed to be wastewater

70% % of wastewater assumed available for municipal use

Column

1 Based on DES County Projections through 2055; interpolated beyond 2055 assuming constant population increase representative of growth from 2045–2055.

2 Based on demands of CAGRD Member Service Areas and Water Providers designated on their own for AWS purposes from Outlook 2003 converted to GPCD for the three-county CAP service area. This demand does not include demands associated with non-irrigation rights and effluent (including some golf courses and parks). To counter balance this, the analysis assumes sufficient effluent supplies will be reserved for these types of uses (30% of effluent generated after 2050) and estimated grandfathered groundwater does not assume non-irrigation rights.

3 Population X gallons per capita per day (GPCD) X 365 days / 325851 gallons per acre-foot.

4 Assumes effluent produced equals 30% of potable demand. The amount of effluent available for municipal providers is assumed to increase from 30% in 2005 to 70% in 2050. Post 2050, the percentage of effluent available for municipal providers remains constant.

5 Post 2020 assumes (603,678 AF M&I subcontract [note: assumes 555,031 AF currently under subcontract, plus 65,647 AF of uncontracted for M&I water allocated in the GRIC Settlement], 47,303 AF HID which expires in 2043 and converts to M&I at that time, 96,295 AF NIA conversion, 154,030 AF Indian Lease, plus 39,198 AF of additional Indian Leases as currently authorized in settlements). Pre 2020 assumes all but additional Indian Lease and NIA conversion.

6 Water farms assumes five water farms each pumping the available supply over a 200 year period: McMullen Valley (18,000 AF), Harquahala Valley (40,000 AF), Butler Valley (32,500 AF),) and Mesa's Pinal County water farm (12,500). and Tucson's Avra Valley water 10,000 AF. City of Scottsdale has the right to 3,460 AF of the Harquahala Valley water. In addition, groundwater can be exported from Yuma to reduce waterlogging in the Yuma area pursuant to the Yuma Groundwater Exchange (up to 200,000 AF total available for 20 yrs, but no use of Yuma water was assumed in this analysis

7 Before 2050, the volume of Colorado River water shown here assumes current wheeling capacity (385,000 AF) less the western Arizona water farms (90,500 AF) and Scottsdale's Planet Ranch (15,000). Note that Mesa's Pinal County water farm (25,000 AF) does not require excess canal capacity. In 2050, as demands exceed existing excess canal capacity, the volume of Colorado River water increases, assuming canal operations and infrastructure are optimized to a new excess canal capacity 585,000 AF. These supplies are finite and will be depleted at some point.

8 Assumes 520,000 AF of assured water supply eligible SRP water (source: Salt River Project, (1996) *Assured Water Supply Study for Salt River Project Member Lands*), 35,000 AF of Agua Fria water, up to 100,000 AF Gila River water, 15,000 AF of Planet Ranch water and 20,000 AF additional surface water supplies. Does not assume irrigation customer supplies or agriculture.

9 Assumes 75,000 AF of grandfathered groundwater demands by water providers serving pre-95 subdivisions. Assumes a one time volume of 1.6 million AF of AWS groundwater allowances. Because this analysis assumes that this volume will be used evenly across a 200-year period at the rate of 80,000 AF per year (This volume could be used over a shorter period, however, many of the designated providers are using this allowance at even lower levels than assumed here). The AWS groundwater allowance is a finite volume, once it is used it will have to be replaced by an alternative supply. Also assumes incidental recharge for designated water providers. This is ongoing and does not terminate in 2095. Post 2035, assumes incidental recharge growth at 3% per year.

10 Sum of Columns 5 through 9.

11 Column 4 divided by Column 10.

Appendix B
Population Projections for Selected Areas Outside of Central Arizona

		2000	2050	2100
Cochise	Southeastern	117,755	212,822	274,500
Benson				
Huachuca City				
Sierra Vista				
Sierra Vista SE CDP				
Subtotal		58,523	105,006	135,685
% of total population		0.480	0.493	0.494
Coconino	Northern	116,320	198,149	248,908
Flagstaff				
Page				
Williams				
Subtotal		72,666	115,406	144,775
% of total population		0.589	0.582	0.582
LaPaz	Western	19,715	30,909	37,978
Parker & Parker Strip CDP				
Subtotal		4,767	6,853	8,585
% of total population		0.2344	0.2217	0.2260
Mohave	Western	155,032	400,695	566,750
Bullhead City				
Kingman				
Lake Havasu City				
Subtotal		100,579	258,674	365,257
% of total population		0.649	0.646	0.644
Yavapai	Northern	167,517	418,671	558,118
Yuma	Western	160,026	377,598	505,302
San Luis				
Somerton				
Wellton				
Yuma				
Subtotal		101,631	236,799	316,163
% of total population		0.635	0.627	0.626

Source: Arizona Department of Economic Security, Research Administration, Population Statistics Unit.
Population projected by Demographic Cohort-Component Population Model. County data approved by Arizona DES Director, March 31, 2006. Population Statistics Unit, Arizona Department of Economic Security (602) 542-5984.
Subplace data adapted from DES Places Projections, (approved by Arizona Department of Economic Security Director, August, 1997)

[1] This paper benefited from discussions with the Global Institute of Sustainability water workshop advisory committee: Guy Carpenter, Brad Hill, Teresa Makinen, Ken Seasholes, and Kathryn Sorensen. The authors, however, are solely responsible for the content and any mistakes or omissions.

[2] Jim Holway and Peter Newell are the Associate Director and Graduate Research Assistant respectively for the Global Institute of Sustainability. Terri Sue Rossi is Planning Analyst for the CAP. This work is based in large part on work the authors previously completed on a background paper for the Morrison Institute for Public Policy "Superstition Vistas: Water Matters". We wish to acknowledge the work of our collaborators on the earlier paper including: Grady Gammage, Jr. Morrison Institute; Bruce Hallin, Salt River Project; and Rich Siegel, Salt River Project

[3] This paper will focus on municipal water supplies, water served by city and town or private water companies to their customers. Future refinements of the paper may provide additional consideration of agricultural and independent industrial water users as well as individual homeowners on their own wells.

[4] An Active Management Area (AMA) is a groundwater basin regulated pursuant to the Groundwater Code (Title 45, Chapter 2, Article 2 of Arizona Revised Statutes). Being in an AMA means water use is restricted. Additional information on AMAs is available through the Arizona Department of Water Resources at www.water.az.gov.

[5] Taking such a long timeframe introduces significant uncertainty. Typically, government population projections do not go beyond a 25 to 50-year timeframe. For this initial discussion paper draft we provide just one set of projections; later drafts may examine several scenarios.

[6]According to CAP's Outlook 2003 study (Central Arizona Project. (2004). Outlook 2003: Municipal Demand Projections for CAWCD's Service Areas Assuming Historic Data through January 2003 VOLUME ONE), the three-county area has a total of 9.6 million people projected for 2035. Of the 9.6 million, 9.34 million people or over 97% of the population is located inside AMAs. This projection is based on the 2003 interim projections developed by the Maricopa and Pima Association of Governments for the three-county area. Broken down by county, 6.8 million people are projected for Maricopa County, 1.6 million people are projected for Pima County and 1.2 million people are projected for Pinal County. Broken down by AMA, 7.3 million people are projected in the Phoenix AMA, 1.6 million people are projected in the Tucson AMA and 0.4 million people are projected for the Pinal AMA. The difference between the Pinal County and Pinal AMA projections is largely due to a large portion of Pinal County being located in the Phoenix AMA.

[7]Arizona Department of Economic Security, Research Administration, Population Statistics Unit. Population projected by Demographic Cohort-Component Population Model. Approved by Arizona DES Director, March 31, 2006.

[8] We developed our own projections for 2055 through 2100. Our projections for each county after 2055 were based on the increase of population between 2045–2055 in the official state projections. This population increase was held constant and added each decade for the totals shown between 2060–2100. We choose this method to project beyond 2055 because it best reflected the slowing growth rate projected in the official state population projections prepared by the Arizona DES. Had we used the average percentage increase between 2045–2055 and held it constant, we would have projected a population of 16.7 million in 2100 for Maricopa, Pinal, and Pima counties (1.5 million higher than the projection we are using for this report).

[9] The data and methods used for the rest of the state is consistent with the methodology used for central Arizona counties. If we had used a constant percentage growth rate, rather than a constant actual population increase, the statewide population projected in 2100 would be 19.7 million. (1.6 million higher than the projection we are using for this report).

[10] The Northern Arizona Municipal Water Users Association (NAMWUA) has estimated a future population of approximately 800,000 people in communities throughout the Prescott AMA, Big Chino-Paulden area, Verde Valley

and Gila and Coconino County areas. NAMWUA estimated a deficit of nearly 70,000 AF of water to serve these communities. Based on this work NAMWUA petitioned for an allocation of 70,000 AF of CAP supplies. The population projections used in this work were specified as being to either 2050 or at buildout for the various communities. Source: NAMWUA Water Demand Projections: Year 2050 (or at buildout).

[11] Communities included in Southeastern region projections include Sierra Vista, Benson, Huachuca City, and Sierra Vista SE CDP (census designated place). These communities were selected by the authors to represent the region to which the CAP canal could potentially be extended. As of the writing of this paper, DES had not published community level population projections compatible with the 2006 county projections. For the purpose of this paper, population numbers for these communities were generated using 1997 DES place projections which projected from 2000 – 2050 and applied to the 2006 DES projections and the authors interpolated data, according to the method described in the following example. The population of Sierra Vista is projected to be 78,687 in 2050 according to DES (1997) which represents 45 % of the 1997 DES projections for Cochise County. Assuming the same percentage applies to the '06 DES projections, we calculated a new population of 95,937 for Sierra Vista in 2050. Between 2040 and 2050, Sierra Vista represented an average of 45.14% of Cochise County according to '97 DES projections. Applying this average percentage to interpolated population for Cochise County for 2100, we calculated a population of 123,917 for Sierra Vista. A detailed table is included in Appendix B.

[12] We use 1998 data for this report because this is the most recent year for which data is available from all three central Arizona AMAs. Differences between 1998 and today would be minor overall, and are most significant in the Tucson AMA due to the expansion of CAP use through recharge and recovery. See Appendix C (through the GIOS website: http://sustainability.asu.edu/gios/waterworkshop.htm) for the most recent water budget for each individual AMA prepared by the Arizona Department of Water Resources. Between 1998 and 2003, Tucson AMA decreased usage of groundwater by 23,000 AF and increased usage of CAP by 59,000 AF. Between 1998 and 2000, Phoenix AMA increased usage of groundwater by 24,000 AF and CAP by 142,000 AF.

[13] An acre-foot of water equals 326,851 gallons and is the amount of water necessary to cover an acre of land to a depth of one foot. An acre-foot is generally considered enough water to serve approximately two households for a year in central Arizona

[14] Native American communities, as sovereign nations are not regulated under the states Active Management Areas, but we have included their water use in the current water budget data since they are part of the central Arizona basins.

[15] Arizona Water Resources Assessment 1994. Data representative of average annual groundwater withdrawals between 1981 and 1985.

[16] Note that for Table 3 and Figure 4a: CAP data includes direct use, recovered credits from previous storage, and CAP water used by agriculture as part of a groundwater savings facility. The CAP data does not include CAP water stored for long-term storage credits through direct recharge facilities by the AZ Water Banking Authority or other storing entities.

[17]Steve Rossi, 2004 City of Phoenix Water Resources Plan, presentation at ASU (9/05)

[18] Native American community water supplies are not examined in this paper, except for those renewable supplies identified through settlement discussions that are considered available for lease off reservation.

[19] These independent industrial users typically include power plants, sand and gravel and mining operations, dairies and feedlots, and certain golf courses. Industries supplied through the municipal water system are captured in the municipal projections for this paper. We assume the independent industrial users will continue to use groundwater, CAP allocations they already hold, or the effluent not used by municipal providers. This is an assumption that could be further evaluated and reconsidered for future revisions to this paper. An additional source of demand not included in these projections is urban flood irrigation, estimated at 140,000 AF in 1995 and projected to increase to 172,000 AF by 2025 (The Third Management Plan for the Phoenix AMA. Arizona Department of Water Resources. 1999). However, at least in the case of SRP, which provides the vast majority of flood irrigation water, the portion

of their supplies used for flood irrigation was also not included in their estimated surface water supply of 520,000 AF used for this paper.

[20] Additional details on the assumptions used to project the per capita water use rates are contained in the column notes for Appendix A.

[21] Per capita consumption for Western Counties was estimated at 250 GPCD (gallons of water use per capita per day) based on a weighted average of 2005 Colorado River water diversions and 2005 DES population estimates for Lake Havasu, Bullhead City, and Yuma. We recognize this is an approximation of total water use and total service area populations. (Population * GPCD * 365 days / 325,851 gallons per acre-ft)

[22] No estimates on Navajo and Hopi water demand and water claims were readily available. These claims potentially represent an additional demand on central Arizona water supplies.

[23] Per capita consumption for southeast Arizona was calculated using an assumed 168 GPCD (Upper San Pedro Basin AMA Review Report, March 2005) for Sierra Vista and Benson areas. Total consumption was calculated by multiplying this per capita use by the population projections for these areas from Table 2.

[24] A subdivision, as defined by ARS 9-463.02, is the splitting of a parcel of land into 6 or more separate parcels at least one of which is less than 36 acres. The Arizona Department of Real Estate enforces the subdivision laws and rules. In general, any new residential development requires the subdivision of land before it can proceed.

[25] For a more detailed overview of the Assured Water Supply rules, please refer to Appendix C (through the GIOS website: http://sustainability.asu.edu/gios/waterworkshop.htm). For further information, please see Arizona Revised Statutes section 45-576 through 45-578 and Arizona Administrative Code Title 12. Natural Resources, Chapter 15, Article 7. Additional information on the Assured Water Supply rules is also available on the ADWR website: www.water.az.gov

[26] Pinal Active Management Area Assured Water Supply Rules Modification Concepts: Final Subcommittee Draft. Approved by Pinal AMA GUAC 2/23/06. Arizona Department of Water Resources. Under the current AWS rules for the Pinal AMA, new subdivisions served by water providers existing prior to 1995 can be served 120 GPCD (gallons per capita per day) of groundwater and subdivisions served by new providers can be served 60 GPCD of groundwater. In addition, the Pinal AMA has more generous extinguishment provisions than the other AMAs for the retirement of agricultural lands holding irrigation grandfathered rights Due to both of these provisions groundwater can be used, without any replenishment obligation, to serve the majority of municipal demands in the Pinal AMA today. This balance of allowable groundwater use was not included in the water budget for this paper, estimating and including this allowable groundwater use is a refinement that could be included in future revisions of the paper.

[27] For further information on the CAGRD please see www.cagrd.com and the background paper in appendix C (through the GIOS website: http://sustainability.asu.edu/gios/waterworkshop.htm).

[28] The CAGRD is required to produce a new plan of operation each 10 years. In order for the CAGRD to continue to enroll new developments, this plan must be approved by the Arizona Department of Water Resources. During the development of the plan of operation for 2006 through 2016, approved in late 2005, a number of parties expressed concern about the CAGRD's ability to continue serving additional growth in demand well beyond 2016 and the CAGRD's lack of legal authority to say no to new applicants. For this paper, we assumed that the CAGRD, or an equivalent institutional structure, would continue to exist.

[29] Reasons often cited for the different supply requirements applied to the CAGRD include: 1) because the CAGRD is responsible for replenishing (through groundwater recharge) water after it has been pumped, it does not need to guarantee the ability to deliver water to meet demands when they occur, 2) the physically available groundwater ensures a reliable water supply to the customer (at least for the 100 years evaluated), so there is some logic to providing the CAGRD flexibility as to when it replaces the groundwater pumped out, 3) the size of the CAGRD and the diversity of its water supply portfolio can provide a significant balance to the risk of loosing any particular

supply source, 4) a number of supplies will be available for periods of much less than 100 years, the CAGRD provides a mechanism to make these supplies eligible for assured water supply purposes by aggregating these supplies to form a long –term portfolio.

[30] This is true for the Phoenix and Tucson AMAs, however, the Assured Water Supply rules in the Pinal AMA currently allow significant groundwater use without a replenishment obligation. New rules under consideration in Pinal AMA would significantly decrease the allowable groundwater use (without replenishment) for new development in the Pinal AMA. (See note 26 above).

[31] An analysis of tree ring data indicate that the long-term average flow of the Colorado River could be as low as 13.5 million AF per year (Stockton, C.W. and G. C. Jacoby. 1976. "Long –term surface water supply and streamflow trends in the Upper Colorado River Basin, Lake Powell Res. Proj. Bull. 18, National Science Foundation, Arlington, VA), though a more recent tree ring study estimated long-term flows of 14.6 million AF (Woodhouse, C.A., S.T. Gray, and D.M. Meko. 2006 "Updated streamflow reconstructions for the Upper Colorado River Basin," Water Resources Research, 42, W05415)**.** By comparison the annual average natural flow for the approximately 100 years of record on the Colorado River is 15.2 million AF. Arizona's ability to divert its full 2.8 million AF entitlement will be influenced both by climate, which could lead to shortages being declared on the river, and by the population and water demand growth of the upper basin states. Many water managers believe the upper basin will never be able to fully use their 7.5 million AF allocation, thus reducing the size of future shortages for the lower basin states.

[32] See Appendix C (through the GIOS website: http://sustainability.asu.edu/gios/waterworkshop.htm) for a link to Colorado River water rights holders.

[33] Fluid Solutions, (2004). *CAGRD Water Supply Study Narrative Report: Evaluation of Water Supplies* prepared for the CAGRD Plan of Operation. Table 1, page 4.

[34] Indian water rights cannot be sold. In Arizona, the only Indian water rights that can currently be leased off-reservation are CAP Indian rights pursuant to specific authorization by Congress. If leased, the term is typically for a maximum of 100 years. The assured water supply rules typically require a 100-year lease, however, 20- to 30-year lease terms may be easier to obtain.

[35] Several water-rights transfers have occurred as part of water-rights settlements approved by Congress (e.g., a transfer of a portion of Yuma Mesa's entitlement to the Ak Chin tribe and a transfer of a portion of Welton Mohawk's entitlement to the Salt River Pima Maricopa Indian Community).

[36] Because the CAP has the ability to divert into the CAP canal any portion of Arizona's entitlements not used along the river a formal sever and transfer may not be necessary to move supplies through the CAP canal into central Arizona.

[37] This is made up of 603,678 in current M & I allocations and an additional 65,647 of M & I supply being reallocated through the Arizona Water Settlements Act.

[38] Arizona State Land Department has an M&I CAP Subcontract for 32,076 AF. Most of this allocation is already committed to serve certain areas of State Land. This volume is not adequate to cover all of the development which may occur on state lands.

[39] Cullom, Chuck, (2005). Interview with staff hydrologist at CAP. This volume is based on an analysis of the five Arizona Indian water rights settlements (Ak Chin, Salt River Pima Maricopa, Ft. McDowell, San Carlos, and GRIC) authorizing leases. The analysis takes into account the volume of CAP water available to the Indian community, the volume already leased and assumptions about how much of the CAP water will be used on reservation.

[40] Semi-annual Status Report: Underground Water Storage, Savings and Replenishment (Recharge) Program. Arizona Department of Water Resources. June 30, 2005.

[41] This volume is significantly lower than the long-term average surface water availability of Salt River Project. Further analysis may be necessary to more precisely estimate this supply. This total also does not include 118,000 AF for urban irrigation (urban flood irrigation demands are also not included in the demand analysis for this report) and the volume of new conservation space water behind Roosevelt Dam. The 520,000 AF number was used in the AWS designation estimate out to 2040, Salt River Project, (1996). *Assured Water Supply Study for Salt River Project Member Lands*.

[42] RWCD's water right is 5.6% of water diverted at Granite Reef, generally averaging about 35,000 AF. After 2080 this water right reverts back to Salt River Project. In addition, portions of this supply have been committed as part of several Indian water rights settlements. Note that we included only 20,000 AF of this water right under "other surface water" in Table 5 and appendix A. Future revisions of this report can refine the estimate of the water available for municipal uses and take into account the 2080 reversion of the water to SRP.

[43] The SRP water rights are fully contained within the Phoenix AMA and are tied to the lands which are part of SRP. These lands are nearly built out already.

[44] These rights are based on storage rights behind New Waddell Dam. MWD has storage rights up to 157,600 acre-feet (i.e. the original storage capacity of the old Waddell Dam). CAWCD has the remaining roughly 540,000 acre-feet. MWD can store Agua Fria river water up to its storage capacity. After this capacity is full, CAWCD can store Agua Fria river water to fill the remaining capacity. These rights are established by stipulation between MWD, the United States and the CAWCD. The average supply available from the Agua Fria is 35,000 acre-feet per year. See Technical Report: Supporting the CAWCD's Application for Permit to Appropriate Waters from Agua Fria River (Application No. 33-89719). Central Arizona Project. 1989.

[45] Phone conversation with Randy Edmond, Area Director, Pinal Active Management Area, Arizona Department of Water Resources. March 2006.

[46] Incidental recharge is water applied to the landscape (parks, golf courses, leakage from distribution systems, etc.) which returns to the aquifer through recharge. The Assured Water Supply rules allow designated providers to use additional groundwater based on incidental recharge which is assumed to be approximately 4% of the total municipal water use in the Phoenix, Pinal and Tucson AMAs.

[47] A development which receives a certificate of assured water supply in the Phoenix and Tucson AMAs during the fourth management period (2010–2020) would be granted an allowable groundwater balance of only five (Phoenix) or two (Tucson)% of it's 100-year demand. After 2025 there is no allowable groundwater balance in the Phoenix and Tucson AMAs. For a designated provider that existed prior to the AWS rules, they received an allowable groundwater balance of 7.5% (Phoenix) or 15% (Tucson) of their 1995 total water demand. In the Pinal AMA, with a different goal, the assured water supply rules allow additional groundwater use for new development (see Note 26 above). However, water users within the Pinal AMA have developed proposals to revise the Pinal AMA assured water supply rules so as to increase the requirement for new development to rely on renewable supplies. The data included in Appendix A and Table 5 includes only the allowable groundwater balance for "designated providers" from the Phoenix and Tucson AMAs. Future refinements of this paper could generate estimates of the additional allowable groundwater use for certificates and for the Pinal AMA. For further information on these allowable balances see appendix C (through the GIOS website: http://sustainability.asu.edu/gios/waterworkshop.htm) or the ADWR website (www.water.az.gov) .

[48] Physical availability standards apply only at the time a certificate is issued or the subdivision is approved. In cases where only a 100-year supply was available, that groundwater may be depleted over the 100 years. However, the lands are still enrolled in the CAGRD after 100 years and there is no legal limitation on the ability of a water provider to continue to access groundwater, if it is available. In areas where the groundwater is not available at greater depth and the supply is depleted, the water provider will have to secure alternative supplies for direct delivery. Ideally, the CAGRD replenishment will occur in a way that provides additional physically available groundwater for the water providers well field, however there is no legal requirement that the replenishment occur in the area of groundwater pumping.

[49] See Title 45, Chapter 2, Article 8.

[50] The Yuma groundwater exchange would not be a 100-year supply. This supply is anticipated to be a 200,000 AF supply that will be withdrawn over a 20- to 30-year period.

[51] The 30% figure is based on comparisons of wastewater production to total water use for various utilities in the Phoenix area. Generally, wastewater production is based on estimates of indoor residential use. If 70% of total deliveries is residential and 40% of residential deliveries is indoor, then approximately 30% of total use would make up the wastewater stream.

[52] Seawater, with total dissolved solids levels or approximately 35,000 ppm,, is more expensive to desalinate and produces a larger brine reject stream than brackish groundwater with TDS levels ranging from 1,000 to 4,000 ppm.

[53] These estimates are based on several sources of information. 1) Central Arizona Project, (2004). CAP Subcontracting Status Report. 2) Fluid Solutions, (2004). *Water Supply Study Narrative Report: Evaluation of Water Supplies* prepared for the CAGRD. 3) Salt River Project, (1996). Assured *Water Supply Study for Salt River Project Member Lands*. 4) numerous Indian water rights settlements including Ak-Chin Indian Community Water Rights Settlement Act 1984, Salt River Pima Maricopa Indian Water Rights Settlement Act 1988, Ft. McDowell Indian Community Water Rights Settlement Act of 1990, San Carlos Indian Community Water Rights Settlement Act of 1990 and Arizona Water Settlement Act (pending), Southern Arizona Water Rights Settlement Act of 1982 and 4) Assumptions described in Appendix A.

[54] Central Arizona Project, (2002). Policy for Use of Excess Canal Capacity.

[55]Dozier, Larry, (2005). Interview with Deputy General Manager of Operations Planning and Engineering at Central Arizona Project.

[56] The Central Arizona Water Conservation District (CAWCD) controls access to wheeling capacity in the CAP canal. While CAWCD has not entered into formal agreements on wheeling capacity in the CAP canal, it has through policy acknowledged three main “interim set asides” or reservations of excess canal capacity. Phoenix received a 38,000 acre-foot per year reservation for transportation of its McMullen Valley groundwater. Scottsdale received a 15,000 acre-foot per year reservation for transportation of Planet Ranch water, and the CAGRD received a reservation of enough excess canal capacity to transport the non-CAP supplies necessary to meet its replenishment obligations as of July 1, 2003, generally considered to be equivalent to 105,000 acre-feet per year. The federal government may also have a role in allocating this access, though the federal authority and what position they may take is currently unknown.