2011 WATER RESOURCE PLAN

CITY OF PHOENIX
WATER SERVICES DEPARTMENT

CITY OF PHOENIX
2011 WATER RESOURCE PLAN

Table of Contents

INTRODUCTION: PLAN OVERVIEW AND PURPOSE

The term “scarcity” is often used to characterize water availability in the Sonoran desert environment. Yet, for more than 100 years, the City of Phoenix has continually overcome obstacles in fulfilling its mission to provide safe, abundant, reliable and affordable water supplies to its customers. Today, the City maintains a well diversified water supply portfolio which is sufficient to meet the needs of this growing community for decades to come. The high level of water supply security the City enjoys today has resulted from the City’s dedication to progressive water supply development projects, and the efforts of our customers to use water more efficiently. A continued focus on these elements will better prepare the City and its customers to adapt to conditions that could change rapidly and significantly.

This 2011 Water Resource Plan addresses a wide array of factors that will influence water availability and water demand over the next 50 years. Chief among these factors are the potential impacts of long-term drought and climate variability, availability of “insurance” supplies, and the ability of customers to adapt water usage to meet available supplies when shortfalls exist. The water supply assessment and deficit management strategies incorporated within this Plan are designed to guide water acquisition, water management and infrastructure actions necessary to ensure sustained water availability for current customers and anticipated growth over the next 50 years under a variety of demand and surface water shortage conditions.

WATER PLANNING GOAL:

Availability of safe, sustainable, reliable and affordable water supplies sufficient to meet the needs of City customers during all foreseeable conditions.

PLANNING APPROACH AND QUESTIONS ADDRESSED

The City’s approach to water resource and demand management planning can be summarized through four basic functions:

- *Anticipating* potential conditions affecting the timing and depth of water supply deficits such as cyclical shortages, climate variability, service area growth rates, per-unit water use, regulatory and institutional developments using the best available scientific and socioeconomic information;

- *Preparing* near-term and long-term strategies for responding to deficits including supply acquisition, infrastructure development, demand management and regional coordination together with action trigger points;

- *Monitoring* water supply and demand conditions such as reservoir levels, watershed health, climate trends, demand trends and growth characteristics to identify progression toward action trigger points; and

- *Acting* on pre-selected plan elements upon reaching trigger points to ensure sufficient implementation lead time.

Basic questions that drive the research and ultimate actionable decisions include: 1) How much growth will Phoenix experience in the next 50 years? 2) When and under what conditions would there be insufficient water available to meet service area demands? 3) What strategies are available, and at what cost, to avoid supply deficits? 4) What is the economic value of reducing or eliminating supply deficits? 5) How much "shortage insurance" can the City afford (i.e. what risk levels can be covered)? and 6) What actions must be taken and at what junctures to reduce or eliminate deficit risk?

The first three chapters of this Plan describe the regional water planning environment, Phoenix's water supply portfolio and the City's water demand characteristics. Chapter 4 illustrates water supply and demand ranges representing a multitude of growth and supply availability scenarios to identify potential deficit conditions at any point in time. Chapter 5 describes a variety of demand and supply strategies available to reduce or avoid supply deficits, and Chapter 6 sets forth key near term actions items to ensure adequate preparation for eventual supply shortages.

INTEGRATION OF PRIOR PLANNING EFFORTS AND REGULATORY REQUIREMENTS

The last complete assessment of Phoenix water supplies was documented in the 2005 Water Resources Plan Update. Since that time, the City has acquired additional CAP supplies, modified its groundwater well inventory, and researched potential impacts of more extreme climate variability than that reflected in historic records. In addition, per-unit water demand and wastewater flows in Phoenix have declined significantly since 2005, and the City has conducted substantive research to assess how these trends may impact supply deficits and future standards for water and wastewater infrastructure.

The City of Phoenix has historically maintained separate water resource, conservation and drought management plan documents for various aspects of water supply sufficiency in the service area. These components have become increasingly interdependent, and as such, this Plan presents an integrated approach in seeking to reduce the risk of future deficits resulting from surface water shortfalls.

This document is consistent with A.R.S. §45-342 which requires water providers to develop and periodically submit a "System Water Plan" to the Arizona Department of Water Resources (ADWR). A System Water Plan by statute is comprised of a Water Supply Plan, a Drought Preparedness Plan and a Water Conservation Plan. The City is exempt from the requirements for a Water Supply Plan on the basis of its current Designation of Assured Water Supply (discussed in Section 2). This *Water Resource Plan*, together with the City's 2000 Drought Management Plan and Ordinance, constitute a Drought Preparedness Plan by addressing both water supply and water demand management approaches in minimizing impacts to Phoenix customers during drought-related shortages. Phoenix complies with the Water Conservation Plan requirements as it is subject to requirements prescribed in ADWR's Management Plans.

SUMMARY OF CONCLUSIONS FROM THIS PLAN

Key conclusions derived from this Plan are as follows:

1. Phoenix is well situated to accommodate anticipated growth over the next 50 years with current water supplies under full supply (non-shortage) conditions;
2. Growth in demand within Phoenix, and among other users dependent on the same source watersheds, increases susceptibility to drought-related surface water shortages which may be intensified by long-term variability in climate patterns;
3. Based on current reservoir storage conditions, the depth of Phoenix's water supply portfolio, reduced demand growth forecasts and recent Colorado River reservoir management agreements, it is unlikely that Phoenix will experience a water supply deficit prior to 2020;
4. Deficits of 20,000 AF per year (approximately 5% of anticipated demand) could occur in the early 2020s, and could climb significantly higher by 2035 under the most severe shortage scenarios anticipated in this Plan;
5. A combination of strategies including demand management, local well utilization and recovery of water stored underground by the Arizona Water Banking Authority (AWBA) will be sufficient to address initial deficits occurring after 2020;
6. The severity of more significant deficits in successive decades can be reduced through gradual implementation of water efficiency improvements, demand curtailment strategies and development of additional water supplies; and
7. Collaborative regional efforts to manage demand and to enhance supplies are likely to provide more cost-effective long term solutions than traditional "go it alone" initiatives.

CHAPTER 1: HISTORY AND CONTEXT

Phoenix's Sonoran Desert setting, with an average precipitation of less than 8 inches per year, is often characterized as being in a perpetual state of drought. The chronology of human activity in this area, from the days of the Hohokam, is invariably tied to the development of water resources. The vibrant economy and quality of life enjoyed by Phoenix residents today is heavily rooted in the large-scale water storage and distribution projects which service the region. The Central Arizona Project (CAP) and Salt River Project (SRP) systems are the product of foresight, dedication and leadership of prior generations which recognized the economic and environmental values of managing water supplies in a desert. A complex and dynamic array of laws, regulations, policies and institutional structures are as much a part of today's water management landscape as the engineering and hydrologic features.

Phoenix's water resources are affected by a wide variety of other influences within the region, the state and the southwest. Issues and uncertainties regarding growth, drought, climate variability, environmental needs, reservoir operations, water quality standards, aquifer management and numerous other factors contribute to the exceptionally dynamic backdrop in which water planning decisions must be made. This section will briefly discuss some of the key features of Phoenix's water planning landscape.

1.1 THE REGIONAL SETTING

The recently released 2010 Census numbers result in an estimated service population of 1.455 million (slightly more than the incorporated area figures). Phoenix service area population represents about 39 percent of Maricopa County figure and 23 percent of Arizona's total population. The Phoenix area economy is represented by a diverse range of industries and has historically been weighted toward growth-related businesses.

Phoenix services an incorporated area of 546 square miles. The water system also serves a portion of the Town of Paradise Valley and provides treatment services to adjacent providers on a limited basis. Surrounding municipalities typically rely on the same source watersheds, though each entity maintains independent water supplies, water utilities and distribution systems (Figure 1-1). Each utility maintains its own unique portfolio of water rights and contracts.

Growth and development within the greater Phoenix metropolitan area, which covers much of Maricopa County, the northern portions of Pinal County and southern portions of Yavapai County, may impact future water supply availability, density and water demand patterns within Phoenix. Significant expansion of the urban area is evident with the emergence of large master planned communities from Surprise and Buckeye to Queen Creek in the last decade. As these surrounding communities grow, the importance of Phoenix as the commercial hub of the region may influence water demand characteristics within the City.

The interrelationships between Phoenix area municipalities and Arizona's Indian Communities also add to the complexity of the local water planning landscape. Phoenix is a party to several Indian water rights settlement agreements, and maintains long term leases of tribal CAP water for a portion of the City's overall supply. The most recent settlement, with the Gila River Indian Community (GRIC), was authorized as a part of the Arizona Water Settlements Act signed by President Bush in December 2004.

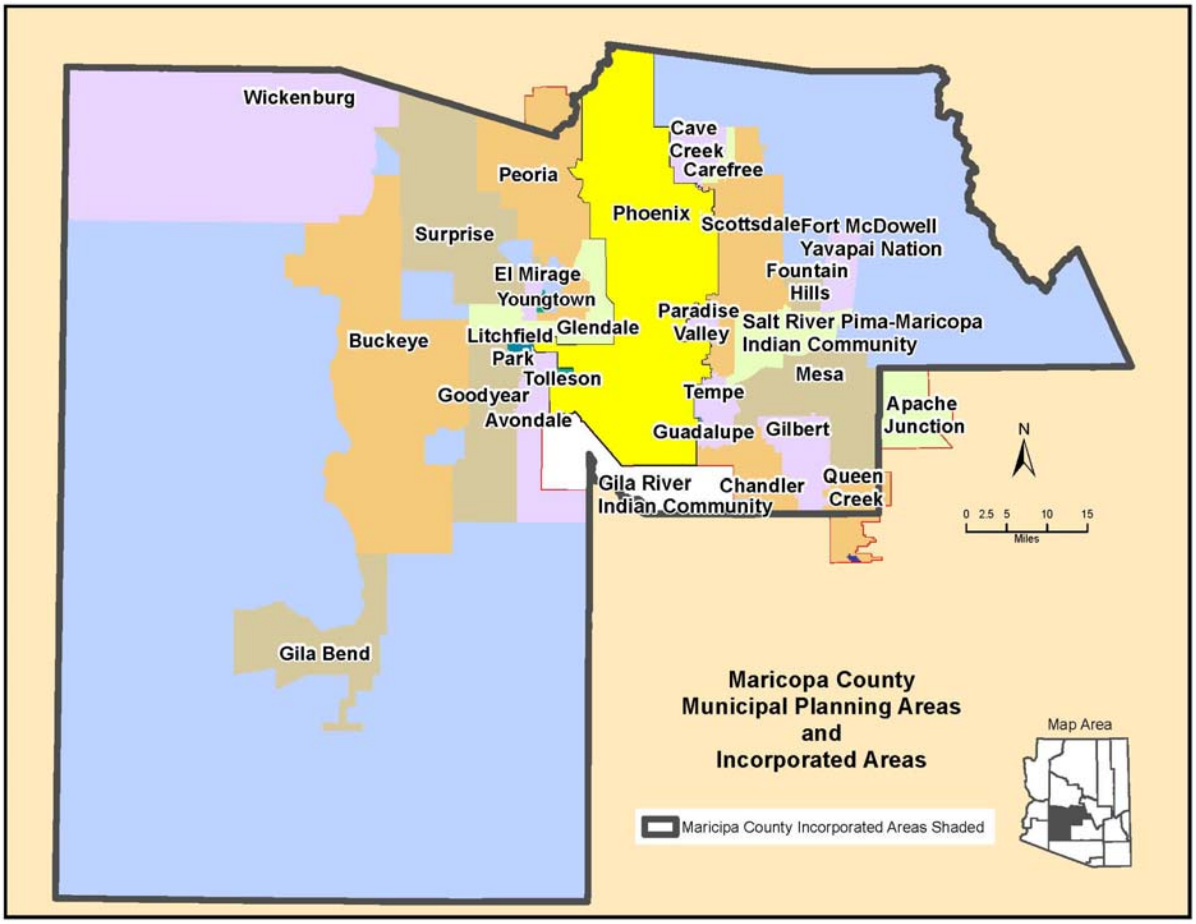


Figure 1-1. Maricopa County Municipalities

1.2 WATER SOURCE SUMMARY

Phoenix relies on four primary water supply sources. The availability of each water supply is governed by unique hydrologic, legal and institutional factors. Surface water is generated from two different watershed areas. SRP supplies water from the Salt and Verde Rivers to eligible lands within the Phoenix service areas which are generally south of the Arizona Canal (Figure 1-2). The remainder of the service area is supplied primarily by Colorado River water delivered by the CAP. Groundwater wells and reclaimed water make up the remainder of the City's water supplies.

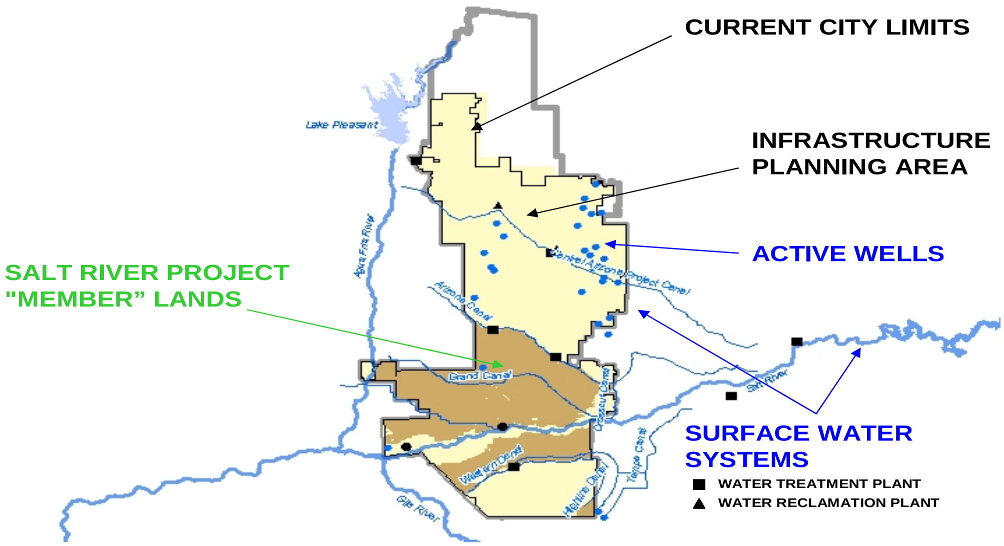


Figure 1-2. City of Phoenix Water Planning Features

The pressures on regional water supplies will escalate with continuing growth in the Phoenix metropolitan area, rural Arizona and throughout the southwest. These challenges are being met with forward-looking actions such as the Central Arizona Project's "Acquire, Develop and Deliver" (ADD Water) process, and a 2007 agreement among the Colorado River Basin states which guides reservoir operations and shortage apportionment.

Phoenix's water sources are described in more detail in Chapter 2.

1.3 AN OVERVIEW OF THE PHOENIX WATER SYSTEM

The initial water system acquired by Phoenix in 1907 utilized groundwater obtained from shallow wells. The relatively brackish and poor-tasting condition of this water led to the tapping and delivery of higher quality water from the Verde River, about 30 miles east of town. The water was delivered through a redwood pipeline which was replaced by a larger capacity concrete pipe in 1931. In the 1940s, deeper wells were drilled about 12 miles east of town.

Today's potable water system encompasses six surface water treatment plants and a network of groundwater wells.

Surface Water Treatment Plants

In 1947, the City's first surface water treatment plant was completed on the Verde River to utilize surface water. As the system grew with the acquisition of several private water companies, it became clear that additional surface water treatment plants were needed. Thus, the City entered into the 1952 "Water Delivery and Use Agreement" with SRP, which allowed water previously used for agriculture to be treated for potable purposes by the City and delivered to urbanized farmlands in the SRP territory. Between 1952 and 1975, the 24th Street, Deer Valley and Val Vista Water Treatment Plants were developed near the SRP canal system to provide water for urbanized lands with rights to SRP supplies.

In 1986, the City began operating the Union Hills Water Treatment Plant on the CAP canal, which had recently been completed. In 2007, the City began operating the Lake Pleasant Water Treatment Plant to serve growth in North Phoenix. Another plant on SRP's Western Canal (in the southern portion of the City) is proposed for construction in the next 10-20 years. This plant would predominantly serve "on-project" areas (those within the SRP boundaries) in the southwest portion of the service area.

In 1990, an interconnect facility was built at the Granite Reef Diversion Dam where the CAP and SRP canal systems intersect. This facility allows CAP water to be sent to Phoenix's water treatment plants on the SRP system (via SRP canals) under both normal and drought conditions. This feature significantly increases the reliability of Phoenix water supplies.

Groundwater Wells

The City has developed or acquired more than 200 groundwater production wells through the years. However, a majority of these wells have been removed from service due to age, reduced efficiency and/or degraded water quality due to groundwater contamination. The City currently has access to 20 active wells which can generate 28 million gallons of water per day (mgd). One of these wells was recently developed as a mechanism to store water underground for later use. Expansion of the well network is being considered to meet needs for operational flexibility, water quality management and to provide a backup source during surface water shortages.

Total System Capacity

The six treatment plants and active well network have a total production capacity of 697 mgd (Table 1-1). The plants, wells, and more than 6,000 miles of water mains are designed to meet the maximum day water demands that occur during the summer months. Other facilities, such as reservoirs, booster stations, and pressure reducing valves are designed to meet "maximum day peak hour demands" and to provide emergency capacity when treatment plants or distribution components are restricted. Large transmission mains provide substantial ability to move water throughout the interconnected system, thus providing a high degree of redundancy.

Table 1-1. Plant Capacities

Facility	Current Capacity (mgd)
Verde [(1)]	50
Val Vista [(2)]	130
Deer Valley	150
24th Street	140
Union Hills	160
Lake Pleasant	80
Wells[(4)]	28
TOTAL	738

[1] To improve operational efficiency, the Verde Water Treatment Plan will be permanently shut down Winter 2011 / 2012.
[2] City of Phoenix share (The City of Mesa maintains 90 mgd of Val Vista capacity)

Agreements with other Entities

The Phoenix system provides water to other systems under a variety of service agreements (treatment, wholesale and/or emergency). The largest of these relates to the Val Vista Treatment Plant, of which 41 percent of the capacity is owned by Mesa. Phoenix also maintains agreements with Scottsdale, Glendale, Tempe, Tolleson, and the Salt River Pima Maricopa Indian Community (SRPMIC). In addition, the City maintains an agreement with Arizona American Water Company to provide potable supplies to Phoenix customers within the incorporated portion of the Anthem development east of Interstate 17. A transmission line to the area, completed in 2005, provides Arizona American with an emergency backup supply for its system which largely serves the County portion of the development west of I-17.

Reclaimed Water Utilization

In 2000, the City began delivering reclaimed water from the 8 mgd Cave Creek Water Reclamation Plant (CCWRP) to turf facilities in northeast Phoenix through a dedicated reclaimed water distribution system. The system delivered approximately 2 mgd to these facilities through 2010. Future expansion of this system will depend on the economic feasibility of serving additional non-potable uses over a wide geographic area in North Phoenix.

Phoenix is a member of the Sub-Regional Operating Group (SROG), a cooperative of Valley cities that own and operate the 91st Avenue Wastewater Treatment Plant (WWTP). The WWTP delivers treated wastewater to the Tres Rios wetlands. This wetlands complex removes nutrients and metals from the treated water. Reclaimed water from the plant is also currently delivered, via the Salt and Gila rivers, to the Buckeye Irrigation Company (BIC) for agricultural use, and via pipeline to Arizona Public Service's Palo Verde Nuclear Generating Station which uses this water for cooling purposes.

Phoenix delivers reclaimed water from its 23rd Avenue WWTP to the Roosevelt Irrigation District (RID) for farming purposes. The arrangement with RID provides the City and the SRPMIC access to SRP supplies through an exchange agreement, and generates groundwater pumping credits to the City through "in-lieu" recharge. These features are more fully discussed in Chapter 2.

1.4 ARIZONA'S 1980 GROUNDWATER MANAGEMENT ACT

The City lies within the Phoenix Active Management Area (AMA), one of several water planning and regulatory areas established by the Legislature in the 1980 Groundwater Code. (Figure 1-3). This comprehensive legislation and associated regulations establish groundwater rights, conservation requirements, subdivision "assured water supply" standards and numerous other features designed to eventually eliminate the overdrafting of groundwater supplies in the area.

The key goal established by the Groundwater Code for the Phoenix AMA is "safe-yield" by the year 2025. This involves the balancing of groundwater withdrawals with the volume of water which recharges area aquifers. The Groundwater Code establishes specific requirements for water providers, farms, industries and others with the intent of meeting the safe yield target. The acquisition of CAP supplies and the continued use of SRP supplies have allowed Phoenix to substantially reduce its groundwater withdrawals in recent years, and thus the City has done its part to meet that goal.

City ordinances have incorporated the State's conservation standards for turf-related facilities and other industries, and the City has developed requirements for the use of non-potable water supplies for certain uses. In addition, the City has adopted regulations penalizing water waste to protect City infrastructure as well as to preserve water supplies. Water conservation has also been incorporated into the City's Water Resources Acquisition fee ordinance.

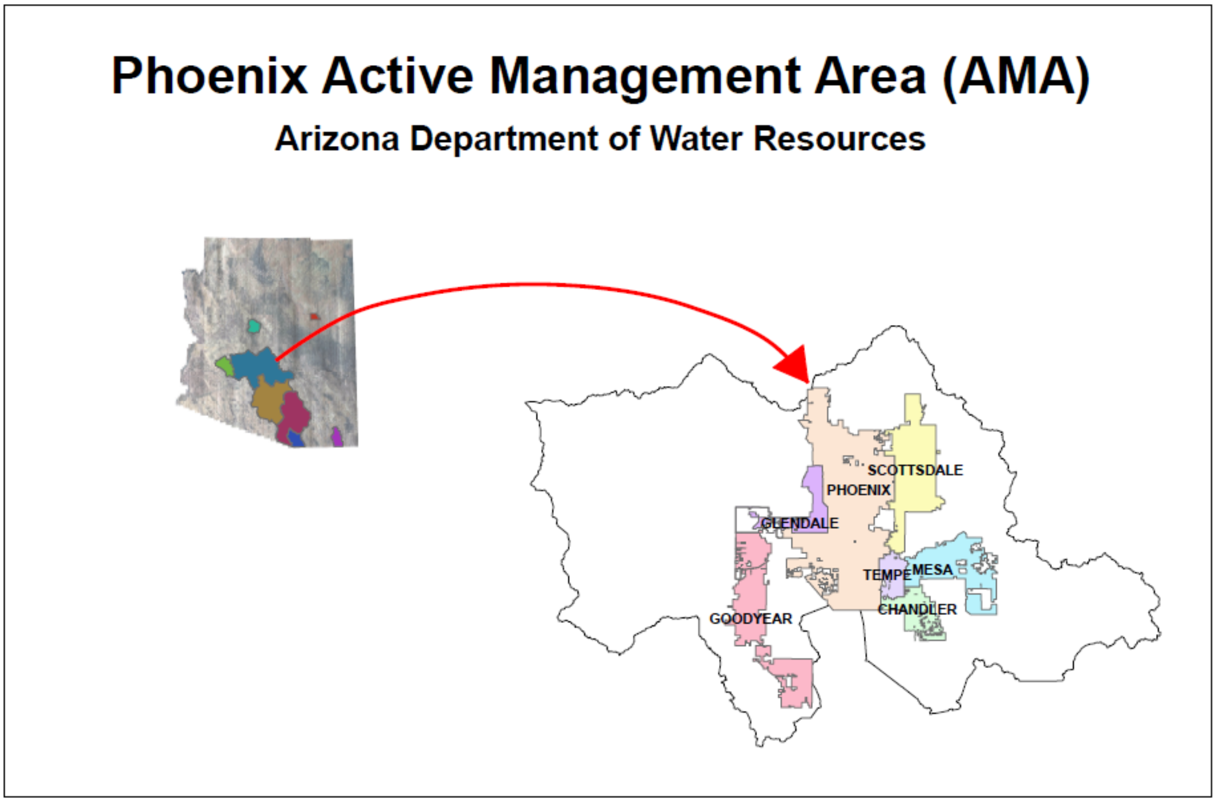


Figure 1-3. Phoenix Active Management Area

Assured Water Supply

Arizona's Assured Water Supply (AWS) Rules became effective in 1995. These Rules require a demonstration of at least 100 years of renewable water supplies for new development. Phoenix's success in water resource planning has led the State of Arizona to grant a "Designation of Assured Water Supply" to the City. This "designation" was recently reconfirmed, and attests that Phoenix maintains sufficient water supplies to serve existing customers and all anticipated growth occurring through the year 2025 (the furthest date considered by the State at this time) for at least 100 years. The City's analysis, discussed later in this plan, concludes that sustainable water supplies exist for all growth currently anticipated through 2060 under normal supply (non-shortage) conditions.

Conservation Requirements

A series of five "management plans" called for under the Groundwater Code specify enforceable conservation targets for municipal, industrial and agricultural water users. Phoenix has been proactive in maintaining compliance with these requirements. Progressive improvements in customer water use efficiency have reduced per-capita usage substantially with the past 15 years. Chapter 3 describes water demand characteristics in more detail.

Central Arizona Groundwater Replenishment District

In 1993, the legislature created a groundwater replenishment function to be governed by the CAP Board of Directors throughout the tri-county CAP service area. This replenishment authority, commonly referred to as the Central Arizona Groundwater Replenishment District (CAGRD), provides a means for landowners and water providers to demonstrate consistency with the State's Assured Water Supply Rules. In effect, the CAGRD allows development to occur on groundwater supplies where subdivision lots or entire service areas have been enrolled as members. Members pay the CAGRD to obtain renewable water supplies to replenish the aquifer, although not necessarily in the same area as the groundwater withdrawals occurred. The supplies accessed by the CAGRD for this purpose need not be permanently available. The CAGRD "Plan of Operation," updated and approved by ADWR in 2005, spells out replenishment options and plans through 2015.

Phoenix is not a member of the CAGRD as renewable supplies are available to the City in sufficient quantities to meet the AWS standard. However, the CAGRD mechanism impacts growth patterns in the region by allowing communities without direct access to renewable water supplies to develop on locally available groundwater supplies (to a maximum depth of 1,000 feet below land surface). Much of the growth occurring in the urban fringe of the Phoenix metropolitan area is made possible by this mechanism. Concerns have been raised regarding the ultimate potential capability of the CAGRD mechanism given its lack of sufficient permanent water supplies and the disconnect between pumping and replenishment.

Colorado River Negotiations

In December 2007, the Secretary of the Interior, following a collaborative effort among the seven Colorado River Basin states, issued a Record of Decision (ROD) establishing the "Colorado River Interim Guidelines for Lower Basin Shortages and Coordinated Operations of Lake Powell and Lake Mead." This ROD establishes criteria for reducing deliveries to the Basin States when certain trigger reservoir levels are reached, and also sets forth guidelines for balancing storage between the two major system reservoirs. Given the CAP's junior status on the Colorado River (it is subject to the first shortages), this ROD is critical in providing a degree of certainty regarding the volume of reduction under various conditions. This is discussed further in Chapters 2 and 4.

1.5 ENVIRONMENTAL COMPLIANCE

Safe Drinking Water Act

The Safe Drinking Water Act (SDWA) was passed by Congress in 1974. The SDWA authorizes the U.S. Environmental Protection Agency (EPA) to set national health-based standards for contaminants. The EPA continually assesses risks associated with numerous organic, inorganic and microbial contaminants, and periodically tightens standards. Examples of recent changes in thresholds that have directly impacted the City include those associated with arsenic and disinfection byproducts. The arsenic standard – reduced from 50 ppb to 10 ppb in 2006, required the City to equip several wells with specialized treatment equipment. The new "Stage 2" disinfection byproduct rule requires that Trihalomethane (THM) levels be reduced within the system by April 2012. The City is currently equipping water treatment plants with Granular Activated Carbon (GAC) filtration systems to meet this requirement.

National Environmental Policy Act

The National Environmental Policy Act (NEPA) establishes national policy and goals for the protection, maintenance, and enhancement of the environment and provides a process for implementing these goals within federal agencies. Water development, treatment, recharge or transmission projects may be subject to this law to the degree that federal funding and/or the utilization of federal lands are involved. The NEPA process consists of an evaluation of an action or its alternatives on the environment and mitigation where appropriate. To comply with NEPA, the federal agency may choose various levels of analyses. The most complex analysis is an Environmental Impact Statement (EIS). An Environmental Assessment (EA) may be done for less complicated projects. In other cases, the federal agency may determine that a finding of no significant impact (FONSI) or a categorical exclusion meets the NEPA standards. The public, other federal agencies and outside parties are afforded an opportunity to provide input into the NEPA process.

Endangered Species Act

The Endangered Species Act is a regulatory program to protect threatened and endangered plants and animals and the habitats in which they are found. The U.S. Fish and Wildlife Service (USFWS) maintains an ongoing list of both endangered and threatened species (plants and animals). The ESA essentially prohibits the “taking” (killing, harming or harassing) of endangered species. Both federal agencies and non-federal parties must comply with the ESA, but obligations under the ESA differ for federal agencies and for non-federal parties. However, projects that are federally funded, permitted, or have some other federal nexus must also be evaluated for compliance with the ESA. In arid regions, most plant and animal species are concentrated near streams and rivers. For this reason, large scale water storage and transmission activities associated with the City water supplies are sometimes implicated in ESA compliance activities. In some cases, current or anticipated impacts to species have resulted in agreements between USFWS and area water purveyors to permit specific activities and to support endangered species and their habitats, while allowing water development and delivery to continue.

For the City, the most prominent ESA issue to date has involved the southwestern willow flycatcher and potential impacts on the City’s Salt River and Verde River water supplies. In 1993, the flycatcher was found nesting at Roosevelt Lake. Negotiations between SRP and the USFWS resulted in the development of a Habitat Conservation Plan (HCP) and the granting of an “Incidental Take Permit” for the flycatcher and other species. Implementation of the HCP provides ESA compliance for the flycatcher and other species, while allowing full utilization of the reservoir, including the City’s “New Conservation Space” (NCS) water stored in the upper reaches of the Roosevelt (discussed further in Chapter 2). The City contributed over $2 million to this program. A similar HCP was subsequently established to cover additional populations of the flycatcher identified at Horseshoe Lake (on the Verde River). The City contributed $5 million to this effort, and was thus able to protect City water stored in that reservoir.

The City’s CAP water supply is potentially impacted by endangered species on the Colorado River. In April 2005, the states of Arizona, Nevada and California, and the USBR completed and initiated funding of the Lower Colorado River Multi-Species Conservation Program. This large scale HCP allows for the present and future operation of the lower Colorado River from Lake Mead to Mexico, while maintaining compliance with the ESA.

Additional ESA compliance issues could develop over time with the listing of additional threatened or endangered species, and with the designation of “critical habitat” areas for these species. The City will continue to monitor ESA issues and may become involved in future activities that allow for continued operation of City functions while maintaining compliance with the ESA.

CHAPTER 2: WATER SUPPLIES AND RELIABILITY

2.1 SUPPLY OVERVIEW

Phoenix's water needs are met through a diverse portfolio of water supplies assembled over many decades. Supplies are commonly grouped into four major categories:

- Surface and groundwater supplies delivered through the SRP;
- Colorado River water delivered through the CAP;
- Groundwater pumped from City wells; and
- Reclaimed water (or treated wastewater effluent).

In a normal supply year, more than 90 percent of the City's demand is met with surface water provided by SRP and CAP (Figure 2-1). In years when SRP reservoirs are low, a portion of the supply may consist of groundwater pumped from SRP wells to compensate for surface water shortfalls. The City also maintains a number of wells for operational flexibility and for use when CAP and/or SRP supplies are reduced. The dynamics of these supplies under a variety of growth and drought scenarios are explored further in Chapter 4.

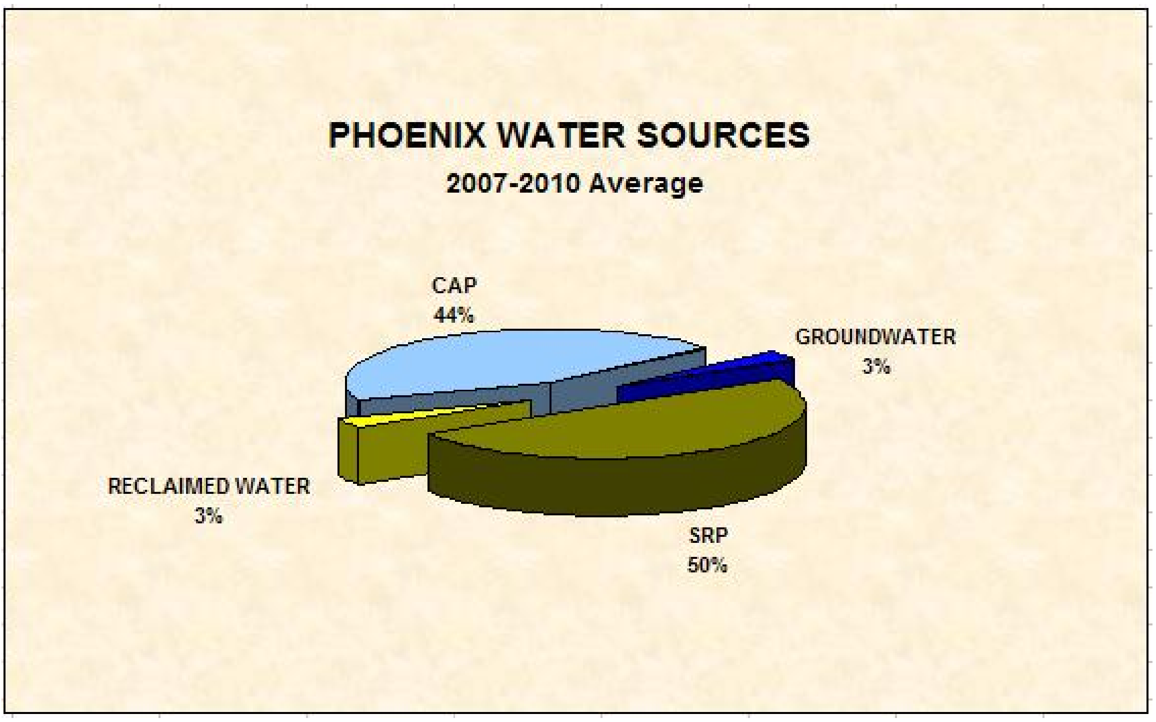


Figure 2-1. City of Phoenix Normal Year Water Supplies

Water supplies available through both the SRP and CAP systems are based on a wide variety of water rights entitlements, contracts, leases, exchanges and other mechanisms. These supplies are divided into those which can be used only within areas entitled to receive SRP water (i.e., lands within the boundaries of SRP), and all other lands within Phoenix. The distribution of these supplies adheres to the legal and contractual obligations associated with each source, but the City's system provides water to all customers in a seamless manner.

2.2 SUPPLIES AVAILABLE FOR SALT RIVER PROJECT MEMBER LANDS

The SRP system is composed of six dams, 1,300 miles of canals and laterals and 255 high-capacity wells. The project delivers approximately one million acre feet (AF) of water per year to municipal, residential and agricultural customers within Project boundaries, which includes portions of several Valley cities. Deliveries for lands within the City of Phoenix encompass between 20 and 25 percent of SRP's on-project deliveries.

The availability of SRP supplies is primarily tied to climatic and runoff conditions in the Salt and Verde river watersheds north and east of Phoenix (Figure 2-2), and to SRP's ability to pump local groundwater. Storage capacity in reservoirs is about 2.3 million AF, and SRP well pumping capacity is about 340,000 AF per year.

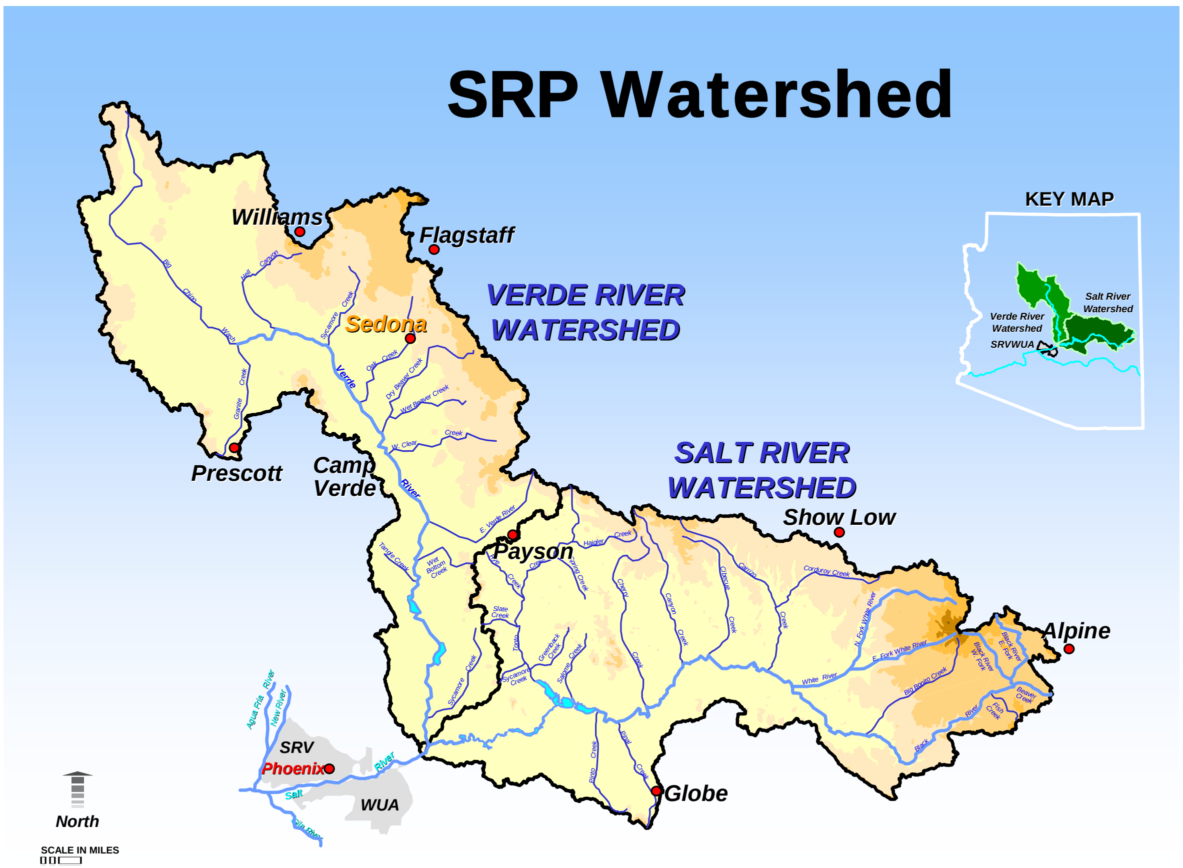


Figure 2-2. Salt and Verde River Watersheds (courtesy Salt River Project)

The lands eligible to receive SRP supplies are commonly referred to as "on-project" lands. More than 100 years ago, these early farmlands lands established rights to the Salt and Verde rivers. The lands were pledged as collateral in exchange for the federal government's construction of Roosevelt Dam and the delivery system under the 1902 National Reclamation Act. The City now receives this water from SRP at water treatment plants, and distributes it to on-project lands which have urbanized. Some lands continue to receive direct deliveries of non-potable supplies from SRP for urban landscape watering purposes.

SRP has historically managed the reservoir system and its extensive well network to maintain a consistent supply of water to shareholders, despite extreme flow variations in the watershed from year to year (Figure 2-3). Only twice in the last 100 years (in 1951 and again in 2003-2004) was there a need for SRP to reduce annual deliveries to on-project lands.

Due to urbanization of the on-project area, many SRP network wells have become "stranded." In effect, these wells which historically produced water for farms (to supplement surface water supplies) are not accessible to the major canals which serve municipal water treatment plants. SRP has considered strategies for restoring well capacity to historic levels to minimize the impact of future surface water shortages on municipalities and on remaining irrigated lands.

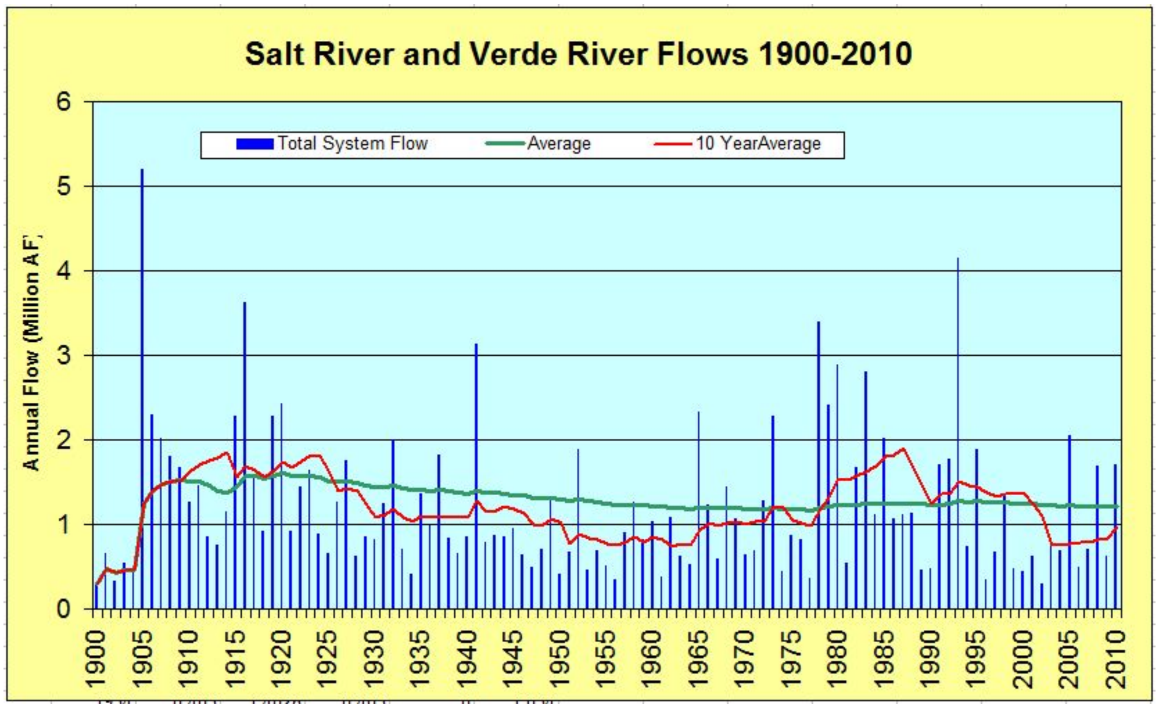


Figure 2-3. Salt and Verde Rivers – Total Annual Inflow 1906-2010 (Courtesy SRP)

Water supplies restricted to on-project use include the following:

- Stored and Developed Water: Stored and Developed Water is surface water stored in SRP reservoirs for use on lands with historic water rights. During dry years or for operational purposes, groundwater pumped by SRP supplements the surface water. Water associated with approximately 83,000 acres of eligible land is currently available to the City of Phoenix. The normal-year allocation is typically 3 AF per acre of member land, but the SRP Board may reduce this allocation under low reservoir conditions, or increase this availability during surplus-flow conditions. The actual amount delivered is demand-limited if the demand is less than 3 acre-feet per acre.

- Normal Flow Rights: Normal Flow Rights are entitlements to the natural flow of the river as it existed before construction of SRP reservoirs. These are the most senior (secure) rights, and are appurtenant to specific on-project lands upon which water was first delivered for use. The quantity to be available varies depending on daily river flow conditions and demand, but is generally expected to be in the range of 45,000 and 70,000 AF per year

- Townsite Lands: Townsite Lands (those comprising the early boundaries of the Phoenix townsite) were not incorporated within the original Reclamation Act. The Townsite Act of 1906 amended the original act and authorized water supplies from reclamation projects to be made available for non-agricultural purposes. Eligibility for delivery of water for these lands has been affirmed in contracts with SRP.

  The City also has access to a small quantity of surface water associated with the Peninsula-Horowitz area in southwest Phoenix. While not considered “on-project” supply, the water right (2 AF of surface water per acre) is similar in that it can be delivered by the Phoenix potable system only for specific urbanized farmlands. Approximately 2,000 acres are eligible, though only a small percentage have urbanized to date.

2.3 SUPPLIES AVAILABLE FOR ALL SERVICE AREA LANDS

With the exception of the SRP supplies described above, all water sources available to the City may be used anywhere within the City limits. These sources include CAP supplies, groundwater, reclaimed water and additional surface water supplies obtained through the SRP system.

Central Arizona Project Supplies

The CAP conveys surface water from the Colorado River at Lake Havasu approximately 190 miles to Phoenix. The CAP continues another 120 miles to its terminus south of Tucson. The canal was completed to Phoenix in 1986 and to Tucson in 1992. The system utilizes a series of pumps and an integral storage reservoir (Lake Pleasant) on the Agua Fria River. The canal was designed to convey 1.5 million acre-feet, for contract deliveries, and is capable of carrying up to 1.8 million AF per year when supplies are available

The City of Phoenix has access to approximately 185,000 AF of CAP water. CAP supplies are available to Phoenix through both long-term sub-contracts and leases with Indian communities. Most of the water is considered “high priority” within the CAP’s priority system (Figure 2-4).

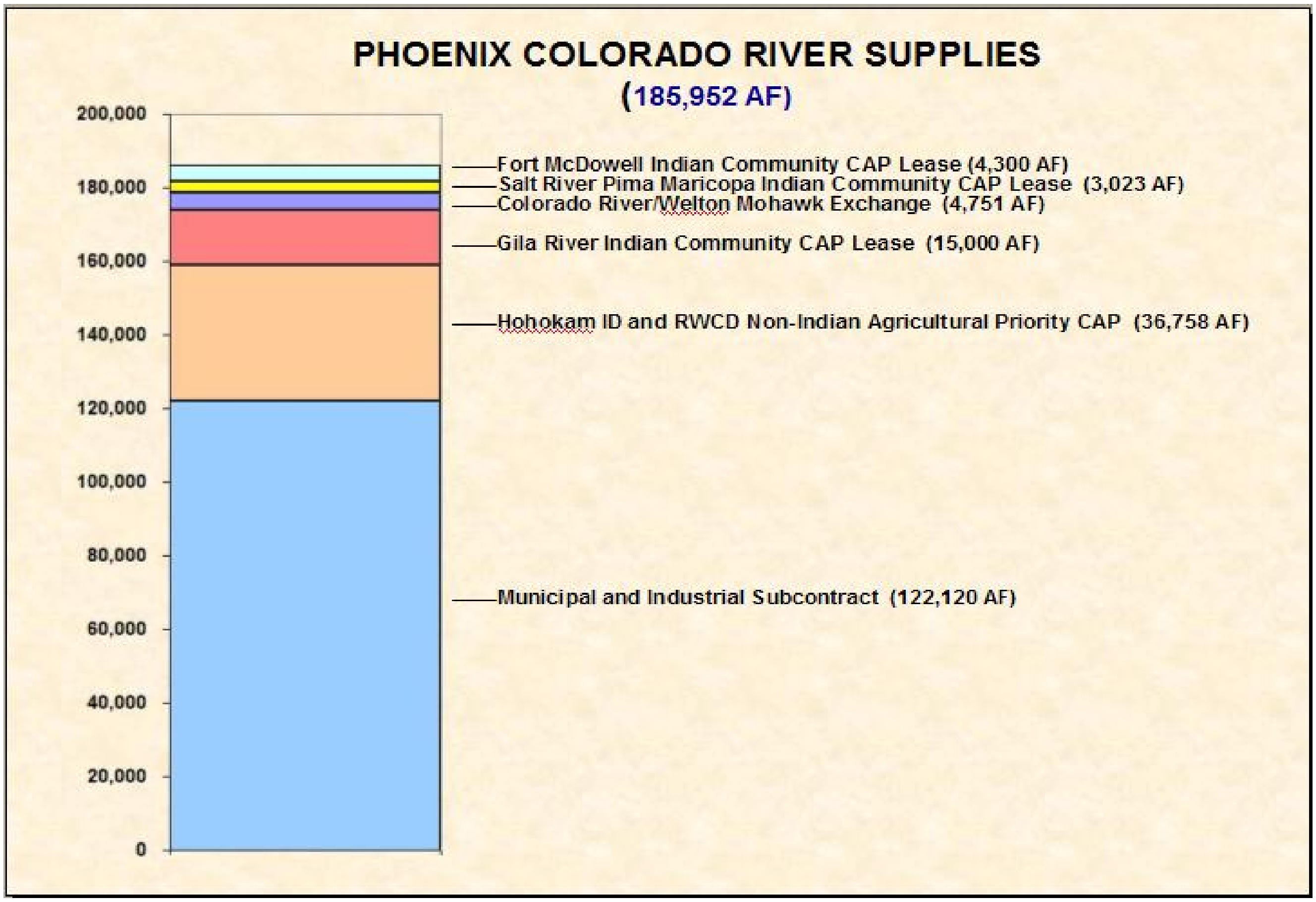


Figure 2-4. CAP Priority System

Through negotiations involving the federal authorization of the CAP, Arizona agreed that the CAP would maintain a junior status on the Colorado River relative to California's 4.4 million acre-foot allocation. This means that when the Federal government deems that there are insufficient supplies available to meet the combined allocations for Arizona, California, Nevada and the Republic of Mexico the 1.5 million AF associated with the CAP would be cut first (along with deliveries to Mexico and Nevada).

Figure 2-5 illustrates variations in Colorado River flows at Lees Ferry (just downstream from Lake Powell). This record of natural flows illustrates a general decline in runoff since the early part of the 20th century when allocations to the seven Colorado River Basin States were quantified. An analysis of 800 years of tree ring records also demonstrates that the flows of the early 1900s are high relative to the long-term average. This information supports a conclusion that the Colorado River system is over allocated when factoring in demands for water that has historically gone unused.

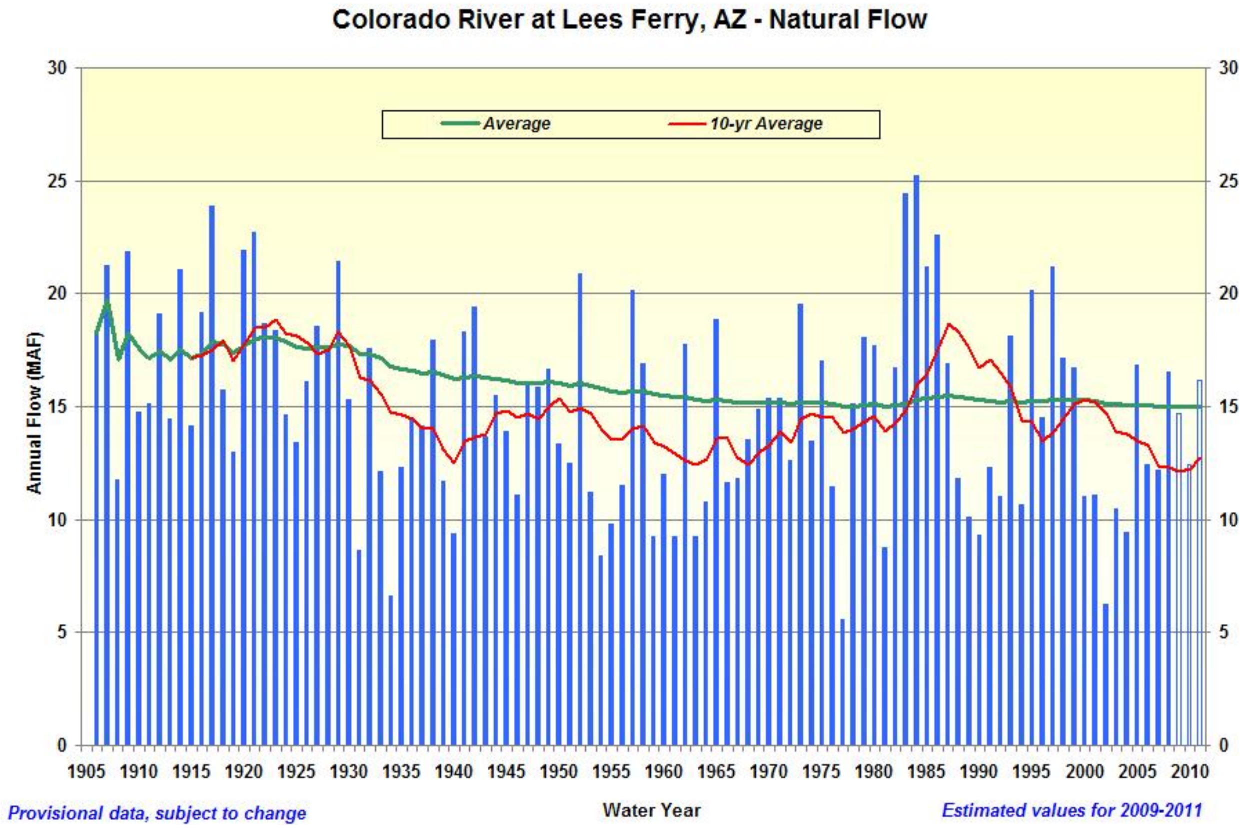


Figure 2-5. Natural Colorado River Flow at Lees Ferry, AZ (Courtesy of USGS/USBR)

Arizona's vulnerability to shortages has led to creative solutions such as the underground storage or "banking" of excess Colorado River supplies through the Arizona Water Banking Authority (AWBA) and by individual water providers. To date, the AWBA has stored more than 2.7 million AF for use during future CAP cutbacks. While this will not fully insulate CAP customers from shortage, it will reduce the impacts.

CAP supplies are summarized as follows:

- Municipal and Industrial Subcontract: Phoenix's Municipal and Industrial (M&I) subcontract with the CAP provides for delivery of up to 122,120 AF of water per year. This includes 8,206 AF associated with the Arizona Water Settlement Act (signed by President Bush in December 2004). M&I subcontracts are among the highest priority allocations (last to be reduced) within the CAP system. All of the "subcontract" water available in Arizona has been allocated.

- Colorado River Exchange: As part of the SRPMIC Water Rights Settlement Agreement, Phoenix obtained 4,751 AF per year of mainstem Colorado River water (after deducting losses). Mainstem Colorado River Water is technically not CAP water, though it is delivered through the CAP system. The water maintains the same priority as M&I CAP allocations.

- Indian Leases: The City maintains long-term leases with the Fort McDowell Indian Community and the SRPMIC for a combined 7,323 AF per year. This Indian-Priority water is similar in standing to M&I water with regard to shortages. Pursuant to the Arizona

Water Rights Settlement Act, which included a settlement of the GRIC water rights claims, Phoenix leases 15,000 AF of CAP per year from GRIC.

- Agricultural-Priority Water*:* In 1993, Phoenix and other cities entered into an agreement with the Hohokam Irrigation & Drainage District to acquire some of the District's CAP allocation. Hohokam water carries agricultural priority (lower priority) through 2043, when the supply is upgraded to an M&I priority. Until 2043, this is Phoenix's most vulnerable supply during Colorado River shortages. The long term contract provides for approximately 36,000 AF per year, though additional water may be available in some years. The City also has access to another 1,000 AF of agricultural-priority CAP which was assigned to Phoenix by the Roosevelt Water Conservation District (RWCD) as part of the SRPMIC Water Rights Settlement Agreement. The allocation can be converted to M&I priority, resulting in 614 AF per year.

- Recovery of Stored CAP*:* Portions of Phoenix's unused CAP water allocation are periodically stored underground at various recharge sites. This water may be recovered (pumped from wells) in future years. To date, the City has stored more than 60,000 AF of CAP water.

- Treatment of CAP Supplies*:* The bulk of the City's CAP supplies are delivered to the Union Hills and Lake Pleasant Water Treatment Plants located near the CAP Canal. Through an "interconnect facility" that allows CAP water to be diverted into the SRP canals, the City can also provide water to treatment plants on the SRP system. This provides additional system reliability and operational flexibility during droughts or treatment plant maintenance and for water quality management.

Other Surface Water Supplies:

The City has access to other surface water supplies from the Salt and Verde rivers which may be used anywhere within Phoenix. These supplies are deliverable through the SRP system, and include the following:

- Gatewater: In 1948, Phoenix entered into a contract with the Federal government and SRP and established a water right for stored water resulting from the construction of gates in the Horseshoe Dam spillway (on the Verde River). Water generated by the spillway gates constructed with Phoenix funds is referred to as "gatewater." The City may accrue up to 150,000 AF of storage credits. This supply is vulnerable to shortages on the Verde. Over the long-term, an average of 25,000 AF is affirmed in the City's 2010 Designation of Assured Water Supply. Phoenix's Gatewater balance stands at approximately 64,500 AF as of Spring 2011.

- Roosevelt Dam New Conservation Space: Roosevelt Dam was modified in the 1990's to increase storage capacity on the Salt River to retain flows in the wetter years. Phoenix and other Valley Cities helped fund the construction of the raised dam. This "New Conservation Space" (NCS) water is available when stored water on the Salt River system exceeds pre-Roosevelt Dam modification capacity. The volume available for storage varies from year to year. Over the long term, an average of 32,300 AF per year is available to the City is affirmed in the City's 2010 Designation of Assured Water Supply. Phoenix's NCS balance stands at approximately 131,000 AF as of Spring 2011.

Reclaimed Water

Approximately 40 percent of water delivered to all Phoenix customers (residential and non-residential) ends up at one of the City's three wastewater treatment plants, and is treated for other uses (Figure 2-6). More than 90 percent of this water is used to meet non-potable water demands in the Valley. This water is currently used through the mechanisms described below.

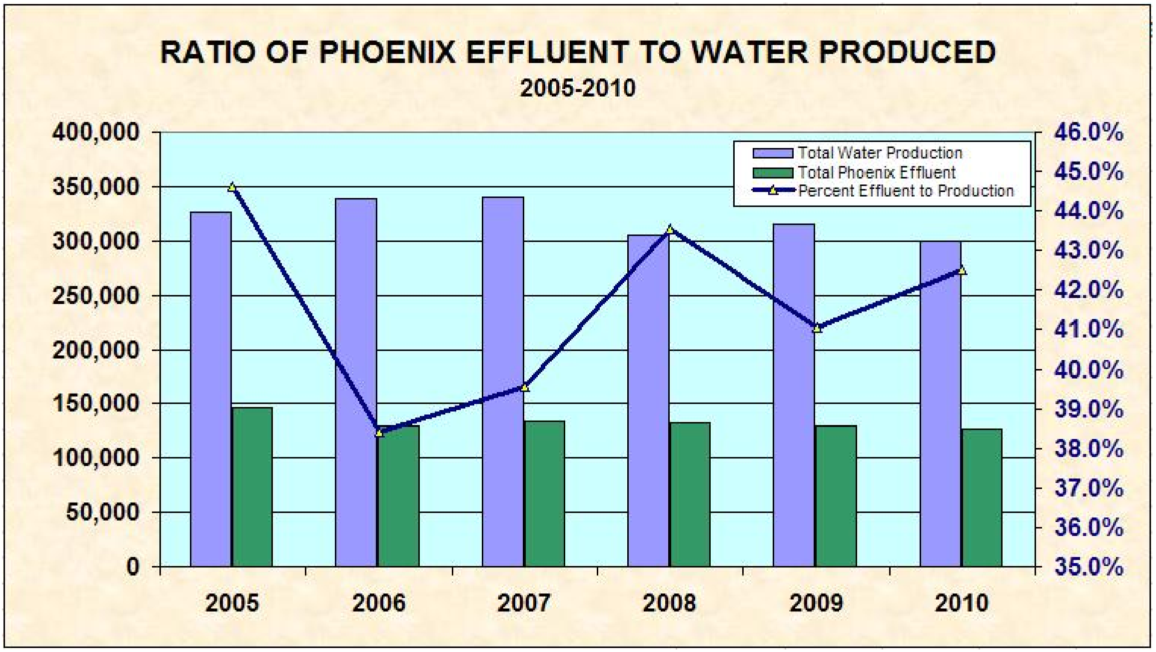


Figure 2-6. Ratio of Effluent to Water Produced

- <u>RID/SRP "Three-Way" Exchange</u>: Phoenix delivers up to 30,000 AF per year of treated wastewater from the 23rd Avenue WWTP to the RID, which delivers the water to farms. RID provides a like amount of groundwater to the SRP canal system. SRP then delivers 20,000 AF of canal water per year to Phoenix water treatment plants, and 10,000 AF to SRPMIC. Phoenix may use SRPMIC's unused water in any year. This exchange was developed as a part of the SRPMIC water rights settlement agreement.

- <u>Reclaimed Water System</u>: The City produces reclaimed water at the CCWRP for use by turf facilities (five acres and larger). Currently, more than 2,000 AF per year is generated for the delivery to those facilities, and the plant can produce up to 8,000 AF per year at its current capacity. The City is continuing to experiment with storing excess reclaimed water underground at the facility for future recovery to meet peak demands.

- <u>Recovery of Stored Effluent</u>: Effluent stored underground at the RID Groundwater Savings Facility (GSF) may be pumped by wells which serve the Rio Salado Restoration Project. This water, when pumped, retains the legal classification of effluent. The expected project requirement is approximately 4,000 AF per year. The City has stored approximately 120,000 AF of reclaimed water to date.

- <u>Tres Rios Wetlands</u>: The Tres Rios Wetlands, a six-mile wildlife habitat restoration project at the confluence of the Salt and Gila Rivers, were substantially expanded in 2010. This wetlands project, a partnership with SROG, the USBR, the U.S. Army Corps of Engineers and other key agencies and volunteer organizations, serves as a means to treat discharge from the 91st Avenue WWTP to improve water quality for other uses. The project consumptively uses approximately 20,000 acre-feet per year.

- Deliveries outside of Service Area: Phoenix and four other municipalities also contract with Arizona Public Service to provide up to 80,000 AF per year of 91st Avenue reclaimed water to the Palo Verde Nuclear Generating Station for cooling of reactors. In addition, through a contract with the BIC, the Buckeye Irrigation Company receives up to 20,000 AF per year of reclaimed water from the 91st Avenue WWTP.

Wells, Groundwater Credits and Hydrogeology

Groundwater may be pumped and used by Phoenix pursuant to Arizona statutes, but with strict controls. The assured water supply regulations establish groundwater allowances credits for Phoenix which may be used at any time. These credits are mostly intended to provide drought relief. Phoenix currently holds more than 2 million AF of groundwater allowance credits for use over a 100 year period. Additional credits are accrued by the City each year to reflect the incidental recharge of local aquifers which results from service area usage. Additional groundwater may be pumped with an increase in available well capacity, though Phoenix has an obligation to replenish any groundwater used in excess of that provided for in statutes.

Though the City has access to substantial groundwater reserves within its service area, challenges pertaining to groundwater quality (in central Phoenix), water table declines (in north Phoenix) and relatively few active service area wells limits the potential for groundwater use.

Based on currently available well capacity of 28 mgd, and applying a 65 percent duty cycle (i.e., frequency of use), Phoenix can produce about 20,000 acre-feet of groundwater per year. This number can be more than doubled if currently inactive wells are brought back into service. A major effort was initiated following adoption of the 2005 Water Resources Plan to identify the potential for expanded well production in Phoenix. The results of this study are discussed further in Chapter 5.

Though the City currently pumps very little groundwater, a large number of City wells draw from the northeast Area aquifer which is roughly bound by Bell Road, Scottsdale Road and 7th Street. This aquifer is accessed by non-City wells and has experienced significant water table declines in past decades. Major efforts have been underway to model this aquifer, collaborate with other entities drawing from the aquifer, and to begin developing mechanisms to replenish depleted supplies.

Recharge

The City maintains permits to recharge the groundwater aquifer with CAP and reclaimed water supplies that are not needed to meet current demands. The storage of this water may be pumped or “recovered” in the future when additional supplies are needed for operational flexibility to meet growth and/or drought related demands. To date, the City has stored more than 60,000 AFof CAP supplies and another 120,000 AF of reclaimed water, primarily through the projects described below.

1. Storage of CAP supplies at the Granite Reef Underground Storage Project (GRUSP)

   GRUSP is an open basin facility maintained by SRP and used by several Valley Cities. Approximately 800,000 AF have been stored at GRUSP since its inception in 1994.

2. Storage of CAP supplies through SRP's Groundwater Savings Facility (GSF)

   Phoenix provides CAP water to SRP to replace groundwater that SRP would have otherwise pumped (this is also referred to as "in-lieu" recharge). Phoenix receives credits for the water remaining in the aquifer (less a minimal "cut to the aquifer").

3. Storage of reclaimed water from the 23rd Avenue WWTP at the RID GSF

   This "in-lieu" recharge project allows Phoenix to accrue credits for groundwater which would have otherwise been pumped if not for the water provided to RID. As previously discussed, some of these credits are being used to supply the Rio Salado River Restoration Project, which includes four recovery wells.

2.4 IMPACT OF WATER QUALITY ON SUPPLIES

Drinking water quality standards have increased in significance as an environmental issue over the last two decades. The criteria defining acceptable water quality are undergoing rapid and often controversial change. Historical indicators of water quality included characteristics such as hardness, coliform bacteria, TDS, and inorganic compounds, such as nitrate, arsenic, chromium, fluoride, and iron. Over time, emphasis has shifted to organic compounds such as pesticides, chlorination by-products and industrial solvents.

Organic Solvents

Organic solvents were first detected in Phoenix drinking water in 1981 when a systematic program was undertaken to sample all water sources for the industrial solvent trichloro-ethylene (TCE). Since the initiation of the TCE detection program, levels of TCE exceeding drinking water standards have been found in six wells (approximately 8 mgd), resulting in their closure. Trace levels (below the maximum contaminant level) of TCE were found in fourteen other wells (approximately 15 mgd), which have been disconnected. The area generally affected by organic solvent contamination is illustrated in Figure 2-7.

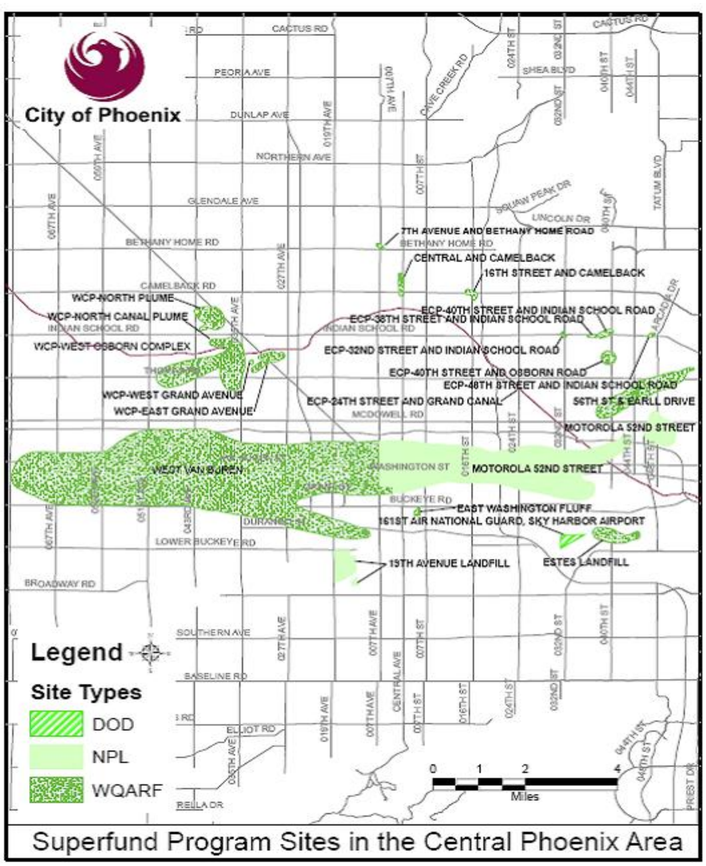


Figure 2-7. Federal and State Superfund Program Sites in the Central Phoenix Area

The detection of widespread TCE contamination in the early 1980s led to investigation and remediation activities undertaken by the ADEQ, EPA, and parties responsible for the contamination. The City of Phoenix has been actively involved in the effort and is monitoring federal and state superfund activities.

To date, the largest contaminant plume in Phoenix extends across central Phoenix, encompassing an area of groundwater which begins at 52nd Street and terminates several miles west to approximately 75th Avenue, generally between McDowell Street and Buckeye Road. This contaminant plume is the result of historical spills and other releases of commercial and industrial solvents from facilities throughout the area, which reached the groundwater and caused contamination. The plume contains TCE, Tetrachloroethene (PCE), Trichloroethane (TCA), and the chemicals that are produced when those contaminants break down. This contaminant plume encompasses the Motorola 52nd Street Superfund site, which is a federal Superfund site listed on EPA's National Priority List (NPL) and the West Van Buren Water Quality Assurance Revolving Fund (WQARF or State Superfund) site. The Motorola 52nd Street Superfund site extends form 52nd Street to 7th Avenue, and the West Van Buren WQARF site extends from 7th Avenue to approximately 75th Avenue.

EPA and ADEQ selected interim cleanup plans for the soils and groundwater at the former Motorola 52nd Street facility in 1989, known as Operable Unit 1 (OU1). Motorola (now Freescale Semiconductor) has been operating a groundwater treatment plant at the 52nd Street facility since 1992. Freescale and Honeywell (formerly Allied Signal at 34th Street and Airlane) have been operating a groundwater treatment plant known as Operable Unit 2 (OU2) at 20th Street and Washington since 2002. The purpose of OU1 and OU2 is to contain or halt the spread of the more highly contaminated groundwater.

In 1997, EPA and ADEQ established a third study area known as Operable Unit 3 (OU3) for contaminated groundwater extending past 20th Street. EPA has been researching additional facilities that could be responsible for contamination and is continuing the groundwater investigation in the OU3 area. The contamination that extends west of 7th Avenue is being addressed by the ADEQ WQARF program as part of the West Van Buren site.

There are other WQARF and federal Superfund sites in the Phoenix area, but the Motorola 52nd street and West Van Buren sites are the largest. There are at least nine WQARF sites in Phoenix where groundwater has been impacted by PCE from dry cleaners. In the West Central Phoenix area, there is a cluster of 5 individual WQARF sites that are affected by solvent contamination from various industries. ADEQ is actively working on these WQARF sites and has been consulting with the City about future water use when developing remedial (cleanup) objectives. In correspondence and discussions with ADEQ and EPA, the City has emphasized that the central Phoenix aquifer is an important future water supply that the City will need to be able to access.

Hydrocarbons

Hydrocarbon contamination (from leaking service station fuel tanks) has also impacted well availability. Individual sites are small and dispersed (typically coinciding with abandoned stations). Because this contamination exists in the best producing portions of the aquifer, cleanup of these sites is also essential.

Pesticides

Pesticide contamination has also resulted in a loss of groundwater production capacity. In 1984, the City initiated a program to sample all water sources for specific pesticides. A total of eight wells have been taken out of service due to high concentrations of pesticides, with a total loss of production of 9,000 AF per year (8 mgd).

Heavy Metals

Heavy metal contamination has also resulted in a loss of groundwater production capacity. High concentrations of chromium, a naturally occurring metal, have resulted in closure of seven wells with a combined capacity of 6,700 AF per year (6 mgd).

Nitrate

Nitrate, an inorganic compound found in elevated concentrations due to leaching of fertilizers used for agriculture, has a significant impact on the City's groundwater production capacity. Since 1987, 39 wells with an aggregate capacity of 68,000 AF per year (61 mgd) have been lost due to nitrate levels approaching or exceeding standards (some of these wells also have high levels of organic substances).

Due to the large number of wells affected by high nitrate levels, the Water Services Department has reduced nitrate concentrations by modifying certain wells to withdraw water from aquifer zones of higher quality, and by blending water sources under plans approved by ADEQ

The total loss of Phoenix well production from 1981 to 2000 due to elevated concentrations of organic and inorganic substances exceeds 90,000 AF per year. This loss stemmed from the closure of more than 60 wells, and represented 60 percent of the total production capacity of all Phoenix wells. Wells which are returned to service in the future will require cleanup of the contaminated aquifers or expensive wellhead treatment systems.

Arsenic

EPA's revised standard for arsenic, a naturally occurring mineral, is mandatory as of January 2006. This new standard of 10 parts per billion (ppb) is considerably lower than the prior maximum contaminant level of 50 ppb, and necessitates the installation of wellhead treatment facilities for several City wells. The initial phase of well modifications addresses 12 wells, with others to follow.

Disinfection Byproducts (Surface Water)

The SDWA, passed in 1987, applies the same organic monitoring requirements to surface water as to groundwater, and imposes more stringent requirements for filtration and disinfection of all surface water sources. Also, as a part of recent drinking water standard revisions, the concentration limit for disinfection by-products has been lowered considerably. Phoenix has taken appropriate steps to manage treatment plants and distribution systems to meet these revised standards.

Pharmaceuticals and Endocrine Disruptors

In recent years, methods of detecting pharmaceutically active compounds in drinking water supplies and reclaimed water have become increasingly sophisticated, and have allowed for detection at extremely low concentration levels (parts per trillion). These compounds are found in reclaimed water supplies, and in river supplies that receive discharges from upstream wastewater treatment plants. To date, EPA has not established maximum contaminant levels for these compounds. The City will continue to monitor developments in this area.

Salinity

Salinity in area source waters is increasingly becoming a key consideration in municipal water supply and infrastructure planning. Higher concentrations of salinity - also referred to as salts or TDS, are progressively accumulating in the soils and water supplies due to the collective impact of irrigation, urban growth, low rainfall and the high mineral content of geologic features. Traditional water treatment practices do not remove salinity

SRP and CAP surface water supplies are naturally high in salinity due to origin source geology. Phoenix surface water sources range from 300 milligrams per liter (mg/L) to about 900 mg/L (Figure 2-8).

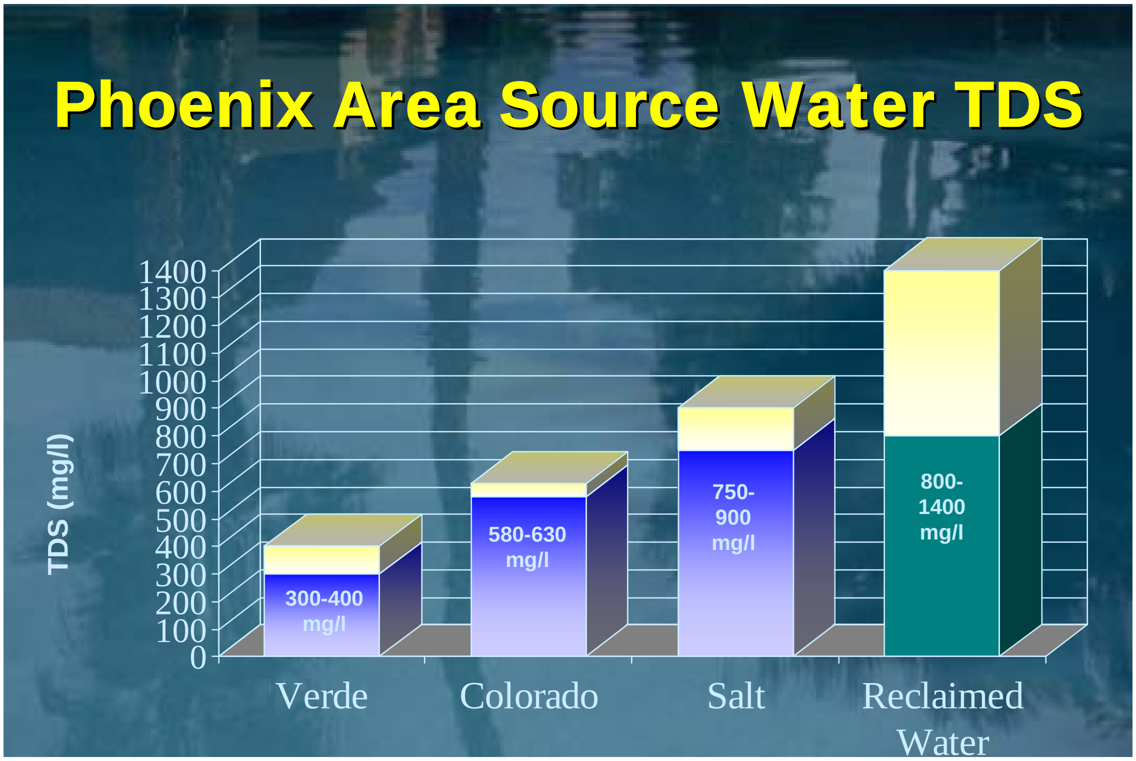


Figure 2-8. Comparison of TDS Levels in Select Phoenix-Area Sources
(Top bar reflects typical range)

TDS in area groundwater ranges from 200 milligrams per liter (mg/L) to more than 2,500 mg/L in the southwest valley (Figure 2-9). Though the EPA has not established a maximum contaminant level (MCL) for salinity, a secondary (non-enforceable) TDS standard of 500 mg/L has been established. This level represents an aesthetic standard, and does not imply any adverse health impacts if the figure is exceeded. Generally, water utilities avoid distributing water in excess of 1,000 mg/L TDS as customer complaints (primarily regarding taste) tend to increase at that level.

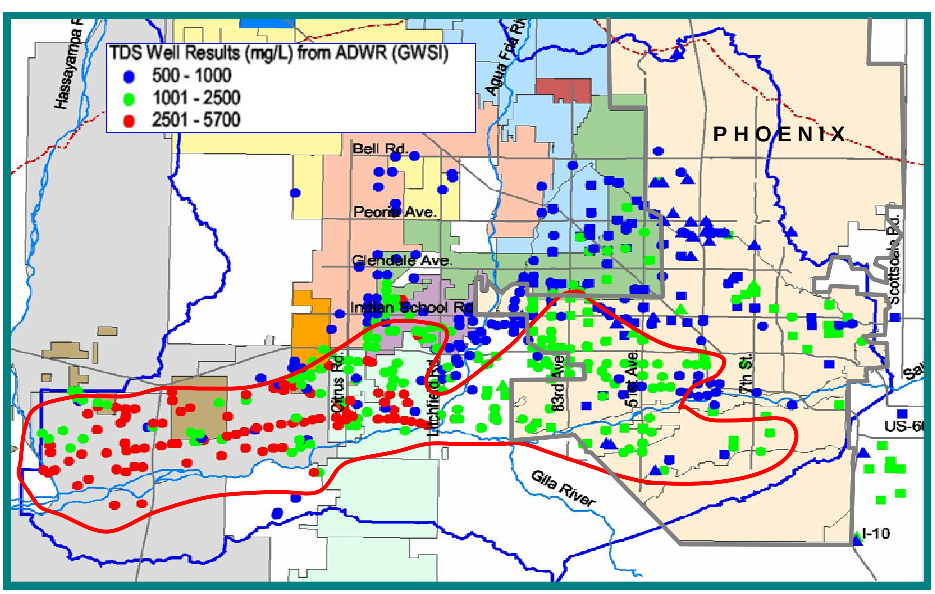


Figure 2-9. Salt Content in Area Water Supplies

Elevated concentrations of TDS in reclaimed water impede the utilization of this supply for irrigation and for groundwater recharge. Increased TDS levels in wastewater are a result of water softener regeneration discharges, industrial cooling, on-site treatment processes and a number of other point sources.

In 2001, the Central Arizona Salinity Study (CASS) was initiated as a comprehensive evaluation of salt impacts in the region, and to identify potential mitigation opportunities. The initial four year two-phase study was initiated by the SROG cities and the USBR, and involved numerous other stakeholders. The first report estimated that more than 1.5 million tons of salt enter the Phoenix metropolitan area annually, and that 1.1 million tons are retained in soils, water supplies and other "salt sinks." The report also concluded that high TDS levels in water supplies result in at least $60 million per year in damages. These costs are in the form of prematurely aging infrastructure and appliances, soil additives, water softening and other related mitigation actions.

Continuing CASS efforts are evaluating the economics and feasibility of controlling salts at various points in the system, from the source watershed to the WWTPs. It is also evaluating methods for managing the concentrated brine by-product from membrane water treatment processes designed to remove salt.

CASS findings indicate that prevention of the entry of salts into surface water and wastewater systems may be the most cost-effective means to addressing salinity problems. From a watershed perspective, the Colorado River Basin Salinity Control Forum (CRBSCF), a consortium of the seven Colorado River Basin states, has achieved substantial success in reducing inflows of salt-laden water into the Colorado River (which occurs primarily in the Upper Basin). In partnership with the USBR and the U.S. Department of Agriculture, the CRBSCF has developed irrigation and conveyance system improvement programs which have prevented the entry of roughly 800,000 tons of salt per year into the Colorado River. This reduction allows the United States to meet standards established in its treaty with Mexico, but also benefits downstream urban users.

With regard to brackish groundwater, desalination technologies are being used to effectively treat this supply in other parts of the Valley, but the major challenge involves disposal of the brine concentrate byproduct. Concentrate management costs can comprise over 70 percent of total costs of a desalination project. In the Phoenix region, the concentrate is typically discharged to wastewater systems. This is not an effective long-term solution as it increases salinity levels in reclaimed water (and thus affects end users). Several research efforts are underway at the local and national levels to identify and develop cost-effective methods of managing concentrate. Phoenix will continue to monitor and support these and other related efforts.

2.5 SURFACE WATER RELIABILITY

Cyclical Drought Susceptibility

Phoenix, like many other municipalities in the region, is predominantly dependent on surface water supplies that are prone to climate-related impacts. Surface water sources represent more than 95 percent of the water delivered annually to City customers. The City's groundwater capacity has declined over time with many wells rendered inactive due to declining water levels, aging equipment or contamination. The City still maintains capability of meeting at least 7 percent of its annual demand from well water, though available wells are not distributed uniformly throughout the service area.

Southwest river systems such as the Salt and Verde Rivers and the Colorado River experience wide fluctuations from year to year in the amount of precipitation and snow melt that generate runoff. These fluctuations occur in short and long term frequencies as evidenced by both recent historical measurements and reconstructed flows based on tree ring research. When 5 to 10 year running averages are used to smooth the annual variations in this data, longer term cycles are observed which transition between wet and dry periods that can endure for many decades.

Reservoir systems are designed to equalize seasonal and annual variations. Dry cycles that extend beyond the system's capacity to store for that variation inevitably generate shortages. In general, the Colorado River system, with substantial storage capacity in Lake Mead and Lake Powell can adapt to longer dry cycles than the Salt-Verde system which can be depleted more rapidly. However, the lower capacity SRP system is also capable of rapid recovery from highly depleted levels (as was the case in 2004-2005) while the Colorado system requires numerous wet years to recover.

Recent tree ring investigations within source watersheds have reconstructed flow records for approximately 800 years. These studies have identified several 20 to 30-year periods of below normal precipitation. The past 100 years of recorded flows do not exhibit such lengthy shortages, and thus prior water resource planning efforts in the West have likely underestimated the potential length and intensity of drought. Though the recovery rates vary within the two watersheds, this research demonstrates that the wet-dry cycles are governed by similar climatic influencers which frequently generate dry conditions in both watersheds simultaneously.

Though historic records and past trends provide valuable insights as to how future conditions could unfold, the timing, degree and duration of supply deficits are highly uncertain. Negotiations such as those embodied in the 2007 "*Colorado River Interim Guidelines for Lower Basin Shortages and Coordinated Operations of Lake Powell and Lake Mead*" (2007 Basin States Agreement) have sought to reduce some of the institutional uncertainty regarding allocation of shortages.

Climate Variability

Potential impacts to water supplies from climate variability are far more uncertain than impacts from cyclical drought as there is no reliable historic basis to serve as a benchmark. Some climate scenarios suggest reductions in long-term flows of 10 to 40 percent due to warmer, drier conditions. In some cases, though, these conditions may also lead to increased storage in downstream reservoirs due to runoff from early snowmelt.

One key distinction between cyclical drought and climate variability is the potential for the development of "new normal" conditions (i.e. a lower water supply baseline). Where cyclical drought conditions are typically followed by periods of full reservoir recovery, a relatively permanent change in long term climate conditions could preclude such recovery. This shift could have profound implications for the volume and types of water supplies needed, demand management strategies, and for future infrastructure capacity. In effect, many trend-based factors utilized for decades in managing water resources may no longer be valid as historic patterns of wet and dry cycles may be affected by climate change.

Phoenix has been partnering with researchers from universities, federal agencies, SRP and CAP in modeling efforts intended to better quantify the potential for climate change impacts in river flows. The efforts involve downscaling several global climate models which incorporate varying levels of precipitation. Downscaling efforts seek to generate more geographically precise estimates of precipitation and temperature variability. Results to date have been inconclusive, and the partnership has been addressing substantive complexities and uncertainties in translating precipitation variability into reliable streamflow estimates.

Water Production and Distribution Infrastructure

The City's existing surface water treatment facilities, wells and major transmission infrastructure includes sufficient capacity to treat and deliver existing supplies under normal conditions. However, as drought shortage conditions intensify, the sources of water selected for mitigating shortfalls could stress the capacity of certain infrastructure such as groundwater wells. For example, if additional canal-delivered supplies (such as high-priority Colorado River water) are available, existing treatment plant capacity is likely sufficient for several decades. If local groundwater sources would be the favored strategy, the existing well network will need to be expanded. This is discussed further in Chapter 5.

Continuing Supply Research

In a normal supply year, surface water available to Phoenix from reservoirs on the SRP and CAP systems substantially exceed the amount needed to meet demands. Thus, low reservoir conditions in the near term may not directly result in shortages to Phoenix. However, as the City and the region grows into available supplies, susceptibility to drought-related surface water shortage increases. Uncertainty regarding supplies currently available to Phoenix is illustrated through the following questions, which drive further research and the development of scenarios presented in Chapter 4:

- At what initial point in time could reductions in available surface water supplies due to cyclical drought impact the City's ability to meet demands?
- To what degree will increasing demands in the Upper Colorado River Basin States (Utah, Colorado, Wyoming and New Mexico) affect supply availability to Arizona?
- What conditions could influence reductions in Colorado River availability beyond the levels anticipated in the Basin States Agreement?
- How long could shortages last on each system?
- In what volume, in what form and at what point in time will supplies from the Arizona Water Banking Authority be available to the CAP to offset shortages to Municipal and Industrial CAP Subcontract allocations?
- How could climate variability impact long-term flows, reservoir storage and deliveries by SRP and CAP?
- What is the probability of low reservoir conditions occurring in both watersheds simultaneously?
- To what degree might surface water availability be impacted by legal, institutional or policy changes?
- For what duration and in what volumes can available groundwater supplies be relied upon without aquifer replenishment?
- How will increased groundwater pumping in the SRP watershed impact river flow and reservoir storage?

CHAPTER 3: WATER DEMAND TRENDS AND IMPLICATIONS

A solid understanding of water demand characteristics and trends is the cornerstone of a water supply and infrastructure needs assessment. At any point in time, Phoenix's water use profile reflects economic drivers and the quality of life desired by its customers. As substantive changes may occur over a relatively short period due to economic and demographic shifts (as evidenced with the recent recession), the City has recognized the need to intensify its efforts to better anticipate potential for future trend changes. This chapter briefly describes some of the current characteristics of Phoenix demand, and the potential implications in planning for water supplies and infrastructure.

3.1 CURRENT PROFILE

Population and Demand

Based on the 2010 Census, the City serves a population of 1.45 million. Though projected population has typically served as a basis for estimating water demand growth, this relationship has become much less prominent in recent years. For example, the City's annual water production has been relatively stable since 1996 despite population growth of more than 25 percent over that period. From the peak demand year of 2002, total demand actually declined by more than 16 percent, while service population increased by nearly 8 percent (Figure 3-1).

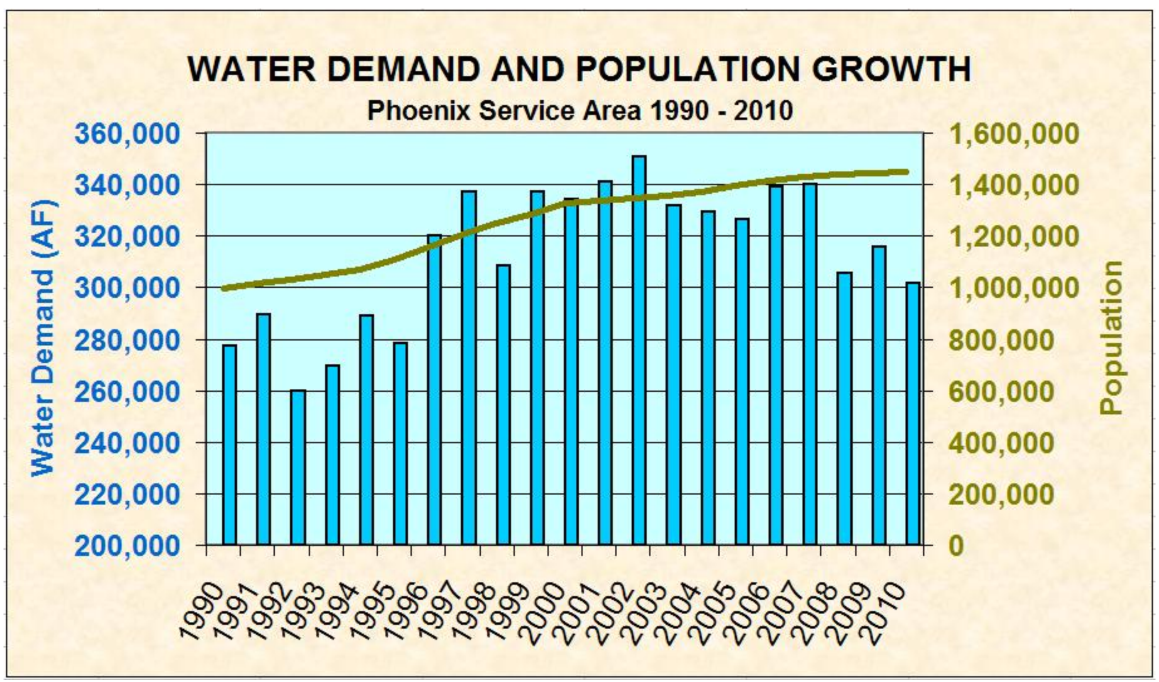


Figure 3-1. Water Demand and Population Growth

This trend toward increased water use efficiency is evident in overall per-capita water demand, which has declined by 25 percent in the last 15 years (Figure 3-2). Contributing factors include improved plumbing fixture standards, smaller residential lots, fewer new pools, growing acceptance of desert landscaping in both new and existing homes, increased customer “water awareness,” and higher water rates.

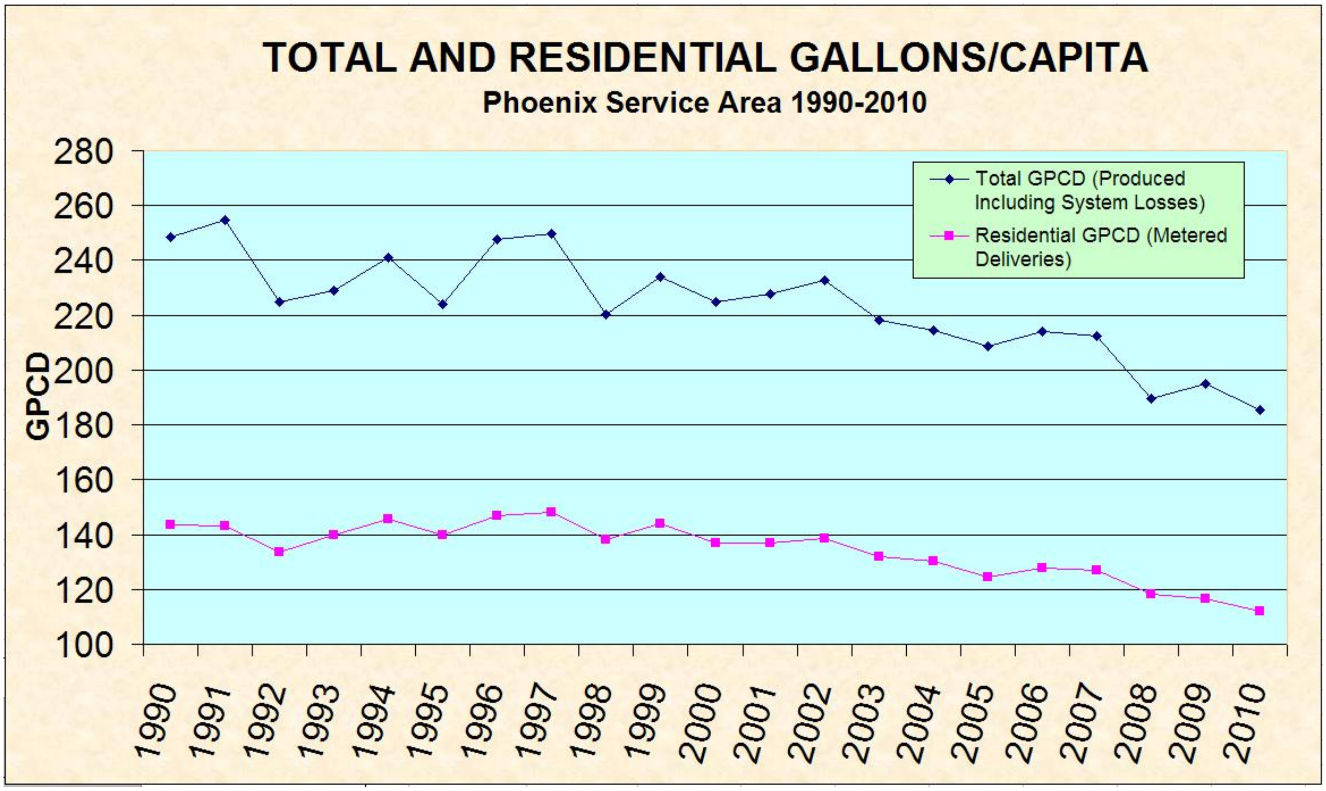


Figure 3-2. Total and Residential Gallons Per Capita

Water Use by Sector

<u>Residential</u>
Residential customers, including single family homes and apartments, comprise almost 90% of the 403,000 accounts served by the City and almost two-thirds of the demand (Figure 3-3). Single-family home demand represents half of total City demand, and approximately 16 percent of water use is for apartments and other multi-family housing.

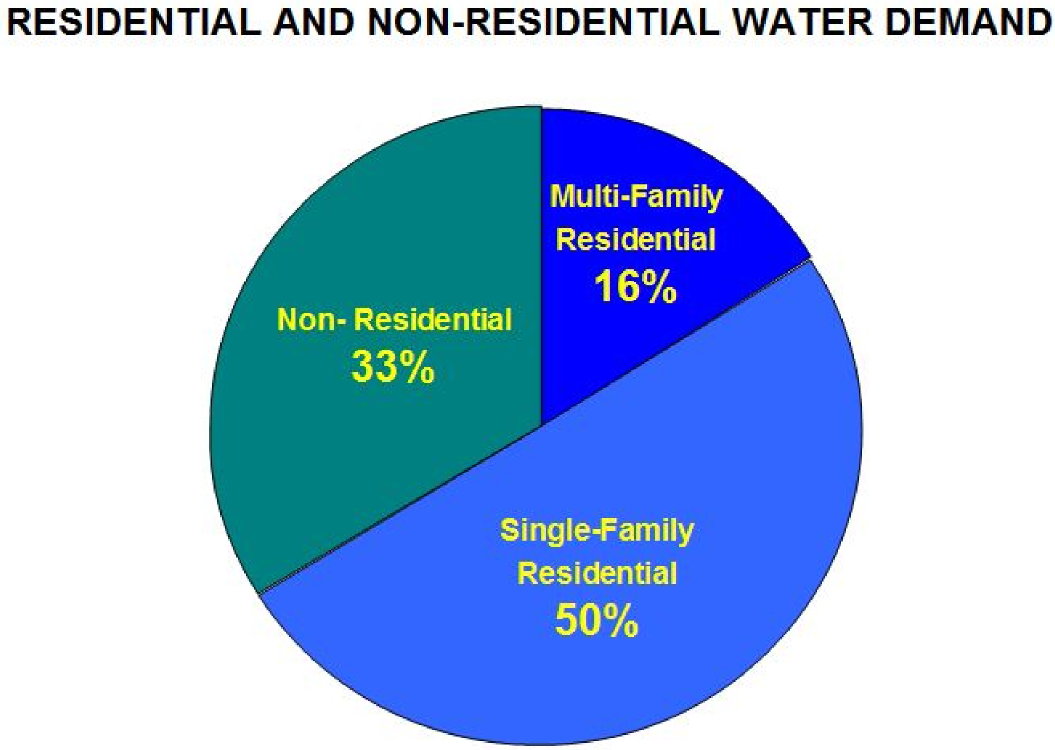


Figure 3-3. Residential and Non-residential Water Demand

Non- Residential

Non-residential water delivered through "irrigation only" meters (for example large turf facilities and common areas) comprise 38 percent of non-residential demand, or about 13 percent of total City demand. Remaining non-residential demand is divided among a number of commercial and industrial categories (Figure 3-4). Demand within these remaining categories also includes incidental landscape water use. Also, while a small volume of potable water is delivered to local golf courses (less than 1 percent of total demand), most of the 33 courses in Phoenix utilize alternate water sources including untreated surface water, high quality recycled water, or groundwater from privately owned wells.

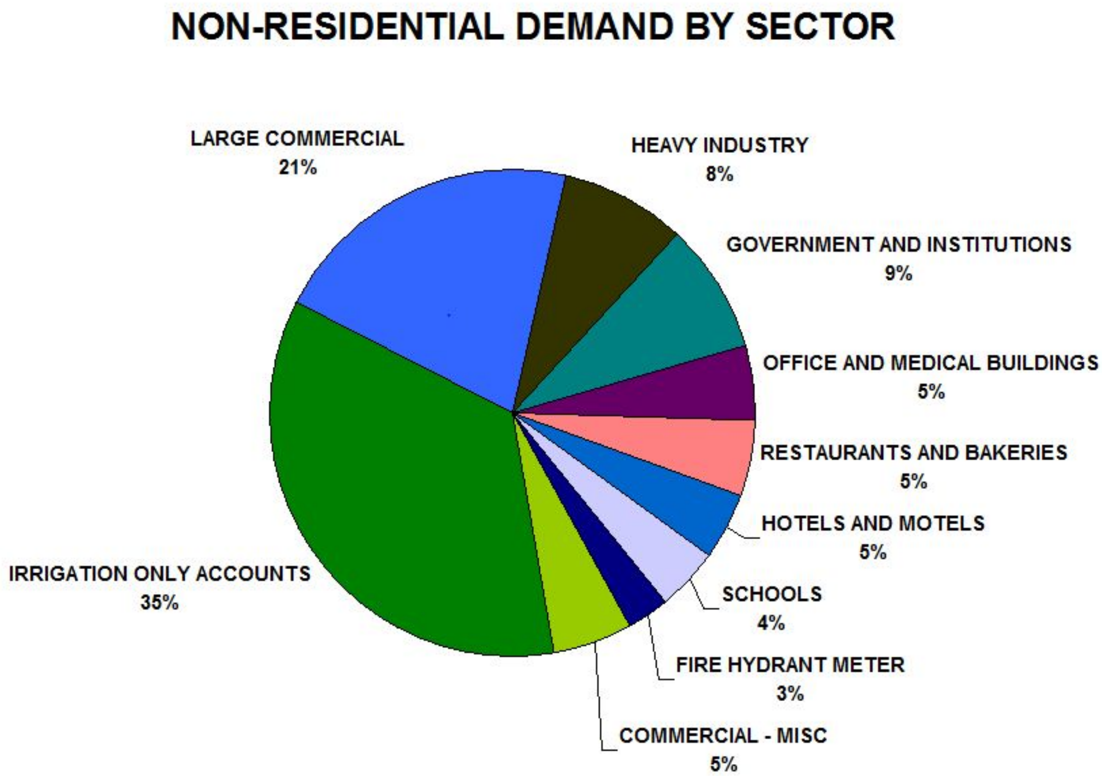


Figure 3-4. Non-residential Demand by Sector

Indoor vs. Outdoor

An estimated 45 percent of the City's total current water deliveries are for outdoor use - predominantly landscape and pools (Figure 3-5). Half of this outdoor use is for single-family residential purposes. These estimates are based on a comparison of water use in winter versus summer months. Further research is underway by the City to better quantify and characterize indoor and outdoor uses. This research is important in determining the degree to which water can be used more efficiently without affecting customer lifestyles or business profitability. The characterization of outdoor use, in particular, is also important in determining the potential for demand curtailment when deficit conditions exist.

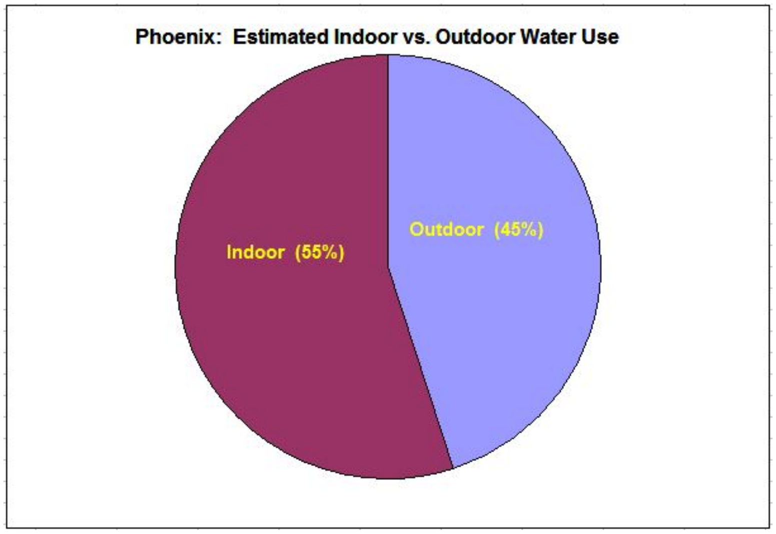


Figure 3-5 – Indoor vs. Outdoor Water Use

Spatial Distribution of Demand

<u>On-Project vs. Off Project</u>
Water use within the SRP-eligible "on-project" areas is roughly half of the City's total demand. The proportion of on-project demand to total demand has declined in recent years as most new development has occurred in "off-project" areas due to greater land availability.

Per-unit usage of City-delivered water is lower in SRP-served areas, largely due to the availability of flood irrigation supplies. SRP typically delivers between 40,000 and 50,000 AF per year of non-potable canal water for landscape irrigation purposes within Phoenix (Figure 3-6). These deliveries to homes and businesses in the on-project areas offset the need to irrigate with potable water. Approximately 14,000 acres are eligible for such deliveries within the City. It is anticipated that over time, this figure will gradually decrease as redevelopment projects choose less water intensive landscape designs.

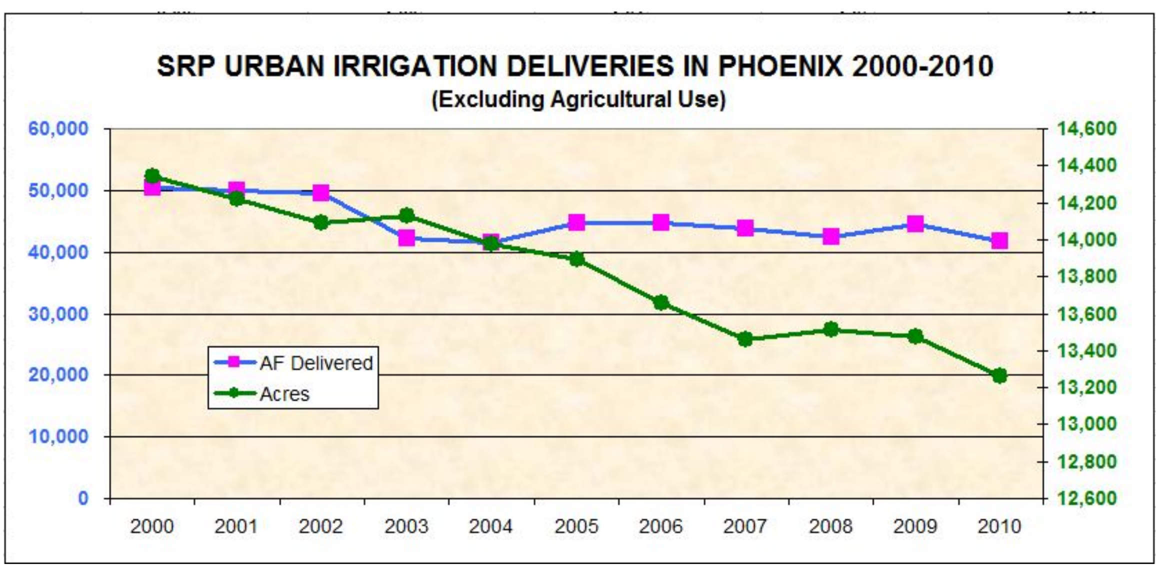


Figure 3-6. SRP Urban Irrigation Deliveries in Phoenix

Usage by area

Water use vary substantially throughout the City based on development patterns, socioeconomic conditions, population density, age of development and numerous other factors (Figure 3-7).

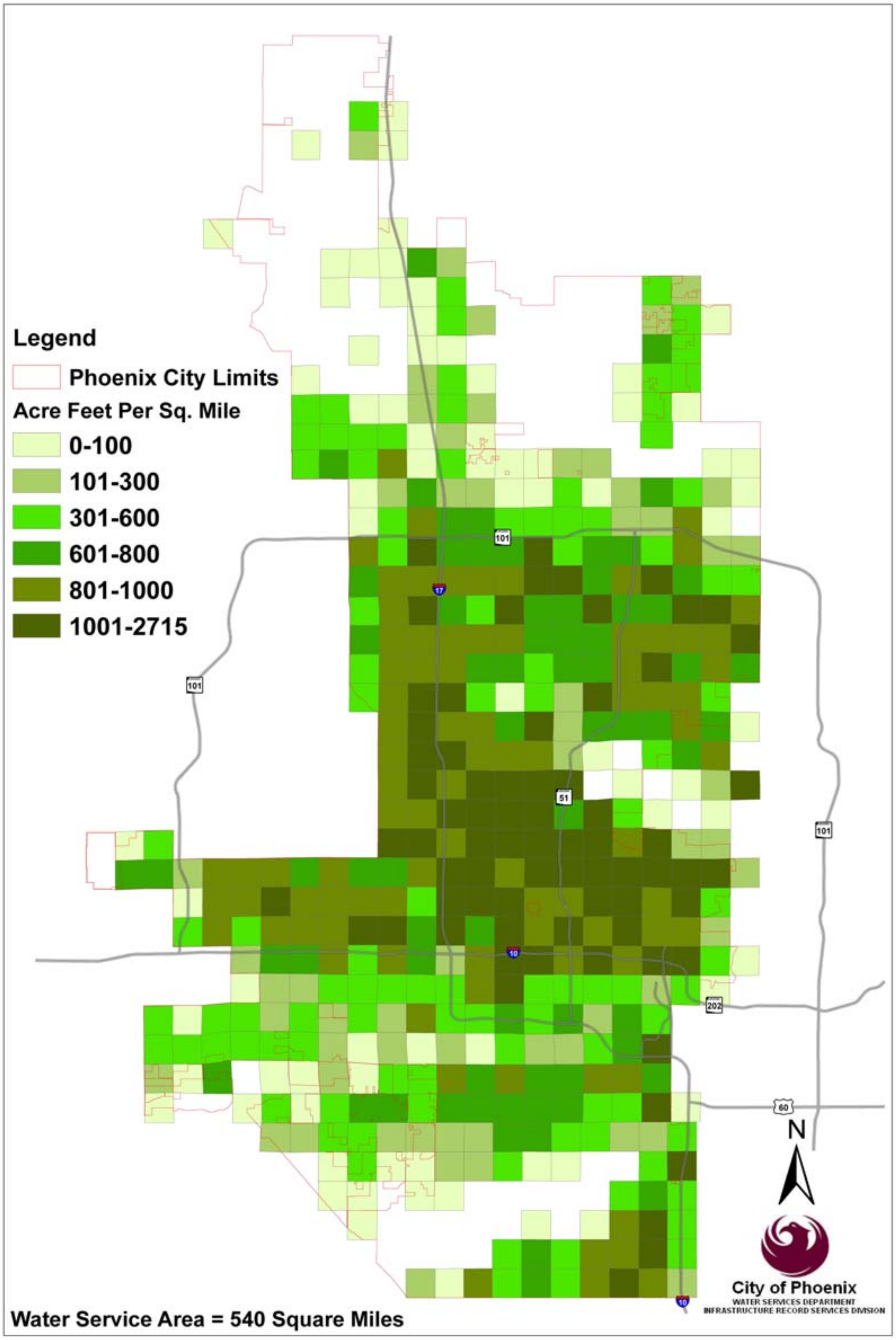


Figure 3-7. Potable System Water Deliveries per Square Mile (2010)

Seasonal System Demands

The City's average daily demand ranges from 140 mgd in winter months to more than 430 mgd in the peak summer months. For single-family residential and non-residential water users, July demand is more than double the February demand (Figure 3-8).

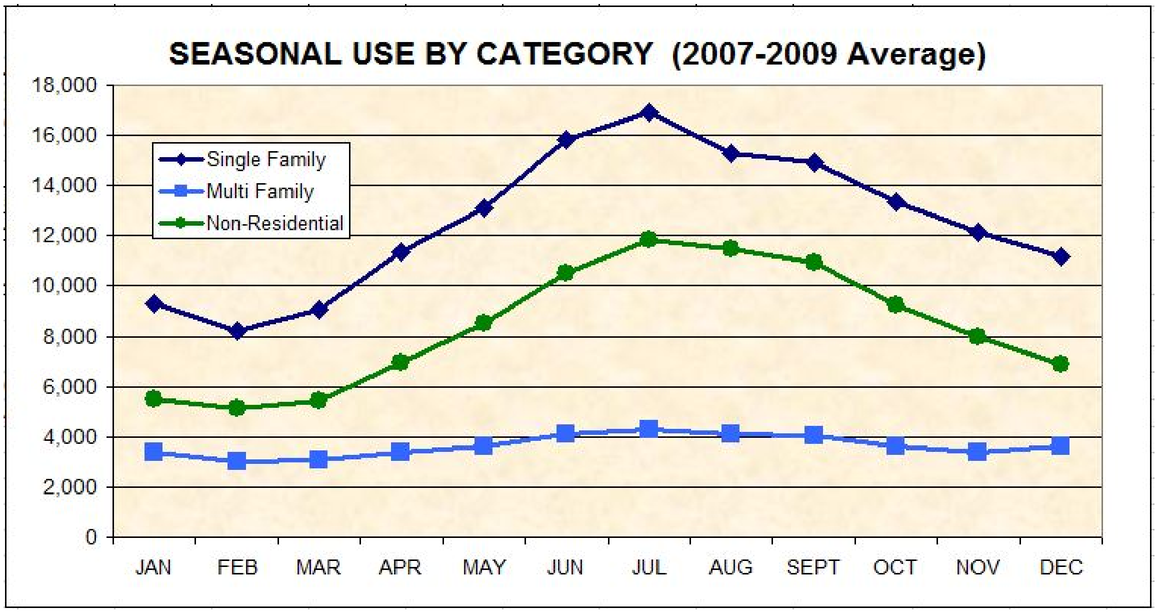


Figure 3-8. Seasonal Use by Category

3.2 DEMAND MANAGEMENT

Conservation and the 1980 Groundwater Code

Conservation and water use efficiency became increasingly important with the passage of Arizona's 1980 Groundwater Management Act and the adoption of associated conservation standards. In accordance with this legislation, the City of Phoenix has:

- Substantially reduced per-capita water consumption to a point well below legally mandated standards (Phoenix has maintained compliance with the ADWR conservation target rates from the inception of the program);
- Managed its distribution system to reduce lost and unaccounted for water below the regulatory standard of 10 percent;
- Limited water applied to golf courses, parks, and other turf-related facilities (at least 10 acres) to 4.9 AF/acre;
- Complied with the state requirement to use specified low water using plants in newly landscaped public rights-of-way;
- Limited the size of water features; and
- Prohibited the development of private lakes.

In 1990, the City adopted a plumbing code to support conservation efforts. This code, which was further reinforced by state and federal water-efficient plumbing standards in 1992, substantially supported the achievement of conservation goals. Phoenix's Water Conservation Plan and related initiatives have included:

- Retrofitting plumbing fixtures and repairing leaks in more than 15,000 older homes;

- Educating customers with regard to optimal water application, water system maintenance, xeriscape principles, and other landscape efficiency principles;
- On-site water efficiency audits for industrial and residential customers;
- Implementing educational programs such as Project WET (Water Education for Teachers);
- Demonstrating water and energy efficiencies in homes such as “Desert House” at the Desert Botanical Gardens, and in partnership with homebuilders, models within new subdivisions;
- In partnership with other Valley cities, developing the well-recognized “Water – Use it Wisely” program to provide basic conservation tips via television, newspapers and other media. The success of this program locally, has led to its adoption in other markets; and
- A comprehensive public awareness program administered though the Water Services Department’s Public Information Office, which imparts water resources, drought and conservation information to customers by way of the award-winning WATERways video series on the City’s television station, the Phoenix website, public speaking events, on-hold messages, school programs, water bill flyers and press contacts.

In addition, Phoenix regularly collaborates with neighboring municipalities in developing and implementing effective regional conservation initiatives, which have served as models for other regions.

Conservation Credit – Water Resource Acquisition Fee

Phoenix assesses a Water Resource Acquisition Fee for each new connection added to the City water system to cover the City’s expense in acquiring long-term dependable supplies for new development. To maximize reduce supply acquisition costs, a program has been developed whereby developers may receive “Conservation Credits” applied toward their Water Resources Acquisition Fees. These credits will apply to developers and builders who choose to incorporate plumbing fixtures that exceed current efficiency standards, or incorporate design elements that have been demonstrated to reduce water demand beyond current practices. The program had been scheduled for implementation in January, 2010, but has been delayed due to a state-imposed moratorium on new acquisition fees.

3.3 DEMAND INFLUENCERS

Understanding the basis behind the decline in average consumption per account is important for developing conservation programs and developing long-term water demand forecasts. The primary contributors to changes in water demand are summarized below, and incorporate recent City studies of characteristics and trends.

Key Drivers of Lower Per-Unit Demand

<u>Integration of water efficient technologies</u>
In 1992 the City of Phoenix became one of the first cities to adopt local water efficiency standards for new plumbing fixtures. Two years later, national standards went into effect triggering significant advancements in plumbing fixture and appliance efficiency. In 2006, the United States Environment Protection Agency launched “Water Sense,” a partnership program intended to promote water efficiency and enhance the market for water-efficient products, programs, and practices. With the support of promotional partners throughout the Country including Phoenix, Water Sense has developed new specifications for a variety of products and services including high-efficiency toilets and certification of landscape

professionals. Products that meet Water Sense specifications can be approved to carry the Water Sense label which helps consumers easily identify efficient fixtures and appliances.

Water Sense and local efforts advocating to raise the efficiency of plumbing fixtures and appliances have played, and will continue to play an important role in promoting further integration of high efficiency technology among local homes and businesses, and in raising the standard for water efficiency. As new standards are adopted there is an immediate impact on the efficiency of new homes and businesses. Also, as older homes and businesses replace fixtures and appliances over time, the higher standards will naturally increase the water use efficiency of previously developed areas. Higher water use efficiency and the corresponding water savings will help to reduce the impact to existing customers should supply shortages occur in the future.

Development of Smaller Residential Lots

Between the 1970's and the 1990's, lot sizes of new homes declined by about 20 percent and potential landscaped area dropped by an estimated 28 percent (Figure 3-9). During the same period, the average home size has increased in livable square footage, which is evident in an increasing proportion of multi-story homes in recent years. This reduction in lot size is a direct response to the rising cost of raw land in recent decades. This trend toward smaller residential lots and larger relative footprints leaves less area available for landscaping, and thus results in lower per-unit water use relative to older homes.

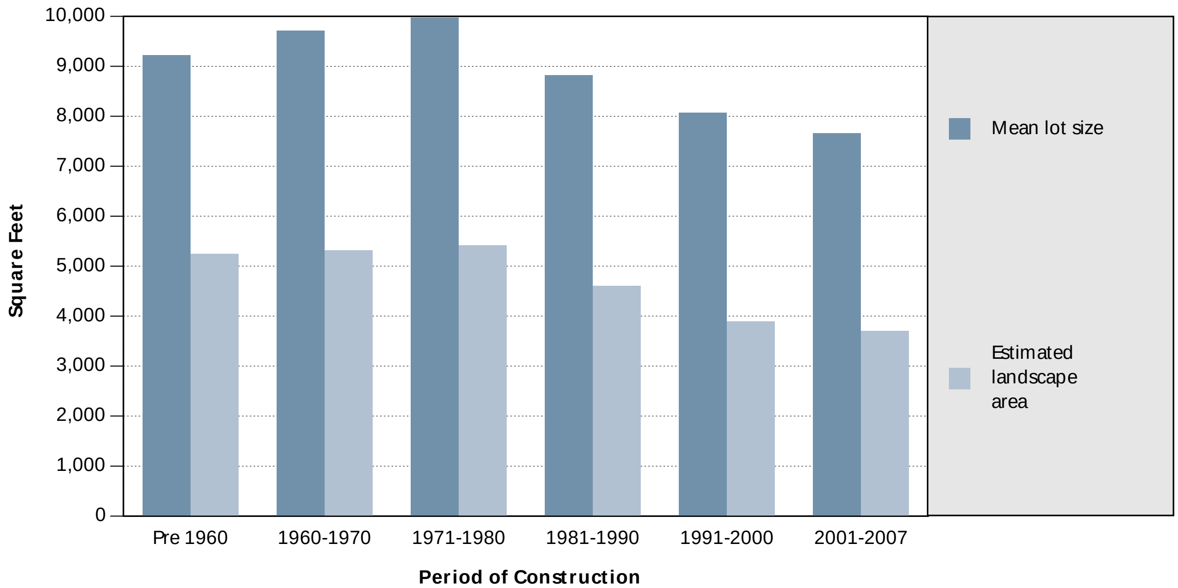


Figure 3-9. Reduction in Lot Size and Landscaped Area

Along with smaller lots, new homes are much more likely to use a mix of grass and desert landscaping, or to eliminate grass entirely. Research based on a sample of 655 single family homes suggests 17 percent of homes built prior to 1995 have no grass landscaping while 29 percent of homes built between 2001 and 2007 do not include lawns. Small lot sizes also result in smaller or fewer swimming pools. In many newer subdivisions, community pools have replaced the traditional backyard pool associated with development occurring in the 1980's and 1990's (Figure 3-10)

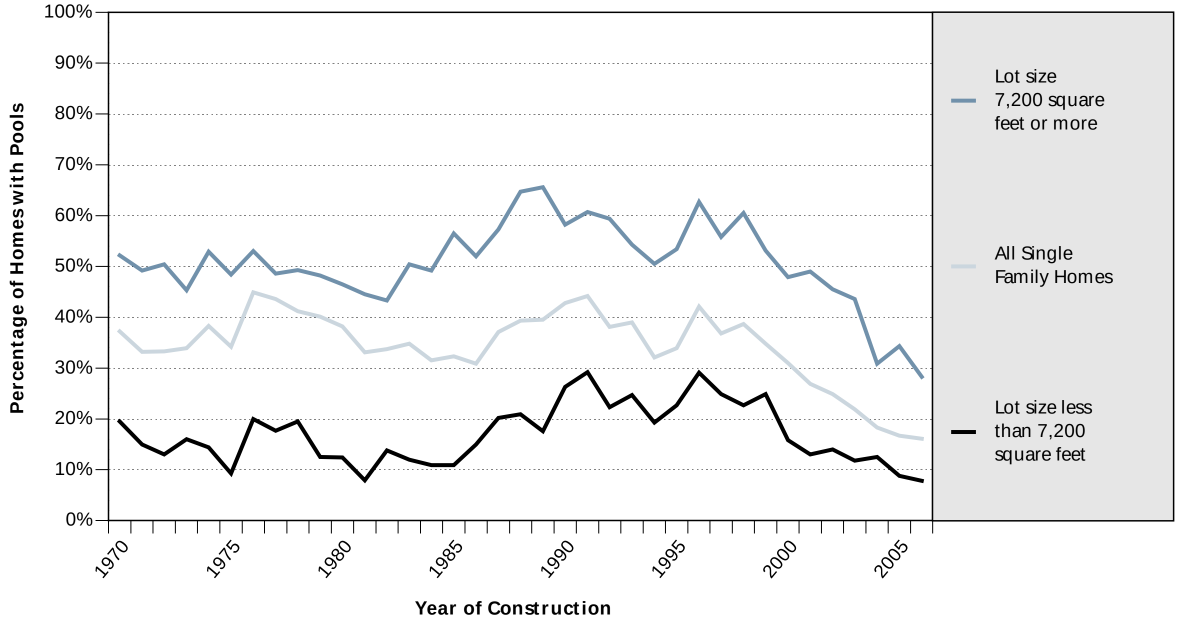


Figure 3-10. Percentage of Home with Pools

Market forces that influence development decisions can have a substantial impact on water use. Monitoring trends in lot size and potential landscape area will continue to be an important factor in forecasting the water demand of new development. Although average lot size declined dramatically during the latest construction boom, it will be important to monitor if this trend will continue under post-recession economic conditions.

<u>Transition to Desert Adapted Vegetation</u>
A trend toward removal of turf and other water-intensive landscapes in favor of desert-adapted landscape has also led to lower per-unit water use. These conversions may result from a customer's desire to modernize landscaping, reduce maintenance requirements, and reduce water expenses or any combination of these factors.

Recent research conducted by the City also identified a greater propensity to under-irrigate traditional water-intensive landscape, although there is considerable variability in this regard. Water costs and maintenance considerations are likely the primary drivers behind this trend, which is seen in both residential and publicly maintained landscaping (such as parks and schools).

<u>Water Pricing Trends</u>
Phoenix water rates have typically been low when compared to other large utilities in the Southwest and nationwide (Figure 3-11). In the past decade, the costs for energy, chemicals and construction – three major components of the water rate base – have increased at rates far above inflation in the past 10 years. During this period, construction expenditures have grown substantially due to an increasing need to replace aging infrastructure. In addition, substantial investments in water treatment infrastructure have become necessary to meet increasingly strict federal water quality standards. As a result, though Phoenix rates continue to be very favorable compared with other water utilities; the City has needed to increase rates over the past 10 years to meet these higher expenses while also meeting debt obligations. Recent price elasticity analyses conducted by the City demonstrate that these rate increases impact customer water demand. However precise attribution of demand reduction due to rates (versus several other factors) is difficult to quantify.

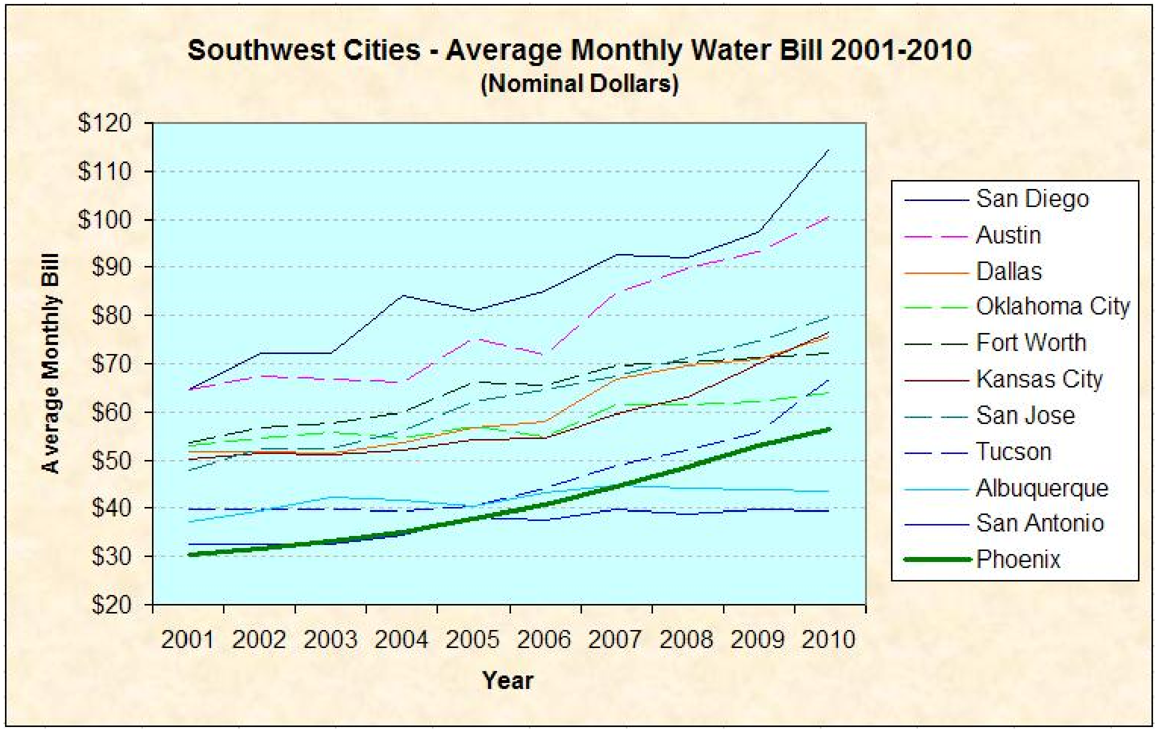


Figure 3-11. Southwest Cities – Average Monthly Water Bill from 2001-2010

<u>Increased Customer Water Awareness</u>

A significant decline in water demand occurred between 2002 and 2003, and this demand has yet to re-emerge. It is likely that the high visibility of drought conditions at that time, played out daily in the news media, created an increased awareness among customers of the value of the resource, and thus may have influenced both behavioral and structural changes in water use. Another significant decline occurred between 2007 and 2008, this time due to the contracted economy, which influenced customer actions to reduce water costs.

The City and its regional partners have been leaders in developing public awareness programs to encourage wise use of water. It is likely that these two recent events provided the catalysts for a large number of customers to take the actions that have been promoted through these programs for several decades.

Other Factors Influencing Demand

Factors which could increase demand over historic rates include increasing urban temperatures (due to urban heat island impacts and climate change), relocation or emergence of a greater proportion of water intensive industries, and economic conditions which are favorable relative to most other regions of the country.

Macro-Climate: Temperature and Precipitation

Year to year fluctuations in temperature and local precipitation influence demand variability. Figures 3-12 and 3-13 illustrate the correlation among these factors. Though a clear relationship exists at the average annual levels, other independent variables such as economic conditions and efficiency trends noted earlier create challenges in establishing predictive values. In addition, the timing and magnitude of precipitation, intensity and duration of summer heat also influence demand fluctuations in shorter time intervals.

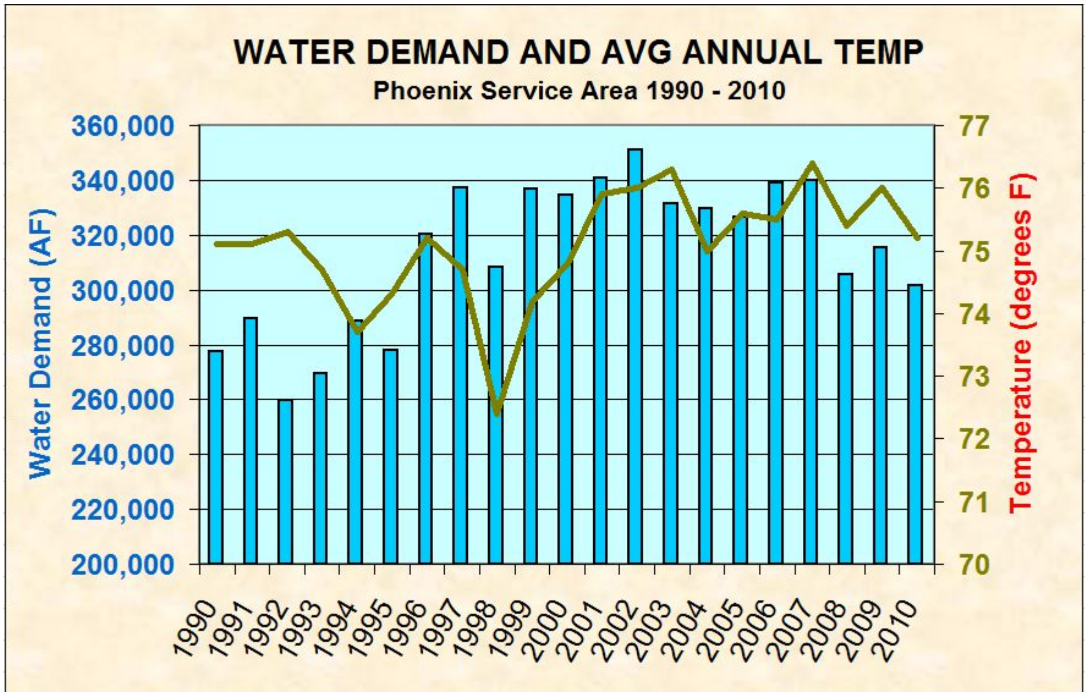


Figure 3-12. Water Demand and Average Annual Temperature

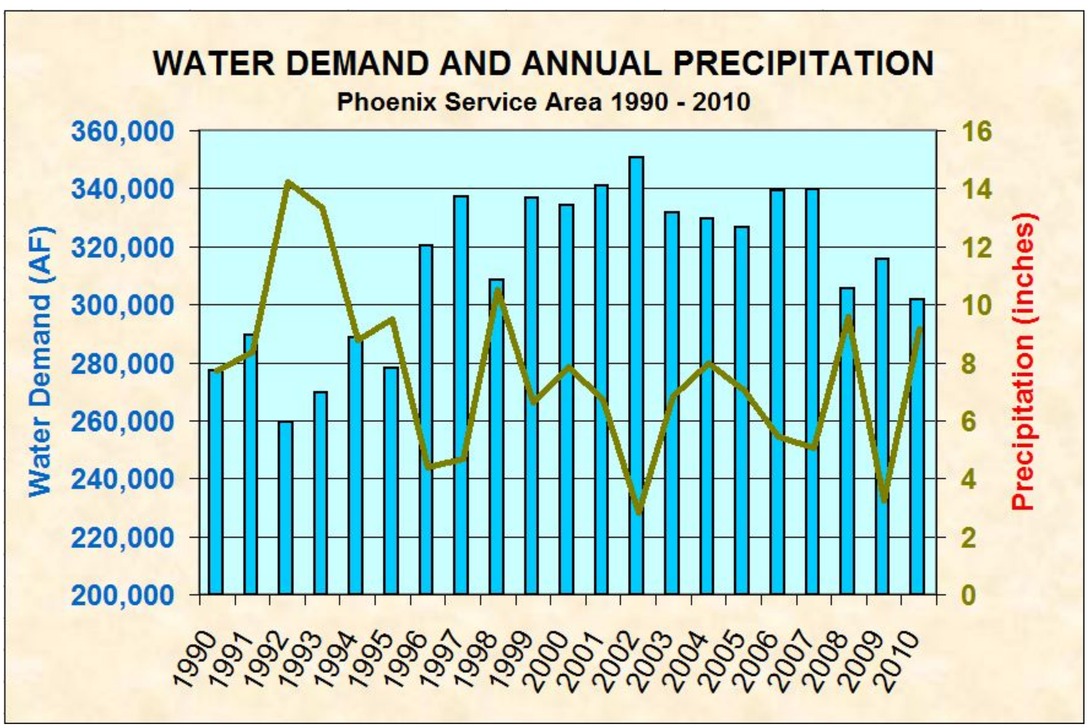


Figure 3-13. Water Demand and Annual Precipitation

Micro-Climate: Urban Heat Island

Summer nighttime temperatures in the urban core have been steadily rising since the 1950's due to the increased percentage of land covered by buildings, concrete and asphalt. These materials retain and thus radiate heat overnight. This trend toward higher nighttime temperatures increases water demand for vegetation (due to higher evapotranspiration (ET) rates) and also indirectly increases water needed for the additional energy needed for structural cooling.

The City and Arizona State University have been partnering in research designed to determine the impact of urban heat island conditions on water demands. A key question of this research is whether enhanced landscape, and thus additional water use, in key locations will provide greater benefits in reducing energy needs for cooling. Preliminary results tend to conclude that portions of the City with low existing ET rates (i.e. less vegetation) will benefit more than those areas which are already well-covered.

Economic Conditions

A strong economy typically results in higher per-unit water use due to higher production. Also, with higher wages, customers tend to expand discretionary uses. This relationship was noted more prominently in past decades. However, other countervailing market conditions (such as smaller lot trend discussed earlier), has made it difficult to forecast demand based on the relative strength or weakness of the economy.

A View from the Sewer

The decline in water demand is also evidenced in reduced sewer flows (Figure 3-14). The City has been measuring and analyzing these flows for purposes of determining the degree to which indoor water use efficiency contributes to the total decline. Also, measurement of flows in both established and new areas help in assessing the potential for additional indoor efficiencies as older appliances and fixtures are replaced in future years.

FIGURE: The decline in total and unit wastewater generation is one indicator that new technology is being integrated in older homes and businesses.

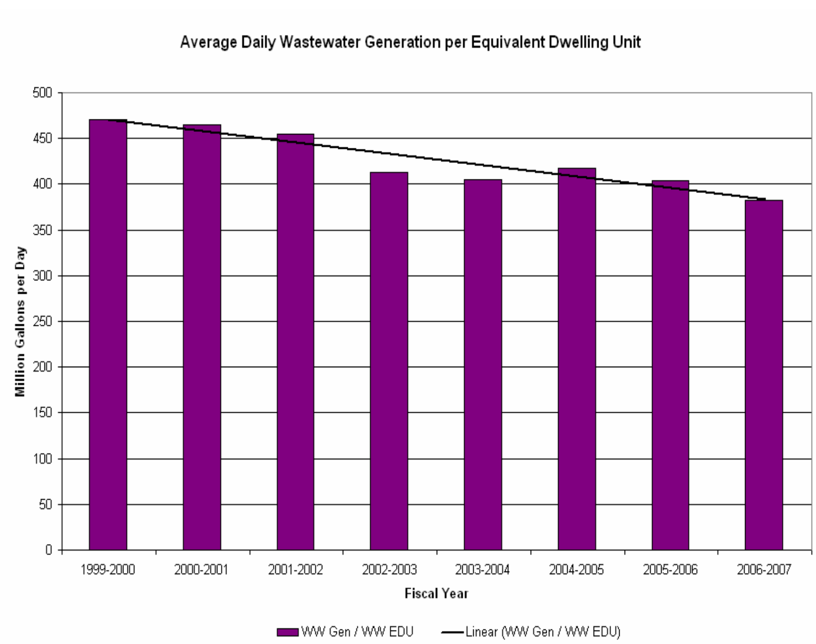


Figure 3-14. Average Daily Wastewater Generation per Equivalent Dwelling Unit

Implications of Continued Trends

Over the next ten years it is expected that further declines in per-unit demand, together with less robust growth rates (compared to prior forecasts) will likely result in minimal increases in overall system demand. The consequences of this "flattening" of demand are being addressed in the City's infrastructure plans as well as this Water Resource Plan. Some of the more significant consequences include the following:

- Water and wastewater infrastructure capacity needs could be significantly reduced over those previously forecasted in previous master planning efforts;
- Revenue growth will continue to be constrained as demand stagnates;
- Rate increases may need to be more robust to keep pace with both fixed capital and O&M commitments (including those necessary to comply with increasingly stringent Federal water quality standards);
- As increased water costs become more prominent in customer budgets, price elasticity will further erode demand;
- Rate structure alternatives such as increasing blocks may need to be implemented to protect both essential uses and rate revenues;
- New capital programs will be difficult to incorporate into the City's Water Capital Improvement Program as prior infrastructure funding commitments compete with critical needs such as system rehabilitation;
- Conservation programs historically aimed at reducing demand under normal conditions will need to be re-directed toward shortage preparation and assisting customers in coping with higher rates;
- Supply availability under non-shortage conditions will be enhanced, stretching current supplies over a longer period and reducing acquisition costs;
- Shortage risk will be reduced over the next 10-15 years as water supplies intended to accommodate growth can serve as a "buffer" or shortage supplement during that time;
- Demand hardening could, over a longer period increase vulnerability to surface water shortages if efficiency savings (versus new supplies) are allocated to growth (to the degree that backup supplies are not acquired for that growth);
- Water ordering and source selection will need to consider impacts on THM mitigation resulting from longer system residence time; and
- Sewer flow rates will continue to decline, thus affecting reclaimed water availability, solids concentrations, collection operations and treatment processes and per-unit treatment costs.

Continuing Demand Research

This planning effort, and continuing efforts, will attempt to address several detailed questions in an attempt to both reduce the range of uncertainty, and to better prepare for a range of outcomes. Many of the questions detailed below cannot be easily quantified or defined at this time, though it is important to consider knowledge gaps in developing action plans and directions for further research. With regard to future water demands, questions include the following:

- What is the range of growth rates and densities the City might expect?
- At what point is the City effectively "built out"?
- How could warmer, drier local conditions resulting from climate changes impact demand?
- What type of exogenous events could influence a higher growth rate or higher demands than currently anticipated?
- How much more water efficient can current customers achieve within current lifestyle and economic conditions?

- To what degree will expanded availability of water efficient technologies permanently reduce per-unit demand?
- How should water made available through increased efficiency be managed?
- To what degree can demand be curtailed during shortage without substantive impacts to the local economy?
- What market forces could substantively affect future demand?
- How does water pricing affect demand under normal conditions and under shortage conditions?
- At what point, and to what degree, could demand be permanently reduced by population and business relocation due to persistent supply shortfalls?
- What other possible demographic, social, climatic or economic trends could influence future demand?

CHAPTER 4: WATER SUPPLY DEFICIT SCENARIOS

Over the past decade, longstanding paradigms regarding water demand growth and drought duration have been challenged. Demand growth in Phoenix has decoupled to some extent from its traditional relationship with population and economic growth. Recent research has provided a better understanding on the potential depth and duration of water supply shortages due to climate variability. These and other findings underscore the futility of basing planning decisions on a rigid "prediction" of future conditions.

A more practical approach starts with defining the "unknowns" which hold implications for future decisions. Some of these unknowns can be explored with the objective of narrowing associated uncertainty. A scenario-driven approach thus seeks to anticipate a broad range of outcomes to maintain flexibility in adapting to conditions as they evolve.

In establishing the range of future conditions, variations in individual factors such as surface water availability, groundwater availability, development density, water efficiency and growth rate are fused into scenarios. These scenarios provide context for the uncertainties, and in combination provide for a better understanding of how a solution could address multiple outcomes. The iterative nature of the planning process, supported by frequent monitoring of actual conditions and the establishment of trigger events or dates, intends to provide ample time to deploy necessary supplies and programs while avoiding premature resource commitments and stranded assets.

4.1 PROCESS FOR DEVELOPING SCENARIOS AND DEFICIT RANGES

Water Budget Model

Variations of several supply and demand assumptions are incorporated into a spreadsheet-based tool to assess the impact of various combinations. This tool is capable of generating numerous scenarios by varying four key elements. These include SRP availability, CAP availability, growth level, and water use efficiency. Ranges within these elements are generally illustrated in Figure 4-1, and described in the following sections.

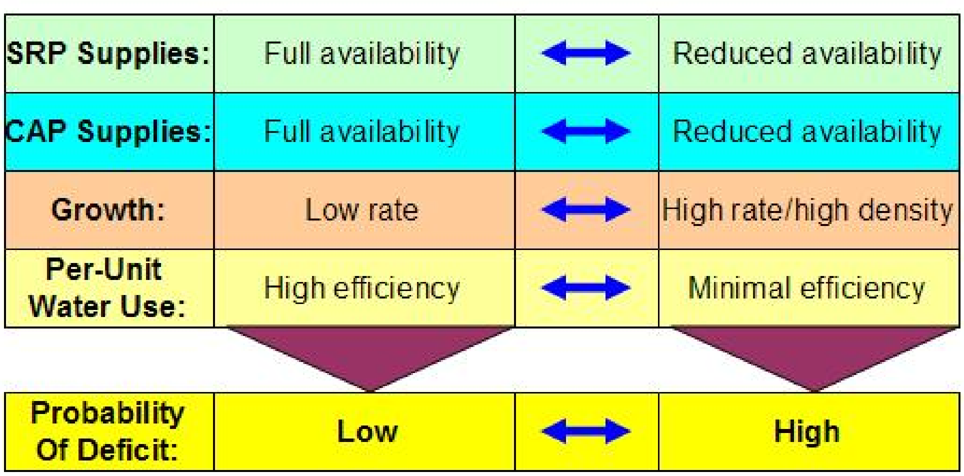


Figure 4-1. Scenario Element Ranges and Probabilities

Cyclical Drought, Climate Variability and Microclimate Factors

<u>Applicable Results from Tree Ring Research</u>

Reliable flow records for the SRP and Colorado River watersheds date back about 110 years. While this period is significant, evaluation of tree ring records by researchers at the University of Arizona have allowed for the reconstruction of flow records for approximately 800 years[3].

This information is valuable in determining the potential frequency, length and probability of long-term wet and dry cycles (Figure 4-2).

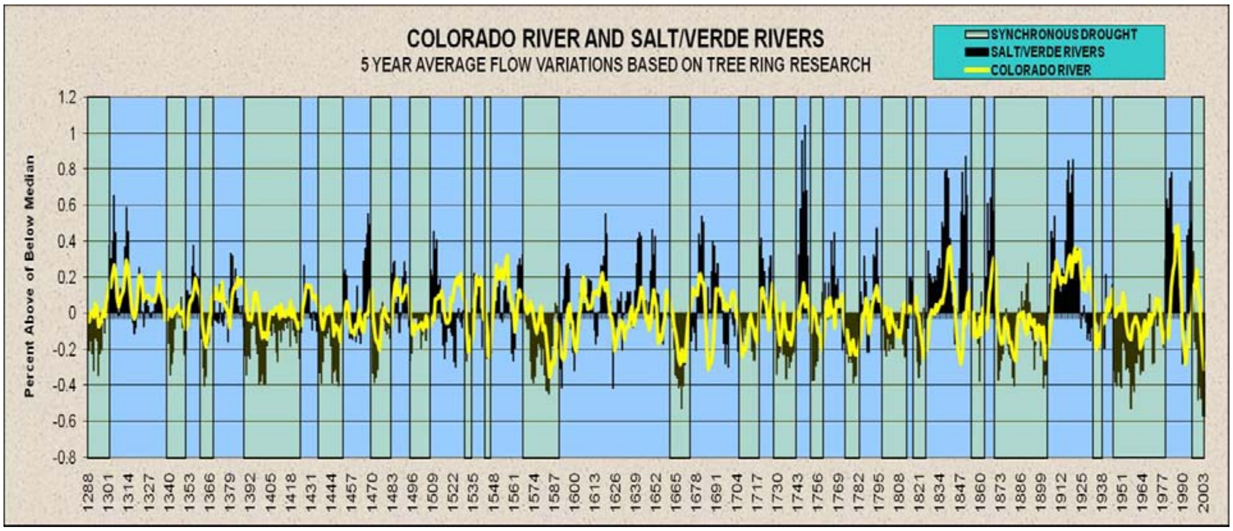


Figure 4-2. Colorado and Salt River Watersheds Reconstructed Year Stream Flow Analysis. Shaded areas reflect lengthy periods of below-normal precipitation and runoff in both watersheds.

The study and follow up evaluations point to a fairly high correlation of simultaneous shortages in both watersheds. In addition, running averages for the 800 year period reveal numerous lengthy dry periods of at least 20 years. Viewed in the context of the current dry cycle for the Colorado River watershed, which has so far extended 13 years, it is conceivable that dry conditions could continue for at least another decade, though occasional wet years may be interspersed (Figure 4-3)

These results point to a need for both supply and demand strategies that can be maintained for extended periods of time.

[3] A Tree-Ring Based Assessment of Synchronous Extreme Streamflow Episodes in the Upper Colorado & Salt-Verde-Tonto River Basins, Final Report, July 2005 A Collaborative Project between The University of Arizona's Laboratory of Tree-Ring Research & The Salt River Project Katherine K. Hirschboeck & David M. Meko, Laboratory of Tree-Ring Research, The University of Arizona

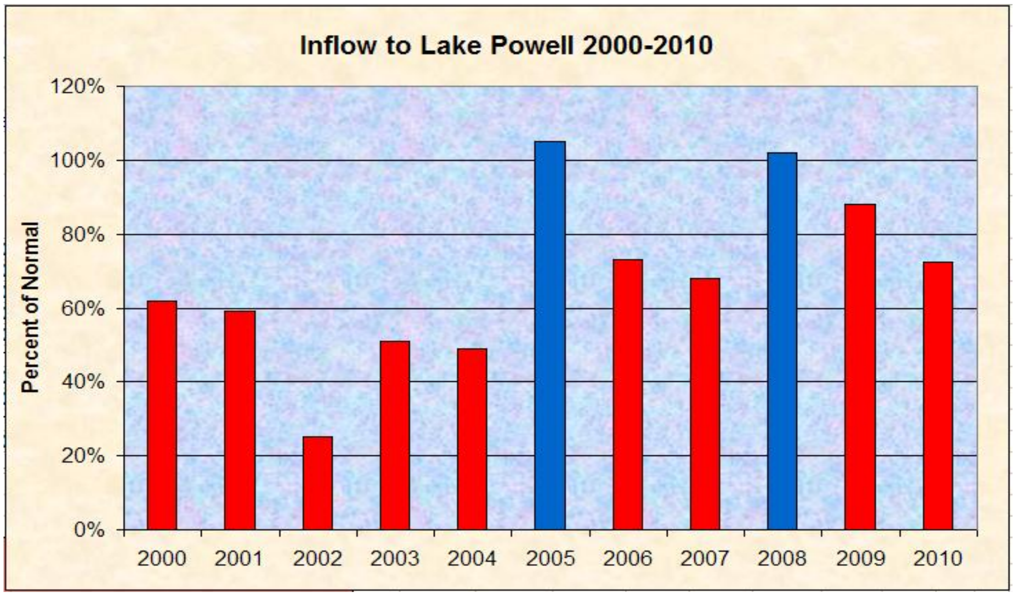


Figure 4-3. Inflow in to Lake Powell

Results from Climate Variability Research

As indicated in Chapter 2, a great deal of uncertainty continues to exist with regard to potential impacts from future climate variability. It is unclear at this time whether this variability will accentuate the cyclical shortages observed in tree ring based flow histories. For this assessment, it may be assumed that the severe shortage conditions described below, if held constant throughout the planning term, would fully encompass long-term flow reductions due to a new and drier climate regime. Since any significant impacts to supplies could be decades in the future, the City will continue to promote a better understanding of potential impacts through continued research. Results of this research may allow potential impacts to be addressed with more specificity in future planning efforts.

Urban Heat Island Impacts

With the documented gradual increase in average nighttime temperatures in Phoenix and surrounding areas due to urbanization, questions regarding the impact on water demand have risen. It can be speculated that if all other elements are held constant, water needed for outdoor uses and cooling purposes could increase. However, water for landscape purposes is still being over-applied in many cases despite efforts to increase efficiencies through conservation programs. In addition, current conservation efforts (as evidenced by declining per-capita consumption) and future conservation measures will likely offset any potential increases in water use to compensate for warmer conditions. Quantification of the true impact of the heat island phenomenon was not attempted in this analysis.

Moderate versus Severe Shortages

The “moderate shortage” scenario in the City’s 2005 Water Resources Plan Update demonstrated a potential deficit in the 2015-2020 time frame. Though the supply assumptions are similar in this plan, demand projections have been reduced substantially due to the significant reductions in per-unit demand over the past 5 years. As a result, a moderate shortage scenario, as defined in that plan is unlikely to create deficit conditions exceeding 10 percent within the 50 year time frame, and not prior to 2040. For this reason, and for simplicity, only severe shortage assumptions have been chosen as the basis for the scenarios in this Plan.

It is also important to note that the scenarios described below consider only supplies that are currently available to the City from a legal and physical standpoint. The City has legal access to additional water supplies which require infrastructure investments to make the water available to the system. These additional supplies are described in the Chapter 5.

Supply Projections and Scenarios

Most of the water obtained from the SRP system can be delivered by Phoenix only to lands with legal rights to that water (referred to as "on-project" or "member" lands). Colorado River water from the CAP, groundwater, effluent and certain varieties of water obtained through SRP can be used anywhere within the service area. For this reason, supply scenarios address "on project" and "off project" portions of the service area as distinct. It is important to note that the distribution system is integrated among the two areas, and accounting for the on/off project distinction is addressed in accounting protocol.

<u>SRP Member Land Supplies</u>

Salt and Verde River surface water supply levels are varied on assumptions relating to the per-acre allocation for on-project lands set annually by the SRP Board of Directors (full allocations are assumed at 3.0 AF/AC). Phoenix also has access to normal flow (run of the river) rights which further increase availability. These supplies can only be used for "on-project" lands, and are "demand constrained," meaning that no more water can be taken than the volume needed to meet actual demands. Water not needed to meet SRP member land demand remains in reservoirs for future on-project uses among all members.

Extended periods of low inflows due to drought in the watershed pose the most significant threat to supply availability. Previous threats in the form of endangered species habitat protection needs and Indian water rights claims have largely been addressed and are not considered in the model.

When shortages develop on the SRP system, Phoenix's normal flow supplies maintain the highest priority. However, the volume is highly subject to runoff conditions in the Salt and Verde River watershed. Under shortage conditions, the analysis assumes normal flow volumes are reduced by roughly one third to correspond with the lowest volume year on record (2002). During extended periods of low precipitation and runoff, and as a result of future development in the watershed, groundwater pumping in the Verde Watershed could increase and potentially further impact these flows.

SRP supplies were modeled at a variety of levels ranging from full supply conditions to severe shortage. Under full supply conditions, the City is entitled to 3 AF per acre of "stored and developed" water. Normal flow supplies vary substantially from year to year, but a typical annual allocation based on demand of all member lands equates to 0.93 AF per acre.[4] The lowest figure on record (for 2002) equated to 0.64 AF per member land acre.

A moderate shortage reflects a reduction to 2.0 acre-feet per acre of "stored and developed" water allocation for SRP shareholders. SRP has reduced the allocation to 2.0 acre-foot per acre level only twice since 1951 (most recently in 2003 and 2004).

Severe shortage reflects a reduction to 1.0 acre-feet per acre of "stored and developed" water allocation for SRP shareholders. SRP maintains significant well capacity to supplement surface water supplies for normal operations and drought, the likelihood of sustained severe

---

[4] Normal Flow is entitled only to specific lands within the on-project area. For simplicity in modeling projected, a per-acre equivalent was applied to all SRP member land acreage. SRP maintains detailed accounting of eligible lands and related water use pursuant to a comprehensive "Water Delivery and Use Agreement" with the City.

shortages of SRP supplies is minimal. All shortage scenarios assume normal flow at the historic 2002 lows.

Actual impacts to Phoenix from SRP shortfalls are highly dependent on demand levels in on-project areas in any given year. On project demand has declined in recent years to approximately 2.0 acre-feet per water right acre, or less than half of the fully available supply. Thus, supply reductions would need to be significant in the near term to create an on-project deficit. It is important to note that growth density will likely increase the per-acre demand over time, thus increasing susceptibility to on-project deficits.

At the discretion of SRP, direct deliveries to SRP urban irrigation customers (from its non-potable system) would likely be proportionately reduced by SRP in the event of surface water shortages. Because most urban irrigation customers have access to potable water from the Phoenix system, it is possible that demand for Phoenix system water could increase under shortage conditions. It is unlikely that this demand increase would be significant due to the substantially higher cost of potable system water.

Figure 4-4 illustrates the range of SRP availability between full supply and severe shortage conditions. As of Summer 2011, SRP reservoirs were nearly full, and thus it is highly unlikely that SRP supply reductions would occur in the near term or impact Phoenix before 2020.

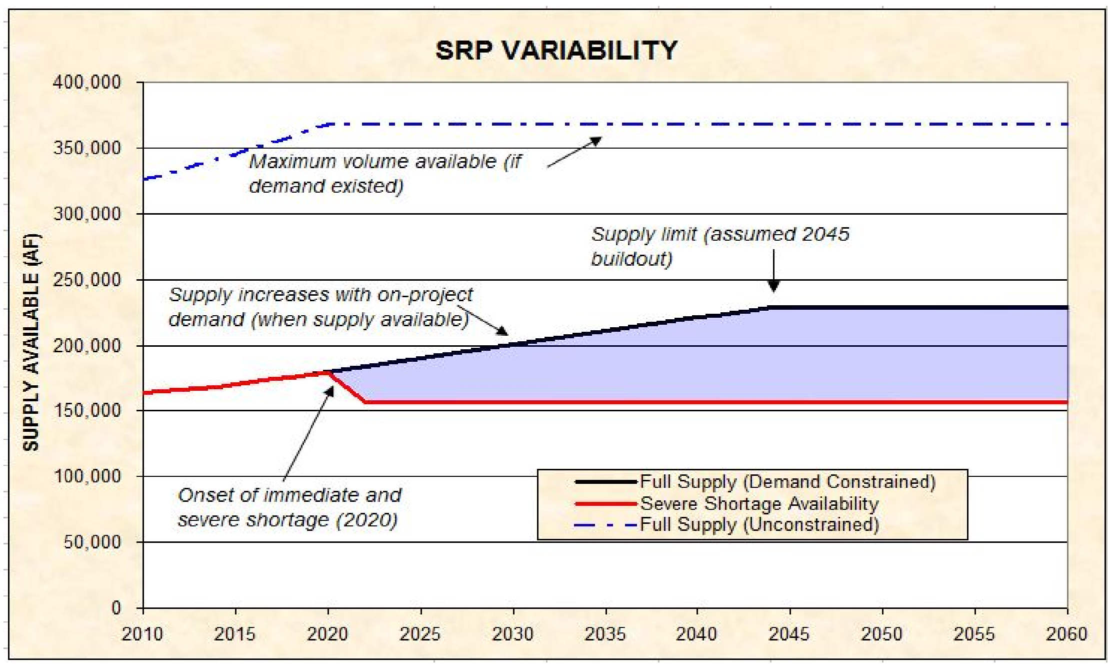


Figure 4-4. Range of SRP availability between full supply and severe shortage conditions

<u>SRP "Off Project Eligible" Supplies</u>

Certain water supplies stored in SRP reservoirs may be used anywhere within the Phoenix service area. These supplies - Gatewater, Roosevelt New Conservation Space (NCS) Water and "Three-Way Exchange" Water (involving RID, SRP and Phoenix) are dependent upon storage conditions in SRP reservoirs.

Roosevelt NCS Water and Gatewater were combined for this assessment. Approximately 195,000 acre-feet are in storage as of Spring 2011, and the storage space is nearly full. Availability of these supplies has been validated at a combined average of 57,500 acre-feet per year through the AWS Designation. These supplies are typically utilized very little during normal supply conditions to preserve availability for periods of shortage. As such, it is assumed that 20,000 acre-feet per year would be used during shortage conditions until the supply is exhausted. This water in storage could thus be used to offset shortages of either SRP or CAP supplies for many years. Losses due to evaporation exceed 5,000 acre-feet per year, and could substantially erode storage over time. For this reason, the City is seeking means to store a portion of this supply underground over time, which would also increase the ability to store additional water in the reservoirs during wet seasons.

Exchange Water received through the SRP system based on deliveries of effluent to RID is assumed at 20,000 AF before 2030 under full supply conditions. The availability of this supply is dependent on the availability of leased SRP wells to facilitate the exchange. During SRP shortage conditions, SRP may need these wells to meet member (on-project) demands, and thus the Exchange water would not be available. The model assumes that when SRP is in shortage, Exchange water is not available. After 2030, it is expected that farm land will steadily be urbanized and farm use will taper off, which ultimately will lead the supply to no longer be available under any conditions.

Colorado River Supplies

Phoenix maintains a variety of contracts and leases for CAP supplies (as discussed in Chapter 3). These supplies do not all respond to shortages uniformly. As such, the characteristics of each were evaluated in detail, and factored into the forecasting process.

Total Colorado River system storage is approximately 62 million AF, with more than 50 million AF in Lakes Powell and Mead. Allocations totaling 16.5 million AF are divided among the seven Colorado River Basin states and Mexico. This volume was based on flow conditions in the early 1900s which were, in retrospect, abnormally high. With flows in the last 50 years averaging 14.2 million AF per year[5], shortages are, in effect, built into the system.

For modeling purposes, shortages to Phoenix's Colorado River supplies are derived from the EIS which supports the 2007 agreement among the Colorado River basin states. The three primary levels of shortage to the Arizona (320,000 AF, 400,000 AF and 480,000 AF) reflect varying Lake Mead elevations (1,075, 1,050 and 1,025 feet above sea level respectively). Nevada and Mexico are also expected to take shortages when Lake Mead reaches these levels.[6] Though the agreement contemplates only the three levels, greater potential shortages are referenced in the EIS. For severe shortage scenario, reductions were pushed to 800,000 AF after 2030 to test impacts. It is important to note that the 2007 agreement incorporates criteria for equalizing flows between Lake Powell and Lake Mead based on annual runoff condition projections. Thus, the triggering of shortage conditions is based on both hydrologic conditions and reservoir operation decisions.[7]

As of Fall 2011,[8] Lake Powell's 24 million acre foot capacity is 73 percent full. Lake Mead's 25.8 million acre-foot capacity is 50 percent full with a water level elevation at 1,115 feet. Storage between the two reservoirs is equalized by the Bureau of Reclamation based on criteria contained in the 2007 agreement. These relatively low storage levels have resulted from below-average runoff conditions over the past decade (Figures 4-5 and 4-6). However, given the substantial volumes remaining in these very large reservoirs, it is unlikely that Phoenix's supplies would be significantly affected prior to 2020 even with a continuation of

---

[5] Based on Virgin flows at Lees Ferry (USGS and USBR)
[6] The U.S. has asserted that Mexico is subject to proportional shortages to its 1.5 million acre-foot entitlement under the 1944 Mexican Treaty, though there is some uncertainty at this stage as to how this will be administered.
[7] http://www.usbr.gov/lc/region/programs/strategies/RecordofDecision.pdf
[8] September 27, 2011: http://lakepowell.water-data.com/; http://lakemead.water-data.com/

below-normal flow conditions.[9] When shortages are ultimately triggered, water use for recharge and agricultural purposes will be reduced first. The majority of Phoenix's CAP supply is based on a "municipal and industrial" subcontract, which is among the highest priority. Thus, while it is possible that the first shortage to CAP could be triggered well before 2020, Phoenix customers are not expected to be impacted.

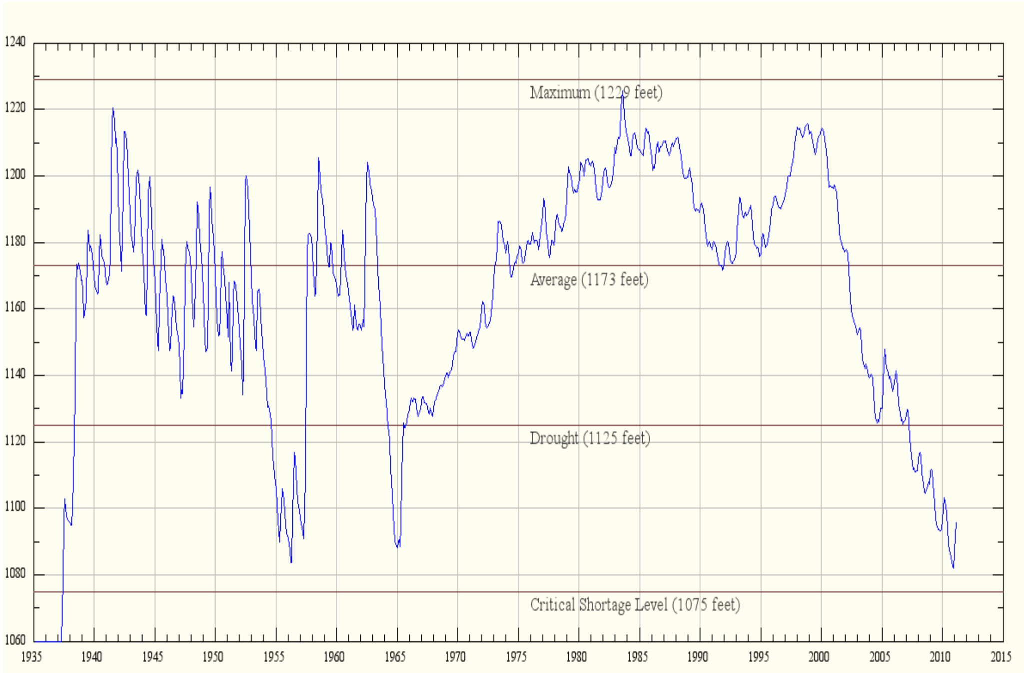


Figure 4-5. Lake Mead Water Level History 1935-2011[10]

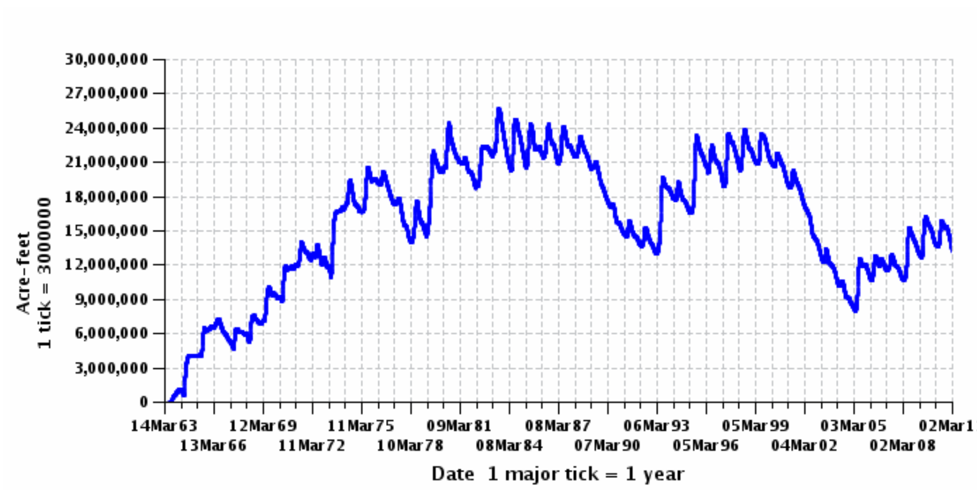


Figure 4-6. Lake Powell Water Level History 1963-2011[11]

[9] As of April 2011, the Bureau of Reclamation does not anticipate that shortage conditions will be triggered in the Lower Colorado River Basin before 2016.
[10] http://www.arachnoid.com/NaturalResources/
[11]htttp://www.usbr.gov/uc/crsp/GetDateInfo?d0=1719&d1=1792&d2=1862&d3=1872&d4=1928&idCount=5&l=LAKE+POWELL

Other factors that will ultimately affect the timing and duration of shortages to Colorado River supplies are development rates in the Upper Colorado River Basin states (Colorado, Wyoming, Utah and New Mexico) as well as climate conditions that are not reflected in historic drought records. The potential for severe CAP deficits over the planning period are illustrated in Figure 4-7.

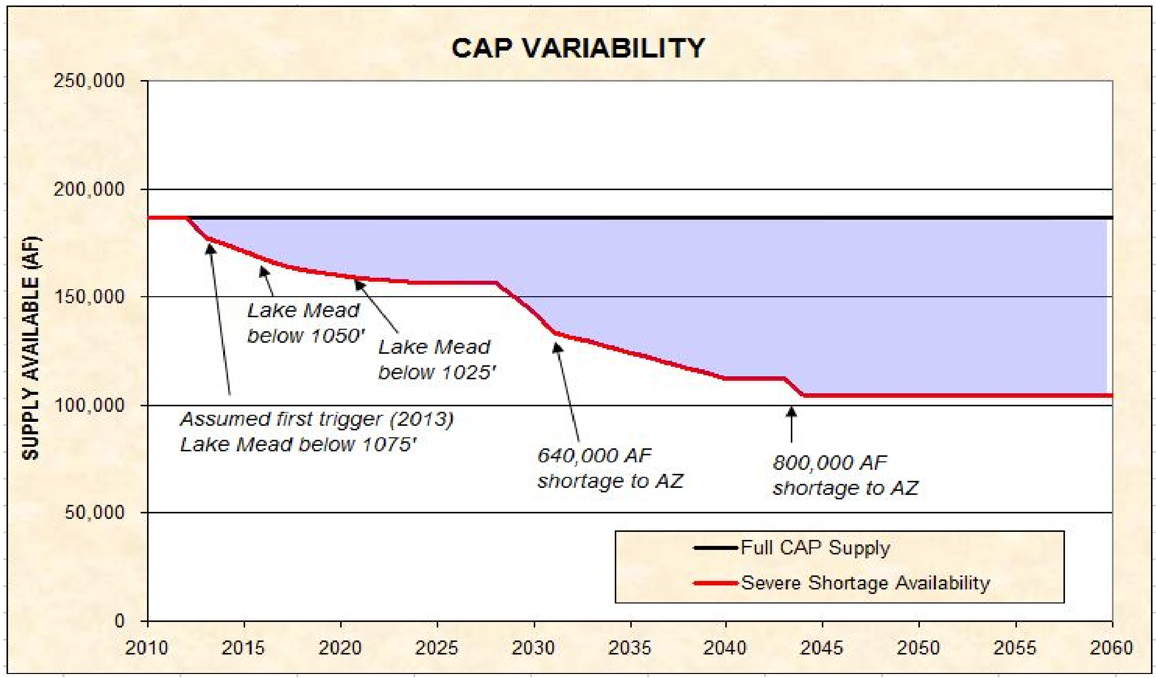


Figure 4-7. CAP Variability (Supply available to Phoenix)

Combined CAP and SRP Availability

In combining surface water supplies, the availability to the full service area can vary between 280,000 and 475,000 acre-feet per year depending on shortage conditions (Figure 4-8). The low supply figure represents an 11 percent reduction from the full supply in the early years. The reduction grows to 41 percent by 2045.

A comparison of “SRP only” and “CAP only” shortages demonstrates that the service area fares better when full supplies are available from SRP. This is primarily due to the availability of NCS and gatewater supplies from the SRP system that can be used to replace some of the lost CAP supply.

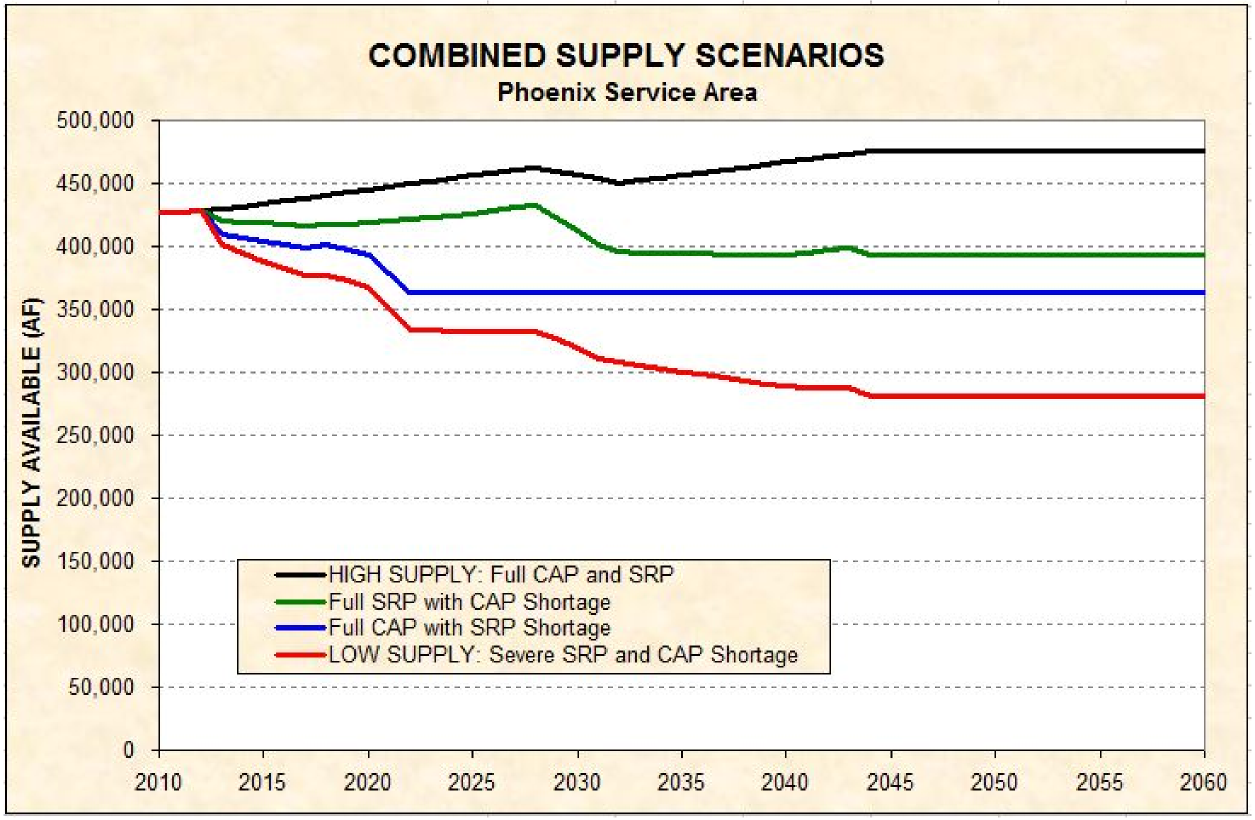


Figure 4-8. Combined CAP AND SRP Variability Scenarios

Groundwater
The City currently maintains 28 mgd of active groundwater well capacity. A static figure of 15,000 acre-feet (reflecting about half of the full-time capacity) was assumed as a base (normal year) supply. Withdrawals in recent years have averaged less than 9,000 acre-feet per year. Sufficient wells exist to produce more than 28 mgd, though rehabilitation and/or treatment may be needed to increase the yield.

Reclaimed Water
The City maintains infrastructure to deliver reclaimed water to golf courses and other turf-related facilities in North Phoenix from the Cave Creek Water Reclamation Plant. To date, annual deliveries have not exceeded 2,000 acre-feet per year. For purposes of this analysis, this value was held constant through the 50 year projection period. It should be noted that effluent delivered to RID for exchange purposes is addressed in this analysis under SRP-delivered supplies as it is physically stored in SRP reservoirs via the exchange agreement. In addition, reclaimed water committed for uses outside of the service area are not considered in this analysis.

Demand Projections and Scenarios
Demand projections have been revised based on an updated analysis of development potential in the City. These figures are lower than MAG-based projections used in the 2005 Plan for two key reasons: 1) per-unit demand has been declining at a much more rapid pace than previously expected; and 2) the prior base-level projections assumed growth rates that exceeded peak levels from the 1990s and mid-2000’s. Given new information regarding buildout potential, and factoring in lingering impacts from the recent recession, it is highly unlikely that these levels will be attained.

Growth Element

Growth assumptions start with rate of increase based on an absorption analysis, and the analysis is geographically separated between on-project and off-project lands. This scenario considers regional economic conditions, the Phoenix General Plan and recent trends in residential and commercial development. Variations include both high and low variations on the base. The growth projections (high, base level and low) reflect annual growth rates of 1.0 percent, 0.8 percent and 0.6 percent respectively and are assumed to top out in the 2045-2055 period as the City is largely built out within its current boundaries. These rates are lower than those experienced during the 1990s and early 2000's, which is to be expected given the increased relative size of the service area today. As of Spring 2011, evidence is building that the actual growth rate could be lower or stagnate for the next 5-10 years, thus delaying the attainment of the levels used in this analysis.

Per-Unit Water Use Element

Per-unit growth assumptions are characterized in terms of gallons per single-family housing unit, gallons per multi-family unit, gallons per square foot (for commercial/industrial), and institutional/landscape uses as a percentage of the total. The use of these values provides for greater refinement than a pure per-capita assumption which does not consider potential divergences between residential and non-residential trends.

Usage levels can be varied to test how varying degrees of permanent demand reductions among both existing accounts and new accounts affect deficits. It is expected that high-efficiency plumbing technologies will become increasingly prevalent and standardized over time, thus providing a continual, but perhaps less rapid, decline in per-unit demand. Rate increases will also likely affect usage rates, especially when tied to shortage conditions.

A "base level" assumption considers all growth will develop at today's efficiency levels and that current customers will remain stable. "Moderate efficiency" gains reflect an assumed 10% reduction for existing customers and 5% for post-2010 development by 2035. The "high efficiency" assumption reflects a 20 percent reduction for existing customers and a 10% reduction for post-2010 customers by gain by 2035. By way of comparison, the City's per-capita rate has decreased by more than 25% over the past 15 years.

Demand Projection Scenarios

When combined, the growth and per-unit elements generate a range of potential demands (Figure 4-9). The low projection assumes that service area growth occurs at a slow pace and that existing customers continue to become more efficient without further incentives or regulation (moderate level). The high demand line reflects fast or high-density growth and no further efficiency improvements for existing and new customers.

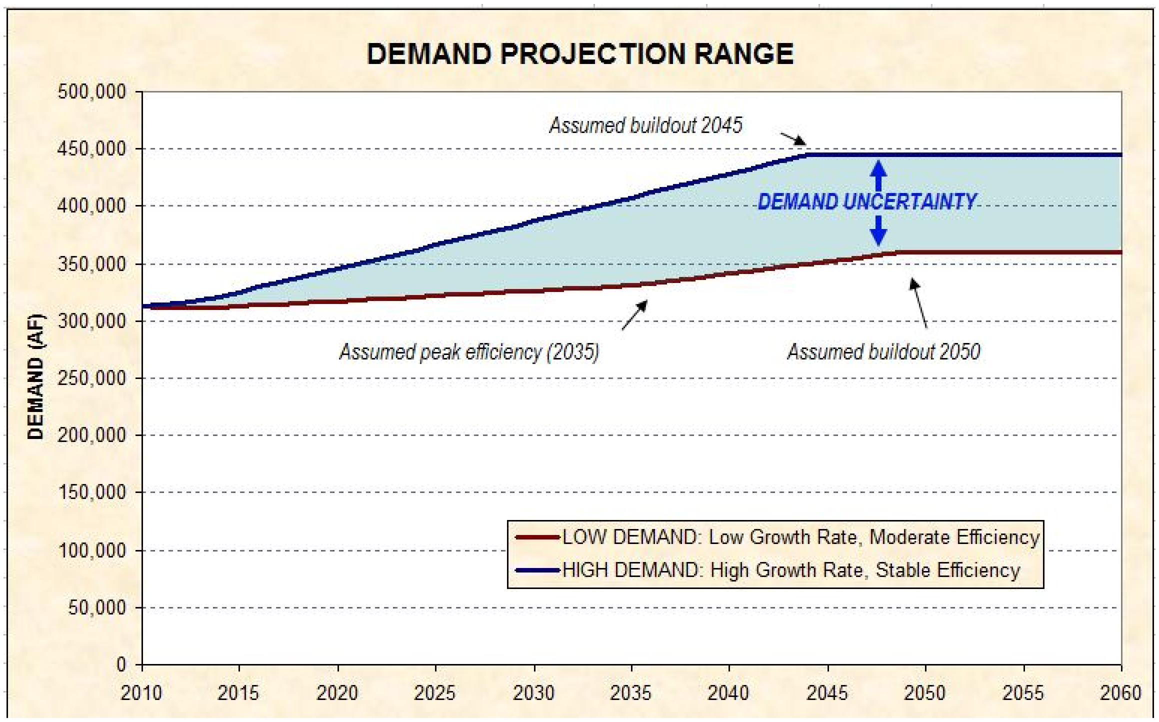


Figure 4-9. Combined growth and per unit demand projection range

4.2 DEFICIT RANGES

Maximum Ranges

Combining the supply availability and demand ranges provides an indication of the timing and potential volume of surplus and deficit conditions over the 50 year planning period (Figure 4-10). Under full supply conditions, Phoenix can meet even the highest anticipated demand level with current supplies. Under worst case conditions (high demand and severe shortage), the deficit ranges from approximately 20,000 AF in 2020 (6 percent of demand) to 165,000 AF per year (37 percent of demand) in 2045.

It should be noted that the deficit range depicts conditions as they could exist at any point in the 50 year window, and thus do not attempt to illustrate system recovery (i.e. a return to full supply conditions). Shortage duration on the Salt/Verde system is unlikely to exceed 10 years while shortages could extend for multiple decades on the Colorado River. This is due to the relative differences in system storage and recovery time requirements (Colorado River reservoirs take much longer to both deplete and recover). Also, while paleoclimate research indicates that drought conditions are more likely to occur on both systems simultaneously, periodic divergences (where one system is full while the other is short) will occur, thus lessening the overall impact.

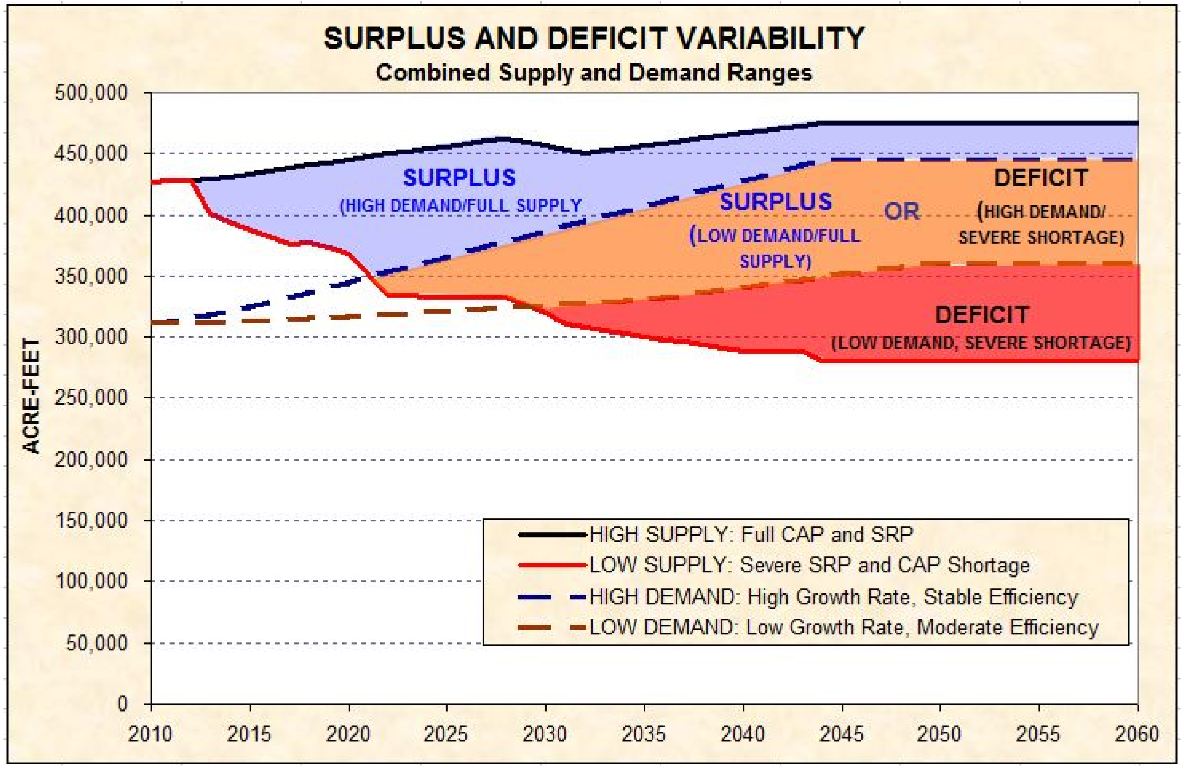
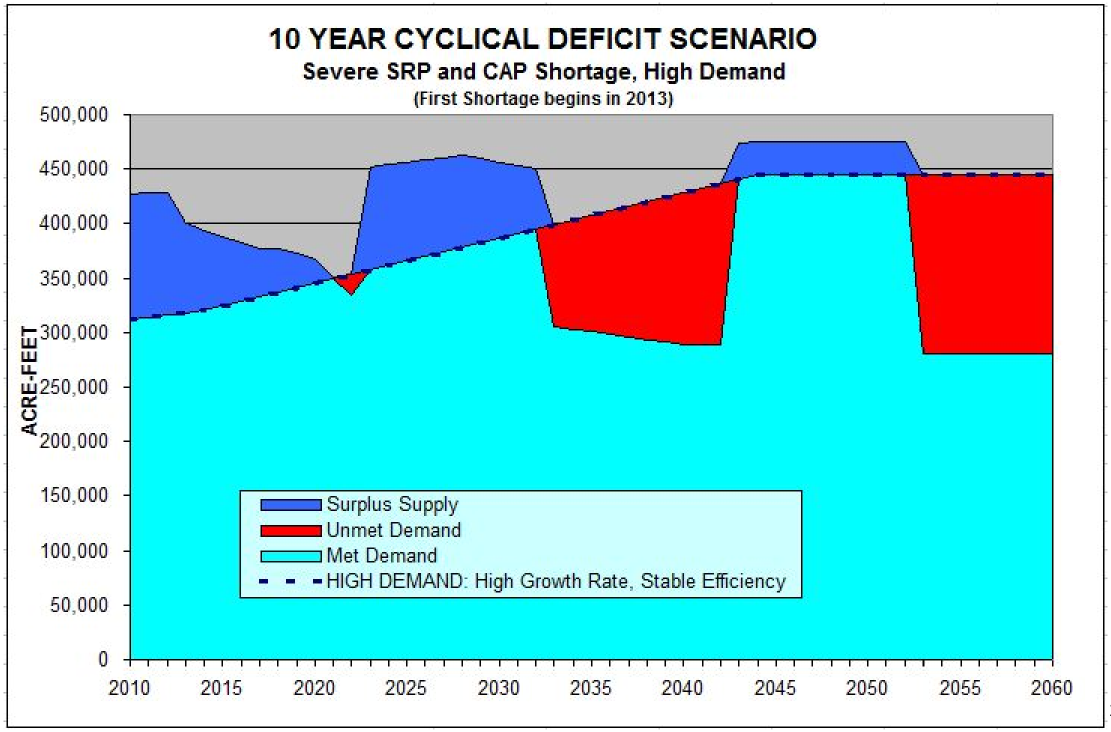


Figure 4-10. Supply and deficit variability

These supply and demand ranges reflect the City's best current understanding of potential future conditions. However, the ranges do not attempt to incorporate exogenous or "black swan" events that could dramatically increase demand or decrease supply (such as natural disasters, terrorism or major infrastructure failures) over a short period of time.

Cyclical Scenarios

The two sample scenarios presented below (Figures 4-11 and 4-12) illustrate the maximum deficits that would occur with hypothetical synchronous shortages on both systems in 10 and 20 year cycles. Both scenarios anticipate periodic recovery of systems.



[12]

Figure 4-11. Severe SRP and CAP shortage 10 year deficit scenario

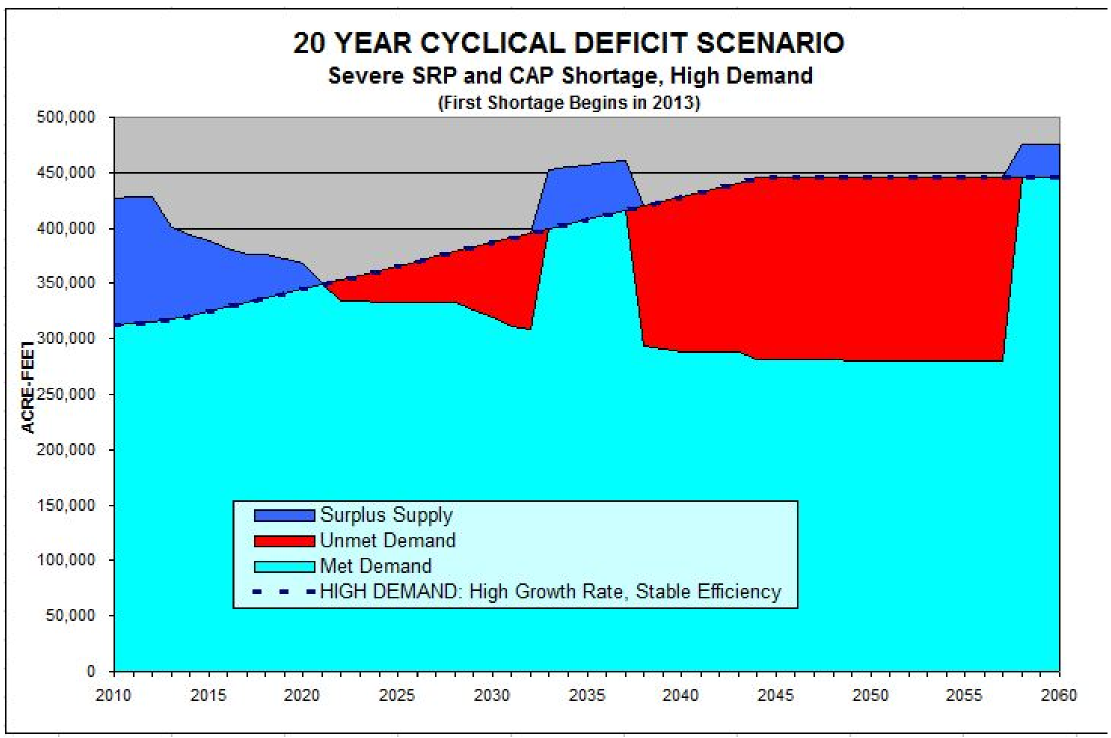


Figure 4-12. Severe SRP and CAP shortage 20 year deficit scenario

[12] First shortage to CAP occurs in 2010, but deficit to Phoenix would not materialize until 2020.

Another means of considering the impacts of cyclical shortages involves the use of the reconstructed flow records. The driest 50 year periods were identified in each of the watersheds, and assumptions were developed regarding supply reductions for each of the systems based on recent decisions and agreements. The results illustrate the cyclical nature of the flow regimes over an extended period (Figure 4-13).

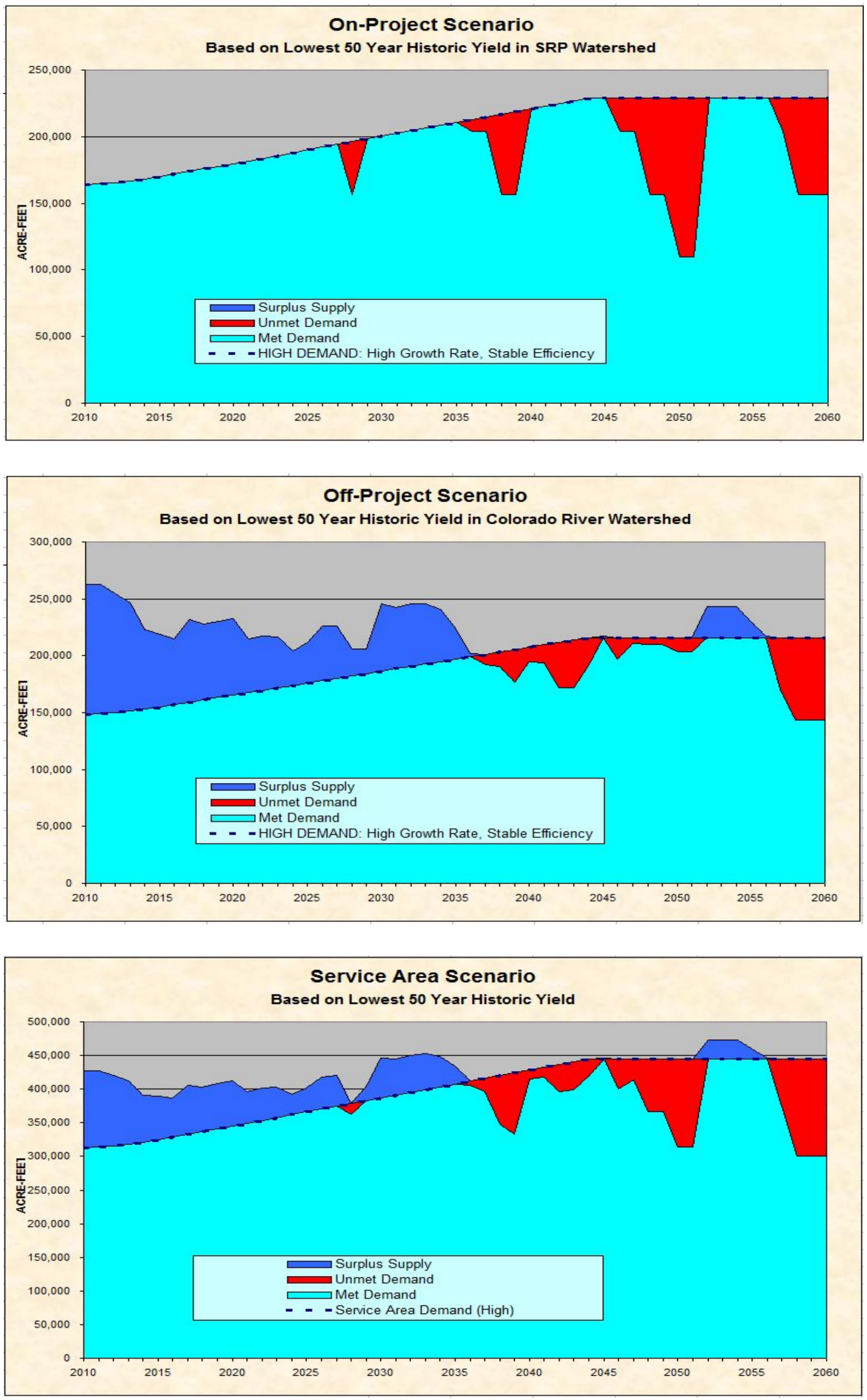


Figure 4-13. Cyclical Supply Availability (Based on Historic Low Flow Periods)

Each of the preceding scenarios considers current conditions (Spring 2011) as the starting point. Full SRP reservoirs significantly reduce on-project shortage probability in the near term, and water stored pursuant to Roosevelt NCS and Gatewater vehicles would be available to offset any CAP-related deficits for several years. On the Colorado River watershed, if below average runoff conditions continue through 2013, it is possible that Lake Mead could drop to elevation 1075, triggering an initial shortage declaration and thus a reduction to CAP. However, as indicated earlier, Phoenix would not likely be impacted by such declarations before 2020 due to the relative high priority of municipal water within the CAP structure.

4.3 CONCLUSIONS

Conclusions derived from the scenarios include:

1. Though reductions in surface water supply availability to Phoenix could occur before 2020, Phoenix is not expected to experience a supply deficit before that date.

2. The large storage volumes and resiliency of the SRP and CAP systems protect the City from drastic and immediate water supply shortfalls. Monitoring of emerging trends provide the City with ample time to prepare deficit mitigation solutions.

3. Phoenix maintains sufficient supplies to meet the highest anticipated demand level throughout the 50 year periods under full supply conditions;

4. Currently available supplies, even when stressed by severe shortages, represent more than 90 percent of demand by existing customers, and therefore new supplies would likely not be necessary if demand was stabilized at current levels;

5. The highest anticipated service area growth scenario results in the most significant deficits which would need to be addressed with additional supply development and potentially rigorous demand curtailment;

6. The potential for deficit conditions (and the need for additional supplies) is significantly less if demand growth follows a lower trajectory;

7. Establishing supplies sufficient to meet a 20,000 acre-foot shortfall starting in the year 2020 is a conservative and reasonably achievable initial planning target.

8. A 2020 deficit of 20,000 acre-feet is more likely to result from CAP shortages, which could be, in whole or in part, mitigated through recovery of groundwater credits stored by the Arizona Water Banking Authority.

9. Continued monitoring of supply conditions and demand trends and periodic reassessment of the assumptions and ranges presented in this chapter is a critical factor in developing appropriate solutions at key inflection points.

CHAPTER 5: DEFICIT MITIGATION STRATEGIES

Strategies for reducing or eliminating water supply deficits include both supply enhancements and demand reduction. The optimal mix of solutions is determined through assessing the timing and volume of the deficit range, lead time for implementation and the relative cost-effectiveness of each strategy.

The "severe shortage" scenario combined with the "high demand" scenario produces a maximum deficit of 165,000 acre-feet in the latter part of the 50 year planning horizon (Figure 5-1). This scenario, as described in the previous chapter, creates deeper shortages than those observed in historic records and is thus considered a reasonable "worst case" for deficit planning purposed. More extreme conditions were modeled and could be considered in future efforts if and when the probability of such extreme conditions is expected to increase. The City will continue to monitor emerging research and watershed management advancements to better incorporate the impacts of climate variability on future supply availability and deficit conditions.

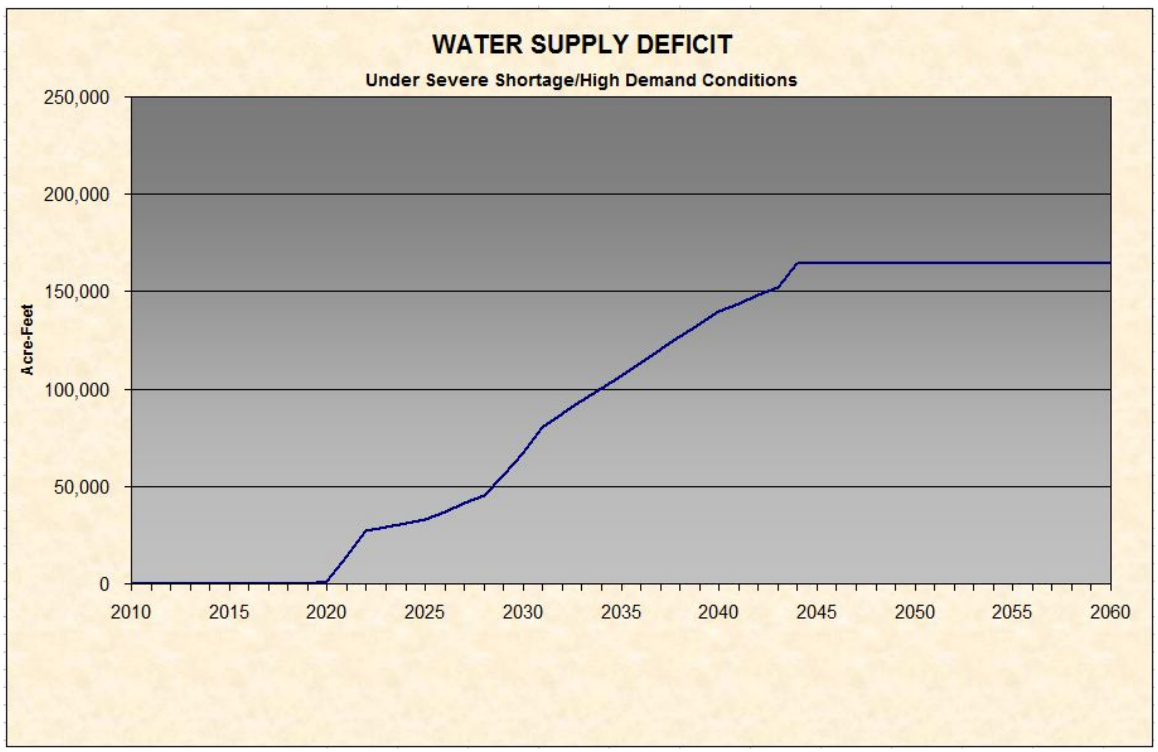


Figure 5-1. Water Supply Deficit under severe shortage/high demand conditions

5.1 DEMAND STRATEGIES

Demand strategies can be grouped into two basic categories. The first involves improved water use efficiency, which has been the goal of Phoenix and State mandated conservation programs for the past three decades. The second involves an immediate curtailment of demand to match reduced supply availability during, or in anticipation of shortage conditions. The two strategies are related in that greater efficiency gains over time reduce the volume which can be curtailed (as there is less discretionary use). Long-term efficiency-related reductions can also play a role in reducing the length and magnitude of future deficit conditions to the degree that the "saved" water can be stored for future use.

Improved Water Use Efficiency

Long-term efficiency improvements have been the objective of traditional conservation programs. These programs rely upon a combination of regulatory, technological and behavioral tools to affect gradual reductions in water use that do not adversely impact customer lifestyles or business profitability. In effect, the reductions are transparent to users. In some cases, efficiency improvements may actually serve to enhance quality of life or support economic stability.

For Phoenix, these structural (permanent) water conservation and water efficiency reductions provide an opportunity for the City to avoid costs in acquiring or developing future supplies needed to mitigate shortages. The City's successful history in substantially reducing per-unit water use has resulted in the ability to meet anticipated growth-related needs for the entire 50 year planning period assuming full supply conditions. However, the City is facing substantially increasing costs for new water supplies to reduce the impact of future shortage conditions. Thus, a continuing emphasis on gradual efficiency improvements over time will likely provide additional cost avoidance benefits. At the watershed level, increased efficiency by all water users may reduce the length and depth of shortage conditions, and help preserve ecological values.

<u>Water Efficiency Strategies</u>

The following strategies will assist in gradually reducing per-unit water use:

- Promote strengthening of national plumbing efficiency standards that will provide indirect long term benefits;
- Expand system leak detection activities and further reduce water lost to leaks where cost-effective in comparison to supply development;
- Support continued research and implementation of water efficiency technologies that over time can lead to substantial efficiency gains;
- Evaluate the relative cost-effectiveness, feasibility and potential consequences of regulatory programs proposed for state legislation and rules;
- Expand customer educational efforts to encourage long-term preparation for deficit conditions through water-efficient landscape choices;
- Explore the potential for changes in the rate structure to preserve flexibility in meeting objectives during both shortages and normal supply conditions;
- Evaluate the cost-effectiveness of incentives to promote early incorporation of promising water-efficient technologies within the service area;
- Establish an industrial, commercial and institutional (ICI) audit and review process to better understand characteristics of these uses and to encourage incorporation of best management practices;
- Re-assess and update the Turf Management Program to better ensure compliance with ADWR requirements and to encourage incorporation of best management practices; and
- Formally establish a "Residential End User Audit Program" to continue the work recently initiated by staff and consultants to better understand residential demand characteristics, including the ratio of indoor to outdoor water use.

Structural vs. Behavioral Efficiency

Surveys conducted by Phoenix in recent years have concluded that customers maintain a relatively high level of awareness with regard to the need for water conservation and efficiency. However, these surveys also demonstrate that this awareness does not directly translate to significant or immediate changes in water use behavior, though this awareness may be beneficial when curtailment action becomes necessary. Structural changes are those that occur passively through the incorporation of water efficient plumbing, appliances and other technologies that are effectively transparent to the customer. Structural efficiency has provided the bulk of the water use reduction benefits in recent years. Price elasticity studies have concluded that progressive water rate increases can impact both behavioral and structural water efficiency levels. As such, continued efforts to quantify the impacts of water rates on demand and revenues are important.

Allocation of Efficiency Gains

In a growing service area, water saved through improved efficiency is typically utilized as a means of serving that growth and thus deferring supply acquisition costs. For a service area that is highly dependant on surface water supplies, this practice results in an unintended consequence of "demand hardening" which subjects all customers to a higher susceptibility to deficits. This occurs because the relative percentage of non-discretionary use is reduced, and thus when shortages occur, curtailments could become necessary for non-discretionary uses. For this reason, the City does not consider "saved" water as a supply for growth.

A more practical solution involves allocating water savings to long term storage which provides benefits during future shortages. Within the Phoenix service area, supplies that can be used citywide (such as CAP or NCS) which are "saved" can effectively be stored underground for future use. Within the "on project" (SRP Member land) areas, water not used is retained in reservoirs for the future benefit of all SRP system members and cannot be stored for future benefit.

As a means to build long-term storage credits, the City can immediately begin using its access to various recharge projects to store and account for off-project water saved through progressive efficiency gains. For on-project savings, the City can track these savings to demonstrate its contribution to maintaining SRP reservoir levels and reducing the depth and duration of future SRP shortages.

Continuing Trend Analysis

Continued monitoring of demand trends (water use characteristics and growth) is critical not only to determine the impact of efficiency gains on water resource needs, but to more effectively plan for future water and sewer infrastructure. The application of per-unit water use and wastewater discharge values that reflect outdated trends will result in the oversizing of plants, transmission lines, pumps, distribution lines and collection systems and thus unnecessary repayment obligations.

Demand Curtailment

A second category of demand reductions are those which become necessary due to impending or actual shortage conditions. Demand curtailment typically entails reducing the most discretionary water uses to protect the least discretionary, and will likely become mandatory when the City is experiencing deficit conditions. Curtailment of uses that are most discretionary will have the least impact while increasingly significant curtailment could entail substantial impacts to customer lifestyles and business profitability.

The City's objective is to avoid the need for curtailment by acquiring sufficient supplies and achieving gains in water use efficiency. However, curtailment must be maintained as an option in the event that other solutions cannot be cost-effectively developed, or implemented in the appropriate time frame.

Curtailment duration is also a significant consideration. Short-term curtailments (1-3 years) would be most likely associated with severe shortages to SRP supplies. This watershed tends to be characterized by shorter-term high-frequency cycles. On the other hand, deficits created by Colorado River shortfalls could exist for a decade or more due to the longer recovery time necessary to fill the much larger reservoirs on that system.

<u>Drought Management Plan</u>

Long-term conservation efforts and other water management strategies may not be sufficient to insulate the City from periodic drought impacts. Recognizing this, in 1990 Phoenix became the first municipality in the state to adopt a comprehensive and phased Drought Management Plan. Under the current Plan, Stage 1 may be declared when a major water supplier (such as SRP or CAP) announces reductions in available supplies. The responses called for a range of voluntary actions in the earlier stages to significant mandatory actions and reductions in Stage 4. Authorization for the Water Services Director to initiate each of the stages is incorporated in City ordinances. The four stages are summarized in Table 5-1.

Table 5-1. Drought Management Plan Trigger Points/Action Elements

Stage	*Trigger Point*	*Action Guidelines*
Stage One: Water Alert	SRP or CAP <u>*announces*</u> reductions in allotments to the City of Phoenix water service area	Voluntary reduction of use for most customers; Mandatory reductions for City departments
Stage Two: Water Warning.	Water deliveries from SRP or CAP <u>*are reduced*</u>.	Voluntary reduction of use for most customers with a goal of 10 percent, Mandatory reduction for City departments; Possible water billing surcharges for certain types of uses, or for all uses of water.
Stage Three: Water Emergency.	Additional SRP or CAP delivery reductions	Mandatory water use reduction programs; Escalating surcharges to meet increased regulation and enforcement expenses.
Stage Four: Water Crisis.	Need to protect human health and safety due to severity of water supply reductions safety.	Further mandatory restriction of uses; Possible shut down of certain commercial or industrial operations; Escalating surcharges on usage to reduce demand to match available supplies.

The Drought Management Plan suggests several tools to effect demand curtailment in response to shortages. Some of these tools such as public education, direct assistance to customers, retrofit programs and leak mitigation can be part of a proactive program implemented years in advance of potential shortage conditions. The items referenced in the drought plan are:

- Public education for voluntary reduction
- Technical assistance to business/industry
- Leak detection and repair
- Residential plumbing retrofit
- Municipal use restrictions
- Outdoor water use restrictions
- Improved meter accuracy
- Pricing policies
- Moratorium on new water connections
- Physical rationing and mandatory reductions
- Voluntary shutdown by large water users
- Mandatory shutdown of large volume users
- Valve restrictions or pressure reduction
- Institutional mechanisms (ordinances and codes)
- Water use reduction guidelines

Planning for Curtailment
The City will seek to expand upon the existing drought plan through the following elements:

- Develop an ongoing outreach and partnering program with large commercial, industrial and institutional water customers to better define and quantify discretionary and non-discretionary uses. This information may be incorporated into industry or customer-specific target reductions to be achieved during water reduced supply conditions.
- Provide specific guidance and support to customers who may wish to convert landscape to drought-tolerant varieties to reduce susceptibility to future reductions, and as a means of achieving long term water cost savings.
- Identify and seek means of protecting the most sensitive customers and water uses during reduced supply conditions.
- Conduct expanded research with regard to the role of landscape water use curtailment in meeting a range of deficit levels, and the economic impacts of varying degrees of curtailment.
- Establish customer-specific or water use-specific surcharge levels well in advance of the need to implement. Advanced knowledge of these surcharge levels will encourage many users to take structural actions in the near term to avoid more significant disruptions to lifestyle and profitability when supply reductions occur, and to reap greater long-term cost savings.

Target Impacts
Phoenix per-capita water use has decreased by more than 25 percent since the mid- 1990's. Considering that further gains will be increasingly difficult to achieve as the most inefficient uses are phased out, a "moderate" target of 8 percent service-area wide was utilized in the deficit reduction model.[13] This reduction is likely to be achieved based on the continuation of structural efficiencies and currently available technologies. It is anticipated that an additional 8 percent could be yielded through monetary incentives, water pricing strategies and/or early

[13] The combined 8% represents an assumption of an additional 10% efficiency among existing customers and 5% for post-2010 development.

incorporation of advanced technologies.[14] In effect, the first 8 percent may be considered a "no cost" or "low cost" solution. The cost of achieving a greater level of efficiency must be compared to the cost of replacement supplies to determine which is most economically practical (Figure 5-2).

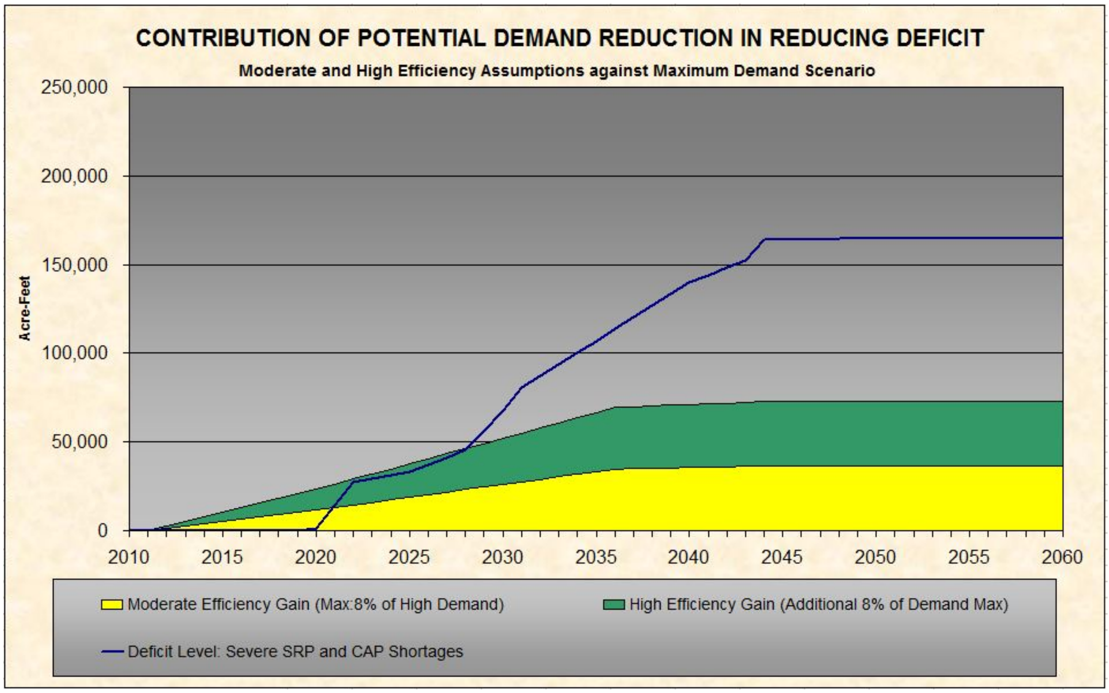


Figure 5-2. Contribution of Potential Demand Reduction in Reducing Deficit

5.2 SUPPLY STRATEGIES

The City has evaluated numerous approaches to deploying additional water supplies for which it currently maintains legal access but lacks physical access (e.g. treatment or delivery infrastructure). These sources include: 1) expanded local groundwater and recharged water supplies, 2) imported groundwater from the City's McMullen Valley farm; and 3) reclaimed water from the City's three plants. In addition, the City may acquire legal access to additional leased CAP water from Arizona's Indian communities as well as CAP subcontract water currently held by ASLD for development of state lands in Phoenix. These additional CAP supplies would easily be accommodated through existing conveyance and treatment infrastructure.

---

[14] The additional 8% represents a total 20% reduction by existing and 10% by post 2010 customers.

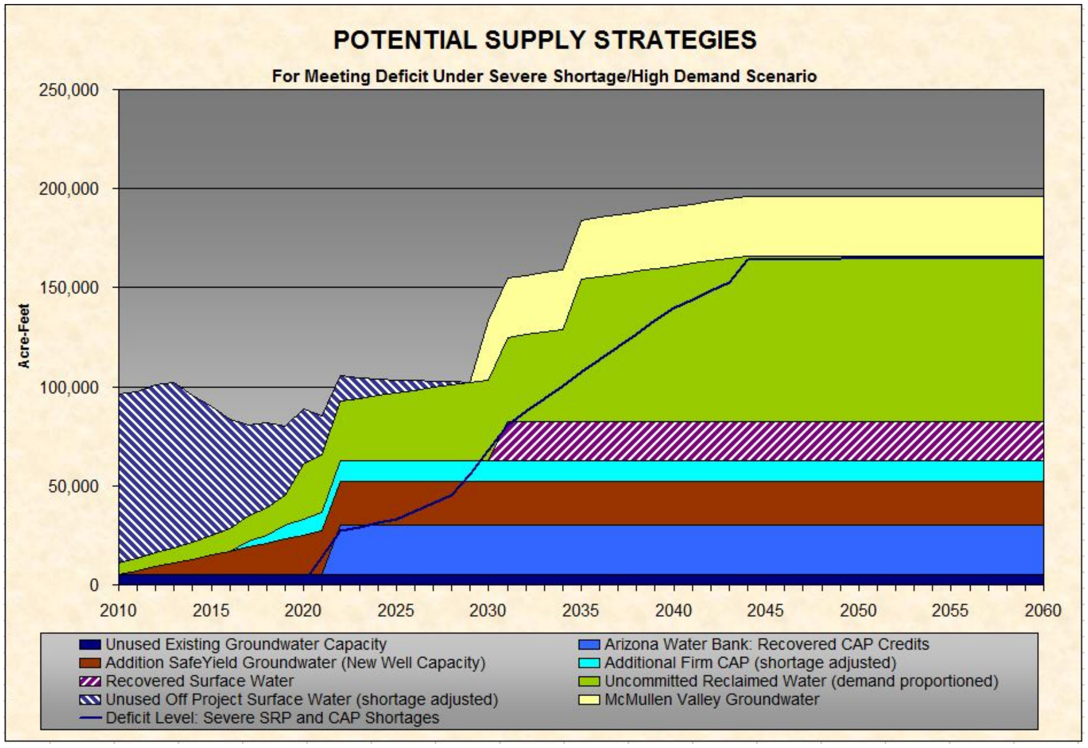


Figure 5-3. Potential Supply Strategies

Figure 5-3 illustrates the role of these and other supply strategies (such as CAP water stored by the Arizona Water Banking Authority) in addressing deficits. These are described in more detail in the following sections.

Sources are “stacked” where those with higher relative certainty are at the base. The order is for illustrative purposes and is subject to modification as costs and access issues are resolved. Except for use of existing groundwater capacity (the first addition), all sources depicted will require substantial investments of capital for acquisition charges, infrastructure development, long term leases and other costs associated with making the supply available to Phoenix customers. There are numerous variables incorporated within this illustration, and as such it is primarily intended to serve as a starting point for further analysis of options and strategies.

The investment philosophy associated with the supplemental supply strategy naturally focuses on developing the highest value supplies first. Though the chart depicts sufficient availability of supplies to meet severe shortages, capital availability limitations will restrict the volume that can be developed. Revenues from the sale or lease of undeveloped supplies could provide revenue sources for implementing higher-value supplies.

In addition to the supplies illustrated in Figure 5-3, a potential exists to obtain water to address deficit conditions through regional collaborative efforts. These efforts, such as the current Acquisition, Development and Delivery (“ADD Water”) program administered by CAP could successfully access additional supplies such as agricultural allocations for farmland along the lower Colorado River and desalinated seawater (directly or through an interstate exchange).

Because the City maintains substantial treatment plant capacity, the opportunity exists to leverage this capacity during shortages. In effect, where it is possible to acquire replacement supplies that can be taken via the SRP or CAP canals directly to these plants, costs of further infrastructure within the service area dedicated to mitigating deficits can be avoided. Thus, in the analysis of the supplies presented below, the relative efficacy of canal-delivered supplies is an important consideration.

Arizona Water Banking Authority "Shortage Insurance"

AWBA has recharged over 3 million acre-feet of Colorado River water for municipal and industrial CAP subcontractors. The water has been stored in numerous aquifer storage facilities within CAP's service area, and the credits for this water will be available for use by CAP when municipal subcontractor allocations are reduced. At present, approximately 75 percent of the 638,000 acre-feet of municipal and industrial subcontract water is used annually. Thus, water stored to date can provide benefits for an extended period if the proper infrastructure is in place.

The means of recovering these credits and related policies are currently being considered by CAP, AWBA and affected subcontractors, and thus the associated costs, and how they will be funded, have not yet been determined. Recovery could include development of new well fields or utilization of existing wells where water has been stored, agreements with municipalities which have unused well capacity and credit exchange agreements. Policy considerations include equity among subcontractors and the percentage of the individual and collective deficits to be covered annually.

It is important that the City obtain clarification from CAP with regard to how and when CAP shortages can be covered with water stored by AWBA. Though deficit conditions are many years away, the planning, coordination, funding and development of capital improvements to make the recovered water available will require substantial effort. The City anticipates that these credits will be available to the City in the form of canal-delivered supplies. The City is unable to accept AWBA credits for recovery from Phoenix service area wells without substantial well expansion expenditures. Wells developed within the service area are more expensive due to treatment, system integration and energy costs.

Expanded Local Groundwater

Service Area Wells

Aside from additional surface water supplies that can use current treatment capacity, local groundwater is the most accessible supplemental supply. Through the City's Designation of Assured Water Supply, legal and physical access to more than 3.5 million acre-feet of groundwater in the Phoenix service area over a 100 year period, (an average of more than 35,000 acre-feet per year) has been demonstrated. The City has the current capability of producing 28 mgd (15-20,000 acre-feet) per year, and typically withdraws between 6,000 and 9,000 AF per year. The City has lost substantial well capacity in the past two decades due to aquifer contamination and aging well conditions. During this time frame, infrastructure investments were directed at expanding capacity to receive CAP supplies.

Opportunities exist to expand well capacity within the service area by rehabilitating older wells and developing new service area wells. These opportunities are detailed in the City's recently completed Groundwater Management Plan (GMP). The GMP describes opportunities to develop 15 additional wells at a cost of $233 million. Development of all identified well opportunities would yield approximately 70,000 acre-feet per year. This higher volume would be allowable in any one year as long as the 100 year average usage does not exceed available groundwater and stored water credits.

The relatively high cost reflects the need for substantial treatment for arsenic, nitrates and other elements. Significant advantages of local groundwater development include: 1) accessibility; 2) the ability to phase in capacity over time as needs develop; 3) the ability to use wells for other purposes such as backing up the system during planned or unanticipated system outages; and 4) ease of development relative to most other water supply solutions.

Major challenges to further expansion of groundwater development within the service area (beyond the wells identified in the GMP) include poor water quality and a lack of sufficient groundwater availability at points in the system where the supply would best be introduced. In addition, collective regional pumping during long-term shortage conditions may impact groundwater availability, though a recent analysis indicates that Phoenix may not be as significantly impacted as other municipalities in the Salt River Valley.

With regard to remediation of contaminated groundwater within Phoenix's service area, it has been the City's stated intent to preserve that water for future service area use. As such, the City has encouraged EPA and ADEQ to expedite remediation actions as the supply is expected to be an important component in meeting future service area demand during surface water shortfalls. A proposed groundwater remediation action within the Roosevelt Irrigation District (RID) would utilize RID wells that exist within the City to extract groundwater which would be treated and distributed to entities outside of the Phoenix service area. This activity would ultimately reduce groundwater water availability to the City.

The efficacy of developing new service area wells for deficit mitigation must consider well needs for other purposes. For example, if new service area wells are the least cost means of meeting other objectives such as water quality management, system peaking and system redundancy, the utilization of these same wells for deficit mitigation can be more easily justified. Correspondingly, if lower cost means are available to meet system needs, new service area wells dedicated strictly for deficit standby may not be cost effective relative to other solutions

<u>Non-Service Area Wells and Groundwater Exchanges</u>
To the degree that development of additional service area wells is not practical or cost effective for deficit mitigation, well capacity from outside of the Phoenix service are could be utilized to access both groundwater and stored water credits. Potential means for accomplishing this include:

- Storage and recovery of surface water supplies from an existing or future recharge facility accessible to the CAP or SRP canal systems.
- Developing an exchange agreement with one or more entities that have CAP allocations and substantial stand-by well capacity. Groundwater would be pumped by the other entity in place of its CAP supply, and Phoenix would take the CAP supply at its treatment plant. By registering the exchange with the State, the water taken by each entity reflects its original character (i.e. the water received at Phoenix's CAP plant would be legally characterized as groundwater).
- Develop an agreement to store and recover water within another provider's service area, also through an exchange agreement. This would be necessary in cases where substantial groundwater depletion would otherwise occur in that provider's service area.

Imported Groundwater: McMullen Valley
In 1986, the City purchased approximately 14,000 acres of farmland in the McMullen Valley, approximately 80 miles west of Phoenix (Figure 5-4). Most of this land is currently leased for farming operations. The City initially intended to utilize this supply to meet growth demands

within the City after 2030, and as such, the acquisition has served as an “insurance policy” to ensure growth needs would be met. The supply, up to 38,000 AF per year, would be conveyed via pipeline to the CAP canal. This groundwater transfer is authorized under state statutes, and the CAP Board has approved an “interim set aside” of 38,000 AF per year of excess CAP canal capacity for this purpose.

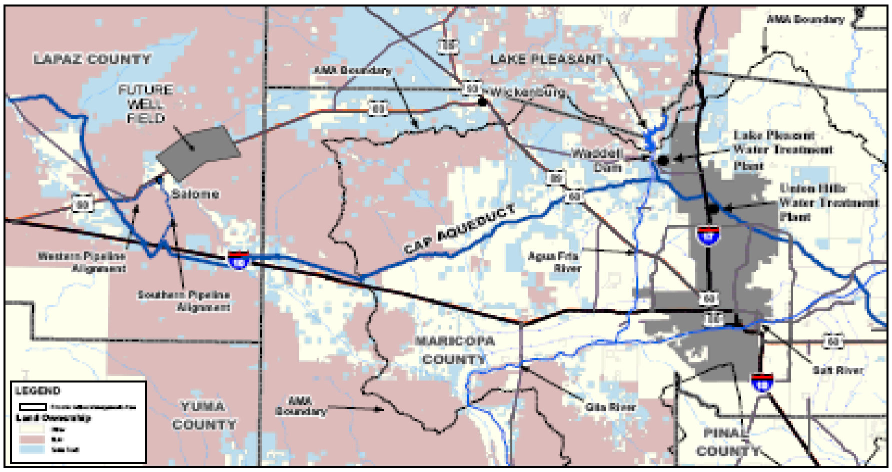


Figure 5-4. Potential McMullen Valley Groundwater Transfer Project

In the years following the City’s acquisition of this property, lower cost surface water supplies have been acquired by the City. These acquisitions, when considered together with lower per-unit water demand projections, have eliminated the need for McMullen Valley water to serve growth. The City recently studied the potential to utilize McMullen Valley groundwater as a supply to mitigate deficits, and the relative cost is significant.

Major considerations in determining the potential for Phoenix’s use of this supply are the timing of need and the volume available. The City is not anticipating the need for this supply for at least 20 years as it is expected that lower cost alternatives will be utilized for the first instances of deficit conditions. Recent groundwater modeling efforts in McMullen Valley foresee continuing groundwater level declines of up to five feet per year due to existing farming activity on both Phoenix-owned and other private lands which generate approximately 90,000 acre-feet of groundwater demand per year. While there is substantial groundwater in storage, and some of the water applied to agriculture infiltrates back to the aquifer, the natural recharge to the basin is only 2,000 acre-feet per year, and thus the supply is not sustainable in the long-term. If Phoenix were to develop this supply for deficit mitigation purposes, it would be with an understanding that it would serve only as a “bridge” to a more permanent sustainable supply.

The City acquired the property for $30.6 million. Pursuant to a 2004 re-financing of the debt, outstanding principal of $21.1 million is scheduled to be retired in 2017, and interest payments totaling $4.1 million will be payable through the remaining term. The McMullen Valley property has been continually leased for farming purposes while under City ownership and the current leases generates approximately $500,000 per year in revenues to the City. Between 20,000 to 25,000 acre-feet per year is currently being pumped for farm operations on City land. Continuing withdrawals for farming will lead to reduced availability of the aquifer for local or other beneficial uses in the future.

Other major challenges associated with the McMullen Valley option include the following:

- Estimated water transfer development costs for are high, currently ranging from $190 million to more than $500 million if treatment becomes necessary;
- The project requires a substantial lead time to develop, and will involve environmental reviews, complex agreements and substantial design efforts in a compressed time frame;
- The project does not lend itself well to a scaled phase-in approach (transmission infrastructure would need to be constructed regardless of the number of wells drilled);
- Upon completion of the necessary infrastructure, wells would need to be periodically operated to preserve their integrity for future use during shortages;
- CAWCD must negotiate a wheeling agreement with the Bureau of Reclamation for the "set aside" to be finalized. The "set aside" may be subsumed into the CAWCD's ADD Water program;
- Scrutiny on groundwater transfers has recently increased due to perceived and actual competition for additional water supplies among different geographic areas of the State; and
- Potential development in the area on non-City lands together with continued farm use of the City lands could deplete supplies at an accelerated rate, and further impact long-term availability.

In recent years, the City has evaluated the potential for replacing farming with low-water use activities such as solar power development. While this is a potentially viable location for such activity, the location currently lacks access to surplus transmission capacity to feed the electric grid. Another option for preserving groundwater might involve partnering with CAP or other cities to construct a pipeline to McMullen Valley which would provide excess CAP water to farms in lieu of groundwater pumping. This pipeline could, during future shortage conditions, be utilized to bring pumped groundwater back to the canal.

Other Surface Water

CAP Allocated for State Lands in Phoenix

When CAP Municipal and Industrial supplies were initially allocated in 1984, the Arizona State Land Department (ASLD) was awarded an allocation of 39,000 acre-feet. Most of this water was intended for State Lands that would ultimately be sold for development and incorporated within certain municipalities. Appendix A of the ASLD CAP Subcontract specifies 12,000 acre-feet per year as being reserved for development of state lands to be served by the City of Phoenix. It is expected that this water will offset some of the needs of state lands, primarily north of the CAP canal. While portions of ASLD's 39,000 acre-feet have been transferred to other area municipalities as specified in ASLD's subcontract, none of the 12,000 AF committed to Phoenix has yet been transferred. Though several large parcels of former state land are now served by the City, it is expected that all future state land conversions in Phoenix will be accommodated with supplies transferred by ASLD.

The cost to the City will reflect ASLD's expenses in maintaining the allocation. If acquired today, the price would be approximately $9 million. This figure predominantly includes past capital payments by ASLD to CAP

White Mountain Apache Indian Leases

Pursuant to the terms of the White Mountain Apache Tribe Water Rights Quantification Agreement, Phoenix will lease over 3,000 AF of CAP water allocated to the White Mountain Apache community. This agreement was approved by Congress in December, 2010, and is expected to be implemented by 2015. If the agreement were to be executed in 2015, the cost to the City would be approximately $9 million. This expense would provide legal access to this leased water for 100 years.

Additional Surface Water Supplies

Additional surface water supplies may become available to Phoenix through other Indian leases, the ADD Water process, or through other cooperative supply development projects. Though all surface water supplies are subject to shortages, the City will be seeking higher priority sources which will be reduced the least during shortage conditions.

Underground Storage and Recovery of Unused Supplies

The success of the Arizona Water Banking Authority in storing more than 3 million acre-feet for CAP subcontractors has significantly reduced the need for Phoenix to independently store water to compensate for future CAP deficits. However, independent storage by Phoenix may still be practical to mitigate shortages that affect both watersheds simultaneously.

The City’s access to substantial excess surface water and reclaimed water supplies during normal conditions can play an important role in generating another supply that can be accessed during reduced supply conditions. Storage of unused Phoenix CAP supplies could generate a minimum of 600,000 AF of groundwater credits (the equivalent of a 20,000 AF supply for 30 years). This water would be most valuable in mitigating on-project deficits since off-project deficits are first satisfied with AWBA credits.

Other sources such as unused NCS supplies and reclaimed water may also be considered for underground storage. Costs would vary based on treatment requirements, recharge method, hydrogeologic suitability, location of recovery and several other factors.

Storage within the Phoenix Service Area

To the degree that expanded well capacity within the service area would cost-effectively provide multiple benefits as described in Section 2 above (e.g. system reliability and water quality management), underground storage may be justified to maintain water table conditions where current and future service area wells may exist, and where substantial declines have occurred such as northeast Phoenix.

Recent investigations have demonstrated that injection of treated water directly to the aquifer through Aquifer Storage and Recovery (ASR) wells is the most effective means to maintain aquifer levels and bank unused supplies in that area. Physical and hydrogeologic constraints in the area preclude basin, vadose zone or in-channel recharge methods which would otherwise be more cost effective. The area benefits from access to both CAP and reclaimed water sources. Phoenix has partnered with Scottsdale to complete a study of groundwater conditions in this area. The two cities could potentially collaborate on aquifer management solutions that benefit both entities.

The City has begun operation of Well #299 which was recently developed as an ASR feature. Operation of this well is being closely monitored to assess its relative success in meeting both storage and recovery objectives in a cost-effective manner. If successful in meeting both physical and economic objectives, further expansion of ASR wells in the northeast and in other key areas of the service area may be justified.

Injection recharge may also be advantageous in augmenting groundwater supplies near the City's Deer Valley Water Treatment Plant where groundwater produced from area wells can augment surface water through blending. This area is encountering continued water level declines due to regional withdrawals. The City may wish to partner with neighboring utilities in efforts to maintain water levels in this area.

Recharge opportunities may also exist in proximity to the 91st Avenue and 23rd Avenue Wastewater Treatment Plants. However, due to relatively high water table conditions in these areas, prospects for long-term storage are diminished. Opportunities relative to reclaimed water are discussed in Section 6 below.

Storage outside the Phoenix Service Area

Recharge potential in the Phoenix service area is somewhat limited due to hydrogeologic constraints. To the degree that well expansion for system reliability or water quality management purposes is not cost effective relative to other solutions, recharge and recovery facilities outside of the Phoenix service area will likely be more practical.

Facilities available to the City include several existing "in-lieu" recharge projects associated with agricultural land. The City currently maintains storage permits at two of these facilities – the Salt River Project's Groundwater Savings Facility, and the Roosevelt Irrigation District Groundwater Savings Facility. Both facilities include lands both within and outside of the City service area. Several other such facilities exist within the Phoenix AMA, and could be suitable candidates for expansion.

The City has maintained an 80,000 acre-foot per year storage permit at the Granite Reef Underground Storage Project (GRUSP) since the 1993 inception of this project. However, in recent years, the project has not been available for substantive storage due to high water table conditions. The costs of maintaining access to this facility have grown substantially in recent years, and the City is thus reconsidering continued participation in this project. Phoenix could consider participating in other existing or planned underground storage facilities.

A key consideration with recharge facilities outside of the City is physical access to recovered supplies. These projects would be most cost effective to the City in instances where recovered water could be discharged directly to canals serving Phoenix treatment plants. During shortage conditions, sufficient capacity would be available in these canals and the costs of treatment and pumping against system pressure (which are incurred with service area wells) would be avoided.

Direct and Indirect Reclaimed Water Use

Reclaimed water represents a relatively firm supply and can be very well suited for shortage mitigation. City investigations have determined that more than 40 percent of water produced for delivery returns to wastewater treatment and reclamation facilities. Though more than 90 percent of discharged wastewater is currently reused for farming, habitat enhancement, turf irrigation and industrial cooling, additional "uncommitted" reclaimed water will be available as a result of growth and diminished farm needs over time. By 2020, between 28,000 and 35,000 acre-feet of uncommitted reclaimed water could be available. This figure could increase to as much as 100,000 acre-feet in 2040.

A wide variety of strategies exist for future utilization of reclaimed water. However, treatment costs, regulatory impediments, storage constraints, geographic constraints and public acceptance hurdles have historically presented challenges in achieving utilization objectives.

National organizations such as the WateReuse Association have made substantial progress in breaking down many of the barriers to effective reclaimed water utilization strategies.

In considering reclaimed water as a source for mitigating shortage conditions, underground storage becomes a critical factor. The City has experimented with vadose zone recharge at its Cave Creek Water Reclamation Plant, and maintains a permit to store unused reclaimed water underground via the RID Groundwater Savings Facility (for amounts in excess of that needed to satisfy the Phoenix-RID-SRP Exchange).

Today, treatment technologies have advanced to the degree that some communities in the US and globally purify reclaimed water and blend the supply with other sources for delivery to potable customers. In the coming decades, Phoenix may choose to do the same and benefit from increasingly sophisticated purification technologies.

In considering potential directions and strategies for utilizing and leveraging reclaimed water supplies, several initial conclusions have emerged:

- **The timing and availability of uncommitted supplies is uncertain**: The City and its Sub Regional Operating Group (SROG) partners maintain commitments of varying time frames and volumes to provide water to: 1) APS's Palo Verde Nuclear Generating Facility (80,000 acre-feet through 2050); 2) the Buckeye Irrigation Company (20,000 acre-feet though 2015 with options to extend to 2030); and the Tres Rios wetlands (19,000 to 23,000 acre-feet per year indefinitely). The City also maintains commitments of approximately 4,000 acre-feet per year to the completed Rio Salado restoration project and another 8,000 acre-feet to the planned Rio Oeste restoration project. Development of the latter project is dependent on availability of funds through the Army Corps of Engineers, and the timing for future funding is uncertain due to proposed federal budget reductions. In addition, the 30,000 acre-feet per year delivered to farms in RID will diminish as an exchange-based supply as agricultural lands in RID phase out over time.[15] For projection purposes, it was assumed that this transition would occur by 2030, and that a replacement mechanism would need to be identified. Finally, approximately 2,000 acre-feet per year has been committed to turf facilities served by the City's reclaimed distribution system in north Phoenix. The Cave Creek Water Reclamation Plant which serves this system is currently off line. Its return to service will likely be dictated by the timing of renewed growth in this area, which is uncertain at this time.

- **The seasonal fluctuation in demand for reclaimed water is inconsistent with the timing of availability**. Most non-potable uses (irrigation, turf watering, habitat maintenance and reactor cooling) encounter their greatest needs in summer months. Because availability of reclaimed water tends to be relatively steady throughout the year, supplies are typically insufficient to meet all needs in summer, and the inverse occurs in Winter. Underground storage and recovery is a commonly used means of balancing supply availability and demands.

- **Geographic availability of reclaimed water, and the viability of utilization solutions, is inextricably linked to the relative economy of wastewater treatment at various locations**: It is unclear at this time whether expansion of the Cave Creek Water Reclamation Plant and the development of an additional plant in north Phoenix

[15] Phoenix is eligible to receive 20,000 acre-feet of SRP supplies at its treatment plants as long as the exchange is functional (i.e. well capacity is available and sufficient land is being farmed). The City may also receive SRPMIC's 10,000 acre-foot volume in any year that the tribe chooses not to take its entitlement.

would avoid greater costs in transporting wastewater to the 91st Avenue plant. If reclaimed water were to be available in large quantities in north Phoenix in the coming decades, it could be treated and blended with CAP water at the Union Hills Water Treatment Plant. If there is greater economy in transporting the wastewater to 91st Avenue, reclaimed solutions might thus be oriented toward utilization in conjunction with a future Western Canal Water Treatment Plant or utilization in the West Valley.

- **Major reclaimed water production points (91st Avenue WWTP and the 23rd Avenue WWTP) are not well suited for distribution to the service area**: These two plants, by design, are in the lower elevations of the service area. Thus, water produced for usage in the service area will necessitate extensive and costly distribution and storage infrastructure, and will entail substantive energy to pump the supply up gradient.

- **Current regulatory standards preclude the use of reclaimed water for potable purposes**. Though current treatment technologies are capable of purifying reclaimed water to potable standards, regulations have not been updated to reflect these advancements. Concerns regarding traces of unregulated compounds (e.g. pharmaceuticals) found in reclaimed are also cited as an impediment to direct potable use. Because detection technologies are becoming increasingly sophisticated, it may be difficult to stay ahead of these concerns, regardless of the exceptionally low relative risks.

- **Dual piping to accommodate reclaimed in new development areas is not cost effective**: Recent investigations in Phoenix growth areas conclude that costs for installing a separate non-potable system for lot-level customers (residences and businesses) could be in excess of $10,000 per AF. As landscape becomes a smaller part of overall use, required volumes on a per-unit basis will diminish. A commitment to such projects would divert capital that could be used to treat reclaimed water to potable standards thus allowing utilization of the existing potable system.

- **Recharge of unused supplies may be the most effective means to use this supply in the next 20 years**. Whether or not Phoenix encounters shortages in the next 20 years, a prudent use of excess reclaimed water would be to enhance and stabilize aquifers. Injection, ASR or other approaches would meet this objective, though aquifer suitability and long term access to stored water is a concern.

- **Salinity concentrations (primarily sodium chloride) in reclaimed water affect the use of this supply for turf and other purposes**. Golf courses and other large turf customers on the City's Cave Creek system have experienced significant challenges in maintaining healthy turf given the salinity concentrations. Treatment of a portion of the water via reverse osmosis may be necessary for the continuity of deliveries for this purpose. Other options may involve blending with CAP or recovered groundwater.

- **Exchange arrangements with West Valley entities could provide cost effective means for utilization of this supply in the mid and longer term time horizons**. Several West Valley entities maintain CAP allocations but do not have the means to accept this water. These entities are better suited geographically to utilize reclaimed water from Phoenix for non potable purposes in the near term, and perhaps for potable use in future decades. In exchange, Phoenix would receive their CAP, which could be easily accommodated through existing WTPs and/or stored in higher-elevation portions of the service area with greater storage capacity and well access.

- **Reclaimed water is still indirectly characterized within the water industry, and consequently by the public as "inferior" to other water sources**. Well-intentioned regulatory-based guidelines which, for example, identify reclaimed distribution systems with "purple pipe" have led to a perception that reclaimed supplies are inferior to non-potable surface water supplies though current treatment methods and technologies demonstrate otherwise. The industry needs to revisit the rationale for describing and characterizing reclaimed water as "different" if it expects future public support for potable use of this source.

- **Highly treated reclaimed water could ultimately be transported to Phoenix surface water impoundments and combined with CAP and SRP supplies for delivery through the potable system**. Notwithstanding the cost of reclaimed treatment and transmission, this approach would effectively employ existing underutilized treatment and distribution infrastructure. On a broader scale, highly treated reclaimed water could be delivered to CAP or SRP raw water facilities and enhance reliability of surface water supplies regionally.

Further development of strategic directions regarding future reclaimed water use will be relatively complex due to the factors and findings discussed above. The City may be best served to establish a long-term potable use objective for all reclaimed water not needed for recharge or non-potable uses. By doing so, all "bridge" (near term) projects would be framed with this end in mind, thus reducing the potential for stranded assets. For example, transmission lines and treatment facilities may initially be utilized to store water underground, and in future decades these same facilities, with appropriate upgrades, could be used in implementing potable blending strategies.

Another advantage of utilizing reclaimed as a potable supply in future decades is the opportunity for the indirect use of existing surface water storage reservoirs to equalize seasonal demand variations. For example, if reclaimed water replaces a portion of CAP or SRP supplies that would have otherwise been used to meet base demand, surface water reservoirs could hold that unused supply for high demand season.

Other Strategies

<u>Desalinated Brackish Groundwater</u>
Groundwater supplies in southwest Phoenix and to the west of the service area are characterized by high TDS levels, in some cases exceeding 2,500 mg/l. This high-TDS water tends to occur in areas with high water table conditions, presenting an opportunity for substantive pumpage during shortage conditions without a precursor need to recharge. Though the costs of treating this water are high, and cost-effective concentrate disposal methods must be identified. Applied research and emerging technologies should reduce these costs and challenges over time. Strategies for utilization of this water must also consider limits imposed by the Groundwater Code and potential groundwater impacts to groundwater levels in the Phoenix service area.

Desalinated Seawater
Phoenix could ultimately become a partner either directly or indirectly (for example through CAP) in efforts to access desalinated sea water to support the regions growth and reduce shortage vulnerability. Though the realization of such an effort will be several decades away, the scope and scale of the effort – like the CAP – will require substantive planning and capital expenditures. A first stage might involve exchanges whereby coastal communities now receiving Colorado River would forego that supply for desalinated water made available by inland entities. The inland entities would then divert Colorado River supplies that would have been delivered to the coast. A second stage, involving development of physical transportation from a coastal area in the US or Mexico, would become necessary upon reaching the capacity limit of the CAP canal.

Graywater
State statues and rules have been progressively modified in recent years to expand opportunities and provide customer incentives to utilize graywater (typically water from showers, tubs and clothes washers). The City does not actively encourage graywater use among customers as the wastewater system efficiently consolidates flows to two major plants, and the vast majority of that water is presently reused. The City supports customers who wish to retain graywater on-site and manage this resource effectively to reduce potable water expenses. Graywater use, however, has minimal if any practical benefits to the City for purposes of addressing deficit supply conditions, nor is it likely to provide meaningful benefits with regard to freeing up water or wastewater system capacity.

Rainwater Harvesting
The City encourages customers who are re-landscaping or establishing landscape plans for new lots to consider effective means of retaining runoff on the property, where practical, to offset water otherwise obtained from the potable system. Passive systems, including contouring and redirection of flow patterns toward trees and other landscape, are less labor intensive than dedicated storage and distribution systems and are thus suitable for a wider variety of customers. A significant limitation in Phoenix is its low annual rainfall (less than 8 inches per year), which constrains the applicability of this strategy. Similar to graywater strategies, rainwater harvesting may provide net cost savings to customers, but will have limited benefits to the City's need for additional supplies to address deficit supply conditions.

The Case for Regional Shortage Response Solutions
Phoenix is one of ten municipalities in the metropolitan area that rely on Salt River Project supplies for a portion of their portfolio, and is one of 57 CAP Municipal and Industrial subcontractors. Phoenix's CAP subcontract supplies in 2044 will represent almost 23 percent of the total M&I water for Arizona. CAP allocations for Phoenix and five other large municipal contractors represent 65 percent of the M&I total. Each provider is unique in the blend of SRP and CAP supplies, the relative seniority of SRP rights, and the availability of groundwater to supplement these supplies during shortage. Thus, shortage on one or both systems will have implications for multiple providers. As water supply and infrastructure costs continue to escalate, regional strategies to reduce shortage risk (such as AWBA for CAP supplies) will be the most practical as traditional "go it alone" approaches will become comparatively costly and inefficient. Establishing regional strategies well in advance of deficit conditions is critical in avoiding the inevitable political, logistical and legal challenges that would occur when the onset of severe shortages begins to affect some entities significantly more than others. As these solutions are developed, complexities involving existing water right structures, contracts and legal constraints will need to be addressed.

City actions should include:

- Participating in and promoting appropriate dialog and initiatives which seek practical long term regional solutions that maximize benefits and protect the regional economy during significant supply shortage events.

- Assessing relative benefits and vulnerabilities to Phoenix in participating in regional solutions.

5.3 IMPACT OF COMBINED STRATEGIES

The relative contributions of major supply and demand strategies described above in meeting deficits arising from severe shortage conditions are illustrated in Figure 5-5. The order of stacking is not intended to imply any specific sequence of implementation, though it would be reasonable to assume that existing groundwater capacity, moderate efficiency improvements and AWBA credits would be "first line" solutions as they entail the least required investment per unit. High-level efficiency savings are not incorporated into this illustration as further investigations are necessary to determine the feasibility and cost of permanent demand reductions at that level. The additional 8 percent which this additional demand reduction would reflect is likely to be achievable as short term (1-3 year) curtailment, and the economic and lifestyle impacts of such curtailment would need to be weighed against the cost of supplies which would protect this demand.

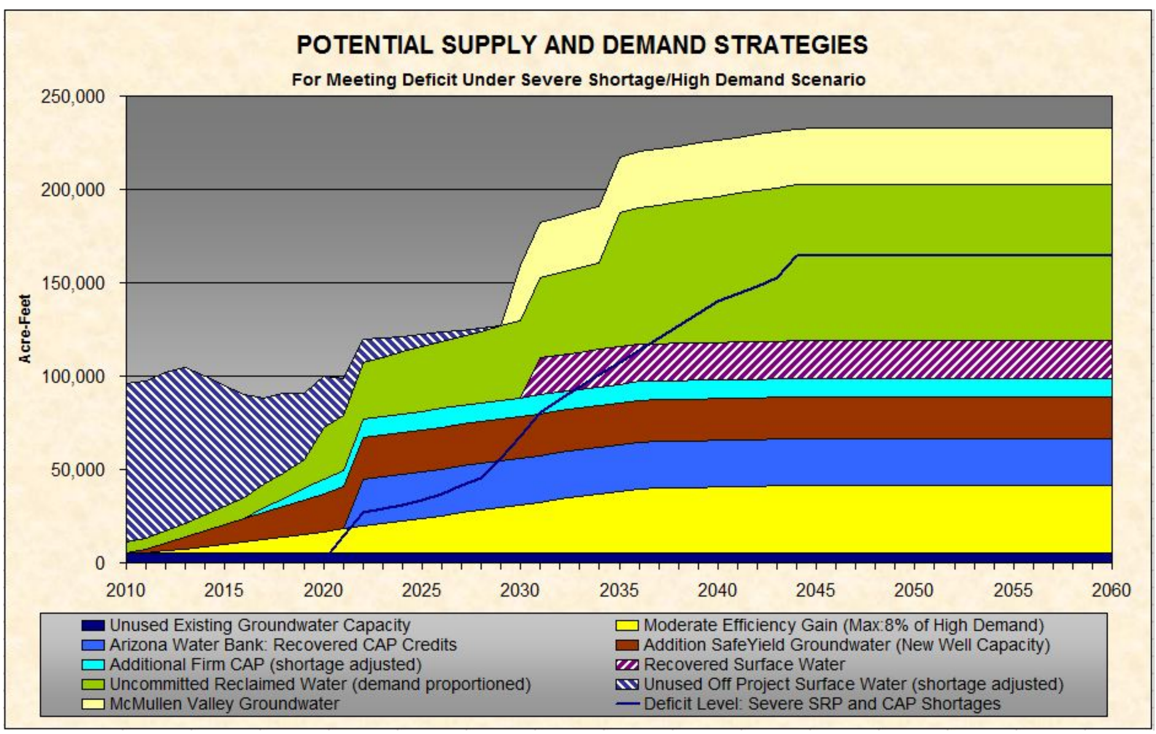


Figure 5-5. Potential Supply and Demand Strategies

5.4 SHORTAGE RESPONSE FRAMEWORK

Table 5-2 describes the sequence of actions that may be taken at any given time based on the earliest projected date that the City would incur shortage-driven water supply deficits. This framework considers the lead time necessary to acquire water resources, to fund, design and construct related infrastructure, and to implement demand reduction initiatives. Information derived from continual monitoring and scenario planning will allow for assessment of future shortage risk (timing and magnitude). This assessment will determine the relative phase and associated actions at any point in time.

Table 5-2. Shortage Response Framework

PHASE	Lead Time	Supply Related Actions	Demand Related Actions
MONITOR	Continuous	- Monitor watersheds, reservoir status and threats to supplies - Identify opportunities for supplemental or "safety net" supplies that can be acquired at a low cost relative to expected future supplies.	- Monitor growth and usage trends; - Anticipate trend changes - Research large water uses to better understand potential for demand reduction - Maintain public awareness
EXPLORE AND PLAN	Near term - decades	- Explore options to fund and deploy supplemental or "safety net" supplies - Acquire necessary supplies or secure access to supplies- - Conceptualize regional scale supplemental supply projects such as infrastructure and supply exchanges, reclaimed water development and desalinization.	- Advocate for plumbing code changes to generate long-term savings - Support customer actions to improve landscape water efficiency - Prepare customers for future drought conditions (landscape retrofits, etc.)
PREPARE AND DEPLOY LONG RANGE	5-10 Years	- For large scale or infrastructure intensive projects, secure funding, develop designs, acquire land access and make other investments to reduce construction lead time - For other projects where multiple purposes may be served (such as new wells for system redundancy), design, fund and construct accordingly.	- Evaluate large commercial and industrial customers and sectors for opportunities to develop cooperative agreements.
DEPLOY SHORT RANGE	2-5 Years	- If supported by a current risk analysis and re-evaluation of shortage impacts, begin constructing necessary facilities.	- Execute demand reduction agreements with specified large customers or sensitive customers in anticipation of shortage. - Establish general customer outreach strategy
OPERATE	1 Year	- Prepare facilities and or supplies for deployment.	- Prepare customers for mandatory demand curtailment measures. - Implement drought surcharge - Implement curtailment measures
MANAGE	During Shortage	- Execute plans for supply deployment - Manage sources in a manner to preserve options (e.g. maintain groundwater reserves to the highest degree practical, etc).	- Assist customers in meeting voluntary or mandatory reduction measures - Enforce mandatory measures.

CHAPTER 6: NEAR TERM ACTIONS

This current assessment demonstrates that the City's most pressing water resource need is "supply insurance" to reduce the impacts of multi-decade surface water shortages that could impact the City after 2020. Though shortage conditions on the Colorado River or SRP systems could emerge before that date, groundwater and supplies reserved for future growth would be available to offset reductions in surface water supplies in that time frame.

The preceding chapter identifies numerous strategies available to reduce the impact of shortages. The purpose of this final chapter is to prescribe specific "no regrets" actions that reflect current conditions and logical near-term progressions. In this manner, and complimented with continual monitoring of conditions, significant expenditures for infrastructure or supply acquisition may be deferred until a critical trigger point is imminent. As conditions change, certain scenarios within the ranges described in Chapter 4 may appear more likely than others, and periodic adjustments to this suite of near-term actions will become necessary.

6.1 First Tier Actions (High Priority)

Groundwater Development Cost Assessment

Additional groundwater wells may be needed in the service area to address water quality objectives, operational flexibility and system redundancy. However, these needs can also be met through various treatment technologies, additional storage and redundant transmission lines. Before it can be determined that additional service area wells are cost effective in reducing future supply deficits, it must first be concluded that wells are cost-effective in meeting operational needs. If other options are more cost effective than wells for meeting operational needs, then the City may find it more prudent, for shortage mitigation purposes, to access groundwater and/or stored water credits indirectly through lower-cost options outside of the service area. The City could partner with other entities in utilizing existing wells that would discharge to the CAP canal or to another provider's system via an exchange. Phoenix would take the available water at its existing water treatment plants.

The study should also address the relative costs of managing aquifer water levels (through recharge and withdrawal management) for existing service area wells. Continued monitoring and evaluation of ASR Well #299 in northeast Phoenix will be necessary to assess cost-effectiveness of expanding the program in this area and elsewhere within the service area. .

This study is a logical extension of the work culminating in the City's Groundwater Management Plan and is fundamental to further decisions on service area wells. Because well development is capital intensive and a program to develop new wells in the service area (should that be the solution) will take many years, it is important that this evaluation be completed by July 1, 2012.

Arizona Water Banking Authority Credit Utilization

The method by which Arizona Water Banking Authority credits are made available for offsetting shortages to Municipal and Industrial CAP Subcontracts is undetermined as of Spring 2011. At the urging of CAP subcontractors, AWBA and CAP have initiated discussions to develop policy and strategies for utilizing these credits. In effect, Phoenix surface water shortfalls which are made up through AWBA credits will offset expenses for more costly supply alternatives. A key consideration in this process is the degree to which shortfalls are offset in any given year, and the number of years the credits can be available.

The City should continue to participate in discussions with CAP and AWBA on this subject with an objective of ensuring that the credits are ultimately deliverable to Phoenix water treatment plants. Secondary objectives include: 1) supporting CAWCD policies for excess water pools that allocate water to the AWBA for M&I and Indian firming; and 2) supporting policies that allow the AWBA to fulfill Arizona's banking obligations to the Southern Nevada Water Authority. Phoenix should encourage completion of a joint AWBA/CAP plan by July 1, 2012.

Demand Reduction Potential Research

The validity of actions associated with supply planning, water infrastructure planning, wastewater infrastructure planning and long-range revenue projections is highly dependent on accurate water demand projections. The City's research efforts over the past three years have begun to uncover certain characteristics and trends that are contrary to historic planning paradigms. Unchecked, the use of outdated demand factors can result in unnecessary costs and unrealistic revenue projections.

The City should continue to evaluate residential and non-residential customers and user categories to more accurately determine: 1) the potential for future demand reduction from structural water efficiency and price influencers; 2) the range of potential curtailment, and associated economic impacts, during shortage conditions; and 3) impacts on wastewater generation and reclaimed water availability. In addition, the City should continue to support continued research of promising water efficiency technologies and promote strengthening of national plumbing efficiency standards consistent with this research. Research should include the relative benefits of customer incentives for early incorporation of these new technologies.

Water Resource Acquisition Fee Update

City policy asserts that expenses for the deployment of future water supplies must be derived from growth-related revenues, which accrue based on collection of Water Resource Acquisition Fees from new development. These fees were recalculated in 2008 based on the 2005 Water Resources Plan. However, the fees have not been activated due to a moratorium on impact fee increases passed by the Arizona Legislature. Given the recent per-unit decline in water demand and resultant changes in supply strategies, the basis of the Water Resource Acquisition Fee, and the associated Conservation Credit Program, should be re-established by January 1, 2013

North Phoenix Reclaimed Water and Wastewater Treatment Needs Assessment

To effectively allocate water development and wastewater funds it is necessary to determine the relative need for additional reclaimed water and wastewater treatment in North Phoenix, versus options involving treatment at 91st Avenue coupled with water exchange agreements that could bring additional CAP to North Phoenix.

Water Resource Capital Improvement Framework

Investments in water resources and infrastructure necessary to reduce or eliminate future supply deficits will need to me made regularly to adequately prepare for these conditions. To adequately support "just in time" investment decisions, relatively accurate estimates of costs associated with each mitigation strategy must be developed and regularly maintained. While substantial effort has already occurred to price many of the strategies presented in Chapter 5, the City should develop a uniform cost assessment protocol to better compare various supply and demand management strategies. The results from periodic evaluation of project costs and benefits will then be incorporated into a 20 year capital improvement framework which addresses deficit mitigation in time frames and volumes specified in regular supply assessment updates.

Supply and Demand Monitoring

Continuous structured monitoring of water use trends and supply conditions is critical in ensuring timely and appropriate decisions regarding deployment of supplies, infrastructure development and implementation of demand management strategies. The City should establish a structure and schedule for this monitoring.

6.2 SECOND TIER ACTIONS

Reclaimed Water Strategic Plan

Uncommitted reclaimed water may be utilized through a wide variety of strategies including direct non-potable use, indirect potable use (through recharge and recovery), exchange and ultimately direct potable use. Determining which strategies are most cost-effective in various time frames will involve a comprehensive and complex assessment. The assessment will need to be preceded by an evaluation of wastewater treatment needs and costs in north Phoenix as the location of discharge is critical in determining the ultimate reuse strategy. Local treatment in north Phoenix would necessitate expanded direct use and recharge strategies while treatment at 91^{st} Avenue would take advantage of consolidating the wastewater with existing flows at that plant.

A reclaimed water strategic plan should incorporate a long-term objective to utilize reclaimed water for potable use (directly and/or indirectly) to the highest degree practical. This objective could focus on future use within the Phoenix service area, and/or the City may wish to market treated water to other area entities as a separate business enterprise to fund acquisition of water supplies necessary to mitigate shortage conditions. In establishing this long-range objective, several compatible interim strategies will need to be developed. These may include:

- Demonstrating the viability of storing reclaimed water via direct injection to maintain water levels in critical well fields;
- Evaluating opportunities to more effectively use reclaimed water for direct non-potable uses within Phoenix, and if blending with raw CAP or groundwater to increase the utility of this supply;
- Evaluating alternatives for the use of effluent from 23^{rd} Avenue WWTP to ultimately replace the existing RID Exchange and RID GSF to prepare for when these instruments are no longer viable;
- Collaborating with regulators and stakeholders in an effort to re-structure and update reclaimed water regulations to reflect current treatment technologies and methods, and to remove barriers to utilization of reclaimed water for its “highest and best use” as a potable supply;
- Evaluating means for reducing salinity in reclaimed water, and for cost-effective methods to manage concentrate; and
- Evaluating reclaimed water pricing policies and ordinances to ensure that pricing appropriately reflects City objectives.

McMullen Valley Asset Management

In the 2005 Water Resources Plan, the City concluded that McMullen Valley groundwater would not be utilized as a supply to meet normal-year demand. This Plan concludes that development of McMullen Valley groundwater for shortage mitigation would not be practical relative to other available options in the foreseeable future. As such, the City's choices are to either: 1) develop a comprehensive strategy for preserving groundwater for future use (e.g. via low water use activities like solar power generation or by serving farmlands with excess CAP when available); or 2) offer the property for sale and retire remaining debt. If the property is ultimately sold, the proceeds (or funds allocated to debt repayment) should be allocated for more cost-effective and sustainable shortage mitigation projects.

Groundwater Exchange Feasibility

To the degree that the City does not need additional wells within the service area for operational purposes, underutilized capacity in wells owned by other entities could be indirectly utilized for shortage mitigation. The City should investigate the costs and feasibility of exchange mechanisms which would effectively allow the City, in partnership with other entities, to accept exchanged groundwater at Phoenix water treatment plants.

Expanded Groundwater Modeling

The City should continue to support expansion of regional groundwater modeling efforts to better understand hydrogeologic characteristics during long-term shortage conditions where aquifers may be highly stressed. The results from this modeling will provide a better basis for Phoenix and its partnering entities to optimize well development, recharge and operational decisions.

State Land CAP Acquisition Plan

An agreement with ASLD should be pursued to gradually transfer 12,000 acre-feet per year of CAP reserved for State lands in Phoenix to the City as land develops.

White Mountain Apache CAP Lease

As of Spring 2011, legislation to authorize the White Mountain Apache Water Rights Settlement continues to await congressional action. This settlement includes authorization for the lease of more than 3,000 acre-feet per year of CAP supplies to the City. Progress should be monitored and options prepared for the ultimate utilization of the supply (which may not be available until approximately 2015).

Climate Variability Research

The City should continue to partner with universities, federal agencies, CAP, SRP and other interested parties in climate variability research focused on assessing potential impacts to the Salt-Verde and Colorado River watersheds and translating results to the local level. Research should also address the correlation of water demand and temperature to estimate the degree to which sustained higher temperatures could affect future water demand.

Recharging Unused CAP and SRP Supplies

Investigate the cost effectiveness of storing and recovering unused CAP or NCS supplies in existing or planned underground storage facilities, or through "in-lieu" facilities outside the City to create an additional bank of surface water supplies directly accessible to the City.

Regional Shortage Coordination

Participate in and promote appropriate dialog and initiatives which seek practical long term regional deficit mitigation solutions to protect the Phoenix and regional economy during shortage conditions. The City will need to continually assess relative benefits to Phoenix and the region for collaborative initiatives versus "go it alone" solutions.

Demand Outreach Needs Assessment

The City has maintained conservation programs which after many years have contributed to the substantial decline in per-unit water usage. Advertising campaigns, teacher education, audits, plumbing retrofits, public information materials, desert landscape training and a host of other activities have provided substantive public awareness benefits. As the needs for demand reduction programs are shifting from traditional conservation initiatives to drought preparedness actions, the value of current functions must be re-assessed to determine applicability to these emerging objectives. Programs for which benefits have diminished over time should be either redirected or eliminated.

Website Expansion

The City's website is an increasingly important tool in reaching customers, especially with regard to water use efficiency strategies and water supply availability status. Whereas the programs have historically relied heavily upon distribution of hardcopy materials, web-distributed resources offer an opportunity to build upon and replace much of the traditional hardcopy distribution. The current website should be expanded to incorporate user-tailored tools for: 1) assessing potential water savings at their home or business; 2) determining the cost-effectiveness of various technologies and practices given current and future water costs; 3) determining susceptibility to impacts from mandated demand curtailment; 4) identifying appropriate guidance regarding water efficient technologies and practices to reduce high water bills. In addition, the web resource expansion should include frequently updated advisories regarding water supply conditions and forecasted earliest shortage dates. Educational resources currently delivered via programs such as Project WET (Water Education for Teachers) and SmartScape (for landscape professionals) should also be incorporated into the web resource to the highest degree practical.

Alternative Water Rate Structures

The City's current seasonal rate structure has been in place for over 20 years. The structure should be re-evaluated to ensure that it will continue to effectively and equitably meet future objectives. In addition to evaluating potential alternative potable rates, the non-potable rate structure (40 percent of potable for raw CAP and 80% of potable for reclaimed water) must also be reconsidered.

Water Loss Control

The City has taken substantive steps to reduce "lost and unaccounted for" water by replacing customer meters and rehabilitating water lines. While these efforts continue, the City should assess the relative costs and benefits of further reducing these losses (versus supply development costs), and establish a target lost water level that reflects this balance.

Industrial, Commercial and Institutional Customer Outreach

Though non-residential use comprises one-third of total demand, the City has little information regarding the characteristics of large users and user groups. An understanding of these characteristics is critical in establishing effective demand management strategies and in projecting future infrastructure needs. Through voluntary audits and/or informal communication, the City should begin working with large industrial, commercial and institutional customers to better understand how water is used in their operations. The economic impacts of curtailment should also be assessed to better determine means for of minimizing these impacts during supply shortage conditions.

Drought Management Ordinance

The City's Drought Management Ordinance was last updated in 2000. Implementation of this ordinance in the 2003-2005 time frame highlighted needs for modifications to reflect appropriate trigger events, to establish sector-specific standards, and to specify surcharges on high discretionary water use during shortages.

Storage and Accounting of Water Efficiency Savings

Develop methods for quantifying and allocating water saved through conservation actions to long term storage accounts (subject to water right limitations).

Customer Demand Reduction Assistance

As water rates rise due to higher operational costs, customers will increasingly be searching for means to reduce water bills. The City should develop a "demand reduction assistance hotline" to assist customers beyond what is available on the web and through other resources. The program may be initiated on a trial basis, and could entail on-site audits or other assistance where desired by the customer.

Voluntary Residential Water Audits

A scalable residential water use audit program should be implemented, initially on a trial basis, to offer voluntary services to customers who: 1) are found to have sudden and unprecedented spikes in water use (from meter and billing records), which may indicate the presence of a leak; 2) contact the City requesting on-site assistance in reducing monthly water bills; or 3) represent the highest water using residences. On the latter point, 20 percent of households use 43 percent of all residential water. Though high water use does not necessarily translate to inefficient use, many homeowners are unaware of the methods available to economically improve efficiency while maintaining current lifestyles. Auditors could make minor repairs and advise these customers regarding best management practices. The recorded results of this program will provide greater insights as to how customers are coping with rate increases, and where the opportunities exist for demand reduction. In addition, recent research has demonstrated that direct contact with customers in instances such as these provide greater likelihood of follow-through actions by customers.

Conservation Ordinance

The City's conservation ordinance is in part based on ADWR's Management Plan requirements. The ordinance needs to be re-assessed and updated, with emphasis on turf management, to better conform to ADWR requirements and to encourage incorporation of best management practices.

ACRONYMS USED IN THIS DOCUMENT

ADEQ	Arizona Department of Environmental Quality
ADWR	Arizona Water Department of Water Resources
AF	Acre feet (1 acre foot = 325,851 gallons)
AMA	Active Management Area
AS&R	Aquifer Storage and Recovery
ASLD	Arizona State Land Department
AWBA	Arizona Water Banking Authority
AWS	Assured Water Supply
BIC	Buckeye Irrigation Company
CAGRD	Central Arizona Groundwater Replenishment District
CAP	Central Arizona Project
CASS	Central Arizona Salinity Study
CCWRP	CCWRP – Cave Creek Water Reclamation Plant
CRBSCF	Colorado River Basin Salinity Control Forum
EA	EA – Environmental Assessment
EIS	EIS – Environmental Impact Statement
EPA	U.S. Environmental Protection Agency
ESA	Endangered Species Act
FONSI	FONSI – Finding of No Significant Impact
GPCD	Gallons Per-Capita Per Day
GRIC	Gila River Indian Community
GRUSP	Granite Reef Underground Storage Project
GSF	Groundwater Savings Facility
HCP	Habitat Conservation Plan
I-17	I-17 – Interstate 17
M&I	Municipal and Industrial
MAG	Maricopa Association of Governments
mg/L	milligrams per liter
mgd	mgd – million gallons per day
NCS	New Conservation Space
NEPA	NEPA – National Environmental Policy Act
NPL	National Priorities List
OU1, OU2, OU3	Operable Unit 1 Operable Unit 2, Operable Unit 3
PPB	Parts Per Billion
RID	Roosevelt Irrigation District
RWCD	Roosevelt Water Conservation District
SDWA	Safe Drinking Water Act
SROG	Sub-Regional Operating Group
SRP	Salt River Project
SRPMIC	Salt River Pima Maricopa Indian Community
TDS	Total Dissolved Solids
USBR	United States Bureau of Reclamation
USFWS	USFWS – U.S. Fish and Wildlife Service
USGS	United States Geological Survey
VOC	Volatile Organic Compounds
WESTCAPS	West Valley Coalition of CAP Subcontractors
WET	Water Education for Teachers
WQARF	Water Quality Assurance Revolving Fund
WWTP	Wastewater Treatment Plant