Chapter 4

WATER AND GROWTH

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The fates of ancient civilizations hint at the risks of growing beyond the natural limits of available water resources. We have seen the consequences of water scarcity in countries that lack economic and technological resources; and even in the United States, long-term drought has caused large-scale dislocations, for example, the Dust Bowl of the 1930s. The settlement of the western United States, however, has been a story of growth driving water development.[1] Historically, investments in reducing water uncertainty have yielded dividends in financial stability and economic growth. The water displays in Nevada's casinos and decorative lakes in Arizona's subdivisions are emblematic of the value of water in attracting growth. Increases in population, however, are leading to stresses on current supplies and competition for new supplies.

Another engine of growth for Arizona is the quality of life provided by its uniquely beautiful environment, in which water is a key ingredient. Yet there has been consistent tension between the water demands of growing populations and the needs of the environment. Use of surface and groundwater for growth of the population and the economy has resulted in significant loss of riparian areas and habitat. Repairing and maintaining Arizona's environmental heritage will be a major challenge as the state's population continues to grow. Recently, river restoration projects, such as those in Phoenix, Mesa and Yuma, have been undertaken to enhance the quality of life for urban residents and visitors. These projects in-

[1] Recent news from California suggests that the role of water in limiting growth may be a more important policy question in the future. The California Court of Appeals rejected a CALFED plan because its environmental review was based on the notion that growth in California is inevitable and therefore required increased water delivery from north to south. The Court said CALFED "appears not to have considered … smaller water exports from the Bay-Delta region which might, in turn, *lead to smaller population growth due to the unavailability of water* to support such growth" (Pitzer, p.3, emphasis added).

volve major commitments of resources over extended periods of time. "The importance of these projects to the quality of … life in the Sonoran Desert is made evident by significant actual and planned public investments" (Megdal, p. 1).

GROWTH AND WATER DEMAND TRENDS

In the 25 year since 1980, Arizona's population has more than doubled from 2.7 million to 6.0 million. Between 1990 and 2004, the highest rates of growth in the state were experienced in Mohave, Yavapai, Pinal and Yuma Counties, while the greatest growth in absolute numbers has been in Maricopa County (with a gain of more than one million people since 1990), Pima, Pinal, and Mohave Counties. Population projections as detailed in Chapter 2 indicate continued high growth rates in these same areas. The needs of the major population centers in Maricopa and Pima Counties are widely known. Although the numbers are smaller, communities in other counties are facing similar challenges. Yavapai County must supply its rapidly growing population and preserve the unique environmental qualities supported by perennial flows in the upper Verde River. Coconino County, with only a slightly lower growth rate has experienced water supply difficulties when drought conditions have reduced normal supplies. Despite aggressive conservation and water rights acquisition measures taken by Flagstaff, the city continues to face potential shortfalls. Table 4.1 shows the total freshwater withdrawals in selected fast growing counties in Arizona.

TABLE 4.1
FRESHWATER WITHDRAWALS IN SELECTED FAST GROWING COUNTIES, 1985-2000
(thousand acre-feet)

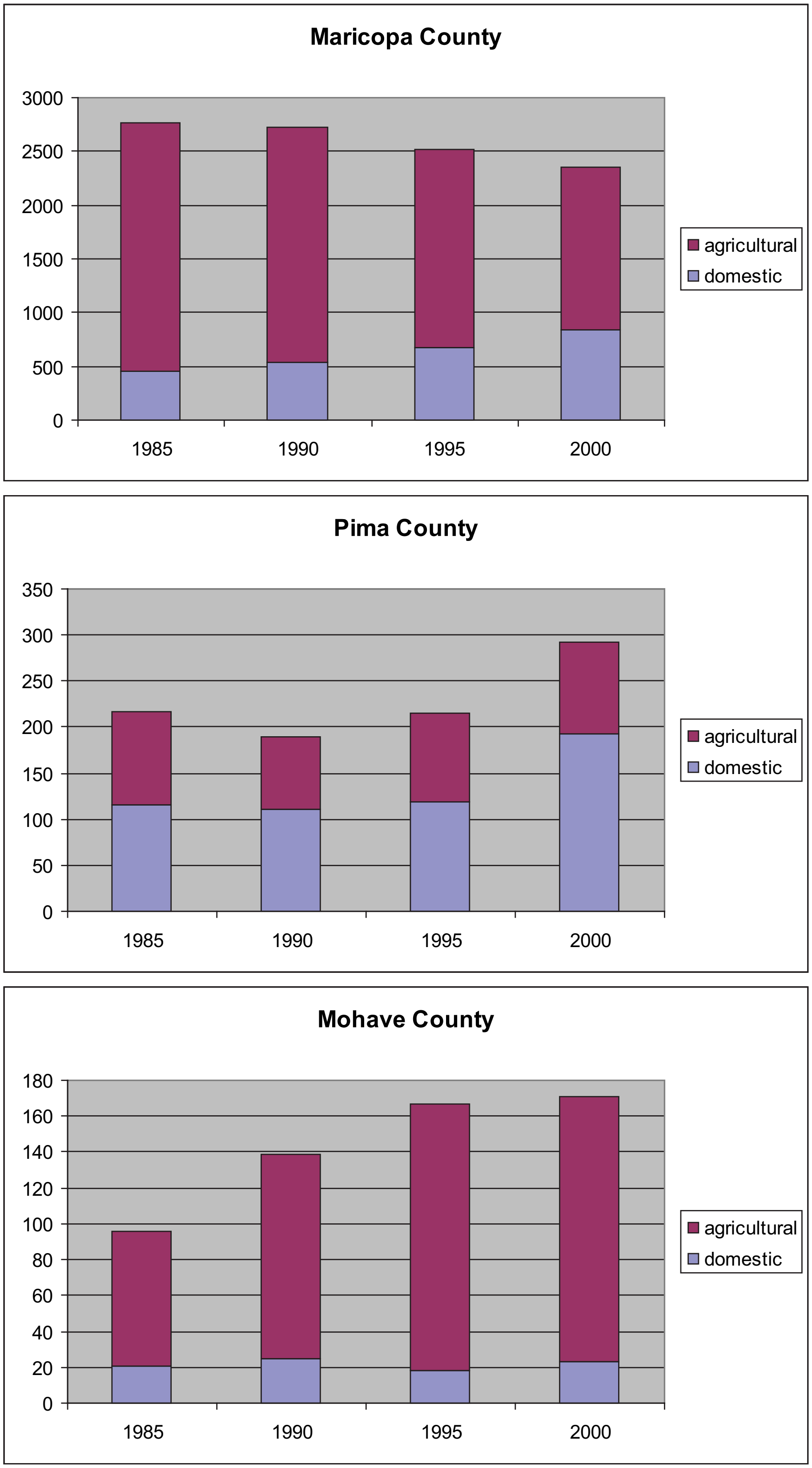
County	1985	1990	1995	2000
Maricopa	2,790	2,800	2,680	2,410
Mohave	114	163	157	172
Pima	260	256	296	337
Pinal	1,100	850	1,410	1,180
Yavapai	78	215	95	92
Yuma	1,480	1,410	1,570	1,640

Source: U.S. Geological Survey, Water-Use Trends in the Desert Southwest—1950-2000.

Increases in urban and suburban population will increase municipal water demand. Water use increases proportionally with population growth if per capita use remains steady. Many factors affect per capita usage. For example, new construction to accommodate growth can include water saving features that reduce per capita consumption. On the other hand, large cities can alter their own climates through creation of urban heat islands, which in turn may lead to higher water use. A larger factor in water demand is the water use habits and expectations of residents. Conservation programs have met with mixed results in the past, and the realistic potential for savings is a subject of debate.

It often is assumed that population growth will occur on previously irrigated farm-lands, and when this happens, total water use will decline. But this has not always been the case. In some places, residential development takes place on desert land, or farmland is merely displaced by development to new agricultural parcels further from cities, and total water use increases. In Maricopa County, total water usage declined between 1990 and 2000, when a 56 percent increase in public supply was more than offset by a 30 percent decrease in agricultural irrigation. On the other hand, no long-term change in water use was recorded when Salt River Project agricultural acreage was converted to residential and commercial development. Figure 4.1 compares changes in agricultural and domestic water use in Maricopa, Pima and Mohave Counties from 1985 to 2000.

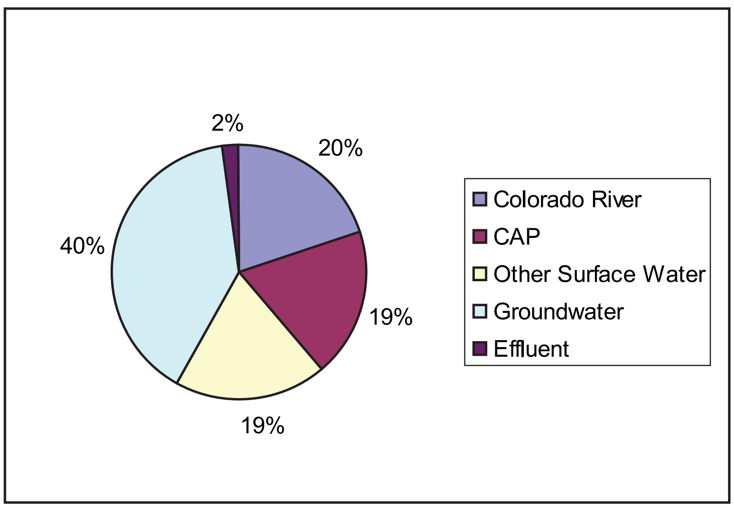
FIGURE 4.1
SALT RIVER PROJECT WATER USE



CURRENT WATER SOURCES

Currently, Arizona draws on four principal sources of water: the Colorado River, other surface water, groundwater and effluent. An average of 39 percent of Arizona's water (2.8 million acre-feet) comes from the Colorado River, and about half of that is delivered through the Central Arizona Project (CAP) to central Arizona. Non-Colorado River surface water sources include the Salt, Verde, Gila and Agua Fria Rivers and the reservoir storage systems located on them. On average, Arizonans get 19 percent of their water (1.4 million acre-feet) from all non-Colorado River surface water sources (Figure 4.2).

FIGURE 4.2
WATER SOURCES



Approximately 40 percent of the water used in Arizona comes from groundwater. In total, Arizona's aquifers hold a very large amount of water, most of it water that has been collecting underground for thousands of years. However, the capability to extract and use this groundwater is limited by a number of factors, including depth, geology and chemistry. Natural recharge, which occurs mainly along mountain fronts and in stream channels, continues to add to this supply. In the most populous areas of the State as well as in areas with irrigated agriculture, however, water is pumped from groundwater sources faster than it is replenished naturally. This has led to declines in water level by hundreds of feet in some areas as well as aquifer compaction, subsidence of the ground surface and soil fissures.

Effluent is treated wastewater. The larger the population, the more effluent is generated. Only a small portion of the effluent that is generated in Arizona is used: approximately 0.14 million acre-feet per year. Effluent in Arizona is used most often for irrigating non-food crops and turf, and industrial cooling. When released to stream beds, it may support riparian ecosystems. In conjunction with stream releases or in separately constructed facilities, it also is used for artificial recharge of aquifers. Combined, these effluent uses represent only two percent of Arizona's water demand.

WATER RESOURCE MANAGEMENT IN ARIZONA

In Arizona, the different sources of water are managed through different systems and under different agencies. Groundwater in populous parts of the state is managed differently from that in less populous areas. In addition, water quality is managed separately from water supply.

Water from the Colorado River is subject to the Law of the River, a collection of interstate compacts and international treaties, Congressional acts, and Supreme Court Decrees resulting from lawsuits between the states sharing the river. The U.S. Bureau of Reclamation is responsible for managing the river, under the decision-making authority of the Secretary of the Interior. The Arizona Department of Water Resources (ADWR) is responsible for making recommendations to the Secretary regarding allocation of Arizona's share of the river, although essentially all of the allocations already have been made.

The CAP is allocated approximately half of Arizona's Colorado River water. Construction on the CAP canal, which carries Colorado River water to users in central Arizona, began in 1973. The first deliveries were made on the incomplete system in 1984, and the project was declared substantially complete in 1993. The canal system has a designed capacity of 1.8 million acre-feet per year, and a total entitlement to 1.5 million acre-feet. The CAP is managed and operated by the Central Arizona Water Conservation District

(CAWCD), an organization formed to contract with the federal government for CAP water and subcontract with water users in central Arizona. The CAWCD implements policies set by its Board of Directors, a 15-member body elected from the CAP's three-county service area: Maricopa, Pima and Pinal Counties. The Board sets CAP rates annually.

The Salt River Project (SRP) manages surface water from its reservoirs on the Salt and Verde Rivers. It is a quasi-governmental organization created to gain federal assistance in building one of the first major water development projects in the West. The Bureau of Reclamation, which constructed the reservoirs, retains title to them. Dams and reservoirs have been added to the system as needs expanded, and the organization has evolved to manage and operate the extensive SRP water and power systems. Land owners in the SRP service area own rights to SRP water. Originally developed for agriculture, about 88 percent of the member lands are now residential. The project allocates water to member lands at a standard rate of three acre-feet per acre, except in times of shortage such as in 2004, when two acre-feet per acre were allocated.

A body of law referred to as "prior appropriation" governs other surface water. The right to use a certain amount of surface water for a specified purpose is acquired through the process of obtaining a permit to take the water, constructing the means for taking the water and conveying it to its point of use, and then using the water. The first person to acquire a right to water from any water body has the highest right to water, while the newest water right holder has the lowest right. In times of shortage, the holders of the older rights receive all of their water before newer rights holders receive theirs. Most of the surface water in Arizona already has been appropriated. ADWR administers the surface water permit program, but the rights holders perform water management, and disputes between rights holders that are not settled between them are litigated.

Arizona law holds that effluent belongs to the entity that generates it (except under certain special circumstances). The entity has the right to recapture the effluent even if the effluent has been discharged to a stream channel for many years and others have appropriated the flow as surface water. ADWR has an interest in effluent as a renewable water resource, especially when it is substituted for groundwater use or recharged to the aquifer in Active Management Areas (AMAs). The uses of effluent are regulated for environmental and public health purposes by the Arizona Department of Environmental Quality (ADEQ) and the U.S. Environmental Protection Agency (EPA). These agencies also share regulatory authority over other activities relating to water quality such as waste discharges, non-point source pollution, groundwater remediation and drinking water treatment.

Groundwater is managed under two systems. In critical groundwater areas, *i.e.*, the AMAs, ADWR regulates the use of groundwater under the authority of the 1980 Groundwater Management Act (GMA). In the rest of the state, groundwater is governed by the reasonable use doctrine: the owner of land has the right to pump groundwater from beneath the land for a reasonable use on the land. Like surface water within the prior appropriations system, under reasonable use, groundwater management is the responsibility of the right holder and intractable disputes between rights holders are litigated. ADWR permits water wells and maintains a registry of well permits.

More comprehensive groundwater management is possible in AMAs through the planning and regulatory activities of ADWR. Since the 1940s, groundwater has been pumped more rapidly in certain parts of the state than it has been replenished, resulting in a condition called "overdraft." AMAs were created in basins where groundwater overdraft had become a critical issue because of population growth and agricultural water uses. The management goals of the AMAs differ in some ways because of their different situations, but they share the overall goal of reducing or halting overdraft.

Four AMAs were created at the time of the GMA passage, Phoenix, Tucson, Pinal and Prescott, and the Santa Cruz AMA, which split off of the Tucson AMA, became a separate AMA in 1994. The boundaries of the AMAs surround major population centers and generally coincide with the boundaries of groundwater basins (Figure 4.3). Eighty percent of Arizona's population lives within the boundaries of these AMAs. Through the mechanisms established in the GMA, ADWR can manage groundwater withdrawal and use to achieve AMA-wide goals. Table 4.2 shows the management goals for each of the AMAs. The GMA also established Irrigation Non-Expansion Areas, where irrigated acreage could not expand.

FIGURE 4.3
ACTIVE MANAGEMENT AREAS AND IRRIGATION NON-EXPANSION AREAS

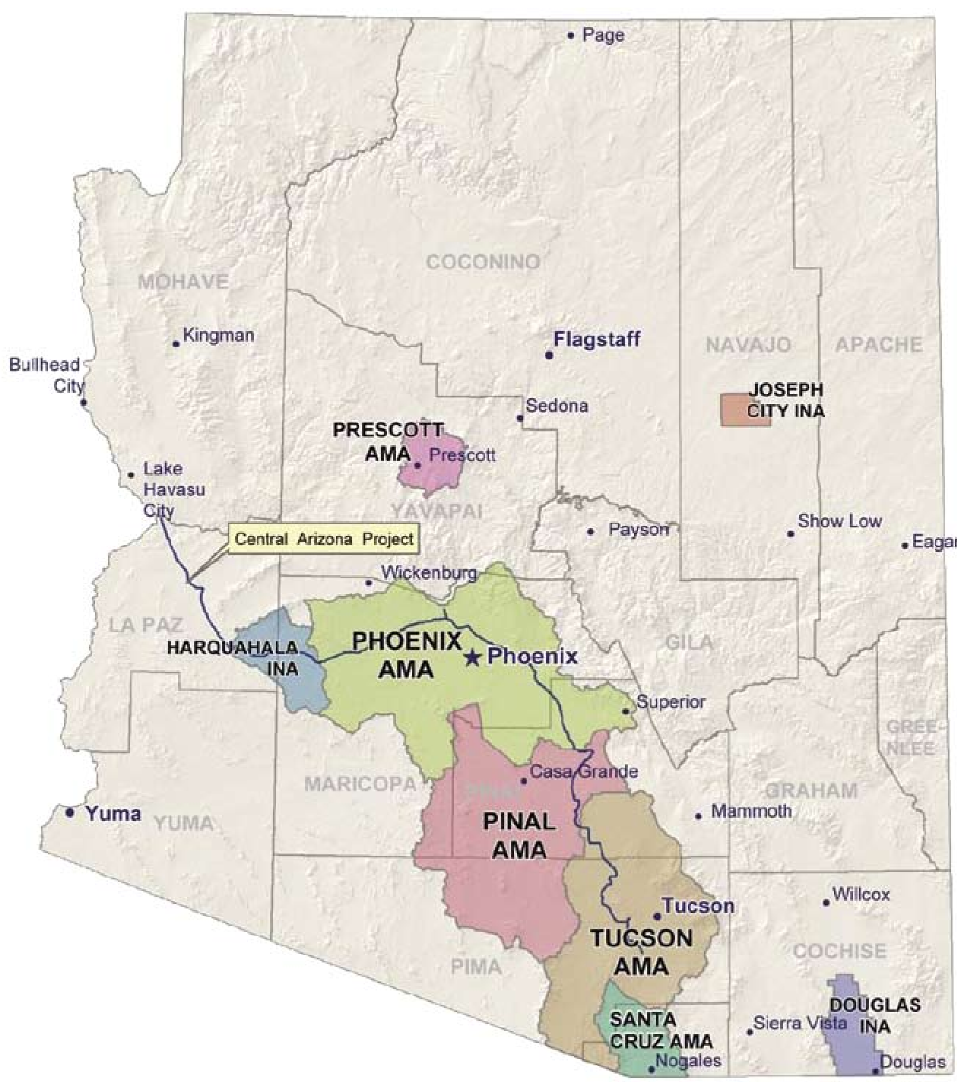


TABLE 4.2
ACTIVE MANAGEMENT AREA GOALS

AMA	Description	Goals
Phoenix AMA	Large, urban area; agricultural use	Safe-yield by 2025
Pinal AMA	Agricultural use; small urban area economy	Extend agricultural economy as long as feasible. Allow development of non-irrigation water uses. Preserve water supplies for non-agricultural uses.
Prescott AMA	Large, urban area	Safe-yield by 2025
Santa Cruz AMA	Small urban area; binational; riparian and water level issues	Maintain safe-yield. Prevent local water tables from declining long-term.
Tucson AMA	Large, urban area	Safe-yield by 2025

Note: Safe-yield is defined as a long-term balance between the annual amount of groundwater withdrawn in the AMA and the annual amount of natural and artificial recharge.
Source: Arizona Department of Water Resources, 2002.

No new areas of Arizona have become AMAs since the passage of the Act. The GMA provides for designation of AMAs where overdraft is identified as a critical problem, and ADWR undertook studies to determine the need in the San Pedro watershed of Cochise County. The ADWR opinion, issued in March 2005, stated that the area did not meet statutory requirements for an AMA. This opinion disappointed environmental interests, but reflected the preferences of most jurisdictions in rapidly growing areas outside AMAs. They continue to prefer local action to formation of an AMA and the state-level regulation that would ensue.

Within AMAs, annual groundwater withdrawals are limited and subject to regulation according to the type of right held by the pumper. There are irrigation rights, non-irrigation rights (Type I and Type II), service area rights and rights pursuant to new groundwater withdrawal permits. Domestic wells with low pump capacities (generally, 35 gallons per minute or less) are exempt from most GMA regulations.

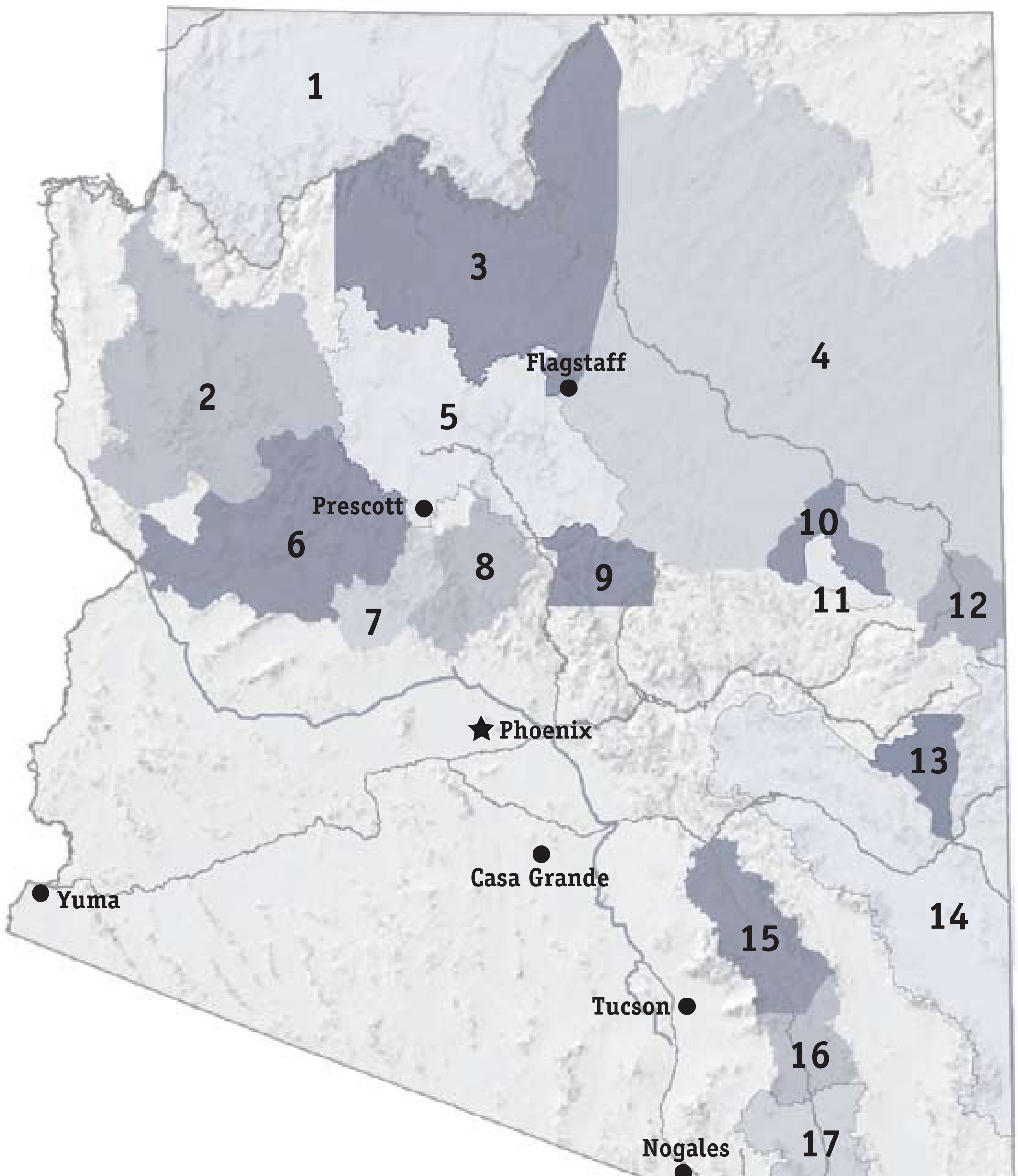
Assured Water Supply and Adequate Supply Rules

Developers of new subdivisions are required to show that they have access to sufficient water to support the needs of the development. Outside of AMAs, developers must obtain a determination of water supply adequacy from ADWR before they can subdivide land and sell lots. However, even when the water supply is determined to be inadequate, lot sales may proceed as long as the first purchaser of the land is informed.

A few new tools exist for counties and communities outside AMAs, to prepare for growth. The Arizona Legislature has required and authorized rural communities to plan for growth and drought. "Growing Smarter" legislation passed in 2000 contains a requirement that growing municipalities with a population larger than 2,500 and counties with more than 125,000 people include a water resources element in their comprehensive plans. The element must identify legally and physically available supplies known to exist, future demand for water, and how the demand will be served. The requirement provided an incentive for the counties and municipalities to plan for growth and include water supplies among the elements included in the plans. The Arizona Rural Watershed Initiative has provided planning and technical assistance to rural areas. Authorizing legislation gave impetus to the creation of watershed partnerships and such alliances have been formed in 17 watersheds (Figure 4.4). Active alliances have focused first on acquiring accurate information about their water situations and informing and educating themselves and their communities. Their combined efforts give them a stronger voice in regional and state decisions.

More effective water management tools are available within AMAs. There, developments either must obtain a Certificate of Assured Water Supply (AWS) from ADWR or must be served by a water provider with an ADWR-issued AWS Designation. In order to obtain a certificate or designation, the developer or provider must show that water is physically, continuously and legally available for 100 years and that it meets federal and state potable water quality standards. In addition, the water supplier must show the financial capability to develop any needed water infrastructure. Finally, use of the water must be consistent with the water management goals of the AMA. This final criterion means that a significant portion of the water used by new developments must come from renewable supplies. For the most part, the renewable water used to meet this requirement in central Arizona is CAP water, even for developments too far distant from the CAP canal to take the water directly. Where groundwater conditions are favorable, the rules allow the developer or provider to offset groundwater use by the new development with recharge of renewable water or substitutions of renewable water for an established groundwater use elsewhere in the AMA.

FIGURE 4.4
RURAL WATERSHED GROUPS



Arizona Watershed Alliance

1 Arizona Strip
2 Northwest Arizona Watershed Council
3 Coconino Plateau Regional Water Study
4 Little Colorado Multi-Objective Management
5 Upper Verde and Middle Verde Studies
6 Upper Bill Williams
7 Upper Hassayampa
8 Upper Agua Fría
9 Northern Gila County Water Plan Alliance
10 Silver Creek
11 Show Low Creek
12 Upper Little Colorado River Partnership
13 Eagle Creek
14 Upper Gila
15 Lower San Pedro
16 Middle San Pedro
17 Upper San Pedro Partnership

Source: Arizona Department of Water Resources.

In the process of developing the AWS rules, it became clear that a mechanism was needed to give developments on AMA land distant from the CAP canal access to renewable supply credits for development. At the same time, Arizona was not using its full entitlement to CAP water. The large quantity of "excess" CAP water represented a financial challenge and a water management opportunity. The State legislature authorized development of a Groundwater Recharge Program and creation of the Central Arizona Groundwater Replenishment District (CAGRD) and Arizona Water Banking Authority (AWBA). These actions all were intended, among other goals, to use water available immediately that otherwise would go unused in Arizona. They also provide ways to buffer CAP users from system shortages and outages. In addition, the recharge program and the CAGRD help developers meet AWS requirements.

The Recharge Program

Arizona's groundwater recharge program allows groundwater users to accrue credits for future water use or to offset current groundwater pumping. Entities with CAP subcontracts can store CAP water they cannot use directly in recharge facilities, either to recover the water at a later date or at a different location. In Groundwater Saving Facilities, water credits are accrued for substituting CAP water for groundwater pumped pursuant to an irrigation, or other, grandfathered right. Water credits also can be earned by recharging effluent. Long-term groundwater storage credits are banked in the account of the storage permit holder. Later recovery of storage credits requires a recovery well permit. Many issues related to recovery of long-term storage credits remain to be resolved, and they are likely to have an impact on how future water supply plans are configured. Table 4.3 shows the number of permitted recharge projects in AMAs as of June 30, 2005.

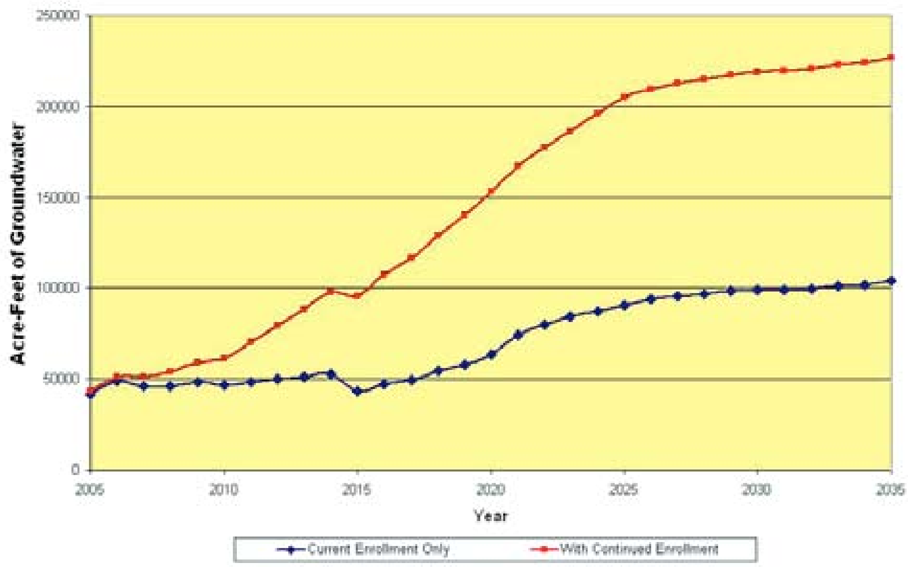
TABLE 4.3
PERMITTED RECHARGE PROJECTS IN AMAS
(June 30, 2005)

	CAP	Effluent	CAP + Effluent	CAP + Surface Water	Surface Water + Effluent	CAP + Effluent + SW	All
Phoenix AMA USF	13	21	3	2		2	41
GSF	5	3	1				9
Prescott AMA USF		3			1		4
GSF							0
Pinal AMA USF		4					4
GSF	3						3
Tucson AMA USF	4	5					9
GSF	6						6
Total AMAs	**31**	**36**	**4**	**3**	**1**	**1**	**76**

Source: Arizona Department of Water Resources, Semi-Annual Status Report, June 30, 2005

Subdivision developers and municipal providers also can comply with AWS requirements by joining the CAGRD. CAGRD members pay the District, which assumes the obligation to replenish excess groundwater use, as determined by implementation of the AWS Rules. This option is especially useful for entities that do not hold CAP subcontracts. Because of such factors as high cost for infrastructure, a few providers with CAP subcontracts and the new developments in their service areas have chosen to use the CAGRD and have requested that their subcontract entitlements be assigned to that organization. The AWS program and the CAGRD function together to ensure that all new subdivisions in AMAs include a substantial proportion of renewable supplies in their water portfolios. The CAGRD, in its most recent 10-year plan of operation, projects enormous growth in demand for its replenishment services over the next 25 years. Figure 4.5 shows CAGRD's replenishment obligation projections for current members only and assuming continuing new enrollments. The integrity of the system rests on its ability to meet its future replenishment obligation. In its most recent 10-year plan, the CAGRD projected declining availability of excess CAP water to the point that the District will not be able to meet its replenishment obligation with excess CAP water by 2020 and possibly as early as 2015. Other sources will have to be used.

FIGURE 4.5
PROJECTED CAGRD REPLENISHMENT OBLIGATIONS



Arizona Water Banking Authority

The AWBA was created in 1996 to fulfill four main objectives, including primarily, storage of water to ensure reliable municipal water deliveries during future shortages on the Colorado River or CAP system failures. It achieves its objectives by storing CAP water in constructed recharge and groundwater savings facilities. The AWBA does not compete with other CAP water users or rechargers, standing last in line in priority. It has, however, used all the unclaimed and unused CAP water in the system. Since its inception, the AWBA has stored or saved more than two million acre-feet of water for Arizona uses. The AWBA also stores some water for Nevada under its interstate banking authority. The AWBA works closely with the CAWCD, which has the responsibility to deliver recovered CAP water in times of shortage or outage of the CAP canal.

TOOLS AND STRATEGIES

To accommodate new growth, planners are examining their water portfolios and looking for ways to expand them. Three main avenues for expansion have been identified.

Demand Management and Conservation

By using less, Arizonans create a source of water to support growth. This is not universally a popular idea, and generally will not lead to conserving behaviors. But metering and prices can motivate conservation behavior that saves consumers money on their water bills. Incentive and assistance programs can lead to changes in infrastructure that make it more water efficient. Regulation and ordinances can mandate or prohibit activities in order to reduce water use.

Maximize Use from Existing Sources

Most water plans include maximizing the use of existing renewable sources of water: CAP subcontracts, other surface water rights and effluent, along with continued use of groundwater. As these sources approach full utilization, problems become more apparent and costs rise. Although southern Arizona is rich in groundwater resources, problems associated with overpumping are already severe in some areas. Groundwater overdraft is drawing down water tables, threatening or destroying ecosystems, and, in some places, causing subsidence. In the headwaters of the Verde, Agua Fria and San Pedro Rivers, groundwater pumping will have to be limited if surface water flows are to be maintained. Even in the best of circumstances, the costs of extracting groundwater rise as depth to water increases, and in Arizona the quality of the water usually worsens with depth.

There will be “excess” CAP water for some years into the future, although the annual amount is projected to decline from 900,000 acre-feet in the year 2005 to just over 100,000 acre-feet in 2049, and to zero in 2050. In addition, some CAP water will be available for redistribution over the next 20 years, although uncertainty occasioned by on-going stream adjudications and Indian water settlements makes it impossible for any entity to plan on acquiring more CAP water from this source. Other Colorado River water that is not allocated to the CAP could be leased or acquired by other mechanisms from Indian and non-Indian irrigation water users with rights to pump directly from the river. However, such transfers would be complicated and would require that third-party impacts be addressed.

Develop New Sources

At this time, the outlook for new water is limited. Importation of groundwater from rural areas of Arizona to urban areas is limited by statute. Only the Butler, McMullen and Harquahala Valleys may be exploited for groundwater export to AMAs. It has been estimated that large quantities of water exist in these basins, but acquiring and transporting the water would be extremely expensive. In addition, weather modification and treatment of poor quality water, *e.g.,* desalination, have been mentioned as future ways to increase water supplies, assuming the technologies are cost effective.

STRATEGIES FOR ASSURING WATER FOR CURRENT AND FUTURE POPULATIONS

Water planning in Arizona has served to accommodate growth, not restrict it. It has been recognized by growth proponents and opponents alike that the more efficiently water resources are managed, the more growth water supplies will support. With current technology, Arizona has enough water to support a population several times its current size, assuming that essentially all the water would go to municipal and industrial users. However, as more than one observer has commented, other environmental stresses and economic dislocations will be felt long before growth reaches the theoretical limits of Arizona's water supply. Finding a smooth path to sustainable water supply is another matter.

Demand Management Strategies

Improvements in treatment and delivery systems, including leak detection and repair are capable of saving large quantities of water. Metering reduces demand by providing consumers with water use information that allows them to monitor and manage their own water use. Other mechanisms that provide users information for the purpose of inducing water conserving behavior include education and assistance programs. These programs have included information, for example, about low-flow plumbing fixtures, low water use landscaping, irrigation scheduling and irrigation system maintenance. Water rates also have been used to induce water saving behavior; tiered water rates, which are relatively low for smaller amounts and rise in steps as the amount of water use increases, tend to discourage the use of very large amounts of water, especially for outdoor uses.

Inducing consumers to make costly structural changes like low water use plumbing and landscaping may be more effectively achieved through incentives, and some incentive programs have been very successful. One strategy reduces water service hook-up fees in exchange for incorporating water saving into house and landscape designs. Another tool is modification of building practices through changes to building codes. Local ordinances cause reduced water demand by restricting uses temporarily in time of drought or other supply emergency. Temporary restrictions have limited hours of use for, or prohibited outright, certain types of use such as outdoor car washing. More permanent reductions have been achieved by ordinances that limit the amount of high water use landscaping in new developments.

Land Use Planning

Land use planning has been used as a growth management tool to create and preserve amenities valued by the community, such as residential character, open space, transportation, historic and cultural heritage. On the other hand, water planning has been used most often to prepare for and accommodate growth. Some people have suggested, however, that water planning can provide a powerful tool for managing growth. There are communities in the United States where a moratorium on new water hookups has been used to slow and redirect building activity to prevent growth from outstripping the ability of a city or county to supply water. Some private water companies in Arizona have had to impose moratoria within their service areas. The AWS rules for new subdivisions have the potential for regulating growth on the basis of water supply availability within AMAs. The existence of the CAGRD has buffered developers from the growth management potential of those rules.

Water Resource Impact and Development Fees

Impact or development fees are common tools used by local jurisdictions to offset the costs imposed by population growth, such as for transportation, education, and other services. The water impact fees do not necessarily reduce water demand, but they provide a source of funds to pay for new supplies to meet new demands. Proponents of such fees argue that the price of new development should reflect the additional costs it imposes on a jurisdiction. Opponents argue, among other things, that development ultimately benefits the entire community, so the whole community should pay.

STRATEGIES FOR AUGMENTING SUPPLIES

Reusing Effluent

Currently more effluent is generated than is reclaimed for direct use or recharged. Effluent is the only source of water that is growing. Growth in effluent follows simply from the fact that more people are washing dishes, taking showers and flushing toilets. Wastewater can be reused through several mechanisms. At the site of use, "graywater," drain water from washers, tubs, showers and other than kitchen sinks, can be used for landscape watering. Water quality guidelines for graywater use have been established by ADEQ. On-site use of graywater reduces demand for water from the potable water system. Although it currently provides an insignificant proportion of water saving to AMAs, its potential is much larger. However, widespread use of graywater could create sewage treatment system problems as a result of reduced flows in sewage lines. It also could affect the water supply plans of providers who are depending on increases in effluent flows based on historical practices (that is, almost no graywater use).

Reuse of wastewater after it has been collected in a central facility for treatment can happen directly after tertiary treatment for turf irrigation or after purification for some industrial uses and potentially for potable uses. Once considered a nuisance, effluent is becoming a valuable commodity. Treated wastewater that meets water quality standards established by ADEQ can be saved for later reuse through recharge. Most municipalities and many developers are planning to use most or all of the effluent they generate in the future. Frequently, water treatment facilities are included in development plans and effluent reuse is specified for golf course and landscaping irrigation. Decorative lakes constructed to enhance the desirability of new residential developments in Arizona were once filled with high quality water, but a law passed in 1987 ended the practice. Such lakes are now filled with treated effluent instead.

Throughout human history wastewater has been used in potable supplies and continues to be used in cities that rely on surface water. Dilution in natural rivers removes the stigma of using treated wastewater directly. As population growth strains existing supplies, direct potable reuse of purified wastewater becomes an important resource option. A major impediment to this use is public disapproval and concern for health implications. With all the unregulated substances of concern moving from wastewater into the environment, water suppliers are looking seriously at the issue. Various entities have investigated recharge of effluent to take advantage of soil-aquifer treatment and blending with native groundwater for potable use. A project using effluent that has been purified by advanced treatment has been approved for a residential development in California.

CAP to Sierra Vista

Residents of Sierra Vista are actively studying the possibility of extending the CAP canal to that city. A feasibility study performed by the Bureau of Reclamation estimated construction would cost $193 million. This estimate is based on a pipeline with enough capacity to carry approximately 30,000 acre-feet of water per year. The same study estimated that the Sierra Vista area would use 38,500 acre-feet annually by 2050. The preferred route would run east along Interstate 10 from the current terminus at Pima Mine Road, turn south at Arizona Highway 90, and end near Fort Huachuca's main gate. Sierra Vista currently has no CAP water subcontract. For Sierra Vista, getting the water may be a greater challenge even than paying for the conveyance. On the other hand, although the Green Valley Community Water Company, only seven miles south of the terminus, actually holds a CAP subcontract for 1,900 acre-feet of water per year, the high cost associated with extending the CAP canal has prevented that area from taking its entitlement.

Other Strategies

Weather modification is a strategy for enhancing the amount and/or timing of precipitation over watersheds. Feasibility studies have been carried out intermittently over several decades with mixed results. Most planners consider the near-term probability of producing more water through weather modification a long shot. Another technologically limited strategy is desalination. The issues of high energy costs and disposal of brine streams have hindered large-scale use of desalination of water for municipal uses in the United States. It can be cost-effective in some situations, and Phoenix, for example, is investigating the possibility of treating and using brackish water from shallow aquifers southwest of the city.

Water harvesting and watershed management are strategies for capturing for human use more of the water that falls as rain or snow. Water harvesting in Arizona generally occurs on site and involves constructing and operating systems that collect, store and distribute precipitation, usually for landscape irrigation. The potential for water harvesting is large, but at the individual lot scale, its success depends on the knowledge and commitment of individual land owners. Watershed management involves manipulating plant cover on watersheds to enhance the amount and/or timing of runoff. Most commonly, management to increase water yields involves removal of phreatophytes (plants that use a lot of water) and thinning of vegetation in general. Watershed management to increase water yields must include an understanding of the implications for water quality, soil stability and unintended environmental consequences.

TRANSFERRING, TRANSPORTING AND IMPORTING WATER

Inter-Sectoral Transfers—the Future of Agriculture

A substantial portion of the water for Arizona's growing population will come from reductions in agricultural irrigation. Currently, agriculture accounts for 80 percent of all water use in Arizona, down from 97 percent in 1950. For the most part, the conversion of agricultural water use to municipal use occurs on or near the farm. A prime example is conversion of SRP member lands from farms to residences. In 1980, the GMA anticipated the gradual decline of agricultural water use inside AMAs as farmland was replaced by municipal development. However, for various reasons, overall, the anticipated decline in agricultural water use has not occurred. Table 4.4 juxtaposes data on irrigated cropland acreage with freshwater withdrawals for agriculture between the years 1990 and 2002.

TABLE 4.4
IRRIGATED CROPLAND AND FRESHWATER WITHDRAWALS FOR AGRICULTURE, 1990-2002

Year	1990	1992	1995	1997	2000	2002
Acres of irrigated cropland (thousands of acres)		903.2		1,016.6		887.1
Freshwater withdrawals (thousands of acre-feet)	6060		6390		6050	

Sources: U.S. Department of Agriculture, Economic Research Service, State Fact Sheets: Arizona, December 8, 2005; U.S. Geological Survey, Water-Use Trends in the Desert Southwest—1950-2000.

Renewable surface supplies provided about 49 percent of agricultural water use in the year 2000. Cities are eyeing these large quantities of renewable water as they look for new sources to meet their growing demand. Non-Indian irrigation water users on the Colorado mainstem include the Yuma County Water Users Association, Yuma Mesa Auxiliary Unit B, North Gila Valley Unit, Wellton-Mohawk Irrigation and Drainage District (IDD), Yuma Mesa IDD and Cibola Valley IDD. A number of different voluntary mechanisms could be used by cities to acquire water supplies from non-Indian irrigators. These include land purchase, temporary and long-term lease arrangement, forbearance,[2] fallowing and other conservation arrangements. Any agreements for acquiring agricultural water will require compliance with applicable state and federal policies.

Outside AMAs groundwater aquifers hold large quantities of water that might supply growing cities. Under current statutes, however, the number of basins from which groundwater may be exported is strictly limited: Butler Valley, McMullen Valley and Harquahala Valley. In addition, importation of groundwater from any of these basins is restricted and limited. A primary consideration will be local third-party impacts: negative economic effects such as lower business revenues, lower retail sales, reduced property values and declining employment. In 1986 Phoenix purchased approximately 14,000 acres of farmland in the McMullen Valley with the intent to retire them for their groundwater rights. Plans call for a pipeline to be built from the water farm to the CAP canal and for the water to be conveyed to the city when growth in demand after 2030 makes the project feasible.

Arizona State Land Department

The Arizona State Land Department (ASLD) owns water rights associated with state lands. That groundwater may be sold. The Department also manages contracts with the federal government, which include the State's entitlement of Colorado River water used on State Trust lands. Currently, the ASLD is allocated a total of 32,076 acre-feet of CAP water. It has not indicated how it plans to utilize its allocation.

[2] Forbearance means that in any one year agricultural parties with rights to use Colorado River water would not take the water to which they are entitled so that others can use it. The right holders are compensated for forgoing their right to a certain amount of water.

Indian Water

A number of Indian communities hold contracts for high priority CAP water, including the Ak-Chin, Gila River, San Carlos, Tohono O'odham, Fort McDowell and Salt River Pima Maricopa Indian Community. The communities are developing plans for using their entitlements, and through existing and pending water settlements, their options include leasing water for off-reservation use. The CAGRD and municipal water providers are hopeful that lease arrangements with Indian communities will provide future water supplies to meet anticipated growth. In addition, water planners are looking toward the Indian communities along the Colorado River mainstem who hold rights to Colorado River water senior in priority to the CAP. The physical means to transport water leased from these communities exists—the CAP canal, but the legal infrastructure for such transfers does not. Lease and transfer agreements would involve the tribal governments and the Secretary of the Interior, and could require congressional approval.

CHALLENGES

Water sustainability is the central concept of a water policy that addresses the challenges of providing for current and future generations. Sustainability is "The ability of current generations to meet their needs without compromising the ability of future generations to meet their needs" (World Commission on Environment and Development). The framers of the 1980 GMA recognized that water sustainability could not be achieved with mined groundwater and consequently mandated programs of regulation and incentives to move to renewable supplies. The AMA goals of Safe Yield by 2025 are the translation into legislative terms of the aspiration to achieve water sustainability; however, it was recognized even then that new strategies would have to be developed to allow for growth beyond the year 2025.

Since 1980, Arizona's rapid growth has brought with it a host of water policy challenges. The challenge of making sure there is enough water to meet future needs is linked with many related water issues, including competition for supplies among users in Arizona, as well as neighboring Colorado River states and Mexico, protecting environmental values and services, and insuring against shortages and drought. Complex issues are at play. Often several parties are eyeing the same water sources to support growth. At its most benign, competition for resources will drive up prices. Areas of the state outside the AMAs are feeling the strains of growth without the water resource protections of the GMA and with fewer financial resources than central Arizona's cities. The very real possibility of long-term drought exacerbates the challenges that exist even under normal rainfall.

Beyond Excess CAP Water

Projections of water use in the year 2050 show that the demand for CAP water will exceed the available supply by almost 90 percent. The Phoenix area cities, Tucson and smaller cities around the state are independently looking for supplies to fill out their water portfolios. All potential new supplies are likely to require complex negotiations over extended periods of time. An unprecedented degree of cooperation will be needed, among municipalities, water providers, state and federal agencies and water user organizations to avoid cutthroat competition. The CAGRD is an important player. It projects significant replenishment obligations by 2035 (over 200,000 acre-feet per year). Thirsty cities will continue to find it costly and difficult, legally and politically, to take water from other parts of the state. Some areas with severely limited water supply sources may face hard choices: sacrificing environmental quality to allow for population growth; limiting growth or supporting it unsustainably with groundwater depletion; locally managing growth in water use or accepting state level regulation.

Rural Arizona

In rural Arizona, the limited size of aquifers and lack of multiple water supply sources combined with limited financial resources constrain choices. Some of the conservation strategies described above have been employed by water stressed cities such as Prescott Valley and Flagstaff. The existence of the Prescott AMA provides a portion of the rapidly growing Verde watershed with groundwater management tools. Outside of AMAs, however, jurisdictions do not have the authority to implement plans by denying well drilling permits, restricting the use of groundwater, or enforcing conservation measures. In addition, it is unclear whether they have the authority to tie approval of the development of new subdivisions to proof of adequate water supplies. Establishment of new AMAs is not a popular strategy at this time, primarily due to an aversion to state-level regulation. Watershed alliances and organizations, such as the Upper San Pedro Partnership are building relationships among diverse interests and beginning to develop creative solutions. Carrying these efforts forward, as growth uses more and more water and the costs of developing new supplies increase, is a major challenge.

Infrastructure

In Arizona the Water Infrastructure Financing Authority (WIFA) was established to manage state revolving loan funds for construction, rehabilitation and/or improvement of drinking water, wastewater and other water quality facilities or projects. Every four years WIFA surveys the projected 20-year capital costs for facilities throughout Arizona in order to provide the U.S. Congress with a basis for allocating funds to the Clean Water Revolving Funds managed by the states. The results of the 1998 survey estimated Arizona's infrastructure need at $2.52 billion. The results of the 2002 survey show Arizona's needs increased 150 percent to $6.3 billion in four years. One of the drivers behind the growth in infrastructure needs was the growth in population, which exceeded expectations during that period and continues to do so today. In 1999, the EPA made a separate estimate of needs just for drinking water infrastructure that projected the 20-year needs at $1.6 billion. This estimate is in line with Arizona's score on the American Society of Civil Engineers (ASCE) report card. The ASCE annual report card for 2005 evaluated the adequacy of Arizona's infrastructure for basic services and found that the state's drinking water infrastructure needs a $1.62 billion investment over the next 20 years. Its wastewater infrastructure will need almost $6.2 billion over the same time period. Figure 4.6 shows WIFA's assessment of 20-year wastewater infrastructure needs, including stormwater. Figure 4.7 shows EPA's assessment of Arizona's 20-year drinking water infrastructure needs.

FIGURE 4.6
20-YEAR NEEDS FOR ARIZONA
$6.3 Billion

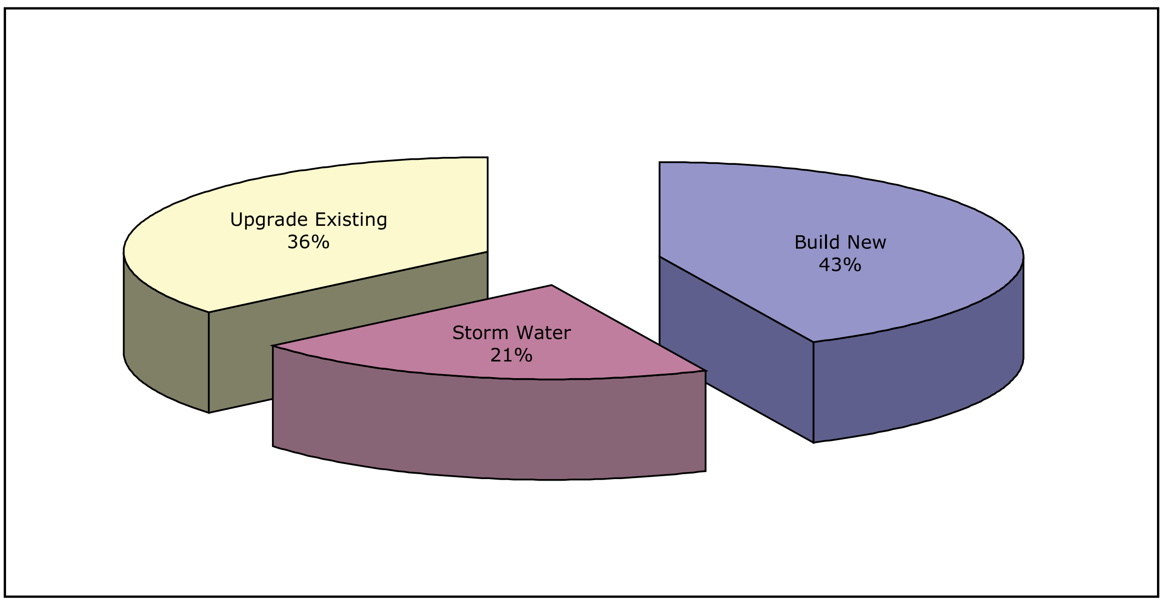
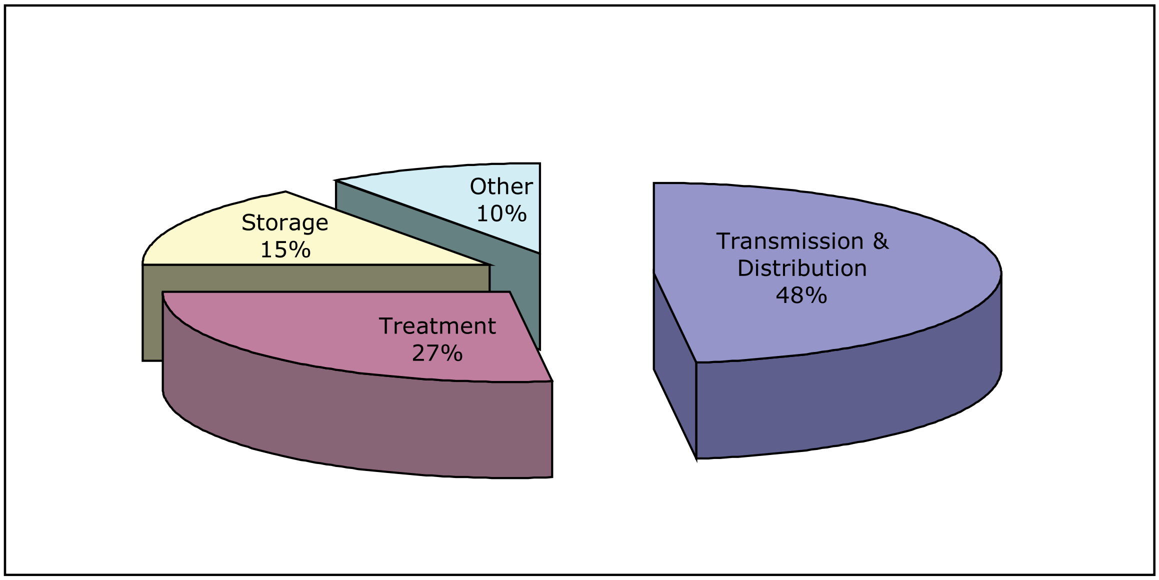


FIGURE 4.7
TOTAL 20-YEAR NEEDS FOR ARIZONA
$1.6 Billion



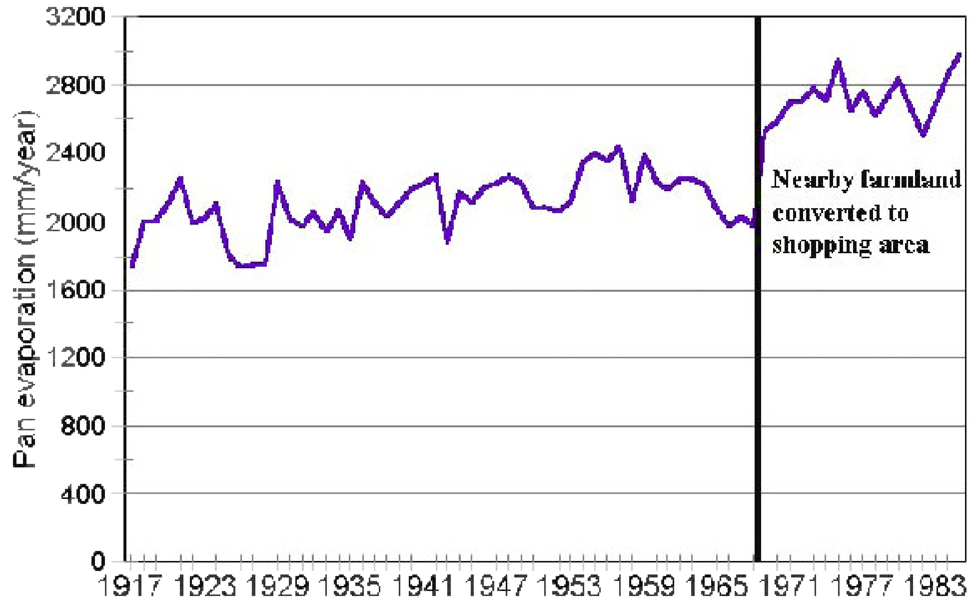
Most of Arizona's water infrastructure needs are for new construction, but Arizona will face challenges with aging infrastructure in the near future. Rural communities will be particularly hard pressed through lack of capital funding and access to water resources. Although enormous investments have been made in major water transportation systems (SRP and CAP), proposals to extend pipelines and canals have been blocked by financial, physical, political and legal obstructions. Meeting the infrastructure needs of fast growing areas beyond the current reach of these water systems will be a major challenge for the state. Legislation approved in 2003 is intended to help small water providers finance water infrastructure. It allows two or more municipal providers to form a multijurisdictional water facilities district for construction and maintenance of water-related facilities, which may be financed from various sources including sale of revenue bonds, grants, user fees and assistance from WIFA.

Long-Term Drought

Unusually hot and dry conditions persist in most of the southwestern United States despite a wet winter in 2005. The year 2002 was one of the driest years in a century and 2005-2006 is shaping up to be even dryer. No one knows whether this is part of a long-term trend toward drier conditions, or whether the climate cycles will return Arizona to the relatively wet conditions of 25 years ago. An understanding of long-term trends in climate is needed to give a context to water supply planning. There is some indication that whatever the immediate future holds, long-term human-induced climate change will alter the hydrologic cycle in important ways. Models used to predict regional impacts of climate change project important consequences for southwestern water management, including increasing temperatures, evaporation and plant water use, reduction in snowpack, and earlier snowmelt and runoff peaks.

One type of “climate change” has been documented. Large cities such as Phoenix have experienced an “urban heat island” effect. Relative to natural landscapes, masonry and pavement absorb more heat during the day and lose it more slowly at night. As a result, Phoenix experiences warmer nighttime temperatures, increased evaporation rates, longer growing seasons and higher transpiration rates for landscape plants. In addition, converting irrigated fields to hard surfaces can produce dramatic changes, as illustrated in Figure 4.8, a graph of pan evaporation in the Phoenix area. These changes trigger greater demand for water and cooling.

FIGURE 4.8
LAND USE CHANGE AND EVAPORATION RATES
Mesa, Arizona, 1917-1985



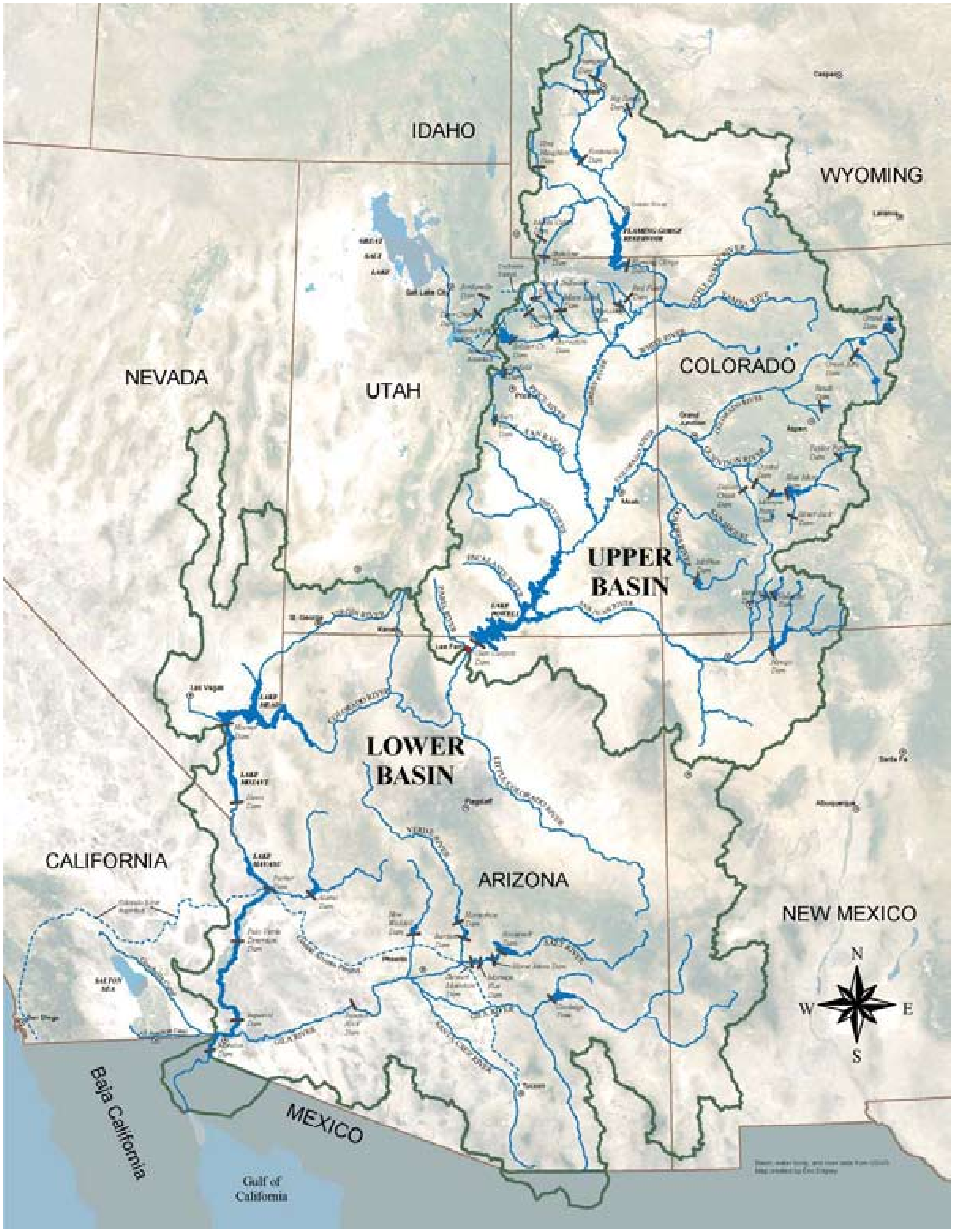
Arizona's major urban areas have been insulated somewhat from the impacts of drought because of large amounts of water storage and CAP water in excess of current needs. Regional drought, however, can mean Colorado River shortages. Shortages will have larger impacts as the population grows. If growth under "normal" conditions will strain Arizona's water resources, then growth under the hotter, drier conditions of natural long-term climate cycles or human-induced climate change will pose an even more serious challenge. The SRP is planning to improve the drought resilience of their water system by rehabilitating disused wells and drilling new wells near their canals. The wells are not intended to supply new water to their customers, but to offset system shortages. The City of Phoenix also is considering expanding its well production, not only to reduce drought impacts, but also in anticipation of recovering stored water credits. The City of Tucson's reliance on indirect use of CAP water through recharge has the added benefit of maintaining a groundwater pumping system that can be used in times of drought.

An increased likelihood of drought does not preclude the possibility of flooding. Planners must therefore continue to be sensitive to flood control and issues respecting the use of floodplains as cities grow. Just as reservoir managers must continue to include the potential for flooding in their operations plans.

The Colorado River Basin

Anxiety is high among all the Colorado River basin states (Figure 4.9) over increasing demands for water: California and Nevada already have grown beyond their entitlements, while Arizona can see clearly that its own growth will require its full entitlement and more within the next 50 years. Growth in the upper basin states will test the law of the river, the current interpretations of its various features, and the calculations on which it is based. Drought conditions in the region are raising the level of urgency in addressing unresolved issues relating to the Law of the River. Meetings among the states to discuss shortage sharing have produced some agreements, but more issues have been aired than resolved. The federal government has threatened to step in and impose its own plan if the parties fail to reach agreement. In general, and especially in the absence of a shortage sharing agreement, the states would prefer not to see the Secretary of the Interior declare a shortage on the river. Arizona is particularly anxious about a shortage because the CAP has such low priority it could, theoretically, be cut off entirely before California gives up a single drop. In the past only normal and surplus conditions have been declared, but the recent drought brought conditions perilously close to shortage.

FIGURE 4.9
THE COLORADO RIVER BASIN



Various reservoir management strategies have been proposed to capture efficiency gains on the system. The upper basin states are concerned with maintaining water levels in Lake Powell. If that reservoir were to dry, the law allows the lower basin states to issue a "compact call" and force the upper basin states to release additional water. None of the basin states wants to see a compact call, because an all out water war would be a likely consequence. If the resulting disputes were to end up in court, no one could predict the outcomes. Yet, legal teams are preparing for the possibility in Arizona and other basin states.

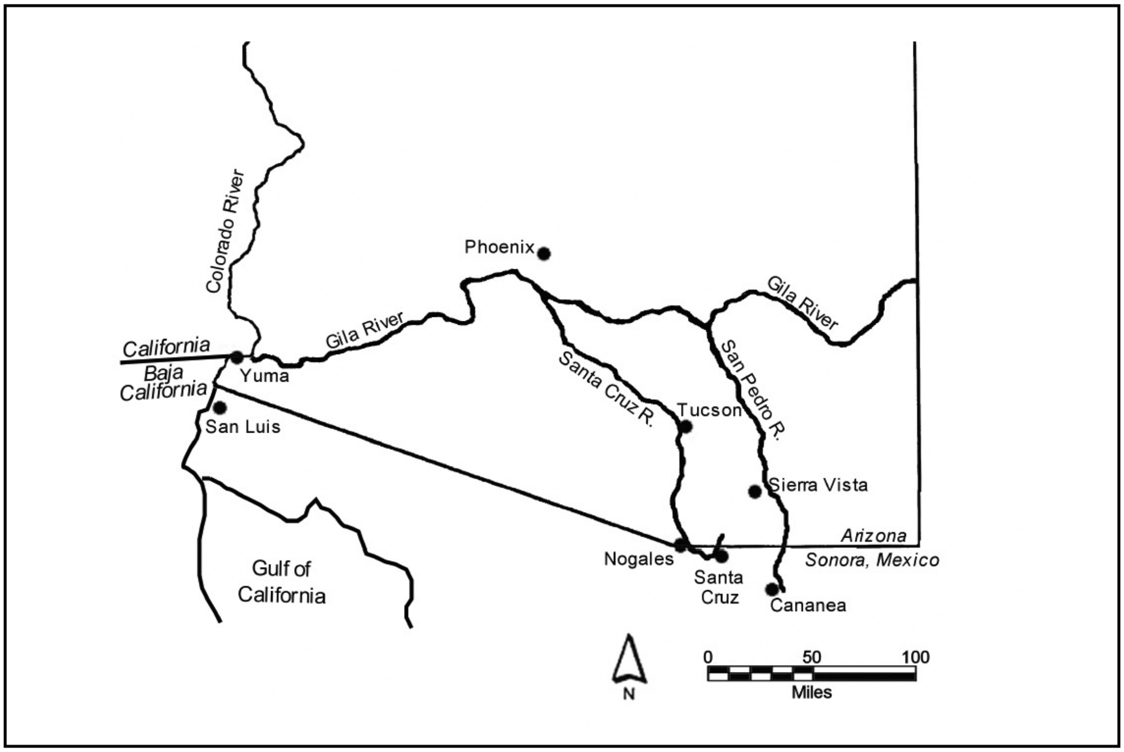
Because of growing demands, entities in both California and Nevada are interested in establishing an interstate water market. For the most part, basin states have discouraged interstate water transfers. Although several kinds of transfer arrangement have been discussed, none has gone forward. So far, the arrangement of the AWBA with Nevada to store water for Nevada in Arizona is the first such interstate water arrangement involving the Colorado River that has passed muster. The phenomenal growth of Las Vegas is forcing that city and the state of Nevada to probe more aggressively for weaknesses in the barriers to water marketing on the river.

The International Border

One thing the basin states have agreed on is asking Mexico to share any shortages on the Colorado River. The United States is obliged under the 1944 treaty to deliver 1.5 million acre-feet of Colorado River water to Mexico. The agricultural activities and communities in the Mexicali Valley expanded and were fully using these flows. Water quality became an issue when activities upstream from the border increased the salinity of the water crossing into Mexico. In the "permanent and definitive solution" of 1973, the United States agreed to deliver water with salinity not to exceed 115 parts-per-million more than the salinity of the water as measured at Imperial Dam. To comply, the United States built a desalination plant, and during construction, diverted highly saline drain water away from the river into the Cienega de Santa Clara. The completed plant operated for only a few months and diversion to the Cienega continued. Restarting the plant could enable storage of an extra 100,000 acre-feet of water in Lake Mead to provide a buffer for the lower basin states against shortage, although the costs, at $305 to $425 per acre-foot of produced water, are steep. Environmentalists opposed restarting the plant if it would mean that drainage diversions to the Cienega would be replaced by concentrated brine waste from the plant. Meetings among the concerned parties recently resulted in agreement on a plan that has yet to be implemented. Border environmental interests also have been concerned about the environmental consequences for the Colorado River Delta in Mexico and the Sea of Cortez. These issues complicate discussion on drought and shortages on the Colorado River.

Ever increasing populations are straining the ability of Arizona and states in Mexico to share border water resources. Populations are growing rapidly, especially on the Mexican side of the border. Along the entire United States-Mexico border, the EPA projects a population increase of 64 percent between 2000 and 2020. Cooperation on border water resources issues is complicated by differences in legal systems, political and decision-making structures, cultures, social structures and customs. In addition, acutely different levels of development and prosperity and different perceptions of environmental quality are challenging agreement and action. Other areas of Arizona facing border water resource challenges include the San Pedro and Santa Cruz River basins, where concern focuses on water that flows north across the border (Figure 4.10).

FIGURE 4.10
ARIZONA-SONORA MAJOR TRANSBOUNDARY RIVERS



Ecosystems

Water development activities, including dam building, surface water diversion and groundwater pumping, have altered or eliminated the flow of water in many of Arizona's rivers. Although there is debate about the net change in the amount of riparian vegetation in Arizona, it is indisputable that much of Arizona's pre-settlement riparian habitat has been lost or severely degraded. A number of negative consequences ensued, such as erosion and stream bank instability, loss of regionally and nationally important habitats, spread of invasive species and noxious weeds, and species extinctions. If protection of Arizona's natural heritage is an important policy goal, water development decisions will have to balance ecosystem needs with human demands.

Species of animals and plants that are dependent on natural flows in streams and habitat supported by stream flows and/or groundwater are threatened by altered and diminished flows and falling water tables. They also may suffer from the water quality effects of changes to the watershed and wastewater flows resulting from development. Legal mechanisms have recently been added to Arizona's water laws that make it possible for water in stream channels to be dedicated to supporting riparian ecosystems. In addition, the Endangered Species Act (ESA) prohibits the "taking" of listed species, a term that includes activities that seriously diminish or damage essential habitat. Complying with ESA requirements complicates planning to use new water supplies or even to increase exploitation of old supply solutions. Costs are increased, and in some cases, promising projects may have to be rejected because of ESA implications.

In Arizona, plans for operating Roosevelt Dam and managing the San Pedro River have been affected by ESA requirements. Because of the Act, the Bureau of Reclamation is adding fish barriers to the CAP canal system to prevent non-native fish species from using the canal to invade Arizona streams. In addition, Arizona participated in the development of the Multi-Species Conservation Plan (MSCP) for the Lower Colorado River, along with California and Nevada. The plan, which wraps together ESA conservation and mitigation actions for several listed species, took nine years to develop and will require a $77.5 million investment from Arizona. Despite the high price tag, the MSCP is expected be much less costly than protecting individual species. As long as there is value to the public of protecting species, these kinds of considerations will continue to be part of water resources development planning.

In Arizona, ecosystem restoration projects have been undertaken to repair some of the damage. Because natural, pre-disturbance water systems usually cannot be restored, supplies from other sources must be committed to these projects. For example, for the Rio Salado project in Phoenix, effluent credits will be recovered by pumping from shallow aquifers. To remain viable, these projects must continue to receive their allotment of water into the future. Meeting the water demands of a growing human population while protecting aquatic ecosystems and the services they provide will require creative problem solving.

Water Quality

New sources of water will require additional consideration of water quality. Phoenix area residents, with their experience of more variable water quality quickly accepted Colorado River water with standard treatment. In Tucson, a state of the art treatment plan was built, yet introduction of CAP water caused a community backlash that forced Tucson Water to close its treatment plant and change its strategy to aquifer recharge, recovery and blending with groundwater. Tucson Water is confident that they have solved the problems that created the backlash, but the utility has not proposed to return to treatment and direct delivery. As effluent use grows, public acceptability and public safety will have to be given high priority.

When agriculture is the primary user of water, tailwater (irrigation runoff) contains concentrated elements from the soils, fertilizers and pesticides. When people in cities and towns are the primary users of water, what they throw into or flush away with their water concentrates in wastewater. Measurable traces of endocrine-disrupting compounds and pharmaceuticals and personal care products are finding their way into streams and groundwater from municipal wastewater. There are many unanswered questions about their persistence, fate, toxicity and removal. Effluent dominated waters, including flows in the Salt River through Phoenix are a major concern. These contaminants persist in the environment and can bio-accumulate in living organisms. They may cause increased breast cancer, sterility and endocrine illness in humans and they are a top priority for the EPA.

Other water contamination that can accompany growth and development of an area are sediments and organic chemicals from constructions sites and paved surfaces, fertilizers and pesticides from residential landscaping, and pollutants from industrial plants and automobiles that find their way into water bodies from the air (acid rain and mercury deposition). Beyond their human health consequences, these contaminants can find their way into the natural waters to affect habitat quality and individual plant and animal species, and may limit biodiversity. This urban and suburban non-point source pollution will be a growing challenge, as will be the need for treatment processes to remove new substances of concern or meet more stringent water quality standards.

Data and Information Needs

For many areas of the state, water supply and water quality information are well developed, but there remain other areas where little is known. A major unmet need is for information on groundwater conditions and the quantities of water available for extraction on a sustainable basis. In addition, data access is a problem even in relatively data-rich areas, such as the AMAs, the San Pedro River basin and the Verde River basin, because data are stored by multiple agencies, usually in different formats. The ADWR is endeavoring to improve access to its data, but efforts have been hampered in the past by the lack of resources. U.S. Geological Survey is undertaking studies in multiple locations around Arizona to improve the information base for rural Arizona. When results are available they will help water managers in those areas deal with their supply challenges, but they are only a beginning.