Chapter 1

WATER IN ARIZONA: CHALLENGES MET AND REMAINING

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> *The situation with respect to groundwater shortage and depletion is critical and growing worse in most sections of Arizona; . . .. As a general rule the present supply is inadequate to meet existing demand, resulting in severe overdrafts against the underground reservoirs.* (Fourth Arizona Town Hall, 1964)

> *The goals set for the next 50 to 100 years should address the needs of sustainable development and preservation of water supplies for future generations of Arizonans. They should include achieving safe-yield in certain areas and looking beyond domestic, industrial and agricultural uses to the effect water use and allocation have on riparian areas, the environment and our overall quality of life.* (Seventy-first Arizona Town Hall, 1997)

> *Arizona water managers, thus far protected from water shortage by legal rights that have guaranteed full delivery of the state's share of the Colorado River despite dire drought conditions, are correct to raise the specter of water shortages in the future.* (Robert Glennon and Jennifer Pitt, 2004)

The Eighty-fifth Arizona Town Hall marks the fifth time in 40 years that it has convened to wrestle in public conversation with the enormous and complex issue of providing, maintaining and ensuring water of sufficient quantity and quality to meet the requirements of the citizens, economy and environment of Arizona. Some topics, such as groundwater depletion and limited water sources in various parts of the state, have remained constant throughout the decades. The completion of the Central Arizona Project (CAP), the creation of the Arizona Department of Water Resources and the promulgation of the Groundwater Management Act are milestones in Arizona's water management history. Now discussions of the terms "safe-yield" and "sustainability" are coming to the forefront as Arizona evaluates the implications of continued growth in the major metropolitan as well as the rural areas of the state. Through the years, Arizonans have become more sensitive and sophisticated in their understanding of environmental relationships involving the human use of water. The public debate now regularly includes concerns about climatic conditions and drought, riparian habitat, endangered species and the hydrologic connection between surface water and groundwater. The policy dialogue has become much more complex during the last four decades. Something of that change is revealed in the partial list of recommendations and conclusions from past Arizona Town Halls recorded in Appendix A. This background report explores the complexity of water management issues facing Arizona at the beginning of the 21st century.

This chapter provides context and institutional background for Chapter 2's discussion of major themes in Arizona's water future. Chapter 3 introduces water-related background material on Arizona's hydrology, population and border with Mexico; while Chapter 4 discusses the implications for water management of climate variability and change. Chapter 5 describes the sources of water available, the institutional aspects of water rights and associated issues. Chapter 6 addresses water management concerns in the five Active Management Areas (AMAs). Chapter 7 introduces the water management issues beyond the boundaries of the AMAs, issues that are significantly different than those faced in the major metropolitan areas. Chapter 8 details the bases and specifics of existing and proposed Indian water settlements, while Chapter 9 outlines environmental issues in the context of changing land use and land cover. Chapter 10 identifies multiple demand management and supply enhancement approaches for addressing water supply issues. The final chapter focuses on key policy and strategic questions for consideration by Town Hall participants.

HISTORICAL AND INSTITUTIONAL PERSPECTIVE

Arizona's history, politics and development patterns are strongly tied to water availability and water management decisions. Arizona's first settlements were all located near surface water streams, and the fate of both ancient and modern residents has been affected by water availability. A thousand years ago, the Hohokam Indians developed an extensive irrigation system in the Gila and Salt River valleys to provide water to their fields. They cultivated thousands of acres and supported a large population. Most current population centers also are located where water is relatively plentiful, though the ability to store and transport it over long distances has dramatically changed development patterns.

Figure 1.1
Major Streams and Rivers

Federal water management policies, such as the Reclamation Act of 1902, have had a significant impact on all aspects of Arizona's water supply and continue to affect water allocations and costs today. The Reclamation Act focused on constructing a water storage and delivery system to encourage irrigation of the western United States and "make the desert bloom." This Act resulted in the development of the Salt River Project (SRP), the CAP and the dams and diversions on the Colorado River (Figure 1.1). Surface water supplies from these sources serve approximately 58 percent of the water demand within the state.

Water Supplies and Sources

Four sources of water are available within Arizona: Colorado River water, other surface water, groundwater and effluent. Each source is managed according to separate rules and definitions that are discussed in Chapter 5. There is considerable complexity to the water rights systems. Colorado River water is available primarily to CAP contractors and users along the Colorado River that have legal rights to a portion of Arizona's allocation. Other significant surface water sources include the Salt, Verde and Agua Fria Rivers that serve the Phoenix metropolitan areas. Groundwater is abundant in many of the alluvial valleys of the state and serves over 40 percent of the water demand.

An acre-foot is 325,851 gallons, or enough water to cover an acre one foot deep. With an average household use of 150 gallons per person per day and an average household size of 2.5 people, an acre-foot can serve almost 2.5 households for a year.

The Colorado River

The Colorado River is among the most heavily regulated rivers in the world, affected by over 50 court decisions, state statutes, interstate compacts and international treaties that are collectively known as the "Law of the River." A key component is the Colorado River Compact of 1922, which divided the Colorado River Basin into an Upper and Lower Basin and apportioned 7.5 million acre-feet annually to each basin. The Upper Basin was required to restrict its use so that the flow of the river at Lee's Ferry would not fall below an aggregate of 75 million acre-feet for any period of ten consecutive years. Although Arizona did not ratify the Compact until 1944, this allocation became the centerpiece of the Law of the River. In addition, the Mexican Treaty of 1944 annually allocated 1.5 million acre-feet of Colorado River water to Mexico, to be increased in times of surplus to 1.7 million acre-feet, but also to be reduced proportionately during years of "extraordinary" drought.

The Colorado River supplies much of the water needs of seven states in the United States, two Mexican states and thirty-four Native American tribes. Ninety percent of the annual streamflow is generated in the Upper Basin. The Bureau of Reclamation estimates the population of the areas served with Colorado River water at 30 million (Bureau of Reclamation, August 2004), with 38 million projected by the year 2020. The associated dams generate an average of 12 billion kilowatt hours of electricity per year.

Meeting water rights obligations in the context of changing societal values and increasing demands is bringing increasing pressure on the Law of the River. Water quality and environmental concerns, particularly the federal Endangered Species Act, also have altered the traditional roles of federal, state and local agencies. The continuing regional drought, including the extreme conditions of 2002, draws attention to the importance of understanding climate variability and change in the context of long-term water supply and the need for proactive mitigation of drought impacts.

Groundwater and the Groundwater Management Act

Groundwater is the sole source of water supply for much of rural Arizona and is relatively plentiful in large alluvial basins. The Colorado Plateau to the north and the southeastern part of the state are dependent solely on groundwater. This source is of critical importance throughout the state, providing over 40 percent of the state's total water supply. Although Arizona adopted a number of groundwater management regulations starting in 1945, no meaningful regulation of groundwater use was in place until the 1980 Groundwater Management Act (GMA). The GMA established the Arizona Department of Water Resources and focused groundwater management efforts within four original AMAs: Phoenix, Pinal, Tucson and Prescott. A fifth AMA, the Santa Cruz AMA, was formed by splitting it off from the Tucson AMA in 1994 (Figure 1.2). For each of the AMAs, the GMA established water management goals focused on limiting the overdraft of groundwater. It also established a new water rights system, precluded the development of new irrigated agricultural land and established a well-measuring and reporting system and a mandatory conservation program. A summary of the history of groundwater management in Arizona is

Figure 1.2
Active Management Areas and Irrigation Non-Expansion Areas

found in Appendix B.

Surface Water

The Gila River and its tributaries is the largest watershed within the state, draining the majority of central Arizona. Important tributaries in southern Arizona are the Santa Cruz and San Pedro Rivers, and in central Arizona, the Salt, Verde and Agua Fria Rivers. However, the majority of flows in the central part of the state have been diverted for agricultural and municipal use. Major reservoir storage systems, such as Roosevelt Dam (Figure 1.3), are located on the Salt, Verde, Gila and Agua Fria Rivers. In-state surface water systems (Figures 1.1 and 4.2) supply about 19 percent or 1.4 million acre-feet of Arizona's water. Although the Little Colorado River that flows from the White Mountains to the Grand Canyon is an important watershed, it does not provide significant surface water supplies for human use.

Figure 1.3 Roosevelt Dam with capacity of 3.43 million acre feet.

Surface water is governed by the prior appropriation doctrine, which provides the highest priority right to the first person that beneficially uses water in the watershed. The SRP is the largest provider of in-state surface water, serving water from the Salt-Verde watersheds to agricultural and municipal users in the Phoenix metropolitan area.

Effluent

Effluent, or treated municipal wastewater, is an expanding water resource for all of Arizona and will be of particular importance in rural communities in the future. Water users in the AMAs and in water-short communities throughout the state have made substantial investments in reclaiming wastewater and expect to more fully utilize the available effluent. Municipal effluent commonly is considered to be a renewable water supply, but it is only truly renewable when its original source is renewable, *i.e.*, CAP or surface water. Essentially, effluent use is the recycling of water. Like CAP water, treated effluent can be used directly or stored underground for future use.

ACHIEVEMENTS AND COSTS TO DATE

Arizona has made significant strides in water management over the last 25 years. Although the water issues facing the state are daunting, they need to be understood in light of what already has been accomplished. Clearly, the most dramatic change was caused by implementation of the GMA itself. It established a long-term water-planning horizon for the state that focused on a long-term water supply. For example, the Assured Water Supply (AWS) program is probably the most far-sighted regulatory program connecting water supply and municipal demand in the country. It requires that a demonstrated 100-year water supply of adequate quality will be available prior to approval of new subdivisions. No other state requires a 100-year renewable water supply prior to development. Appendix C summarizes the Assured Water Supply Program. The GMA charted a course for the municipal sector in AMAs to move away from groundwater and towards renewable water supplies through the AWS Program. The AWS Rules, adopted in 1995, require the use of renewable supplies and are based on the expectation that municipal and industrial demand will continue to grow while the demands of other sectors will diminish over time.

The Central Arizona Project

The CAP is the backbone of the State's renewable water supply system. The CAP is designed to bring 1.5 million acre-feet of Arizona's 2.8 million acre-foot Colorado River allocation into central and southern Arizona. The CAP aqueduct has the capacity to annually deliver a total of 1.8 million acre-feet, and its total cost exceeded $4 billion. The CAP aqueduct is 336 miles long and includes 15 pumping stations that lift the water from Lake Havasu to its terminus south of Tucson. The CAP service area is limited to Maricopa, Pinal and Pima Counties. It is operated by the Central Arizona Water Conservation District, which has taxing authority and a board elected by the citizens within its three-county service area. Authorized in 1968, the CAP is critical to achieving a sustainable water supply for the central portions of the state (Figure 1.1). The CAP system, along with its storage, flood control and delivery components, is a major investment in water supply sustainability for the state. By providing a renewable supply to replace dependence on mined groundwater, the investment in the CAP already has proven essential to limiting groundwater overdraft and providing water supplies during drought.

Although the three-county CAP service area contains 82 percent of the population of the state, substantial development pressure is facing communities in other counties. In addition to providing water to its subcontractors, the CAP system has been delivering excess Colorado River water to several entities that store water underground for various purposes and has delivered substantial quantities of water to offset shortages in the SRP system. SRP purchased and exchanged nearly 500,000 acre-feet from the CAP between 1996 and 2003.

Institutional Innovations

The conversion from dependence on mined groundwater to use of renewable supplies from the Colorado River has required the development of new institutions as well as major financial investments. For example, soon after the adoption of the GMA it became clear that recharge would be a major component of storing and utilizing renewable water supplies. In 1986, significant legislation was adopted that established the Underground Water Storage and Recovery Program summarized in Appendix D. Since 1986 there have been numerous refinements and additional components. This program has been very successful and, as of 2002, had resulted in the development of 66 storage facilities, primarily in the AMAs, and storage of over three million acre-feet of water in the state.

Another institutional innovation that has been very successful is the Arizona Water Banking Authority (AWBA), which was established in 1996 to store excess Colorado River water for use during future shortage years and to support other water management objectives as well as interstate water banking. Annual water use is strongly affected by agricultural demand and the availability of other surface water supplies within the state. The AWBA, in combination with incentive pricing programs to encourage the short-term use of CAP water for agriculture and underground storage, has enabled the full use of Arizona's allocation.

Indian Water Right Settlements

Significant progress also has been made in finalizing Indian water rights claims. One of the biggest variables in Arizona's water supply picture has been how much water will be allocated to the Native American tribes in the state and how that water ultimately will be used on and off the reservations. As discussed in Chapter 8, settlements have now been completed with eight tribes and four more settlements are pending. Tribal water rights claims are based on the federal reserved rights doctrine—the "Winters Doctrine" of 1908. The Winters Doctrine indicates that the priority date of the water rights for reservations is the date the reservation was established, and the volume of the right is based on the purpose of the reservation. The large amount of potentially irrigable acreage on the Gila River Indian Community reservation, along with their significant historical dependence on the Gila River, has led to a large water right claim. The total volume of water associated with tribal settlements in the Arizona Water Rights Settlement Act, currently pending before Congress, is roughly half the total CAP allocation. Because tribal lands are not subject to the GMA, tribes will have the opportunity to expand irrigated acreage on reservations. However, other provisions are intended to mirror the limitations of the GMA.

The total amount of CAP water that will be available to Indian communities under the pending Arizona Water Rights Settlement Act is 665,000 acre-feet, just short of one-half the total CAP water available. The tribes may choose to lease some of this water for off-reservation uses within Arizona. There are restrictions within the settlements themselves on how the water can be used off reservation, but leasing is expected to be an outcome of several tribal settlements and already is the source of water for non-reservation communities such as Anthem in Maricopa County. Indian settlements also have important water management implications outside of reservations because of the multiple agreements with water users who are part of the settlements. In several cases, these agreements constrain the way water can be used in the vicinity of the reservation, and they also have more comprehensive impacts on water availability by limiting new agricultural production and new wells in the affected watershed. For example, the Gila River Indian Community Settlement, now pending before Congress, includes agreements that affect water users in Safford, Duncan, Pima, Fort Thomas, Winkelman and Kearny as well as three mining companies. Indian water settlements are discussed in more detail in Chapter 8.

SUSTAINABILITY

Discussion of future water needs for Arizona should be in the context of policy objectives that are clearly articulated. Throughout this background report the various authors use the words *sustainable*, *sustainable development* and *sustainability*–terms that have risen in importance in scholarly analysis and policy debates regarding water management and water science. All three of Arizona's state universities have research centers focused on sustainability issues.

The management goal for three of the five AMAs (Phoenix, Prescott and Tucson) is "safe-yield . . . a water management goal which attempts to achieve and thereafter maintain a long-term balance between the annual amount of groundwater withdrawn in an AMA and the annual amount of natural and artificial recharge in an AMA" (A.R.S. 45-562 A). However, there is a distinction between *safe-yield*, which focuses on the amount of water that can be pumped from an aquifer for water supply purposes without causing overdraft, and *sustainable yield* or *sustainable development*, which many hydrologists view as more comprehensive concepts that would maintain surface flows that recharge the groundwater and provide water for environmental uses as well (Appendix E). Since *sustainability* is a concept that is approached differently by various individuals based on personal values and is much-debated, this background report uses the most commonly accepted <u>working</u> definition, that of the Brundtland Commission: "*The abil-*

ity of current generations to meet their needs without compromising the ability of future generations to meet their needs" (World Commission on Environment and Development, 1987).

Scale affects the application of the definition of sustainability. For example, Colorado River water that is diverted into Arizona is viewed as a "renewable" supply from the perspective of the state of Arizona, unlike groundwater that is in most cases renewed over such a long period of time that it is viewed as non-renewable. However, diverting water from the Colorado River affects the sustainability of downstream users and environments outside of the state and, therefore, has consequences that may be overlooked when viewing the water use only from the perspective of Arizona's water users. For example, the Colorado River Delta environment has changed substantially over time as larger quantities of water have been dammed and diverted upstream, and this in turn has affected water flows to Mexico and the marine environment in the Gulf of California.

Temporal issues also are of concern, since the impacts of water management decisions may not become obvious until many years later. For example, there was little evidence of subsidence of the land surface in the Tucson basin until about a decade ago. Since then, subsidence avoidance has become a major policy objective for Tucson Water. Because we are dependent on the use of groundwater models to understand water movement and availability in the subsurface, because impacts of groundwater pumping are commonly not recognized for decades and because the hydrologic system itself changes over time, a long-term view is needed in water supply planning.