SECTION

I

AMA Overview

Chapter 1 Water Management Approach

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Preface

Section I of the Third Management Plan provides an overview of the Arizona Department of Water Resources' (Department) water management approach, a description of the physical conditions, hydrology, and water resources of the Tucson Active Management Area (AMA), and a detailed description of the characteristics of various water use sectors within the AMA. The physical water resources data presented in Chapter 2 and the historic water use and associated water use trends described in Chapter 3 provided the Department with important information from which it developed a baseline water budget. Information presented in this section was also used in developing water management programs which are presented in Section II and the future conditions and directions presented in Section III.

In Section I, the Department intends to provide the reader with a better understanding of the management approach, the water resources, and the water use characteristics of the Tucson AMA. Such an overview is necessary to better appreciate the reasoning, perspective, and methods being used by the Department as it continues to develop a long-term water management strategy, with particular emphasis on the third management period (2000 to 2010).

CHAPTER

1

Water Management Approach

1.1 CHAPTER ORIENTATION

This chapter describes the goals, objectives, and contents of the Third Management Plan within the context of the Arizona Department of Water Resources (Department) and the Groundwater Code (Code). It also provides an overview of the Tucson Active Management Area (AMA). The following topics are discussed:

- Arizona Department of Water Resources' mission
- Overview of the Code and some of its key provisions
- A discussion of the safe-yield concept and other management goals
- An institutional overview of the Tucson AMA
- The principles, objectives, and contents of the Third Management Plan
- Emerging challenges for the Tucson AMA

1.2 THE ARIZONA DEPARTMENT OF WATER RESOURCES

The Department was created by the 1980 Groundwater Code to manage the water resources of Arizona. The Department administers state laws, explores methods of augmenting water supplies to meet future demands, and works to develop public policies that promote efficient use and equitable allocation of available water supplies. To secure long-term water supplies for Arizona, the Department oversees the use of surface water and groundwater in the state and represents the state's interests in interstate and federal issues. The mission of the Department is:

> *To ensure a long-term, sufficient and secure water supply for the state; to develop public policy which promotes efficient use and equitable distribution of water in an environmentally and economically sound manner; and, to promote the management of floodplains and dams to reduce loss of life and damage to property.*

1.3 THE ARIZONA GROUNDWATER CODE

In 1980, Arizona made a commitment to the long-term management and conservation of its limited groundwater supplies through the passage of the Code, which is the cornerstone of Arizona's water management efforts. The goals of the Code are to eliminate severe groundwater overdraft in areas of the state where groundwater supplies have been rapidly diminishing and to provide the means for allocating Arizona's limited groundwater resources to most effectively meet the state's changing water needs.

The Code limits withdrawals of groundwater within AMAs to holders of groundwater rights, service area rights, and groundwater withdrawal permits, and to small domestic water users. Under the Code, water uses existing in 1980 were allowed to continue within the limits established under a new water rights system, and new uses were required to be consistent with the management plans and goals of the AMAs. Readers who are not familiar with the different types of groundwater rights established by the Code are encouraged to read the Glossary of Terms attached as a supplement to the management plan. The Code also contains provisions to limit groundwater use through conservation and the use of renewable water sources. The full text of the Code can be found on the following Web site: www.azleg.state.az.us

1.3.1 The Groundwater Problem

The Code was enacted in response to serious water level declines in the aquifers in the central and southern parts of the state. Groundwater overdraft in Arizona has resulted in the lowering of groundwater levels by as much as 600 feet in some locations. In some areas, groundwater depletion has made it economically infeasible to pump water, has caused the lowering and cracking of the land surface (subsidence), and has resulted in water quality problems due to the migration of contaminated water and general deterioration of

aquifer water quality with depth. Continued overdraft of groundwater supplies will exacerbate these problems.

In the Tucson AMA, groundwater is currently used at twice the rate it is replenished. Groundwater overdraft in the AMA has lowered water levels by up to 200 feet in Tucson Water's Central Wellfield. Subsidence has occurred in several areas of the AMA and is projected to increase if groundwater declines continue. Decreased well productivity has been observed in some areas because the most productive portions of the aquifers have been dewatered. The total volume of existing groundwater rights and withdrawal permits exceeds natural and incidental recharge by a factor of 2.8.

1.3.2 Provisions of the Groundwater Code

The regulatory provisions of the Code are focused primarily on areas of the state that have been designated as AMAs. These areas are located where competition for groundwater is most intense, primarily in the central and southern parts of the state. Statewide, there are provisions addressing well drilling, registration, and construction requirements; water adequacy requirements for new subdivisions; and limitations on transportation of groundwater across watershed boundaries.

Within AMAs, the Code established a new groundwater rights system strictly limits groundwater withdrawals; prohibits the development of new irrigated farmland; requires new subdivisions to have long-term, dependable supplies; and requires measuring and reporting of groundwater withdrawals. Management goals are established for each AMA, and a series of five management plans containing mandatory conservation requirements for industrial, municipal, and agricultural water users must be developed. Other programs within AMAs include conservation assistance, augmentation, and monitoring of the water supplies.

The Code also established Irrigation Non-Expansion Areas (INAs). Within these areas there can be no new irrigated land, and owners of large wells are required to meter their water use and file annual reports with the Department. Otherwise, groundwater management in INAs is not highly structured.

1.3.2.1 Creation of the Active Management Areas and Irrigation Non-Expansion Areas

Upon enactment of the Code, four AMAs were established: Phoenix, Tucson, Pinal, and Prescott. In 1994, the Santa Cruz AMA was created from the southeastern portion of the Tucson AMA to allow more focus on international issues and the unique hydrology of the area. Boundaries of the AMAs are based primarily on groundwater basin divides, but they take into account water use patterns as well.

The Code also established two INAs: Douglas and Joseph City. A third INA, Harquahala, was designated by the director in 1982. Figure 1-1 shows the location of the five AMAs and the three INAs. The Douglas INA is managed from the Tucson AMA office. Figure 1-2 shows the boundaries and major features of the Tucson AMA.

1.3.2.2 The Management Goals

For three of the AMAs, Prescott, Tucson, and Phoenix, the management goal to be reached by the year 2025 or earlier is safe-yield. The attainment of this goal is expected to occur incrementally over the five management periods. However, it is clear that from a supply-availability perspective the goal will be easier to attain in the early years while Colorado River supplies are in surplus. Maintaining the safe-yield goal beyond 2025 may become more and more difficult over time as demand increases due to municipal and industrial growth and renewable supply surpluses decrease.

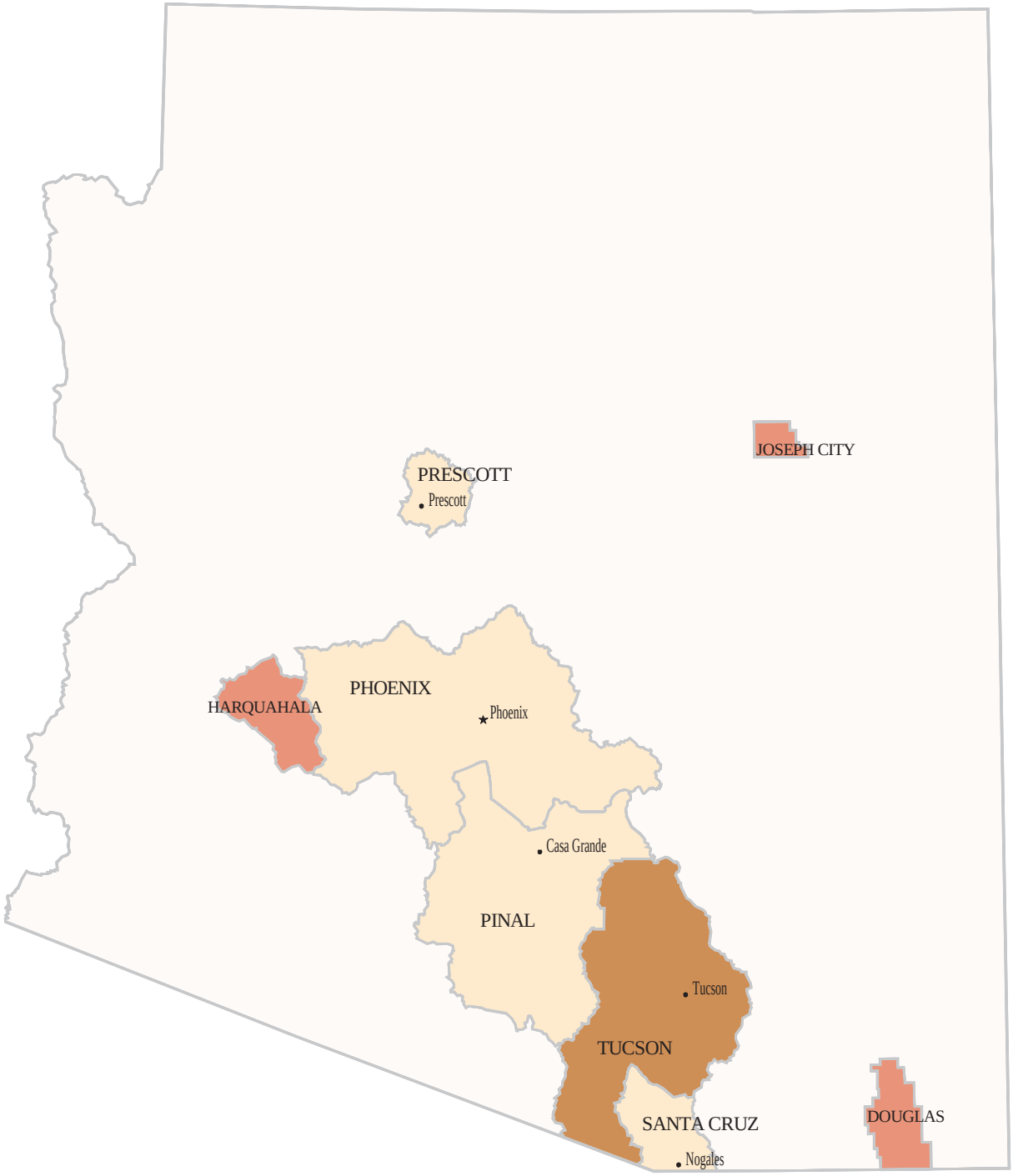


Figure 1- 1

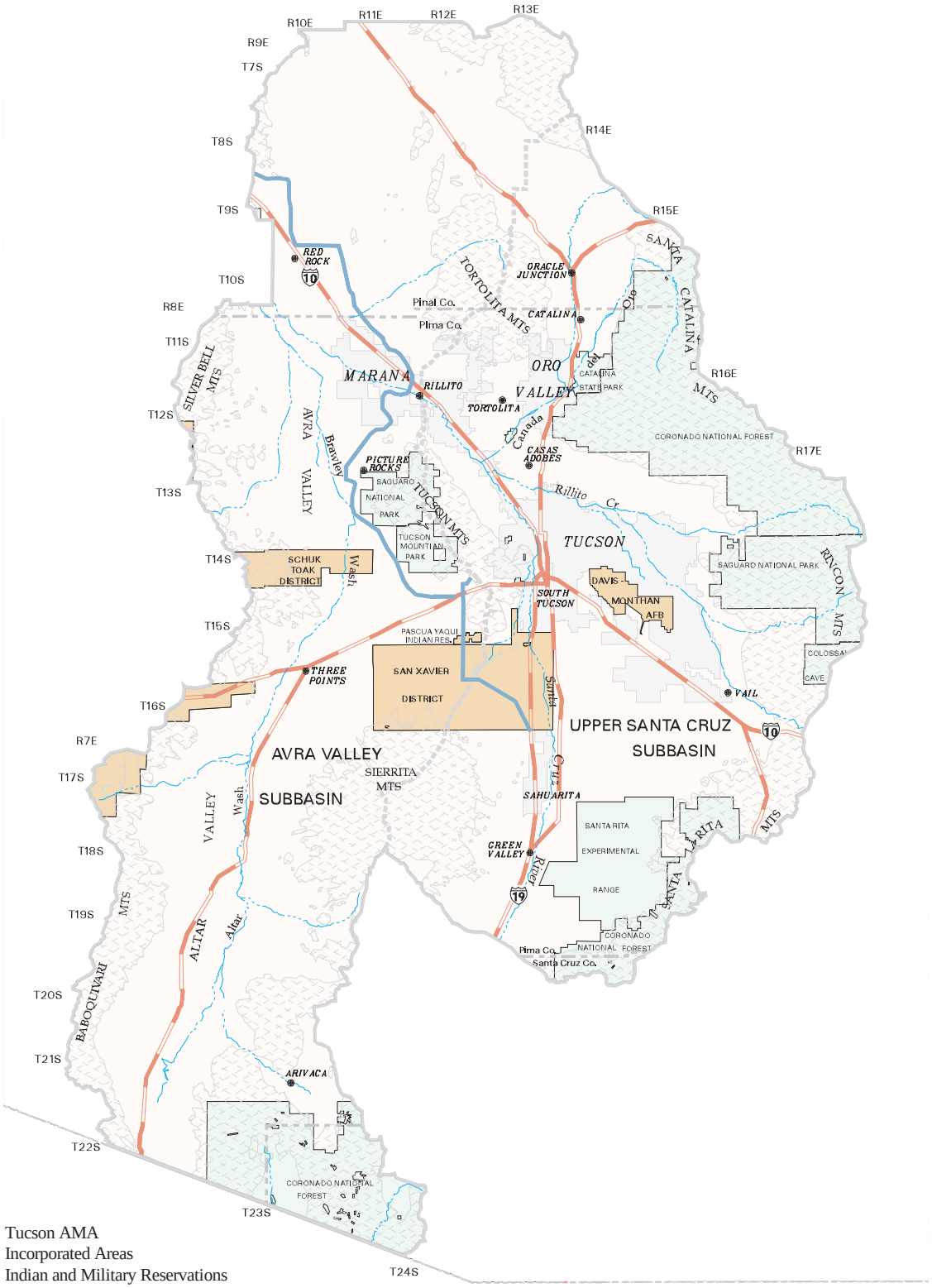
Active Management Areas
and Irrigation Non-Expansion Areas

Tucson AMA
AMAs
INAs
State Boundary

0 12 24 36 48
Miles

North

ORIGINAL SOURCE
Arizona Department of Water Resources
Geographic Information System



- Tucson AMA
- Incorporated Areas
- Indian and Military Reservations
- National Forest
- Hardrock
- Streets and Highways
- CAP Canal
- Subbasins
- Counties
- Rivers and Streams

Figure 1- 2

Tucson Active Management Area

0 3 6 9 12 Miles

North

ORIGINAL SOURCE

Arizona Department of Water Resources
Geographic Information System

In order to address the unique hydrologic nature of the Santa Cruz AMA, the goal identified for that AMA is to maintain safe-yield and prevent local water tables from experiencing long-term declines. In the Pinal AMA, where a predominately agricultural economy exists, the goal is to protect the agricultural economy as long as feasible and preserve water supplies for future non-agricultural purposes.

Safe-yield, as defined in the Code, means "to achieve and thereafter maintain a long-term balance between the annual amount of groundwater withdrawn in an active management area and the annual amount of natural and artificial groundwater recharge in the active management area." A.R.S. § 45-561(12). The volume of groundwater that can be withdrawn while maintaining a safe-yield condition in the AMA will not be a fixed amount; it will change due to annual variations in incidental recharge, natural recharge, and artificial recharge. If long-term water level trends (after adjusting for stored credits) show declining water tables on an AMA-wide average basis, groundwater withdrawals will have to be reduced and the safe-yield volume estimate adjusted accordingly. If long-term water levels rise (after adjusting for stored credits) above the level expected due to variations in incidental recharge, natural recharge, and safe-yield recharge, groundwater withdrawals may be increased. These evaluations of the impacts of withdrawals on localized long-term water levels could be made at regular intervals to ensure long-term groundwater level stability.

Information from annual water use reports is used to estimate the volume of groundwater withdrawals, water stored, and recovered water in an AMA. Water budgets are constructed to illustrate the total supply and demand picture. At the point in time where water budget estimates indicate groundwater withdrawals have been reduced to a safe-yield volume, groundwater levels will need to be monitored in the context of a hydrologic model to ensure that a safe-yield condition is maintained and to understand the effects of stored water. Hydrologic models can be used to predict changes in water levels based on projected groundwater pumping and credit recovery patterns and to verify assumptions in the water budget. The Department's subsidence monitoring and gravity surveys will be increasingly useful in verifying whether water level rises result from increases in storage or from changes in aquifer compaction over time.

Safe-yield is achieved on an AMA-wide basis; the Code does not recognize localized achievement of safe-yield. The amount of groundwater pumped under safe-yield conditions is not allocated on a subbasin or local basis. It is recognized that as safe-yield conditions are attained on an AMA-wide basis some areas could be depleted, some areas of active recharge could be in surplus, and other areas could achieve a localized balance between the amount of water recharged and pumped.

Since the development of the Second Management Plan, new information has become available regarding the physical availability and distribution of water supplies. For example, recent publications by the United States Geological Survey have heightened awareness of the potential for land subsidence in the AMAs. This improved understanding of the risks associated with ongoing pumpage in certain areas brings a new perspective to safe-yield. A more site-specific, local resource management approach may be needed. Additional tools may be required to develop a more resource-based, localized water management program.

During the third management period, a critical area management strategy will be evaluated that establishes additional water management goals for specific geographic areas within the AMA. These goals may relate to mitigation of subsidence, water supply reliability, water quality management, implementation of Indian water rights settlements, or other groundwater supply-related considerations.

1.3.2.3 Management Plans

To achieve the management goal for each AMA, water conservation and management requirements are established in each of five management periods. The five management periods are as follows:

First Management Period:	1980-1990
Second Management Period:	1990-2000

Third Management Period:	2000-2010
Fourth Management Period:	2010-2020
Fifth Management Period:	2020-2025

Requirements for each management period are described in separate management plans prepared for each AMA. Management plans include water conservation requirements for agricultural, municipal, and industrial groundwater users; a water quality assessment and management program; an augmentation and recharge program; conservation assistance programs; and other management programs that define how the AMA will achieve its management goal.

The management plans also quantify the volume of the groundwater right for agricultural and municipal users. For example, in the case of Irrigation Grandfathered Rights, the right established in the Code is to irrigate particular acres of land that were historically irrigated. The volume of water that may be applied to that acreage, the "water duty," is defined in the management plans. Similarly, service area rights for municipal users are not quantified in the Code but are quantified through the gallons per capita per day program in the management plan.

In each successive management period, the preparation of a management plan provides the Department and AMA water users with the opportunity to analyze the effectiveness of previous water management efforts and address water management issues in the AMA. Adjustments in water management strategies and conservation requirements are made in each successive plan to help achieve management goals.

The First Management Plan was the first step toward a comprehensive and effective management program. The plan initiated conservation programs and focused attention on important water management issues. The Second Management Plan expanded on the conservation programs of the First Management Plan and integrated water augmentation into the AMA management strategy. The Second Management Plan placed a strong focus on evaluation of conservation potential and implementation of water conservation measures to achieve cost-effective levels of efficiency in water use. New programs for conservation and augmentation assistance were included as well.

Even after the implementation of two management plans, groundwater remains a significant source of supply for municipal, agricultural, and industrial uses in all five AMAs. The total annual groundwater overdraft in the Tucson AMA decreased from 179,000 acre-feet in 1985 to close to 164,000 acre-feet in 1995, but remains a serious problem.

The third management period constitutes the midpoint in Arizona's effort to achieve its groundwater management goals. After the end of the third management period in 2010, there will be only 15 years left to achieve safe-yield by 2025. The Third Management Plan establishes a water management strategy that encompasses the use of water conservation, augmentation, recharge, and water quality management by the agricultural, municipal, and industrial sectors to help achieve the safe-yield goal by 2025. In order to achieve safe-yield, all water supplies must be used efficiently, and mechanisms need to be developed to replace existing groundwater use with renewable supplies.

Water conservation requirements in the Third Management Plan are similar in structure to those established in the Second Management Plan. Changes in the Third Management Plan address comments received from regulated water users, additional water management issues, and local water management concerns. The Third Management Plan describes the developing role the Department and the water users must play in meeting local, regional, and statewide water management objectives. Achievement of safe-yield and other objectives will require community-wide support and commitment.

1.3.2.4 Assured Water Supply Program

The Code prohibits the sale or lease of subdivided land in an AMA without the demonstration of an assured water supply. The Assured Water Supply Program (AWS Program) was instituted in 1980, but substantially strengthened in 1995 with adoption of the Assured Water Supply Rules (AWS Rules). Under the AWS Rules, new development within an AMA must demonstrate that sufficient water supplies of adequate quantity and quality are available to meet proposed uses for 100 years. The AWS Rules require the utilization of these supplies to be consistent with the safe-yield management goal of the AMA. Only after demonstration of sufficient water supply can a development be approved for sale to the public.

The AWS Rules apply to developers who seek a Certificate of Assured Water Supply (Certificate of AWS) for an individual subdivision and to water providers seeking a Designation of Assured Water Supply (Designation of AWS). A Designation of AWS results from a demonstration that there are adequate water supplies available to the provider to meet current and future demands of the customers currently on their system, and the demands of customers they have committed to serve, for 100 years. The water supplies used to demonstrate an assured water supply may include surface water, effluent, imported groundwater, credits from extinguishment of groundwater rights, a quantity of allowable groundwater use specified by the AWS Rules, or water stored pursuant to an underground storage permit. The AWS Program plays a key role in achievement of the management goal since it requires the largest water use sector in the AMA to move from dependence on mined groundwater to the use of renewable supplies.

1.3.2.5 Revisions to the Groundwater Code

Since 1980, the Code has undergone numerous changes to address emerging water management issues. Sections have been added to limit use of water in artificial lakes, address underground storage and recovery of water, limit transfer of groundwater between groundwater basins statewide, establish groundwater replenishment districts and other entities designed to facilitate the use of renewable supplies, establish the water conservation assistance program, and provide alternative municipal and agricultural conservation programs. In addition, numerous changes have been made to expand or clarify previous language and deregulate small groundwater users.

Throughout this process, the fundamental concepts of allocating the right to use groundwater and planning for the efficient and economic use of the water have been preserved. The Code, as comprehensive as it is, does not contain detailed instructions on how to manage water resources. Instead it provides a framework from which water management decisions are made in the AMAs. The Department and the water users, through the development and implementation of the management plans and community-based decisions, must establish the management strategies that lead to efficient water management and achieving safe-yield and related management goals.

1.4 GOVERNMENTAL AND INSTITUTIONAL SETTING

Water management activities within the Tucson AMA are carried out by a number of entities. City, county, special district and regional government functions include retail water delivery, flood control, wastewater management, water quality management, planning, and zoning. Several user groups, advisory committees, citizen's groups, and other organizations play significant roles in developing legislative and policy guidelines and educational programs relating to water resources use and conservation. The Groundwater Users Advisory Council (GUAC) for each AMA advises the director of the AMA and the director of the Department on issues relating to groundwater management in the AMA.

The Central Arizona Water Conservation District (CAWCD), also known as the Central Arizona Project (CAP), is a multi-county governmental agency that was formed to reimburse federal CAP canal construction costs, operate the CAP canal, and deliver CAP water to users in AMAs. The CAWCD is

overseen by an elected board of 15 members, which represents the three-county service area of the district. The Central Arizona Groundwater Replenishment District (CAGRD) is a tax-exempt public improvement district authorized by state legislation to acquire water supplies to replenish aquifers depleted by district members. It is an organizational unit of the CAWCD and is overseen by the CAWCD board. CAWCD has been involved in construction of three demonstration recharge projects in the Tucson AMA.

The Arizona Water Banking Authority (AWBA) was created in 1996, primarily to ensure that Arizona's municipal and industrial allocations of Colorado River water will be protected in times of shortage. The AWBA uses several funding sources to buy excess CAP water and recharge it for the future benefit of users both inside and outside of the CAP service area. The AWBA is authorized to store water to support the management objectives of the AMAs and to engage in interstate water banking under specified conditions. The AWBA has a five-member appointed board chaired by the director of the Department. The AWBA staff are housed in the Department's offices.

The Arizona Water Protection Fund (AWPF) was established in 1994 to provide grant monies for implementation of projects to protect or restore the state's riparian areas. The Fund may be used to purchase CAP water or effluent for riparian enhancement. The AWPF Commission oversees the grants process; the director of the Department serves as an ex-officio member on the Commission and the staff are located within the Department.

At the state level, the Arizona Department of Environmental Quality (ADEQ) develops and enforces water quality regulations. Through recent legislation (amending provisions of the Water Quality Assurance Revolving Fund or WQARF) the Department and ADEQ jointly participate in specified activities related to protection of groundwater quality and remediation.

The Arizona Corporation Commission (ACC) regulates the activities of private water companies, particularly those related to rate-setting. The Arizona Department of Real Estate works with the Department to assure availability of water for new subdivisions.

Federal water management activities in the Tucson area include the Bureau of Reclamation's involvement in regional water supply planning, possible construction of terminal storage facilities for CAP water, and research into treatment alternatives for CAP water. The Bureau of Reclamation also participates in negotiations to provide water resources to Indian communities on behalf of the Secretary of the Interior. Additional federal water management activities include an Army Corps of Engineers' River Basin Study, the Environmental Protection Agency's Superfund program, and the National Pollutant Discharge Elimination System permit program. The United States Geological Survey works independently and in conjunction with the Department and others in the collection and analysis of hydrologic and subsidence-related data and flood warning information.

The Tohono O'odham and Pascua Yaqui Indian Nations are involved with issues related to the use of groundwater and renewable water supplies. The San Xavier and Schuk Toak Districts of the Tohono O'odham Nation are the focus of ongoing negotiations related to the Southern Arizona Water Rights Settlement Act, federal legislation addressing water claims in the Tucson AMA.

1.5 DEVELOPMENT OF THE THIRD MANAGEMENT PLAN

Preparation of the Third Management Plan has been guided by a set of overriding principles and specific objectives. These principles and objectives and the Third Management Plan development process are described below.

1.5.1 Guiding Principles in Program Development

The Code provides the Department with a series of management tools, some of which are more effective than others. In addition to the Code, general management principles have been developed to guide the operations of the Department and preparation of the Third Management Plan. These are:

- **The authorities granted to the Department must be integrated into a coordinated strategy for meeting the management goal of the AMA.** Numerous tools are provided by the statutory structure to assist in meeting water management objectives. These tools include: (1) groundwater rights components of the Code, (2) assured water supply provisions, (3) underground storage and recovery provisions, (4) permitting requirements and conditions, (5) authority to develop well-spacing rules, (6) AWBA and AWPF activities, (7) conservation and augmentation assistance programs, and (8) water use reporting and enforcement authorities. All of these activities must be integrated and focused toward meeting the goal.

- **Effective water management must include both supply augmentation and demand management programs.** Supply augmentation includes substitution of renewable supplies for non-renewable groundwater resources, storage of excess renewable water for future use, utilization of effluent, and meeting new demands with renewable supplies. The major focus of demand management is water conservation and restrictions on certain uses such as lakes. Demand management extends the availability of existing water supplies to serve more uses over a longer time frame.

- **Effective and efficient water management must take a long-term perspective and be regional in scope.** The Department is responsible for ensuring that sustainable water supplies are available for future generations. If possible, safe-yield should be achieved sooner than 2025, and efforts to ensure that the goal can be maintained after 2025 should be encouraged.

- **All water sources need to be included in any long-term, comprehensive water management strategy.** Because groundwater use reductions are dependent on the efficient utilization of non-groundwater sources, the inclusion of these sources in a water management program is essential.

- **Water users must have an integral role in management program development and implementation.** Water users with expertise in their own water use sector must play a major role in development and implementation of water management programs in order to ensure the success of these programs.

- **Water management efforts must consider economic impacts and feasibility.** Attaining water management goals requires the expenditure of public and private funds, which must be used as effectively and efficiently as possible. Therefore, water management strategies must be developed using sound economic principles.

- **Educating the public on water issues and involving the public in developing management programs are essential to building and sustaining an effective water management effort.** It is ultimately the members of the public who are asked to commit to implementing water management strategies. It is essential to provide them with the information they need to make informed choices and the opportunity to participate in developing water management programs.

- **Water management efforts should be consistent with, and enhance, the quality of life in the community.** Social values and environmental quality considerations are integral to the development of water management approaches in Arizona. Adverse impacts on the quality of life and the potential for economic development must be avoided to the greatest extent possible.

- **The Department's water management efforts must recognize that individual customers, water users, water providers, municipal governments, and the real estate industry are important decision-makers.** The role of the Department's programs and regulatory tools is to create a decision-making environment that results in good water management decisions and investments.

- **Renewable water supplies available today must be used to meet the needs of the future.** Excess CAP water available during the third management period must be managed to meet growing AMA demands and to provide adequate supplies during future water shortages. Underground storage of excess CAP water by the AWBA and by AMA water providers is an important component of successful water management.

- **Water management programs should provide a stable institutional framework creates an environment of certainty in water resource decision-making.** Water users and providers must commit to, and implement, long-range plans in a world of evolving regulations. The provision of a predictable framework within which these regulations will evolve reduces uncertainty. Additionally, management programs must be clearly stated and free of ambiguity, while maintaining flexibility to respond to changing conditions.

- **Local water management issues must be addressed as regional and statewide strategies are developed.** There must be recognition of the impacts that regional or statewide water management programs can have on local water users.

- **Water management programs should be based on the premise that future issues are unlikely to be the same as those we have encountered in the past, and that the pace of change is likely to increase.** In order to provide maximum flexibility for the future, data bases must be enhanced and tools developed to identify trends early and to test scenarios that vary from current conditions.

1.5.2 Third Management Plan Objectives

The following objectives must be achieved during the third management period:

- The Department will establish and implement Third Management Plan water conservation requirements among all groundwater users as equitably as possible. Public acceptance and economic, technical, health, and environmental constraints will be considered when establishing these requirements. Flexibility will be provided as appropriate to address water users who, while implementing effective conservation measures, may not be able to comply with specific conservation regulations. Unique circumstances may be addressed through alternative conservation requirements designed to result in equivalent conservation or through variance or administrative review procedures provided for by statute.

- The Department will maintain conservation requirements initiated by the Second Management Plan that were effective and expand them where appropriate. The Department will recognize existing conservation efforts in setting Third Management Plan conservation standards.

- The Department will provide financial and technical assistance to implement water conservation, augmentation, monitoring, and recharge measures.

- The Department will encourage development of infrastructure that will allow use and storage of renewable water supplies.

- The Department will expand public assistance and public education efforts to reach a larger portion of the public.

- The Department will provide incentives, as appropriate, to encourage water conservation and water augmentation activities consistent with water management objectives.

- Department staff will actively participate in regional and local water management planning and cooperative projects.

- The Department will collect, analyze, and maintain data in order to provide the information necessary to identify water management issues and trends and to propose appropriate and timely solutions.

- The Department will endeavor to enhance water quality management efforts in order to preserve the quality and quantity of water available for existing and future needs.

- The Department will encourage recharge activities in areas where storage of renewable supplies will be beneficial from a water management perspective. Management of both storage and recovery activities will be required to protect future water supplies and the storage capacity of the aquifers.

- The Department will encourage coordination between the many agencies that affect water policy, particularly the CAWCD, AWBA, CAGRD, ADEQ, and the ACC.

- The Department will work with the state's political leadership, water users, and the public to identify and develop the tools and additional statutory authority necessary to achieve water management goals and objectives, including reaching safe-yield by 2025.

1.5.3 Third Management Plan Development Process

Development of the Third Management Plan has involved data collection and analysis, issues identification, and program development. Public participation has been an important component of the process throughout the development of the Third Management Plan.

1.5.3.1 Program Development and Implementation

This Third Management Plan is the result of a three-staged work effort began in 1994. The first stage involved data collection and analysis culminating in development of a "State of the AMA" (SOAMA) report was widely distributed. In the second stage, issues identified in the SOAMA report and raised by the community were addressed in issue papers describing the issue and identifying recommended alternatives. The third stage involved developing recommended alternatives into program concepts and, ultimately, into the program chapters and legal requirements presented in the Third Management Plan. Throughout preparation of the Third Management Plan, public input and technical research have been used to identify issues, objectives, and solutions.

1.5.3.2 Public Participation

Multiple levels of public input have been used in development of the Third Management Plan. The Code established a five-member Groundwater Users Advisory Council (GUAC) for each AMA. The GUAC members are appointed by the Governor to represent the groundwater users in the area and advise the director of the Department and the AMA director on matters relating to water management within the AMA. Tucson AMA staff met regularly with the GUAC to obtain member opinions and recommendations

on all components of this plan. The GUAC meetings were open to the public, and interested groups and individuals communicated their views and recommendations in this forum. Pursuant to A.R.S. § 45-421(1), the GUAC must comment on the proposed plan before it is promulgated by the director.

The Department also consulted with numerous technical advisory committees (TACs) and groups comprised of technical experts, water providers, industry representatives, agricultural representatives, scientists, and other organizations and individuals concerned with water use and water resource issues. TACs were established to review material, identify issues, and advise the Department in the development of programs in the following areas:

• Municipal	(Phoenix and Tucson AMAs)
• Agricultural	(Phoenix and Tucson AMAs)
• Turf-related Facilities	(Phoenix and Tucson AMAs)
• Metal Mining Facilities	(Tucson AMA)
• Sand and Gravel Facilities	(Joint committee for the Tucson, Phoenix, and Pinal AMAs)
• Large-scale Power Plants and Cooling Facilities	(Joint committee for the Tucson and Phoenix AMAs)
• Dairy and Feedlot Operations	(Joint committee for the Tucson, Phoenix, and Pinal AMAs)
• Augmentation and Recharge	(Phoenix and Tucson AMAs)

The TACs met over approximately a two-year period, and members spent considerable time reviewing data, discussing issues, and assisting in developing regulatory programs. Participation by the TACs was critical in development of the management plan. Technical review was also provided by outside committees and experts on the water quality, water resources, and water budget chapters. Public comments were received in meetings with interested parties and during and after presentations to civic organizations and the general public. The Department's philosophy is to maximize public input on the content of the management plans to ensure that the public's concerns and ideas are adequately incorporated.

Additional public input is obtained through formal public hearings conducted after the proposed plan is completed. A.R.S. § 45-570. In these hearings the Department presents information in support of the plan and obtains comments regarding the plan. Before the plan is adopted, the director of the Department may revise the plan and must prepare a written response to the written and oral comments submitted as part of the hearings process.

1.6 THIRD MANAGEMENT PLAN CONTENT

The Third Management Plan addresses water conservation, water quality, water augmentation, and related water management programs for the years 2000 to 2010, and comprises the following five primary elements:

- Assessment of the status of water supplies and demands in the AMA
- Mandatory conservation and monitoring requirements for agricultural, municipal, and industrial groundwater users and groundwater distribution systems
- Water supply augmentation and recharge program
- Water quality assessment and management program
- Conservation, augmentation, and monitoring assistance program

Statutory guidelines provided in A.R.S. §§ 45-566 and 566.01 direct that the following components be included in the Third Management Plan:

- New irrigation water duties for each farm unit
- An alternative agricultural program for Irrigation Grandfathered Right holders
- Additional reasonable reductions in per capita use to those specified in the Second Management Plan
- A Non-Per Capita Conservation Program for municipal providers
- Appropriate conservation measures for individual users on municipal systems
- Conservation or rate-of-use requirements for deliveries of untreated water
- Reasonable conservation requirements for small municipal providers
- Additional economically reasonable requirements for groundwater distribution by cities, towns, private water companies, and irrigation districts
- Conservation requirements for industrial uses based on the use of the latest commercially available conservation technology consistent with reasonable economic return
- A program for additional augmentation of water supplies by AMAs, if feasible, including incentives for artificial groundwater recharge
- Cooperation with the Arizona Department of Environmental Quality in developing a groundwater quality assessment for the AMAs including suggestions for groundwater protection
- A program for conservation assistance to water users
- At the discretion of the director, a program subsequent to January 1, 2006 for the purchase and retirement of grandfathered groundwater rights
- A determination of historic annual net recharge for AMAs in which a groundwater replenishment district is located
- For the Santa Cruz AMA, an evaluation of the potential impact of that AMA's Third Management Plan on the Tucson AMA
- For the Tucson, Phoenix, and Pinal AMAs, advice to the Arizona Water Banking Authority (AWBA) regarding whether storage in the AMA would help achieve the management goal, where such storage should occur, and whether extinguishment of long-term storage credits would help to achieve the management goal for the AMA

In addition, the Department describes in the Third Management Plan the groundwater management issues emerging in the AMA and what programs or changes in statute or rule may be required to resolve these issues.

Information is provided throughout the Third Management Plan to explain its development, educate interested individuals regarding the water management issues facing the AMA, and provide information useful in developing future water management policies for the AMA. Throughout the document there are significant policy statements regarding how the Department proposes to manage the AMA's water supplies pursuant to the provisions of the Code and the provisions of the Third Management Plan. The regulatory requirements for groundwater users and water distribution systems are printed in italics for easy reference and are located at the ends of Chapters 4 and 5, after each industrial use sector in Chapter 6, and in Chapters 8 and 9.

1.7 EMERGING CHALLENGES FOR THE TUCSON ACTIVE MANAGEMENT AREA

Several major challenges are emerging as the AMA moves into the third management period. The foremost challenge is achieving full utilization of available CAP supplies, including excess supplies that may only be available in the short term. Augmentation efforts are particularly important during the third management period, because during this period of relative abundance of Colorado River water, water must be stored to offset future periods of limited supplies and to achieve other management objectives. The Central Arizona Project (CAP) is clearly the major source of new supplies for the AMA, and utilization plans need to be implemented quickly.

The current volume of grandfathered groundwater right allotments far exceeds the amount of groundwater available for pumping under safe-yield conditions. During the second management period significant actions were taken toward reaching safe-yield, including establishment of the AWBA and the AWS Program. During the third and subsequent management periods, additional major changes in legislation or rules may be needed to improve the likelihood of achieving the safe-yield goal.

Another important challenge is addressing physical availability problems within specific geographic subareas of the AMA. While recognizing that the groundwater management goal for the Tucson AMA is defined as achieving safe-yield on a basin-wide basis, localized water management may be necessary to fully achieve the Code's stated policy of "protecting and stabilizing the general economy and welfare of this state and its citizens...." Localized issues may arise in areas experiencing rapid declines in water tables and possible subsidence and areas with water quality constraints or limited access to renewable water supplies. The AWS Rules will contribute to a more localized approach to water management in cases where groundwater deficits make it necessary for developers to obtain and deliver water supplies other than groundwater. Mechanisms such as recharge activities conducted by the AWBA, the CAGRD, and others also have the potential to address local water management issues. Addressing these major challenges will become an important part of the Tucson AMA's groundwater management strategy.

Groundwater and non-groundwater sources are managed under different statutes with limited integration and consistency in approach. As municipal growth increases demand for renewable supplies, sound management of all sources of water is warranted. It is recognized that there are major obstacles to conjunctive management of water supplies, but it is a worthy long-term goal.

1.8 CONCLUSION

The Third Management Plan is designed to outline the region's water management needs and present the Department's blueprint for working with water users to achieve the Tucson AMA's water management goals and objectives. Continued commitment will be needed from the Department and the public to reduce dependence on groundwater and achieve water conservation goals. With the support of the community, the Department can respond to changing water issues and needs while maintaining technical assistance and regulatory programs that ensure a dependable water supply for Arizona's future.

CHAPTER

2

Overview of Water Resources

2.1 INTRODUCTION

The Tucson Active Management Area (AMA) covers 3,866 square miles in southeastern Arizona and includes the Avra Valley Subbasin and the northern part of the Upper Santa Cruz Valley Subbasin (Figure 1-2). The Avra Valley Subbasin includes Avra Valley in the north and Altar Valley in the south (these are typically divided by the line between township 15 south and township 16 south). The AMA is in the basin and range physiographic province, characterized by broad, gently sloping alluvial basins separated by north to northwest trending fault block mountains. Elevations in the Tucson AMA range from 1,860 feet above mean sea level at the northwestern end of the AMA near Red Rock to 9,453 feet above mean sea level at Mount Wrightson in the southeastern portion of the AMA.

On July 1, 1994, the Santa Cruz AMA was formed. This new AMA consists of 716 square miles made up of the southern portion of the Upper Santa Cruz Valley Subbasin, an area formerly within the borders of the Tucson AMA. The Pima/Santa Cruz County line marks the approximate location of the divide between the Tucson AMA and the Santa Cruz AMA (Figure 1-2).

Average precipitation in the Tucson AMA ranges from 11 inches at the lower elevations to as much as 28 inches in the surrounding mountains (Brazil, et al., 1981, Arizona Meteorological Network (AZMET), 1995). Rainfall is seasonal, occurring in the winter months from frontal storms and in the summer from thunderstorm or "monsoon" activity. Average high temperatures in Tucson range from 67 degrees in January to 103 degrees in July. Summer rainfall activity coincides with the period of greatest evaporation potential. Average annual evapotranspiration is approximately 77 inches per year.

There are a number of factors that influence groundwater conditions in the Tucson AMA. These include the hydrogeologic characteristics of the two subbasins in the AMA, surface water flows, groundwater withdrawals, natural and artificial recharge, subsidence potential, and quality of groundwater in different locations. To avoid further damage from groundwater level declines and increasing subsidence, reliance on groundwater supplies needs to be reduced. Long-term stability of the AMA's water supply depends on conversion to effluent and Central Arizona Project (CAP) water, the primary renewable water sources available in this AMA.

Factors affecting groundwater conditions in the AMA and a description of available renewable water supplies are discussed in the following sections:

- Data sources
- Surface water conditions
- Geologic and aquifer characteristics
- Groundwater conditions
- Subsidence
- Water quality limitations
- Availability and utilization of renewable supplies

2.2 DATA SOURCES

Data sources describing hydrologic conditions in the AMA are available from the Arizona Department of Water Resources (Department), other state agencies, federal agencies, and water utilities. Some of the major data sources are described below.

2.2.1 Arizona Department of Water Resources Basic Data and Hydrology Divisions

The Department's Basic Data Division conducts annual water level measurements during periods of relatively low water demand in the late fall, winter, and early spring at 106 designated index wells

throughout the AMA. More in-depth analysis occurs every five years when approximately 600 wells are measured for water levels during this cooler time period when water levels in wells are more likely to be representative of regional water levels. Water samples are collected from approximately 12 wells each year in the spring or summer when wells are typically actively pumped and are analyzed for common inorganic constituents and selected trace metals. These data are periodically used to prepare hydrologic maps addressing water levels and water quality. Tucson AMA maps were published showing 1981/82 data for the Upper Santa Cruz Valley Subbasin and 1981 data for the Avra Valley Subbasin (Murphy and Hedley, 1984, Reeter and Cady, 1982, respectively). A map series updating water levels with 1994/95 data for both subbasins was published in 1997 (Hammett and Sicard, 1997).

The Department's Hydrology Division is participating in a cooperative subsidence monitoring effort with the United States Geological Survey (USGS), Tucson Water and Pima County using Global Positioning System monitoring equipment. This equipment tracks changes in land surface elevation over a broad area using a ground-to-satellite measurement system. Baseline data will be collected in 1998 followed by annual monitoring at stations throughout the area to detect year-to-year changes. In conjunction with subsidence monitoring activities, gravity meters will be used to generate data on the volume of groundwater in storage in the aquifer.

2.2.2 Arizona Department of Water Resources Computer Model

A three dimensional transient flow groundwater model of the Tucson AMA is being prepared as a tool to evaluate water resources in the AMA. The Department's Hydrology Division is preparing the model using information from previous groundwater models prepared by the Department and the USGS, and using additional water resources data on past and current groundwater conditions. The model will be completed in 1999. The Tucson AMA model can be used to project the regional impacts of CAP water recharge and recovery, future pumpage, and other supply and demand factors on water levels, groundwater storage, potential land subsidence, and aquifer productivity.

2.2.3 Other Agencies

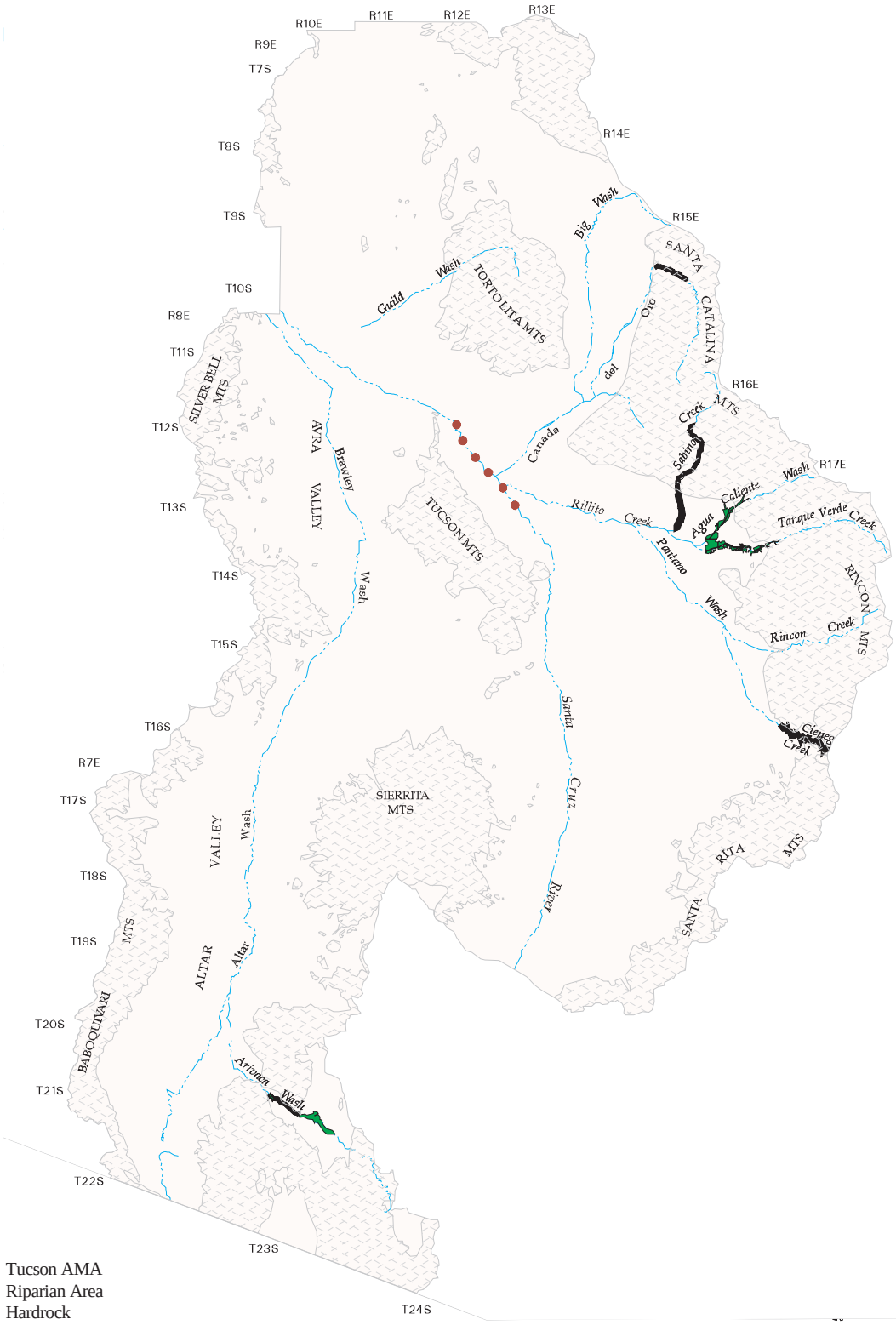
Water resources information is compiled by federal, state, and local entities in addition to the Department. Water quality sampling for organic and inorganic constituents is required by the Arizona Department of Environmental Quality (ADEQ) under the federal Clean Water Act. Results of this sampling are available in compiled databases at ADEQ.

The USGS has published numerous reports on water resources including recent reports on subsidence potential in the subbasins of the AMA (Hanson and Benedict, 1994; Hanson, Anderson and Pool, 1990; Anderson, 1988) and effluent recharge in the Santa Cruz River (Galyean, 1996). Basic hydrogeologic and water quality conditions were the subject of several reports in 1973 (Davidson, 1973; Laney, 1972). A network of stream gages is maintained by the USGS to monitor flow on a number of streams in the AMA including the Santa Cruz River, Rillito Creek, Sabino Creek, Tanque Verde Creek, Pantano Wash, Rincon Creek, and Arivaca Wash (Tadayon, et al., 1998).

The Pima Association of Governments has published 52 documents on water quality issues in the AMA (Pima Association of Governments, 1995). Tucson Water, the City of Tucson's water utility, compiles annual static water level reports for its wellfields and service area, and reports subsidence readings from a network of 13 extensometers monitored on a cooperative basis with the USGS (Tucson Water, 1997).

2.3 SURFACE WATER CONDITIONS

The main surface water drainage in the Tucson AMA is the Santa Cruz River which is about 60 miles long within the AMA (Figure 2-1). The Santa Cruz River originates in Arizona, then flows south into Mexico



Tucson AMA
Riparian Area
Hardrock
Rivers and Streams
Perennial Reach
Effluent-Dominated Reach

Figure 2- 1

Surface Water Features

ORIGINAL SOURCE
Arizona Department of Water Resources
Geographic Information System
Pima County Flood Control District

0 3 6 9 12
Miles
North

before bending west and north and reentering the United States east of Nogales, Arizona. The river flows north through both the Santa Cruz and Tucson AMAs in the Upper Santa Cruz Valley Subbasin, then flows northwest into the Avra Valley Subbasin. Surface water is present during some time periods in the reach of the river located within the Santa Cruz AMA as a result of precipitation events and effluent discharges from the Nogales International Wastewater Treatment Plant, which is located about 20 miles south of the Santa Cruz/Tucson AMA boundary. Under some conditions, surface water flows cross the Santa Cruz AMA boundary into the Tucson AMA. Within the Tucson AMA, the nine mile reach of the Santa Cruz River that flows north of the two regional wastewater treatment plants is perennial due to the volume of treated effluent discharged into the channel at Roger and Ina Roads. With the exception of this Tucson-area effluent-dominated reach, the remainder of the Santa Cruz River within the Tucson AMA is ephemeral and flows in response to rainfall events. In large precipitation events, the Santa Cruz River channel may carry sufficient surface water flows to cross the boundary into the adjacent Pinal AMA.

Major tributaries to the Santa Cruz River in the Upper Santa Cruz Valley Subbasin include the Cañada del Oro, which makes up the northern part of the Upper Santa Cruz Valley Subbasin, and Rillito Creek and its tributaries, which drain the area north and east of Tucson. Tributaries to Rillito Creek include the Pantano Wash and Tanque Verde Wash, which in turn receive flow from Sabino Creek, Rincon Creek, and Cienega Creek. In the Avra Valley Subbasin, Altar Wash originates in the southern portion and flows northward to become Brawley Wash. Brawley Wash flows to the north and northwest through Avra Valley to its confluence with the Santa Cruz River. A portion of Arivaca Wash in the southeastern portion of the Avra Valley Subbasin is perennial. Cienega Creek, Sabino Creek, and the Cañada del Oro have small perennial reaches within their lengths. Continued surface water flows in perennial reaches of Cienega Creek and Arivaca Wash depend on the maintenance of high groundwater tables in these areas.

Surface water flow recharges the Tucson AMA aquifer after infiltrating down through stream channel sediments. Stream channel recharge is a component of net natural recharge as discussed in section 2.5.3 and is incorporated into water supply estimates in the water budget as described in Chapter 11.

2.4 GEOLOGIC AND AQUIFER CHARACTERISTICS

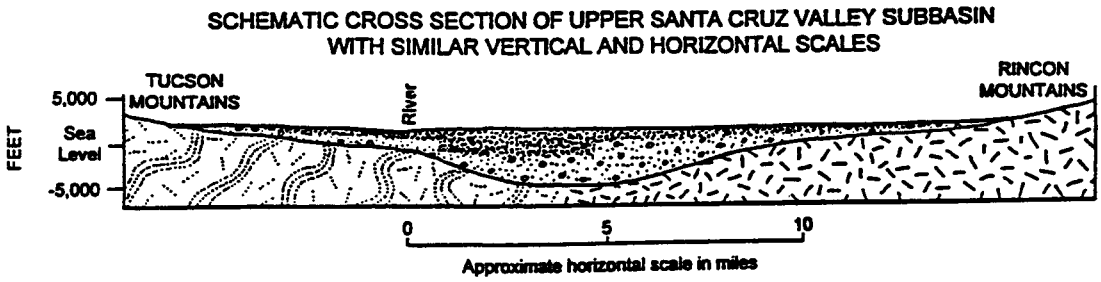
The Upper Santa Cruz Valley Subbasin and the Avra Valley Subbasin consist of alluvial basins and the surrounding mountains. The alluvial basins are composed of deep layers of sediments containing substantial volumes of groundwater. The composition and productivity of these sediment layers differs in the two subbasins of the Tucson AMA.

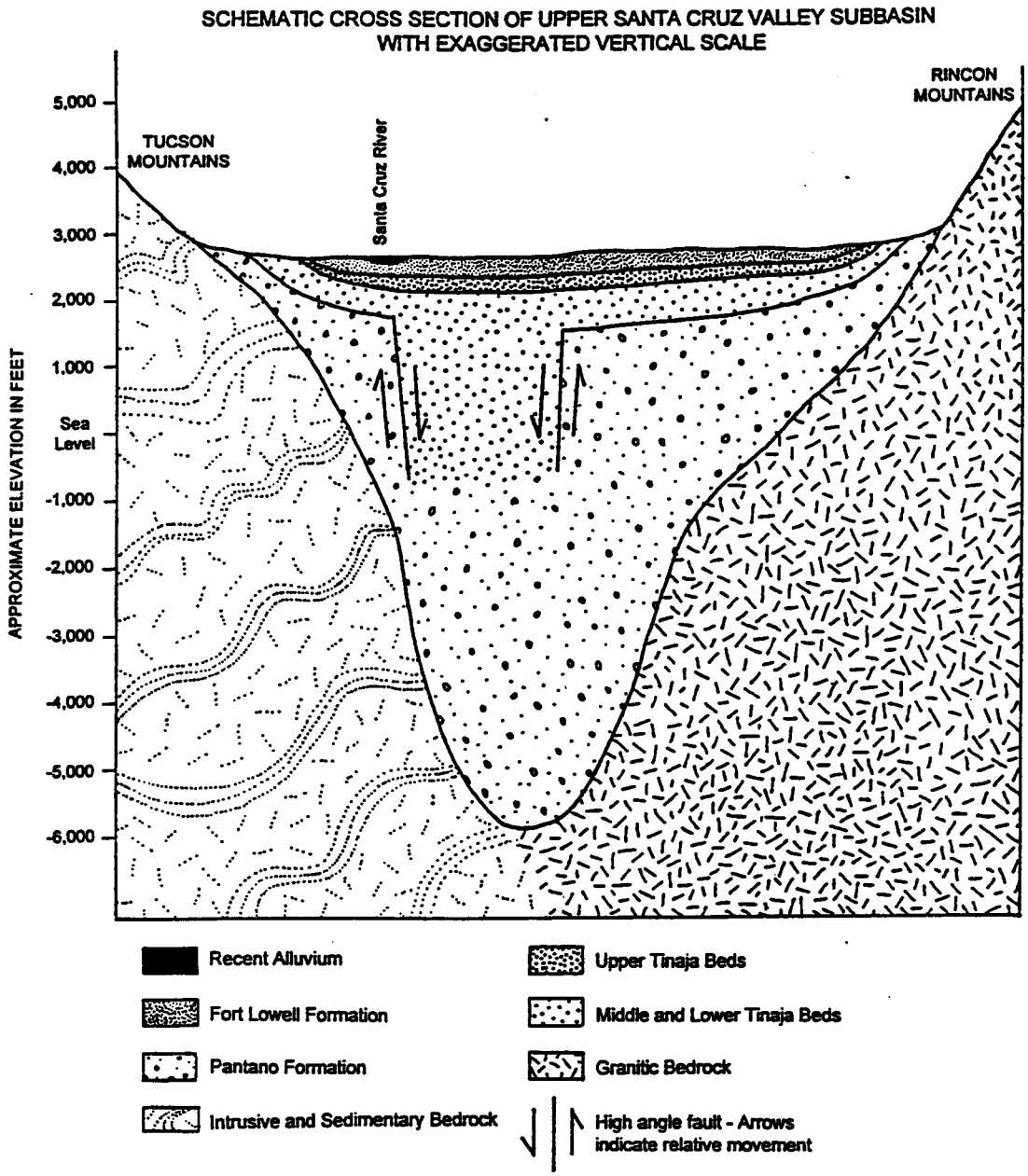
2.4.1 Upper Santa Cruz Valley Subbasin

The depth to bedrock at the center of the Upper Santa Cruz Valley Subbasin is in excess of 11,000 feet (Hanson and Benedict, 1994). Alluvial sediments in this basin have been divided into four hydrogeologic units that are, in descending order: (1) surficial or recent alluvial deposits, (2) the Fort Lowell Formation, (3) the Tinaja Beds, and (4) the Pantano Formation (Davidson, 1973) (Figure 2-2). These four units are hydrologically connected to varying degrees and form the main regional aquifer of the subbasin. Below the basin-fill sediments is the Basement Unit, which forms the impermeable bedrock floor of the basin and extends to the surrounding mountain sides. This bedrock has little groundwater storage and low production capacity and is not considered to be a reliable aquifer.

Each of the four units in the Upper Santa Cruz Valley Subbasin have unique geologic and water bearing characteristics. Recent alluvial deposits occupy the streambed channels of the Santa Cruz River and its major tributaries. These deposits are usually less than 100 feet thick (Davidson, 1973). The recent alluvium consists of predominantly unconsolidated sand and gravel and generally has high infiltration

FIGURE 2-2
SCHEMATIC CROSS SECTION OF THE UPPER SANTA CRUZ VALLEY SUBBASIN
TUCSON ACTIVE MANAGEMENT AREA





rates. The Fort Lowell Formation underlies the recent alluvial deposits and consists of unconsolidated to moderately consolidated sands and silts 300 to 400 feet thick throughout most of the basin (Davidson, 1973). In the past, the Fort Lowell Formation supplied most of the water used in the Tucson basin. Portions of this formation are now partially or completely dewatered (Tucson Water, 1998).

The Tinaja Beds underlying the Fort Lowell Formation consist of sandstones and conglomerates ranging to siltstones and mudstones with a total thickness of up to 5,000 feet in the center of the basin (Davidson, 1973). The Tinaja Beds consist of upper, middle, and lower units, and have become the principal supply source of groundwater in the Tucson Basin. The upper Tinaja Beds yield groundwater more readily than the middle and lower Tinaja Beds. The Pantano Formation underlies the Tinaja Beds and is up to 6,400 feet thick on the far eastern border of the AMA near Davidson Canyon (Davidson, 1973). It is composed of consolidated sandstones, conglomerates, and mudstones. Because of its great depth and the degree of cementation, it has relatively low well yields. The Pantano Formation is not widely used as a source of groundwater.

2.4.2 Avra Valley Subbasin

Alluvial sediments in the Avra Valley Subbasin have been divided into two units known as the upper alluvial unit and the lower alluvial unit (Hanson et al., 1990). The upper alluvial unit is composed of silt and gravel, and includes streambed deposits that occupy Altar and Brawley Washes and their major tributaries. The thickness of the upper unit ranges from less than 100 feet to as much as 1,000 feet (Hanson et al., 1990). The lower alluvial unit is thousands of feet thick and consists of gravel and conglomerates along the margins of the subbasin grading to silts and mudstones along the subbasin's central axis (Hanson et al., 1990). Most groundwater production in the Avra Valley subbasin is from the upper unit.

2.4.3 Effects on Recharge

The zone below land surface and above the water table is known as the vadose zone. In cases where groundwater levels have declined, the vadose zone can include sediments that were formerly saturated with water. In the case of natural recharge and various forms of managed recharge, variations in the way water moves through these sediments affects where and how water recharges the aquifer. In some locations, layers of silt or clay in the vadose zone may impede the downward migration of the water so that even though this water infiltrates through surface sediments it may not reach the groundwater aquifer. The movement of water once it has reached the groundwater table is affected by the direction of groundwater flow in that location, the characteristics of the aquifer material, the volume of water that has been recharged, and other site-specific variables. Variations in vadose zone and aquifer layers that affect the velocity and path of recharging water need to be taken into consideration in water management and recharge efforts.

2.5 GROUNDWATER CONDITIONS

Several types of maps are used in the following discussion to illustrate groundwater conditions in the Tucson AMA. These maps are based on the location of the water table–the "surface" of the groundwater–relative to either land surface, sea level, or the water table at a different point in time (Figure 2-3). When this information is known for a number of wells in an area, lines of equal elevation (contour lines) can be drawn showing the water table surface. Depth-to-water maps indicate how deep the top of the water table is beneath the surface of the land at different locations (Figure 2-3A). Water level elevation maps are used to show the level of the water table relative to average (mean) sea level (Figure 2-3A). The slope of the water table and the direction of groundwater flow can normally be determined using a water level elevation map. Water level change maps show areas where the water table has fallen or risen during a given time period (Figure 2-3B). Groundwater conditions change over time due to natural and human-

induced changes in the amount of water being added to, or removed from, the groundwater system. Because groundwater flows very slowly underground, the effects of pumping and recharge can alter the shape of the water table for long periods of time. Water that is naturally or artificially recharged can mound up underground, while pumping can create a cone of depression in the water table (Figure 2-3C). The current status and long-term changes in groundwater levels in the Tucson AMA are discussed in the following sections.

2.5.1 Depth to Groundwater

Depths to water in the AMA vary substantially depending, in part, on land surface elevations and proximity to natural drainage areas. In 1995, the depth to water in the Upper Santa Cruz Valley Subbasin ranged from less than 100 feet to over 600 feet below land surface (ft bls) (Figure 2-4). In 1995, depths to water in the Avra Valley Subbasin ranged from less than 200 to over 700 ft bls in Altar Valley, and from less than 200 to greater than 500 ft bls in Avra Valley (Figures 1-2 and 2-4). In general, depths to water tend to be shallower near rivers and major washes and deeper near mountain fronts where land surface elevations are higher.

2.5.2 Groundwater Levels

Groundwater levels in the Tucson AMA have changed substantially in the last 50 years as a result of groundwater pumping for municipal, agricultural, and industrial uses. Current and historical water level elevations, and changes in these elevations over time, are discussed and illustrated in the following sections.

2.5.2.1 Past Groundwater Levels

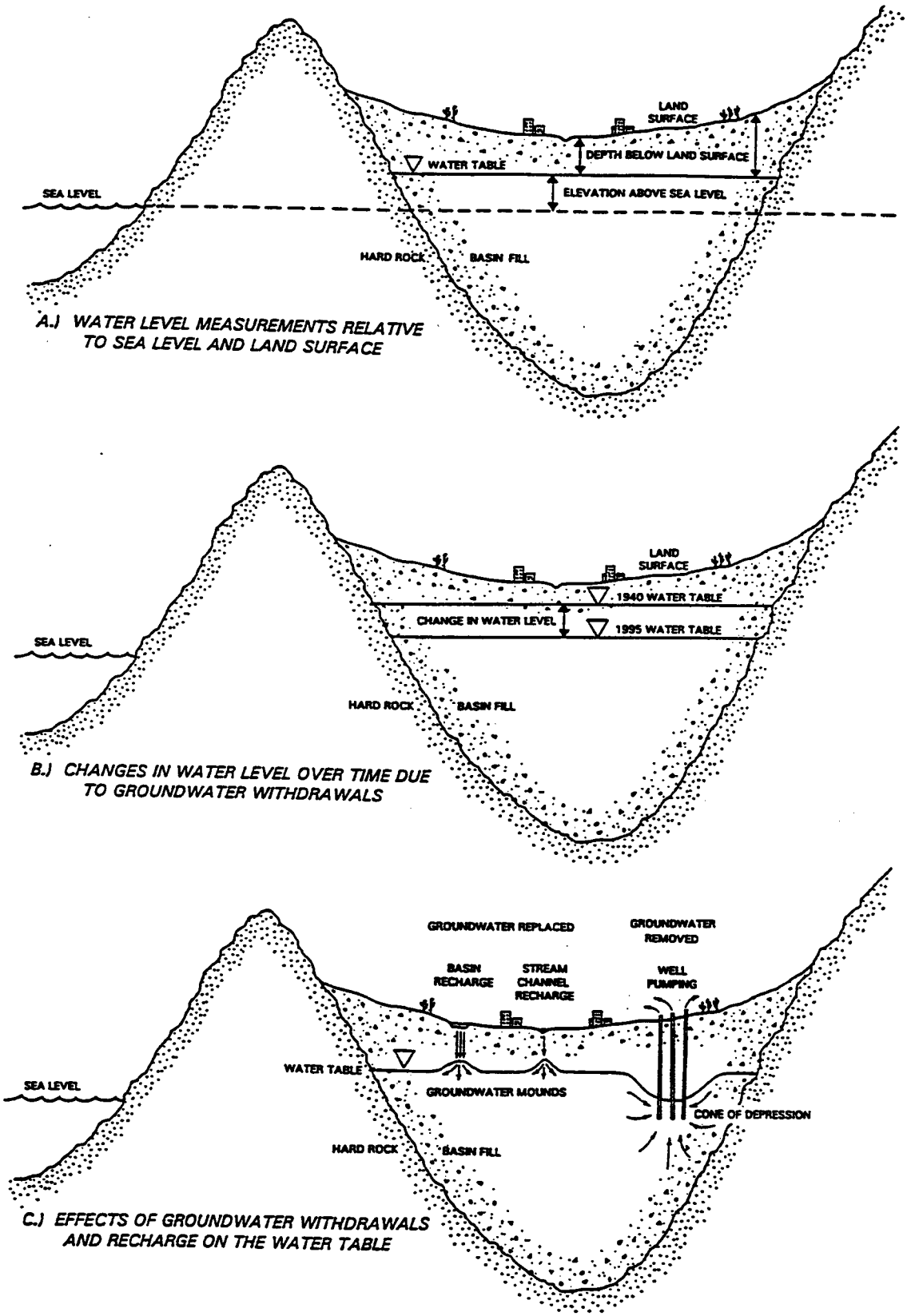
Water level elevations prior to major groundwater development in the AMA indicate that groundwater flowed toward the north and northwest at a fairly constant slope (Figure 2-5). Groundwater development intensified beginning in the late 1940s and early 1950s and has continued since that time. By 1965, water level contours were deflected by groundwater pumping for municipal use in the City of Tucson's Central Wellfield. By 1982, a cone of depression had developed in the Green Valley/Sahuarita area due to groundwater pumping by local copper mines (Figures 1-2 and 2-6).

2.5.2.2 Current Groundwater Levels

The deflection of groundwater elevation contours continued to increase between 1982 and 1995 in the City of Tucson's Central Wellfield and in the vicinity of pumping by metal mines in the Green Valley/Sahuarita area (Figures 2-6 and 2-7).

Water level elevations in the Upper Santa Cruz Valley Subbasin in 1995 generally decreased from 2,950 feet above mean sea level (ft above msl) in the southern portion of the subbasin, and from 3,050 ft above msl in the northern Cañada del Oro drainage, to around 1,900 ft above msl in the northwest portion of the subbasin where groundwater flows into the Avra Valley Subbasin (Figure 2-7). In the Avra Valley Subbasin, water level elevations ranged from 3,100 ft above msl in southern Altar Valley to 1,600 ft above msl at the northwest border of the Tucson AMA where groundwater flows into the adjacent Pinal AMA. With the exception of the Cañada del Oro area where groundwater flows south and then west, groundwater in both AMA subbasins generally flows north and northwest toward the northwest boundary of the AMA. The water table is presently at land surface and results in flowing surface water in Cienega Creek and Arivaca Wash. Other streams in the AMA generally flow as a result of snowmelt and stormwater flow.

FIGURE 2-3
CONCEPTS IN MAPPING GROUNDWATER LEVELS



2.5.2.3 Change in Groundwater Levels Over Time

Declines in groundwater levels reaching 200 feet in the City of Tucson's Central Wellfield and 150 feet in the Green Valley/Sahuarita area are indicated on a map of water level changes between around 1940 and 1995 (Figure 2-8).

A cone of depression is a "bowl" shape created in the groundwater table as a result of groundwater pumpage from a well (Figure 2-3C). Once a cone of depression is created, groundwater in the vicinity of the cone stops moving with the regional flow pattern and instead moves toward the center of the depression. If the rate of pumping continues, the cone of depression grows, getting deeper and broader. If multiple wells are being pumped, regional water level declines can occur as shown in Figure 2-8.

Water level hydrographs have been compiled to show water level changes between 1950 and 1995 at individual wells in the AMA (Figure 2-9). The location of these wells is shown on Figure 2-8. These hydrographs generally indicate that long-term water level declines have occurred in most locations. Groundwater levels have declined as much as 200 feet in the City of Tucson's Central Wellfield due to municipal pumpage, with declines averaging up to 4 to 5 feet per year. Declines have occurred steadily in the Central Wellfield since the 1950s (Figure 2-9A). Northwest of the Green Valley/Sahuarita area, pumping by copper mines has resulted in a 160-foot water level decline (Figure 2-9B). Additional areas of groundwater decline include 90 feet in southern Avra Valley due to municipal pumping by the City of Tucson, 70 feet in northwest Avra Valley due to agricultural pumping, and 50 feet in the lower Cañada del Oro area due to municipal uses (Figures 2-9C, D, and E, respectively).

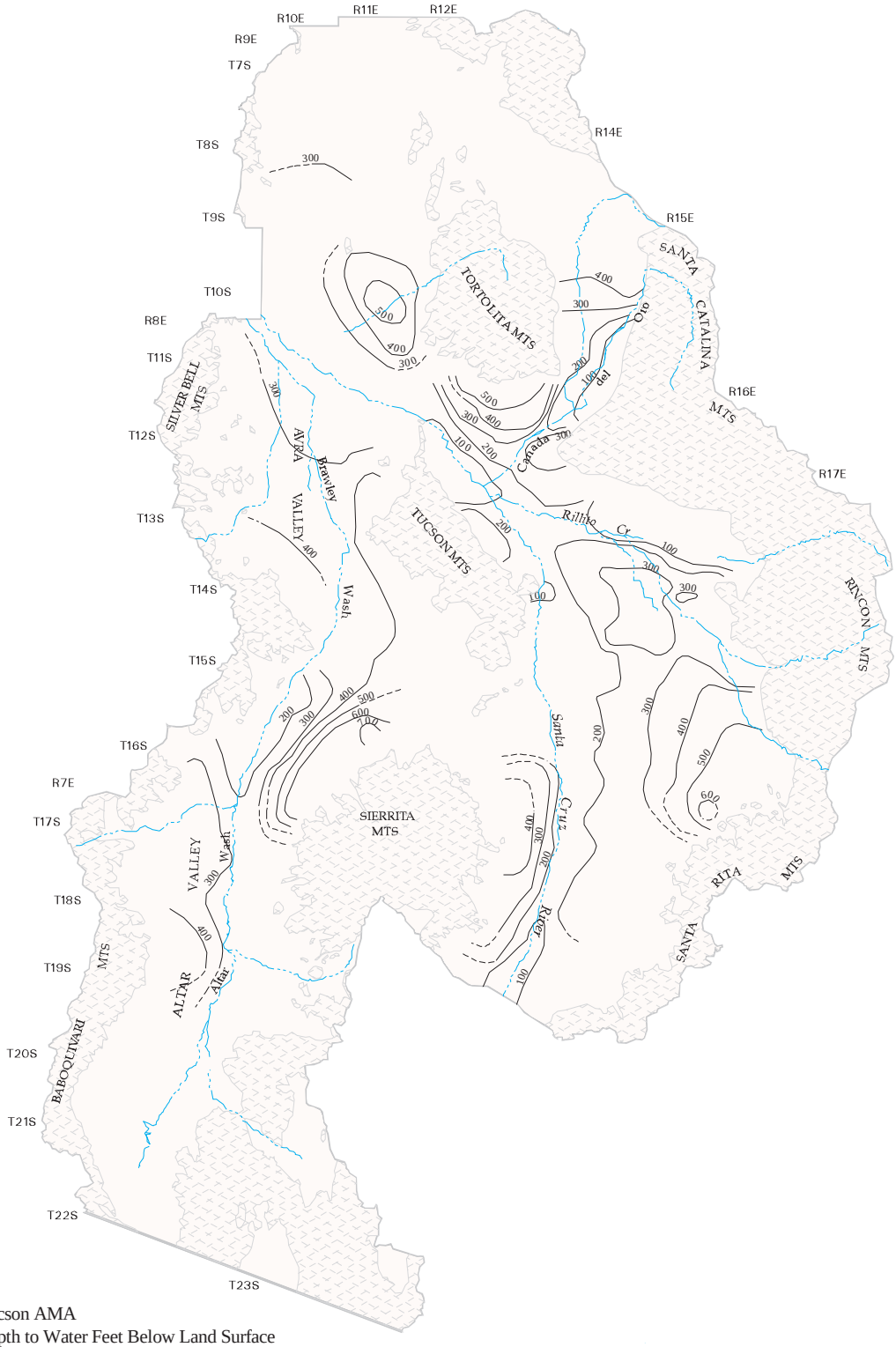
While overall water levels have continued to decline in much of the AMA, some areas have experienced water level rises since the late 1970s. The greatest rises have occurred along the Santa Cruz River where larger than average flood flows since the late 1970s resulted in increased natural recharge. Rises of up to 80 feet have occurred along the Santa Cruz River just north of the Santa Cruz/Tucson AMA boundary resulting from increased infiltration of flood flows and effluent discharges, and decreased agricultural and mine pumpage during this period (Figure 2-9F). Under some conditions there is sufficient surface water in the Santa Cruz River to flow from the Santa Cruz AMA into the Tucson AMA.

Since the late 1970s, water levels have risen 60 feet in the area southeast of Marana due to increased natural recharge from the Santa Cruz River and decreased agricultural pumpage (Figures 2-9G). Effluent discharges to the Santa Cruz River have also contributed to rising water levels along the river. Rises of 30 feet in the upper reaches of the Cañada del Oro since the late 1970s may be due to increased mountain front recharge and infiltration of stream channel runoff occurring during years of high precipitation (Figure 2-9H.). In several of these areas, water levels have recovered to water levels present around 1940.

Groundwater levels in the future will depend on the amount and location of groundwater pumping; recharge of CAP water; direct use of CAP water by agriculture, industry, and municipal users; direct use and recharge of treated effluent; and changes in water demand. The Tucson AMA groundwater model will be used to project water level changes in the future based on various supply, demand, and recharge scenarios.

2.5.3 Net Natural Recharge

Average net natural recharge resulting from infiltration of precipitation and groundwater underflow is estimated at 60,800 acre-feet per year in the Tucson AMA (Table 2-1). Of this total, an estimated 51,300 acre-feet of net natural recharge occurs in the Upper Santa Cruz Valley Subbasin and 9,500 acre-feet occurs in the Avra Valley Subbasin.



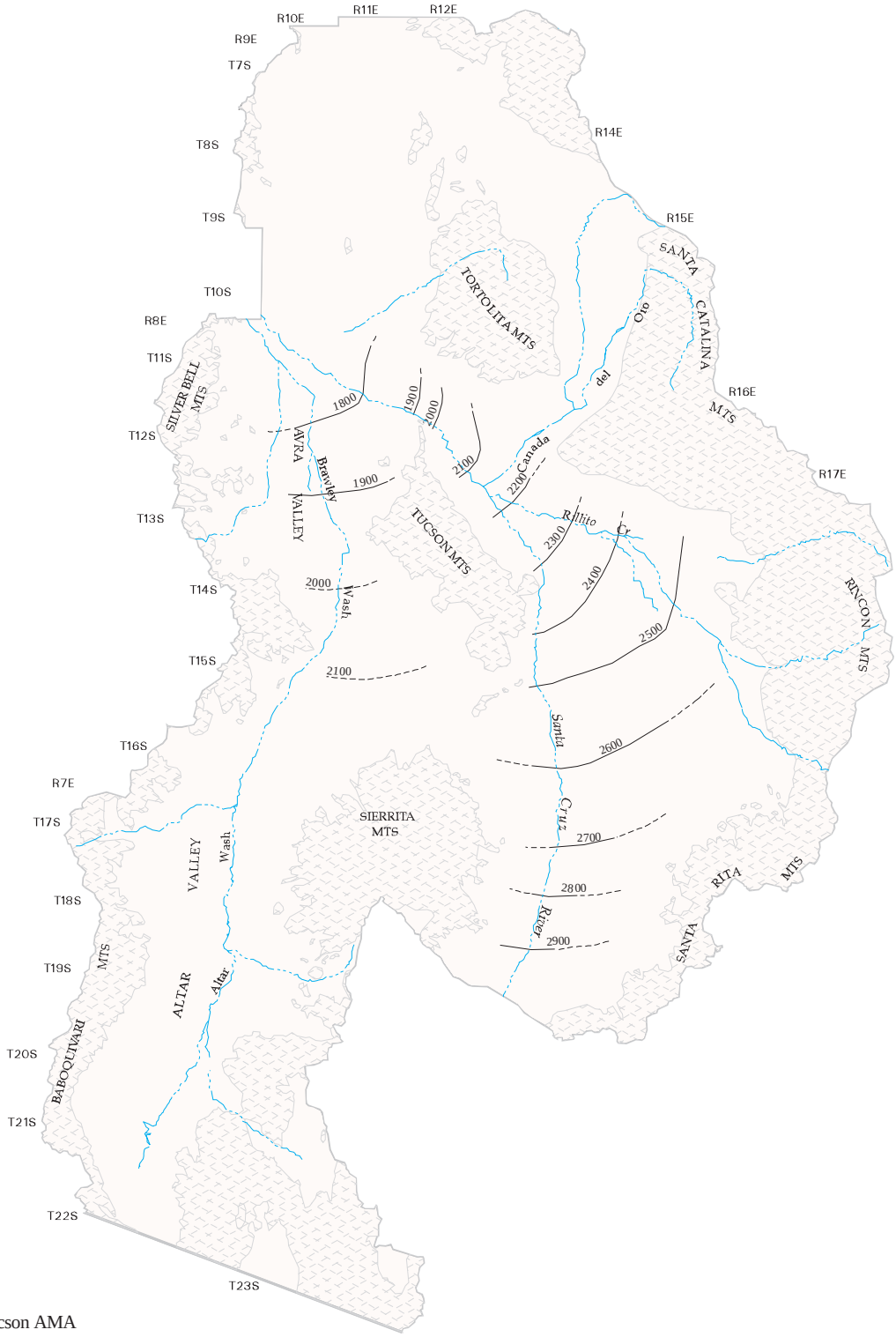
Tucson AMA
Depth to Water Feet Below Land Surface
Approximate Depth to Water Feet Below Land Surface
Hardrock
Rivers and Streams

Figure 2- 4

Depth to Water
1995

0 3 6 9 12
Miles
North

ORIGINAL SOURCE
Arizona Department of Water Resources
Hydrology Division



Tucson AMA
Water Elevation Feet Above Mean Sea Level
Approximate Elevation Feet Above Mean Sea Level

Hardrock
Rivers and Streams

Figure 2- 5

Water Elevations
1940

0 3 6 9 12
Miles

North

ORIGINAL SOURCE
Arizona Department of Water Resources
Hydrology Division

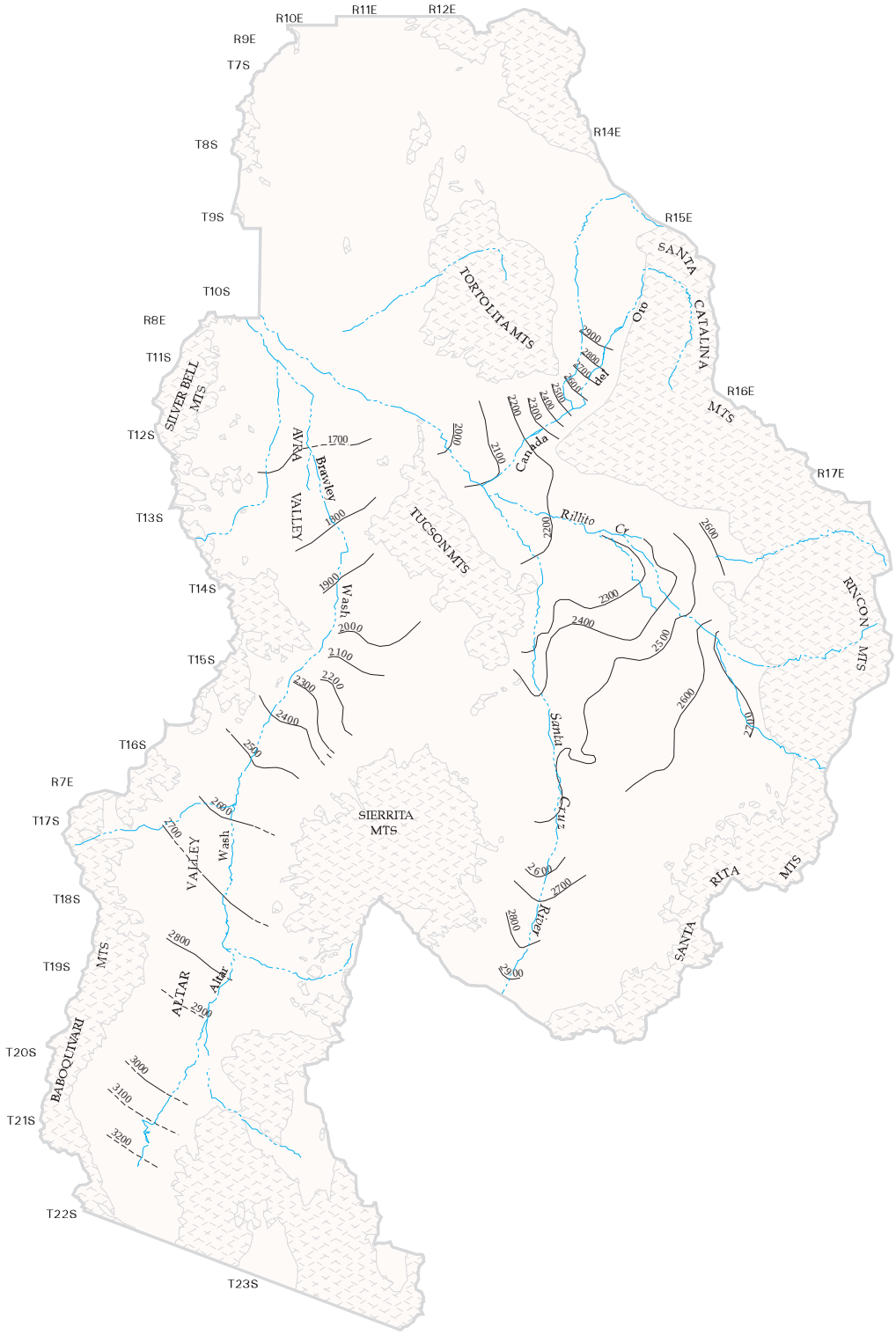


Figure 2- 6

Water Elevations
1981 - 1982

- Tucson AMA
- Water Elevation Feet Above Mean Sea Level
- Approximate Elevation Feet Above Mean Sea Level
- Hardrock
- Rivers and Streams

0 3 6 9 12
Miles

North

ORIGINAL SOURCE

Arizona Department of Water Resources
Hydrology Division

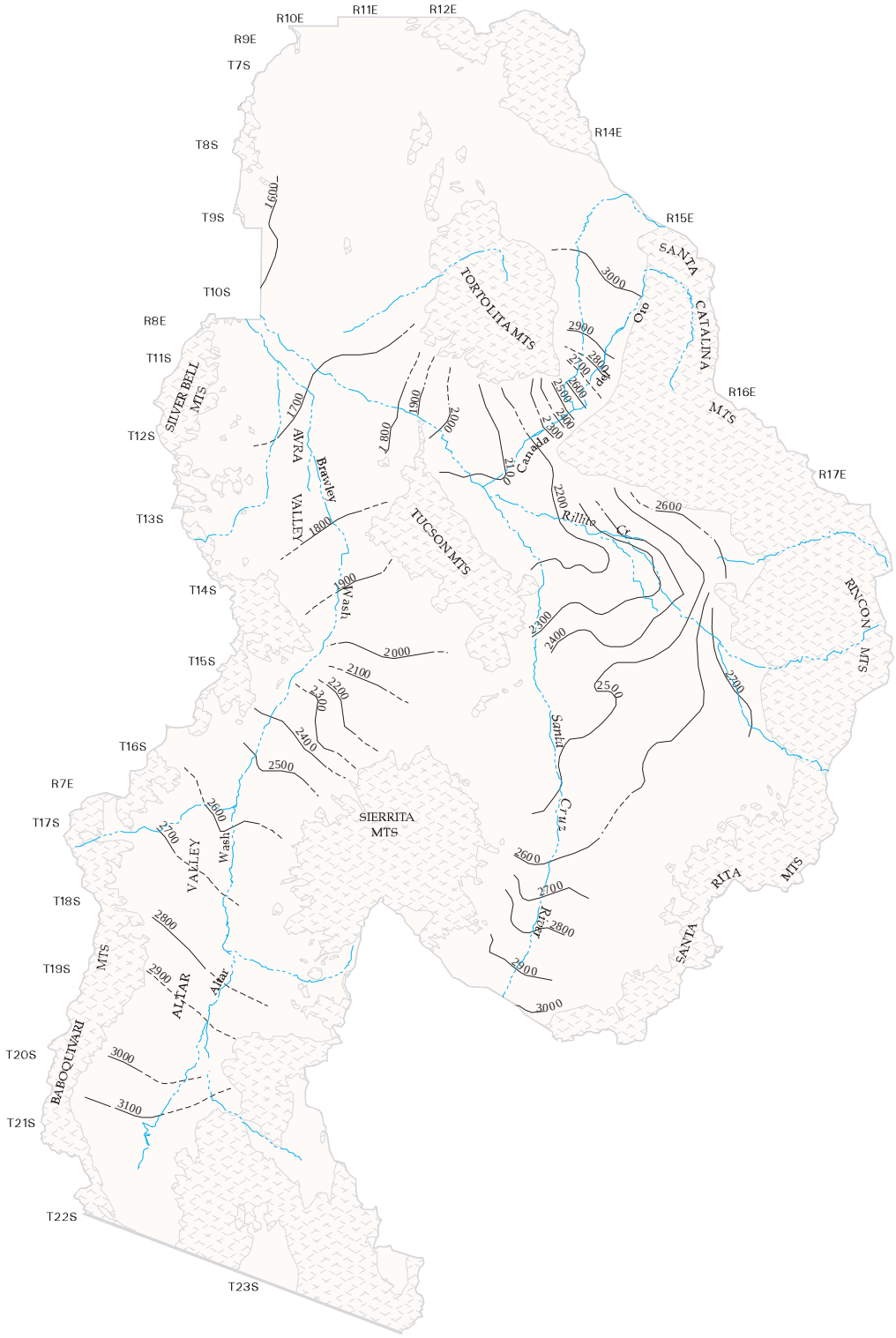


Figure 2- 7

Water Elevations
1995

- Tucson AMA
- Water Elevation Feet Above Mean Sea Level
- Approximate Elevation Feet Above Mean Sea Level
- Hardrock
- Rivers and Streams

0 3 6 9 12 Miles

North

ORIGINAL SOURCE

Arizona Department of Water Resources
Hydrology Division

TUCSON AMA

MAP	HYDROGRAPH
A	D-14-14 24BAA
B	D-16-13 34AAB2
C	D-15-11 05CCD
D	D-10-10 05DAD
E	D-12-13 22BBB
F	D-19-13 09CAA
G	D-12-11 20AAA
H	D-10-14 29DCA

Tucson AMA
Water Elevation Changes in Feet
Hardrock
Rivers and Streams
Wells Used for Hydrographs

Figure 2- 8

Water Elevation Changes
1940 - 1995

0 3 6 9 12
Miles
North

ORIGINAL SOURCE
Arizona Department of Water Resources
Hydrology Division

FIGURE 2-9
WATER LEVEL HYDROGRAPHS AT SELECTED LOCATIONS
TUCSON ACTIVE MANAGEMENT AREA

FIGURE 2-8A. WELL D-14-14 24BAA
CENTRAL WELLFIELD

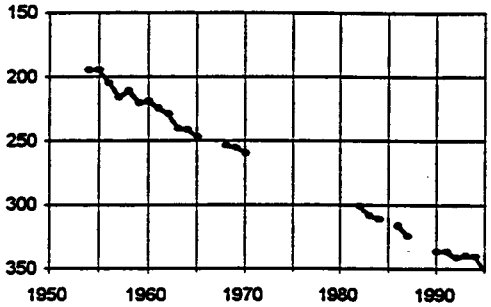


FIGURE 2-8B. WELL D-16-13 34AAB2
NORTHWEST OF SAHUARITA

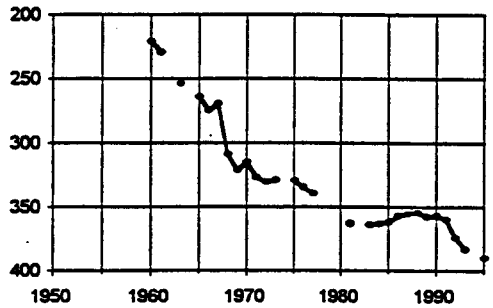


FIGURE 2-8C. WELL D-15-11 5CCD
SOUTHERN AVRA VALLEY

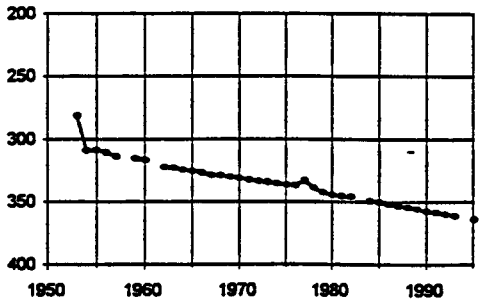


FIGURE 2-8D. WELL D-10-10 5DAD
NORTHWEST AVRA VALLEY

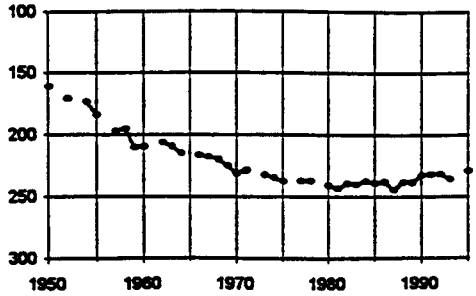


FIGURE 2-8E. WELL D-12-13 22BBB
LOWER CANADA DEL ORO

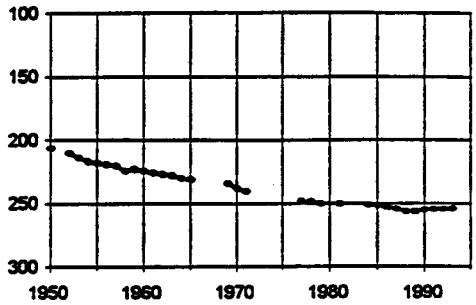


FIGURE 2-8F. WELL D-19-13 9CAA
SOUTHERN GREEN VALLEY AREA

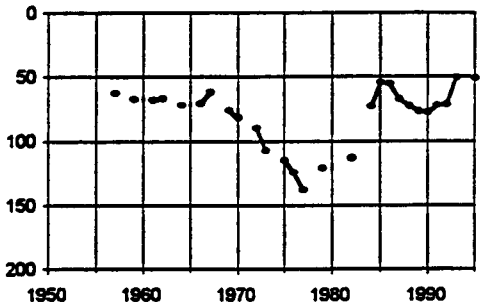


FIGURE 2-8G. WELL D-12-11 20AAA
SOUTHEAST OF MARANA

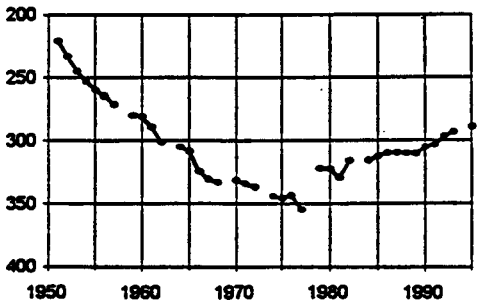
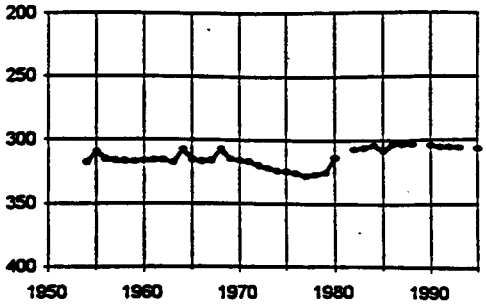


FIGURE 2-8H. WELL D-10-14 29DCA
UPPER CANADA DEL ORO



Rainfall and snowmelt replenish the aquifer as mountain front recharge, which occurs in channels at the margins of mountain ranges. Mountain front recharge in the Upper Santa Cruz Valley Subbasin is estimated at 27,000 acre-feet each year. In the Avra Valley Subbasin, mountain front recharge is around 11,900 acre-feet per year.

TABLE 2-1
NET NATURAL RECHARGE COMPONENTS IN THE WATER BUDGET
TUCSON ACTIVE MANAGEMENT AREA

Elements of Net Natural Recharge	Volume (acre-feet)
UPPER SANTA CRUZ VALLEY SUBBASIN	
Mountain Front Recharge	27,000
Stream Channel Recharge[1]	31,000
Groundwater Inflow from Santa Cruz Active Management Area[2, 3]	8,700
Groundwater Outflow to Avra Valley Subbasin[3]	(15,400)
Total Net Natural Recharge in Upper Santa Cruz Valley Subbasin	**51,300**
AVRA VALLEY SUBBASIN	
Mountain Front Recharge	11,900
Stream Channel Recharge	6,700
Groundwater Inflow from Upper Santa Cruz Valley Subbasin[3]	15,400
Groundwater Outflow to Pinal Active Management Area[3]	(24,500)
Total Net Natural Recharge in Avra Valley Subbasin	**9,500**
TOTAL NET NATURAL RECHARGE IN TUCSON ACTIVE MANAGEMENT AREA	**60,800**

[1] Surface water that flows in the Santa Cruz River from the Santa Cruz AMA into the Tucson AMA is accounted for in the Tucson AMA water budget only if it infiltrates into the groundwater aquifer within the boundary of the Tucson AMA, in which case it is accounted for as stream channel recharge in the Upper Santa Cruz Subbasin.
[2] Surface water that infiltrates into the groundwater aquifer within the boundary of the Santa Cruz AMA can eventually flow as groundwater into the Tucson AMA, in which case it is accounted for as groundwater inflow in the Tucson AMA water budget.
[3] Groundwater inflow and outflow can vary over time due to changes in effluent discharge conditions, artificial recharge conditions, and groundwater pumping at or near the AMA boundaries.

Groundwater conditions in the Tucson AMA are greatly affected by intermittent but occasionally large surface water flows in the Santa Cruz River and its tributaries originating from precipitation. Surface water flows recharge the groundwater system in the vicinity of the stream as water infiltrates through the stream channel sediments to the underlying aquifer. Under some conditions, surface water in the Santa Cruz River flows out of the Santa Cruz AMA and into the Tucson AMA. While flow across the boundary varies substantially from year-to-year, the long-term median streamflow exiting the Santa Cruz AMA into the Tucson AMA is about 13,800 acre-feet per year as measured at the USGS Continental streamgage located about ten miles north of the Tucson AMA boundary. This surface water flow is accounted for in the Tucson AMA water budget only if it infiltrates into the groundwater aquifer within the boundary of the Tucson AMA, in which case it is accounted for as stream channel recharge in the Upper Santa Cruz Subbasin. Stream channel recharge in the Upper Santa Cruz Valley Subbasin is estimated at 31,000 acre-

feet per year and in the Avra Valley Subbasin at about 6,700 acre-feet per year. Infiltration of treated effluent discharged to the Santa Cruz River from Pima County's regional wastewater treatment plants in the Tucson AMA is not a component of net natural recharge calculations.

Groundwater inflow to the Tucson AMA occurs as a result of the northward flow of groundwater from the Santa Cruz AMA into the Tucson AMA in the Upper Santa Cruz Valley Subbasin. Estimates of groundwater inflow at this location range from 6,800 to 10,600 acre-feet per year. A long-term mean inflow of 8,700 acre-feet per year is used in the net natural recharge calculation. Within the boundary of the Tucson AMA, an estimated 15,400 acre-feet of groundwater flows out of the Upper Santa Cruz Valley Subbasin into the adjacent Avra Valley Subbasin in the area north of the Tucson Mountains. Groundwater exits the Tucson AMA and flows north into the Pinal AMA at the northwestern border of the Avra Valley Subbasin in the vicinity of Picacho Peak. Estimates of this outflow range from 19,000 to 30,000 acre-feet per year, with a long-term mean outflow of 24,500 acre-feet used in net natural recharge calculations.

Mean groundwater inflow and outflow volumes could vary in the future. One important variable is the volume of effluent discharged to the Santa Cruz River from wastewater treatment plants located along the river in the Santa Cruz and Tucson AMAs. Mexico has the right, at any time, to retain that country's portion of wastewater before it goes to the Nogales International Wastewater Treatment Plant or to recapture the effluent before it is discharged to the river. A portion of the effluent discharged from this plant infiltrates back to the aquifer and can affect groundwater inflow to the Tucson AMA. At the regional Pima County wastewater treatment plants at Roger Road and Ina Road in the Tucson AMA, the volume of effluent being released could vary due to changes in direct use of effluent or recharge activities with effluent. Effluent flowing from these regional plants affects water levels in the Marana area and subsequent groundwater outflow to the Pinal AMA. Other factors that could affect groundwater inflow and outflow are precipitation events, flood flows, and water-related activities at or near the AMA boundaries including CAP recharge and recovery and groundwater pumping levels.

2.5.4 Groundwater Storage Trends

The perception that there is a vast and effectively inexhaustible supply of readily available groundwater in Tucson AMA aquifers is inaccurate. Water users in the Tucson AMA pump more groundwater from the aquifers than is replenished by natural or artificial recharge, resulting in groundwater overdraft and a decrease in the volume of groundwater stored in aquifers in the AMA. Based on estimates of historical pumpage, evapotranspiration, and net natural and incidental recharge in the Tucson AMA, a preliminary estimate has been made that groundwater removed from AMA aquifers since around 1940 ranges from 6 to 8 million acre-feet depending on assumptions made about aquifer characteristics. This constitutes a range of from 7 percent to 9 percent of the estimated 70 million acre-feet of groundwater in storage down to 1,200 feet below land surface around 1940.

While a relatively small percentage of groundwater has been removed from storage, it represents the depletion of groundwater from the most productive and easily accessible layers of the aquifer. Future depletions will occur in deeper and less productive layers of the aquifer, with a corresponding increase in costs and detrimental effects. In general, the quality of the water decreases with depth due to increasing mineral content with depth.

The Tucson Water service area covers a fraction of the land area of the AMA but provides water service to 80 percent of the municipal population. It is estimated that 12.7 million acre-feet of groundwater storage remains down to 1,000 feet in depth in those portions of the Upper Santa Cruz Valley and Avra Valley that are within the Tucson Water service area (Malcolm Pirnie, 1996). This area includes the Central Wellfield where water level declines of as much as 200 feet have occurred. Tucson Water has observed decreasing productivity in many of its wells due to declining water levels (Tucson Water, 1998).

Estimates of groundwater in storage in Arizona have typically been made to depths of 1,000 to 1,200 feet below land surface. While extraction of water is possible to a depth of 1,200 feet or more below land surface, this can result in substantial damage to the aquifer and overlying land. The water table in the most heavily pumped areas of the aquifer is still generally within 400 feet of the land surface, but this has already resulted in negative consequences. The lowering of water levels has destroyed riparian habitat, caused erosion, displaced existing groundwater users, and reduced stream flows. As overdraft continues, a number of problems can result. Groundwater must be withdrawn from deeper levels of the aquifer resulting in a loss of productivity in wells and a corresponding need to deepen or replace existing wells. Pumping costs increase as the depth to water increases. Because the total dissolved solids content of the groundwater tends to increase with depth, the quality of pumped groundwater may decrease as older groundwater from deeper zones is pumped. Enlarging areas of water level decline and changes in regional groundwater flow patterns can increase the chance that contaminated groundwater moves from current locations. A recent computer modeling study indicates that aquifer compaction, land subsidence, land fissuring, and loss of aquifer capacity may occur in the Tucson AMA as water levels continue to decline (Hanson and Benedict, 1994). As land subsides, aquifer layers are compressed and can permanently lose some of their capacity to store water.

Because of these negative consequences, estimates of groundwater storage need to be understood in a larger context than volume alone. The intricacies of the hydrogeologic system and the interconnected nature of groundwater flow makes all users vulnerable to these declines; and this vulnerability is increasing with time and further depletion. To project the possible impacts of further groundwater declines, the Tucson AMA computer model will be used to estimate groundwater storage for different aquifer layers and to project changes in storage over time using various pumping and recharge scenarios. The groundwater underlying the AMA has accumulated over many thousands of years, but is being depleted in the time frame of decades. Ultimately, the only way to avoid damages from groundwater decline is to stop groundwater overdraft.

2.6 SUBSIDENCE

Land subsidence can occur when groundwater is withdrawn to such a degree that portions of an aquifer become dewatered and, due to the weight of overlying land, this material becomes compacted. This results in a drop in elevation at the land surface and can result in cracks and fissures.

Land subsidence can cause considerable damage to sewer, water, and gas pipelines; canals; wells; roads; buildings and other infrastructure. In addition, when aquifer material compacts, several characteristics of the aquifer can change. The pore space available to store water is reduced. This in turn could reduce the ease with which water moves through the aquifer material and the productivity of wells in the area of compaction. If these changes occur, they are generally irreversible.

Computer models have been used by the USGS to estimate a range of maximum potential land subsidence in subbasins within the Tucson AMA (Hanson 1989; Hansen et al., 1990; and Hanson and Benedict, 1994). Results of the modeling studies indicate that by 2025, maximum potential land subsidence in the City of Tucson's Central Wellfield could reach 1.2 feet or 12 feet depending on the assumptions made about the characteristics of the aquifer materials being compressed (Hanson and Benedict, 1994). These subsidence estimates are based on the assumption that pumping and natural recharge rates continue at 1986 levels through the year 2025 and that water levels decline more than 400 feet below 1940 water levels. Potential subsidence in the City of Tucson's Santa Cruz Wellfield located north of Sahuarita could reach 0 feet or 4 feet during this time period depending on the assumptions used (Hanson and Benedict, 1994). Maximum potential subsidence in northern Avra Valley could reach 0.9 feet or 14.7 feet (Hanson, et al., 1990). The Avra Valley subsidence estimate is based on the assumption that pumping levels and natural recharge rates continue at levels experienced in the mid-1970s, and also depends on the assumptions made

about aquifer material characteristics. The highest estimates of maximum potential land subsidence are shown in Figure 2-10 (Hansen and Benedict, 1994; Hansen et al., 1990).

If land subsides at the same rate over a large area, there is less impact to surface activities than if adjacent land subsides at different rates. Such "differential subsidence" can occur when subsurface conditions change over a short distance. This can occur near bedrock, around faults, and in areas where the composition of subsurface sediments change abruptly. Based on the maximum subsidence potential projected in the USGS modeling studies, it appears the depth of land subsidence could vary from 2 feet to 10 feet in the vicinity of downtown Tucson by 2025 and from 2 feet to 14 feet in the central area of Avra Valley by 2025 (Figure 2-10).

In the Tucson AMA, there is already some evidence of aquifer compaction and associated land subsidence attributed to aquifer dewatering. Fissuring, aquifer compaction, and subsidence have been observed in northern Avra Valley. In 1988, an earth fissure in Avra Valley damaged the CAP aqueduct, costing about $50,000 in repairs (Slaff, 1993). Sink holes have been reported near the Santa Cruz River within the San Xavier District (Hoffman, et al., 1997). These sinkholes are not directly related to regional subsidence but may be related to localized water level declines.

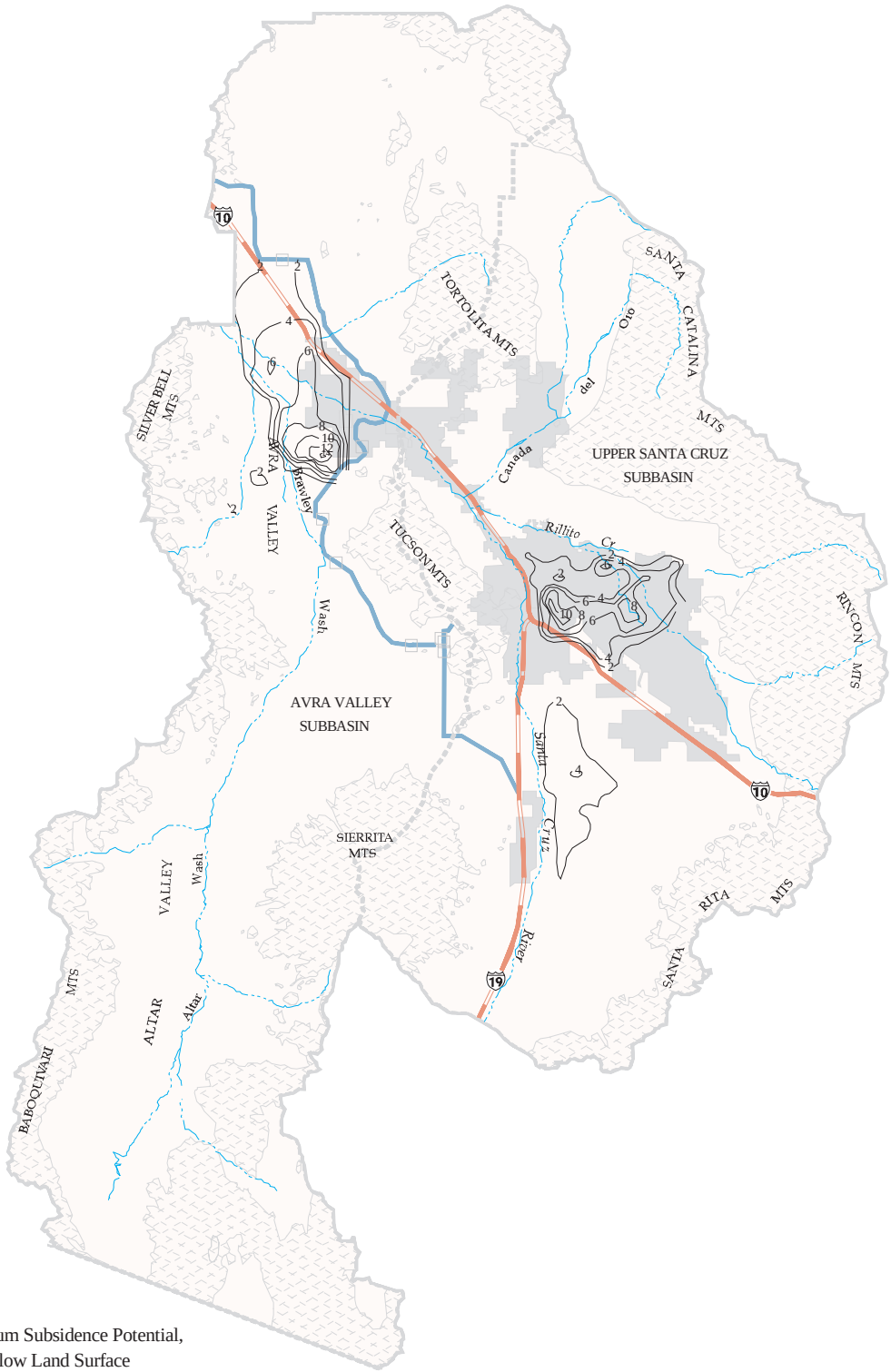
Aquifer compaction and associated land subsidence of nearly 0.5 feet had occurred south of Davis-Monthan Air Force Base by 1980 (Anderson, 1988). Subsidence monitoring has been conducted since the early 1980s by Tucson Water and the USGS using extensometers to measure aquifer compaction. In the northern Avra Valley subbasin, subsidence has been measured at 1.1 feet (Anderson, 1989). Measurement of compaction at specific locations in the time period between 1980 and 1995 were reported in the Tucson Water Annual Static Water Level Report for 1995 (Tucson Water, 1997). Results indicated compaction of from 0.02 feet to 0.18 feet at seven locations in the Upper Santa Cruz Subbasin and from 0.01 feet to 0.11 feet at seven locations in the Avra Valley Subbasin.

Future land subsidence can be minimized by halting groundwater pumping in vulnerable areas or by recharging water in the vicinity of the declining water table. Water should be recharged close to the compacting layer to be most effective, so well-injection recharge is a more useful strategy for addressing subsidence than basin recharge. Recharge could reduce the amount of compaction and could possibly result in the compacted layers rebounding to some extent. But in general, once subsidence has occurred, the addition of water to the subsurface cannot return land to its full original elevation (Slaff, 1993). Even though water levels may recover to previously high levels after subsidence occurs, because the aquifer material has been compacted, the space available for groundwater storage is reduced so less groundwater is available for pumping.

The Department currently monitors subsidence using extensometers and Global Positioning System (GPS) data. New technological developments in radar imaging from satellites shows promise for measuring changes in land surface elevation. This technology is known as radar interferometry. The combination of existing subsidence measuring approaches with the possible future use of radar interferometry could improve understanding of the areal extent and degree of land subsidence.

2.7 WATER QUALITY LIMITATIONS

The presence of elevated concentrations of inorganic and organic constituents can make water unacceptable for potable use prior to treatment due to health concerns or due to negative aesthetic characteristics. In some cases, this water may be acceptable for nonpotable uses in place of potable quality groundwater. Instances where the presence of elevated inorganic and organic constituents impact water supply are briefly addressed below. Water quality conditions in the Tucson AMA are discussed in depth in Chapter 7.



Maximum Subsidence Potential, Feet Below Land Surface
Incorporated Areas
Hardrock
Tucson AMA
Rivers and Streams
Interstates
Subbasins
CAP Canal
CAP Pumping Stations

Figure 2- 10

Maximum Projected Subsidence Potential by 2025

0 3 6 9 12
Miles

North

ORIGINAL SOURCE
U.S. Geological Survey
Water-Resources Investigations
Report 90-4178, 1990
Report 93-4196, 1994

2.7.1 Inorganic Constituents

Nitrates, sulfates, and total dissolved solids have been detected in groundwater in the Tucson AMA at concentrations exceeding established EPA primary and secondary maximum contaminant levels (Pima Association of Governments, 1994). Isolated areas of elevated sulfate and total dissolved solids concentrations have been detected near mining and agricultural operations in the AMA. Trace metals including silver, cadmium, chromium, lead, and selenium have been detected in groundwater in isolated areas. A few metals have been detected in groundwater samples associated with industrial waste disposal sites, airports, and mining areas. In most cases, these detections have not occurred in public supply wells and have not affected water supplies.

2.7.2 Volatile Organic Compounds

Groundwater supply wells associated with industrial and transportation facilities have been shut down in several areas of the AMA due to contamination from volatile organic compounds and fuels. Remediation of groundwater from contaminated sites is proceeding in the AMA, and a portion of this remediated water is being delivered to potable customers. As a result of the Water Consumer Protection Act passed in 1995, direct delivery of remediated water might be halted and the remediated water discharged into the Santa Cruz River bed instead.

2.8 AVAILABILITY AND UTILIZATION OF RENEWABLE SUPPLIES

To achieve safe-yield in the Tucson AMA by 2025, it is necessary to decrease reliance on groundwater supplies. An important component of this reduced reliance is to increase the use of renewable water supplies. The major renewable water supplies available in the Tucson AMA are secondary-treated effluent, secondary-treated effluent that has undergone additional treatment and is delivered through the City of Tucson's reclaimed water distribution system, and CAP water used either directly or through recharge and recovery projects.

The use of renewable supplies by the agricultural, municipal, and industrial sectors is described in chapters 3, 4, 5, and 6. Issues associated with the availability and potential use of CAP water and effluent are discussed in the Augmentation and Recharge Program in Chapter 8. The projected reduction in overdraft due to the use of renewable water supplies is shown in the AMA water budget in Chapter 11.

2.8.1 Effluent

Total production of effluent from all wastewater treatment plants in the Tucson AMA was approximately 68,600 acre-feet in 1995. The majority of this effluent, 65,400 acre-feet, is treated by the Pima County Wastewater Management Department at two regional wastewater treatment plants located along the Santa Cruz River at Roger Road and Ina Road.

In 1995, around 1,800 acre-feet of the effluent produced at these plants was delivered directly to the Cortaro Marana Irrigation District for agricultural irrigation, 1,200 acre-feet was delivered directly to turf facilities, and 7,000 acre-feet was diverted to the City of Tucson's reclaimed system for delivery to turf facilities located throughout the City and County. The remaining 55,400 acre-feet of effluent was released into the Santa Cruz River channel where the majority infiltrated into the aquifer as incidental recharge. Outlying wastewater treatment plants in the Pima County wastewater treatment system produced around 2,800 acre-feet of treated effluent in 1995. This effluent was generally stored in ponds adjacent to the treatment plants where it then evaporated or infiltrated into the ground.

Under the terms of the Southern Arizona Water Rights Settlement Act (SAWRSA), 28,200 acre-feet per year of the effluent generated at the Pima County regional wastewater treatment plants is granted to the

United States Secretary of the Interior to be used for the benefit of the Tohono O'odham Nation. This water is not currently being used by the Secretary, but may be recharged or directly used in the future. Of the remaining effluent generated at the regional plants, the City of Tucson controls 90 percent and Pima County controls 10 percent.

The first artificial effluent recharge project operating in the Tucson AMA, the Sweetwater Recharge Facility, began recharging effluent treated at the City of Tucson's reclaimed plant in the late 1980s. This recharged effluent is pumped out annually for delivery through the City's reclaimed system. Future uses of effluent may include additional recharge projects. The City of Tucson and the Secretary of the Interior are applying for a "managed recharge facility" permit for their portions of the effluent being discharged into the Santa Cruz River. This permit would allow the City and the Secretary to accrue recharge credits for 50 percent of this passively recharging effluent. These credits could be recovered by pumping groundwater from locations in the AMA away from where the effluent recharge occurred. The implications of effluent recharge and recovery on the AMA water budget are addressed in Chapter 11.

Use of effluent is projected to increase in the future due to the City's extensive reclaimed water system and support for effluent use, and Pima County's ordinance requiring new golf courses to utilize renewable supplies. The dissolved solids content of effluent is expected to increase with the increased utilization of CAP water. This may have implications for future use of effluent supplies. Reuse of effluent reduces the burden on groundwater supplies and redistributes the effluent throughout the geographical area where groundwater levels are steadily dropping. By using effluent directly, higher quality groundwater can be retained to meet potable needs or can remain in the ground to stabilize groundwater declines.

2.8.2 CAP Supply

CAP water is the most abundant source of renewable supply available for use in the Tucson AMA. The available allocation and current use of CAP water in the Tucson AMA is discussed below, along with the key entities from outside the AMA that facilitate its use in the state.

2.8.2.1 CAP Allocation and Use in the Tucson Active Management Area

The Central Arizona Project was constructed to annually deliver 1.5 million acre-feet of Arizona's allocation of Colorado River water to central and southern Arizona through a series of aqueducts and pumping stations. The project is over 300 miles long, and lifts Colorado River water 2,400 feet to its final destination in Tucson. CAP water was originally allocated in 1983 among Indian users, non-Indian municipal users, industrial users, and agricultural users to parties who requested an allocation. Contracts for the allocations are made with the Central Arizona Water Conservation District, which is also responsible for operating and maintaining CAP infrastructure and managing the repayment of construction costs to the federal government.

CAP allocations available for importation into the Tucson AMA total 215,333 acre-feet per year, of which 138,920 acre-feet is allocated to the City of Tucson. More detail on CAP allocations in the Tucson AMA is available in Chapter 8. Planned large-scale importation of CAP water for direct delivery by Tucson Water was expected to reduce groundwater overdraft by the mid-1990's but was curtailed due to water quality problems experienced when CAP water was delivered directly to municipal users. The subsequent passage of the Water Consumer Protection Act in 1995 limits direct delivery and injection recharge of CAP unless stringent water quality criteria are met. As a result of curtailed CAP deliveries, groundwater overdraft has continued at high levels. The Water Consumer Protection Act is discussed in more detail in Chapter 8.

In 1995, 10,100 acre-feet of CAP was delivered in the AMA for use in recharge projects. In 1996 and 1997, CAP deliveries for direct and indirect recharge totaled 19,600 acre-feet and 33,300 acre-feet,

respectively. Recharge projects currently constitute the main use of CAP water within the Tucson AMA. Direct recharge allows water to infiltrate into underlying aquifer layers and can occur in basins, streambeds, or injection wells. Indirect recharge, through groundwater savings programs, allows existing groundwater to remain underground by physically replacing specific groundwater uses with CAP water. Recharge projects are administered statewide by the Department under the 1994 Underground Water Storage, Savings and Replenishment Program. Direct and indirect recharge projects that have received permits in the Tucson AMA are discussed in Chapter 8. Current permitted recharge capacity is not sufficient to utilize all of the available CAP water.

The ultimate use of the CAP allocations that are available for use in the Tucson AMA will significantly affect the AMA's ability to reach safe-yield. This use could include direct recharge, indirect recharge in cooperation with agriculture and mines, sufficient water quality treatment to make direct use acceptable to the public, or a combination of these. The future level of CAP utilization will depend on the success of recharge projects and studies on water quality treatment options.

2.8.2.2 Outside Entities Affecting CAP Use and Management

The Assured Water Supply Program (AWS Program), the Central Arizona Groundwater Replenishment District (CAGRD), the Central Arizona Water Conservation District (CAWCD), and the Arizona Water Banking Authority (AWBA) all encourage CAP use in the AMAs.

Under the 1995 Assured Water Supply Rules (AWS Rules), new residential development within the Tucson AMA must demonstrate that sufficient water supplies are available to meet proposed uses for 100 years, consistent with achieving the safe-yield goal. Because continued dependance on mined groundwater is not consistent with the safe-yield goal, renewable water use is required. This has been a major impetus behind the increasing use of CAP water in the AMA. The AWS Rules are described in more detail in Chapter 5.

Membership in the CAGRD is one way to demonstrate that sufficient water supplies are available to meet the requirements of the AWS Program. Under the AWS Program, the CAGRD acquires water supplies that it uses to replenish aquifers in the AMA from which groundwater has been pumped for use on member lands and in member service areas. To meet its replenishment obligations, the CAGRD can use several strategies including: (1) storing water at replenishment projects it constructs and operates on behalf of its members, (2) recharging water as a cooperator at a state demonstration project or other recharge facility, or (3) purchasing recharge credits that have previously been accrued by CAWCD or another entity.

The CAWCD establishes the pricing structure for CAP water and administers CAP contracts and subcontracts. The pricing structure created for CAP water by the CAWCD affects the volume of water other entities can afford to purchase for recharge or direct use. As part of its activities, the CAWCD operates state demonstration projects at which excess CAP water may be recharged for future withdrawal during canal outages, shortages on the Colorado River, or to meet CAGRD replenishment obligations.

Each year, the AWBA purchases a portion of Arizona's unused entitlement of Colorado River water and brings it into central Arizona via the CAP aqueduct for storage in AMAs. One of the objectives of the AWBA is to store water for recovery in years of shortage when Colorado River entitlements are reduced for the state of Arizona. This storage is necessary, in part, because Arizona may receive less than its full entitlement during years of shortage on the river. The AWBA, CAGRD, and CAWCD are addressed further in Chapter 8.

2.9 SUMMARY AND CONCLUSIONS

Water levels have declined substantially in the Tucson AMA since around 1940. The City of Tucson's Central Wellfield and the area of metal mine pumping in the Green Valley/Sahuarita area have experienced the greatest declines. Some recovery of groundwater levels has occurred since the mid-1980s along the Santa Cruz River and in northern Avra Valley due primarily to increased flood flows in the river and some localized decreases in groundwater pumping.

Net natural recharge of around 60,800 acre-feet replenishes the AMA's aquifers, but overdraft continues due to growing water demand. Groundwater in storage has decreased by an estimated 6 to 8 million acre-feet since around 1940. This decline has resulted in depletion of the upper layer of the aquifer and some land surface subsidence. The potential for additional subsidence exists as long as groundwater levels continue to decline. There have been some well closures due to groundwater contamination. The renewable supplies available for use in the Tucson AMA are effluent and CAP water. Use of both supplies will be necessary to offset groundwater pumping and achieve the AMA's safe-yield goal.

Hydrogeologic conditions in the AMA are deteriorating and make the need for achieving safe-yield increasingly urgent. Since the vulnerability to damage from continued water level declines varies from location to location in the AMA, it is necessary to focus water management efforts on addressing critical areas of the AMA as well as reaching an AMA-wide balance. It is essential that renewable supplies are put to use in the AMA in such a way that localized conditions are effectively addressed.

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CHAPTER

3

Water Use Characteristics

3.1 INTRODUCTION

This chapter describes current and historical water use by each of the three water demand sectors in the Tucson Active Management Area (AMA): municipal, industrial, and agricultural users. It also briefly describes demographic and economic characteristics that influence water use. Water use patterns for each sector are discussed, including past trends in water use and anticipated growth patterns. Sources of water supply, trends in the use of these supplies and anticipated future supply utilization are discussed. The projections discussed in this chapter are based on the "Third Management Plan Scenario" in Chapter 11, the Water Budgets and Projections Chapter of this Plan, which assumes implementation of Third Management Plan programs. Finally, a water budget of past and current demand and supply conditions relative to safe-yield is presented that illustrates the need for continued conservation and augmentation efforts during the third management period in order to reach the AMA safe-yield goal.

The Tucson AMA includes portions of Pima, Santa Cruz, and Pinal Counties. Incorporated cities and their 1995 populations include Tucson (455,299), South Tucson (5,570), Marana (5,309), Oro Valley (19,657), and Sahuarita (2,159). The AMA population within unincorporated areas of the three counties totaled approximately 280,482 in 1995. Part of the Schuk Toak District and the entire San Xavier District of the Tohono O'odham Nation are located within the AMA boundaries, as are the Pascua Yaqui tribal lands. However, these lands are not under the jurisdiction of the Arizona Department of Water Resources (Department). The population on the Tohono O'odham District lands within AMA boundaries was approximately 1,500 in 1995. The population on Pascua Yaqui tribal lands was approximately 3,810 in 1995. Over 95 percent of the region's population resides within the northern part of the Upper Santa Cruz Valley subbasin which includes the Tucson metropolitan area, Oro Valley, the eastern portion of Marana, Green Valley and Sahuarita. The remaining population is centered in the Avra Valley subbasin communities of Three Points (Robles Junction) and Arivaca, and the western portion of Marana. According to Department of Economic Security estimates and projections, the 1995 population of approximately 768,017 within the current borders of the Tucson AMA is projected to reach about 1,005,400 by 2010 and 1,266,500 by 2025. The majority (78 percent) of the population in the Tucson AMA is served by Tucson Water, the water utility operated by the City of Tucson. The Tucson AMA contains one consolidated irrigation distribution system that serves over 80 farms and is operated by the Cortaro Marana Irrigation District. The area's economy is based on a variety of industries including government, education, aviation and aerospace industries, retail trade, tourism, medical and health care, telecommunications, real estate development, construction, agriculture, and copper mining.

Each water demand sector has unique water use characteristics that influence the sector's ability to contribute to meeting the AMA management goal of achieving safe-yield. Agricultural use includes water used for crop irrigation by irrigation grandfathered right holders. Municipal use includes water supplied by cities, towns, private water companies and irrigation districts for domestic, industrial and commercial purposes. Industrial use includes groundwater withdrawn pursuant to non-irrigation grandfathered rights or permits for industrial purposes. Table 3-1 illustrates that municipal water use has increased since 1985 and agricultural use has declined. Industrial water use has remained at approximately 19 percent of the total AMA demand.

Table 3-2 shows the volume of each source of water used by each regulated sector in the years 1985, 1990 and 1995. Historically, water users in the Tucson AMA have been groundwater dependent. This has continued to be the case although effluent use has increased and Central Arizona Project (CAP) water is now available within the AMA but is not being directly used for potable purposes. Delivery of CAP water to a number of farms in the AMA began in 1993 under the Department's groundwater savings program (see Chapter 8). At groundwater savings facilities, recipients (typically farms) use CAP water supplied by a water storer with an excess supply, in-lieu of pumping groundwater. Water storers (typically municipal providers, Central Arizona Water Conservation District (CAWCD), or the Arizona Water Banking Authority) accrue CAP water storage credits that can be recovered in the future by pumping groundwater.

The CAP water used on the groundwater savings facility is considered to be groundwater for water accounting purposes and so is not shown as CAP water in Table 3-2. When the water storer recovers the storage credits, the water will be considered CAP water for water accounting purposes. No recovery had occurred through 1995. Effluent and CAP water use is expected to increase in the future, especially in the municipal sector as water storers begin to recover their credits.

TABLE 3-1
WATER USE BY SECTOR
1985, 1990, AND 1995
TUCSON ACTIVE MANAGEMENT AREA

Sector	1985		1990		1995	
	Total Use (Acre-feet)	% of AMA	Total Use (Acre-feet)	% of AMA	Total Use (Acre-feet)	% of AMA
Agricultural	114,450	40	93,801	34	97,180[1]	31
Municipal	115,735	40	129,444	48	154,894	50
Industrial	55,744	20	48,743	18	60,204	19
TOTAL	**285,929**	**100**	**271,988**	**100**	**312,278**	**100**

[1] 1995 agricultural data do not include the water usage of exempt small rights; rights <10 acres in size were deregulated in 1994.
NOTE: Municipal water use associated with exempt wells (wells that pump less than 35 gallons per minute) is not shown.
NOTE: Agricultural use includes canal losses.

TABLE 3-2
WATER USE BY SOURCE
1985, 1990, AND 1995
TUCSON ACTIVE MANAGEMENT AREA

Year	Municipal Use (Acre-feet)	Agricultural Use (Acre-feet)	Industrial Use (Acre-feet)	Total Use (Acre-feet)
1985 TOTALS	115,735	114,450	55,744	285,929
CAP Water	0	0	0	0
Effluent	3,080	3,446	356	6,882
Groundwater	112,655	111,004	55,388	279,047
1990 TOTALS	129,444	93,801	48,743	271,988
CAP Water	0	0	0	0
Effluent	6,279	3,986	769	11,034
Groundwater	123,165	89,815	47,974	260,954
1995 TOTALS	154,894	97,180[2]	60,204	312,278
CAP Water	103 [1]	0	0	103 [1]
Effluent	7,711	1,801	782	10,294
Groundwater	147,080	95,379	59,422	301,881

[1]In 1995, Tucson Water used 103 AF of CAP water for treatment plant maintenance.
[2]1995 agricultural data do not include the water usage of exempt small rights; rights <10 acres in size were deregulated in 1994.
NOTE: Municipal water use associated with exempt wells is not shown.
NOTE: Agricultural use includes canal losses.

In this chapter, the following topics are discussed in the order listed:

- Agricultural Water Use Characteristics
- Municipal Water Use Characteristics
- Industrial Water Use Characteristics
- Current Water Budget
- Conclusions

3.2 AGRICULTURAL WATER USE CHARACTERISTICS

This section describes agricultural water users, trends in agricultural water use, agricultural water demand and supplies, the status of flexibility account credits, and some factors that influence agricultural water use.

Certificates of Irrigation Grandfathered Rights (IGFRs) were issued to farmers in the early 1980s if two or more acres of land were irrigated between 1975 and 1980. In 1994, legislation removed the conservation requirements for IGFRs that were ten acres or less in size, provided they were not part of an integrated farming operation. Certificates of IGFRs designate the number of irrigation acres allowed to be irrigated. A water duty and a maximum annual groundwater allotment are established by the management plan for each IGFR (see Chapter 4). With few exceptions, no new land greater than two acres in size can be irrigated within an AMA.

The total amount of water currently allotted annually under the Second Management Plan to all IGFRs in the Tucson AMA is approximately 153,000 acre-feet. If the holder of an IGFR uses less than the total annual water allotment for his acreage, the unused portion is credited in an irrigation flexibility account for that IGFR. The balance in this account is cumulative. Flexibility accounts may be debited if more than the annual water allotment is used. The total amount of flexibility account (flex) credits accumulated by the end of 1995 for all Tucson AMA IGFRs was about 673,000 acre-feet. Most IGFRs have accumulated many credits while some have accumulated very few.

It is probable that most of the accumulated agricultural flex credits will not be used since they can only be used pursuant to an IGFR. Accumulated credits may be used on some IGFRs as conservation requirements become more stringent and in cases where farms irrigate full acreage or multiple crops. Also, under certain conditions, farmers may transfer flex credits accumulated during the preceding calendar year from one IGFR to another. This provision provides flexibility in the types of crops and amount of acreage that farmers may choose to irrigate and to avoid being in a flex debit or noncompliance situation. Currently there are no IGFRs with a debit flex account balance in the Tucson AMA.

Cotton is the predominant crop grown in the Tucson AMA and is usually rotated with winter wheat or barley. Pecan trees grown by Farmers Investment Company (FICO) are the major crop grown in the Green Valley and Sahuarita area south of Tucson. Other crops grown in the Tucson AMA include grain sorghum, alfalfa, pasture grasses, and vegetables. Pasture grass predominates the crops grown in the southern portion of the Tucson AMA. Cropping patterns have not changed significantly in the Tucson AMA since the verification of crops grown during the historic period of 1975 to 1980. Some fluctuations in cropped acreage since this historic period have been observed primarily due to market demands and federal programs.

Most on-farm irrigation systems within the Tucson AMA are flood irrigated and consist of sloped fields served by siphon tube application from a concrete ditch to the field. Some field applications are made through turnouts and gate structures. Many fields have been converted to modified slope, which involves leveling the lower portion of the field to contain runoff. Some farms have installed level basin irrigation systems that are typically more water efficient systems if properly managed. Other irrigation systems

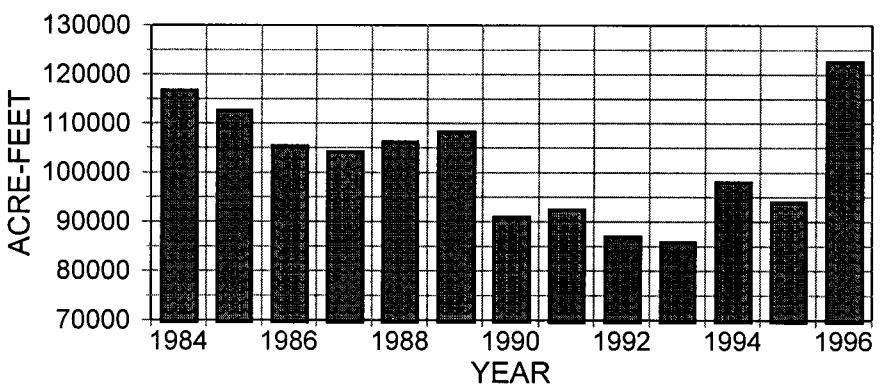
found in the Tucson AMA, but utilized to a much lesser extent, include sprinkler and trickle (drip) application methods.

3.2.1 Agricultural Water Demand

There is currently a total of 205 IGFRs over ten acres in size (or less than ten acres in size but part of an integrated farming operation) in the Tucson AMA. The irrigation acres associated with these rights total about 35,000 acres with a maximum annual groundwater allotment of 153,258 acre-feet. Agricultural water use currently accounts for about one-third of the total annual water use in the Tucson AMA. Generally, water demand for irrigated agriculture decreased from 1985 through 1995 although it fluctuated during this period. Water demand is influenced by many factors that vary annually, including weather. A total of 93,816 acre-feet of water use was reported by regulated IGFRs in 1995. In 1996, agricultural water use increased by more than 20 percent; however, it is difficult to predict if this trend will continue. Recent agricultural water use increases are thought to be a result of the Federal Agriculture Improvement and Reform Act of 1996 and improved market conditions. Figure 3-1 graphically shows agricultural water use from the years 1984 to 1996.

During the second management period, seven Areas of Similar Farming Conditions (ASFCs) were established in the Tucson AMA for the purpose of evaluating irrigation water use characteristics and conservation potential. These areas were designated based on specific criteria related to farming conditions located throughout the AMA. Figure 3-2 displays the boundaries of these seven ASFCs and the location of irrigation acreage. Table 3-3 displays 1995 water use by ASFCs.

FIGURE 3-1
HISTORIC AGRICULTURAL WATER USE
1984-1996
TUCSON ACTIVE MANAGEMENT AREA



There are three irrigation districts in the Tucson AMA: Cortaro Marana Irrigation District (CMID), Avra Valley Irrigation District (AVID), and Flowing Wells Irrigation District (FWID). FWID is primarily a municipal water provider and can serve only 76 irrigation acres. There are also two IGFRs in the Pinal County portion of the Tucson AMA that receive water from the Central Arizona Irrigation and Drainage District (CAIDD). The CAIDD delivers water primarily to farms in the Pinal AMA. Farms within the CMID, AVID, and FICO make up the majority of the agricultural land in the Tucson AMA. A description of these areas follows.

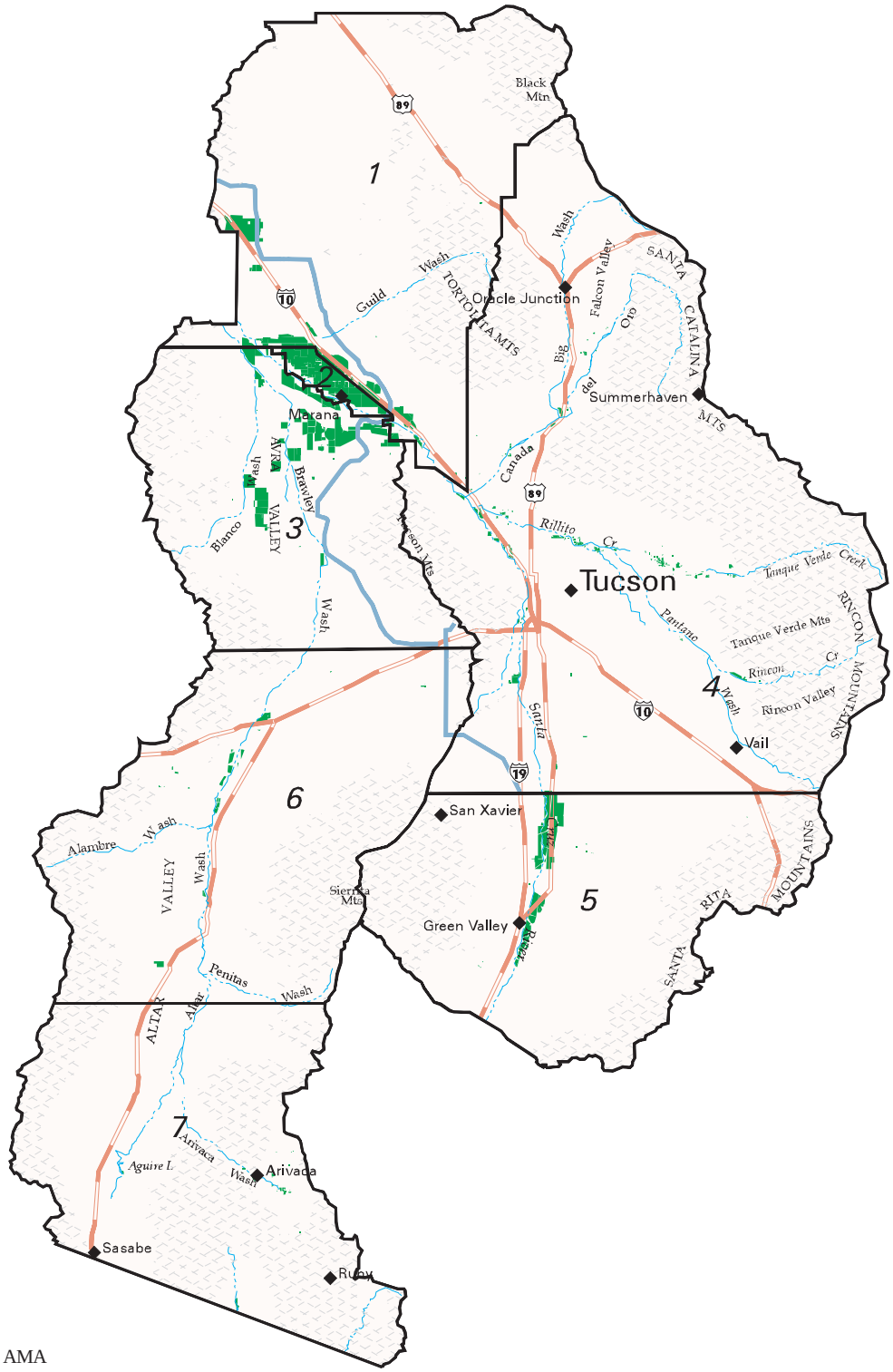


Figure 3- 2

Irrigation Acreage Within Areas Of Similar Farming Conditions

ORIGINAL SOURCE
Arizona Department of Water Resources
Geographic Information System

TABLE 3-3
REGULATED IRRIGATED GRANDFATHERED RIGHT CHARACTERISTICS BY AREAS OF SIMILAR FARMING CONDITIONS FOR 1995
TUCSON ACTIVE MANAGEMENT AREA

ASFC	IGFRS	Irrigation Acres	Annual Allotment (AF)	Water Use (AF)	Percent Use	Flex Account Credits (AF)
1	12	3,843	18,209	2,382	3	140,438
2	63	10,543	41,789	28,483	30	138,950
3	41	11,360	45,693	29,693	31	227,053
4	54	1,914	7,450	1,230	1	58,448
5	9	5,909	34,763	30,681	33	64,126
6	13	1,103	4,305	1,279	1	34,443
7	13	282	1,049	68	<1	9,223
Total	205	34,954	153,258	93,816	100	672,681

ASFC = Areas of Similar Farming Conditions
IGFRs = Irrigation Grandfathered Rights
AF = Acre-feet

3.2.1.1 Cortaro-Marana Irrigation District

CMID (ASFC 2) is the only agricultural irrigation district in the Tucson AMA with a consolidated irrigation delivery system. It provides water to 63 regulated IGFRs and 10 exempt IGFRs less than 10 acres in size, totaling about 11,000 acres of farmland the majority of which is in the Avra Valley subbasin. Cotton makes up about 70 percent of the total cropped acres, grains (wheat, barley, and sorghum) make up about 25 percent, and the remaining 5 percent is made up of alfalfa hay, vegetables, and nuts. Irrigation water use in CMID has annually averaged approximately 35,000 acre-feet from the years 1987 through 1995. Only four IGFRs within CMID have consistently reported zero annual water use.

CMID's delivery system consists of about 54 miles of concrete lined canals and eight miles of pipeline. There are currently 27 irrigation wells in the Cortaro area (southern end of CMID's distribution system of pipelines and canals) that pump from water levels that average 115 feet below land surface. An additional 18 irrigation wells in the Marana area (northern end of CMID's distribution system) pump groundwater from a depth that currently averages 263 feet.

CMID declined to sign a contract for CAP water. However, as a groundwater savings facility, CMID does receive CAP water, which it uses in-lieu of pumping a portion of its groundwater. In addition, an average of about 3,000 acre-feet of effluent is purchased annually from Pima County and delivered to CMID via a ditch from the Ina Road Water Pollution Control Facility (wastewater treatment plant). The effluent is blended with groundwater prior to delivery for irrigation.

3.2.1.2 Avra-Valley Irrigation District

AVID (ASFC 3) is located in the northern part of the Avra Valley subbasin, predominantly west of the Santa Cruz River. AVID contains about 11,000 acres of farmland that is associated with 41 regulated IGFRs and 15 exempt IGFRs less than 10 acres in size. Cropping patterns in AVID consist of about 80 percent cotton, 12 percent grains (wheat, barley, and sorghum), 3 percent alfalfa, 1 percent millet, 1 percent lettuce, and the remaining 3 percent is made up of miscellaneous crops. Irrigation water use in AVID has annually averaged approximately 27,000 acre-feet from the years 1987 through 1995. Only two IGFRs within AVID have consistently reported zero annual water use. Farmers within AVID operate their irrigation systems independently using groundwater wells and on-farm irrigation distribution systems.

AVID was initially formed to obtain CAP water, however, the district declined to sign a CAP water contract. A groundwater savings facility that utilizes CAP water includes several of the farming operations in AVID.

3.2.1.3 Farmers Investment Company

The IGFRs associated with FICO (within ASFC 5) are divided into two separate operating areas with pecans being the predominant crop grown in both areas. The southern part of FICO includes about 1,800 acres and is referred to as the Continental Farm. The northern section is known as the Sahuarita Farm and has approximately 4,000 acres. Annual water use at FICO has averaged approximately 28,000 acre-feet from the years 1987 through 1995. All of the water used at FICO for irrigation comes from privately owned wells and is predominantly applied using flood irrigation techniques. Most of the farm fields are basin leveled and are irrigated using efficient water management techniques. FICO has also begun researching the potential use of drip irrigation systems on established orchards. FICO currently uses groundwater for irrigation, but use of CAP water and/or effluent is being explored.

3.2.1.4 Red Rock Area

ASFC 1 has 12 regulated IGFRs covering nearly 4,000 acres. Only 1 IGFR in this area is an exempt IGFR less than 10 acres in size. Four of the 12 IGFRs have consistently reported zero annual water use. One large IGFR, consisting of 2,022 irrigation acres was not irrigated from 1990 through 1996, which contributed to the relatively large accumulation of flex account credits in this area. Since this time, the farm has been converted from pecan trees to row crops. In 1997, this IGFR entered into a groundwater savings project arrangement with the Department and was irrigated with CAP water.

3.2.1.5 Other Agricultural Areas

Other agricultural areas within the Tucson AMA include the Tucson area (ASFC 4), the Altar Valley (ASFC 6), and farmland in the Arivaca area (ASFC 7). Cropping patterns and annual water use from 1987 through 1995 have remained relatively constant in each of these areas. In 1995, the total water use in these areas made up less than 3 percent of the total agricultural water use in the Tucson AMA.

ASFC 4 has 54 regulated IGFRs and 145 exempt IGFRs less than 10 acres in size. Twenty two of the 54 regulated IGFRs have consistently reported zero annual water use. Many of the IGFRs that irrigate in this area grow bermuda grass or alfalfa hay for pasture.

ASFC 6 has 13 regulated IGFRs and two exempt IGFRs less than 10 acres in size. Five of the 13 regulated IGFRs have consistently reported zero annual water use. Pasture grass is the predominant crop in this area.

ASFC 7 has 13 regulated IGFRs and six exempt IGFRs less than 10 acres in size. Six of the 13 regulated IGFRs have consistently reported zero annual water use. Irrigated pasture consisting of bermuda grass and alfalfa is the primary crop grown in this area.

3.2.2 Agricultural Water Supplies

Most agricultural water demand in the Tucson AMA is supplied by groundwater. Effluent is used to a lesser extent. No agricultural entities in the Tucson AMA have contracted for CAP allocations. However, CAP water is used on some farms through groundwater savings facilities as described previously.

Table 3-4 displays the amount of reported annual agricultural water use by source and the percent of agricultural use to the total water use in the Tucson AMA for the years 1987 to 1996. Groundwater values include all of the water used on IGFRs including in-lieu use on groundwater savings facilities and CMID's water use, which is reported as surface water. The effluent column is primarily the effluent delivered to CMID.

TABLE 3-4
AGRICULTURAL WATER DEMAND BY WATER SOURCE
1987 THROUGH 1995
TUCSON ACTIVE MANAGEMENT AREA

Year	Groundwater (Acre-feet)[1]	Effluent (Acre-feet)	Total Water Use (Acre-feet)	Percent of Total AMA Use
1987	100,700	3,375	104,075	38
1988	102,645	3,527	106,172	38
1989	103,846	4,277	108,123	36
1990	86,863	3,986	90,849	34
1991	89,663	2,698	92,361	33
1992	84,803	2,077	86,880	32
1993	83,750	2,015	85,765	31
1994[2]	95,152	2,793	97,945	32
1995[2]	92,015	1,801	93,816	30
1996[2]	119,862	2,676	122,538	35

[1] CAP water delivered to Groundwater Savings Facilities is shown as groundwater. Also, the water reported by CMID as surface water is considered to be groundwater by the Department pending adjudication of surface water rights; it is included as groundwater in this table.
[2] 1994, 1995 and 1996 data do not include the water usage of exempt small rights; rights <10 acres in size were deregulated in 1994.
NOTE: Canal losses are not included in demand numbers.

CMID reported 12,910 acre-feet of "surface water" use in 1995. This water is withdrawn from wells and is considered by the Department to be groundwater pending adjudication of surface water rights. A total of 10,100 acre-feet of CAP water was used by groundwater savings facilities in 1995. For purposes of water budget accounting, in-lieu water delivered to groundwater savings facilities is considered groundwater. In addition, about 1,801 acre-feet of effluent use was reported by CMID in 1995.

3.2.3 Indian Agriculture

Indian agricultural water use is expected to increase within the Tohono O'odham Nation during the third management period. However, the Nation is not subject to the regulations of the 1980 Groundwater Management Act. CAP allocations to the San Xavier and Schuk Toak Districts are listed in Table 8-1 of Chapter 8. The San Xavier District has the potential to rebuild their irrigated farmland and develop additional agricultural land with water and funds available through the Southern Arizona Water Rights Settlement Act. Department projections show that about 5,000 acre-feet of agricultural water from CAP sources may be used on the San Xavier District by the year 2005. The Schuk Toak District is currently developing a farm that is expected to utilize 10,800 acre-feet of CAP water per year by the year 2010.

3.3 MUNICIPAL WATER USE CHARACTERISTICS

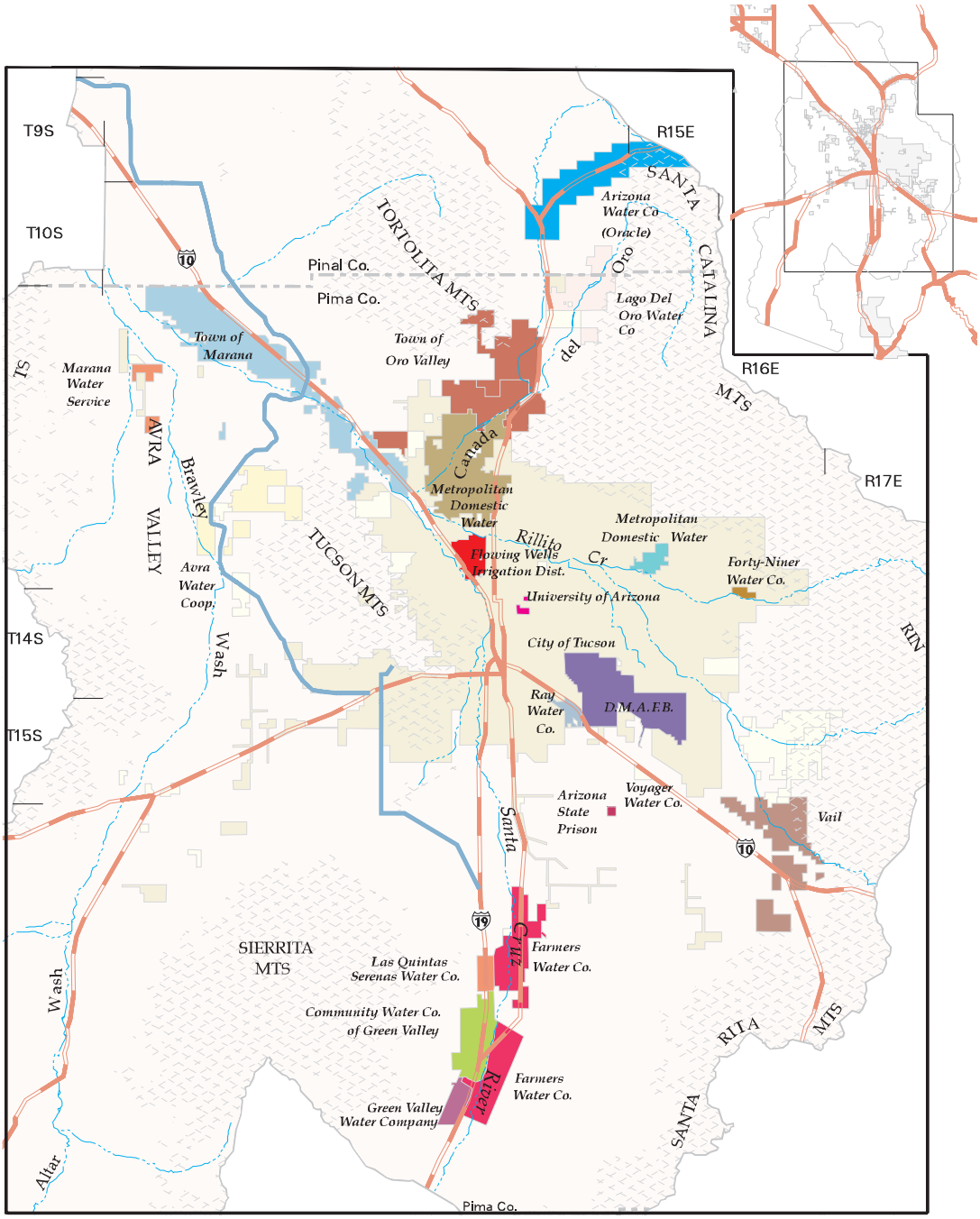
This section describes the categories of municipal water users and the usage patterns of specific water users. It also describes the available water supplies in the Tucson AMA and reports trends in the usage of those supplies.

The Groundwater Code (Code) defines municipal use as "all non-irrigation uses of water supplied by a city, town, private water company or irrigation district..." A.R.S. § 45-561.11. Municipal water providers serve water pursuant to service area rights, and may be operated by incorporated cities and towns or by private water companies. A private water company may be a member-owned or corporately-owned entity that distributes or sells water and is regulated by the Arizona Corporation Commission. There are also quasimunicipal providers that are governed by an elected board of directors. These include domestic water improvement districts, irrigation districts and water user's associations. The Department also regulates the following entities as water providers if they pump water from one or more non-exempt wells (wells that pump over 35 gallons per minute): large institutional facilities such as schools, prisons and military installations; mobile home parks; homeowner's associations; and well cooperatives. By definition, large municipal providers serve over 250 acre-feet of water (about 81 million gallons) per year and small municipal providers annually serve 250 acre-feet of water or less. There are 151 water providers in the Tucson AMA regulated under the municipal conservation program. The 19 large provider service areas and some small provider service areas are located on Figure 3-3.

Municipal water use is analyzed volumetrically and in terms of the average gallons per capita per day (GPCD) rate of the water users. This form of analysis allows a comparison of the relative water use per customer of each water provider to its GPCD conservation requirement and is used to assess conservation potential. The GPCD conservation requirement for water providers is an allocation tool that has the effect of quantifying the service area right based on population served.

3.3.1 Municipal Water Demand

Municipal water demand has increased with population growth. Municipal providers are required to meet water conservation requirements, as described in Chapter 5. Water use by the municipal sector is expected to continue to increase during the third management period, although an increase in renewable supply utilization is also anticipated due to provisions of the Assured Water Supply Rules (AWS Rules) (also described in Chapter 5). These rules require use of renewable water supplies in the demonstration of an assured water supply. This is expected to result in a significant decline in groundwater use by this sector.



Tucson AMA
Hardrock
Rivers and Streams
Streets and Highways
Counties
CAP Canal

Figure 3- 3

Water Provider Service Areas

0 3 6 9 12
Miles

North

ORIGINAL SOURCE
Arizona Department of Water Resources
Geographic Information System

Table 3-5 shows historic municipal demand in the Tucson AMA from all sources (groundwater, effluent and CAP water), by year from 1985 through 1996, and the percent of total AMA demand served by these sources each year. In general, the proportion of municipal water use compared to other sectors has increased since 1985. However, because agricultural use increased in 1996, the municipal proportion of water use in the AMA decreased that year. Small providers historically represent 2 to 3 percent of municipal demand.

TABLE 3-5
TOTAL MUNICIPAL WATER DEMAND [1]
1985 THROUGH 1996
TUCSON ACTIVE MANAGEMENT AREA

Year	Large Providers (Acre-feet)	Small Providers (Acre-feet)	Municipal Use (Acre-feet)	Total Population[2]	Percent of Total AMA Use
1985	113,007	2,728	115,735	569,863	40 %
1986	120,977	2,702	123,679	595,982	46 %
1987	126,745	2,847	129,592	623,232	47 %
1988	129,161	2,963	132,124	631,282	47%
1989	138,196	2,992	141,188	642,433	47%
1990	126,744	2,700	129,444	650,043	48%
1991	129,310	2,591	131,901	657,611	47%
1992	133,996	2,574	136,570	688,781	50%
1993	136,823	2,581	139,404	709,120	50%
1994	142,513	5,946[3]	148,459	742,074	48%
1995	149,454	5,440	154,894	764,026	50%
1996	157,352	5,362	162,714	768,854	47%

[1] Total Municipal Demand includes all sources of water, including effluent; does not include exempt well demand.
[2] Total Population includes only the population served by large and small providers. This is not the total population of the AMA.
[3] In 1994, a change to the definition of large providers resulted in 20 large providers being reclassified as small providers. As a result, water use by small providers increased significantly in 1994 over previous years.

In 1995, the 19 large providers in the Tucson AMA supplied 149,454 acre-feet of groundwater and effluent, or 96 percent of total municipal demand. Tucson Water supplied 117,083 acre-feet of groundwater and effluent or about 76 percent of total municipal demand. Small municipal providers used 5,440 acre-feet or 4 percent of the municipal demand. Altogether, municipal water users used 154,894 acre-feet in 1995, or approximately 50 percent of the AMA's total water use. Five percent, or 7,711 acre-feet, of the total use was supplied with effluent, primarily to turf-related facilities.

Table 3-6 summarizes large municipal provider population, water use, and the total, residential, non-residential, and lost and unaccounted for water GPCD rates for 1985, 1990 and 1995 (lost and unaccounted for water is water that was withdrawn, diverted and/or received by the provider but that was not delivered to a customer). In 1985, the average total GPCD for large providers was estimated at 176 GPCD. By 1990 the rate had dropped to 169 GPCD and in 1995 it increased slightly to 172 GPCD.

Residential rates have remained fairly constant while non-residential water use rates have declined due to increased effluent use by turf-related facilities.

TABLE 3-6
LARGE MUNICIPAL PROVIDER GALLONS PER CAPITA PER DAY RATES
1985, 1990, AND 1995
TUCSON ACTIVE MANAGEMENT AREA

Year	Population	Total GPCD	Residential GPCD	Non-Residential GPCD	Lost GPCD
1985	556,850	176	113	45	18
1990	635,076	169	113	43	13
1995	736,326	172	113	41	18

GPCD = Gallons per capita per day

Figure 3-4 compares the total GPCD rates of Tucson Water to the average total GPCD rate of the other large water providers from 1985 to 1996. The GPCD rate calculation includes all water used except direct use effluent and effluent recovered within the area of impact, as defined in Chapter 5 section 5-101 (7). The total GPCD rate is lower overall for Tucson Water and declined from 171 to 164 GPCD between 1985 and 1995 while the average of the other providers' use was about 205 GPCD in both 1985 and 1995. Between 1985 and 1995, Tucson Water's residential rate averaged about 110 GPCD, about 11 GPCD lower than the average residential rate for the other large providers in 1995. Non-residential use declined by 6 GPCD for Tucson Water but increased by 11 GPCD for other large providers during the same period. Contributing to the increase is golf course construction and lack of reclaimed water use outside the Tucson Water service area. Tucson Water is the only provider that has a reclaimed water distribution system. In 1996, water use increased in both the Tucson Water service area and the service areas of other large providers. Higher GPCD rates have coincided with years of hot and dry weather and late or below average summer rainfall.

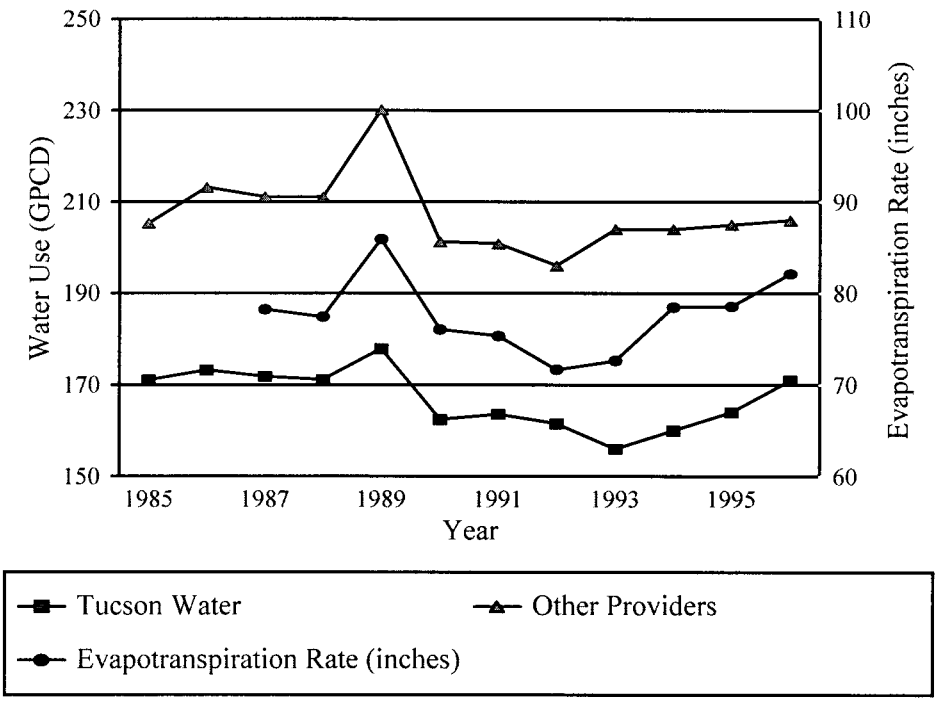
Total GPCD rates for individual large water providers range from about 80 GPCD to over 800 GPCD. Changes in GPCD rates are attributable to several variables, including disproportionate non-residential growth, conservation programs, economic factors, weather, inaccurate data and other variables. Residential GPCD rates range from around 65 GPCD to about 300 GPCD, but only two large providers have residential GPCD rates over 170. Residential GPCD use is strongly correlated to the age of the housing units, the type of landscaping, the number of persons per household, water rates in the service area, and the income level.

Figure 3-4 also compares the evapotranspiration rate (ETo) to the GPCD rate. ETo is an indication of the amount of water lost by a well-watered reference crop through transpiration by plants and through evaporation from the soil surface. The ETo value is based on temperature, relative humidity, wind speed, precipitation, soil temperature and incident solar radiation. Comparison of ETo with GPCD demonstrates the close correlation between water use and weather. From 1987 through 1997, the average ETo measured at the University of Arizona Campbell Avenue Farm was 77.57 inches and ranged from 71.67 inches in 1992 to 85.93 inches in 1989. GPCD rates peaked in 1989 as a result of a record hot, dry year. For the Third Management Plan, municipal water use was analyzed for conservation potential using a four-year average (1992 through 1995) rather than a single year to account for weather variations. The four-year average includes two cool, wet weather years and two hot, dry weather years, thus reducing under or over estimation of conservation potential.

3.3.1.1 Large Providers

Figure 3-5 depicts 1995 water use and GPCD rates for municipal providers separated into the following categories: (1) municipalities and districts, (2) private water companies, and (3) institutional providers. Municipalities and districts use the largest volume of water and have relatively low per capita rates. Tucson Water's high volume of water use is so much larger than any other provider that its water use characteristics dominate the "municipalities and districts" category. Private water companies and providers that serve institutional facilities generally have higher per capita rates because they have relatively small populations compared to the amount of their non-residential use. Also shown in Figure 3-5 are small municipal water providers. Small municipal water providers include a wide variety of water users (discussed in section 3.2.1.3). They represent about 5,000 acre-feet of annual municipal use and have an average per capita rate comparable to that for municipalities and districts.

FIGURE 3-4
LARGE PROVIDER GPCD AND EVAPOTRANSPIRATION
1985-1996
TUCSON ACTIVE MANAGEMENT AREA

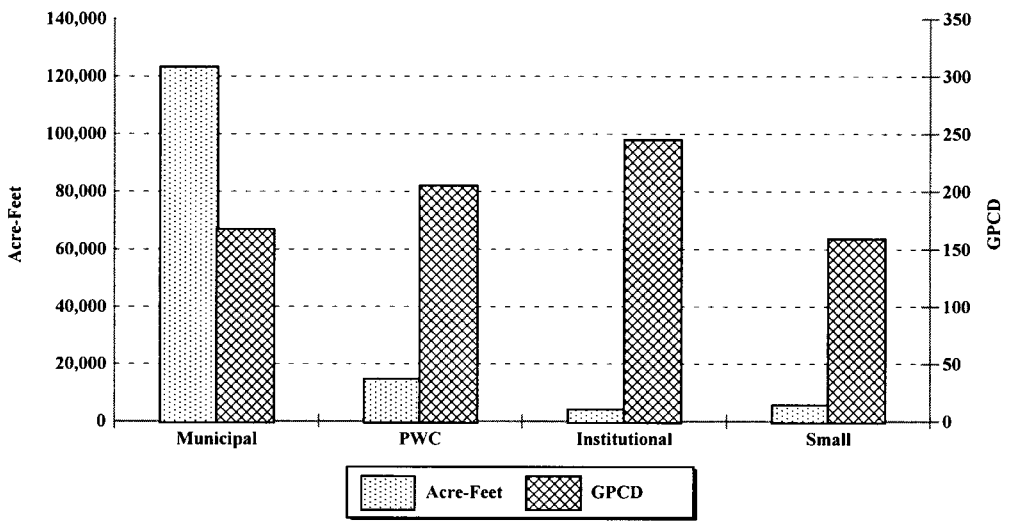


In addition to Tucson Water, which served 109,927 acre-feet of groundwater in 1995 to almost 600,000 people, the two largest water suppliers to municipal users in the AMA are the Metropolitan Domestic Water Improvement District (MDWID) and the Town of Oro Valley. In 1995, MDWID served 8,557 acre-feet of groundwater to a population of almost 41,000, and the Town of Oro Valley served 5,707 acre-feet of groundwater to about 23,500 water users. Table 8-A1 in Chapter 8 shows the Assured Water Supply status of all of the designated providers in the Tucson AMA.

3.3.1.1.1 Municipalities and Districts

Three municipalities serve water in the Tucson AMA: the City of Tucson, the Town of Oro Valley, and the Town of Marana. In 1995, these municipalities served approximately 84 percent of the AMA population and provided 82 percent of the water served by water providers. There are two districts that function as quasimunicipal providers: MDWID and FWID. These two providers served about 8 percent of the population and 8 percent of the water used in 1995. Table 3-7 shows percentages of water use and population for municipalities and districts in 1995. The single family residential water use category includes detached dwelling units. The multifamily residential water use category includes apartments, duplexes, triplexes, townhouses, condominiums and mobile home parks. Typically, a multifamily housing unit uses less water than a single family housing unit because exterior water demand is less per unit.

FIGURE 3-5
1995 MUNICIPAL WATER USE
TUCSON ACTIVE MANAGEMENT AREA



Note: The "Municipal" category includes special districts that function as municipal providers.

Tucson Water

While Tucson Water serves a large portion of the Tucson metropolitan area both inside and outside of the city limits, it is operated by the City of Tucson and water rates and policy are set by the Tucson Mayor and City Council. Approximately 40 percent of the population served by Tucson Water is located outside the city limits. Approximately 55 percent of the housing units in the service area are single family, which represents 75 percent of the residential demand and more than half of the total demand in the service area. Non-residential water service comprises about a quarter of Tucson Water's deliveries and includes schools, hospitals, shopping centers, manufacturing, offices, stores, restaurants and turf-related facilities such as golf courses and parks. Only about one percent of Tucson Water's potable water deliveries were to turf-related facilities in 1995. Most turf customers receive effluent through Tucson Water's reclaimed water system.

The Town of Oro Valley Water Utility

The Town of Oro Valley Water Utility was created in 1996 when the town purchased Rancho Vistoso and Cañada Hills water companies. Oro Valley Water Utility serves about 3 percent of the AMA large provider population and supplies 4 percent of total municipal water use. About half of the deliveries in

Oro Valley are to residential customers, primarily single family residences. About 19 percent of the households served by Oro Valley Water Utility in 1996 were within age-restricted communities. Oro Valley has a high percentage of non-residential use (48 percent), including groundwater deliveries to five golf courses, which constituted 38 percent of total deliveries in the service area in 1996.

The Town of Marana

From 1992 through 1997, the Town of Marana acquired several water systems within the town boundaries, including Honea Water Company, Cortaro Water Users Association and portions of Marana-Picture Rocks Water Service and IM Water Company. The population and water use numbers displayed in Table 3-7 include portions of the service area not actually acquired until 1996 or 1997; these are included for purposes of presenting data that reflects more current patterns of use. Ninety-three percent of Marana Municipal deliveries are to residential customers, primarily single family homes. Seven percent of the water service is to mixed commercial and government office customers. Many residences are mobile or manufactured homes on individual lots. The greater frequency of gardens, evaporative cooling, pasture and livestock in rural residential areas like Marana tends to cause GPCD rates to be higher than those for urban areas. In 1995, Marana Municipal served less than 1 percent of the AMA large provider population.

TABLE 3-7
1995 MUNICIPALITY AND DISTRICT WATER USE
TUCSON ACTIVE MANAGEMENT AREA

	Providers				
	City of Tucson	Town of Oro Valley	Town of Marana	MDWID	FWID
Population	597,017	22,479	3,277	40,870	14,951
Total Use[1] (Acre-feet)	109,927	5,707	518	8,557	2,842
Residential Use (Acre-feet)	74,396	2,857	451	6,770	2,135
Residential Use as a % of Total Use	75%	52%	93%	84%	82%
% Single Family Residential	70%	97%	89%	89%	45%
% Multifamily Residential	30%	3%	4%	11%	55%
Non-residential Use (Acre-feet)	24,580	2,599	32	1,258	480
Non-residential Use as a % of Total Use	25%	48%	7%	16%	18%

[1] Includes residential, non-residential, and lost and unaccounted for water use.

Metropolitan Domestic Water Improvement District

Metropolitan Domestic Water Improvement District (MDWID) serves much of the northwest portion of the Tucson metropolitan area. The MDWID service area consists partly of unincorporated areas and partly of areas within the town limits of Oro Valley. MDWID served about 6 percent of the AMA large provider population and 6 percent of the water used in 1995. Deliveries are primarily to single family residential

customers. Multifamily residential deliveries, primarily apartments, comprise about 13 percent of MDWID's residential service. Non-residential customers include schools, medical facilities, shopping areas, offices, restaurants and a park.

Flowing Wells Irrigation District

Flowing Wells Irrigation District serves a former agricultural area south of the Rillito River and east of Interstate 10. The District is nearly built out and very little additional development is projected within the service area. FWID serves areas within the City of Tucson as well as unincorporated areas in Pima County. FWID provides water for about 2 percent of the AMA large provider population and water uses. Most deliveries are to residential customers. About 62 percent of residential housing units are mobile or manufactured homes in mobile home parks, 23 percent are site-built single family residences and 15 percent are multifamily units. Non-residential customers include schools, shopping areas, offices, restaurants and light manufacturing and account for approximately 18 percent of the service area demand.

3.3.1.1.2 Private Water Companies

There are 11 private water companies in the Tucson AMA that are large providers. They serve a range of development from relatively small, slow-growing areas to rapidly growing areas northwest of Tucson and in the Green Valley/Sahuarita area south of Tucson. Development in these areas typically consists of either urban or rural single family residences or golf-centered retirement communities. In 1995, private water companies served about 6 percent of the AMA's large provider population and 7 percent of the water use. During the second management period growth within the service areas of small private water companies has caused several to become large providers, while other existing large private water companies have been acquired by municipalities or reorganized as domestic water improvement districts.

Residential deliveries comprise the majority of the water served by private water companies in the Tucson AMA. Farmers Water Company is a notable exception, with about 60 percent of its water deliveries going to non-residential uses, primarily pecan processing. Also, about 60 percent of deliveries made by private water companies that serve golf-centered residential communities, such as Forty-Niner Water Company and Green Valley Water Company, serve turf-related facilities. Per capita use varies widely among the private water companies, not only because of the huge impact of golf course water service, but also because of the impact of larger lots and higher income levels.

3.3.1.1.3 Institutional Providers

There are three large providers in the Tucson AMA with institutional characteristics as defined in the Institutional Provider Program (IPP) in the Second Management Plan. To qualify for the IPP, providers must serve over 90 percent of their water to non-residential uses. Only one large provider, the Arizona State Prison Complex - Tucson, is currently in the IPP. In addition to personal water use by inmates, the prison uses water for institutional food service, laundry, and landscape watering. The other two providers with institutional water use patterns are the University of Arizona and Davis-Monthan Air Force Base (DMAFB). Arizona State Prison Complex -Tucson, University of Arizona, and Davis-Monthan Air Force Base served about 3 percent of the water use and large provider population in the AMA in 1995.

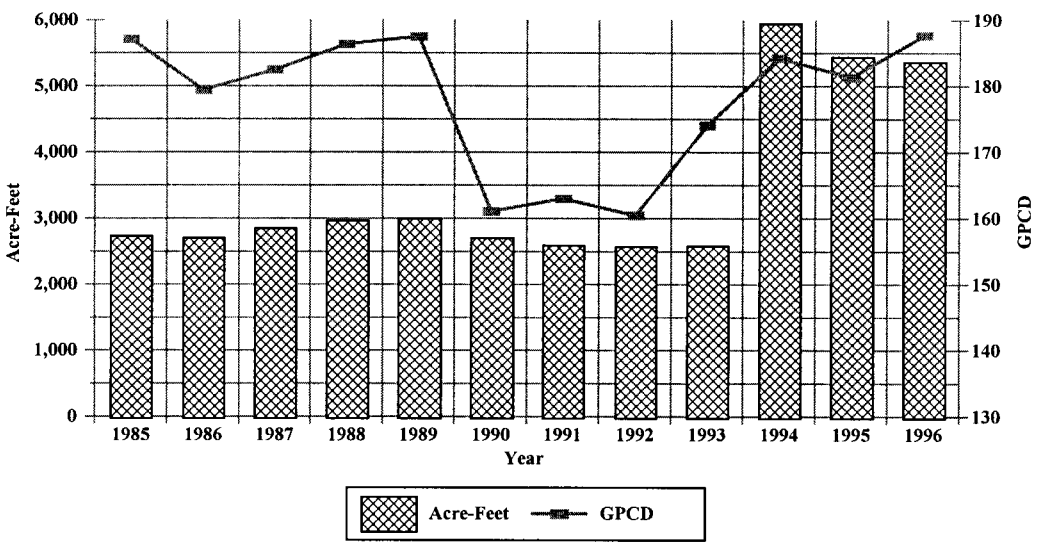
About 20 percent of University of Arizona water deliveries are to campus student housing, 2 percent to student union facilities and 25 percent for heating and cooling. The remaining 53 percent includes landscape watering and uses in classroom and laboratory buildings. Effluent use for landscape watering, installation of more efficient plumbing fixtures, and reduction of turfed area has contributed to reductions in volumetric water use and GPCD rates since 1987.

DMAFB is a federal facility that has made many water conserving changes over the past ten years in exterior irrigation practices and through the metering of buildings. Deliveries include about 42 percent to base housing and 14 percent to the base golf course. These deliveries are metered. The remainder of deliveries are unmetered and are used for commercial and recreational facilities, dormitories, non-residential landscape watering, and aircraft maintenance.

3.3.1.2 Small Providers

There are currently 127 active small municipal providers in the Tucson AMA. Figure 3-6 shows the average GPCD rate and volume of groundwater used by small municipal providers between 1985 and 1996. The average GPCD rate has fluctuated from 187 GPCD in 1985 to 161 GPCD in 1990, and 188 in 1996. A large decline in GPCD rates from the late 1980s to the early 1990s was likely the result of higher than average rainfall and lower than average evapotranspiration rates in the early 1990s compared to low rainfall and high evapotranspiration rates in the late 1980s. In 1994, a legislative change to the large provider definition resulted in 20 of the large providers being reclassified as small providers, resulting in an increase in the volume accounted for as small provider water use (see Table 3-5). The average per capita rate of the reclassified providers was 186, which resulted in increasing the total small provider average GPCD rate. In addition, between 1994 and 1996, low amounts of summer rainfall and higher than average evapotranspiration rates impacted per capita use.

FIGURE 3-6
SMALL PROVIDER WATER USE
1985-1996
TUCSON ACTIVE MANAGEMENT AREA



The 127 small providers are divided into five general categories as follows: 40 well cooperatives, 33 mobile home parks, 32 private water companies regulated by the Arizona Corporation Commission (ACC), five institutional-type providers (small providers are not eligible for the Institutional Provider Program), and 17 miscellaneous providers. Miscellaneous small providers include apartment complexes, motels and group housing that operate non-exempt wells. Small providers serve a wide range of residential developments in urban, suburban and rural areas. While the majority of small provider water deliveries are made to residential customers, per capita usage is highly variable due to differences in water rates, household income and lifestyle. In 1996, small providers delivered less than 3 percent of the municipal water used in the Tucson AMA.

3.3.2 Municipal Water Supplies

Groundwater is the predominant water supply served to municipal users. Effluent is served to turf-related facilities, landscaped medians, schools, and parks for irrigation. CAP water is not currently served directly to municipal users but in 1996, 2,800 acre-feet of CAP water were stored in underground storage facilities and almost 17,000 acre-feet were stored at groundwater savings facilities for later recovery by municipal providers. Tucson Water is currently prohibited from directly serving CAP water to its potable customers by a citizen's initiative passed in 1995 called the Water Consumers Protection Act (WCPA). Further discussion of the CAP delivery problems experienced by Tucson Water and the WCPA can be found in Chapter 8, section 8.2.2.1.2. Table 3-2 shows water use by source for 1985, 1990, and 1995. A small volume of CAP water was used in 1995 to maintain Tucson Water's Hayden-Udall CAP Water Treatment Plant.

3.3.2.1 Groundwater

In 1985, municipal groundwater use was 112,655 acre-feet or 97 percent of municipal supply. By 1995, it had increased to 147,080 acre-feet, or 95 percent of the total municipal water supply. Effluent use makes up the balance of water supply, increasing from 3 percent in 1985 to 5 percent in 1995. By the year 2010, municipal demand could be as much as 200,000 acre-feet even if municipal water providers meet the Third Management Plan conservation requirements. However, if use of renewable supplies increases from current levels, groundwater use could decrease substantially.

Providers designated as having an assured water supply are limited in the amount of mined groundwater they can use. As of May 1998, six providers had received Designations of Assured Water Supply. As provided for in the AWS Rules, these providers will need to replenish any mined groundwater used to serve both current and projected new demands in excess of their "groundwater allotment" (see Chapter 5, section 5.3). New subdivisions within the service area of nondesignated providers must independently obtain a Certificate of Assured Water Supply. While these new subdivisions are subject to a groundwater replenishment obligation, the current demand of undesignated providers (about 21,000 acre-feet) is not subject to groundwater replenishment and they can continue to use groundwater to meet this demand. This on-going groundwater mining is contrary to the Department's efforts to encourage the use of renewable supplies.

3.3.2.2 Effluent

Effluent has been used on a limited basis for golf course watering since the late 1970s. In 1984, the City of Tucson began operation of a reclaimed water distribution system to deliver effluent throughout its service area. In 1985, 3,080 acre-feet of reclaimed water and secondary effluent were used by the municipal sector. In 1990, the municipal sector used 6,279 acre-feet of reclaimed water and secondary effluent. A total of 7,711 acre-feet of reclaimed water and secondary effluent was accounted for as municipal use. Effluent use is projected to reach 18,800 acre-feet by 2010, or 9 percent of municipal water demand. Turf-related facilities served by municipal providers have an incentive to convert to effluent due to the City of Tucson's delivery policies and the favorable cost of effluent delivered through the City's reclaimed system as compared to the cost of potable groundwater delivered by the City.

While effluent use has increased since 1980, actual use is falling short of the assumptions in the Second Management Plan water budget of utilization of 40 percent of the region's effluent by the year 2000. Due to cost constraints, ownership issues, and location of treatment plants and delivery systems in relation to potential users, direct use of effluent has been slower to develop than was anticipated. In 1995, about 85 percent of the treated wastewater generated at the two regional wastewater treatment plants was discharged into the Santa Cruz River. However, improvements in treatment technologies, changing attitudes, and

increasing permitting and monitoring costs associated with discharging effluent into public waterways have facilitated efforts to utilize effluent as a water supply.

3.3.2.3 Central Arizona Project Water

Ten water providers in the Tucson AMA hold subcontracts for 163,033 acre-feet of CAP water (as shown in Chapter 8, Table 8-1). Six water providers held water storage permits for CAP water as of May, 1998. These permits allow the providers to store water at underground storage facilities or groundwater savings facilities and to earn long-term storage credits that may be accumulated for future use and recovered in a different location than where the water was stored. Recovered water retains the legal character of the originally stored water regardless of the hydrologic connection between the points of storage and recovery. Storage and recovery of CAP water helps to mitigate some of the water quality and access problems that have frustrated efforts to utilize CAP water as a directly delivered potable supply in the Tucson AMA. Tucson Water directly delivered more than 46,000 acre-feet of CAP water to potable customers in 1993 and more than 22,000 acre-feet in 1994. However, since that time CAP water has not been delivered for direct potable use due to water quality problems that are discussed in detail in Chapter 8.

3.4 INDUSTRIAL WATER USE CHARACTERISTICS

This section discusses the types of industrial water users and the water use patterns that are particular to each industrial subsector. It also includes an explanation of the water supplies available to industrial users and the constraints on utilizing renewable supplies. Industrial water users pump groundwater from their own wells pursuant to a Type 1 or Type 2 non-irrigation grandfathered right or a groundwater withdrawal permit. These rights and permits have annual volumetric allotments. Industrial users are subject to annual conservation requirements described in Chapter 6. All industrial users have general conservation requirements. In addition, the following industrial user groups in the Tucson AMA have specific conservation requirements:

- Turf-Related Facilities (≥10 acres)
- Sand and Gravel Facilities (>100 acre-feet/year)
- Metal Mining Facilities (>500 acre-feet/year)
- Large-Scale Power Plants (>25 megawatts)
- Large-Scale Cooling Facilities (>1000 tons)
- Dairy Operations (monthly average ≥100 lactating cows/year)
- New Large Landscape Users (>10,000 square feet)
- New Large Industrial Users (>100 acre-feet/year)

3.4.1 Industrial Water Demand

Water demand fluctuates for the industrial sector depending on market conditions, weather patterns, population, and industry-specific variables. While industrial water use is limited by the total volume of grandfathered rights and permits, some new permits can be issued to support industrial uses. Demand by most industrial use sectors has been relatively constant since 1987 with the exception of metal mine use which has fluctuated due to changes in the worldwide demand for copper.

With urban growth comes construction of golf courses, schools, parks, shopping centers, and other industrial facilities. It is anticipated that most future general industrial development will be served by municipal providers, although existing industrial right holders are also expected to increase their use in the future. Urban expansion into previously rural areas may also impact the operations of some industrial users. For example, encroaching urbanization may result in complaints about dust and noise generated by sand and gravel facilities and may affect the location of future sites.

3.4.1.1 Historic and Current Demand

Beginning in 1987, the reporting requirements of the First Management Plan went into effect, and the data reported by industries to the Department improved. As a proportion of overall AMA demand, industrial use has fluctuated between 15 to 20 percent since 1987 as shown in Table 3-8. The Tucson AMA has the largest industrial sector as a percentage of total AMA water use when compared to the other AMAs. Because of this, water conservation efforts and efforts to promote use of renewable supplies by industrial users is a focus of Tucson AMA water management activities.

Table 3-9 contains detailed water use information for 1995, including the number of industrial facilities by category, associated water rights and permits, and the volume used in 1995. Industrial users currently use considerably less water than they are entitled to use pursuant to their grandfathered water right and permit allotments. The actual allotment associated with the industrial sector is 192,462 acre-feet per year not including emergency dewatering and hydrologic testing permits. The difference between the allotment volume and actual use is partially explained by the process used to establish grandfathered water rights. Type 2 non-irrigation grandfathered right allotments for industrial users were based on the highest pumpage year from 1975 to 1980. Industrial water use is associated with production levels that in some cases were high during this period; production levels and annual water use can fluctuate widely in response to varying economic conditions. In addition, some industrial users have ceased operations entirely, although they have retained their water rights.

TABLE 3-8
WATER USE BY INDUSTRIAL USERS 1987-1995
TUCSON ACTIVE MANAGEMENT AREA

	Total Industrial Water Use Per Year (acre-feet)								
User Category	**1987**	**1988**	**1989**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**
Metal Mining	22,309	23,899	31,606	32,443	39,605	36,536	38,721	43,523	41,359
Turf-Related[1]	6,315	6,857	7,287	7,059	7,118	6,782	6,858	7,204	7,961
Sand & Gravel	4,386	3,383	3,408	3,296	2,323	2,869	3,847	4,458	5,176
Electric Power	1,679	2,728	2,766	1,942	1,325	1,772	1,835	2,521	1,609
Dairies	70	72	51	53	62	46	48	70	73
Other Indus. >100 AFA	3,021	2,719	2,443	2,154	2,318	2,457	2,618	2,852	2,754
Other Indus. <100 AFA	3,093	2,995	2,703	1,796	2,574	1,575	1,407	1,531	1,272
Total Indus.	40,872	42,654	50,263	48,743	55,325	52,036	55,334	63,159	60,204
% of Total AMA Demand	15%	15%	17%	18%	20%	19%	20%	20%	19%

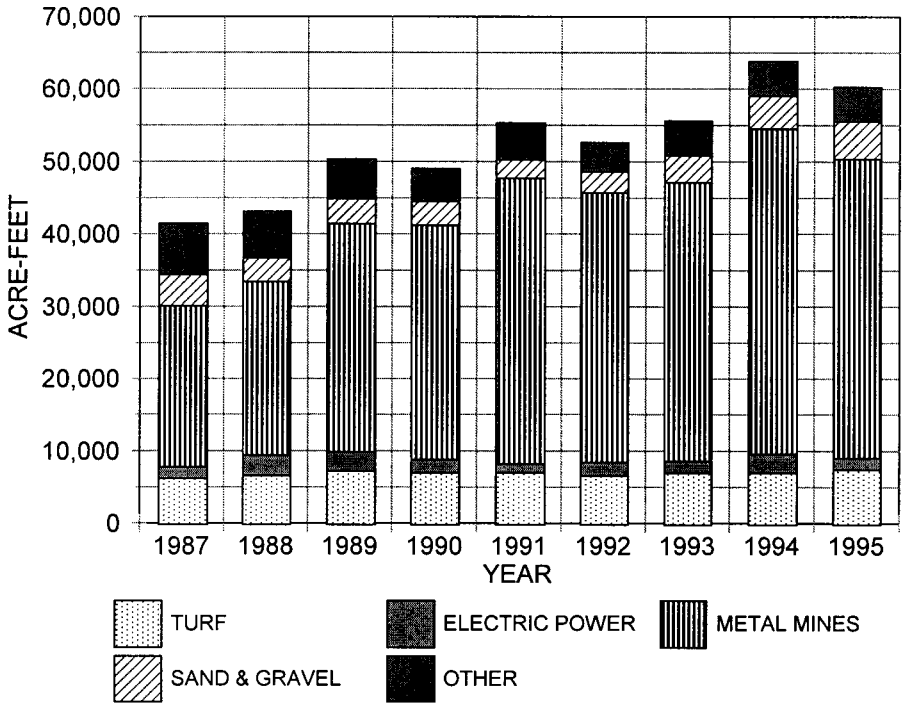
[1] Industrial Turf-related facilities pump groundwater from their own wells pursuant to a Type 1 or Type 2 non-irrigation grandfathered right or a groundwater withdrawal permit. Water served to turf-related facilities by municipal providers is included in the municipal providers' water use in section 3.2.

TABLE 3-9
INDUSTRIAL GROUNDWATER RIGHTS AND WITHDRAWAL SUMMARY
1995
TUCSON ACTIVE MANAGEMENT AREA

User Category	1995 Groundwater Use (AF)	1995 Total Water Use (AF)	Right or Permit Allotments [1] (AF)	Type of Right or Permit	Number of Facilities
Metal Mines	41,359[2]	41,359[2]	63,098	Type 1 non-irrigation rights Type 2 mineral extraction rights Mineral extraction permits	4
Turf-Related	7,179	7,961	11,034	Type 1 non-irrigation rights Type 2 non-irrigation rights Industrial use permits	28
Sand and Gravel	5,176	5,176	17,194	Type 1 non-irrigation rights Type 2 non-irrigation rights Type 2 mineral extraction rights General industrial use permits Mineral extraction permits	15
Other Industrial	4,026	4,026	90,855	Type 1 non-irrigation rights Type 2 non-irrigation rights Industrial use permits[1]	340[1,3]
Electric Power	1,609	1,609	10,071	Type 2 electrical generation rights	2
Dairies	73	73	210	Type 2 non-irrigation rights	1
TOTAL	59,422	60,204	192,462		390

[1] Does not include emergency dewatering, temporary dewatering or hydrologic testing permits.
[2] Includes 2,982 acre-feet withdrawn from San Xavier District by ASARCO not pursuant to groundwater rights and permits.
[3] Number of groundwater rights and permits

FIGURE 3-7
TRENDS IN INDUSTRIAL WATER USE
1987 THROUGH 1995
TUCSON ACTIVE MANAGEMENT AREA



3.4.1.2 Water Demand by Industrial Subsector

3.4.1.2.1 Metal Mines

Metal mining is by far the largest water using industrial category in the Tucson AMA, using 41,359 acre-feet in 1995 (Table 3-9). Four metal mines are currently operating in the Tucson AMA: Cyprus Sierrita, Cyprus Twin Buttes, ASARCO Mission Complex and ASARCO Silver Bell. In 1995, the activities of the Cyprus Sierrita and Twin Buttes mines consumed 27,389 acre-feet. ASARCO Mission Complex withdrew 10,771 acre-feet pursuant to their groundwater allocation in 1995, plus an additional 2,982 acre-feet of groundwater pumped from the San Xavier District by agreement with the District, for a total of 13,753 acre-feet of groundwater use. Groundwater withdrawn from the District is not subject to state reporting and management requirements for groundwater. ASARCO Silver Bell Mine used only 217 acre-feet of groundwater in 1995, but has constructed a new solvent extraction/electrowinning plant at the site that will lead to increased copper production and water use. Metal mining is anticipated to maintain current water use rates through 2025. Metal mines are projected to use approximately 47,000 acre-feet in 2010.

3.4.1.2.2 Turf-Related Facilities

Turf-related facilities constitute the next largest industrial user category in the Tucson AMA and include 12 golf courses, four parks, four cemeteries, and eight schools served by their own industrial groundwater rights rather than by a water provider. Other turf facilities are served by municipal providers and are included in the discussions of municipal water use in section 3.2. In 1995, 7,961 acre-feet of water was served to industrial turf-related facilities for watering turf grass and other landscaping, and for filling lakes and ponds. Ninety percent, or 7,179 acre-feet, of the total water used was groundwater. The 782 acre-feet

of effluent used by two golf courses and one cemetery was the only effluent used by industrial users in 1995. Most of these turf-related facilities predate the Code and are served by Type 2 non-irrigation grandfathered rights. These facilities are located in the Tucson metropolitan area, Marana and Green Valley. At the time of development, the facilities tended to be on the outskirts of the urbanized area or in newly developed rural areas. Industrial user golf courses developed after 1980 are situated on lands with Type 1 non-irrigation grandfathered rights. One school is served by a general industrial use permit. Most future industrial user turf-related facilities are anticipated to be developed on lands with Type 1 rights. A small number of Type 2 rights may become available to serve new facilities as older industrial facilities in urbanized areas are converted to effluent use.

3.4.1.2.3 Sand and Gravel Facilities

Sand and gravel facilities used 5,176 acre-feet of groundwater in 1995. In the Tucson AMA, 15 sand and gravel facilities are clustered along the banks of the Santa Cruz River or along sand and gravel deposits in the Tucson, Green Valley and Marana areas. These sand and gravel facilities are served by Type 1 non-irrigation grandfathered rights, Type 2 non-irrigation grandfathered rights, and Type 2 mineral extraction rights or general industrial use permits that allow them to withdraw up to approximately17,000 acre-feet of groundwater annually. Sand and gravel use is expected to expand to meet increased materials needs from the construction industry.

3.4.1.2.4 Other Subsectors

In 1995, the electric power industry used 1,609 acre-feet and the one remaining dairy in the AMA used 73 acre-feet. Groundwater demand by electric power is not projected to parallel population growth because the electric power needed to meet increasing demand is likely to be imported, rather than generated within the AMA. The one dairy currently operating in the AMA is expanding the size of the dairy herd and water use is expected to increase. It is not anticipated that any additional dairies will be constructed in the AMA. Miscellaneous industrial users that do not fit into the definitions of the specific regulatory categories constitute the "other" industrial user category. Some of the largest users included in this category are cement manufacturing plants, hospitals, bottling plants, electronics plants, aerospace facilities, shopping centers, and resorts. This group used 4,026 acre-feet of groundwater in 1995. There are currently no feedlot operations in the AMA. The number and water use of new large landscape users, new large industrial users, and large-scale cooling facilities have not yet been identified in the AMA. Cooling tower use, however, is expected to increase with time as the number of offices, shopping centers, schools, hospitals, and other large facilities increase along with population growth.

3.4.2 Industrial Water Supplies

The industrial sector in the Tucson AMA is almost entirely groundwater dependent and uses less renewable water supplies than either the agricultural or municipal sectors. Effluent is used only by turf-related facilities and constitutes about one percent of overall industrial water use. Water supply sources and volumes from 1987 to 1995 are shown in Table 3-10.

Because industrial users have the legal authority to withdraw groundwater up to the annual allotment of their rights and permits, subject to conservation requirements, they have no economic incentive to use more costly renewable water supplies. In addition, physical access to renewable supplies is often limited because potential users are far from conveyance facilities. No industrial user in the AMA holds a CAP subcontract. Use of effluent supplies must be negotiated with the entities who control this supply: the City of Tucson, Pima County, and the United States Secretary of the Interior. Some industrial users also have water quality requirements depending on the industrial process involved and may need to treat water or remove salts or other constituents from renewable supplies prior to their use, which can add to the expense of alternative water supplies. Some industrial users could use non-groundwater supplies if cost,

availability, and water quality conditions were met. Potential users include metal mines, sand and gravel operations, large-scale electric power plants, and large-scale cooling facilities as discussed in Chapter 6. Opportunities for use of renewable supplies by the industrial sector will be explored in the third management period.

TABLE 3-10
WATER SUPPLY SOURCES SERVING INDUSTRIAL USES
1987 THROUGH 1995
TUCSON ACTIVE MANAGEMENT AREA

Year	Groundwater		Effluent		Total Water Use (AF)
	Volume (AF)	Percent of Total Water Use	Volume (AF)	Percent of Total Water Use	
1987	40,323	99%	549	1%	40,872
1988	41,987	98%	667	2%	42,654
1989	49,619	99%	644	1%	50,263
1990	47,974	98%	769	2%	48,743
1991	54,654	99%	671	1%	55,325
1992	51,475	99%	561	1%	52,036
1993	54,684	99%	650	1%	55,334
1994	62,371	99%	788	1%	63,159
1995	59,422	99%	782	1%	60,204

AF = Acre-feet

3.5 CURRENT WATER BUDGET

The water budget shown in Table 3-11 contains information on water use within each demand sector in 1990 and 1995, as well as hydrologic components described in Chapter 2. This water budget reflects actual conditions in 1990 and 1995, except where factors are averaged over time as is the case with net natural recharge. The budget contains more municipal groundwater use than is shown in previous sections of this chapter because it includes estimates of water use by owners of exempt wells and Indian water use. The water budget indicates more agricultural water use in 1995 than shown in previous sections because it includes an estimate of water use for exempt small irrigation rights.

Mined groundwater constituted over half of the total water supply in 1995, leaving the AMA far from reaching its safe-yield goal. Demand for groundwater consistently exceeds water supplied through natural and incidental recharge. While around 10,100 acre-feet of CAP water was recharged in 1995, this volume does not appear in the water budget because the associated CAP recharge credits were not recovered to meet sector demands in 1995. Approximately 100 acre-feet of CAP water was used for treatment plant maintenance in 1995, and this volume does appear in the budget. Demand in all sectors increased between 1990 and 1995 resulting in a corresponding increase in groundwater overdraft between these years. Water budget projections of demand and supply through 2025 are described in depth in Chapter 11.

TABLE 3-11
WATER BUDGET
1990 AND 1995
TUCSON ACTIVE MANAGEMENT AREA

	1990	1995
Municipal Sector		
Demand - TOTAL	130,100	155,500
Non-Indian [1]	130,000	155,400
Indian [2]	100	100
Supply - TOTAL	130,100	155,500
CAP Water[3]	0	100
Effluent	6,300	7,700
Groundwater	123,800	147,700
Agricultural Sector		
Demand - TOTAL	93,800	98,000
Non-Indian [1]	93,800	98,000
Indian [2]	0	0
Supply - TOTAL	93,800	98,000
CAP Water[3]	0	0
Effluent	4,000	1,800
Groundwater	89,800	96,200
Industrial Sector		
Demand - TOTAL	48,800	60,200
Supply - TOTAL	48,800	60,200
CAP Water[3]	0	0
Effluent	800	800
Groundwater	48,000	59,400
Other Demand		
Demand - Evapotranspiration	3,700	3,700
Supply - Groundwater	3,700	3,700
TOTAL DEMAND	276,400	317,400
Total Groundwater Use	265,300	307,000
(Less) Net Natural Recharge [4]	60,800	60,800
(Less) Incidental Recharge	70,300	82,300
Groundwater Overdraft	134,200	163,900

[1] Non-Indian demand indicates demand for uses off Tohono O'odham Indian Reservation lands and includes exempt wells and water served to the Pascua Yaqui tribal lands by Tucson Water

[2] Indian Demand comprises demand on the San Xavier and Schuk Toak Districts of the Tohono O'odham Reservation.

[3] CAP water use is shown in the water budget only if CAP water recharge credits have been recovered or CAP water was used directly

[4] Net Natural Recharge is composed of the following components: mountain front and stream channel recharge, and groundwater inflow less groundwater outflow.

3.6 CONCLUSIONS

Water use by the municipal and industrial sectors has increased since 1985 and recent agricultural water use is at levels comparable to the mid-1980s following reductions in use in the early 1990s. All sectors continue to use predominantly groundwater although effluent use and use of CAP water through in-lieu arrangements and direct recharge are increasing. These water supply and demand trends illustrate that considerable water conservation and renewable water use efforts are needed to achieve the Tucson AMA safe-yield goal by 2025.

The Third Management Plan programs in Section II of this plan discuss in detail the Department's conservation and augmentation strategies for the third management period. These programs are designed to result in progress toward meeting the AMA safe-yield goal.

SECTION

II

Regulatory Programs

Chapter 4 Agricultural Conservation Program

Chapter 5 Municipal Conservation Program

Chapter 6 Industrial Conservation Program

Chapter 7 Groundwater Quality Management Program

Chapter 8 Augmentation and Recharge Program

Chapter 9 Water Management Assistance Program

Chapter 10 Plan Implementation

Preface

Section I provided an overview of the Arizona Department of Water Resources' (Department) statutory authority and management objectives, and described the physical, climatic, demographic, and water use characteristics of the active management area (AMA). Long-term water level declines, land subsidence, and water quality problems, coupled with current and projected groundwater over-drafting estimates, provide compelling justification for the development of progressive and responsible water management programs.

This section of the Third Management Plan is entitled "Regulatory Programs" because the programs described are required of groundwater users or are preconditions to obtaining certain permits or financial assistance. The regulatory chapters that follow describe specific requirements for groundwater users within the AMA. Programs contained in this section include mandatory conservation requirements, a criterion for demonstrating consistency with the management plan by applicants for Certificates of Assured Water Supply, additional programs designed to encourage the use of renewable water sources, recharge program eligibility and operational criteria, criteria for obtaining financial assistance for water management programs, and plan implementation activities, including the Department's compliance and enforcement program.

Chapters 4, 5, and 6 contain the agricultural, municipal, and industrial conservation programs, respectively. Chapter 7 discusses the Department's groundwater quality management program and provides an assessment of water quality within the AMA. Chapter 8 describes the Department's augmentation and recharge program, and Chapter 9 discusses the Department's water management assistance program. Finally, Chapter 10 outlines the Department's policies and procedures for implementation of the Plan.

The regulatory programs are based on a philosophy developed by the Department over the course of the last two management periods. In the first management period, the Department focused on the conservation of groundwater as its primary management goal. In the second management period, the Department continued to enhance the conservation programs, but also implemented a program for the augmentation of water supplies, which included incentives for the increased use of renewable supplies. In the third management period, the Department's focus is on both conservation of groundwater and augmentation of water supplies. The Department's regulatory philosophy is based on its overall water management goals for the management plans: the conservation of groundwater through the efficient use of all water sources and the augmentation of water supplies to ensure a long-term, secure water supply.

The safe-yield goal and the overall mission statement of the Department are guiding concepts in the agency's activities. An understanding of the basic framework of the regulatory programs requires knowledge of the components of the safe-yield goal and the Department's compliance approach. The framework is described below.

- **The AMA Management Goal: Safe-yield**

  "Safe-yield" by January 1, 2025 is the management goal of the Tucson AMA. "Safe-yield" is defined by statute to mean:

  > [A] groundwater management goal which attempts to achieve and thereafter maintain a long-term balance between the annual amount of groundwater withdrawn in an active management area and the annual amount of natural and artificial recharge in the active management area. A.R.S. § 45-561 (12).

The statute specifies that safe-yield is "a long-term balance." Thus, the hydrologic conditions in the AMA cannot simply be viewed in the short-term, but rather must be viewed over a longer period of time. Further, establishing a "balance" is more complicated than comparing the total amount of groundwater withdrawals for the AMA to the amount of recharge occurring in the area in a given year.

In analyzing whether an AMA is at a safe-yield condition, the Department considers the following factors which impact groundwater levels and water in storage:

1. Net natural recharge: Net natural recharge in a given year is the volume of water that naturally recharges the groundwater supply minus the natural depletions to the groundwater supply over the course of that year. The components of net natural recharge that increase the groundwater supply are stream channel infiltration, mountain front recharge, and groundwater inflow into the AMA. The components that naturally deplete the groundwater supply are groundwater outflow out of the AMA and water loss due to evapotranspiration. Infiltration of treated effluent discharged to surface water channels is not a component of net natural recharge.

2. Incidental recharge: Incidental recharge originates as groundwater or surface water which percolates down to the water table during and after its use for human activity. In the Tucson AMA, the volume of incidental recharge is largely dependent on the quantity of municipal effluent discharged into stream channels, and the volume and efficiency of agricultural and mining water use. It should be noted that incidental recharge that occurs during the use of the water may not be permitted as an underground storage activity under the state's Underground Water Storage (UWS) Program. Water that is treated after its use for municipal purposes, becomes effluent, and is released into a natural streambed, however, is specifically recognized by the UWS Program as eligible to become a managed underground storage activity. *See A.R.S. §§ 45-801.01 et seq.* As is more fully explained below, storage credits that are accrued through an effluent discharge that has been permitted as a managed storage facility cannot be counted as a contribution to safe-yield.

3. Artificial recharge: Under the state's UWS Program, A.R.S. §§ 45-801.01 *et seq.*, persons may undertake recharge projects to purposely add water to an aquifer without the right to withdraw it in the future. However, artificial recharge is commonly used as a storage mechanism to accrue credits with the expectation of future recovery. Stored water for which credits have been issued cannot be counted as a contribution to safe-yield, because it is already allocated to the water storer. Therefore, this type of water has no impact on the safe-yield volume; however, it does result in a temporary increase in groundwater in storage.

   Not all water stored under the UWS Program can be recovered. The volume of recharge which is allocated permanently to the aquifer, or the "cut to the aquifer" that results from generation of certain types of recharge credits does benefit the aquifer and is a component of the safe-yield groundwater supply. In addition, any non-recoverable storage that is conducted under the UWS Program in a given year can be included in the safe-yield volume for that year. Recharge credits that are generated and then subsequently extinguished prior to use are also a component of the safe-yield supply.

4. Groundwater pumping: Annual pumpage volumes from the AMA's aquifers are considered in the safe-yield calculation. Withdrawals in association with irrigation grandfathered rights, non-irrigation grandfathered rights, groundwater withdrawal permits, and undesignated municipal providers are calculated as debits to the groundwater system.

Also considered in the safe-yield calculation as a debit to the system is the volume of groundwater allowed through the Assured Water Supply Program for each Designation and Certificate of Assured Water Supply issued prior to 2025. The Department concluded in the development of the Assured Water Supply Rules that a limited quantity of the groundwater in storage could be allocated as a portion of the allowable water supply for each applicant. This groundwater can be used at any time in the 100 year period; however, it is expected that this allowance will be used in the early years while other supplies are being developed, or to offset groundwater pumpage during shortage years in CAP supplies.

5. Committed demand: Committed demand is an important component in the calculation of safe-yield. In the context of an application for a Designation of Assured Water Supply, the applicant must demonstrate the physical availability of a water supply for a 100 year period which includes sufficient water to serve current, committed, and projected demand. Committed demand is associated with platted, undeveloped lots which will be served in the future. In the assured water supply demonstration process, all demands, including the committed demand, must be determined to be physically available. This demand is reflected in the safe-yield calculation. Outside of the designation process, committed demand is associated with unbuilt subdivisions for which a Certificate of Assured Water Supply already exists. In addition, lots that otherwise fall outside of the Assured Water Supply Program requirements represent a potential future demand. This committed groundwater demand must be counted as already having been "allocated" when examining safe-yield. To do otherwise would allow groundwater to be allocated multiple times to multiple developments, resulting in an underestimation of the long-term demands on the AMA's aquifers.

The volume of groundwater that can be withdrawn while maintaining a safe-yield condition in the AMA is not a fixed amount; it will change due to annual variations in incidental, natural, and artificial recharge, as well as other factors listed above. The groundwater system is in a state of "overdraft" as long as groundwater withdrawals exceed the sum of the naturally and incidentally recharged volumes plus the portion of the artificially recharged volume that will not be withdrawn later as storage credits.

Because water level changes are direct indicators of changes in groundwater storage, they are the measured data which support the other factors of the safe-yield analysis. However, changes in water levels are expected to continue even after achievement of safe-yield, as stored credits are recovered and entities with assured water supply designations utilize their groundwater allotments. An AMA that is at safe-yield should not experience broad-ranging, significant, and continuing declines in average water levels after adjustments are made for the factors just described. Therefore, water levels are considered in making the safe-yield determination.

- **Total Water Use Conservation Requirements and "Stacking"**

With the wide array of water resources available in Arizona as an alternative to groundwater, including surface water, effluent, CAP water, and poor quality remediation water, the Department attempts to provide incentives that will promote use of these alternative supplies whenever and wherever possible. At the same time, we recognize that groundwater is often a very accessible and inexpensive source of supply, whereas the alternative sources can be expensive and difficult to use. The Department also recognizes that groundwater is our state's "emergency" supply, and it must be available for use whenever the other alternatives run short. Groundwater is particularly valuable as a long-term drought supply, to buffer the effect of changes in surface water availability. In order to maximize the supply of groundwater, and ensure sufficient supplies of

water, all sources must be utilized efficiently.

For these reasons, the Department believes that it is both impractical and unwise to consider groundwater use as the only measure of regulatory compliance. The level of groundwater use that is reasonable is relative to the amount of water used from other sources. To ensure that groundwater users make reasonable use of groundwater, and to encourage efficiency and flexibility in the use of alternative supplies, the regulatory strategy includes evaluation of the total water use of each water user and provider, and setting conservation requirements based upon that total water use. In keeping with the Department's statutory obligations and limitations, however, the conservation requirements of the management plan only apply if groundwater is used.

The Department's regulatory program is, therefore, structured around the concept of "stacking" different types of water, by type, in a compliance hierarchy, with groundwater on top. If a total water use conservation requirement is exceeded by a user of groundwater, the amount of the violation of that requirement will be measured by the amount of groundwater used in excess of the regulatory requirements. This strategy will ensure that if groundwater is being used, it is being used as wisely and efficiently as economically possible. This system also provides the flexibility needed by most users of commingled supplies, allowing groundwater to be used as needed to supplement alternative sources

- **Flexibility in the Components of the Regulatory Plan**

The Department recognizes that water use varies by year and locality. Therefore, the Department has provided maximum flexibility when administering the regulatory provisions of the management plan. For example, most regulatory provisions include a basic program, with one or more alternative programs designed to meet special circumstances. The basic program is generally designed to place simple numerical limits on water use, leaving the means of achieving those limits wholly up to the water user or provider. The alternative programs tend to remove numerical limits in favor of specific conservation measures more suitable to the water user.

Another component of regulatory flexibility is the establishment of "flexibility accounts" for most allotment-based requirements. These accounts generally allow water users to borrow or bank water from one year to the next in order to overcome the variation in use caused by weather or other unforseen circumstances. Flexibility accounts are mandated by statute for agricultural users, and the Department has used this example to incorporate flexibility accounting into municipal and industrial programs as well.

- **Administrative Review and Variance of Conservation Requirements**

Even with the general flexibility of the regulatory programs, the Groundwater Code (Code) recognizes that certain individual conservation requirements may pose hardship in certain circumstances. To allow relief in these situations, the Code provides for an administrative review and variance process. The emphasis in this process is on the impact of a particular conservation requirement as it is applied to an individual water user. Administrative review and variance are fact-intensive inquiries which may result in some regulatory relief and are considered on a case-by-case basis.

- **Accounting for Water Use**

Many water providers deliver a mix of water types. In order to determine compliance with conservation requirements, the Department must adopt a set of policies for commingled systems. The Department is continuing to develop policies for "volumetric" accounting.

Generally, a water provider delivering different types of water through a commingled system cannot determine which type of water a customer actually received. Therefore, the provider is generally asked to account for all deliveries to its customers on a volumetric as opposed to molecular basis. This allows the provider to compute the percentage of each type of water delivered in a given year, and apply that same percentage to the water delivered to each customer, regardless of the type of water actually received by the customer. This volumetric accounting policy works well for most providers, because of its simplicity and certainty. Individual circumstances may warrant individual consideration, however, and the Department is constantly reviewing its policies on volumetric accounting to recognize necessary exceptions. Generally speaking, however, the Department does not recognize accounting which shows a concentration of deliveries of certain types of water to certain users if the delivery system is physically commingled.

- **Enforcement**

  An effective conservation plan requires effective enforcement. The Department is given wide ranging enforcement authority in the statutes to ensure that all water users are contributing their share to the overall goal of groundwater conservation and augmentation of water supplies. While the statutes allow the imposition of substantial monetary penalties for violating either water use limitations or conservation requirements, the Department is also given considerable discretion in how that enforcement program will be managed. Overall, the Department's philosophy has been that the ability to correct management deficiencies and save groundwater is more important than collecting monetary penalties. Therefore, most of the Department's regulatory efforts to date have involved voluntary "consent orders" where the water user in violation agrees to adopt conservation measures, guarantee future compliance, or otherwise mitigate the impact of the violation on the state's groundwater resources in exchange for waiver or reduction of the civil penalties. This approach has worked well in the past, and has been particularly useful in making the transition from a state where groundwater use was essentially unregulated to a state where water regulation has become a fact of everyday life.

  In the third management period, the Department will continue its policy of reviewing each suspected violation on an individual basis. The Department will also continue its policy of working with any water user in violation of the groundwater laws to make certain that all the surrounding circumstances are understood and to explore alternative means by which the problem might be solved. In some cases, however, violations are not matters of inadvertence or misunderstanding, but are repeat offenses or voluntary decisions based on economic considerations, lack of planning, or careless disregard for the resource. During the third management period, the Department will strive to identify these latter types of violations and pursue stringent civil penalties. By so doing, the Department intends to bring greater equity and fairness to the common goal of saving our groundwater supply. Alternative mechanisms to achieve compliance while encouraging achievement of local water management goals will also be explored.

The foregoing synopsis of the Department's regulatory approach is intended to assist the reader in understanding the reasons behind the mandatory conservation requirements in the following regulatory chapters. In addition, we have included a Plan Implementation Chapter which gives more definitive explanation to many of the administrative policies and procedures introduced here. Finally, it has always been the Department's policy to offer assistance to anyone seeking to better understand or comply with the conservation requirements imposed by the management plans, or the requirements of the Groundwater Code. The AMA offices, or the central office in Phoenix, can provide valuable support on most water management issues.

CHAPTER

4

Agricultural Conservation Program

4.1 INTRODUCTION

The Agricultural Conservation Program for the Third Management Plan has been developed to contribute to the achievement of the safe-yield goal by the year 2025 for the Tucson Active Management Area (AMA). The agricultural sector's contribution to meeting the Tucson AMA's safe-yield goal is projected to come from a combination of improved on-farm water management practices, utilization of renewable supplies, and the reduction of irrigated acreage due to urban and industrial development.

As discussed in Chapter 3, agriculture is responsible for about one-third of the total annual water use in the Tucson AMA. In 1995, approximately 94,000 acre-feet of water were used for agricultural irrigation purposes. Most of this water came from groundwater sources. Other sources of water used for agricultural irrigation include treated effluent and Central Arizona Project (CAP) water through the Arizona Department of Water Resources' (Department) Groundwater Savings Program.

Under the Groundwater Code (Code), only land associated with a Certificate of Irrigation Grandfathered Right (IGFR) can be legally irrigated with groundwater within an AMA. A.R.S. § 45-465. These certificates were issued by the Department based on crops and acreage planted from the years 1975 to 1980. Land not irrigated during this time period may not be irrigated with any water unless one of the exceptions stated in the Code applies. A.R.S. § 45-452. For each IGFR, the Department establishes a maximum annual groundwater allotment based on certain statutory criteria.

At this time, the Department is deferring adoption of a Base Program under A.R.S. § 45-566(A)(1) as part of the Agricultural Conservation Program. This delay is based on concerns which have been raised by the agricultural community regarding the proposed adoption of an agricultural conservation program that includes water duties based upon an 85 percent irrigation efficiency.

Presently, the Department is adopting the Historic Cropping Program that was authorized by A.R.S. § 45-566.02 and conservation requirements for irrigation distribution systems. Participation in the Historic Cropping Program is voluntary, and those who do not participate will be subject to the agricultural conservation requirements established by the Second Management Plan until the Department adopts a Base Program for the Third Management Plan. Descriptions of the Historic Cropping Program and the irrigation distribution system conservation program are detailed in this chapter.

In addition to these regulatory conservation programs, the Department will continue to encourage the efficient use of renewable water supplies by the agricultural sector through other water resource management methods. During the third management period, indirect recharge at groundwater savings facilities, effluent reuse programs, and water management assistance program funds will contribute to the water management activities in the Tucson AMA.

In this chapter, the following topics are discussed in the order listed:

- Statutory Provisions
- Irrigation Water Duties and Maximum Annual Groundwater Allotments
- Agricultural Conservation Program Components
- Non-regulatory Water Resource Management Strategies
- Future Directions
- Agricultural Conservation Requirements and Monitoring and Reporting Requirements

4.2 STATUTORY PROVISIONS

The Code limits uses of groundwater for irrigation purposes in AMAs in several ways. These statutory provisions are described below.

4.2.1 Third Management Plan

A.R.S. § 45-566 requires the director to follow established guidelines in developing management plans for the third management period (the years 2000 to 2010). For the agricultural sector, in the plan for each AMA, the director:

- Shall establish an irrigation water duty for each farm unit to be reached by the end of the third management period.
- May establish one or more intermediate water duties to be reached at specified intervals during the third management period.
- Shall calculate the irrigation water duty or intermediate water duties as the quantity of water reasonably required to irrigate the crops historically grown in the farm unit and shall assume the maximum conservation consistent with prudent long-term farm management practices within areas of similar farming conditions, considering the time to amortize conservation investments and financing costs.
- After computing the irrigation water duties or intermediate water duties, may adjust the highest 25 percent of the water duties within an area of similar farming conditions by reducing each water duty in an amount up to 10 percent, except that in making the adjustment, no water duty may be reduced to an amount less than the highest water duty within the lowest 75 percent of the water duties computed within an area of similar farming conditions.
- Shall grant an exemption from the irrigation water duties at any time during the third management period if an applicant can demonstrate to the director's satisfaction that the applicant's farm unit meets specific hydrologic conditions regarding waterlogging or basin outflow.
- Shall establish additional economically reasonable conservation requirements for the distribution of groundwater by cities, towns, private water companies, and irrigation districts within their service areas.

4.2.2 New Irrigated Lands Prohibited

Under A.R.S. § 45-452, only acres of land which were legally irrigated at any time from January 1, 1975 through January 1, 1980, which are capable of being irrigated, and which have not been retired from irrigation or conveyed for a non-irrigation use, may be irrigated with any water unless one of the following exceptions apply:

- Surface water may be used pursuant to decreed or appropriative rights established before June 12, 1980. A.R.S. § 45-452(A).
- Existing acreage irrigated with surface water may be replaced with new acreage if the surface water right is severed and transferred to the new acreage. A.R.S. § 45-172.
- State universities may irrigate new acreage not to exceed a total of 320 acres of land with not more than five acre-feet of groundwater per acre per year. A.R.S. § 45-452(I).

- Correctional facilities under the jurisdiction of the Arizona Department of Corrections may irrigate new acreage not to exceed a total of 10 acres of land with not more than four and one-half acre-feet of water per acre per year for the purpose of producing plants for consumption by inmates as part of a prisoner work program. A.R.S. § 45-452(J).

- Existing acreage damaged by floodwaters may be replaced with new acreage. A.R.S. § 45-465.01.

- Existing acreage which has a condition that limits irrigation efficiency may be replaced with new acreage. A.R.S. § 45-465.02.

4.2.3 Maximum Annual Groundwater Allotments

Under A.R.S. § 45-465, the maximum annual groundwater allotment for each IGFR is determined by multiplying the irrigation water duty by the water duty acres. The irrigation water duty is the annual amount of water in acre-feet per acre that is reasonable to apply to irrigated land to produce the crops historically grown (1975 to 1980) divided by an assigned irrigation efficiency. Water duty acres are the highest number of acres in a farm, taking land rotation into account, that were legally irrigated during any one year from 1975 to 1980. The maximum annual groundwater allotment may be used to irrigate any or all of the irrigation acres in the farm unit. Irrigation acres are the acres in the farm which were legally irrigated at any time from 1975 to 1980.

4.2.4 Flexibility Account Provisions

In order to provide farmers with sufficient flexibility to address varying climatic conditions and to take advantage of changing agricultural market conditions, the Code requires the director to establish a flexibility (flex) account for each farm which receives a maximum annual groundwater allotment. A.R.S. § 45-467. In 1987, the Department began implementing these provisions in the Tucson AMA.

Under the flex account statute, a right holder may accumulate both flex account credits and debits. If a right holder uses water during a year in excess of the farm's maximum annual groundwater allotment, the flex account is debited. A negative balance which exceeds 50 percent of the annual allotment, results in a violation of the conservation requirement. If a right holder uses less water during a year than the farm's maximum annual groundwater allotment, the flex account is credited. Accrued flex account credits are not limited, can be used at any time in future years, and may be used to offset a debit. In addition, under certain conditions right holders may transfer the flex account credits accumulated during the preceding calendar year from one IGFR to another. A.R.S. § 45-467(O).

4.2.5 Historic Cropping Program

In 1998, the legislature adopted A.R.S. § 45-566.02 that directs the Department to include in the Third Management Plan an agricultural conservation program entitled the Historic Cropping Program. Laws 1998, Ch. 274, § 1. Under this program, the director must calculate the maximum annual groundwater allotment as provided in A.R.S. § 45-465 and must calculate the irrigation water duty using an irrigation efficiency of 75 percent. In areas deemed by the director to have limiting soils, the statute authorizes the director to use an irrigation efficiency as low as 70 percent. In addition, the director may not register credits to the flex account established under A.R.S. § 45-467 which cause the credit balance to exceed 75 percent of the maximum annual groundwater allotment established under the Historic Cropping Program. This program is described in more detail in section 4.4.1.

4.2.6 Small Irrigation Grandfathered Rights

In 1994, legislation was passed that deregulated small IGFRs. A small IGFR is defined as an irrigation grandfathered right appurtenant to a farm with ten or fewer irrigation acres, and that is not part of an integrated farming operation of more than ten acres. Under A.R.S. §§ 45-563.02 and 632(D), small IGFRs are not required to report annual water use or to comply with water duty limitations. Small IGFRs make up about one half of the IGFRs in the Tucson AMA. Based on reporting data submitted to the Department prior to 1994, agricultural water use on these small rights accounted for approximately one percent of the total annual irrigation water use.

4.3 IRRIGATION WATER DUTIES AND MAXIMUM ANNUAL GROUNDWATER ALLOTMENTS

The irrigation water duty is the primary component of the Historic Cropping Program and is used to determine the maximum annual groundwater allotment for each IGFR. The following sections describe how the Department determines water duties and maximum annual groundwater allotments.

4.3.1 Calculation of Irrigation Water Duties

The irrigation water duty is the quantity of water reasonably required per acre to annually irrigate the crops historically grown in a farm unit from 1975 to 1980. The crops historically grown in each farm unit were verified and established during the first management period. The Department calculates the irrigation water duty for each IGFR using the following formula:

$$\textit{Irrigation Water Duty} = \frac{\textit{Total Irrigation Requirement Per Acre}}{\textit{Assigned Irrigation Efficiency}}$$

In this formula, the irrigation water duty is calculated by dividing the total water requirements to produce the crops historically grown by an assigned irrigation efficiency. Each component of the formula is discussed below.

4.3.1.1 Assigned Irrigation Efficiencies

Irrigation efficiency is a measure of the overall effectiveness of water application during a crop season. The effectiveness is a function of many variables including evaporation loss, soil intake rate, water application rates, irrigation system type, crop type, and irrigation water management practices.

The assigned irrigation efficiency establishes a benchmark value which is determined for each management period in accordance with statutory provisions. For the Historic Cropping Program, the assigned irrigation efficiency for farms with non-limiting soils is 75 percent as prescribed by A.R.S. § 45-566.02.

4.3.1.2 Total Irrigation Requirement

The total irrigation requirement for each farm unit equals the amount of water needed annually to satisfy the sum of the irrigation requirements for all of the crops historically grown. For each crop, the irrigation requirement (IR) consists of the amount of water needed to meet: the consumptive use (CU) requirement of the crop, plus any other needs (ON) that the crop may have, plus any needed leaching allowance (LA), less the amount of any effective precipitation (EP). The total irrigation requirement is calculated by the following equation:

$$IR = CU + ON + LA - EP$$

The components of the total irrigation requirement equation are discussed below.

4.3.1.2.1 Consumptive Use

The consumptive use requirement of a crop is the amount of water used in transpiration and building of plant tissue, together with the amount of water evaporated from adjacent soil during the growing season. Crop consumptive use values are based on accepted scientific methods and commonly used values for the Tucson AMA. Appendix 4 lists the consumptive use requirement for each crop historically grown in the Tucson AMA during the years 1975 to 1980 based upon data currently available.

4.3.1.2.2 Other Needs

Water required by certain crops for purposes other than consumptive use is referred to as "other needs" water. Some vegetable crops, such as lettuce, need additional water for germination, cooling, and quality control. The Department makes adjustments for those crops which have "other needs." Appendix 4 lists the "other needs" requirements for crops historically grown in the Tucson AMA.

4.3.1.2.3 Leaching Allowance

In some situations, a crop may require additional water for leaching or deep percolation. A leaching allowance may be necessary to prevent salts from accumulating in the crop root zone when high levels of total dissolved solids (TDS) are present in the irrigation water. If the accumulated salts in the soil profile are not leached below the root zone, soil salinity will increase and eventually inhibit plant growth and yields.

The procedure used to calculate the leaching allowance for a crop is shown by the following equation:

$$LA = \frac{AE}{0.85}\left[CU\left[\frac{1}{1 - \frac{EC_w}{5EC_e - EC_w}} - 1\right]\right]$$

In this equation, LA = leaching allowance for the crop; AE = assigned irrigation efficiency for the farm unit; CU = consumptive use requirement of the crop; EC_w = electrical conductivity of the irrigation water (expressed in millimhos per centimeter); and EC_e = tolerance of the crop to soil salinity as indicated by the electrical conductivity of the soil saturation extract (expressed in millimhos per centimeter).

Most irrigation water in the Tucson AMA is of adequate quality for irrigation purposes. Consequently, the Department did not include any leaching allowances in the calculation of irrigation requirements for crops grown in the Tucson AMA. If, however, a particular irrigation water supply has an EC_w value greater than 1.5 millimhos per centimeter (a concentration of approximately 1,000 milligrams per liter of TDS), the right holder may apply to the Department for an administrative review as discussed in Chapter 10.

4.3.1.2.4 Effective Precipitation

Effective precipitation is defined as the amount of precipitation occurring before and during the growing season that is available for plant growth. Because precipitation is minimal and varies considerably by year and location in the Tucson AMA, effective precipitation is difficult to quantify and is not subtracted from

the total irrigation requirements for the crops historically grown. However, managing the use of precipitation to offset use of other water supplies could be an important irrigation water management tool.

4.3.2 Calculation of Maximum Annual Groundwater Allotments

The maximum annual groundwater allotment for each IGFR is determined by multiplying the irrigation water duty by the water duty acres. These calculations are governed by A.R.S. § 45-465 (see section 4.2.3).

4.4 AGRICULTURAL CONSERVATION PROGRAM COMPONENTS

The following section describes the Agricultural Conservation Program for the Third Management Plan that is being adopted at this time. This program consists of two main parts: the Historic Cropping Program and the irrigation distribution system conservation requirements program. Each of these programs is described below.

4.4.1 Historic Cropping Program

The Historic Cropping Program was developed by the Department pursuant to A.R.S. § 45-566.02. As required by this statute, for the Historic Cropping Program, the Department will calculate the water duty and maximum annual groundwater allotment by dividing the total irrigation requirement per acre by an assigned irrigation efficiency of 75 percent. In areas determined by the director to have limiting soils, the director may use an assigned irrigation efficiency as low as 70 percent for the water duty calculation. As further required by A.R.S. § 45-566.02, the use of flex account provisions will be limited.

In order to qualify for the Historic Cropping Program, the IGFR owner must satisfy the following requirements: (1) file an application with the Department, (2) reduce any debit balance in the existing flex account to an amount which does not exceed 25 percent of the existing maximum annual groundwater allotment, (3) reduce any flex account credits in the existing flex account balance to an amount which does not exceed 75 percent of the existing maximum annual groundwater allotment, and (4) provide documentation showing that an actual irrigation efficiency of 75 percent has been, or will be, achieved on the farm on a seasonal basis. Once an IGFR owner has been accepted into the Historic Cropping Program, the right holder must remain in the Historic Cropping Program during the entire third management period, unless there is a change in IGFR ownership.

Participants in the Historic Cropping Program will be subject to limitations on their ability to accumulate flex account credits and debits. Right holders will only be allowed to accrue flex account credits up to 75 percent, and flex account debits up to 25 percent, of their maximum annual groundwater allotment calculated for the Historic Cropping Program. Any IGFR owner, or any person entitled to use groundwater pursuant to that IGFR, who uses groundwater in an amount which causes the farm's flex account to be in arrears in excess of 25 percent of the maximum annual groundwater allotment will be considered in violation of the conservation requirement. In addition, participants in the Historic Cropping Program will not be allowed to sell or purchase flex account credits.

In addition to these flex account credit provisions, participants will also be required to comply with certain reporting requirements. Participants must provide information regarding irrigation water management practices, irrigation system type, and the acreage and type of crops grown to assist the Department in determining program effectiveness.

The Historic Cropping Program requires a high level of farm management. Specific entrance and performance criteria must be satisfied, and only owners of IGFRs may apply (see section 4.7). IGFR

owners interested in participating in the Historic Cropping Program may file an application beginning January 1, 2000 on forms provided by the Department.

4.4.2 Irrigation Distribution System Conservation Program

For the third management period, the director is required to establish "additional economically reasonable conservation requirements for the distribution of groundwater by cities, towns, private water companies and irrigation districts within their service areas." A.R.S. § 45-566(A)(5). The same conservation requirements were part of the Second Management Plan. A.R.S. § 45-565(A)(5).

In the Second Management Plan, private water companies and irrigation districts which distributed 20 percent or more of their total water deliveries for irrigation use by January 1, 1990, were required to reduce their irrigation distribution system lost and unaccounted for water either by lining all their canals, or by operating their delivery systems so that the total quantity of lost and unaccounted for water is 10 percent or less of the total quantity of water withdrawn, diverted, or received during a year. These requirements become effective upon commencement of operation or by January 1, 2000, whichever is later. A Department review of the conservation practices of the largest irrigation districts located within AMAs has shown that the Second Management Plan distribution system conservation requirements are being achieved by most districts.

For the Third Management Plan, the irrigation distribution system conservation requirements established by the Second Management Plan will continue to apply to irrigation districts and private water companies which, as of January 1, 2000, distribute 20 percent or more of their total water deliveries for irrigation use. These irrigation districts and private water companies will be required to reduce their irrigation distribution system lost and unaccounted for water either by lining all their canals, or by operating their delivery systems so that the total quantity of lost and unaccounted for water is 10 percent or less of the total quantity of water withdrawn, diverted, or received during a year. These requirements become effective upon the commencement of operation or by January 1, 2002, whichever is later. Until this time, the Second Management Plan irrigation distribution system conservation requirements will apply.

If a private water company or irrigation district has economic circumstances which prevent timely compliance with the irrigation distribution system conservation requirements, a variance of up to five years may be requested as provided by A.R.S. § 45-574. Information submitted in support of the variance request must include a complete water loss reduction plan, prepared by a registered civil engineer, which contains:

- A complete construction design document which shows specifications for repairing or modifying the irrigation distribution system. The document must include material specifications, proposed design specifications, installation and construction specifications, and any other engineering information or specifications necessary to complete the proposed rehabilitation of the distribution system.

- A detailed list of engineering costs and the proposed investment options designed to pay for the system improvements.

- The final completion date for the rehabilitation.

- If applicable, a system operating guide to reduce lost and unaccounted for water to a minimum. This guide may be modified as the rehabilitation progresses.

The procedures for obtaining a variance are described in Chapter 10, section 10.3.1.

4.4.3 Program Summary

The Department is adopting an Agricultural Conservation Program for the Third Management Plan that consists of two parts, the Historic Cropping Program and the irrigation distribution system conservation program, each of which is designed to assist in achieving the water resource management goal for the Tucson AMA. The Historic Cropping Program is a new program which the legislature authorized in 1998 through the enactment of A.R.S. § 45-566.02. Pursuant to this legislation, the irrigation efficiency used to calculate the maximum annual groundwater allotment for non-limiting soils is set at 75 percent and the flexibility account provisions of A.R.S. § 45-467 are restricted. The irrigation distribution system conservation requirements are essentially a continuation of requirements that were established for the Second Management Plan. These requirements are designed to assure that the amount of lost and unaccounted for water from water distribution systems is kept to a minimum. Both the Historic Cropping Program and the irrigation distribution system conservation program provide important tools for achieving the water management goal for the Tucson AMA. To further the attainment of this water management goal, the Department will also adopt a Base Program pursuant to A.R.S. § 45-566(A)(1) in the future.

4.5 NON-REGULATORY WATER RESOURCE MANAGEMENT STRATEGIES

In addition to the Agricultural Conservation Program, there are other water resource management options which are available to achieve the water management goal for the Tucson AMA. These options are described below.

4.5.1 Effluent

In 1991, the Legislature amended A.R.S. § 45-467 to exclude effluent from consideration in determining the amount of any debit to be registered to a farm's flex account. Laws 1991, Ch. 112, § 3. Under this amendment, a person using groundwater on a farm pursuant to an IGFR may use an unlimited amount of effluent on the farm without any debit being registered to the farm's flex account as a result of effluent use. This amendment created an incentive for the use of effluent.

During the Third Management Plan, the Department will study alternative ways to increase the use of effluent. In the past, effluent utilization for agricultural irrigation has been limited primarily by the lack of necessary infrastructure. Other requirements, such as the wastewater reuse rules adopted by the Arizona Department of Environmental Quality, have limited the types of crops which can be irrigated solely by effluent. As effluent treatment techniques improve and more effluent becomes accessible to the agricultural sector, the Department expects that effluent use for agricultural purposes will increase.

4.5.2 Groundwater Savings Program (Indirect Recharge)

A reduction in agricultural groundwater use has occurred in the Tucson AMA as a result of indirect recharge opportunities first authorized by the Legislature in 1990 and later reauthorized in 1994 as the groundwater savings program. Laws 1994, Ch. 291, § 32; Laws 1990, Ch. 176, § 14. Historically, agricultural water use in the Tucson AMA had been supplied primarily from groundwater resources. In the early 1990s, the agricultural sector began to utilize CAP water through the incentives provided by the groundwater savings program and arrangements made with non-agricultural water providers. This increased use of renewable water supplies has decreased groundwater use by the agricultural sector in the Tucson AMA.

4.5.3 Conservation Assistance Program

Non-regulatory efforts such as the Conservation Assistance Program have contributed to the reduction of agricultural water use in the Tucson AMA. The Irrigation Conservation Assistance Program (ICAP),

funded primarily by the Conservation Assistance Program, is currently in its fourth year of operation. The ICAP is a cooperative program with the Department, the Pima Natural Resources Conservation District, the USDA Natural Resources Conservation Service (NRCS), and more recently the United States Bureau of Reclamation (USBR). The ICAP provides irrigation scheduling and water application rate information to participating farmers in the Tucson AMA. A computer program which integrates crop type, field and soil conditions, and weather conditions is used by ICAP to assist farmers in the conservation of water.

Conservation Assistance Program funds were also used to produce a video entitled "Saving Water in Agriculture, Surface Irrigation." The production of this video was made possible through a cooperative effort between the Department, USBR, NRCS, and a private consultant. This video and accompanying manual is intended to educate farm managers and irrigators about efficient on-farm irrigation water management techniques.

Additional Conservation Assistance Program funds were made available to evaluate the utilization of treated effluent on farms in the Tucson AMA. Effluent is a renewable water supply which has the potential to significantly reduce the amount of groundwater used by agriculture.

The use of Conservation Assistance Program monies to fund programs designed to assist the agricultural sector in the conservation of groundwater resources is expected to extend into the third management period. The Department will continue to encourage programs which promote efficient agricultural water use. The Conservation Assistance Program is described more fully in Chapter 9.

4.6 FUTURE DIRECTIONS

To achieve the goal of safe-yield in the Tucson AMA, reductions in agricultural groundwater use need to continue. The increased utilization of renewable water supplies to replace groundwater use, combined with demand reduction efforts to enhance on-farm irrigation water management practices, are key factors in meeting this water resource management goal.

During the third management period, the Department will continue to provide the agricultural sector with technical and conservation planning assistance to reduce its reliance on groundwater supplies. The Department will investigate incentives for, and encourage, the increased use of effluent and CAP water through groundwater savings projects. In addition, agreements between the USBR and the Tohono O'odham Nation under the Southern Arizona Water Rights Settlement Act may provide alternative water sources to the agricultural sector.

The Department will continue to work cooperatively with the agricultural community to determine appropriate conservation requirements under A.R.S. § 45-566(A)(1), and to develop additional alternative agricultural conservation programs in the Tucson AMA for the third management period.

The Department will continue to support funding for conservation, education, and the use of renewable supplies in order to achieve the water management goal for the Tucson AMA. These monies may be used to assist farmers with irrigation water management practices and for the infrastructure to convey renewable water supplies to farms.

The Department will also continue to monitor crop and water use patterns during the third management period to evaluate agriculture's contribution to achieving the Tucson AMA's safe-yield goal, and the impacts of Department programs on farming operations. Urbanization impacts on agriculture as well as water use trends due to agricultural market conditions will be evaluated for future planning needs.

The Agricultural Conservation Program for the Third Management Plan is a step toward achieving the water resource management goal of safe-yield for the Tucson AMA. During the third management period, this program will continue to be evaluated for its effectiveness in achieving this goal.

4.7 AGRICULTURAL CONSERVATION REQUIREMENTS AND MONITORING AND REPORTING REQUIREMENTS

4-101. Definitions

In addition to the definitions set forth in Chapters 1 and 2 of Title 45 of the Arizona Revised Statutes, the following words and phrases used in sections 4-101 through 4-105 of this chapter shall have the meanings set forth below, unless the context otherwise requires:

1. *"Assigned Irrigation Efficiency" is defined as the maximum economically feasible levels of conservation within areas of similar farming conditions which each right holder is expected to achieve.*

2. *"Canal" is defined as a waterway constructed for the purpose of transporting water to a point of delivery, including main canals and lateral canals.*

3. *"Farm" is defined under A.R.S. § 45-402.*

4. *"Farm Unit" is defined under A.R.S. § 45-402.*

5. *"Flexibility Account" is an account maintained under A.R.S. § 45-467.*

6. *"Irrigation Acre" is defined under A.R.S. § 45-402.*

7. *"Irrigation Distribution System" is defined as a system of canals, flumes, pipes, or other works which are owned or operated by an irrigation district or private water company and used to deliver water for irrigation use.*

8. *"Irrigation Water Duty" is defined under A.R.S. § 45-566 which, for the Third Management Plan, is the total irrigation requirement to produce the crops historically grown divided by the assigned irrigation efficiency.*

9. *"Lost Water" is defined as water from any source, including effluent, which enters an irrigation distribution system and is lost from the system during transportation or distribution due to seepage, evaporation, leaks, breaks, phreatophyte use, or other causes.*

10. *"Maximum Annual Groundwater Allotment" is defined as the maximum amount of groundwater which may be used per year for the irrigation of each irrigation acre in the farm which is calculated pursuant to A.R.S. § 45-465.*

11. *"On-farm Seasonal Irrigation Efficiency" is defined as the total water requirements to produce a crop divided by the total quantity of water actually applied to that crop during one growing season.*

12. *"Total Quantity of Lost and Unaccounted for Water" is defined as the total quantity of water from any source, including effluent, withdrawn, diverted, or received by an irrigation district or private water company during a calendar year less the total deliveries of water from any source, including effluent, made by the irrigation district or private water company during the calendar year that are measured or estimated based on a generally accepted method of estimating water use.*

13. *"Water Duty Acres" is defined under A.R.S. § 45-461.*

4-102. Base Agricultural Conservation Program Requirements

Unless the owner of a Certificate of Irrigation Grandfathered Right (IGFR) is regulated under the Historic Cropping Program described in section 4-103, the IGFR owner and any person who is entitled to use groundwater pursuant to that IGFR shall continue to comply with the agricultural conservation requirements established by the Second Management Plan until the director adopts a Base Program for the Third Management Plan.

4-103. Historic Cropping Program

A. Application for Regulation under the Historic Cropping Program

Only an owner of an IGFR may apply to be regulated under the Historic Cropping Program. Beginning January 1, 2000, an application may be filed by an IGFR owner at any time prior to the first compliance date for the agricultural conservation requirements established in the Fourth Management Plan. An application for regulation under the Historic Cropping Program shall be on a form prescribed by the director and shall include the following information:

1. *The name, address, and phone number of the IGFR owner.*

2. *The number of the Certificate of Irrigation Grandfathered Right.*

3. *The name, address, and phone number of any person entitled to use groundwater under the IGFR.*

4. *For each of the three previous years, the number of acres and types of crops planted and the amount of water used to irrigate the planted acres.*

5. *For each of the three previous years, the type of irrigation system which has been used, including percent of slope, length of runs, and method of field application.*

6. *For each of the three previous years, a description of all water conservation practices used on the farm, including the name of any conservation program or irrigation water management service used on the farm.*

B. Criteria for Approval of Application

The director shall approve a complete and correct application for regulation under the Historic Cropping Program if the following requirements are satisfied:

1. *Any negative flexibility account balance in the farm's flexibility account does not exceed 25 percent of the maximum annual groundwater allotment in effect at the time that the application is made.*

2. *Any positive flexibility account balance in the farm's flexibility account does not exceed 75 percent of the maximum annual groundwater allotment in effect at the time that the application is made. In order to satisfy this requirement, the IGFR owner may sell or convey any excess credits as provided by A.R.S. § 45-467, or the IGFR owner may relinquish any excess credits.*

3. *The IGFR owner demonstrates that the average on-farm seasonal irrigation efficiency achieved on the farm's irrigation acres during the previous three years was 75 percent or greater. If the IGFR owner cannot demonstrate that an average on-farm seasonal irrigation efficiency of at least 75 percent has been achieved during the previous three years, the IGFR owner shall agree in writing to develop and implement at least one of the following:*

   a. *Enroll in a Department-sponsored or private irrigation management services program throughout the entire third management period or until the IGFR owner can demonstrate to the Department that an average on-farm seasonal irrigation efficiency of at least 75 percent has been achieved during the previous three years.*

   b. *Install a conservation system improvement, approved by the Department, designed to enable the IGFR owner to achieve an on-farm seasonal irrigation efficiency of at least 75 percent.*

C. Historic Cropping Program Requirements

An IGFR owner who has been approved for regulation under the Historic Cropping Program and any person using groundwater pursuant to that IGFR shall comply with the provisions of this section.

1. *The IGFR owner and any person entitled to use groundwater under that IGFR shall comply with the irrigation water duty and maximum annual groundwater allotment established by the director under this section, beginning with the calendar year in which the IGFR owner is accepted into the Historic Cropping Program, and continuing thereafter until the first compliance date for any substitute conservation requirement established in the Fourth Management Plan. The director shall establish the irrigation water duty and maximum annual groundwater allotment in the same manner that the director established the irrigation water duty and maximum annual groundwater allotment assigned to the IGFR in the Second Management Plan, except that the director shall use an assigned irrigation efficiency of 75 percent. In areas deemed by the director to have limiting soils, the director may use an assigned irrigation efficiency as low as 70 percent.*

2. *The IGFR owner, and any person entitled to use groundwater under that IGFR, may use the maximum annual groundwater allotment assigned to the IGFR to irrigate only the irrigation acres to which the IGFR is appurtenant.*

3. *The IGFR owner and any person entitled to use groundwater under that IGFR shall not use water for irrigation purposes during a calendar year in an amount which exceeds the maximum annual groundwater allotment assigned to the right, except as provided in the flexibility account provisions of A.R.S. § 45-467, as modified in subsection D of this section, and any rules adopted by the director.*

D. Flexibility Account Provisions

Under the Historic Cropping Program, the flexibility account provisions of A.R.S. § 45-467 shall apply to the IGFR owner and any person entitled to use groundwater under that IGFR with the following modifications:

1. *If the amount of water used to irrigate the farm in any year is less than the maximum annual groundwater allotment established for the farm pursuant to subsection C, paragraph 1 of this section, the amount of any credit registered to the farm's flexibility account pursuant to A.R.S. § 45-467 shall not exceed the difference between the existing balance in the account and a positive account balance of 75 percent of the maximum annual groundwater allotment. The director shall not register a credit to the farm's flexibility account in any year in which the account has an existing positive account balance equal to or greater than 75 percent of the maximum annual groundwater allotment.*

2. *The IGFR owner and any person entitled to use groundwater under that IGFR who are regulated under the Historic Cropping Program shall not:*

   a. *Purchase or sell flexibility account credits to another IGFR owner or any other person entitled to use groundwater under another IGFR regardless of whether they are regulated under the Historic Cropping Program.*

   b. *Transfer credits from the flexibility account of one farm to another farm even if the farms are owned by the same IGFR owner.*

3. *The maximum excess amount of groundwater that may be used pursuant to A.R.S. § 45-467 shall not exceed 25 percent of the maximum annual groundwater allotment established for the farm pursuant to subsection C, paragraph 1 of this section. The IGFR owner and any person entitled to use groundwater under that IGFR violate this section if the flexibility account maintained for the IGFR is in arrears at any time in excess of this amount.*

E. Reporting Requirements

In addition to the information required to be submitted in the annual report required by A.R.S. § 45-632, the IGFR owner and any person entitled to use groundwater pursuant to that IGFR shall submit the following information in the report:

1. *The name, address, and phone number of any person entitled to use groundwater under the IGFR.*

2. *The number of acres and types of crops planted and the amount of water used to irrigate the planted acres.*

3. *The type of irrigation system which has been used, including percent of slope, length of runs, and method of field application.*

4. *A description of all water conservation practices used on the farm, including the name of any conservation program or irrigation water management service used on the farm.*

F. Duration of Regulation under Historic Cropping Program

1. *Except as provided in paragraph 2 of this subsection, after the director approves an application for regulation under the Historic Cropping Program, the IGFR owner and any person entitled to use groundwater pursuant to that right shall be regulated under the Historic Cropping Program until the first compliance date for any substitute agricultural conservation requirement established in the Fourth Management Plan.*

2. *After the director approves an application for regulation under the Historic Cropping Program, the IGFR owner must remain in the Historic Cropping Program during the entire third management period, except that a subsequent owner of the IGFR may file a written request to leave the Historic Cropping Program with the director within 90 days after acquiring an ownership interest in the IGFR. The director shall grant the request unless the director determines that the request is being made for the purpose of circumventing the provisions of paragraph 1 of this subsection, in which case the request will be denied. In the event that an IGFR is owned by more than one person, this paragraph does not apply unless all owners have conveyed their interests in the IGFR and all subsequent owners join in filing a written request with the director to leave the Historic Cropping Program.*

4-104. Conservation Requirements for Irrigation Distribution Systems

A. Applicability

The irrigation distribution system conservation requirements set forth in subsection B below apply to irrigation districts and private water companies which, as of January 1, 2000, distribute 20 percent or more of their total water deliveries for irrigation use.

B. Conservation Requirements

By January 1, 2002 or upon commencement of operation, whichever is later, and continuing thereafter until the first compliance date of any substitute requirement in the Fourth Management Plan, each irrigation district and private water company owning or operating an irrigation distribution system shall either:

1. *Line all canals used to deliver water for irrigation use with a material that allows no more lost water than a well-maintained concrete lining, or*

2. *Operate and maintain its distribution system so that the total quantity of lost and unaccounted for water is 10 percent or less of the total quantity of water from any source, including effluent, withdrawn, diverted, or received by the irrigation district or private water company on either a calendar year basis or a three-year average basis based on that calendar year and the two preceding calendar years.*

4-105. Monitoring and Reporting Requirements for Irrigation Districts and Private Water Companies

A. Applicability

The monitoring and reporting requirements set forth in subsection B below apply to irrigation districts and private water companies which, as of January 1, 2000, distribute 20 percent or more of their total water deliveries for irrigation use.

B. Monitoring and Reporting Requirements

For calendar year 2002 and for each calendar year thereafter until the compliance date for any substitute requirement in the Fourth Management Plan, each irrigation district and private water company owning or operating an irrigation distribution system shall submit in its annual report required by A.R.S. § 45-632, the following information as it applies to the irrigation district or private water company:

1. *A map showing the irrigation distribution system, including those portions which have lined canals and those portions which have unlined canals, unless a current map is on file with the Department.*

2. *The number of miles of lined canals and the number of miles of unlined canals in the irrigation distribution system.*

3. *The total quantity of water from any source, including effluent, which was withdrawn, diverted, or received by the irrigation district or private water company during the calendar year.*

4. *The total quantity of water from any source, including effluent, delivered by the irrigation district or private water company to all water users during the calendar year.*

5. *An estimate of the irrigation district's or private water company's total quantity of lost and unaccounted for water for the calendar year. This quantity shall be determined by a generally accepted engineering method.*

APPENDIX 4
CONSUMPTIVE USE AND OTHER NEEDS BY CROPS[1]
TUCSON ACTIVE MANAGEMENT AREA

Crop	Consumptive Use (acre-feet per acre)		Other Needs (acre-feet per acre)
	ASFC[2] 1 - 6	ASFC 7	All ASFCs
Grain Crops			
Barley	1.83	1.83	-----
Corn, Grain	2.67	2.50	-----
Maize (Sorghum)	2.67	2.17	-----
Oats, Grain	1.83	1.83	-----
Rye	1.83	1.83	-----
Sorghum, Grain	2.67	2.17	-----
Wheat	1.83	1.83	-----
Field Crops			
Castor Beans	3.70	3.70	-----
Cotton	3.08	2.58	-----
Peanuts	2.75	-----	-----
Pinto Beans	-----	1.17	-----
Safflower	3.33	-----	-----
Soybeans	1.85	-----	-----
Orchard Crops (Nut)			
Pecans, without Groundcover	4.33	3.58	-----
Pecans, with Groundcover	5.67	-----	-----
Pistachios	4.17	3.50	-----
Forage Crops			
Alfalfa[3]	4.08	3.42	-----
Bermuda Grass	3.50	3.42	-----
Hay, Annual (Non-Alfalfa)	2.25	1.50	-----
Native Pasture	1.75	1.75	-----
Permanent Pasture (Fescue)	5.75	4.67	-----
Sudan Grass	2.25	1.50	-----
Vegetable Crops			
Carrots	1.38	-----	.75
Chili Peppers	-----	2.33	.50
Corn, Sweet	1.63	1.42	.87

APPENDIX 4
CONSUMPTIVE USE AND OTHER NEEDS BY CROPS[1]
TUCSON ACTIVE MANAGEMENT AREA

Crop	Consumptive Use (acre-feet per acre)		Other Needs (acre-feet per acre)
	ASFC[2] 1 - 6	ASFC 7	All ASFCs
Lettuce, All	.71	.71	2.44
Onions, Dry	1.94	-----	.75
Tomatoes, All	2.00	-----	.50
Vegetables, Mixed	2.00	-----	.50
Fruit			
Apricots	3.92	3.00	-----
Cantaloupe, Late	-----	1.33	.50
Citrus, All	3.75	-----	-----
Grapes	-----	2.50	.50
Peaches	3.92	-----	-----
Plums	3.92	-----	-----
Watermelons	1.75	-----	.50
Miscellaneous Crops			
Jojoba	3.00	-----	
Christmas Trees	2.50	2.25	
Nursery Stock	3.00	-----	

[1] Based on crops that were reported in the 1975 to 1980 history.
[2] Areas of Similar Farming Conditions (see Chapter 3, section 3.1.3)
[3] Based on the average historical high yield of alfalfa in Pima County of 6.5 tons per acre and a consumptive use (CU) rate of 7.5 acre-inches per acre per ton of production, rounded to the nearest acre-inch. Farm units that demonstrated historic yields above this average were assigned higher CU rates accordingly, not to exceed a high CU value of 5.67 acre-feet per acre. ASFC 7 was based on an average historical high yield for Santa Cruz County of 5.5 tons per acre.

Sources: Consumptive Use of Water by Major Crops in Southwestern United States. Conservation Research Report #29, Agricultural Research Service, USDA, (1982).

FAO Irrigation and Drainage Paper # 24, Food and Agriculture Organization of the United Nations (revised 1977).

APPENDIX 4
ASSIGNED CONSUMPTIVE USE (CU) VALUES FOR CROPS ASSOCIATED WITH FARM UNITS TEN ACRES OR LESS
TUCSON ACTIVE MANAGEMENT AREA

HIGH CONSUMPTIVE USE CROPS

Crops with a CU value of 4.30 acre-feet per acre or more in ASFCs[1] 1-6, are assigned a CU value of 5.00 acre-feet per acre. Crops with a CU value of 3.60 acre-feet per acre or more in ASFCs 7 are assigned a CU value of 4.50 acre-feet per acre.

Alfalfa
Pecans (with and without Groundcover)
Permanent Pasture (Fescue)
Pistachios

MEDIUM CONSUMPTIVE USE CROPS

Crops with a CU value of 2.25 to 4.30 acre-feet per acre in ASFCs 1-6, are assigned a CU value of 3.25 acre-feet per acre. Crops with a CU value of 2.25 to 3.60 acre-feet per acre in ASFCs 7 are assigned CU value of 3.00 acre-feet per acre.

Apricots	Grapes	Peaches
Bermuda Grass	Guayule	Peanuts
Corn, Grain	Jojoba	Plums
Cotton	Nectarines	Rappini
Citrus, All	Nursery Stock	Safflower
Chili Peppers	Olives	Sorghum (Grain, Double Cropped)
Christmas Trees	Okra	Sugar Beets

LOW CONSUMPTIVE USE CROPS

Crops with a CU value less than 2.25 acre-feet per acre in all ASFCs are assigned a CU value of 2.00 acre-feet per acre.

Barley	Cucumbers, All	Mixed Vegetables	Rye
Beets, Table	Ensilage	Native Pasture	Sorghum, Grain
Broccoli	Hay, Annual (Non-Alfalfa)	Oats, Grain	Sudan Grass
Cabbage, All	Lettuce, All	Onions, All	Summer Squash and Zucchini
Cantaloupe, All	Maize	Parsnips	Tomatoes, All
Carrots	Melons, All	Pinto Beans	Turnips and Rutabaga
Cauliflower	Miscellaneous Vegetables	Potatoes	Wheat
Corn, Sweet		Radishes	

[1]ASFCs = Area of Similar Farming Conditions (see section 3.2.1)

CHAPTER

5

Municipal Conservation Program

5.1 INTRODUCTION

The primary goal of the Municipal Conservation Program is to assist the Tucson Active Management Area (AMA) in moving toward safe-yield by gradually reducing per capita water consumption, encouraging the best available water conservation practices, and maximizing the efficient use of renewable water supplies, including effluent. For the third management period, the Arizona Department of Water Resources (Department) will increase its efforts to promote the substitution of groundwater use with renewable supplies and encourage artificial recharge. The Department supports the efficient use and equitable distribution of water in an environmentally and economically sound manner through long-range planning, cooperative regional efforts, technical assistance, and regulatory programs. The efficient use of all sources of water and replacement of groundwater sources by renewable supplies will ensure that the groundwater supply will be available when needed.

Municipal water providers include cities, towns, private water companies, and irrigation districts that deliver groundwater for non-irrigation uses such as residential, commercial, governmental, industrial, and construction uses. Municipal water providers can also include well cooperatives, mobile home parks, and improvement districts. The Department regulates municipal providers serving more than 250 acre-feet of water for non-irrigation use annually as large municipal providers. Those providers serving 250 acre-feet or less annually are regulated as small municipal providers. Large and small providers have different conservation and reporting requirements. Appendix 5A contains a list of all the large and small municipal water providers in the Tucson AMA as of 1998.

The municipal sector accounts for about half of the total Tucson AMA water use. During the second management period, population growth rates in the AMA averaged almost 3 percent per year. Population is expected to continue to increase by 2 to 3 percent a year during the third management period with a corresponding increase in municipal water demand. Although substantial direct use of Central Arizona Project (CAP) water was expected during the second management period, this did not occur and groundwater continues to be the dominant water supply in the AMA. The use of effluent to irrigate turfed areas is increasing but still constitutes a small proportion of municipal water use. The Assured Water Supply Rules (AWS Rules) adopted by the Department in 1995 require new development to demonstrate that it will be consistent with the achievement of safe-yield in the AMA. A.A.C. R12-15-705. This is accomplished by demonstrating that renewable supplies will be used to satisfy a majority of the demand. The Assured Water Supply Program (AWS Program) is expected to have a significant impact on renewable supply use by the municipal sector during the third management period and result in long-term reductions in municipal groundwater overdraft.

Reductions in the gallons per capita per day (GPCD) water use rates of large municipal providers are required by the Groundwater Code (Code). Conservation programs instituted by water providers in response to regulatory requirements of the First and Second Management Plans have not resulted in achieving the GPCD reductions that were expected. A series of hot, dry years in the mid-1990s and increases in exterior water use have contributed to an increase in the AMA average GPCD rate since 1990. Increased conservation efforts and increased use of renewable supplies are needed in order to make progress toward achieving the safe-yield goal by 2025.

This chapter contains the following sections:

- Statutory Provisions
- AWS Program
- First and Second Management Plans
- Municipal Program Issues
- Third Management Plan Municipal Conservation Program
- Non-Regulatory Efforts
- Future Directions

5.2 STATUTORY PROVISIONS

5.2.1 Per Capita Requirements for Large Municipal Providers

The Code requires that the management plans for each AMA include a conservation program for municipal uses. For the First, Second, and Third Management Plans, the Code expressly mandates that the programs require reasonable reductions in per capita use. A.R.S. §§ 45-564(A)(2), 45-565(A)(2), and 45-566(A)(2). As originally enacted, the Code did not exempt any municipal providers from the requirement to achieve reductions in per capita use. Consequently, the Municipal Conservation Program in the First Management Plan established maximum GPCD requirements for all municipal providers, regardless of size.

In 1986, the Legislature amended the statutes governing the Second and Third Management Plans to exempt "small municipal providers" from the requirement to achieve reasonable reductions in per capita use. Laws 1986, Ch. 107, §§ 2 and 3. Instead of requiring small municipal providers to achieve reductions in per capita use, the statutes require the director to establish "reasonable conservation requirements for small municipal providers." A.R.S. §§ 45-565(A)(4) and 45-566(A)(4). Until 1994, "small municipal provider" was defined in the Code as "a city, town, private water company or irrigation district that supplies water for non-irrigation use, serves less than five hundred people and supplies less than one hundred acre-feet of water for non-irrigation use during a calendar year." Laws 1986, Ch. 107, § 1. In 1994, the Legislature changed the definition of small municipal provider to "a municipal provider that supplies 250 acre-feet or less of water for non-irrigation use during a calendar year." A.R.S. § 45-561(13).

Two other statutory amendments have created exceptions to the requirement that municipal providers achieve reasonable reductions in per capita use. In 1991, the Legislature exempted large untreated water providers from the requirement to achieve reductions in per capita use. Laws 1991, Ch. 211, §§ 16, 17, and 18. In 1992, the Legislature enacted legislation requiring the director to include in each management plan a Non-Per Capita Conservation Program for large municipal providers as an optional, alternative program to the program requiring reductions in per capita use. Laws 1992, Ch. 183, §§ 5, 7, and 9. The latter amendment is described in greater detail in the following section.

5.2.2 Non-Per Capita Conservation Requirements for Large Municipal Providers

Each provider regulated under the Non-Per Capita Conservation Program (NPCCP) is required to implement specific residential and non-residential conservation programs for interior and exterior water use, a public education program relating to water conservation, and a program to meter most service area connections. Additionally, providers who are regulated under the NPCCP are required to either reduce their groundwater pumping consistent with the AWS Rules (A.A.C. R12-15-701, *et seq.*) or eliminate their use of mined groundwater by the year 2010. The NPCCP is a performance-based program with compliance determined by the effective implementation of stipulated conservation measures and the required groundwater use reduction. For the Third Management Plan, the statutory requirements for the NPCCP are found at A.R.S. § 45-566.01.

5.2.3 Conservation Requirements for Individual Users

In addition to requiring the director to establish conservation requirements for municipal providers, the Code requires the director to establish in the Third Management Plan "such other conservation measures as may be appropriate for individual users." A.R.S. § 45-566(A)(2). An "individual user" is a person or entity who receives water from a municipal provider for a non-irrigation use. In the Third Management Plan, the director has established conservation requirements for the following individual users: (1) turf-related facilities, (2) large-scale cooling facilities, and (3) publicly-owned rights-of-way.

A municipal provider that receives notice of an individual user conservation requirement is responsible for complying with the requirement with respect to all individual users to which it serves water and to which the requirement applies, with two exceptions. First, the municipal provider is not responsible for complying with the requirement with respect to an individual user that has received notice of the requirement directly from the director. In that case, the individual user is responsible for complying with the requirement. Second, if the requirement is substantially identical to an industrial conservation requirement, the municipal provider is not responsible for complying with the requirement with respect to an individual user which it has identified in writing to the Department by a specified date. If the individual user was in existence when the management plan was adopted, the municipal provider must have identified the individual user to the Department at least 90 days before the management plan was adopted. A.R.S. § 45-566(B). If the individual user came into existence after the management plan was adopted, the municipal provider must identify the individual user to the Department within 90 days after it begins serving water to the individual user. If the municipal provider identifies a new individual user to the Department more than 90 days after it begins serving water to the individual user, the municipal provider will be responsible for complying with the individual user requirement until the end of the year in which it first identifies the user to the Department. See section 5-111 of the municipal conservation requirements.

5.2.4 Distribution System Requirements

The director is required to include in the Third Management Plan "additional economically reasonable conservation requirements for the distribution of groundwater by cities, towns, private water companies and irrigation districts within their service areas." A.R.S. § 45-566(A)(5). Distribution system requirements for municipal providers consist of a requirement to limit lost and unaccounted for water and a requirement to meter deliveries. See section 5-112 of the municipal conservation requirements.

5.3 ASSURED WATER SUPPLY PROGRAM

The Code requires persons proposing to offer subdivided lands for sale or lease within an AMA to demonstrate that the proposed subdivision has an assured water supply. A.R.S. § 45-576. If a subdivider fails to demonstrate that a proposed subdivision has an assured water supply, the plat for the subdivision may not be approved by a city, town, or county, and the State Real Estate Commissioner may not issue a public report authorizing the sale or lease of the subdivided lands. A.R.S. § 45-576(B) and (C).

There are two mechanisms for demonstrating that a proposed subdivision has an assured water supply. First, the subdivider may apply for and obtain a Certificate of Assured Water Supply (Certificate of AWS) from the director. Second, the subdivider may obtain a written commitment of water service for the subdivision from a city, town, or private water company which the director has designated as having an assured water supply. A.R.S. § 45-576(A). For both of these purposes, "assured water supply" means that sufficient water of adequate quality will be continuously available to meet the water needs of the proposed use for at least 100 years; that the projected use is consistent with the management plan and achievement of the management goal for the AMA; and that the financial capability has been demonstrated to construct the water facilities necessary to make the supply of water available for the proposed use, including a delivery system and any storage facilities or treatment works. A.R.S. § 45-576(I).

In 1995, the Department adopted rules to carry out the purposes of the assured water supply statute. A.A.C. R12-15-701, *et seq*. The AWS Rules specify in detail what an applicant for a Certificate of AWS or a Designation of Assured Water Supply (Designation of AWS) must demonstrate. Of particular relevance to the Municipal Conservation Program are the requirements for demonstrating that a proposed use is consistent with the management plan and achievement of the management goal for the AMA.

5.3.1 Consistency With Management Goal

In order to demonstrate that a proposed use is consistent with the management goal for the Tucson AMA, the AWS Rules require applicants to demonstrate that renewable supplies, including groundwater replenished by the Central Arizona Groundwater Replenishment District (CAGRD), will be used to satisfy most of the water demand of the development or water service area for 100 years. A.A.C. R12-15-705. For a municipal provider applying for a Designation of AWS, this means that most of the water demand for both existing and new customers must be met with water supplies other than mined groundwater.

5.3.2 Consistency With Management Plan

In order to demonstrate consistency with the AMA's management plan, the AWS Rules generally require that an applicant be in compliance with its management plan requirements. For municipal providers, the applicable management plan requirements are the municipal provider conservation requirements set forth in section 5.10 of this chapter. Thus, if a municipal provider applying for a Designation of AWS is regulated under the Total GPCD Program, the provider must either be in compliance with its total GPCD requirement or with the terms of a stipulation and consent order entered into to remedy non-compliance with the GPCD requirement in order to demonstrate consistency with the management plan. *See* A.A.C. R12-15-706(B).

An applicant for a Certificate of AWS is not subject to the municipal provider conservation requirements set forth in the management plan because the applicant is not a municipal provider as defined in A.R.S. § 45-561. However, certain uses that may be associated with a certificate application, such as turf-related facilities, large-scale cooling facilities, and landscaping or water features in publicly owned rights-of-way, are subject to the individual user requirements in section 5-111(A) of the municipal conservation requirements if groundwater will be used. For all individual users, whether served by a designated or undesignated provider, either the entity delivering water or the individual user (e.g. homeowners association, turf-related facility owner, etc.) will be responsible for compliance with the individual user requirements.

The water use of a new subdivision will also affect a municipal provider's ability to meet its GPCD requirement. While individual users or the entity delivering water to them are responsible for meeting the individual user requirements, new subdivisions should be developed in a manner consistent with the municipal provider's conservation requirements in the management plan. This could be accomplished by some relatively simple and voluntary efforts by the certificate applicant or the homebuilder. A few examples are:

- Establish Conditions, Covenants, and Restrictions or other conditions that will limit landscaping within the subdivision
- Provide lot buyers with written water conservation information, including irrigation management of automatic irrigation timers
- Landscape model homes in accordance with Xeriscape™ principles
- Feature water conservation fixtures and appliances in model homes
- Limit high water use vegetation in common areas and model homes to those areas that provide significant recreational benefits
- Provide low water use landscaping packages to homebuyers
- Design in simple water harvesting features in landscaping designs
- Locate hot water heaters to minimize long hot water pipe runs or install looped systems
- Include community pools in large developments as an alternative to individual home pool installation

To assist in this effort, the Department funded production of a brochure entitled "Water Conservation Strategies for Developers and Builders" that is available from the Tucson AMA. In addition, the application for a Certificate of AWS requires submittal of general information to allow the Department to estimate the water demand of the subdivision. These include submittal of any Conditions, Covenants, and Restrictions or other conditions that will limit exterior water demand and any proposed conservation practices, policies, devices, etc. that may be utilized.

5.3.2.1 Consistency With Management Plan Criterion for Applicants for Certificates of Assured Water Supply

Some subdivisions include a golf course and other non-residential water uses. Demands associated with non-residential use are considered to be part of the subdivision offering if they will be part of the common promotional plan and they are covered by the official definition of a subdivision (A.R.S. § 32-2101). A golf course may be the single largest water use associated with a development. An 18-hole golf course typically uses enough water on an annual basis to meet the needs of more than 1,400 new single family households in the Tucson AMA. Because of this large volume of water, a person applying for a Certificate of AWS must demonstrate the following:

> That any new golf courses to be included within the development plan will be designed to comply with any applicable turf-related facility conservation requirements contained in Chapter 6 of this management plan. To make this demonstration, the applicant shall describe in its application the design and landscaping plans for any golf courses that will be included within the development.

When the AWS Rules are revised, more specific Consistency with Management Plan requirements for Certificates of AWS may be included.

5.3.3 Assured Water Supply Role in the Municipal Conservation Program

The AWS Rules are expected to result in reductions in mined groundwater use and greater reliance on renewable water supplies compared to pre-Rule water use. This will be a great benefit to the Tucson AMA as groundwater supplies are preserved for future use. However, as the utilization of renewable supplies increases as a result of the AWS Rules, the Municipal Conservation Program will continue to focus on the efficient use of all water supplies. As growth in the Tucson AMA continues, the stress on renewable supplies will also increase. The programs developed for the Third Management Plan are aimed at increasing the efficiency of water use in the municipal sector. It is the goal of the Department to use the AWS Rules along with the Municipal Conservation Program and incentives for the use of renewable supplies to bring the AMA closer to the achievement of safe-yield.

5.4 FIRST AND SECOND MANAGEMENT PLANS

For the First and Second Management Plans, the Department was required by statute to focus on per capita reductions as a mechanism to move the municipal sector toward safe-yield. Reductions in GPCD rates result in conservation of the groundwater supply. To achieve these reductions, the Total GPCD Program was established as the base program for all municipal providers.

The Department began with a basic percentage reduction approach in the First Management Plan and moved to addressing each provider's unique water use characteristics in the Second and Third Management Plans. In each management period, the Department has addressed additional water management concerns through technical assistance, new incentives for the use of renewable supplies, and corrections to data and assumptions based on the availability of new data and technologies. In addition to the Total GPCD Program, voluntary alternative programs that were not based solely on per capita reductions were developed in the Second Management Plan for providers able to limit or reduce reliance

on groundwater supplies. The intent of these programs is to allow providers more flexibility in managing water demand in exchange for their commitment to limit groundwater use.

5.4.1 First Management Plan Approach

The approach to municipal conservation in the First Management Plan was to incrementally reduce the water use by all providers toward an ultimate target of 140 GPCD. The higher the calculated GPCD rate of a particular provider, the greater the required reduction in per capita use. The 1980 census population and total water use were used to calculate each provider's 1980 GPCD rate, from which a total GPCD requirement was calculated that moved the provider one quarter of the way from its 1980 GPCD rate to 140 GPCD. Providers at or under 140 GPCD in 1980 were not required to conserve further but were not permitted to use more than 140 GPCD per year.

This approach to GPCD reductions assumed that all providers had the same potential to reduce per capita water use in their service area. Providers were given the opportunity to request a modification of their total GPCD requirement if they considered them unreasonable or if there were technical or factual errors in calculating the requirement.

Both small and large municipal water providers were regulated in the same manner in the First Management Plan. In addition, there was a "Special Provider" category for service areas which were dominated by non-residential/institutional uses whose water use patterns and conservation potential could not be adequately characterized by per capita rates. These special providers were assigned a residential GPCD requirement and specific conservation requirements for non-residential uses.

5.4.2 Second Management Plan Approach

During development of the Second Management Plan, the Department took into account the unique situations and growth patterns within each service area that influence the provider's ability to reduce per capita use. It was recognized that new users should be more efficient than existing users due to low-flow plumbing fixture ordinances and the trend toward installation of low water use landscapes. It was also recognized that existing users with high water use rates had greater conservation potential than those with lower water use rates.

The approach to setting GPCD requirements for large municipal providers in the Second Management Plan was based on an analysis of conservation potential for each service area using 1985 as the base year. Conservation potential for existing residential uses was estimated by comparing existing water use patterns to assumed levels of savings that could accrue by implementing selected conservation programs which had been successfully implemented in Arizona, California, and other regions in the United States. These savings were applied to the existing residential GPCD rate for each large municipal provider to develop a per capita target for existing residential uses. New residential uses were assumed to come in at a model water use rate that reflected low water use landscaping practices and low flow plumbing fixtures. Non-residential uses were held constant from base year levels. The full allotment for existing turf-related facilities was allowed. The percentage of lost and unaccounted for water was assumed to stay at the base year level. However, if it was under 5 percent, it was assumed to be at 5 percent; and, if it was over 10 percent, it was assumed to be at 10 percent.

Providers whose base year GPCD rate was under a certain level were not required to conserve further, while those with relatively high GPCD rates were assumed to have greater conservation potential. A total GPCD requirement was established for each large municipal provider combining the assumptions for existing residential, new residential, non-residential, turf-related facility use, and lost and unaccounted for water. A final and two intermediate per capita requirements were set for each water provider in an attempt to encourage providers to make progressive conservation efforts throughout the management period.

Because non-residential uses may continue to increase and, in most cases, are not subject to Certificate of AWS requirements limiting groundwater use, modifications to the total GPCD requirement for disproportionate increases in non-residential growth were not allowed in the Second Management Plan. To address this, the Department established the Alternative Conservation Program (ACP) which regulates providers based on a residential per capita requirement and the implementation of specific non-residential conservation measures. In order to participate in this more flexible program, providers were required to limit their groundwater withdrawals to a historic level, which required them to utilize renewable supplies or retire groundwater rights to serve the remaining demand.

Additionally, providers that served predominantly non-residential/institutional uses were allowed to apply for the Institutional Provider Program (IPP) which replaced the "Special Provider" program in the First Management Plan.

In the Second Management Plan, small municipal providers were not assigned a total GPCD requirement. Instead, they were required to comply with the following requirements: minimize waste, maximize efficiency of outdoor watering, encourage reuse, and reduce the GPCD rate in their service areas.

5.4.3 Overview of Changes During the Second Management Period

Since 1990, the Second Management Plan has been modified twice. In general, changes were made to the municipal conservation program to provide incentives for use of non-groundwater sources, to encourage conservation through a grants program, and to add a non-per capita conservation program. Additionally, a legislative change created an incentive for municipal providers to use groundwater withdrawn pursuant to approved remedial action projects.

5.4.3.1 Management Plan Modifications

5.4.3.1.1 First Modification (1992)

An exclusion for the use of untreated CAP water was included in the first modification. Providers that were willing to make a commitment to ultimately serve effluent to a non-residential customer, but did not yet have access to it, were allowed to serve untreated CAP water to the customer without having that water counted in the total GPCD rate for up to ten years. This incentive was adopted to encourage construction of the necessary non-potable distribution system before the effluent is available so that service of effluent will begin sooner.

The Conservation Assistance Grants Program was adopted to provide financial, planning, technical, and other support and services to all regulated sectors. Each year grants are awarded to support education, projects, and research that promote water conservation. The funds to support the grants program come from a portion of the groundwater withdrawal fee paid by all regulated groundwater users in each AMA.

5.4.3.1.2 Second Modification (1995)

Legislation passed in 1994 and incorporated into the second modification redefined small municipal providers as those providers serving 250 acre-feet of water or less annually. Small municipal providers had previously been defined as those serving 100 acre-feet of water or less annually or serving a population of 500 people or less. The intent of this legislation was to focus conservation efforts on providers with higher water use and greater conservation potential. In the Tucson AMA, passage of this legislation reduced the number of large municipal providers from 44 to 18. However, by 1998 two small providers had transitioned back into the large municipal provider category.

The NPCCP, adopted by the Legislature in 1992 and incorporated into the second modification, exempts qualified large municipal providers from per capita conservation requirements by substituting reasonable conservation measures (RCMs) that target both residential and non-residential users in place of per capita requirements. A.R.S.§ 45-565.01(A). Providers who elect to enter this program are required to gradually eliminate the use of mined groundwater in their service area.

The second modification provided an incentive for the use of renewable supplies that allowed large municipal providers whose annual groundwater use was 30 percent or less of their total annual water use to remain at or below their Second Management Plan First Intermediate GPCD requirement. This incentive could be used in each year that the provider achieved the groundwater limitation standard of 30 percent or less, through the year 1999.

5.4.3.2 Legislative Change

In 1997, legislation was enacted providing an incentive for municipal providers to use groundwater withdrawn pursuant to an Environmental Protection Agency (EPA) or Arizona Department of Environmental Quality (ADEQ) "approved remedial action" project. Prior to the passage of this bill, the withdrawal and use of groundwater, regardless of its quality, was counted as groundwater use in the determination of compliance with the management plan conservation requirements (see Chapter 10). This legislation requires the Department to account for remediated groundwater withdrawn pursuant to an approved remedial action project in the same manner as surface water for determining compliance with the management plan conservation requirements adopted in the Third, Fourth, and Fifth Management Plans. Thus, this groundwater is counted as surface water in the compliance determination. Laws 1997, Ch.287, § 51(B). Although the 1997 legislation did not expressly apply to conservation requirements adopted in the Second Management Plan, an amendment passed in 1999 applies these accounting principles to the Second Management Plan. Laws 1999, Ch. 295, § 49. The Department has indicated through a substantive policy statement how it will apply the incentive to Second Management Plan conservation requirements beginning in 1998. Section 5.7 contains a discussion of this incentive as it applies to the Third Management Plan.

5.5 MUNICIPAL PROGRAM ISSUES

Throughout the preparation of the Third Management Plan, extensive input was obtained from the municipal water use sector to identify issues and concerns that need to be addressed during the third management period. This section summarizes the key issues and concerns raised by the Department and by water providers in these discussions. These issues have been taken into consideration in program development. Some issues require legislative change or other actions not under the Department's control.

5.5.1 Private Water Company Issues

Some municipal water providers regulated under the Municipal Conservation Program are privately-owned companies separate from the city, town, or county in which they are located. While local plumbing and landscape ordinances may apply within the private water company service area, the water company itself lacks the authority to enact or enforce ordinances regulating water use by its customers. In addition to being regulated by the Department, private water companies are regulated by the Arizona Corporation Commission (ACC), an elected body whose mission includes exercising exclusive state regulatory authority over public service corporations (public utilities) in the public interest. The ACC monitors the operations of approximately 350 private water utility companies throughout Arizona, reviewing company financial records and recommending revenue requirements and rates and charges to be collected. The regulatory responsibilities of the ACC are fully defined in Article XV of the Arizona Constitution and §§ 40-201, *et seq.*, Arizona Revised Statutes, including A.R.S. § 40-250, requiring that all public service corporations obtain ACC approval before establishing or changing any rate.

Private water companies have raised several issues regarding the relationship of the Department's requirements and the ACC's view of rate recovery associated with the requirements. The most significant issues identified include: (1) the perception of uncertainty in the ability to recover the holding costs of CAP subcontracts and financing the construction of facilities for receipt and use of renewable supplies and (2) the impact of the ACC's position in rate cases that implementation of conservation programs is discretionary because the Department does not identify and mandate specific conservation programs or measures needed to be carried out by the provider.

These issues have been extensively reviewed and discussed by the Department staff, private water company representatives, and ACC staff. The ACC has indicated that "although they cannot guarantee recovery of costs prior to their incurrence" they would consider cost recovery for the use of renewable supplies and the implementation of conservation measures, applying the principles of "used and useful" and "least-cost alternative." In the past, these principles have meant that a provider would have to be actively providing a resource in order to recover costs and any conservation measure implemented would have to be the most cost-effective option before the recovery of costs would be allowed. Private water companies argue that these principles do not guarantee cost recovery as they are considered by the ACC on a case-by-case basis.

During the development of the Third Management Plan, the Department explored the possibility of establishing a municipal conservation program designed specifically for private water companies. In order to meet the goals of the Department and obtain the support of the ACC, the Department considered a program which would mandate specific conservation measures and reduce reliance on groundwater supplies. It was determined that additional statutory authority would be needed to implement such a program and the Department decided not to pursue this action at this time. However, Department staff, with the cooperation of the regulated community, will continue to explore options, including continued dialogue between the two agencies aimed at establishing a united strategy to achieve the most economically efficient reduction in groundwater reliance by private water companies and providing more certainty of cost recovery.

5.5.2 Use of Renewable Water Supplies

The primary renewable supplies available to the Tucson AMA are CAP water and effluent. Municipal subcontractors hold a total of 163,033 acre-feet of CAP subcontract water in the AMA. Precipitation and groundwater underflow result in about 60,800 acre-feet of net natural recharge annually within the AMA, which is less than half of the approximately 160,000 acre-feet of annual municipal demand.

In the Tucson AMA, the use of CAP water has been controversial due to problems with the initial delivery of treated CAP water to municipal customers of the City of Tucson. CAP deliveries began in 1992 but, due to problems with taste, odor, discolored water, and corroded plumbing, deliveries were discontinued in 1994. Proposition 200, the Water Consumer Protection Act passed by City of Tucson voters on November 7, 1995, prohibits direct potable delivery of CAP water to Tucson Water customers unless treated to the standard of Avra Valley groundwater. Due to these limitations there has been greater focus on recharge as well as an investigation of increased CAP water use by non-municipal entities. Evaluation of recharge projects and direct delivery options continues (see Chapter 8).

There is a significant difference between current costs to utilize groundwater supplies and costs to use renewable supplies. Although the Department cannot subsidize renewable supply use, the Department has attempted to make renewable supplies a more attractive choice through various incentives. Municipal providers expressed multiple concerns through Technical Advisory Committee meetings and written communications that the incentives for utilization of renewable water supplies in the management plans are inadequate. In the first and second management periods, the management plans focused primarily on conservation requirements. Although the AWS Rules have increased the emphasis on the use of renewable

water supplies, there is a perceived need to provide additional incentives to utilize these supplies. Some have recommended that the use of renewable resources be facilitated by exempting such deliveries from conservation requirements or discounting renewable supply use in the compliance calculation. However, long-term demand and supply projections indicate Tucson AMA providers could potentially fully utilize their CAP water and that a lower GPCD rate will eventually be necessary to maintain safe-yield. The Department recognizes the importance of encouraging the use of renewable supplies while continuing to stress that all available water supplies must be used efficiently.

A number of incentive programs for the use of renewable supplies were included in the Second Management Plan and some are included in this plan (see Chapter 8 for a summary of all incentives). For example, in the Third Management Plan, effluent used directly or recovered within the area of impact does not count in the GPCD calculation. Several other incentives were considered for inclusion in the Third Management Plan. Because of the creation of the Arizona Water Banking Authority, which is expected to fully utilize the state's CAP allocation, and for other reasons, additional municipal CAP utilization incentives may not be useful. It has been suggested that one or more task forces be established to review the issues associated with ways to maximize the likelihood of achieving safe-yield, tools needed to manage water on a more localized basis, and the appropriateness of developing additional regulatory incentives. It may be necessary to develop both legislation and modifications to the management plans to adopt a comprehensive strategy that addresses these various concerns.

In the meantime, the option of extinguishing recharge credits or storing non-recoverable water in particular areas as a compliance mechanism may be considered during the third management period, even in advance of a violation. Providers who anticipate an allotment violation are encouraged to develop a proactive response program in cooperation with the Department (see section 10.7.3 of the Plan Implementation Chapter).

Table 5-1 lists the volume of CAP water directly delivered and recharged from 1992 to 1996. Direct delivery was largest in 1993 when Tucson Water began serving CAP water directly to customers. Deliveries tapered off after this due to problems with the quality of the delivered CAP water. While recharge amounts increased in an attempt to continue to use as much CAP water as possible, CAP use since 1993 has been substantially below the 1993 level, and the 1993 volume was less than a third of the municipal allocation available for use.

TABLE 5-1
DIRECT MUNICIPAL CAP DELIVERIES AND CAP RECHARGE
TUCSON ACTIVE MANAGEMENT AREA

Year	Direct Deliveries (acre-feet)	Recharge (acre-feet)	Total (acre-feet)
1992	7,840	0	7,840
1993	46,315	5,297	51,612
1994	22,250	3,588	25,838
1995	103[1]	10,137	10,240
1996	127[1]	19,624	19,751

[1] Water used for treatment plant maintenance

Effluent is currently being delivered for irrigation to turf-related facilities, landscaped medians, and schools and parks that are not turf-related facilities. In 1995, municipal provider customers, primarily golf courses, used over 7,700 acre-feet of effluent. Use of effluent is limited by the extent of the delivery system, water quality needs, cost compared to other sources, ownership issues, and other factors.

5.5.3 Assured Water Supply Issues

The AWS Rules do not address residual overdraft associated with existing municipal uses or new municipal uses on unsubdivided lands. Unless changes are made to the Code or to the AWS Rules, these uses can be addressed only through implementation of water conservation measures, including renewable supply incentives. In the Tucson AMA, the demand associated with existing municipal uses is nearly 160,000 acre-feet per year. Of this annual demand, approximately 22,000 acre-feet is associated with municipal providers who have chosen not to apply for a Designation of AWS (15 large providers and 134 small providers) and therefore are not required to replace groundwater use with renewable supply use. Groundwater use by almost all exempt well owners is also not subject to a requirement for replacement with renewable supplies. It will be difficult to reach safe-yield if these demands continue to be met with mined groundwater.

The physical availability criteria in the AWS Rules raise another water management issue. These criteria allow localized groundwater depletions to continue to 1,000 feet below the land surface as long as corresponding replenishment occurs somewhere in the AMA. This is consistent with the concept of a basin-wide approach to groundwater management but is not consistent with other water management objectives such as supply reliability, critical area management, and subsidence avoidance.

5.5.4 Total Gallons Per Capita Per Day Program Issues

Municipal providers are responsible for ensuring efficient water use by their customers, including: single family (single family homes or mobile homes on their own lots); multifamily (apartments, town homes, patio homes, duplexes, tri-plexes, and master metered permanent resident mobile home parks); commercial (stores, shopping centers, and malls); industrial (golf courses, cemeteries, factories, schools, and parks); government (city or county office buildings and associated grounds); and construction (dust control, and metered fire hydrant use during road or highway work). For providers regulated under the Total GPCD Program, compliance is determined by comparing the provider's actual GPCD usage rate with the provider's total GPCD requirement for the year.

When the Second Management Plan total GPCD requirements were assigned in 1990, the Department received many requests for administrative review. Adjustments were requested for a number of reasons, including inaccurate population projections, seasonal population, historical disproportionate increases in non-residential growth, and inaccurate assumptions for new residential growth.

Population projections for 1992, 1995, and 2000 were one of the factors used in the Second Management Plan to calculate total GPCD requirements for each large municipal provider. There are several uncertainties associated with using population projections in the total GPCD calculations. The economic forecast at the time the projections are developed can influence the projections; the ratio of single family to multifamily projections can influence the per capita water use rate; and the way a provider actually grows in relation to the projections can either make it easier or more difficult for a provider to meet its requirements.

To address these uncertainties in the Third Management Plan, population projections will not be used to calculate a total GPCD requirement. Instead, an annual GPCD requirement will be calculated using a component method that uses actual new single family and multifamily populations at model use rates combined with water use components for existing residential, non-residential, existing turf-related

facilities, and lost and unaccounted for water. This approach is discussed in more detail in section 5.6.1.1.1 of this chapter.

Seasonal visitors, those customers not maintaining a legal residence in the State of Arizona, do not count as resident service area population in GPCD calculations due to the definition of resident population used by the Census Bureau. This population can skew GPCD rates to make it appear that water use is becoming more or less efficient, depending on whether or not the proportion of seasonal population to resident population is decreasing or increasing. Providers that can demonstrate a significant impact due to seasonal population can request an administrative review of the annual population estimate.

The practice of water providers reporting the number of service connections rather than the actual number of housing units served can also result in inaccurate GPCD calculations because it will result in an inaccurate population estimate. This may occur in areas where one service connection serves more than one housing unit at the address as when manufactured homes are installed or removed from an existing meter or when a primary residence has a guesthouse attached to the same meter.

The ratio of residential to non-residential demand can also impact the GPCD rate of a water provider. Adding a new large non-residential customer can drastically increase overall water demand and negatively impact a provider's ability to achieve compliance with the total GPCD requirement. The First Management Plan contained a provision which allowed a provider experiencing a disproportionate increase in non-residential use to apply for a modification to its total GPCD requirement to accommodate the increased non-residential use. Although the Second Management Plan did not contain this provision, it did contain other provisions which allowed a provider to remain in compliance while serving disproportionately increasing non-residential uses. For example, delivery of effluent, other than effluent recovered outside the area of impact of an underground storage project, was excluded when determining a provider's compliance with its GPCD requirement. Thus, a provider could serve an unlimited amount of effluent to a non-residential customer without the service having any impact on its GPCD rate. Additionally, the ACP and the NPCCP were developed in the Second Management Plan to allow the non-residential sector to grow without per capita restrictions if renewable water supplies were used.

Because designated providers must reduce their groundwater use for both existing and new water users, the concern that new non-residential customers will use groundwater becomes less of an issue. In the Third Management Plan, the Department will continue to offer alternative programs and an effluent use incentive to allow for flexibility to address disproportionate non-residential growth.

5.6 THIRD MANAGEMENT PLAN MUNICIPAL CONSERVATION PROGRAM

Conservation requirements have been established pursuant to the statutory provisions of the Code for large municipal providers and small municipal providers. This section details the programs and requirements that have been developed for the Third Management Plan.

5.6.1 Conservation Requirements for Large Municipal Providers

In order to establish conservation requirements for large municipal providers in the Second Management Plan, the Department identified existing water use patterns and service area characteristics that influence a provider's water conservation potential. Assumptions about future service area population growth and water supply and demand were also included in the analysis. This assessment was referred to as the "municipal provider profile." Using population projections for 1992, 1995, and 2000, targets for each water use sector or component (existing residential, new residential, non-residential, turf-related facility, and lost and unaccounted for water) were combined to establish a preassigned total GPCD requirement. Two intermediate requirements in 1992 and 1995 were established to allow a phase-in to achieve the final Second Management Plan requirement in 2000.

For the Third Management Plan, the Department used a similar approach to identify water use characteristics. Information obtained from annual water use reports included water deliveries, monthly water use by sector, water source, and number of housing units added to the service area annually. Additional information included: (1) annual population estimates based on the provider-supplied housing unit information from the annual reports, (2) Department of Economic Security persons per housing unit data, and (3) individual interviews with water providers to assess existing water conservation programs and determine water conservation potential.

In the Third Management Plan, the Department will not use population projections in combination with water use components to preassign total GPCD requirements. Instead, each component is assigned a separate water use rate, and a total GPCD requirement will be calculated each year based on actual population growth within each service area. As in the Second Management Plan, there will be two intermediate and a final GPCD requirement for all large municipal providers. Each large municipal provider will be noticed of its GPCD components for its service area and the method for calculating a total GPCD requirement. Providers may apply for a variance from or an administrative review of the conservation requirements within 90 days after the notice is given.

As an alternative, a large municipal provider may apply to be regulated under the Non-Per Capita Conservation Program (NPCCP), the Alternative Conservation Program (ACP), or the Institutional Provider Program (IPP). The following sections describe the base municipal conservation program and how it was developed and briefly describes the alternative conservation programs.

5.6.1.1 Total Gallons Per Capita Per Day Program

As in previous management periods, the base municipal program for the Third Management Plan is the Total GPCD Program. All large municipal providers regulated under this program must limit the overall GPCD water usage within its service area to the amount allowed under its total GPCD requirements.

For the third management period, an annual total GPCD requirement will be calculated for each water provider using a component method. The components of the total GPCD requirement are existing residential use, new single family residential interior use, new single family residential exterior use, new multifamily residential use, turf-related facility use, non-residential use, and lost and unaccounted for water. Each large provider has an assigned per capita per day or per housing unit per day component use as shown in Table 5-5 of section 5.10 or described in section 5-103.B. The component calculation is described in more detail in Appendix 5C.1-2. The sum of the component volumes for each provider will be multiplied by the actual population or housing units in the service area each year to determine the annual total GPCD requirement for the provider. The resulting allowable volume will be compared to the actual amount of water withdrawn, diverted, or received in the calendar year to determine whether the water provider is in compliance.

5.6.1.1.1 Total Gallons Per Capita Per Day Program Development

<u>Existing Residential Conservation Potential</u>

Conservation potential is an estimate of the amount of reduction in water use that may result from implementing conservation measures or programs. To determine the existing residential conservation potential of each large municipal provider in the Second Management Plan, the Department used a base year to determine water use rates for existing residential water users then analyzed residential water use patterns and selected appropriate conservation programs. This analysis resulted in a GPCD reduction for existing users that was factored into the total GPCD requirement for the provider. In developing the Third Management Plan, staff conducted a detailed analysis of all assumptions used to estimate the conservation potential of existing residential users in the Second Management Plan. This included an extensive

inventory and analysis of available water conservation devices, measures, and programs. Adjustments were made to the Second Management Plan assumptions on water savings, market penetration, and installation rates based on documented water savings from water conservation programs throughout the United States, including the southwest.

The average monthly water use for the years 1992 through 1995 was used to determine the conservation potential for existing residential water use in the Tucson AMA. These "base year" data for each provider are shown in Appendix 5D. Four categories of water use were established to indicate existing residential interior and exterior conservation potential. Depending on the average interior and exterior water use within each service area, providers were categorized as having no potential, minimum potential, moderate potential, or maximum potential as shown in Table 5-2.

The Department assigned appropriate conservation measures to the minimum, moderate, and maximum categories that could be implemented to achieve water savings commensurate with the provider's conservation potential. Additionally, the Department evaluated existing conservation programs within each service area and, based on this information, the conservation savings assigned to a provider was adjusted to take into account programs already implemented. The water savings associated with each conservation measure were applied to the provider's water use characteristics to calculate the existing residential component.

TABLE 5-2
TUCSON AMA EXISTING RESIDENTIAL
CONSERVATION POTENTIAL CATEGORIES
TUCSON ACTIVE MANAGEMENT AREA

Category	INTERIOR Single Family/Multifamily GPCD	EXTERIOR Single Family GPHUD
No Potential	≤57	≤118
Minimum Potential	58-74	119-177
Moderate Potential	75-87	178-236
Maximum Potential	>87	>236

GPCD = gallons per capita per day
GPHUD = gallons per housing unit per day

Models for New Residential Users

For new residential water users, those residential users who begin to receive water from a municipal provider after 2000, the Department utilized a similar model-based approach to that used in the Second Management Plan. Current water fixture flow rates, existing technology, and behavioral patterns were evaluated and incorporated into updated models for new interior and exterior water use. In addition, data from several residential water use studies and surveys conducted during the second management period were used to develop the Third Management Plan models.

The interior residential water use model was updated to reflect performance specifications for toilets, showerheads, and faucet aerators in current local, state, and federal plumbing codes; use of water-efficient clothes washers and dishwashers; and documented, typical water use behavioral patterns. It should be noted that low-flow toilet requirements limit water use to 1.6 gallons per flush; however, to compensate for

occasional double-flushing, the model rate for toilets was adjusted to 1.7 gallons per flush. A miscellaneous water use component was added to the Third Management Plan model to allow for reasonable water consumption associated with fixtures and appliances not specifically addressed as model components. Behavioral patterns affecting the duration and frequency of use of plumbing fixtures and water using appliances were reevaluated based on data obtained from residential flow trace studies conducted in the Phoenix area and other communities throughout the United States and Canada sponsored by the American Water Works Association Research Foundation. As a result, an interior residential model use rate of 57 GPCD, a 4 GPCD decrease from the Second Management Plan model of 61 GPCD, will be used as an interior component for all new residential water users through the third management period (see Table 5-3). Detailed assumptions used to establish the interior residential water use model are described in Appendix 5E.

The exterior water use model for new single family development for the second management period considered average swimming pool demand, evaporative cooling demand, and efficient water application for typical landscaping. The same approach, using updated information, was used for the Third Management Plan. Because exterior water use is largely independent of the number of persons per household, the exterior model is expressed in gallons per housing unit per day (GPHUD). It has been observed that, for new residential development in the Tucson AMA, the landscaped area which requires regular water application is relatively consistent for all lot sizes (Craft, 1997). The approach for the third management period assumes that the same potential exists for all new housing units to implement landscaping patterns appropriate to the local climate and practice efficient water application. Thus, a single model for all new single family residential development was used.

TABLE 5-3
THIRD MANAGEMENT PLAN
INTERIOR WATER USE MODEL FOR NEW RESIDENTIAL DEVELOPMENT
TUCSON ACTIVE MANAGEMENT AREA

Device	Model Assumption	Model Use Rate
Toilet	5 flushes/person/day * 1.7 gallon/flush	9 GPCD
Shower/Bath	(2.5 gpm * 7.9 min/shower * 0.9 shower/person/day) + (32.5 gal/bath * 0.1 bath/person/day)	21 GPCD
Faucets	Kitchen & Bathroom 2.5 gpm* 4 minutes/person/day	10 GPCD
Dishwasher	9.8 gal/load * 0.2 loads/person/day	2 GPCD
Clothes Washer	30.3 gal/load * 0.3 loads/person/day	9 GPCD
Miscellaneous		6 GPCD
TOTAL		**57 GPCD**

Note: Figures are rounded

In 1997, the Department conducted a survey of outdoor water use practices at new housing in cooperation with the University of Arizona, Tucson Water and Metropolitan Domestic Water Improvement District (Craft, 1997). Responses were received from occupants of over 600 single family residences built since 1991. The results of the survey provided valuable information on the frequency of installation of evaporative coolers, swimming pools, pool covers, and spas; the size and number of gardens and turf areas; and the number and types of landscaping plants typical of new housing. In 1996, the Phoenix AMA

provided funding for a survey of evaporative cooler use which was performed by the University of Arizona in conjunction with the City of Phoenix (Karpiscak, et al, 1998). Findings from these studies were also used to develop the exterior model. Landscape water use and landscaping design assumptions are based on the potential for the provider to promote the use of, provide incentives for, and educate new residents about the benefits of using low water use plants and practicing efficient landscape watering. Efficient landscape watering techniques include the use of drip irrigation systems and proper water application scheduling.

In addition to the Phoenix AMA evaporative cooler study and the Tucson AMA landscape survey, other data used in developing the exterior residential model were a survey of swimming pool and spa contractors and owners, a compilation of Tucson area evapotranspiration and rainfall data, University of Arizona horticultural research data, and a landscape watering schedule developed by the Pima County Cooperative Extension Service (Pima County Cooperative Extension Service, 1996). Although it is recognized that not all homeowners will meet the model use rate individually, it is anticipated that new per capita water use on average over an entire service area will conform to the model rate. It was assumed that new homes have the potential to implement appropriate landscaping practices and that providers have a stronger ability to influence a new homeowner's decisions than those in an established neighborhood.

The model rate for new single family exterior residential water use is 118 GPHUD in the Third Management Plan. The new multifamily exterior residential water use model is 21 GPCD. This number was derived by assuming that there is a 20 percent conservation potential in the average AMA multifamily exterior rate of 26 GPCD based on results from multifamily water audits performed in the AMA. Table 5-4 summarizes the assumptions used to develop the single family exterior water use model for the Third Management Plan. Details of the assumptions are contained in Appendix 5F.1-4.

TABLE 5-4
EXTERIOR WATER USE MODEL FOR NEW SINGLE FAMILY RESIDENTIAL DEVELOPMENT
TUCSON ACTIVE MANAGEMENT AREA

	Model Use Rate
Pool Use	11 GPHUD
Spa Use	4 GPHUD
Evaporative Cooling	5 GPHUD
Landscape Watering	98 GPHUD
Single Family Residential Exterior Total	**118 GPHUD**

GPHUD = gallons per housing unit per day

Non-Residential Water Use

The Third Management Plan base year, composed of the average annual non-residential water use from 1992 to 1995 exclusive of water served to turf-related facilities, was evaluated and compared to the Second Management Plan base year use. In general, the lower of the two base year numbers was used to set the Third Management Plan non-residential per capita component. Long-term residential and non-residential growth are typically proportionate in most service areas. Those large water providers experiencing dramatically disproportionate long-term non-residential growth may apply for the ACP or the NPCCP. In both of these programs, constraints on non-residential GPCD are removed in return for a commitment from the water provider to limit groundwater pumping and to encourage all customer classes to practice

maximum water use efficiency. Currently, per capita non-residential water use is 5 percent less than was assumed in the Second Management Plan due primarily to increased use of effluent, which is not included in the GPCD calculation. In the Third Management Plan, the Department will continue to regulate certain non-residential customers of municipal water providers as individual users including turf-related facilities, large-scale cooling facilities, and landscaping and water features in public rights-of-way as described in section 5-111 of the municipal conservation requirements.

Turf-Related Facility Water Use

In the Second Management Plan, the maximum annual water allotment of a turf-related facility was factored into a water provider's total GPCD requirement if that turf-related facility was in existence by the mid-1980s and was served groundwater by that provider. The allotments for turf-related facilities that were developed after the mid-1980s were not factored into a water provider's total GPCD requirement. As a result, use of groundwater on a new turf-related facility had the effect of reducing the amount of groundwater that could be served to other customers of the water provider if the provider was to meet its total per capita requirement. If an existing turf-related facility converted from groundwater to another water supply such as effluent or if the provider no longer served the facility, the maximum annual allotment for the facility was still factored into the provider's total GPCD requirement

In both the Second and Third Management Plans in years when the existing turf-related facility uses less than its full allotment, the balance of the allotment is credited to the water provider's flexibility account. In years with higher water demand, an existing turf-related facility can use water in excess of its allotment, within the credit and debit limits in the provider's flexibility account, without adversely impacting the per capita compliance status of the provider. However, the turf-related facility is still required to meet its allotment requirement in order to be in compliance with the conservation requirements for turf-related facilities (see section 6.3.8 of Chapter 6). If a provider replaces groundwater deliveries to a turf-related facility with effluent, the provider benefits by (1) not having the effluent delivery count in its GPCD rate when determining compliance, and (2) by retaining the volume of the turf-facility allotment in the calculation of its total GPCD requirement. This provides a substantial incentive to providers to serve effluent.

In a manner similar to that in the Second Management Plan, the combined maximum annual water allotments for Second Management Plan existing turf-related facilities are factored into the annual calculation of the provider's per capita requirement as the turf-related facility component in the Third Management Plan. This component is factored into the annual requirement if the water provider converts from serving groundwater to serving any other source of water. However, if the provider no longer serves the facility, the allotment is not included in the turf-related facility component. For example, if the golf course is owned by a homeowners' association that decides to discontinue water service from the provider and serve the existing facility through recovery of CAP recharge credits, the maximum annual water allotment for the golf course is not included in the water provider's turf-related facility component. In the Second Management Plan, the provider would have retained the volume of the allotment in its total GPCD requirement under this scenario. As in the Second Management Plan, allotments for new turf-related facilities are not factored into the calculation of a provider's GPCD requirement. The Third Management Plan approach is designed to discourage development of new groundwater-dependent turf-related facilities and to prevent water providers from receiving an allotment of water for facilities they no longer serve. Appendix 5G lists the turf-related facilities that are included in the turf-related facility component for water providers. The component will be adjusted if a water provider no longer serves the facility.

This approach assumes that new golf courses within service areas will be served with direct use effluent or effluent recovered within the area of impact, which are not counted in determining compliance with gallons per capita per day requirements. Additional groundwater for new turf-related facilities is not allocated in the turf-related facility component, which is combined with the other components in the

calculation of a provider's total gallon per capita per day requirement. However, there may be cases where direct use effluent and effluent recovered within the area of impact will not be physically available to serve a new turf-related facility, or cases where such effluent will eventually be used but is not currently available, or not available in sufficient quantity. In these cases, an existing large municipal provider may apply for an administrative review.

In the case where direct use effluent and effluent recovered within the area of impact will not be physically available to serve the new turf-related facility within a reasonable period of time, the provider will receive a permanent adjustment to its per capita requirement, if effluent recovered outside the area of impact of the storage is used to serve the new facility. In the case where direct use of effluent or effluent recovered within the area of impact is committed to serve the facility and delivery of the effluent will be initiated within four years, but a longer period is necessary for sufficient effluent to be produced to serve the entire facility, the provider will receive a temporary adjustment to its total GPCD requirement with no requirement to use effluent recovered outside the area of impact during the transition period. The adjustment will remain in effect only until sufficient direct use effluent or effluent recovered within the area of impact is available to serve the entire facility, not to exceed eight years, and may be adjusted as the volume of effluent use increases. The adjustment will be terminated if the infrastructure necessary to deliver the effluent to the facility is not in place at the beginning of the fourth year after the provider commences service to the facility.

In either case, the adjustment will consist of an addition to the provider's turf-related facility component in the amount of the turf-related facility's allotment as calculated under the conservation requirements in Chapter 6. However, no adjustment will be granted above a volume that would allow the provider to use more water for non-residential use during a year than an amount calculated by multiplying the provider's base period non-residential GPCD use rate (including turf-related facility use), or 21 GPCD, whichever is higher, by the provider's service area population for the year, then by the number of days in the year.

Lost and Unaccounted for Water

In the Third Management Plan, large municipal providers must limit the amount of water that is lost and unaccounted for in their distribution systems each year to no more than 10 percent of all water withdrawn, diverted, or received in that year. Second Management Plan per capita requirements were held to lost and unaccounted for water use rates in the base year. Providers with less than 10 percent lost and unaccounted for water in the base year were assumed to be able to maintain this lower rate throughout the second management period. Because the Third Management Plan regulatory standard is 10 percent for all providers, those with lower loss rates will be allowed their actual lost and unaccounted for water each year up to the 10 percent limit in the calculation of the provider's annual total GPCD requirement.

5.6.1.1.2 Total Gallons Per Capita Per Day Compliance

Each provider's compliance with the Total GPCD Program will be determined annually by comparing the large municipal provider's actual annual volumetric usage of all water (except CAP exclusion water, direct use effluent, and effluent recovered within the area of impact) withdrawn, received, and diverted for non-irrigation use to the volume of water the provider could legally withdraw, divert, or receive during the year for non-irrigation use. The amount of water the provider can legally withdraw, divert, or receive during the year for non-irrigation use is calculated by multiplying the provider's total GPCD requirement for the year, as calculated using the component methodology, by the provider's service area population as of July 1 of the year, and then multiplying the product by the number of days in the year. Any credits or debits in the provider's flexibility account will be taken into account when determining compliance, as discussed below.

Flexibility Account

To account for the impacts of weather variations on municipal water use, the Department established a municipal flexibility account for each large provider in the Second Management Plan to determine compliance with the total GPCD requirement. This same approach will be used to determine compliance with total GPCD requirements in the Third Management Plan. Under the flexibility account approach, if a water provider uses less water in a year than is allowed by its total GPCD requirement, a credit is registered to the provider's flexibility account in the amount of the difference. If a provider uses more water during a year than is allowed by its total GPCD requirement, a debit is registered to the provider's flexibility account in the amount of the difference. The maximum credit accumulation is 30 GPCD. The maximum debit accumulation allowed is 10 GPCD. The provider is considered out of compliance with its total GPCD requirement if the debit accumulation exceeds 10 GPCD.

Annual Population Estimates

At the beginning of the management period, the initial service area population for each water provider is calculated using the latest Census numbers, which are disaggregated by unit type (single family, multifamily) to determine the base or "existing" housing unit count. Each year water providers are requested to report the total number of new housing units added to the service area. The reported new units are added to the "existing" housing units to derive the total housing unit figure for that year. Occupancy rates and persons per occupied housing unit rates from the latest Census are applied to the housing unit count to derive an estimated service area population.

5.6.1.2 Non-Per Capita Conservation Program

The NPCCP was added to the Second Management Plan in 1995 after being developed in cooperation with representatives of the water using community. This program requires a provider to implement specific conservation measures within its service area instead of requiring compliance with per-capita conservation requirements. A provider in this program must implement reasonable conservation measures, or RCMs, for interior and exterior residential water uses, interior and exterior non-residential uses, as well as an education program. The RCMs must be designed to result in water use efficiency within the provider's service area equivalent to the water use efficiency assumed in the provider's total GPCD requirement.

The Department has established a list of standard RCMs which are designed to achieve an efficiency equivalent to the assumptions used in the Total GPCD Program. However, if the standard RCMs do not fit the service area characteristics of a provider, the program allows the provider the flexibility to substitute measures that are designed to achieve the same savings yet fit the characteristics of the provider's service area. For the third management period, the Department will establish a steering committee to assist the Department in reviewing the existing standard RCMs, the substitute RCMs, and development of monitoring and reporting requirements which would be beneficial to the administration of the alternative programs. This steering committee will be made up primarily of Department staff and representatives of large municipal providers that are regulated under an alternative program. Other persons whom the director considers to be beneficial may also be included.

5.6.1.2.1 Groundwater Use Reduction Requirement

The provider must meet one of the following requirements to be eligible to participate in the NPCCP: (1) the provider must be a member of a groundwater replenishment district, (2) the provider must be designated as having a 100-year assured water supply under the Department's AWS Rules, or (3) the provider must implement a plan to eliminate mined groundwater withdrawals by 2010.

5.6.1.2.2 Reasonable Conservation Measures

A set of Standard Residential, Non-Residential, and Education RCMs were developed by the Department with the aid of an advisory group composed of conservation program experts. Each RCM prescribes actions that must be taken by the provider to achieve water use efficiencies in each water use category. Providers who have already implemented these measures will be required to implement additional conservation measures to qualify for the program consistent with their existing conservation potential. Standard RCMs include interior, exterior, and education measures and are described in Appendix 5H.1-3. Substitute RCMs (Appendix 5H.4) were developed to allow a provider to develop a conservation program tailored to the characteristics of its service area.

In order for a provider to use a Substitute RCM in place of a Standard RCM, the provider must apply to the director and demonstrate that the Substitute RCM will be designed to achieve a water use efficiency equivalent to the Standard RCM.

Standard RCMs

A. Residential Interior
   1. Water Audit and Fixture Retrofit Program for Existing Residential Customers
   2. Ordinance or Condition of New Service Prohibiting Installation or Replacement of Plumbing Fixtures in Residential Housing Units Unless Fixtures Meet Water Savings Standards

B. Residential Exterior
   1. Audit Program for Existing Residential Customers
   2. Landscape Watering Advice Program for Existing and New Residential Customers
   3. Ordinance or Conditions of New Service for Model Homes in New Residential Developments
   4. Prohibit the Creation of Covenants, Conditions, and Restrictions Which Require the Use of Water-Intensive Landscaping or Which Prohibit the Use of Low Water Use Landscaping in New Residential Developments
   5. *One additional landscape RCM from the three below(choice of one of the following):*
      (1) Ordinance or Condition of New Service Limiting Use of Turf and Other Water-Intensive Landscaping in New Multifamily Developments, **or**
      (2) Ordinance or Condition of New Service Limiting Use of Turf and Other Water-Intensive Landscaping in Common Areas of New Single Family and Multifamily Developments, **or**
      (3) Rebate Program for New Residential Customers

C. Non-Residential Interior
   1. Interior Audit Program for Existing Facilities
   2. Ordinance or Condition of New Service Prohibiting Installation or Replacement of Plumbing Fixtures in Non-Residential Facilities Unless Fixtures Meet Water Savings Standards
   3. Distribution of Conservation Information to all New Non-Residential Customers and Submittal of Water Use Plan by New Large Facilities

D. Non-Residential Exterior
   1. Exterior Audit Program for Existing Non-Residential Customers
   2. Landscape Ordinance or Condition of New Service for New Facilities

E. Education
   1. Public Information and Education Program

5.6.1.2.3 Compliance with the Non-Per Capita Conservation Program

A provider regulated under the NPCCP is in compliance with the program if it implements the agreed to RCMs and limits its use of groundwater to the amount allowed under the AWS Rules or the amount allowed under the straight-line reduction, whichever is applicable. The Department will use the written agreement for the NPCCP to monitor progress with the program. Each year, along with the Annual Water Withdrawal and Use Report, the municipal provider will be required to submit a progress report describing the implementation of each RCM, the cost of implementing the program, estimated or actual water savings, and a description of any difficulties with the program. Providers regulated under the NPCCP will also be required to comply with the individual user, distribution system, and monitoring and reporting requirements contained in this chapter.

5.6.1.3 Alternative Conservation Program

The ACP was developed for the Second Management Plan to give large municipal providers with disproportionately increasing non-residential water use an alternative to the Total GPCD Program. The program allows providers with disproportionately increasing non-residential water use the flexibility to serve those non-residential uses while achieving water use efficiency levels comparable to those set by the Total GPCD Program. The ACP consists of the following requirements: (1) a groundwater use limitation, (2) a residential GPCD requirement, and (3) non-residential RCMs. As of 1998, there were no Tucson AMA providers in the ACP.

5.6.1.3.1 Groundwater Use Limitation Requirement

A provider regulated under the ACP must limit its annual groundwater use as follows: (1) if the provider is designated as having an assured water supply, it must limit its annual groundwater use to the amount it can use consistent with the AWS Rules, or (2) if the provider is not designated as having an assured water supply, it must limit its annual groundwater use to its largest legal groundwater use during any one year from 1980 through 1989 if it was serving water on or before January 1, 1990 or to 50 percent of its largest legal volume of groundwater use during any one year from January 1, 1990 through 1999 if it began serving water after January 1, 1990 but before January 1, 2000. This requirement can be met by permanently extinguishing grandfathered rights within the AMA or by serving groundwater that will be replenished by a groundwater replenishment district, remediated groundwater that is accounted for as surface water under section 5-114 of the municipal conservation requirements, groundwater withdrawn outside the AMA, or renewable water supplies.

5.6.1.3.2 Residential GPCD Requirement

Each provider regulated under the ACP is required to comply with a residential GPCD requirement that is calculated using the GPCD and GPHUD components for existing residential, new single family and new multifamily water users. These components are derived using the same methodology as that used to calculate the residential portion of the total GPCD requirement. The residential GPCD requirement is recalculated annually based on growth within the service area using the same calculation used for the residential components of the Total GPCD Program. The residential GPCD calculation methodology is described in Appendix 5I.

5.6.1.3.3 Reasonable Conservation Measures

Providers regulated under the ACP must implement specific conservation measures for non-residential water users. Providers who have already implemented these measures will be required to implement additional conservation measures to qualify for the program. The non-residential requirements for the

Third Management Plan have been modified and are now identical to the interior and exterior non-residential requirements for the NPCCP. The requirements are as follows:

A. Non-Residential Interior
   1. Interior Audit Program for Existing Facilities
   2. Ordinance or Condition of New Service Prohibiting Installation or Replacement of Plumbing Fixtures in Non-Residential Facilities Unless Fixtures Meet Water Savings Standards
   3. Distribution of Conservation Information to all New Non-Residential Customers and Submittal of Water Use Plan by New Large Facilities

B. Non-Residential Exterior
   1. Exterior Audit Program for Existing Non-Residential Customers
   2. Landscape Ordinance or Condition of New Service for New Facilities

Providers may also request a substitute measure for any non-residential requirements to be approved by the director.

5.6.1.3.4 Compliance with the Alternative Conservation Program

A provider regulated under the ACP is in compliance with the program if it does not exceed its residential GPCD requirements, implements the agreed to non-residential RCMs, and limits its use of groundwater to the amount allowed under the AWS Rules or the amount allowed under the historic use limitation, whichever is applicable. The Department will use the written agreement for the ACP to monitor progress with the program. Each year, along with the Annual Water Withdrawal and Use Report, the municipal provider will be required to submit a progress report describing the implementation of each non-residential RCM, the cost of implementing the program, estimated or actual water savings, and a description of any difficulties with the program. Providers regulated under the ACP will also be required to comply with the individual user, distribution system, and monitoring and reporting requirements contained in this chapter.

Groundwater Use Limitation Requirement

A provider regulated under the ACP is in compliance with the groundwater use limitation requirement of the ACP if no more groundwater is used in the calendar year than is allowed pursuant to the provisions of the program.

Residential GPCD Requirement

Compliance with the residential GPCD requirement will be determined in a manner similar to that used to determine compliance with the total GPCD requirement. As in the Total GPCD Program, there is a flexibility account for providers regulated under the ACP. However, because the requirement only applies to residential GPCD use, the maximum positive balance is 21 GPCD and the maximum negative balance is 7 GPCD. The residential GPCD use rate will be compared to the residential GPCD requirement plus any credits or minus any debits accrued in the flexibility account. The residential GPCD requirement will be calculated on an annual basis by adding together the assigned residential components. Providers with an annual GPCD rate that exceeds the maximum flexibility account debit will be considered out of compliance with the residential GPCD requirement.

Non-Residential Requirement

A provider regulated under the ACP is in compliance with the non-residential requirement if it implements the agreed to standard non-residential RCMs or any substitute non-residential RCMs approved by the director.

5.6.1.4 Institutional Provider Program

The IPP in the Second Management Plan replaced the special provider category in the First Management Plan and is continued in the Third Management Plan. The IPP allows those providers with primarily non-residential type uses and who are unable to economically utilize non-groundwater sources to be regulated under a program that focuses on the specific water use characteristics of their service area. The IPP is designed for large municipal providers who supply more than 90 percent of their total water deliveries to non-residential water users. Specifically, these non-residential uses include prisons, hospitals, military installations, airparks, and schools. A provider may request admission to this program by submitting an application in writing to the director at any time during the third management period. If the request is approved, the provider will be assigned conservation measures specific to the non-residential uses in its service area and a maximum residential GPCD rate. The Department will grant institutional provider status only if the Total GPCD Program is not appropriate and the provider demonstrates that it cannot qualify for the ACP or the NPCCP by limiting its groundwater use, retiring grandfathered groundwater rights, or using alternative sources of water.

5.6.2 Conservation Requirements for New Large Municipal Providers

A new large municipal provider is defined as a city, town, private water company, or irrigation district that begins serving more than 250 acre-feet of non-irrigation water per year after January 1, 2000. All new large municipal providers will initially be assigned to the Total GPCD Program. Their total GPCD requirement will be calculated consistent with the component methodology used for existing large municipal providers.

The base year for new large municipal providers will be the year or years preceding the first year the provider began serving more than 250 acre-feet unless the director determines that water use during that period is not representative. The Department will use residential water use data for the base year to conduct an analysis of conservation potential and calculate a GPCD component for existing residential users. New users will be assigned the new residential model rates of 57 GPCD interior and 118 GPHUD exterior for new single family development and 57 GPCD interior and 21 GPCD exterior for new multifamily development. The non-residential component will be based on the actual non-residential water use rate in the service area (excluding turf-related facility water use) up to 21 GPCD. Lost and unaccounted for water may constitute up to 10 percent of the total annual water use.

A new large provider may apply for an administrative review requesting a temporary adjustment to its total GPCD requirement in order to serve a turf-related facility. A temporary adjustment will be allowed if the provider demonstrates that direct use effluent or effluent recovered within the area of impact is committed to serve the turf-related facility beginning in four years, but a longer period is necessary for sufficient effluent to be produced to serve the entire facility. The adjustment will remain in effect only until sufficient direct use effluent or effluent recovered within the area of impact is available to serve the entire facility, not to exceed eight years, and may be adjusted as the volume of effluent use increases. The adjustment will be terminated if the infrastructure necessary to deliver the effluent to the facility is not in place at the beginning of the fourth year after the provider commences service to the facility. A permanent adjustment will not be granted to a new large municipal provider. If a new large municipal provider cannot serve a turf-related facility under its existing per capita requirement and direct use effluent or effluent recovered within the area of impact will not be physically available to serve the facility within a reasonable period of time, the provider may enroll in the Non-Per Capita Conservation Program or the Alternative Conservation Program, if it wishes to serve the facility.

Each new large municipal provider will be notified of its total GPCD requirement and will be given two full years to comply with the requirement. A new large municipal provider may apply for the NPCCP or

the ACP in accordance with the provisions of these programs and is subject to the individual user requirements.

5.6.3 Conservation Requirements for Consolidated Providers and Providers that Acquire or Convey a Portion of a Service Area

If two or more municipal providers consolidate their service areas and their combined water use is more than 250 acre-feet or if a large municipal provider acquires a portion of another provider's service area, the consolidated provider, acquiring provider, or conveying provider will receive a recalculated or revised conservation requirement. A consolidated provider will be assigned to the Total GPCD Program and its GPCD requirement will be calculated by prorating the respective per capita component rates, populations, and water use as appropriate. A consolidated provider may apply for the NPCCP or the ACP. If one of the consolidated providers was regulated under one of those programs prior to the consolidation, the consolidated provider's application for the program must include only the information that has changed since the provider filed its initial application. Providers that acquire or convey a portion of a service area continue to be regulated under the conservation program they were regulated under prior to the acquisition or conveyance. However, if they were regulated under either the NPCCP or the ACP they must reapply for regulation under the program within 180 days after the acquisition or conveyance and must submit only the information that has changed since the original application was filed.

5.6.4 Conservation Requirements for Small Municipal Providers

A small municipal provider is a provider that serves 250 acre-feet or less of water for non-irrigation use during a year. Small municipal providers are exempt from per capita conservation requirements. Instead the director is required to establish "reasonable conservation requirements" for small municipal providers. In the Third Management Plan, as in the Second Management Plan, small municipal providers are required to minimize waste of all wter supplies, maximize efficiency in outdoor watering, encourage reuse of water supplies, and reduce total GPCD water use.

5.6.5 Regulatory Requirements for all Municipal Providers

5.6.5.1 Individual User Requirements

An individual user is a person who receives water from a municipal provider for non-irrigation use. For the Third Management Plan, the director is required to establish "such other conservation measures as may be appropriate for individual users." A.R.S. § 45-566(A)(2). In the Second Management Plan, individual user requirements were established for turf-related facilities, publicly owned rights-of-way, and new large-scale cooling facilities. These requirements have been retained for the Third Management Plan with some modifications.

Turf-related facilities are subject to an allotment-based conservation requirement. Landscaping planted after December 31, 1986 in publicly owned rights-of-way and watered with groundwater may be planted only with plants from the Low Water Use/Drought Tolerant Plant List (Appendix 5B). The large-scale cooling tower requirements have been modified from the Second Management Plan requirements which applied only to towers built after January 1, 1990 with a total capacity of 250 tons or more. The Third Management Plan regulates large-scale cooling facilities of all ages with a total capacity of 1,000 tons or more.

In addition to these individual user requirements, the Third Management Plan contains an individual user requirement that was not included in the Second Management Plan. Groundwater may not be used to maintain a water feature installed in a publicly owned right-of-way after January 1, 2002.

Either the individual user or the municipal provider serving the individual user is responsible for complying with the individual user requirement. See section 5.2.3 for a discussion of how responsibility is determined.

5.6.5.2 Distribution System Requirements

All municipal providers are required to limit lost and unaccounted for water use in their service area. Lost and unaccounted for water includes line leakage, meter under-registration, evaporation or leakage from storage ponds or tanks, system and hydrant leaks or breaks, and illegal connections. Lost and unaccounted for water is defined as the total water from any source, except direct use effluent, withdrawn, diverted, or received in a year minus the total amount of authorized deliveries made by the municipal provider in that year. Small municipal providers must maintain lost and unaccounted for water volumes at no more than 15 percent. Large municipal providers are required to maintain systems not to exceed 10 percent lost and unaccounted for water.

Water that is put to a beneficial use and water system operation uses, whether metered or estimated, are not counted as lost or unaccounted for water. For the third management period, the Department will allow providers to either meter or estimate (using approved estimating procedures) the volume of water used pursuant to regulatory requirements such as well purging and line flushing. Providers may also estimate water for uses such as construction or fire services. However, all other water uses must be metered. This is especially important for large distribution systems which tend to have many hundreds of customers and many miles of distribution pipe. For a complete listing of uses that can be estimated, refer to Appendix 5J.

5.6.5.3 Monitoring and Reporting Requirements

All municipal providers are required to annually report to the Department the total volume of water used within the service area and the total volume of water delivered for various municipal purposes. In addition, the provider must calculate the volume of lost and unaccounted for water within the service area and report the total number of housing units, by unit type, added to the service area from July 1 of the previous calendar year to July 1 of the reporting year. Most municipal providers maintain a database and tracking system of this information for the previous 12 months. Maintaining this type of information allows municipal providers to identify difficulties in the operation of the distribution system and better meet water management objectives within their service areas.

Large municipal providers are required to separately measure and report the amount of water delivered each month for the following uses and categories: irrigation; residential separated into single family and multifamily; and non-residential separated into turf-related, commercial, industrial, government, construction, surface water treatment, and other uses.

All municipal providers are required to annually submit to the Department an updated service area and distribution system map that includes all potable and non-potable distribution lines greater than 4 inches, all potable treatment facilities, all well sites, all non-potable treatment facilities, and other information.

Large municipal providers regulated under the NPCCP or the ACP are required to submit a progress report that includes an evaluation of the results of implementing the reasonable conservation measures in accordance with their written stipulated agreement.

5.7 INCENTIVES FOR THE USE OF RENEWABLE SUPPLIES AND REMEDIATED GROUNDWATER

Incentives have been developed to increase the use of non-groundwater supplies. Effluent that is used directly or stored underground and recovered from within the area of impact is not counted in the per capita rate calculation for municipal providers regulated under the Total GPCD Program or the ACP.

Providers who have committed to serve effluent, but have not yet fully developed the resource, can enter into an agreement with the Department to exclude from their total GPCD usage rate CAP deliveries to non-residential facilities that have committed to use effluent when it becomes available. In order to qualify for this exclusion, the facility must commit to be fully utilizing the effluent within a ten year period.

In 1997, the Legislature enacted legislation significantly revising the Water Quality Assurance Revolving Fund (WQARF) program to provide incentives for the use of remediated groundwater to facilitate the treatment of contaminated groundwater. Among other things, the WQARF legislation provides that when determining compliance with management plan conservation requirements, the Department shall account for groundwater withdrawn pursuant to approved remedial action projects under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) or Title 49, Arizona Revised Statutes, consistent with the accounting for surface water. Laws 1997, Ch. 287, § 51(B). See Chapter 7, section 7.4.4.6.3. Groundwater withdrawn pursuant to an approved remedial action project retains its legal character as groundwater for all other purposes under Title 45, Arizona Revised Statutes, including all other laws regulating groundwater withdrawal and use, such as the assessment of withdrawal fees pursuant to A.R.S. § 45-611 *et seq.*, as well as laws regulating water exchanges as set forth in A.R.S. § 45-1001 *et seq.*, the transportation of groundwater as set forth in A.R.S. § 45-541 *et seq.*, withdrawals of groundwater for transportation to active management areas as set forth in A.R.S. § 45-551 *et seq.*, and underground water storage, savings, and replenishment as set forth in Title 45, Chapter 3.1, Arizona Revised Statutes.

For each approved remedial action project, the annual amount of groundwater that is eligible for the remediated groundwater accounting incentive is the maximum annual volume of groundwater that may be withdrawn pursuant to the project, as specified in the consent decree or other document approved by the EPA or ADEQ. However, if the project was approved prior to June 15, 1999 and the maximum annual volume of groundwater that may be withdrawn pursuant to the project is not specified in a consent decree or other document approved by the EPA or ADEQ, the annual amount of groundwater that is eligible for the remediated groundwater accounting incentive is the highest annual use of groundwater withdrawn pursuant to the project prior to January 1, 1999. The director may modify the annual amount of groundwater that is eligible for the accounting incentive if an increase in withdrawals is necessary to further the purpose of the project or if a change is made to the consent decree or other document approved by the EPA or ADEQ.

In order to qualify for the remediated groundwater accounting incentive, a person must notify the director in writing of the anticipated withdrawal of the groundwater prior to its withdrawal. The notification must include a copy of a document approved by ADEQ or the EPA such as the Remedial Action Plan (RAP), Record of Decision (ROD) or consent decree. Unless specified in the document, the notification must include the volume of groundwater that will be pumped annually pursuant to the project, the time period to which the document applies, and the annual authorized volume of groundwater that may be withdrawn pursuant to the project. The notification must also include the purpose for which the remediated groundwater will be used and the name and telephone number of a contact person. Additionally, at the time the notice is given, the person must be using remediated groundwater pursuant to the approved remedial action or must have agreed to do so through a consent decree or other document approved by ADEQ or the EPA. Remediated groundwater which qualifies for the accounting must be metered and reported separately from groundwater that does not qualify for the accounting. (See section 5-114 of the Municipal Conservation Requirements).

5.8 NON-REGULATORY EFFORTS

In 1991, the Department initiated a grant program to provide funds for conservation assistance and augmentation of water supplies in the AMAs. Individual AMA programs focus on the areas of highest water conservation potential in each water use sector (municipal, industrial, and agricultural) based on total water usage, current water use practices, and potential for implementation of new conservation technologies. Funding for each AMA's grant program comes from an annual withdrawal fee levied and collected from all regulated groundwater users in the AMAs.

By the end of 1997, 21 municipal conservation grants had been awarded in the Tucson AMA for a total of over $250,000. In addition, many of the information and education grants that have been funded are applicable to municipal users. A conservation assistance staff person in the Tucson AMA has provided direct assistance to municipal users including developing informational brochures, providing conservation materials and information, and assisting in the development of conservation programs. Water providers are now sharing resources and initiating cooperative efforts on conservation programs and grants between water companies. These efforts promote a basin-wide approach to conservation and build a cooperative relationship between the Department and water providers.

In the first few years of the program, grants focused on training large turf-related facility irrigators to use water more efficiently. Indoor water conservation programs included a plumbing retrofit program and a rebate program for replacing high volume toilets with 1.6 gallon per flush toilets. Education programs include a monthly water conservation column in a children's newspaper; interactive displays on historic, current, and future water supply and demand; development of water related curricula for grades K-12; educational materials and displays on greywater use, rainwater harvesting, and low water use landscaping; and a CD-ROM on "Xeriscape"™ plant materials and techniques. The Conservation Assistance Program is discussed in detail in Chapter 9, and a listing of conservation programs funded through the program is provided in Appendix A.

There has been considerable interest in the conservation grants program from municipal providers, and grant funded programs have proven to be successful. Providers have expressed interest in obtaining additional assistance in predicting the potential for success of conservation programs because programs can be expensive to implement. In addition, more research is needed on exterior water use since this use appears to be higher than expected for new housing in some areas. Additional education may be necessary to address proper landscape watering practices for low water use landscapes.

5.9 FUTURE DIRECTIONS

The municipal sector will be expected to continue to reduce reliance on groundwater in the third management period through a combination of conservation and augmentation activities and the requirements of the AWS Program. While municipal providers have implemented conservation programs and have increased use of renewable water supplies, including effluent and indirect CAP water use, the municipal sector is growing and is projected to be responsible for 52 percent of the AMA water demand by the end of the third management period and approximately 62 percent in 2025.

To promote renewable supply use, the Department will work with the municipal sector and others on the development of meaningful and equitable incentives that are consistent with overall water management objectives. This may involve the formation of a task force to work on solutions. The Department will continue to assist in regional planning activities and technical studies that result in direct use of renewable supplies by the municipal sector.

The AWS Program has partially addressed the utilization of renewable water supplies by municipal providers by limiting the amount of groundwater that can be used. However, there is still a considerable

amount of groundwater pumping allowed by designated water providers under the AWS Rules that needs to be evaluated in the context of its impact on safe-yield. In addition, the water use associated with existing customers of undesignated providers and municipal uses that are not subject to the AWS Rules represent a continuing demand on the aquifer. During the third management period, the Department needs to investigate mechanisms, including legislative changes, to address this residual overdraft.

The development of "critical area" programs within AMAs will be a major focus of the Department's activities during the third management period. This may involve the development of water management strategies to address localized water conditions that affect the ability of municipal providers to develop and maintain adequate water supplies. This could include developing incentives for direct use of renewable supplies and promoting withdrawals from areas experiencing recharge rather than areas experiencing severe declines. Restricting the ways in which new service areas can be established may also be considered.

A remaining issue that needs to be addressed in the third management period is to design a conservation program approach for private water companies that meets both the ACC standards and the AMA goal to achieve safe-yield. The Department will continue to work with the ACC in the development of policies related to water conservation and supply acquisition and on conditions for appropriate recovery of costs associated with the Department's regulatory programs.

There are ongoing issues about the effectiveness of water conservation programs. To the extent feasible, the Department will assist in designing follow-up studies and analyses to evaluate program effectiveness. This may include focusing the Conservation Assistance Program on municipal research or evaluation projects. Throughout the third management period, the Department will work to improve water use data collection to support both planning and conservation program evaluation efforts. The Department will also continue to provide direct conservation assistance to water providers to assist them in meeting their regulatory requirements.

5.10 MUNICIPAL CONSERVATION REQUIREMENTS AND MONITORING AND REPORTING REQUIREMENTS

5-101. Definitions

In addition to the definitions set forth in Chapters 1 and 2 of Title 45 of the Arizona Revised Statutes, unless the context otherwise requires, the following words and phrases used in this chapter shall have the following meanings:

1. *"Canal" means a waterway constructed for the purpose of transporting water to a point of delivery, including main canals and lateral canals.*

2. *"CAP water" means Central Arizona Project water.*

3. *"Common area" means a recreational or open space area or areas owned and operated as a single integrated facility and maintained for the benefit of the residents of a housing development.*

4. *"Construction use" means a use of water for construction purposes, including the use of water for dust control, compaction, and preparation of building materials on construction sites.*

5. *"Direct use effluent" means effluent that is transported directly from a facility regulated pursuant to Title 49, Chapter 2, Arizona Revised Statutes, to an end user. Direct use effluent does not include effluent that has been stored pursuant to Title 45, Chapter 3.1, Arizona Revised Statutes.*

6. *"Effluent recovered within the area of impact" means effluent that has been stored pursuant to Title 45, Chapter 3.1, Arizona Revised Statutes, and recovered within the stored effluent's area of impact. For purposes of this definition, "area of impact" has the same meaning as prescribed by A.R.S. § 45-802.01.*

7. *"Excluded CAP water" means CAP water that is excluded from a municipal provider's total GPCD requirement pursuant to section 5-103, subsection E.*

8. *"Existing individual user" means an individual user that was receiving water from a municipal provider as of the date the Third Management Plan was adopted.*

9. *"Existing large municipal provider" means a large municipal provider that was in operation and was serving water on or before January 1, 2000.*

10. *"Existing non-residential customer" means, with respect to a large municipal provider regulated under the NPCCP described in section 5-104 or the ACP described in section 5-105, a non-residential customer to whom the provider served water on the date the provider was accepted for regulation under the program.*

11. *"Existing residential customer" means, with respect to a large municipal provider regulated under the NPCCP described in section 5-104, a residential customer to whom the provider served water on the date the provider was accepted for regulation under the program.*

12. *"Existing residential housing units" means housing units that first began using water prior to July 1, 2000.*

13. *"Existing residential population" means the portion of the service area population of a municipal provider that resides in existing residential housing units.*

14. *"Exterior water use" means non-residential or residential uses of water for landscaping, pools, evaporative cooling systems, decorative fountains, and other outdoor uses of water.*

15. *"Extinguish" means, for the ACP's groundwater use limitation requirement, to cause a grandfathered groundwater right to cease to exist through a formal process established by the director.*

16. *"GPCD" means gallons of water per capita per day.*

17. *"GPHUD" means gallons of water per housing unit per day.*

18. *"Housing unit" means a group of rooms or a single room occupied as separate living quarters. Housing unit includes a single family home, a patio home, a townhouse, a condominium, an apartment, a permanently set-up mobile home, or a unit in a multifamily complex. Housing unit does not include a mobile home in an overnight or limited-stay mobile home park or a unit in a campground, motel, hotel, or other temporary lodging facility. A housing unit may be occupied by a family, a family and unrelated persons living together, two or more unrelated persons living together, or by one person.*

19. *"Incidental recharge" and "incidental recharge factor" have the definitions prescribed by A.R.S. § 45-561.*

20. *"Individual user" means a person receiving water from a municipal provider for non-irrigation uses to which specific conservation requirements apply, including turf-related facilities, large-scale cooling facilities, and publicly-owned rights-of-way.*

21. *"Interior water use" means non-residential or residential indoor uses of water, including toilet flushing, bathing, drinking, and washing.*

22. *"Landscapable area" means the entire area of a lot less any areas covered by structures, parking lots, roads, and any other area not physically capable of being landscaped.*

23. *"Large municipal provider" means a municipal provider serving more than 250 acre-feet of water for non-irrigation use during a calendar year.*

24. *"Large-scale cooling facility" means a facility that has control over cooling operations with a total combined cooling capacity greater than or equal to 1,000 tons. For the purposes of this definition, the minimum cooling tower size that shall be used to determine total facility cooling capacity is 250 tons. A large-scale cooling facility does not include a large-scale power plant that utilizes cooling towers to dissipate heat.*

25. *"Lost and unaccounted for water" means the total quantity of water from any source, except direct use effluent, withdrawn, diverted, or received by a municipal provider during a calendar year for non-irrigation use less the total quantity of authorized deliveries of water from any source, except direct use effluent, made by the municipal*

provider during the calendar year for non-irrigation use that are metered deliveries or deliveries that the municipal provider accounts for by a method of estimating water use approved by the director.

26. *"Mined groundwater" has the definition prescribed by A.R.S. § 45-561.*

27. *"Multifamily housing unit" means a mobile home in a mobile home park and any permanent housing unit having one or more common walls with another housing unit located in a multifamily residential structure and includes a unit in a duplex, triplex, fourplex, condominium development, town home development, or apartment complex.*

28. *"Municipal distribution system" means a system of pipes, canals, or other works within a municipal provider's service area that are owned and operated by the provider to collect, store, treat, or deliver water for non-irrigation use.*

29. *"Municipal provider" means a city, town, private water company, or irrigation district that supplies water for non-irrigation use.*

30. *"New individual user" means an individual user that begins receiving water from a municipal provider after adoption of the Third Management Plan.*

31. *"New large provider" means a municipal provider that begins serving more than 250 acre-feet of water for non-irrigation use during a calendar year after January 1, 2000.*

32. *"New multifamily housing units" means multifamily housing units that first begin using water on or after July 1, 2000.*

33. *"New multifamily population" means the portion of the service area population of a municipal provider that resides in new multifamily housing units.*

34. *"New non-residential customer" means, with respect to a large municipal provider regulated under the NPCCP described in section 5-104 or the ACP described in section 5-105, a non-residential customer that begins receiving water from the provider after the provider is accepted for regulation under the program.*

35. *"New residential customer" means, with respect to a large municipal provider regulated under the NPCCP described in section 5-104, a residential customer that begins receiving water from the provider after the provider is accepted for regulation under the program.*

36. *"New single family housing units" means single family housing units that first begin using water on or after July 1, 2000.*

37. *"New single family population" means the portion of the service area population of a municipal provider that resides in new single family housing units.*

38. *"Non-residential customer" means a person who is supplied water by a municipal provider for a non-irrigation use other than a residential use.*

39. *"Non-residential exterior water use" means, with respect to a large municipal provider regulated under the NPCCP described in section 5-104 or the ACP described in section 5-105, water supplied by the provider and used for exterior water use purposes by non-residential customers, other than individual users, within the provider's service area.*

40. *"Non-residential interior water use" means, with respect to a large municipal provider regulated under the NPCCP described in section 5-104 or the ACP described in section 5-105, water supplied by the provider and used for interior water use purposes by non-residential customers, other than individual users, within the provider's service area.*

41. *"Reasonable Conservation Measures" or "RCMs" means policies, practices, rules, regulations, ordinances, or the use of devices, equipment, or facilities, that meet either of the following criteria:*

    a. *An established and generally accepted practice among water providers that results in efficient use or conservation of water; or*

    b. *A practice for which sufficient data are available from existing water conservation projects to indicate that significant water conservation or conservation related benefits can be achieved, that the practice is technically and economically reasonable and not environmentally or socially unacceptable, and that the practice is not otherwise unreasonable for most water providers to implement.*

42. *"Residential customer" means a person who is supplied water by a municipal provider for a residential use.*

43. *"Residential exterior water use" means, with respect to a large municipal provider regulated under the NPCCP described in section 5-104, water supplied by the provider and used for exterior water use purposes by residential customers within the provider's service area.*

44. *"Residential interior water use" means, with respect to a large municipal provider regulated under the NPCCP described in section 5-104, water supplied by the provider and used for interior water use purposes by residential customers within the provider's service area.*

45. *"Residential use" means a non-irrigation use of water related to the activities of a single family or multifamily housing unit or units, including exterior water use.*

46. *"Service area" has the definition prescribed by A.R.S. § 45-402.*

47. *"Service area population" means the number of people residing in housing units connected to distribution lines maintained by the municipal provider within its service area that are being served as of July 1 of the applicable year, as determined pursuant to section 5-103, subsection D.*

48. *"Service connection" means a coupling of a municipal provider's distribution system and its customer's water system.*

49. *"Single family housing unit" means a detached dwelling, including mobile homes not in mobile home parks.*

50. *"Small municipal provider" means a municipal provider that supplies 250 acre-feet or less of water for non-irrigation use during a calendar year.*

51. *"Turf-related facility" means any facility, including cemeteries, golf courses, parks, schools or common areas within housing developments, with a water-intensive*

landscaped area of 10 or more acres. Turf-related facilities include, but are not limited to, those facilities listed in Appendix 6A.

52. *"Water-intensive landscaped area" means, for a calendar year, an area of land that is watered with a permanent water application system and planted primarily with plants not listed in Appendix 5B (Low Water Use/Drought Tolerant Plant List), and any modifications to the list, and the total surface area of all bodies of water filled or refilled with water from any source, including effluent, that are an integral part of the landscaped area. Bodies of water used primarily for swimming purposes are not an integral part of a landscaped area.*

5-102. Large Municipal Providers - Conservation Programs

A. *Beginning with the calendar year determined under Section 5-103, subsection A, paragraph 2, and continuing until the first compliance date for any substitute requirement in the Fourth Management Plan, a large municipal provider shall be regulated under the Total GPCD Program described in section 5-103, unless the provider has applied for and been accepted for regulation under the NPCCP described in section 5-104 or the ACP described in section 5-105 or is designated as an institutional provider under section 5-107.*

If a large municipal provider is accepted into the NPCCP, the ACP, or is designated as an institutional provider, the provider shall continue to comply with its total GPCD requirement until the first compliance date assigned by the director for the provider under the ACP, the NPCCP, or as an institutional provider.

A large municipal provider that was regulated under the NPCCP, the ACP, or the IPP under the Second Management Plan and that applies to be regulated under the same program in the Third Management Plan within 180 days following adoption of the plan shall continue to be regulated under the NPCCP, the ACP, or the IPP under the Second Management Plan, whichever applies, until January 1, 2002 or until the director approves or denies the provider's application under the Third Management Plan, whichever is later.

B. *A large municipal provider may apply for the NPCCP as described in section 5-104. If the director approves the application, the provider shall comply with the requirements of the NPCCP beginning on a date determined by the director but not later than January 1 of the year following the year in which the application is approved.*

C. *A large municipal provider may apply for the ACP as described in section 5-105. If the director approves the application, the provider shall comply with the requirements of the ACP beginning on a date determined by the director but not later than January 1 of the year following the year in which the application is approved.*

D. *A large municipal provider may apply for designation as an institutional provider pursuant to section 5-107. If the director approves the application, the provider shall comply with the institutional provider requirements assigned by the director beginning on a date determined by the director but not later than January 1 of the year following the year in which the application is approved.*

E. *All municipal providers shall comply with individual user requirements, distribution system requirements, and applicable monitoring and reporting requirements as prescribed in sections 5-111, 5-112, and 5-113.*

5-103. Large Municipal Provider Total Gallons Per Capita Per Day Program

A. Total GPCD Requirement

1. *Beginning with the calendar year determined under paragraph 2 of this subsection, and for each calendar year thereafter until the first compliance date for any substitute municipal conservation requirement in the Fourth Management Plan, a large municipal provider regulated under the Total GPCD Program shall not withdraw, divert, or receive water from any source, except direct use effluent, effluent recovered within the area of impact and excluded CAP water, for non-irrigation use during a year in a total amount that exceeds its total GPCD requirement for the year as calculated in subsection B of this section, except as provided in the flexibility account provisions in section 5-106.*

2. *A large municipal provider regulated under the Total GPCD Program shall begin complying with its total GPCD requirements as calculated under subsection B of this section beginning with calendar year 2000, except that if the provider's total GPCD requirement for the year 2000 as calculated under subsection B of this section is lower than the provider's final total GPCD requirement under the Second Management Plan, the provider shall begin complying with its total GPCD requirements as calculated under subsection B of this section beginning with calendar year 2002.*

B. Calculation of the Annual Total GPCD Requirement

A large municipal provider's total GPCD requirement for a year shall be calculated as follows:

1. *For each calendar year 2000 through 2004, multiply the provider's existing residential population for the year, as calculated pursuant to subsection D of this section, by the first intermediate GPCD component for existing residential population as assigned to the provider in Table 5-5.*

   For calendar years 2005 through 2009, multiply the provider's existing residential population for the year, as calculated pursuant to subsection D of this section, by the second intermediate GPCD component for existing residential population as assigned to the provider in Table 5-5.

   For the calendar year 2010, and for each calendar year thereafter until the first compliance date for any substitute total GPCD requirement in the Fourth Management Plan, multiply the provider's existing residential population for the year, as calculated pursuant to subsection D of this section, by the final GPCD component for existing residential population as assigned to the provider in Table 5-5.

2. *Multiply the provider's new single family population for the year, as calculated pursuant to subsection D of this section, by 57 GPCD.*

3. *Multiply the number of new single family housing units within the provider's service area as of July 1 of the calendar year in question by 118 GPHUD.*

4. *Multiply the provider's new multifamily population for the year, as calculated pursuant to subsection D of this section, by 78 GPCD.*

5. *Multiply the provider's total service area population for the year, as calculated pursuant to subsection D of this section, by the GPCD component for non-residential use as assigned to the provider in Table 5-5.*

6. *Determine the provider's allocation for turf-related facilities for the year as follows:*

   a. *Add together the maximum annual water allotments in Appendix 5G, in acre-feet, for those turf-related facilities assigned to the provider in Appendix 5G to which the provider served water from any source during the year. For any year in which the provider served water from any source to all of the turf-related facilities assigned to the provider in Appendix 5G, the sum of the allotments is shown in Table 5-5. The sum is the provider's turf-related facility component for the year.*

   b. *Multiply the component from subparagraph a of this paragraph by 325,851 gallons and then divide the product by the number of days in the year.*

7. *Divide the provider's allowable lost and unaccounted for water by the number of days in the calendar year. The provider's allowable lost and unaccounted for water is the lesser of the following:*

   a. *the provider's actual lost and unaccounted for water for the year, in gallons.*

   b. *an amount calculated by multiplying the total gallons of water from any source, except direct use effluent, withdrawn, diverted, or received by the provider during the year by 10 percent.*

8. *Add the results from paragraphs 1 through 7 of this subsection and then divide the sum by the provider's annual service area population as of July 1 of that year. The quotient is the provider's total GPCD requirement for the calendar year.*

C. Compliance with Total GPCD Requirement

The director shall determine if a large municipal provider is in compliance with its total GPCD requirement for a calendar year pursuant to the flexibility account provisions in section 5-106, using the provider's service area population as calculated in subsection D of this section.

D. Calculation of Large Municipal Provider's Service Area Population

The director shall calculate a large municipal provider's service area population for a calendar year as follows, unless the director has approved an alternative methodology for calculating the provider's service area population prior to the calendar year in question:

1. *Determine the number of existing single family housing units and existing multifamily housing units served by the provider's distribution system as of July 1, 2000 less any existing single family housing units and any existing multifamily housing units removed from the provider's distribution system between July 1, 2000 and June 30 of the calendar year in question.*

TABLE 5-5
EXISTING RESIDENTIAL, NON-RESIDENTIAL, AND TURF-RELATED FACILITY COMPONENTS
TUCSON ACTIVE MANAGEMENT AREA

Provider	Existing Residential (GPCD)			Non-Residential[1] (GPCD)	Turf-related Facility[2] (AF/year)
	TMP 1	TMP 2	TMP Final		
Arizona Water Company	98	98	98	8[1]	0
ASPC - Tucson[3]	N/A	N/A	N/A	N/A	N/A
Avra Water Coop	109	108	108	4[1]	0
City of Tucson	110	108	106	37	2,871.2[2]
Community Water Company of Green Valley	111	110	110	21	0
Davis-Monthan Air Force Base	124	121	119	161	358.8[2]
Farmers Water Company	147	139	133	116	0
Flowing Wells Irrigation District	126	121	118	21	149.1[2]
Forty-Niner Water Company	275	255	240	15[1]	504.5[2]
Green Valley Water Company	149	149	149	27	1,386.6[2]
Lago del Oro Water Company	124	123	122	23	628.1[2]
Las Quintas Serenas Water Co.	107	104	102	15[1]	0
Marana Water Service	137	135	133	0[1]	0
Metropolitan DWID	145	141	137	25	0
Ray Water Company	104	102	102	8[1]	0
Town of Oro Valley	130	129	128	40	1,555.2[2]
Town of Marana	114	113	112	7[1]	0
University of Arizona	40	40	40	199	0
Voyager Water Company	80	80	80	23	0

TMP = Third Management Plan
AF = acre-feet
ASPC = Arizona State Prison Complex
DWID = Domestic Water Improvement District

1 *Providers with a non-residential component less than 21 GPCD may increase their non-residential component up to 21 GPCD.*

2 *The number shown in this column is the sum of the maximum annual water allotment for all turf-related facilities assigned to the provider in Appendix 5G. In any year in which the provider serves water from any source to some, but not all, of the turf-related facilities assigned to the provider in Appendix 5G, the provider's turf-related facilities component for the year is the sum of the maximum annual water allotments shown in Appendix 5G for the turf-related facilities listed in that appendix to which the provider served water during the year.*

3 *Institutional Provider*

2. *Adjust these totals by the respective average annual vacancy rate for single family housing units and multifamily housing units as calculated from the most recent census or other approved source of information.*

3. *Multiply the adjusted number of existing single family housing units calculated in paragraph 2 of this subsection by the average number of persons per occupied single family housing unit as calculated in accordance with the most recent census or other approved source of information.*

4. *Multiply the adjusted number of existing multifamily housing units calculated in paragraph 2 of this subsection by the average number of persons per occupied multifamily housing unit as calculated in accordance with the most recent census or other approved source of information.*

5. *Add the products from paragraphs 3 and 4 of this subsection. The sum is the provider's existing residential population.*

6. *Determine the number of new single family housing units and new multifamily housing units added to the provider's distribution system between July 1 of the previous calendar year and July 1 of the calendar year in question, less any new single family and new multifamily housing units removed from the system during that period.*

7. *Adjust these totals by the respective average annual vacancy rate for single family housing units and multifamily housing units as calculated from the most recent census or other approved source of information.*

8. *Multiply the adjusted number of new single family housing units calculated in paragraph 7 of this subsection by the average number of persons per occupied single family housing unit as calculated in accordance with the most recent census or other approved source of information.*

9. *Multiply the adjusted number of new multifamily housing units calculated in paragraph 7 of this subsection by the average number of persons per occupied multifamily housing unit as calculated in accordance with the most recent census or other approved source of information.*

10. *Add the product from paragraph 8 to the provider's new single family population as of July 1 of the previous year and add the product from paragraph 9 to the provider's new multifamily population as of July 1 of the previous year. The sums are the provider's new single family population and new multifamily population.*

11. *Add the results from paragraphs 5 and 10. The sum is the provider's service area population for the calendar year.*

E. Exclusion of Deliveries of Central Arizona Project Water from Total GPCD Requirement

1. *Exclusion*

A large municipal provider may apply to the director to have CAP water delivered by the provider to a non-residential customer excluded from the provider's total water use when determining the provider's compliance with its total GPCD requirement as established

pursuant to subsection B of this section. The director shall grant a one time exclusion for a period not to exceed ten years if the director finds that all of the following apply:

a. *The provider will ultimately serve direct use effluent to the non-residential customer from a wastewater treatment plant that is either in existence or planned for construction; the provider will begin replacing the deliveries of CAP water with direct use effluent as soon as direct use effluent becomes available for delivery to the non-residential customer from the treatment facility; and the provider will completely replace the deliveries of CAP water with direct use effluent within a reasonable period of time, not to exceed ten years.*

b. *The CAP water that the provider will deliver to the non-residential customer cannot be delivered through the provider's potable water distribution system to any of its customers located outside the boundaries of a water users association, as defined in A.R.S. § 10-140, because of treatment facility or distribution system limitations, and the provider's CAP water treatment facilities and potable water distribution system have a reasonable level of capacity.*

c. *Granting the exclusion will result in the non-residential customer receiving effluent sooner than it would if the exclusion is not granted, and the effluent that the non-residential customer will receive as a result of the exclusion would not otherwise be put to a direct beneficial use by the provider.*

d. *Neither the NPCCP described in section 5-104 of this chapter nor the ACP described in section 5-105 of this chapter are currently an appropriate conservation program for the provider.*

e. *If the non-residential customer is a turf-related facility, a large-scale cooling facility, or a publicly owned right-of-way, the customer will be required to comply with conservation requirements during the duration of the exclusion identical to the conservation requirements that would apply to the customer under section 5-111 of this chapter if the customer was using groundwater.*

f. *If the CAP water that the provider will deliver to the non-residential customer is to be recovered by the provider pursuant to a recovery well permit issued under Title 45, Chapter 3.1, Arizona Revised Statutes, the provider is unable to deliver CAP water to the customer except from a recovery well.*

2. *Duration of Exclusion*

The duration of any exclusion granted pursuant to paragraph 1 of this subsection shall be determined by the director at the time the exclusion is granted and shall not exceed ten years. After the exclusion has become effective, the director may at any time rescind the exclusion or reduce the amount of the exclusion as determined pursuant to paragraph 3 of this subsection if the director determines that one of the following applies:

a. *The large municipal provider is not delivering all available direct use effluent to the non-residential customer.*

b. *The large municipal provider will not entirely replace the deliveries of CAP water with direct use effluent by the date determined by the director to be reasonable at the time the exclusion was granted.*

c. *The large municipal provider's CAP water treatment facilities or potable water distribution system no longer have a reasonable level of capacity.*

3. *Amount of Exclusion*

During the duration of any exclusion granted pursuant to paragraph 1 of this subsection, the amount of CAP water that shall be excluded from the large municipal provider's total water usage in any calendar year shall be calculated as follows:

a. *Determine the amount of CAP water delivered by the provider to the non-residential customer during the calendar year and then subtract from that amount any amount of water used by the non-residential customer during the year in excess of the conservation requirements applicable to such use as set forth in section 5-111 of this chapter.*

b. *The amount of CAP water that shall be excluded from the provider's total water use during the calendar year shall be the volume from subparagraph a above but not to exceed the lesser of the following:*

1) *The amount of effluent that will be available for direct delivery by the provider to the non-residential customer during the last year of the exclusion, as determined by the director at the time the exclusion is granted.*

2) *The amount of groundwater that would have been used by the non-residential customer during the year if the provider had not served CAP water to the customer, as determined by the director.*

4. *Agreement by Non-Residential Customer Not to Use Groundwater; Exception*

An exclusion granted pursuant to paragraph 1 of this subsection shall not become effective until the non-residential customer agrees in writing that it will not use groundwater from a source other than the large municipal provider during the duration of the exclusion, except during any temporary period in which the provider is unable to deliver a sufficient quantity of water to the customer because of distribution system failure or other emergency, and provided that the customer applies to the director in writing for permission to use the groundwater within seven days after commencement of the provider's distribution system failure or other emergency and the director approves the application in writing.

5. *Deliveries of Groundwater by Large Municipal Provider to Non-Residential Customer Included in GPCD Requirement; Exception*

During the duration of any exclusion granted pursuant to paragraph 1 of this subsection, any groundwater delivered by the large municipal provider to the non-residential customer shall be included in determining the provider's compliance with its GPCD requirement, except for groundwater delivered by the provider to the non-residential customer during any temporary period, not to exceed 30 days, in which the provider is unable to deliver a sufficient quantity of CAP water or direct use effluent to the customer because of distribution system failure or other emergency, and provided that the provider applies to the director in writing for an exclusion of such groundwater from its GPCD requirement within seven days after commencement of the distribution system failure or

other emergency and the director approves the application in writing for a specified period of time.

5-104. Non-Per Capita Conservation Program

A. Eligibility for the Non-Per Capita Conservation Program

A large municipal provider may apply for the NPCCP if any of the following applies:

1. *The provider is a member of a groundwater replenishment district established under Title 48, Chapter 27, Arizona Revised Statutes.*

2. *The service area of the provider has qualified as a member service area under Title 48, Chapter 22, Arizona Revised Statutes, or as a water district member under Title 48, Chapter 28, Arizona Revised Statutes, and the conditions established under A.R.S. § 45-576.01(B)(2) and (3) are met by the conservation district or the water district, as applicable, for the AMA in which the service area is located.*

3. *The provider has developed a plan to both:*

   a. *Reduce the proportion of mined groundwater supplied by it for use within its service area such that the result computed by dividing the volume of mined groundwater supplied by the provider for use within its service area in a year by the volume of all water supplied by the provider for use within its service area in that year does not exceed:*

      1) *Two-thirds for 2000.*
      2) *Three-fifths for 2001.*
      3) *Eight-fifteenths for 2002.*
      4) *Seven-fifteenths for 2003.*
      5) *Two-fifths for 2004.*
      6) *One-third for 2005.*
      7) *Four-fifteenths for 2006.*
      8) *One-fifth for 2007.*
      9) *Two-fifteenths for 2008.*
      10) *One-fifteenth for 2009.*

   b. *Deliver no mined groundwater for use within its service area after January 1, 2010.*

4. *The provider is designated as having an assured water supply under rules adopted by the director pursuant to A.R.S. § 45-576.*

B. Application for Non-Per Capita Conservation Program

A large municipal provider's application for the NPCCP must be approved by the provider's governing body and must include the following:

1. *A description and evaluation, including implementation dates, of the provider's existing conservation programs.*

2. *A description of conservation programs the provider intends to implement if approved for the NPCCP, including a time schedule for implementing the programs.*

3. *If the provider is applying for the NPCCP under subsection A, paragraph 3, a water supply plan demonstrating that the provider will reduce the proportion of mined groundwater supplied by it within its service area to the proportions described in that subparagraph and that it will deliver no mined groundwater after January 1, 2010.*

4. *If the provider intends to comply with subsection D of this section by implementing one or more substitute RCMs in lieu of a standard RCM or if the provider requests the director to modify a level of conservation potential for the provider's service area pursuant to subsection D, paragraph 1, subparagraph a of this section, an analysis of water use within the provider's service area that includes all of the following:*

    a. *If the provider intends to implement one or more substitute RCMs, information demonstrating that the substitute RCM or RCMs will be designed to achieve a water use efficiency within the provider's service area equivalent to the efficiency that would result from implementation of the standard RCM or RCMs.*

    b. *The amount of water used each month during the past three years by each of the following water use sectors, as applicable: (1) residential (disaggregated by single family and multifamily), (2) commercial, (3) industrial, (4) turf-related facilities, (5) government, (6) construction, (7) distribution system losses, and (8) any other uses. The provider is not required to include this information if it has already been reported to the Department.*

    c. *An identification and evaluation of the water use sectors described in paragraph b of this subparagraph that have the highest water conservation potential.*

5. *If the provider is requesting an individual incidental recharge factor under subsection C, paragraph 2 of this section:*

    a. *A copy of a hydrological study that demonstrates the amount of water withdrawn, diverted, or received for delivery by the provider for use within its service area during each of the preceding five years and the amount of incidental recharge that was attributable to the provider during those years. The study shall be prepared consistent with the methodology contained in Appendix 5K.*

    b. *A copy of a hydrological study projecting the average annual amount of water that will be withdrawn, diverted, or received for delivery by the provider for use within its service area during the management period and the average annual amount of incidental recharge that will be attributable to the provider during the management period.*

6. *Any other information required by the director.*

C. *Incidental Recharge Factor*

1. *Standard Incidental Recharge Factor*

    The standard incidental recharge factor for the Tucson AMA for the third management period is 4 percent. The standard incidental recharge factor shall be used to calculate the amount of mined groundwater supplied during a year by a large municipal provider that applied for the NPCCP under subsection A, paragraph 3 of this section, unless the

provider applies for and is granted an individual incidental recharge factor pursuant to paragraph 2 of this subsection.

2. *Individual Incidental Recharge Factor*

   A large municipal provider that applies for the NPCCP under subsection A, paragraph 3 of this section, may request an incidental recharge factor that is different than the standard incidental recharge factor set forth in paragraph 1 of this subsection by submitting the information described in subsection B, paragraph 5 of this section, with its application. The director shall establish a different incidental recharge factor for the provider as described in Appendix 5K if the information submitted by the provider demonstrates that the ratio of the average annual amount of incidental recharge expected to occur within the provider's service area during the third management period to the average annual amount of water expected to be supplied by the provider for use within its service area during the third management period is different than the standard incidental recharge factor. If the director establishes an individual incidental recharge factor for the provider under this paragraph, the individual incidental recharge factor shall be used to calculate the amount of mined groundwater supplied by the provider during a year.

D. Criteria for Approval of Application

A large municipal provider that applies for the NPCCP shall be approved for the program only if all of the following conditions are satisfied, as applicable:

1. *The provider agrees in writing to implement RCMs that the director determines will, if properly implemented, result in the achievement of a water use efficiency within the provider's service area equivalent to the water use efficiency assumed in the provider's total GPCD requirements for the third management period. To comply with this requirement, the provider must agree in writing to implement the following RCMs for the following water use categories and programs beginning on a date agreed upon by the director and the provider:*

   a. *Residential Water Use*

      1) *<u>Residential interior water use category</u> - The provider shall agree in writing to implement the residential interior standard RCMs described in Appendix 5H.1. In lieu of implementing one or both of the standard RCMs, the provider may agree to implement one or more of the residential interior substitute RCMs or system-related substitute RCMs listed in the substitute RCM list described in Appendix 5H.4 if the director determines that the substitute RCM or RCMs will be designed to achieve a water use efficiency within the provider's service area equivalent to the efficiency that would result from implementation of the standard RCM.*

      2) *<u>Residential exterior water use category</u> - The provider shall agree in writing to implement the residential exterior standard RCMs described in Appendix 5H.1. In lieu of implementing one or more of the standard RCMs, the provider may agree to implement one or more of the residential exterior substitute RCMs or system-related substitute RCMs listed in the substitute RCM list described in Appendix 5H.4 if the director determines that the substitute RCM or RCMs will be designed to achieve a water use efficiency within the provider's service area*

equivalent to the efficiency that would result from implementation of the standard RCM.

3) *Implementation level - The provider shall agree to implement residential interior or exterior RCMs for existing residential customers at the implementation level (minimum, moderate, or maximum) that corresponds to the level of conservation potential that the director determined existed for interior and exterior water use by existing residential users within the provider's service area when the director established the provider's total GPCD requirements for the third management period, as shown in Appendix 5L.*

   The director may modify a level of conservation potential shown for a provider in Appendix 5L if the provider requests a modification in an application for administrative review pursuant to A.R.S. § 45-575(A) or in the provider's application for regulation under the NPCCP, and the provider demonstrates that the level of conservation potential shown in Appendix 5L is not accurate for the provider's service area. A provider requesting a modification of a level of conservation potential shall submit to the director a water use analysis containing the information described in subsection B, paragraph 4 of this section. If the level of conservation potential for interior or exterior water use by existing residential users as shown in Appendix 5L or as modified by the director is "no reduction," the provider is not required to implement any RCMs for existing residential customers in that water use category.

b. *Non-Residential Water Use*

1) *Non-residential interior water use category - The provider shall agree in writing to implement the non-residential interior standard RCMs described in Appendix 5H.2. In lieu of implementing one or more of the standard RCMs, the provider may agree to implement one or more of the non-residential interior substitute RCMs or system-related RCMs listed in the substitute RCM list described in Appendix 5H.4 if the director determines that the substitute RCM or RCMs will be designed to achieve a water use efficiency within the provider's service area equivalent to the efficiency that would result from implementation of the standard RCM.*

2) *Non-residential exterior water use category - The provider shall agree in writing to implement the non-residential exterior standard RCMs described in Appendix 5H.2. In lieu of implementing one or both of the standard RCMs, the provider may agree to implement one or more of the non-residential exterior substitute RCMs or system-related RCMs listed in the substitute RCM list described in Appendix 5H.4 if the director determines that the substitute RCM or RCMs will be designed to achieve a water use efficiency within the provider's service area equivalent to the efficiency that would result from implementation of the standard RCM.*

c. *Public Education Program*

The provider shall agree in writing to implement the education standard RCM described in Appendix 5H.3. In lieu of implementing the standard RCM, the provider may agree to implement one or more of the education substitute RCMs listed in the

substitute RCM list described in Appendix 5H.4. The substituted RCM or RCMs must not duplicate other RCMs that the provider will implement as part of the NPCCP.

2. *If the provider is applying for the NPCCP under subsection A, paragraph 1 of this section, the provider will be accepted into the program only if the conditions established in A.R.S. § 45-576.01(A)(2) and (3) are met by the groundwater replenishment district of which the provider is a member.*

3. *If the provider is applying for the NPCCP under subsection A, paragraph 2 of this section, the provider will be accepted into the program only if the conditions established in A.R.S. § 45-576.01(B)(2) and (3) are met for the AMA by the multi-county water conservation district or AMA water district of which the provider is a member.*

4. *If the provider is applying for the NPCCP under subsection A, paragraph 3 of this section, the provider will be accepted into the program only if the director has determined that the provider will reduce the proportion of mined groundwater supplied within its service area to the proportions described in that subparagraph.*

5. *If the provider is applying for the NPCCP under subsection A, paragraph 4 of this section, the provider will be accepted into the program only if the director determines that the provider is designated as having an assured water supply under the rules adopted by the director under A.R.S. § 45-576.*

E. Non-Per Capita Conservation Program Requirements

A large municipal provider regulated under the NPCCP shall comply with the following requirements, as applicable, until the effective date of any substitute conservation requirements established in the Fourth Management Plan:

1. *The provider shall implement the RCMs agreed to in writing under subsection D, paragraph 1 of this section, beginning on a date agreed upon by the director and the provider.*

2. *If the provider applied for the NPCCP under subsection A, paragraph 3 of this section, the provider shall reduce the proportion of mined groundwater supplied within its service area to the proportions described in that paragraph. A provider's failure to comply with this requirement during any year will be excused if the provider demonstrates to the director's satisfaction that the failure was due to drought conditions or the failure of a surface water distribution system.*

3. *If the provider applied for the NPCCP under subsection A, paragraph 4 of this section, the provider shall not supply groundwater for use within its service area in an amount that exceeds the amount of groundwater that the provider may supply for use within its service area consistent with the rules adopted by the director pursuant to A.R.S. § 45-576. If the provider's designation of assured water supply is revoked or otherwise terminates after the provider is accepted into the program, the amount of groundwater the provider may supply for use within its service area consistent with the rules shall be determined by the director as the amount of groundwater the provider would have been allowed to supply under the rules if the provider's designation of assured water supply had not been revoked or terminated.*

5-105. Alternative Conservation Program

A. Eligibility for the Alternative Conservation Program

A large municipal provider is eligible to apply for the ACP if one of the following applies:

1. *The provider is designated as having an assured water supply under rules adopted by the director pursuant to A.R.S. § 45-576.*

2. *The provider agrees to limit its annual use of groundwater withdrawn from within the AMA as provided in subsection C, paragraph 1, subparagraph a, item 2 of this section.*

B. Application for Alternative Conservation Program

A large municipal provider's application for the ACP must be approved by the provider's governing body and must include the following:

1. *A plan to limit the provider's overall groundwater withdrawals as required by subsection C, paragraph 1 of this section.*

2. *A description and evaluation, including implementation dates, of the provider's existing conservation programs.*

3. *A description of the proposed conservation strategies for all existing and new non-residential customers to be implemented by the provider under this program and the provider's schedule for implementation of all proposed conservation measures.*

4. *If the provider intends to comply with subsection C, paragraph 3 of this section, by implementing one or more substitute non-residential RCMs in lieu of a standard non-residential RCM, an analysis of water use within the provider's service area that includes all of the following:*

    a. *A demonstration that the substituted RCM or RCMs will be designed to achieve a water use efficiency within the provider's service area equivalent to the efficiency that would result from implementation of the standard RCM.*

    b. *The amount of water used each month during the past three years by each of the following water use sectors, as applicable: (1) residential (disaggregated by single family and multifamily), (2) commercial, (3) industrial, (4) turf-related facilities, (5) government, (6) construction, (7) distribution system losses, and (8) any other uses. The provider is not required to include this information if it has already been reported to the Department.*

    c. *An identification and evaluation of the water use sectors described in subparagraph b of this paragraph that have the highest water conservation potential.*

C. Alternative Conservation Program Requirements

1. *Groundwater Use Limitation Requirement*

    a. *Beginning with a calendar year agreed upon by the director and a large municipal provider regulated under the Alternative Conservation Program and for each*

calendar year thereafter until the first compliance date for any substitute requirement in the Fourth Management Plan, the provider shall limit its annual use of groundwater withdrawn from within the AMA to the following, as applicable:

1) If the provider is designated as having an assured water supply under the rules adopted by the director pursuant to A.R.S. § 45-576, the amount of groundwater that the provider may use consistent with the rules, including any amount of groundwater that will be replenished by a conservation district pursuant to Title 48, Chapter 22, Arizona Revised Statutes.

2) If the provider is not designated as having an assured water supply under the rules adopted by the director pursuant to A.R.S. § 45-576, one of the following, as applicable:

a) If the provider was serving water as a large municipal provider on or before January 1, 1990, the provider's largest legal groundwater use during any one calendar year from calendar year 1980 through calendar year 1989.

b) If the provider began serving water as a large municipal provider after January 1, 1990 but before January 1, 2000, 50 percent of the provider's largest legal groundwater use during any one calendar year from January 1, 1990 through calendar year 1999.

b. The large municipal provider may achieve compliance with the groundwater use limitation requirement described in subparagraph a, item 2 of this paragraph, by permanently extinguishing or causing to be permanently extinguished grandfathered rights to groundwater as described in subparagraph c of this paragraph, by serving groundwater that will be replenished by a conservation district pursuant to Title 48, Chapter 22, Arizona Revised Statutes, by using remediated groundwater that is consistent with the accounting for surface water as provided in section 5-114 or by substituting non-groundwater supplies or groundwater withdrawn from outside the AMA for groundwater withdrawn from within the AMA or by a combination of these methods.

c. Extinguishment of Groundwater Uses Associated with Grandfathered Rights

1) Applicability

Only irrigation grandfathered rights, Type 1 non-irrigation grandfathered rights and Type 2 non-irrigation grandfathered rights, as described in A.R.S. §§ 45-462 through 45-465, may be extinguished to meet the groundwater use limitation requirement. The large municipal provider shall not receive credit toward the achievement of the groundwater use limitation requirement for the extinguishment of either a Type 2 non-irrigation grandfathered right used for electrical energy generation or mineral extraction or processing purposes or a Type 1 or Type 2 non-irrigation grandfathered right owned or previously owned by a municipal provider and used or previously used to serve the municipal provider's service area.

2) *Annual Credits*

The director shall determine the amount of annual credit a large municipal provider obtains for extinguishment of grandfathered rights to groundwater as follows:

a) *For each irrigation grandfathered right extinguished or caused to be extinguished by the provider, the annual credit shall be the amount calculated by multiplying 1.5 acre-feet per acre by the number of water duty acres associated with the extinguishment, less any debits, in acre-feet, in the farm's operating flexibility account at the time the right is extinguished.*

b) *For each Type 1 non-irrigation grandfathered right or portion of such right extinguished or caused to be extinguished by the provider, the annual credit shall be the amount calculated by multiplying 1.5 acre-feet per acre by the number of acres to which the Type 1 non-irrigation grandfathered right is appurtenant or a proportional amount thereof if only a portion of the right is extinguished.*

c) *For each Type 2 non-irrigation grandfathered right extinguished or caused to be extinguished by the provider, the annual credit shall be the full amount, in acre-feet, of the certificated Type 2 non-irrigation grandfathered right.*

3) *Proof of Extinguishment*

In order for a large municipal provider to obtain an annual credit for extinguishing or causing to be extinguished a grandfathered right to groundwater, the holder of the grandfathered right must deliver the Certificate of Grandfathered Right to the director before the calendar year in which the credit will be used, request that the grandfathered right be extinguished, and direct that the provider receive the annual credit. Only one provider may receive annual credit for any one portion of a grandfathered right that has been extinguished.

d. *Compliance*

The director shall determine whether a large municipal provider is in compliance with its groundwater use limitation requirement, as described in subparagraph a, item 2 of this paragraph, in a calendar year as follows:

1) *Add together the amount of annual credits received by the provider for extinguishing grandfathered rights to groundwater after January 1, 1990 pursuant to subparagraph c of this paragraph and pursuant to the ACP in the Second Management Plan.*

2) *Calculate the total volume of groundwater, in acre-feet, which the provider withdrew, diverted, or received during the calendar year for use within the provider's service area. In making this calculation, the director shall not include any groundwater that a conservation district replenished or is obligated to replenish under Title 48, Chapter 22, Arizona Revised Statutes, or any remediated groundwater qualifying under section 5-114.*

3) *Subtract the amount calculated in item 1 above from the volume calculated in item 2 above.*

4) *A provider is in compliance with its groundwater use limitation requirement if the amount calculated in item 3 of this subparagraph is equal to or less than the following, as applicable:*

   a) *If the provider was serving water as a large municipal provider on or before January 1, 1990, the provider's largest legal groundwater use during any one calendar year from calendar year 1980 through calendar year 1989.*

   b) *If the provider began serving water as a large municipal provider after January 1, 1990 but before January 1, 2000, 50 percent of the provider's largest legal groundwater use during any one calendar year from January 1, 1989 through calendar year 1999.*

   Annual credits that are not needed by the provider to comply with its groundwater use limitation requirement in one calendar year shall not carry forward to any following calendar year.

2. *Residential GPCD Requirement*

   a. *Beginning with a calendar year agreed upon by the director and a large municipal provider regulated under the ACP and for each calendar year thereafter until the first compliance date for any substitute requirement in the Fourth Management Plan, the provider shall not serve water from any source, except direct use effluent and effluent recovered within the area of impact, for residential use during a calendar year in a total amount that exceeds its residential GPCD requirement for the year, except as provided in the flexibility account provisions in section 5-106. Each year the annual residential GPCD requirement for a provider regulated under the ACP shall be calculated as follows:*

   1) *For each calendar year through 2004, multiply the provider's existing residential population for the year, as calculated pursuant to section 5-103, subsection D, by the first intermediate GPCD component for existing residential population as assigned to the provider in Table 5-5.*

      For calendar years 2005 through 2009, multiply the provider's existing residential population for the year, as calculated pursuant to section 5-103, subsection D, by the second intermediate GPCD component for existing residential population as assigned to the provider in Table 5-5.

      For the calendar year 2010 and for each calendar year thereafter until the first compliance date for any substitute GPCD requirement in the Fourth Management Plan, multiply the provider's existing residential population for the year, as calculated pursuant to section 5-103, subsection D, by the final GPCD component for existing residential population as assigned to the provider in Table 5-5.

   2) *Multiply the provider's new single family population for the year, as calculated pursuant to section 5-103, subsection D, by 57 GPCD.*

3) Multiply the number of new single family housing units within the provider's service area as of July 1 of the calendar year in question by 118 GPHUD.

4) Multiply the provider's new multifamily population for the year, as calculated pursuant to section 5-103, subsection D, by 78 GPCD.

5) Add the products from items 1 through 4 of this subparagraph and then divide the sum by the provider's service area population as of July 1 of the calendar year. The quotient is the provider's residential GPCD requirement for the calendar year.

b. Compliance with Residential GPCD Requirement

The director shall determine if a large municipal provider regulated under the ACP is in compliance with its residential GPCD requirement pursuant to the flexibility account provisions in section 5-106.

3. Non-Residential Requirement

a. A large municipal provider regulated under the ACP shall agree in writing to implement the following non-residential RCMs beginning on a date agreed upon by the director and the provider:

1) <u>Non-Residential Interior Requirements</u> - The provider shall agree in writing to implement the non-residential interior standard RCMs described in Appendix 5H.2. In lieu of implementing one or more of the standard RCMs, the provider may agree to implement one or more of the non-residential interior substitute RCMs or system-related RCMs listed in the substitute RCM list described in Appendix 5H.4 if the director determines that the substitute RCM or RCMs will be designed to achieve a water use efficiency within the provider's service area equivalent to the efficiency that would result from implementation of the standard RCM.

2) <u>Non-Residential Exterior Requirements</u> - The provider shall agree in writing to implement the non-residential exterior standard RCMs described in Appendix 5H.2. In lieu of implementing one or both of the standard RCMs, the provider may agree to implement one or more of the non-residential exterior substitute RCMs or system-related RCMs listed in the substitute RCM list described in Appendix 5H.4 if the director determines that the substitute RCM or RCMs will be designed to achieve a water use efficiency within the provider's service area equivalent to the efficiency that would result from implementation of the standard RCM.

5-106. Compliance with Total GPCD Requirement and Residential GPCD Requirement - Flexibility Account

A. Total GPCD Program Flexibility Account

The director shall determine if a large municipal provider regulated under the Total GPCD Program is in compliance with its annual total GPCD requirement through the maintenance of a flexibility account for the provider that shall operate as follows:

1. *Each provider regulated under the Total GPCD Program shall be assigned a flexibility account. The beginning balance in the flexibility account of a provider that was regulated under the Total GPCD Program in the Second Management Plan shall be the ending balance in the flexibility account maintained for the provider under section 5-105 of the Second Management Plan. The beginning balance in the flexibility account of all other large municipal providers shall be zero.*

2. *Following each calendar year in which the provider withdraws, diverts, or receives groundwater for non-irrigation use, beginning with the calendar year determined under section 5-103, subsection A, paragraph 2 or the calendar year in which the provider first becomes a large municipal provider, whichever is later, the director shall adjust the provider's flexibility account as follows:*

    a. *Determine the total gallons of water from any source, except direct use effluent, effluent recovered inside the area of impact and excluded CAP water, withdrawn, diverted, or received by the provider during the calendar year for non-irrigation use and then subtract that amount from the amount of water the provider could legally withdraw, divert, or receive during the calendar year for non-irrigation use, as calculated in subparagraph d of this paragraph.*

    b. *If the result in subparagraph a above is negative, debit the flexibility account by this volume.*

    c. *If the result in subparagraph a above is positive, credit the flexibility account by this volume.*

    d. *The amount of water that a provider regulated under the Total GPCD Program can legally withdraw, divert, or receive for non-irrigation use during a calendar year is calculated by multiplying the provider's total GPCD requirement for the calendar year, as calculated pursuant to section 5-103, subsection B, by the provider's service area population as of July 1 of the year, as calculated pursuant to section 5-103, subsection D, and then multiplying the product by the number of days in the calendar year.*

3. *The account balance existing in a provider's flexibility account after the adjustment provided for in paragraph 2 of this subsection is made shall carry forward subject to the following limitations:*

    a. *The maximum positive account balance allowed in the flexibility account of a provider regulated under the Total GPCD Program shall be calculated by multiplying the provider's service area population as of July 1 of the calendar year by a GPCD rate of 30 and then multiplying that product by the number of days in the calendar year. If the account balance exceeds the maximum positive account balance after any credits are registered, the balance carried forward shall equal the maximum positive account balance allowed in the provider's flexibility account for that year.*

    b. *The maximum negative account balance allowed in the flexibility account of a provider regulated under the Total GPCD Program shall be calculated by multiplying the provider's service area population as of July 1 of the calendar by a GPCD rate of -10 and then multiplying that product by the number of days in the calendar year. If the account balance exceeds the maximum negative account balance after any debits are registered, the balance carried forward shall equal the*

maximum negative account balance allowed in the provider's flexibility account for that year.

B. *Alternative Conservation Program Flexibility Account*

The director shall determine if a large municipal provider regulated under the ACP is in compliance with its annual residential GPCD requirement through the maintenance of a flexibility account for the provider that shall operate as follows:

1. *Each provider regulated under the ACP shall be assigned a flexibility account with a beginning balance to be calculated by the director based on the ending balance in the provider's flexibility account while the provider was regulated under the Total GPCD Program or under the ACP of the Second Management Plan, whichever applies.*

2. *Following each calendar year in which the provider delivers groundwater for residential use, beginning with the calendar year agreed upon by the director and the provider, the director shall adjust the provider's flexibility account balance as follows:*

   a. *Determine the total gallons of water from any source, except direct use effluent and effluent recovered within the area of impact, served by the provider during the calendar year for residential use, and then subtract that amount from the amount of water the provider could legally serve during the calendar year for residential use, as calculated in subparagraph d of this paragraph.*

   b. *If the result in paragraph a above is negative, debit the flexibility account by this volume.*

   c. *If the result in paragraph a above is positive, credit the flexibility account by this volume.*

   d. *The amount of water that a provider regulated under the ACP can legally serve for residential use during a calendar year is calculated by multiplying the provider's residential GPCD requirement for the calendar year, as calculated pursuant to section 5-105, subsection C, paragraph 2, by the provider's service area population as of July 1 of the year as calculated pursuant to section 5-103, subsection D, and then multiplying the product by the number of days in the calendar year.*

3. *The account balance existing in a provider's flexibility account after the adjustment provided for in paragraph 2 of this subsection is made shall carry forward subject to the following limitations:*

   a. *The maximum positive account balance allowed in the flexibility account of a provider regulated under the ACP shall be calculated by multiplying the provider's service area population as of July 1 of the calendar year by a GPCD rate of 21 and then multiplying that product by the number of days in the calendar year. If the account balance exceeds the maximum positive account balance after any credits are registered, the balance carried forward shall equal the maximum positive account balance allowed in the provider's flexibility account for that year.*

   b. *The maximum negative account balance allowed in the flexibility account of a provider regulated under the ACP shall be calculated by multiplying the provider's service area population as of July 1 of the calendar year by a GPCD rate of -7 and*

then multiplying that product by the number of days in the calendar year. If the account balance exceeds the maximum negative account balance after any debits are registered, the balance carried forward shall equal the maximum negative account balance allowed in the provider's flexibility account for that year.

C. Compliance Status

If the adjustment to a large municipal provider's flexibility account following a calendar year as provided for in subsection A or B of this section causes the account to have a negative account balance that exceeds the maximum negative account balance allowed in the provider's flexibility account for the year as calculated in subsection A, paragraph 3, or subsection B, paragraph 3, the provider is out of compliance for that calendar year.

5-107. Conservation Requirements for Institutional Providers

A. *If a large municipal provider operates primarily for the purpose of serving water to institutions, including prisons, hospitals, military installations, airparks, and schools, and supplies or expects to supply more than 90 percent of its total non-irrigation deliveries to one or more of these institutions, the provider may apply to the director for designation as an institutional provider. The director may deem a facility other than one of those listed above as an institution if its water use characteristics are similar to the types of institutions listed above.*

B. *A large municipal provider regulated as an institutional provider in the Second Management Plan may reapply to the director to be designated as an institutional provider under the Third Management Plan any time after it has been noticed of its total GPCD requirements for the Third Management Plan.*

C. *A large municipal provider applying for designation as an institutional provider shall apply on a form prescribed and furnished by the director. The large provider shall provide information in sufficient detail to allow the director to evaluate the provider's conservation potential and to establish appropriate conservation requirements for the provider.*

D. *The director shall approve a large municipal provider's application for designation as an institutional provider if the provider meets the criteria in subsection A of this section and demonstrates that it does not qualify for the NPCCP or the ACP.*

E. *Each large municipal provider designated as an institutional provider shall be assigned mandatory conservation requirements and monitoring and reporting requirements, including a maximum residential GPCD requirement and appropriate conservation measures for non-residential uses. The institutional provider shall comply with the assigned conservation requirements by the date specified by the director, but not later than January 1 of the year following the year in which the provider's application is approved, and shall remain in compliance with those requirements until the first compliance date for any substitute requirements in the Fourth Management Plan.*

5-108. Consolidation of Municipal Provider Service Areas; Acquisition of a Portion of Another Municipal Provider's Service Area

A. Notification

1. *If two or more municipal providers consolidate their service areas into one service area, the consolidated provider shall notify the Department of the consolidation within 30 days after the consolidation becomes effective.*

2. *If a municipal provider acquires a portion of another municipal provider's existing service area, both the acquiring provider and the conveying provider shall notify the Department of the acquisition within 30 days after the acquisition becomes effective.*

B. Regulation of Consolidated Provider

1. *Upon consolidation, a consolidated provider that qualifies as a large municipal provider shall be regulated under the Total GPCD Program described in section 5-103, unless the consolidated provider applies for and is accepted for regulation under the NPCCP described in section 5-104 or the ACP described in section 5-105.*

2. *If the consolidated provider is regulated under the Total GPCD Program, the director shall establish a total GPCD requirement for the consolidated provider consistent with the methodology used by the director to establish the consolidating providers' total GPCD requirements as set forth in Appendix 5C.1. The director shall also establish and maintain a flexibility account for the consolidated provider in accordance with section 5-106, subsection A, with a beginning balance to be established by the director based on the ending balances in the flexibility accounts of the consolidating providers.*

3. *If the consolidated provider is accepted for regulation under the ACP, the director shall establish a residential GPCD requirement for the consolidated provider consistent with the methodology used by the director to establish the consolidating providers' residential GPCD requirements as set forth in Appendix 5I. The director shall also establish and maintain a flexibility account for the consolidated provider in accordance with section 5-106, subsection B, with a beginning balance to be established by the director based on the ending balances in the flexibility accounts of the consolidating providers.*

4. *If the consolidated provider applies for regulation under the NPCCP or the ACP and one of the consolidating providers was regulated under that program immediately prior to consolidation, the consolidated provider's application for regulation under the program shall include only the information required by section 5-104 or section 5-105 that has changed since the consolidating provider filed its application for the program.*

C. Regulation of Acquiring Provider

1. *Except as provided in paragraph 2 of this subsection, a large municipal provider that acquires a portion of another provider's existing service area shall continue to be regulated under the conservation program that the acquiring provider was regulated under immediately prior to the acquisition.*

2. *If the acquiring provider was regulated under either the NPCCP described in section 5-104 or the ACP described in section 5-105 immediately prior to the acquisition, the acquiring provider shall be regulated under the Total GPCD Program beginning on*

January 1 of the first calendar year after the acquisition unless the provider reapplies to be regulated under the NPCCP or the ACP, whichever is applicable, within 180 days after the acquisition. If the acquiring provider reapplies to be regulated under the NPCCP or the ACP within 180 days after the acquisition, both of the following shall apply:

a. The provider shall continue to be regulated under the NPCCP or the ACP, whichever is applicable, until the director makes a final decision on the provider's application.

b. The acquiring provider's application shall include only the information required by section 5-104 or section 5-105 that has changed since the provider filed its original application for the program.

3. If the acquiring provider is regulated under the Total GPCD Program after the acquisition, the director shall establish a new total GPCD requirement for the provider consistent with the methodology used to establish the provider's total GPCD requirement in Appendix 5C.1, taking into account the addition to the provider's service area. The director may also adjust the balance in the acquiring provider's flexibility account maintained under section 5-106, subsection A, to take into account the balance in the conveying provider's flexibility account at the time of the conveyance.

4. If the acquiring provider is regulated under the ACP after the acquisition, the director shall establish a new residential GPCD requirement for the provider consistent with the methodology used to establish the residential GPCD requirements in Appendix 5I, taking into account the addition to the provider's service area. The director may also adjust the balance in the acquiring provider's flexibility account maintained under section 5-106, subsection A, to take into account the balance in the conveying provider's flexibility account at the time of the conveyance.

D. Regulation of Conveying Provider

1. Except as provided in paragraph 2 of this subsection, a large municipal provider that conveys a portion of its service area to another provider and that qualifies as a large municipal provider after the conveyance shall continue to be regulated under the conservation program that the provider was regulated under immediately prior to the conveyance.

2. If the conveying provider was regulated under either the NPCCP described in section 5-104 or the ACP described in section 5-105 immediately prior to the acquisition and if the conveying provider qualifies as a large municipal provider after the conveyance, the conveying provider shall be regulated under the Total GPCD Program beginning on January 1 of the first calendar year after the acquisition unless the provider reapplies to be regulated under the NPCCP Program or the ACP, whichever is applicable, within 180 days after the conveyance. If the conveying provider reapplies to be regulated under the NPCCP or the ACP within 180 days after the conveyance, both of the following shall apply:

a. The provider shall continue to be regulated under the NPCCP or the ACP, whichever is applicable, until the director makes a final decision on the provider's application.

b. *The provider's application shall include only the information required by section 5-104 or section 5-105 that has changed since the provider filed its original application for the program.*

3. *If the conveying provider is regulated under the Total GPCD Program after the conveyance, the director shall establish a new total GPCD requirement for the provider consistent with the methodology used to establish the total GPCD requirements in Appendix 5C.1, taking into account the reduction in the provider's service area. The director may also adjust the balance in the conveying provider's flexibility account maintained under section 5-106 to take into account the reduction in the provider's service area.*

4. *If the conveying provider is regulated under the ACP after the conveyance, the director shall establish a new residential GPCD requirement for the provider consistent with the methodology used to establish the residential GPCD requirements in Appendix 5I, taking into account the reduction in the provider's service area. The director may also adjust the balance in the conveying provider's flexibility account maintained under section 5-106 to take into account the reduction in the provider's service area.*

5-109. Conservation Requirements for New Large Municipal Providers

A. Total GPCD Program

1. *A new large municipal provider shall be assigned to the Total GPCD Program described in section 5-103 and shall comply with its annual total GPCD requirement no later than the second full calendar year after the provider is given written notice of the requirement by the director and for each calendar year thereafter until the first compliance date for any substitute requirement in the Fourth Management Plan.*

2. *A new large municipal provider's total GPCD requirement for a year shall be calculated as follows:*

   a. *For calendar years 2002 through 2004, multiply the provider's existing residential population for the year, as calculated pursuant to section 5-103, by the provider's first intermediate GPCD component for existing residential population as determined by the director after the provider qualifies as a new large provider. In determining the provider's first intermediate GPCD component for existing residential population, the director shall assume the implementation of conservation measures appropriate for the characteristics of the provider's existing service area population for calendar years 2002 through 2004, taking into consideration already existing conservation measures.*

   For calendar years 2005 through 2009, multiply the provider's existing residential population for the year, as calculated pursuant to section 5-103, by the provider's second intermediate GPCD component for existing residential population as determined by the director after the provider qualifies as a new large provider. In determining the provider's second intermediate GPCD component for existing residential population, the director shall assume the implementation of conservation measures appropriate for the characteristics of the provider's existing service area population for calendar years 2005 through 2009, taking into consideration already existing conservation measures.

For the calendar year 2010 and for each calendar year thereafter until the first compliance date for any substitute total GPCD requirement in the Fourth Management Plan, multiply the provider's existing residential population for the year, as calculated pursuant to section 5-103, by the provider's final GPCD component for existing residential population as determined by the director after the provider qualifies as a new large provider. In determining the provider's final GPCD component for existing residential population, the director shall assume the implementation of conservation measures appropriate for the characteristics of the provider's existing service area population beginning in calendar year 2010, taking into consideration already existing conservation measures.

b. *Multiply the provider's new single family population for the year, as calculated pursuant to subsection D of section 5-103, by 57 GPCD.*

c. *Multiply the number of new single family housing units within the provider's service area as of July 1 of the calendar year by 118 GPHUD.*

d. *Multiply the new multifamily population for the year, as calculated pursuant to subsection D of section 5-103, by 78 GPCD.*

e. *Determine the provider's non-residential GPCD by dividing the total non-residential water delivered, in gallons, during the calendar year by the service area population for the calendar year, as calculated pursuant to subsection D of section 5-103, and dividing by the number of days in the year. The non-residential GPCD component equals the non-residential GPCD rate for the calendar year up to 21 GPCD. If the non-residential GPCD rate for the calendar year is greater than 21 GPCD, the non-residential component shall be 21 GPCD.*

f. *Divide the provider's allowable lost and unaccounted for water by the number of days in the calendar year. The provider's allowable lost and unaccounted for water is the lesser of the following:*

   1) *the provider's actual lost and unaccounted for water for the year, in gallons.*

   2) *an amount calculated by multiplying the total gallons of water from any source, except direct use effluent, withdrawn, diverted, or received by the provider for non-irrigation use during the year by 10 percent.*

g. *Add the results from paragraphs a through f of this section and then divide the sum by the provider's annual service area population as of July 1 of that year, as determined pursuant to section 5-103, subsection D. The quotient is the provider's total GPCD requirement for the calendar year.*

3. *The director shall determine if a new large municipal provider is in compliance with its annual total GPCD requirement pursuant to the flexibility account provisions in section 5-106.*

B. Non-Per Capita Conservation Program

A new large municipal provider may apply for regulation under the NPCCP in accordance with section 5-104.

C. Alternative Conservation Program

1. Application

A new large municipal provider may apply for regulation under the ACP in accordance with section 5-105.

2. Substitute Groundwater Use Limitation Requirement

A new large municipal provider accepted into the ACP is exempt from complying with the groundwater use limitation requirement as described in section 5-105, subsection C, paragraph 1, subparagraph a, but shall limit its annual groundwater use to the following amount as applicable:

a. If the provider is designated as having an assured water supply under the rules adopted by the director pursuant to A.R.S. § 45-576, the amount the provider is allowed to use under those rules.

b. If the provider is not designated as having an assured water supply under the rules adopted by the director pursuant to A.R.S. § 45-576, the amount that it would be allowed to use if it was designated as having an assured water supply under those rules, as determined by the director.

3. Annual Residential GPCD Requirement

a. Requirement

A new large municipal provider regulated under the ACP shall comply with its annual residential GPCD requirement for each calendar year as described in section 5-105, subsection C, paragraph 2, subparagraph a.

b. Calculation of Annual Residential GPCD Requirement

Each year the annual residential GPCD requirement for a new large municipal provider regulated under the ACP shall be calculated as follows:

1) Multiply the provider's existing residential population for the year, as calculated pursuant to section 5-103, subsection D, by the GPCD component for existing residential population as determined by the director. The GPCD components shall assume the implementation of conservation measures appropriate for the characteristics of the provider's service area, taking into consideration already existing conservation measures.

2) Multiply the provider's new single family population for the year, as calculated pursuant to section 5-103, subsection D, by 57 GPCD.

3) Multiply the number of new single family housing units within the provider's service area as of July 1 of the calendar year in question by 118 GPHUD.

4) Multiply the new multifamily population for the year, as calculated pursuant to subsection D of section 5-103, by 78 GPCD.

5) *Add the products from items 1 through 4 of this subparagraph and then divide the sum by the provider's service area population as of July 1 of the calendar year. The quotient is the provider's residential GPCD requirement for the calendar year.*

c. *Compliance with Annual Residential GPCD Requirement*

The director shall determine if a new large municipal provider regulated under the ACP is in compliance with its annual residential GPCD requirement pursuant to the flexibility account provisions in section 5-106.

4. *Non-Residential Conservation Programs*

A new large municipal provider regulated under the ACP shall implement conservation programs for its non-residential customers in accordance with section 5-105, subsection C, paragraph 3.

5-110. Conservation Requirements for Small Municipal Providers

By January 1, 2002 or upon commencement of service of water, whichever is later, and until the first compliance date for any substitute requirements in the Fourth Management Plan, a small municipal provider shall adopt and implement a program to achieve the following goals:

1. *Minimize waste of all water supplies.*

2. *Maximize efficiency in outdoor watering.*

3. *Encourage reuse of water supplies.*

4. *Reduce its total GPCD usage.*

5-111. Individual User Requirements for Municipal Providers and Individual Users

A. Individual User Requirements

Beginning January 1, 2002, or upon commencement of service of water, whichever is later, and for each calendar year thereafter until the first compliance date for any substitute requirement in the Fourth Management Plan, the municipal provider or individual user responsible for compliance with the individual user requirements under subsection B of this section shall comply with the following, as applicable:

1. *The municipal provider or individual user shall serve water to, or use water within, a turf-related facility only in accordance with sections 6-302 through 6-305 of the Industrial Chapter of the Third Management Plan, and shall comply with the monitoring and reporting requirements set forth in section 6-203 of the Industrial Chapter, as though the individual user were an industrial user. The person responsible for compliance shall also comply with the requirements contained in section 6-202 of the Industrial Chapter, if applicable, as though the individual user were an industrial user.*

2. *The municipal provider or individual user shall serve water to, or use water within, a large-scale cooling facility only if the person using water at the facility complies with all*

applicable conservation requirements contained in sections 6-602 and 6-603 of the Industrial Chapter of the Third Management Plan as though the person was an industrial user. The person responsible for compliance shall also comply with the applicable monitoring and reporting requirements contained in section 6-203 and the conservation requirements contained in section 6-202 of the Industrial Chapter, if applicable, as though the individual user were an industrial user.

3. *The municipal provider or individual user shall serve or use groundwater for the purpose of watering landscaping plants planted on or after January 1, 1987 within any publicly owned right-of-way of a highway, street, road, sidewalk, curb or shoulder that is used for travel in any ordinary mode, including pedestrian travel, only if the plants are listed in Appendix 5B. The director may waive this requirement upon request from the municipal provider or individual user if a waiver of this requirement is in the public interest. This requirement does not apply to any portion of a residential lot that extends into a publicly owned right-of-way.*

4. *The municipal provider or individual user shall not serve or use groundwater for the purpose of maintaining a water feature, including fountains, waterfalls, ponds, water courses, and other artificial water structures installed after January 1, 2002 within any publicly owned right-of-way of a highway, street, road, sidewalk, curb or shoulder that is used for travel in any ordinary mode, including pedestrian travel. The director may waive this requirement upon request from the municipal provider or individual user if a waiver of this requirement is in the public interest. This requirement does not apply to any portion of a residential lot that extends into a publicly owned right-of-way.*

B. Responsibility for Compliance with Individual User Requirements

1. *A municipal provider shall be responsible for complying with an individual user requirement set forth in subsection A of this section for an existing individual user unless one of the following applies:*

   a. *The provider identified the existing individual user to the director on a form provided by the Department and received by the director no later than 90 days before the adoption of the Third Management Plan.*

   b. *The director gave written notice of the individual user requirement to the individual user within 30 days after the adoption of the Third Management Plan.*

2. *An existing individual user that has been given written notice of an individual user requirement by the director shall be responsible for complying with the individual user requirement beginning on the date specified in the notice.*

3. *A municipal provider shall be responsible for complying with an individual user requirement set forth in subsection A of this section for a new individual user unless one of the following applies:*

   a. *The municipal provider identifies the new individual user to the director on a form provided by the Department. If the provider identifies the new individual user to the director within 90 days after the provider begins serving water to the new individual user, the municipal provider shall not be responsible for complying with the individual user requirement at any time. If the provider identifies the new individual user to the director more than 90 days after the provider begins serving water to the*

new individual user, the provider shall be responsible for complying with the individual user requirement beginning on the date the new individual user first receives water from the provider until the end of the calendar year in which the provider identifies the individual user to the director.

b. The director has given written notice of the individual user requirement to the individual user and the individual user is responsible for complying with the requirement.

4. A new individual user that has been given written notice of an individual user requirement by the director shall be responsible for complying with the individual user requirement beginning on the date specified in the notice.

C. Notification of New Individual User by Municipal Provider

Beginning January 1, 2002 and continuing thereafter until the first compliance date for any substitute requirement in the Fourth Management Plan, a municipal provider shall notify a new individual user in writing of its individual user requirements as set forth in subsection A of this section before commencement of service of water to the individual user.

5-112. Conservation Requirements for Municipal Distribution Systems

For the calendar year 2002 or the calendar year in which the provider commences service of water, whichever is later, and for each calendar year thereafter until the first compliance date for any substitute requirement in the Fourth Management Plan:

1. A large municipal provider shall not operate a municipal distribution system in a manner such that lost and unaccounted for water exceeds 10 percent of the total quantity of water from any source, except direct use effluent, withdrawn, diverted, or received by the large municipal provider for non-irrigation use on an annual or three-year average basis.

2. A small municipal provider shall not operate its municipal distribution system in a manner such that lost and unaccounted for water exceeds 15 percent of the total quantity of water from any source, except direct use effluent, withdrawn, diverted, or received by the small municipal provider for non-irrigation use on an annual or three-year average basis.

5-113. Monitoring and Reporting Requirements for Municipal Providers and Individual Users

For the calendar year 2002 or for the calendar year in which the municipal provider commences service of water, whichever is later, and for each calendar year thereafter until the first compliance date for any substitute requirement in the Fourth Management Plan:

1. A large municipal provider shall separately measure and report in its annual reports required by A.R.S. §§ 45-468 and 45-632 the total quantity of water from any source, including effluent, delivered each month for: (a) irrigation uses; (b) residential uses by category, including single family and multifamily; (c) non-residential uses by category, including commercial uses, industrial uses, government uses, construction uses, and other uses; and (d) turf-related facility use.

2. A municipal provider shall report the following in its annual report required by A.R.S. § 45-632:

a. *The total quantity of water from any source, disaggregated by each source, withdrawn, diverted, or received by the provider for non-irrigation use during the reporting year, as separately measured with a measuring device in accordance with paragraph 6 of this subsection.*

b. *The total quantity of water from any source, including effluent, withdrawn, diverted, or received by the provider for irrigation use during the reporting year.*

c. *The total quantity of effluent, disaggregated by direct use effluent, effluent recovered within the area of impact, and effluent recovered outside the area of impact, served by the provider during the reporting year for non-irrigation use.*

d. *The number of single family housing units added to the provider's service area from July 1 of the previous calendar year to July 1 of the reporting year.*

e. *The number of multifamily housing units added to the provider's service area from July 1 of the previous calendar year to July 1 of the reporting year.*

f. *The total number of single family housing units and multifamily housing units served by the provider as of July 1, 2000.*

g. *The number of single family housing units and the number of multifamily housing units added to the provider's service area between July 1, 2000 and July 1 of the reporting year.*

h. *The provider's total quantity of lost and unaccounted for water during the calendar year.*

i. *The percentage of the total quantity of water from any source, except effluent, withdrawn, diverted, or received by the provider during the calendar year that is lost and unaccounted for water.*

3. *In addition to the information required by paragraphs 1 and 2 of this section, a large municipal provider regulated under the NPCCP described in section 5-104 shall include the following in its annual report required by A.R.S. § 45-632:*

   a. *The information listed in the monitoring and reporting requirement sections of those RCMs set forth in Appendix 5H.1-4 that the provider agrees in writing to implement pursuant to section 5-104, subsection E, paragraph 1.*

   b. *If the provider applied for the NPCCP under section 5-104, subsection A, paragraph 4, the information required to be submitted by the provider under the Assured Water Supply Rules adopted by the director pursuant to A.R.S. § 45-576.*

   c. *Any other information required by the director in order to determine the provider's compliance with the NPCCP.*

4. *In addition to the information required by paragraphs 1 and 2 of this section, a large municipal provider regulated under the ACP described in section 5-105 shall include in its annual report required by A.R.S. § 45-632:*

a. *A status report describing progress in implementing the provider's programs proposed in its application, specifically including the provider's proposed conservation plan.*

b. *The information listed in the monitoring and reporting requirement sections of those RCMs set forth in Appendix 5H.2 and 5H.4 that the provider agrees in writing to implement pursuant to section 5-105, subsection C, paragraph 3.*

5. *A large municipal provider shall meter water deliveries to all service connections on its municipal distribution system, except connections to fire services, dwelling units in individual multifamily units, mobile homes in a mobile home park with a master meter, and construction users.*

6. *A municipal provider shall make all water use measurements using measuring devices in accordance with the Department's measuring device rules, R12-15-901, et seq., Arizona Administrative Code.*

7. *An individual user shall meet the monitoring and reporting requirements prescribed in the Industrial Chapter, if applicable, as though the individual user were an industrial user.*

5-114. Remediated Groundwater Accounting for Conservation Requirements

A. Accounting

Groundwater withdrawn pursuant to an approved remedial action project under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) or Title 49, Arizona Revised Statutes, and used by a person subject to a conservation requirement established under this chapter, shall be accounted for consistent with the accounting for surface water for purposes of determining the person's compliance with the conservation requirement, subject to the provisions of subsections B through D of this section.

B. Amount of Groundwater Eligible for Accounting

For each approved remedial action project, the annual amount of groundwater that is eligible for the remediated groundwater accounting provided in subsection A of this section is the project's annual authorized volume. The annual authorized volume for a remedial action project approved on or after June 15, 1999 is the maximum annual volume of groundwater that may be withdrawn pursuant to the project, as specified in a consent decree or other document approved by the United States Environmental Protection Agency (EPA) or the Arizona Department of Environmental Quality (ADEQ). The annual authorized volume for a project approved prior to June 15, 1999 is the highest annual use of groundwater withdrawn pursuant to the project prior to January 1, 1999, except that if a consent decree or other document approved by the EPA or ADEQ specifies the maximum annual volume of groundwater that may be withdrawn pursuant to the project, the project's annual authorized volume is the maximum annual volume of groundwater specified in that document. The director may modify the annual authorized volume for a remedial action project as follows:

1. *For an approved remedial action project associated with a treatment plant that was in operation prior to June 15, 1999, a person may request an increase in the annual authorized volume at the same time the notice is submitted pursuant to subsection C of this section. The director shall increase the annual authorized volume up to the maximum treatment capacity of the treatment plant if adequate documentation is submitted to the*

director demonstrating that an increase is necessary to further the purpose of the remedial action project and the increase is not in violation of the consent decree or other document approved by the EPA or ADEQ.

2. *A person may request an increase in the annual authorized volume of an approved remedial action project at any time if it is necessary to withdraw groundwater in excess of the annual authorized volume to further the purpose of the project. The director shall increase the annual authorized volume up to the maximum volume needed to further the purpose of the project if adequate documentation justifying the increase is submitted to the director and the increase is not in violation of the consent decree or other document approved by the EPA or ADEQ.*

3. *The director shall modify the annual authorized volume of an approved remedial action project to conform to any change in the consent decree or other document approved by the EPA or ADEQ if the person desiring the modification gives the director written notice of the change within thirty days after the change. The notice shall include a copy of the legally binding agreement changing the consent decree or other document approved by the EPA or ADEQ.*

C. Notification

To qualify for the remediated groundwater accounting provided in subsection A of this section, the person desiring the accounting must notify the director in writing of the anticipated withdrawal of groundwater pursuant to an approved remedial action project under CERCLA or Title 49, Arizona Revised Statutes, prior to the withdrawal. A municipal provider may submit notice on behalf of an individual user. At the time the notice is given, the person desiring the accounting must be using remediated groundwater pursuant to the approved remedial action project or must have agreed to do so through a consent decree or other document approved by the EPA or ADEQ. The notice required by this subsection shall include all of the following:

1. *A copy of a document approved by ADEQ or the EPA, such as the Remedial Action Plan (RAP), Record of Decision (ROD) or consent decree, authorizing the remediated groundwater project. Unless expressly specified in the document, the person shall include in the notice the volume of groundwater that will be pumped annually pursuant to the project, the time period to which the document applies, and the annual authorized volume of groundwater that may be withdrawn pursuant to the project.*

2. *The purpose for which the remediated groundwater will be used.*

3. *The name and telephone number of a contact person.*

4. *Any other information required by the director.*

D. Monitoring and Reporting Requirements

To qualify for the remediated groundwater accounting for conservation requirements as provided in subsection A of this section, groundwater withdrawn pursuant to the approved remedial action project must be metered separately from groundwater withdrawn in association with another groundwater withdrawal authority for the same or other end use. A person desiring the remediated groundwater accounting for conservation requirements shall

indicate in its annual report under A.R.S. § 45-632 the volume of water withdrawn and used during the previous calendar year that qualifies for the accounting.

REFERENCES

Craft, M., 1997. *Draft Summary of Landscape Survey Results*, for ADWR, unpublished.

Karpiscak, et al, 1998. *Evaporative Cooler Water Use in Phoenix*, Journal American Water Works Association Vol.90, Issue 4 (April 1998).

Pima County Cooperative Extension Service, Low 4 Program, 1996. *How to Develop a Drip Irrigation Schedule* and *Plant Water Requirements, Tucson, Arizona*. Landscape Water Conservation Workshop materials.

APPENDIX 5A
MUNICIPAL WATER PROVIDERS
TUCSON ACTIVE MANAGEMENT AREA

Provider	Right Number	Large Provider	Small Provider	Organization
Arizona DOC Juvenile Facility	56-000361		X	Correctional Institution
Arizona State Prison Complex - Tucson	56-000362	X		Correctional Institution
Acacia Gardens Mobile Home Park	56-000006		X	Mobile Home Park
Adobe Manor Mobile Home Park	56-000008		X	Mobile Home Park
Antle WC	56-000012		X	Miscellaneous
Arivaca Townsite Coop	56-000014		X	Private Water Company
Arizona Motel	56-000276		X	Miscellaneous
Arizona Land Department (Picacho Pecans)	56-000360		X	Miscellaneous
Arizona WC	56-000016	X		Private Water Company
Artesian Springs Mobile Home Park	56-000017		X	Mobile Home Park
Avra Water Coop	56-000019	X		Private Water Company
Baker/Triano	56-000312		X	Miscellaneous
Bakers Dozen Well Group	56-000266		X	Well Cooperative
Bean, David	56-000275		X	Miscellaneous
Bermuda Gardens Trailer Park	56-000021		X	Mobile Home Park
Campbell Estates Trailer Park	56-000032		X	Mobile Home Park
Carolanne Drive Homeowners Association	56-000034		X	Well Cooperative
Casitas de Castillian	56-000036		X	Well Cooperative
Catalina Country Mobile Home Park	56-000038		X	Mobile Home Park
Catalina Village Apts	56-000151		X	Apartment Complex
Catalina Vista Mobile Home Park	56-000039		X	Mobile Home Park
City of Tucson Water Department	56-000001	X		Municipality
Colonial Mobile Home Park	56-000045		X	Mobile Home Park
Community WC of Green Valley	56-000046	X		Private Water Company
Cortaro Acres Homeowners Association	56-000050		X	Well Cooperative
Coyote Lane Water Well	56-000051		X	Well Cooperative
Crescent Manor Mobile Home Park	56-000053		X	Mobile Home Park
Davis-Monthan Air Force Base	56-000058	X		Defense Institution
DeConcini, Ora, et al.	56-000346		X	Miscellaneous
Desert Shores RV & Mobile Home Park	56-000062		X	Mobile Home Park
Desert Willows Mobile Home Park	56-000066		X	Mobile Home Park
Despoblado WC	56-000067		X	Private Water Company
Diablo Village WC	56-000068		X	Private Water Company
Diamond Grove Estates	56-000025		X	Mobile Home Park
E & T WC	56-000070		X	Private Water Company
Evergreen Air Center	56-000354		X	Miscellaneous
Far Horizons Coop	56-000078		X	Mobile Home Park
Far Horizons East	56-000079		X	Mobile Home Park
Farmers WC	56-000080	X		Private Water Company
Federal Correctional Institution	56-000081		X	Correctional Facility
Flowing Wells ID	56-000084	X		Irrigation District
Foothills Mobile Home Park	56-000086		X	Mobile Home Park
Forty-Niner WC	56-000088	X		Private Water Company
Gator WC	56-000092		X	Well Cooperative
Glover, Jr., J.E.	56-000256		X	Miscellaneous
Goodman WC	56-000347		X	Miscellaneous
Graf, Estate of Milton	56-000096		X	Well Cooperative
Green Valley WC	56-000302	X		Private Water Company

APPENDIX 5A
MUNICIPAL WATER PROVIDERS
TUCSON ACTIVE MANAGEMENT AREA

Provider	Right Number	Large Provider	Small Provider	Organization
Halcyon Acres #2	56-000099		X	Private Water Company
Halcyon Acres Water Users Association	56-000098		X	Private Water Company
Hanning Snyder Coop	56-000101		X	Well Cooperative
Hermosa Vista WC	56-000103		X	Well Cooperative
Hohokum Trailer Park	56-000105		X	Mobile Home Park
Homeowners Water Coop	56-000106		X	Well Cooperative
Hum WC	56-000359		X	Miscellaneous
Hutchison, Jr., B.W.	56-000308		X	Well Cooperative
I.M. WC	56-000300		X	Private Water Company
Introspect Health Care	56-000352		X	Health Care Institution
Ironwood Well	56-000342		X	Well Cooperative
Islas, Reuben	56-000315		X	Well Cooperative
Jensen, R.	56-000337		X	Well Cooperative
Jero Investors	56-000137		X	Mobile Home Park
Jones, Lonny	56-000288		X	Well Cooperative
K & V WC	56-000116		X	Miscellaneous
Kino Mobile Home Park	56-000121		X	Mobile Home Park
La Casita WC	56-000366		X	Private Water Company
La Cholla Airpark	56-000123		X	Well Cooperative
La Cholla Mobile Home Park	56-000269		X	Mobile Home Park
Lago del Oro WC	56-000245	X		Private Water Company
Larsen, P.A.	56-000270		X	Miscellaneous
Las Quintas Serenas WC	56-000128	X		Private Water Company
Latter-Day Saints Church	56-000335		X	Miscellaneous
Lazy 'C' Water Service	56-000131		X	Private Water Company
Lazy A Mobile Home Park	56-000129		X	Mobile Home Park
Lazy Acres Mobile Home Park	56-000130		X	Mobile Home Park
Lazy Bones Mobile Home Park	56-000348		X	Mobile Home Park
Leiber Bros. WC	56-000167		X	Private Water Company
Loeffler Lane Homeowners Association	56-000055		X	Association
Logan Hills WC	56-000134		X	Private Water Company
Los Cerros WC	56-000138		X	Private Water Company
Lyn Lee WC	56-000141		X	Private Water Company
MPL Corporation	56-000330		X	Miscellaneous
Marana Municipal Water System	56-000107	X		Municipality
Marana-Picture Rocks Water Service	56-000246	X		Private Water Company
Martin, Don	56-000143		X	Miscellaneous
McPherson, David	56-000028		X	Miscellaneous
Mesa Del Oro WC	56-000144		X	Well Cooperative
Mesaland WC	56-000145		X	Private Water Company
Mesquite Well Owners	56-000260		X	Well Cooperative
Metropolitan DWID	56-000349	X		Improvement District
Mirabell WC	56-000146		X	Private Water Company
Mission Palms Apartments	56-000365		X	Apartment Complex
Ocotillo Community Well	56-000320		X	Well Cooperative
Oracle Villa Apartments	56-000324		X	Apartment Complex
Orchard Valley Mobile Home Park	56-000154		X	Mobile Home Park
Pan Chiva Hills WC	56-000319		X	Well Cooperative
Pantano Properties Homeowners Association	56-000305		X	Well Cooperative

APPENDIX 5A
MUNICIPAL WATER PROVIDERS
TUCSON ACTIVE MANAGEMENT AREA

Provider	Right Number	Large Provider	Small Provider	Organization
Picacho Peak WC	56-000162		X	Miscellaneous
Pinal Greens Garden	56-000325		X	Miscellaneous
Posta Quemada Ranch	56-000345		X	Miscellaneous
Quail Creek W.C.	56-000367		X	Private Water Company
Rancho La Linda Homeowners Association	56-000172		X	Well Cooperative
Rancho Los Amigos	56-000173		X	Mobile Home Park
Rancho del Conejo WC	56-000171		X	Private Water Company
Ranchwood Mobile Home Park	56-000176		X	Mobile Home Park
Ray WC	56-000247	X		Private Water Company
Red Rock WC	56-000179		X	Private Water Company
Rillito Water Users	56-000182		X	Private Water Company
Rincon Country RV Resort East	56-000301		X	Mobile Home Park
Rincon Creek WC	56-000183		X	Private Water Company
Rincon Ranch Estates WC	56-000184		X	Private Water Company
Rincon WC	56-000185		X	Private Water Company
Rio Vista Mobile Home Park	56-000186		X	Mobile Home Park
Riverside Apartments	56-000187		X	Apartment Complex
Saguaro WC	56-000135		X	Private Water Company
Sahuarita Village WC	56-000191		X	Association
Samalayucca Improvement	56-000192		X	Well Cooperative
Sandario WC	56-000193		X	Private Water Company
Schnelle, J.	56-000293		X	Well Cooperative
Shinn, Betty J.	56-000323		X	Miscellaneous
Siete Casas Joint Venture	56-000321		X	Well Cooperative
Silver Cholla Park	56-000198		X	Mobile Home Park
Sleepy Hollow Mobile Home Park	56-000199		X	Private Water Company
Solana y Sombra Mobile Home Park	56-000200		X	Mobile Home Park
Spanish Trail WC	56-000170		X	Private Water Company
Speedway Well Owners	56-000355		X	Well Cooperative
Summit WC	56-000204		X	Well Cooperative
Summit Water Coop	56-000205		X	Well Cooperative
Sun Valley Trailer Park	56-000206		X	Mobile Home Park
Sunkist Well Homeowners Association	56-000328		X	Well Cooperative
T & C Mobile Estates	56-000218		X	Mobile Home Park
Tewa Heights Homeowners Association	56-000309		X	Well Cooperative
Thim Utility	56-000209		X	Private Water Company
Three Points Water Coop	56-000210		X	Well Cooperative
Town of Oro Valley Water Utility	56-000368	X		Municipality
Tucson Meadows Mobile Home Park	56-000220		X	Mobile Home Park
Twin Peaks Homeowners Association	56-000316		X	Well Cooperative
University of Arizona	56-000268	X		Educational Institution
VA Medical Center	56-000356		X	Health Care Institution
Vail WC	56-000060		X	Private Water Company
Val Verde Subdivision	56-000307		X	Well Cooperative
Val Verde, Inc.	56-000225		X	Well Cooperative
Valle Verde Del Norte	56-000227		X	Well Cooperative
Via Verde West	56-000231		X	Mobile Home Park
Villa Capri Trailer Park	56-000232		X	Mobile Home Park
Vista del Norte	56-000234		X	Mobile Home Park

APPENDIX 5A
MUNICIPAL WATER PROVIDERS
TUCSON ACTIVE MANAGEMENT AREA

Provider	Right Number	Large Provider	Small Provider	Organization
Voyager WC	56-000221	X		Private Water Company
Well Coop	56-000281		X	Well Cooperative
Winterhaven Water & Development Co.	56-000237		X	Association
Worden WC	56-000238		X	Private Water Company

WC = Water Company
ID = Irrigation District
DWID = Domestic Water Improvement District

APPENDIX 5B
LOW WATER USE/DROUGHT TOLERANT PLANT LIST
TUCSON ACTIVE MANAGEMENT AREA

The Low Water Use/Drought Tolerant Plant List for the Tucson AMA is filed in the Department's Tucson AMA Office. A copy of the list, effective as of March 1998, follows in this Appendix. Since the list may be amended using the procedure described below, a current list is available upon request from the Tucson AMA office or the Department's public information office in Phoenix.

PROCEDURE FOR MODIFICATION OF LOW WATER USE PLANT LIST FOR THE TUCSON ACTIVE MANAGEMENT AREA

A. A person who seeks to add a plant or plants to the Low Water Use Plant List for the Tucson AMA or delete a plant or plants from the list may apply at any time to the director for a modification of the list. The application shall be made on a form prescribed and furnished by the director.

B. The director shall review each request for a modification of the list. The director may request additional information from the applicant and may seek information from other sources as may be necessary to determine whether the list should be modified.

C. If the director approves the addition of a plant to the list, the director shall place the plant on a supplemental list that shall be considered an addendum to the list. The supplemental list shall be available from the Tucson AMA Office or from the public information office upon request. If the director approves the deletion of a plant from the list, the deleted plant or plants shall be listed as deleted on the supplemental list.

D. The director shall conduct an annual review of the list and issue a modified plant list no later than March 1 of the following year. As a result of the review, the director may add plants to the list, delete plants from the list, or both.

APPENDIX 5B
LOW WATER USE/DROUGHT TOLERANT PLANT LIST
TUCSON ACTIVE MANAGEMENT AREA

OFFICIAL REGULATORY LIST FOR:

Arizona Department of Water Resources,
Tucson Active Management Area
City of Tucson
Pima County

The plants on this list can be grown with moderate to no supplemental irrigation once they are established. Occasionally, for good appearance, supplemental irrigation may be applied during the growing season. In addition to the cacti on this list, any cacti salvaged and tagged in compliance with state agricultural and horticultural regulations may be used.

Even though all of the plants on the Low Water Use/Drought Tolerant Plant List meet the Department's standard for low water consumption, please check the regulations of the governing jurisdiction to determine whether a particular plant selection meets all locational, aesthetic, or functional requirements. For example, plants used for screening may have to be evergreen, have dense foliage, and grow to required heights. On the other hand, plants used within sight visibility triangles may have height restrictions. In some applications, there may be a requirement for native materials or a "desert or natural appearance."

Some plants on the list may fall under more than one plant type category and this is noted (i.e., Acacia constricta can be grown as a tree or a shrub depending upon the growth habit that is preferred). Cultivars of plants listed may also be planted in regulated areas.

Applications for additions, deletions, or exceptions to the list may be submitted to the Department of Water Resources, Tucson Active Management Area Office, for consideration. Phone: (520) 770-3800; Fax: (520) 628-6759.

APPENDIX 5B
LOW WATER USE/DROUGHT TOLERANT PLANT LIST
TUCSON ACTIVE MANAGEMENT AREA

Key to symbols

(sh)	Semi-hardy -- some dieback in a hard frost
(t)	Tender -- severely damaged or killed in a hard frost
*	Toxic; may be harmful if eaten For more information, call Arizona Poison Control Center at 626-6016
#	Exceptions to the nomenclature in Hortus III
A	Accent Plant
an	Annual
C	Cactus
cl	Seasonal Color (showy flowers, fall color or berries)
Gc	Groundcover
Gr	Ornamental Grass
I	Invasive -- may spread and intrude into natural areas
p	Perennial
S	Shrub
Sc	Succulent (other than cacti)
T	Tree
V	Vine
CD	Chihuahuan Desert Region - broadly interpreted to include a large area of north central and northwest Mexico, southwest Texas, southern New Mexico, and extreme southeast Arizona
SD	Sonoran Desert Region - broadly interpreted to include the arid and semi-arid areas of northwest Mexico, southeast California, and most of Arizona south of the Mogollon Rim

Note: Chihuahuan and Sonoran Desert Regions annotated by Matt Johnson, Native Plant Society.

Approximate Watering Needs (depending on soil and climate conditions)

1	No supplemental irrigation once established.
2	Once a month during the growing season once established.
3	Twice a month during the growing season once established.
4	Once a week during the growing season once established.

APPENDIX 5B
LOW WATER USE/DROUGHT TOLERANT PLANT LIST
TUCSON ACTIVE MANAGEMENT AREA

Plant Type Category	Region	Low Water Use/ Drought Tolerant Plant List	Watering Needs		
Gc,an	SD	Abronia villosa	1		Sand verbena
T	Africa	Acacia abyssinica	3	(sh)	Abyssinian Acacia
T	Austr.	Acacia aneura	2	(sh)	Mulga
S	SD	Acacia angustissima	2	(sh)	White Ball Acacia
S,T	CD	Acacia berlandieri	3		Guajillo
T,S*	SD,CD	Acacia constricta	1		Whitethorn Acacia, Mescat
T,S	Austr.	Acacia crasspedocarpa	1		Waxleaf Acacia
T,S	Austr.	Acacia cultriformis	2	(sh)	Knife-Leaf Acacia
T,S	SD,CD	Acacia greggii	1		Cat's Claw Acacia
T,S,cl	SD,CD	Acacia minuta (smallii)	2		Southwestern Sweet Acacia
S	Austr.	Acacia notabilis	2		Acacia
S,Gc	Austr.	Acacia redolens	2		Prostrate Acacia
S,T	CD	Acacia rigidula	3		Black Brush Acacia
T,cl	Austr.	Acacia salicina	2	(sh)	Weeping Wattle
T	Austr.	Acacia saligna	1-2	(sh)	Wattle Tree
T	CD	Acacia schaffneri	1-2		Twisted Acacia
T	Austr.	Acacia stenophylla	1-2		Pencilleaf Acacia
T	SD	Acacia willardiana	1-2	(sh)	Palo Blanco
Sc	CD	Agave americana	1-2		Century Plant
Sc	SD	Agave colorata	1		Agave
Sc	CD	Agave filifera	1-2		Agave
Sc	Mex.	Agave geminiflora	2	(sh)	Twin-flowered agave
Sc	SD	Agave huachucensis	1-2		Huachuca Agave
Sc	CD	Agave lophantha (univittata)	2		Agave
Sc	SD	Agave ocahui	1-2		Ocahui Agave
Sc	SD	Agave palmeri	1		Palmer Agave
Sc	Mex.	Agave parryi v. truncata	2		Artichoke Agave
Sc	CD	Agave victoriae-reginae	1-2		Victoria Regina Agave
Sc	SD	Agave vilmoriniana	1-2	(sh)	Octopus Agave
Sc,cl	Africa	Aloe barbadensis	2-3	(sh)	Barbados Aloe
Sc,cl	Africa	Aloe ferox	2-3	(sh)	Cape Aloe
Sc,cl	Africa	Aloe saponaria	2-3	(sh)	Mediterranean Aloe
Sc, cl	Africa	Aloe variegata	2-3		Partridge Breast Aloe
S	SD,CD	Aloysia gratissimma	2		Fragrant Bush, Bee Brush
S	SD,CD	Aloysia wrightii	2		Wright's Oregano, Lemon Verbena
S	SD	Ambrosia (Franseria) deltoidea	1		Triangle-leaf Bursage
S	SD	Ambrosia (Franseria) dumosa	1		White Bursage
S	SD	Anisacanthus thurberi	2		Desert Honeysuckle
V,cl	SD	Antigonon leptopus	2-3	(t)	Queen's Wreath
Gr,cl	SD,CD	Aristida purpurea	1		Purple three-awn
S	SD,CD	Asclepias linaria	2		Pine-Leaf Milkweed

APPENDIX 5B
LOW WATER USE/DROUGHT TOLERANT PLANT LIST
TUCSON ACTIVE MANAGEMENT AREA

Plant Type Category	Region	Low Water Use/ Drought Tolerant Plant List	Watering Needs		
A	SD	Asclepias subulata	2	(sh)	Desert Milkweed
an	SD	Aster bigelovii	1	(t)	Aster
an	SD,CD	Aster tanacetifolius	1	(t)	Aster
S	SD,CD	Atriplex canescens	1		Four-Wing Saltbush
S	SD	Atriplex lentiformis	1		Quail Bush
S	SD	Atriplex lentiformis breweri	1-2		Brewer Saltbush
S	Austr.	Atriplex nummularia	1		Old Man Saltbush
S	SD	Atriplex polycarpa	1		Desert Saltbush
S	Austr.	Atriplex semibaccata	2		Australian Saltbush
S,I	SD	Baccharis sarothroides (male only)	1-2		Desert Broom
S,Gc	SD	Baccharis sarothroides `Centennial'	2-3		Centennial
p,cl	SD	Bahia absinthifolia	2		Desert Daisy
p,cl*	SD,CD	Baileya multiradiata	1-2		Desert Marigold
S	SD	Berberis harrisoniana	3		Barberry
S	SD	Berberis trifoliata	3		Agritos
Gr,cl	SD,CD	Bothriochloa barbinodis	1		Cane beardgrass
V,S,cl	Brazil	Bougainvillea spp.	3	(t)	Bougainvillea
Gr	SD,CD	Bouteloua chondrosioides	2		Sprucetop grama
Gr,cl	SD,CD	Bouteloua curtipendula	2		Sideoats grama
Gr,cl	SD	Bouteloua eriopoda	3		Black Grama
Gr	SD,CD	Bouteloua gracilis	2		Blue grama
Gr	SD	Bouteloua hirsuta	2		Hairy grama
Gr	SD,CD	Bouteloua rothrockii	1		Rothrock grama
T	Austr.	Brachychiton populneus	2-3		Bottle Tree
T	SD	Brahea (Erythea) armata	2-3		Mexican Blue Palm
Gr	CD	Buchloe dactyloides	2-3		Buffalo grass
S,cl	CD	Buddleia marrubifolia	2-3		Wooly Butterfly Bush
Sc,cl	S. Afr.	Bulbine frutescsns	2	(sh)	Shrubby bulbine
S,cl*	CD	Caesalpinia (Poinciana) mexicana	2		Mexican Bird of Paradise (Yellow)
S,cl*	Argent.	Caesalpinia (Poinciana) gilliesii	1-2		Yellow Bird of Paradise
S,cl*	Carib.	Caesalpinia pulcherrima	3	(sh)	Red Bird of Paradise
S,cl	SD	Calliandra californica	2-3		Red Fairy Duster, Baja Fairy Duster
S,cl	SD	Calliandra eriophylla	1		Fairy Duster, False Mesquite
S,cl	SD	Calliandra peninsularis	2-3	(sh)	Red Calliandra, Baja Fairy Duster
T,S,cl	Austr.	Callistemon citrinus	3	(sh)	Lemon Bottlebrush
Gc,cl	CD	Calylophus hartwegii	3		Calylophus
V,cl	SD,CD	Campsis radicans	2-3		Common Trumpet Creeper
C	SD	Carnegiea gigantea	1		Saguaro
Gc,Sc,cl	Africa	Carpobrotus edulis	3	(t)	Ice Plant

APPENDIX 5B
LOW WATER USE/DROUGHT TOLERANT PLANT LIST
TUCSON ACTIVE MANAGEMENT AREA

Plant Type Category	Region	Low Water Use/ Drought Tolerant Plant List	Watering Needs		
S,cl	Austr.	Cassia artemisioides	2-3	(sh)	Wormwood Senna, Feathery Cassia
S,cl	Austr.	Cassia nemophila (eremophila)	2		Green Cassia
S,cl	Austr.	Cassia phyllodinea	2-3		Silvery Cassia
T	Austr.	Casuarina cunninghamiana	3		Australian Pine
T	Austr.	Casuarina stricta	2-3		Coast Beefwood
T,cl		Catalpa x chilopsis	4		Chitalpa
Gr,cl	SD	Cathostecum erectum	1		False grama
S	SD,CD	Celtis pallida	1-2		Spiny or Desert Hackberry
T	SD,CD	Celtis reticulata	2		Netleaf or Western Hackberry
p,cl	Medit.	Centaurea cineraria	3		Dusty Miller
Gc,Sc,cl		Cephalophyllum `Red Spike'	2		Red Spike Ice Plant
T	Medit.	Ceratonia siliqua	3	(sh)	Carob, St. John's Bread Tree
T,cl	SD	Cercidium floridum	2-3		Blue Palo Verde
T,cl	SD,CD	Cercidium hybrid 'Desert Museum'	1		Desert Museum Palo Verde
T,cl	SD	Cercidium microphyllum	1		Littleleaf or Foothill Palo Verde
T,cl	SD	Cercidium praecox	2	(sh)	Palo Brea
T,cl	SD	Cercidium sonorae	1-2		Sonoran Palo Verde
T,S	CD	Cercis canadensis var. mexicana	3		Mexican Redbud
C	S. Am.	Cereus peruvianus	1-2	(sh)	Peruvian Cereus
T	Spain	Chamaerops humilis	2-3		Mediterranean Fan Palm
T,S,cl	SD,CD	Chilopsis linearis	2-3		Desert Willow
S,cl		Chrysactinia mexicana	3		Damianita
V,I	CD	Cissus incisa	1-2		Desert Grape Ivy
V	SD	Cissus trifoliata	1-2		Desert Grape Ivy
S	SD,CD	Condalia warnockii var. kearneyana	1		Condalia
S,Gc,cl*	Medit.	Convolvulus cneorum	1-2		Bush Morning Glory
Gc,cl	Africa	Convolvulus mauritanicus	3	(sh)	Ground Morning Glory
T,S,cl	CD	Cordia boissieri	2-3	(sh)	Anacahuita, Texas Olive
S,cl	SD,CD	Cordia parvifolia	1-2		Littleleaf Cordia
Gr	Arg.	Cortaderia selloana	3		Pampas Grass
T	SD,CD	Cupressus arizonica	2		Arizona Cypress
T	SD	Cupressus glabra	2-3		Smooth Bark Cypress
T	India	Dalbergia sissoo	3	(sh)	Rosewood
S	SD	Dalea bicolor var. argyrea	2-3		Silver Dalea
Gc,cl	Mexico	Dalea capitata	3		Yellow Dalea
S,cl	CD	Dalea frutescens	2-3		Black Dalea

APPENDIX 5B
LOW WATER USE/DROUGHT TOLERANT PLANT LIST
TUCSON ACTIVE MANAGEMENT AREA

Plant Type Category	Region	Low Water Use/ Drought Tolerant Plant List	Watering Needs		
Gc	CD	Dalea greggii	2-3		Trailing Indigo Bush
S,cl	SD	Dalea pulchra	2-3		Indigo Bush
S,cl	SD	Dalea versicolor var. sessilis	3		Indigo Bush, Dalea
A	CD	Dasylirion acrotriche	1		Green Desert Spoon
A	SD,CD	Dasylirion wheeleri	1		Sotol, Desert Spoon
Gc,p,cl*	SD	Datura wrightii	3	(sh)	Sacred Datura
Gr	SD,CD	Digitaria californica	1		Arizona cottontop
an,cl	S. Afr.	Dimorphotheca sinuata	4		African Daisy, Cape Marigold
S	SD,CD	Dodonaea viscosa	1-2	(sh)	Hopbush
Gc,p,cl	SD,CD	Dyssodia acerosa	2-3		Dogweed
Gc,an,p,cl	SD,CD	Dyssodia pentachaeta	2-3		Dyssodia
C,cl	SD	Echinocactus grusonii	1-2		Golden Barrel
C,cl	CD,SD	Echinocereus spp.	1		Hedgehog, Rainbow Cactus
C,cl	S. Am.	Echinopsis spp.	1		Easter Lily, Sea Urchin Cactus
S,cl	SD	Encelia californica	1-2	(sh)	California Brittlebush (green)
S,cl	SD	Encelia farinosa	1-2	(sh)	Brittlebush
S	SD	Ephedra nevadensis	3		Ephedra
Gr	SD,CD	Eragrostis intermedia	1		Plains lovegrass
S,cl	Austr.	Eremophila decipiens	1		Emu Bush
Gr	SD,CD	Erioneuron pulchellus	1		Fluffgrass
an,cl	SD	Eschscholtzia californica	2-3		California Poppy
an,cl	SD	Eschscholtzia mexicana	3		Mexican Gold Poppy
T	Austr.	Eucalyptus camaldulensis	2		Red River Gum
T	Austr.	Eucalyptus campaspe	2-3	(sh)	Silver Gimlet
T	Austr.	Eucalyptus formanii	2		Eucalyptus
T,cl	Austr.	Eucalyptus leucoxylon (rosea)	2		White Iron Bark
T	Austr.	Eucalyptus microtheca	1-2		Tiny Capsule Eucalyptus
T	Austr.	Eucalyptus polyanthemos	2		Silver Dollar Gum
T	Austr.	Eucalyptus rudis	2		Desert Gum
T	Austr.	Eucalyptus spathulata	3		Swamp Mallee
S	CD	Euphorbia antisyphilitica	1		Wax Plant, Candelilla
Gc		Euphorbia myrsinites	2		Euphorbia
A,Sc,cl*	Africa	Euphorbia rigida (biglandulosa)	2		Gopher Plant
T,S,cl	S. Am.	Feijoa sellowiana	3		Pineapple Guava
C,cl	SD,CD	Ferocactus spp.	1		Barrel Cactus
A,cl	SD,CD	Fouquieria splendens	1		Ocotillo
an,cl	CD	Gaillardia pulchella	3		Fire Wheel, Blanket Flower
Gc,cl	Africa	Gazania rigens	3-4		Treasure Flower Gazania

APPENDIX 5B
LOW WATER USE/DROUGHT TOLERANT PLANT LIST
TUCSON ACTIVE MANAGEMENT AREA

Plant Type Category	Region	Low Water Use/ Drought Tolerant Plant List	Watering Needs		
Gc,cl	Africa	Gazania rigens leucolaena	3-4	(t)	Trailing Gazania
T,cl	S. Am.	Geoffreya (Gourleia) decorticans	1		Chilean Palo Verde
S,cl	SD	Gossypium harknessii	2	(t)	Gossypium
S,cl	SD,CD	Haplopappus (Ericameria) laricifolius	1		Turpentine Bush
A	CD	Hesperaloe funifera	1-2		Giant Hesperaloe
A,cl	CD	Hesperaloe parviflora	1-2		Red Yucca, Red-Flowered Hesperaloe
Gr	SD	Hetropogon contortus	3		Tanglehead
S	SD,CD	Hibiscus coulteri	2		Yellow Hibiscus, Coulter's Hibiscus
Gr	SD,CD	Hilaria berlangeri	2		Curly mesquite
Gr	SD,CD	Hilaria mutica	1		Tobosa grass
Gr	SD,CD	Hilaria rigida	2		Big galleta grass
p,cl	SW US	Hymenoxys acaulis	3		Angelita Daisy
S	SD	Hyptis emoryi	3	(sh)	Desert Lavendar
S	SD	Jatropha cardiophylla	1		Limberbush
S,cl	CD	Jatropha dioica	1	(t)	Jatropha
T,S	Asia	Juniperus chinensis	3		Juniper (many culitvars)
T	SD,CD	Juniperus deppeana	3		Alligator Bark Juniper
S		Juniperus sabina	3		Sabine Juniper
S,cl	SD	Justicia (Beloperone) californica	2-3	(t)	Chuparosa
S,cl	SD	Justicia candicans	3	(sh)	Red Jacobinia
S,cl	SD	Justicia spicigera	3	(sh)	Mexican Honeysuckle, Firecracker Bush
S,cl*	S. Am.	Lantana camara	3-4	(t)	Bush Lantana (many cultivars)
Gc,cl*	S. Am.	Lantana montevidensis	3-4	(t)	Trailing Lantana
S,cl	SD,CD	Larrea tridentata (divaricata)	1		Creosote Bush, Greasewood
Gr	CD	Leptochloa dubia	3		Green Sprangle-Top
T,S,cl	CD	Leucaena retusa	1-2		Golden Leadball
S,cl	CD	Leucophyllum spp.	2		Texas Ranger (all cultivars)
Gc,an,cl	Eurasia	Linum grandiflorum `Rubrum'	3		Scarlet Flax
an,cl	SD,CD	Linum lewisii	3		Blue Flax
an,cl	SD	Lupinus arizonicus	1		Lupine
an,cl	SD	Lupinus sparsiflorus	1		Desert Lupine
an,cl	SD	Lupinus succulentus	1		Arroyo Lupine
S	SD	Lycium exsertum	1		Lycium
S	SD	Lycium fremontii	1		Wolfberry
T,S	SD	Lysiloma thornberi	2-3	(sh)	Feather Tree
V,cl	Amer.	Macfadyena unguis-cati	2-3		Cat's Claw Vine
Gc,Sc,cl		Malephora crocea	2-3		Croceum, Ice Plant

APPENDIX 5B
LOW WATER USE/DROUGHT TOLERANT PLANT LIST
TUCSON ACTIVE MANAGEMENT AREA

Plant Type Category	Region	Low Water Use/ Drought Tolerant Plant List	Watering Needs		
C,cl	SD,CD	Mamillaria spp.	1-2		Mamillaria Cactus
V,cl	CD	Mascagnia lilacina	2-3		Lavender Orchid Vine
V,cl	SD,CD	Mascagnia macroptera	2-3	(sh)	Yellow Orchid Vine
S	SD,CD	Maytenus phyllanthoides	2		Mangle Dulce
Gc,p,cl	SD,CD	Melampodium leucanthum	2		Blackfoot Daisy
V,cl	SD	Merremia aurea	2-3	(t)	Yellow Merremia
S,cl	SD	Mimosa dysocarpa	2		Velvetpod
Gr	SD	Muhlenbergia dumosa	3-4		Bush Muhlenbergia, Bamboo Muhly
Gr,cl	SD	Muhlenbergia emersleyi	1		Bullgrass
Gr,cl	SD,CD	Muhlenbergia porteri	1		Bush muhly
Gr	SD	Muhlenbergia rigens	3		Deer grass
Gr,cl	SD	Muhlenbergia rigida	3		Muhlenbergia
Gc	Austr.	Myoporum parvifolium	3		Myoporum
S	Medit.	Myrtus communis	3		True Myrtle, Roman Myrtle
S,cl		Nandina domestica	3		Heavenly Bamboo (many cultivars)
S,cl*	Medit.	Nerium oleander	2-3		Oleander (many cultivars)
A	SD	Nolina bigelovii	1-2		Beargrass
A,T	SD	Nolina matapensis	1-2		Tree Beargrass
A	SD	Nolina microcarpa	1-2		Beargrass
A	SD	Nolina parryi	1-2		Parry's Beargrass
Gc,cl	CD	Oenothera berlandieri (speciosa)	3		Mexican Evening Primrose
p,cl	SD	Oenothera caespitosa	2-3		Tufted Evening Primrose
Gc,cl	CD	Oenothera stubbei	2-3		Chihuahuan Primrose, Baja Primrose
T	Medit.	Olea europaea `Swan Hill'	3		Swan Hill Olive
T	SD,CD	Olneya tesota	1	(sh)	Desert Ironwood, Tesota
C	SD,CD	Opuntia spp.	1		Prickly Pear, Cholla
Gr	SD,CD	Oryzopsis hymenoides	3		Indian ricegrass
Gc,cl	Africa	Osteospermum fruticosum	3-4	(sh)	Trailing African Daisy
Gr	SD	Pappophorum mucronulatum	1		Pappusgrass
T,I,cl	SD,CD	Parkinsonia aculeata	1-2		Mexican Palo Verde
V	SD	Passiflora foetida	3	(sh)	Passion Flower
A,Sc,cl*	SD	Pedilanthus macrocarpus	2		Slipper Flower
Gr	Africa	Pennisetum setaceum `Cupreum'	1-2		Purple fountain grass
p,cl	W US	Penstemon ambiguus	2		Pink Plains Penstemon
p,cl	CD	Penstemon baccharifolius	1		Cutleaf Penstemon
p,cl	SD,CD	Penstemon barbatus	1		Beardtongue Penstemon

APPENDIX 5B
LOW WATER USE/DROUGHT TOLERANT PLANT LIST
TUCSON ACTIVE MANAGEMENT AREA

Plant Type Category	Region	Low Water Use/ Drought Tolerant Plant List	Watering Needs		
p,cl	SD	Penstemon eatoni	1		Eaton's Penstemon
p,cl	SW US	Penstemon palmeri	2		Palmer Penstemon
p,cl	SD	Penstemon parryi	1		Parry Penstemon
p,cl	SD	Penstemon pseudospectabilis	1		Canyon Penstemon, Mohave Beardtongue
p,cl	CD	Penstemon superbus	1		Superb Penstemon
Gc	Africa	Pentzia incana	1-2		Karoo Bush
an,cl	SD	Phacelia campanularia	2-3		Desert Canterbury Bells
an,cl	SD	Phacelia tanacetifolia	2-3		Tansy Phacelia
T		Phoenix canariensis	3		Canary Island Date Palm
T	Asia	Phoenix dactylifera	3		Date Palm
Gc,cl		Phyla nodiflora	3-4		Lippia
T		Pinus edulis	2-3		Piñon Nut Pine
T#	Asia	Pinus eldarica	2		Afghan Pine
T	Medit.	Pinus halepensis	2		Aleppo Pine
T	Mojave	Pinus monophylla	2		Singleleaf Piñon Pine
T	Medit.	Pinus pinea	2-3		Italian Stone Pine
T	Asia	Pinus roxburghii	3		Chir Pine
T	Africa	Pistacia atlantica	2		Mt. Atlas Pistache
T,cl	Asia	Pistacia chinensis	3		Chinese Pistache
T,cl		Pistacia terebinthus x integerrima	3		Pistache hybrid terebinthus x integerrima
T	Asia	Pistacia vera	2-3		Pistachio
T	CD	Pithecellobium flexicaule	2	(sh)	Texas Ebony
T	SD	Pithecellobium mexicanum	3		Mexican Ebony
T	CD	Pithecellobium pallens	2	(sh)	Tenaza
T	Austr.	Pittosporum phillyraeoides	2		Willow Pittosporum
an	SD,CD	Plantago spp.	1-2		Indian Wheat
T#	S. Am.	Prosopis (So. Am. hybrid)	2		Thornless Mesquite (So. Am. hybrid)
T#	S. Am.	Prosopis alba	2		Argentine Mesquite
T#	S. Am.	Prosopis chilensis	2		Chilean Mesquite
T#	CD	Prosopis glandulosa glandulosa	2		Honey or Texas Mesquite
T	SD,CD	Prosopis pubescens	2		Screwbean Mesquite
T#	SD	Prosopis velutina	2		Velvet Mesquite
p,cl	SD,CD	Psilostrophe cooperi	2		Paper Flower
S,T,cl	India	Punica granatum	2-3		Pomegranate
S,cl		Pyracantha (red berried types)	3		Pyracantha (many cultivars)
T	SD,CD	Quercus arizonica	3		Arizona White Oak
T,cl	W.Tx.	Quercus buckleyi	2-3		Texas Red Oak
T	SD,CD	Quercus emoryi	3		Emory Oak

APPENDIX 5B
LOW WATER USE/DROUGHT TOLERANT PLANT LIST
TUCSON ACTIVE MANAGEMENT AREA

Plant Type Category	Region	Low Water Use/ Drought Tolerant Plant List	Watering Needs		
T		Quercus ilex	3		Holly Oak
T*	Medit.	Quercus suber	2		Cork Oak
S	W.U.S.	Quercus turbinella	2-3		Shrub Live Oak
T	SEU.S.	Quercus virginiana	3		Southern Live Oak
T,I	Africa	Rhus lancea	2		African Sumac
S,cl	CD	Rhus microphylla	2		Littleleaf Sumac
S	SD	Rhus ovata	2		Sugar Bush, Sugar Sumac
S,cl	CD	Rhus virens	2		Evergreen Sumac
S,Gc,V		Rosa banksiae	3		Lady Banks Rose,Tombstone Rose
S,cl	Medit.	Rosmarinus officinalis	2-3		Bush Rosemary
S,cl	SD	Ruellia californica	3	(t)	Ruellia
S,cl	SD	Ruellia peninsularis	3	(t)	Ruellia
Sc,Gc		Ruschia uncinatus	2		Ruschia
S,p,cl	CD	Salvia chamaedryoides	2-3		Blue Sage
S,cl		Salvia clevelandii	3		Cleveland Sage
an,cl	SD	Salvia columbariae	3		Chia
S,cl	CD	Salvia farinacea	3-4		Mealy Cup Sage
S,cl	CD	Salvia greggii	2-3		Texas Red Salvia,Autumn Sage
S,cl	SD	Salvia mohavensis	2		Mohave Sage
T	SD,CD	Sambucus mexicana	2		Mexican Elderberry
S,Gc	Medit.	Santolina chamaecyparissus	2-3		Lavender Cotton
Gc,S,cl	Medit.	Santolina virens	3-4		Green Santolina
T*	SD,CD	Sapindus saponaria	3-4		Soapberry
T	S.Am.	Schinus molle	2-3		California Pepper Tree
p,cl*		Senecio cineraria	3		Dusty Miller,Silver Plant
p,cl	SD	Senna covesii	1-2		Desert Senna
S	CD	Senna lindheimeriana	4	(sh)	Senna
S,p,cl	SD,CD	Senna wislizenii	2		Cassia,Shrubby Senna
Gc	Africa	Sesuvium verrucosum	2	(t)	Sea Purslane,Ice Plant
Gr	SD,CD	Setaria macrostachya	3		Plains Bristle Grass
S	SD	Simmondsia chinensis	1-2		Jojoba,Goat Nut
S,T,cl*	CD	Sophora secundiflora	2-3		Mescal Bean,Texas Mountain Laurel
p,cl	SD,CD	Sphaeralcea spp.	1		Globe-Mallow
Gr	SD,CD	Sporobolus airoides	3		Alkali Sacaton
Gr	SD,CD	Sporobolus contractus	1		Spike Dropseed
Gr	SD,CD	Sporobolus cryptandrus	3		Sand Dropseed
Gr	SD,CD	Sporobolus flexuosus	2		Mesa Dropseed
Gr	SD,CD	Sporobolus wrightii	1		Sacaton
C	SD	Stenocereus (Lemaireocereus) thurberi	1	(t)	Organ Pipe Cactus

APPENDIX 5B
LOW WATER USE/DROUGHT TOLERANT PLANT LIST
TUCSON ACTIVE MANAGEMENT AREA

Plant Type Category	Region	Low Water Use/ Drought Tolerant Plant List	Watering Needs		
Gr	SD,CD	Stipa neomexicana	2		New Mexicofeathergrass
p,cl	SD	Tagetes lemmoni	3-4		Mountain Marigold
T	Asia	Tamarix aphylla	1		Athel Tree,Tamarisk
S,cl	SD,CD	Tecoma stans var. angustata	2-3	(sh)	Trumpet-Bush
S,cl	Africa	Tecomaria capensis	4	(sh)	Cape Honeysuckle
Gc,p	Medit.	Teucrium chamaedrys (prostratum)	2-3		Prostrate Germander
S		Teucrium fruticans	3		Bush Germander
Gr	SD,CD	Trichloris crinita	2		Two-feather trichloris
C		Trichocereus spp.	1-2		Trichocereus Cactus
Gr	SD,CD	Tridens muticus	2		Slim tridens
T,cl	CD	Ungnadia speciosa	3		Mexican Buckeye
S,T#	SD	Vauquelinia californica	2		Arizona Rosewood
p,cl	SD	Verbena gooddingii	3-4		Goodding Verbena
p,cl	S.Am.	Verbena peruviana	4		Peruvian Verbena
p,cl	S.Am.	Verbena tenuisecta(pulchella)	3		Moss Verbena,Fineleaf Verbena
an,cl	SD,CD	Verbesina encelioides	2		Crown Beard
p,cl	SD	Viguiera deltoidea	2		Golden Eye
T,S,cl		Vitex agnus-castus	2		Chaste Tree,Monk's Pepper
T	SD	Washingtonia filifera	2		California Fan Palm
T	SD	Washingtonia robusta	2-3	(sh)	Mexican Fan Palm
T,S	China	Xylosma congestum	3-4		Xylosma
A	SD	Yucca aloifolia	1		Spanish Bayonet Yucca
A	SD,CD	Yucca baccata	1		Banana Yucca
A	CD	Yucca brevifolia	1		Joshua Tree
A	CD	Yucca carnerosana	1		Giant Dagger Yucca
A	SD,CD	Yucca elata	1		Soaptree Yucca
Sc	U.S.	Yucca glauca	1		Small Soapweed Yucca
A	U.S.	Yucca recurvifolia(pendula)	2		Pendulous or Curveleaf Yucca
A,cl	CD	Yucca rigida	1		Blue Dagger Yucca
A	CD	Yucca rostrata	1		Beaked Yucca
Sc	SD	Yucca schottii	1		Mountain Yucca
A	CD	Yucca treculeana	1		Tree Yucca
A	SD	Yucca whipplei	1		Our Lord's Candle
Gc,cl	SD	Zauschneria californica	3		Hummingbird Trumpet
S,cl	SWUS	Zexmenia hispida	2-3	(sh)	Rough Zexmenia
p,cl	SD,CD	Zinnia acerosa	1		Desert Zinnia
p,cl	CD	Zinnia grandiflora	2		Rocky Mountain Zinnia
T,I	Asia	Zizyphus jujuba	2		Chinese Date

APPENDIX 5C.1
TOTAL GPCD CONSERVATION PROGRAM
CONSERVATION REQUIREMENT CALCULATION
TUCSON ACTIVE MANAGEMENT AREA

A. Residential:

1. Existing Residential Allotment

   a. Determine the population in single family housing units as of July 1, 2000,
   Determine the population in multifamily housing units as of July 1, 2000,
   Add the SF and MF Population to determine Year 2000 Residential Population;

   b. Multiply the year 2000 residential population by the provider's existing residential GPCD component (Table 5-5), multiply this number by the number of days in the year and divide the product by 325,851;

   c. The result is the annual volumetric allotment, in acre-feet, for existing residential uses. Reasonable reductions in GPCD are included in the annual target calculation.

2. New Single Family and Multifamily Residential Allotment:

   a. Determine the new single family housing units added since July 1, 2000,
   Determine the new single family population (post-7/1/00) for the calendar year,
   Determine the new multifamily housing units added since July 1, 2000,
   Determine the new multifamily population (post-7/1/00) for the calendar year;

   b. Multiply the new single family population by the interior rate for new single family residential development, 57 GPCD, then multiply the result by the number of days in the year and divide the product by 325,851;

   c. Multiply the new single family housing units by the exterior rates for new single family residential development, 118 GPHUD, then multiply the result by the number of days in the year and divide the product by 325,851;

   d. Multiply the new multifamily population by the rate for new multifamily residential development, 78 GPCD, then multiply the result by the number of days in the year and divide the product by 325,851;

   e. The sum of the results of paragraphs b, c, and d is the annual volumetric allotment, in acre-feet, for new residential uses.

3. Add the existing residential allotment and the new residential allotment. The sum is the TOTAL RESIDENTIAL ALLOTMENT for the calendar year.

B. Non-Residential:

1. Multiply the total population for the calendar year by the provider's non-residential GPCD component from Table 5-5, multiply the result by the number of days in the year and divide the product by 325,851;
2. The result is the volumetric allotment, in acre-feet, for non-residential uses for the calendar year.

APPENDIX 5C.1
TOTAL GPCD CONSERVATION PROGRAM
CONSERVATION REQUIREMENT CALCULATION
TUCSON ACTIVE MANAGEMENT AREA

C. Turf-Related Facilities:

The turf-related facilities component is the sum of the maximum annual water allotments, in acre-feet, for the turf-related facilities assigned to the provider in Appendix 5G. The allotment for a turf-related facility is included only if the facility is served water from any source by the provider during the calendar year.

D. Lost and Unaccounted For Water (LUW):

1. Subtract the total amount of water served during the calendar year for residential, non-residential, turf-related facilities, and system-related uses from the total amount of water withdrawn, received, diverted and recovered during the calendar year. The remainder is the LUW volume.
2. Divide the LUW volume by the total amount of water withdrawn, received, diverted and recovered for the calendar year and multiply the result by 100.

3a. If the product is **less than or equal to** 10 percent, the volume of lost and unaccounted for water from D.1 is the volumetric allotment, in acre-feet, for the calendar year.

3b. If the product is **greater than** 10 percent, multiply the total amount of water withdrawn, received, diverted and recovered for the calendar year by 10 percent. The product is the volumetric allotment, in acre-feet, for lost and unaccounted for water for the calendar year.

APPENDIX 5C.2
TOTAL GPCD CONSERVATION PROGRAM
CONSERVATION REQUIREMENT CALCULATION EXAMPLE
TUCSON ACTIVE MANAGEMENT AREA

Example: The existing population is comprised of the occupants of housing units being served by the water provider as of July 1, 2000. The new population is comprised of occupants of housing units added to the provider's service area after July 1, 2000.

1) EXISTING HOUSING UNITS/POPULATION

a. Existing (7/1/00) SF Housing Units	= 23,089
b. Existing (7/1/00) MF Housing Units	= 4,132
c. TOTAL EXISTING RESIDENTIAL HOUSING UNITS	**= 27,221**
d. Existing (7/1/00) SF Population	= 72,554
e. Existing (7/1/00) MF Population	= 8,785
f. TOTAL EXISTING RESIDENTIAL POPULATION	**= 81,339**

2) NEW HOUSING UNITS/POPULATION

a. New SF Housing Units Added after July 1, 2000	= 7,717
b. New MF Housing Units Added after July 1, 2000	= 1,381
c. TOTAL NEW RESIDENTIAL HOUSING UNITS	**= 9,098**
d. New SF Population Added since July 1, 2000	= 24,258
e. New MF Population Added since July 1, 2000	= 2,937
f. TOTAL NEW RESIDENTIAL POPULATION	**= 27,195**

3) COMPONENT RATES

a. Existing Residential GPCD Component	= 115 (1)
b. New Residential SF Interior GPCD Component	= 57 (2)
c. New Residential SF Exterior GPHUD Component	= 118 (2)
d. New Residential MF Residential GPCD Component	= 78 (2)
e. Non-Residential GPCD Component	= 32 (3)

4) COMPONENT ALLOTMENTS IN ACRE-FEET

a. Existing Residential = 81,339 people x 115 GPCD x 365 / 325851	= 10,478 AF/YR
b. New SF Interior = 24,258 people x 57 GPCD x 365 / 325851	= 1,549 AF/YR
c. New SF Exterior = 7,717 housing units x 118 GPHUD x 365 / 325851	= 1,020 AF/YR
d. New MF Residential = 2,937 people x 78 GPCD x 365 / 325851	= 257 AF/YR
e. Residential Allotment	**= 13,304 AF/YR**
f. Non-Residential = 108,534 people x 32 GPCD x 365 / 325851	= 3,890 AF/YR
g. Non-residential Allotment	**= 3,890 AF/YR**
h. Turf-related Facility = the MAWA for one 18-hole golf course	**= 428 AF/YR**
i. Lost/Unaccounted Water Component @ 10 percent of total annual use	= 1,958(4)AF
j. Lost/unaccounted For Allotment	**= 1,958 AF**
k. TOTAL ALLOTMENT = Res. + Non-Res. + Turf + LUW	**= 19,580 AF**

5. ANNUAL TOTAL GALLONS PER CAPITA PER DAY REQUIREMENT

Total GPCD Requirement =19,580 AF x 325,851 / 108,534 / 365 **= 161 GPCD**

(1) The existing GPCD components are listed in Table 5-5 for each large provider. The number given here is for example purposes only.

(2) The New Single Family Interior and Multifamily GPCD and Single Family Exterior GPHUD components are based on the requirements for the Tucson AMA. See Appendices 5E and 5F.

(3) Non-Residential GPCD components are listed in Table 5-5. For providers assigned a non-residential component less than 21 GPCD, the non-residential component may increase up to 21 GPCD during any calendar year.

(4) The Lost and Unaccounted for Water component may vary in any calendar year. The component will equal the amount of lost and unaccounted for water for the calendar year, not to exceed 10%.

APPENDIX 5D
BASE PERIOD (1992-1995) WATER USE DATA FOR LARGE MUNICIPAL PROVIDER
TUCSON ACTIVE MANAGEMENT AREA

Provider	Single Family Residential Use (GPCD)	Multifamily Residential Use (GPCD)	Non-Residential Use (GPCD)	Turf-Related (AF/YR)	Lost Water (%)
Arizona WC	72	35	8	0	15
ASPC - Tucson[1]	N/A	N/A	N/A	N/A	N/A
Avra Water Coop	109	0	4	0	9
City of Tucson	124	90	37	874	8
Community WC of Green Valley	119	99	21	0	8
Davis-Monthan Air Force Base	125	40	162	224	NR
Farmers WC	181	137	136	0	6
Flowing Wells ID	181	104	21	124	9
Forty-Niner WC	291	171	15	478	3
Green Valley WC	125	0	27	1,433	3
Lago Del Oro WC	125	0	29	429	2
Las Quintas Serenas WC	108	114	15	0	9
Marana Water Service	138	0	0	0	16
Metropolitan DWID[2]	162	91	25	43	7
Ray WC	114	79	8	0	4
Town of Marana[3]	117	68	7	0	13
Town of Oro Valley[4]	141	39	42	1,632	3
University of Arizona	0	40	199	0	NR
Voyager WC	149	78	23	0	15

WC = Water Company
ID = Irrigation District
DWID = Domestic Water Improvement District
NR = not reported
N/A = not applicable

1 Institutional Provider
2 Includes Hub Water Company
3 Includes Cortaro WUA, IM WC Palo Verde System, Marana Municipal Water System & Marana-Picture Rocks Water System; Happy Acres & Picture Rocks Systems
4 Includes Cañada Hills and Rancho Vistoso Water Companies

APPENDIX 5E
INTERIOR WATER USE MODEL FOR NEW RESIDENTIAL DEVELOPMENT
SINGLE AND MULTIFAMILY UNITS
TUCSON ACTIVE MANAGEMENT AREA

1. **1.7 g/flush Toilet**[1]
   A. 4.5 flush per day national average[2]
   B. Adjusted to 5 flushes per day to reflect higher retiree population in AZ.
   C. Average flush for ULF toilets 1.7 gallons[2]
   D. *Calculation:*

   1.7 gallons/flush * 5 flushes per person per day = **8.5 GPCD**

2. **2.5 gpm Showerhead**[1]
   A. 7.9 minutes per shower national average[2]
   B. 0.9 shower per person per day[3]
   C. 2.5 gallons per minute
   D. *Calculation:*

   7.9 minutes per shower * 2.5 gallons per minute * 0.9 shower per day = **17.8 GPCD**

3. **Low Water Use Dishwasher**
   A. 9.8 gallons per cycle[4]
   B. 0.2 cycle per person per day[2]
   C. *Calculation:*

   9.8 gallons per cycle * 0.2 cycle per person per day = **2.0 GPCD**

4. **Low Water Use Clotheswasher**
   A. 30.3 gallons per cycle[4]
   B. 0.30 cycle per person per day[2]
   C. *Calculation:*

   30.3 gallons per cycle * 0.3 cycle per person per day = **9.1 GPCD**

5. **Bathtub**
   A. 32.5 gallons average bathtub volume at maximum fill.
   B. Use/person/day set at 0.1 to allow 1 bathing event/person/day: 0.9 shower/person/day + 0.1 bath/person/day = 1.0 bathing event/person/day.
   C. *Calculation:*

   32.5 gallons per bath *0.1 bath per person per day = **3.3 GPCD**

6. **2.5 gpm Faucets**
   A. 10 GPCD national average faucet use[5]
   B. 2.5 gallons per minute
   C. *Calculation:*

   4.0 minutes per person per day * 2.5 gallons per minute = **10.0 GPCD**

[1] City of Tucson and Pima County Plumbing Codes, adopted 1992.
[2] Mayer, P., DeOreo, W., Nelson, J., Opiz, E. & Allen, B., "North American Residential End Use Study Progress Report", Proceedings of 1997 American Water Works Association Annual Conference, AWWA, 1997.
[3] City of Mesa and Logan, Simpson & Dye, "Final Paper: Multi-Family Exterior/Interior Water Use Efficiency Evaluation", October, 1996.
[4] Data from ADWR Phoenix AMA, Phoenix Area survey March, 1997 average water consumption by 3 models most often installed in new housing.
[5] Data from John O. Nelson Water Resources management for AWWA WaterWiser™ (www.waterwiser.org), after Mayer, et. al., AWWA, 1997.

7. Miscellaneous[5]

A. Estimated unidentified flow trace volume = **6.0 GPCD**

New Residential Interior Water Use Model Summary

Toilet	9 GPCD
Shower	18 GPCD
Dishwasher	2 GPCD
Clotheswasher	9 GPCD
Bathtub	3 GPCD
Faucets	10 GPCD
Miscellaneous	6 GPCD
	57.0 GPCD

[5] Data from John O. Nelson Water Resources management for AWWA WaterWiser™ (www.waterwiser.org), after Mayer, et. al., AWWA, 1997.

APPENDIX 5F.1
EXTERIOR WATER USE MODEL FOR NEW RESIDENTIAL DEVELOPMENT
SINGLE FAMILY HOUSING UNITS
TUCSON ACTIVE MANAGEMENT AREA

SWIMMING POOLS

Average Water Consumption

1. Evaporation[1]
   A. Average April, 1986 - February, 1999, Reference Evapotranspiration (ETo) = 77.56 inches/yr
   B. Average January, 1987 - February, 1999, Rainfall = 10.65 inches/yr
   C. *Calculation:*

      77.56 in/yr ETo - 10.65 in/yr rainfall = 66.91 in/yr
      66.91 inches per year / 12 inches per foot = 5.58 ft/yr
      400 square feet * 5.58 ft/yr * 7.48 gal/cubic foot = **16,684 gallons/year**

2. Backwash[2]
   A. Recommended backwash 2 to 4 minutes 23 times a year at 75 to 85 gallons per minute
   B. *Calculation:*

      2 minutes * 75 gpm * 23 times/year = **3,450 gallons/year**

3. Maintenance Refill[2]
   A. Average pool size is 400 square feet of surface by 5 feet deep
   B. Allow for a refill once every ten years - ADWR assumption
   C. *Calculation:*

      400 * 5 = 2,000 * 7.48 = 14,960 gallons per new pool
      14,960 gallons / 10 years = **1,496 gallons/year**

4. Initial Fill
   A. Average pool size is 400 square feet of surface by 5 feet deep
   B. *Calculation:*

      400 * 5 = 2,000 * 7.48 = **14,960 gallons**

5. Total Annual Demand
   A. Total Demand for Pool:

Evaporation	16,684 gallons/year
Backwash	3,450 gallons/year
Initial Fill	14,960 gallons/year
Maintenance Refill	1,496 gallons/year
	36,590 gallons/year

   B. Savings From Pool cover:[1]
      1) Average Oct. - Apr. Reference Evapotranspiration (ETo) = 32.40 inches/yr
      2) Average Oct. - Apr. Rainfall = 6.14 inches/yr
      3) *Calculation:*

         32.40 in/yr ETo - 6.14 in/yr rainfall = 26.26 in/yr
         26.26 inches per year / 12 inches per foot = 2.19 ft/yr
         400 square feet * 2.19 ft/yr * 7.48 gal/cubic foot = **6,547 gallons per year**

[1] ETo and rainfall from Arizona Meteorological Network, Tucson Station (www.ag.arizona.edu/AZMET)
[2] Data from National Spa and Pool Institute, ADWR Phoenix AMA telephone interview, December, 1995.

APPENDIX 5F.1
EXTERIOR WATER USE MODEL FOR NEW RESIDENTIAL DEVELOPMENT
SINGLE FAMILY HOUSING UNITS
TUCSON ACTIVE MANAGEMENT AREA

SWIMMING POOLS

Installation Rates[3]

A. 21.24% of respondents to survey of housing units built 1992-1995 in Tucson Water and Metro Water District service areas have a pool or intend to install one.
B. 2.12% of new housing install a pool per year.
C. 59.22% of pool owners use a pool cover from October through April.
D. *Calculation:*

Evaporation	16,684 gallons/year * 21.24%	=	3,544 gallons/year
Backwash	3,450 gallons/year * 21.24%	=	733 gallons/year
Initial Fill	14,960 gallons/year/10 years* 21.24%	=	318 gallons/year
Maintenance Refill	1,496 gallons/year * 21.24%	=	318 gallons/year
			4,912gallons/year
Cover	6,547 gallons/year * 59.22% * 21.24%	=	-824 gallons/year
			4,089 gallons/year

Demand per Housing Unit per Day
4,089 gallons/year / 365 days/year = **11.20 GPHUD**

[3] Craft, Marti, data from exterior water use survey of single family residential housing built 1992-1996, Tucson Water and Metro Water District service areas, for ADWR, 1997.

APPENDIX 5F.2
EXTERIOR WATER USE MODEL FOR NEW RESIDENTIAL DEVELOPMENT
SINGLE FAMILY HOUSING UNITS
TUCSON ACTIVE MANAGEMENT AREA

SPAS

Average Water Consumption

1. Evaporation[1]
   A. Average April, 1986 - February, 1999, Reference Evapotranspiration (ETo) = 77.56 inches/yr
   B. Average January, 1987 - February, 1999, Rainfall = 10.65 inches/yr
   C. *Calculation:*
      77.56 in/yr ETo - 10.65 in/yr rainfall = 66.91 in/yr
      66.91 inches per year / 12 feet per inch = 5.58 ft/yr
      36 square feet * 5.58 ft/yr * 7.48 gal/cubic foot = **1,502 gallons/year**

2. Maintenance Refill[4]
   A. Average spa size is 36 square feet of surface by 4 feet deep
   B. Allow for refill 4 times per year
   C. *Calculation:*
      36 * 4 = 144 * 7.48 =1,077 gallons * 4 = **4,308 gallons/year**

3. Total Annual Demand
   A. Total Demand for Spa:

Evaporation	1,502 gallons/year
Maintenance Refill	4,308 gallons/year
	5,810 gallons/year

   B. Savings From Pool cover:[1]
      1) Average Oct. - Apr. Reference Evapotranspiration (ETo) = 32.40 inches/yr
      2) Average Oct. - Apr. Rainfall = 6.14 inches/yr
      3) *Calculation:*
         32.40 in/yr ETo - 6.14 in/yr rainfall = 26.26 in/yr
         26.26 inches per year / 12 feet per inch = 2.19 ft/yr
         36 square feet * 2.19 ft/yr * 7.48 gal/cubic foot = **589 gallons per year**

Installation Rates[3]

A. 28.42% of respondents to survey of housing units built 1992-1995 in Tucson Water and Metro Water District service areas have a spa or intend to install one.
B. 54.55% of spa owners use a spa cover from October through April.
C. *Calculation:*

Evaporation	1,502 gallons/year * 28.42%	=	427 gallons/year
Maintenance Refill	4,308 gallons/year * 28.42%	=	1,224 gallons/year
			1,651 gallons/year
Cover	589 gallons/year * 54.55% * 28.42%	=	-91 gallons/year
			1,560 gallons/year

Demand per Housing Unit per Day

1,560 gallons/year / 365 days/year = **4.27** GPHUD

[4] Data from ADWR, Tucson AMA, survey of Tucson Area spa owners, November, 1997.

APPENDIX 5F.3
EXTERIOR WATER USE MODEL FOR NEW RESIDENTIAL DEVELOPMENT
SINGLE FAMILY HOUSING UNITS
TUCSON ACTIVE MANAGEMENT AREA

EVAPORATIVE COOLERS

Average Water Consumption[5]

1. Average water consumption per cooling season for evaporative coolers with a bleed-off system is 23,462 gallons (2,905.9 cooling hours per season @ 8.1 gallons per hour).
2. Average water consumption per cooling season for evaporative coolers without a bleed-off system is 11,621 gallons (2,908.9 cooling hours per season @ 4.0 gallons per hour).
3. 40.98% of coolers utilize a bleed-off system.
4. 59.02% of coolers do not utilize a bleed-off system.
5. *Calculation:*

23,462 * 59.02%	=	13,846 gallons
11,621 * 40.98%	=	4,763 gallons
		18,609 gallons

Installation Rates[3]

1. 3.99% of respondents to survey of housing units built 1992-1995 in Tucson Water and Metro Water District service areas have only evaporative cooling.
2. 10.70% have both evaporative and refrigeration cooling.
3. Dual system households average cooling hours per season 59.52% of cooler only households cooling hours
4. *Calculation:*

18,609 gallons/year * 3.89%	=	724 gallons/year
18,609 gallons/year * 10.42% * 59.52%	=	1,154 gallons/year
		1,878 gallons/year

Demand per Housing Unit per Day

1,878 gallons/year / 365 days/year = **5.14 GPHUD**

[5] Data from Karpiscak, M., Babcock, T., France, G., Zauderer, J., Hopf, S. And Foster, K., "Evaporaive Cooler Water Use In Phoenix", Journal, Vol. 90, Issue 4 (April, 1998), American Water Works Association.

APPENDIX 5F.4
EXTERIOR WATER USE MODEL FOR NEW RESIDENTIAL DEVELOPMENT
SINGLE FAMILY HOUSING UNITS
TUCSON ACTIVE MANAGEMENT AREA

LANDSCAPING

Average Water Consumption

1. Turf
   A. Median turf area for surveyed housing units built 1992-1995 is 553 square feet[3]
   B. Water application at 60% of average annual reference evapotranspiration (77.56 inches)[1]
   C. Effective rainfall at 50% of annual average (10.65 inches)[1]
   D. Irrigation efficiency for residential sprinkler systems at 75%
   E. *Calculation:*

      77.56 inches * 60% = 46.54 inches
      10.65 inches * 50% = 5.33 inches
      46.54 inches - 5.33 inches = 41.22/ 12 = 3.43 feet * 553 sq.ft. = 1,899 cu.ft.
      1,899 cu.ft * 7.48 = 14,207 gallons / 75% = **18,942 gallons**

2. Garden
   A. Median garden area for surveyed housing units built 1992-1995 is 183 square feet [3]
   B. Water application at 70% of average annual reference evapotranspiration (77.56 inches)[1]
   C. Effective rainfall at 10% of annual average (10.65 inches)[1]
   D. Irrigation efficiency for basin or soaker hose watering at 70%
   E. *Calculation:*

      77.56 inches * 70% = 54.29 inches
      10.65 inches * 10% = 1.07 inches
      54.29 inches - 1.07 inches = 53.22 / 12 = 4.44 feet * 183 sq.ft. = 812 cu.ft.
      812 cu.ft * 7.48 = 6,072 gallons / 70% = **8,674 gallons**

3. Trees
   A. Mean number of trees for surveyed housing units built 1992-1995 is 1.60 high water use species, 73.54% evergreen, 26.46% decidious; 0.40 medium water use species, 60.70% evergreen, 39.30% decidious; 7.78 low water use species, 17.59% evergreen, 82.41% decidious.[3]
   B. Water application (% of average reference evapotranspiration)[1,6]
      1) High water use species 58.0%
      2) Medium water use species 35.5%
      3) Low water use species 19.5%
   C. Reference Evapotranspiration[1,6]
      1) HWU and MWU evergreen species, annual average, 77.56 inches
      2) LWU evergreen species, Mar. - Nov. average, 68.40 inches.
      3) HWU decidious species, April - October average, 58.95 inches
      4) MWU & LWU deciduous species, April - September average, 53.14 inches
   D. 14 foot average canopy diameter at maturity = water demand at 96 gallons/inch of ET_{tree} [6]
   E. Effective rainfall at 10% of annual average (10.65 inches), Mar. - Nov. average (7.12 inches), Apr.-Oct. average (5.50 inches), or Apr. - Sep. average (4.83 inches)[1]
   F. Irrigation efficiency = 70%[7]

APPENDIX 5F.4
EXTERIOR WATER USE MODEL FOR NEW RESIDENTIAL DEVELOPMENT
SINGLE FAMILY HOUSING UNITS
TUCSON ACTIVE MANAGEMENT AREA

LANDSCAPING

G. *Calculation:*

77.56 inches * 58.0% = 44.98 inches
75.10 inches * 35.5% = 26.66 inches
68.40 inches * 19.5% = 13.34 inches
58.95 inches * 58.0% = 34.19 inches
53.14 inches * 35.5% = 18.86 inches
53.14 inches * 19.5% = 10.36 inches
10.65 inches * 10% = 1.07 inches, 7.12 inches * 10% = 0.71 inch, 5.50 inches*10% = 0.55 inch, 4.83 inches*10% = 0.48 inch

44.98 - 1.07 = 43.92 * 96 = 4,217 gallons * 1.60 HWU trees * 73.54% = 4,973 gallons
34.19 - 0.55 = 33.64 * 96 = 3,230 gallons * 1.60 HWU trees * 26.46% = 1,370 gallons
26.66 - 0.93 = 25.73 * 96 = 2,470 gallons * 0.40 MWU trees * 60.70% = 600 gallons
18.86 - 0.48 = 18.38 * 96 = 1,765 gallons * 0.40 MWU trees * 39.30% = 278 gallons
13.34 - 0.71 = 12.63 * 96 = 1,212 gallons * 7.78 LWU trees * 17.59% = 1,658 gallons
10.36 - 0.48 = 9.88 * 96 = 949 gallons * 7.78 LWU trees * 82.41% = 6,079 gallons
14,958 gallons

14,958 gallons / 70% = **21,369 gallons**

4. Shrubs, accents, groundcover, vines
   A. Average number of plants for surveyed housing units built 1992-1995 is 1.02 high water use species,12.43 medium water use species, 9.86 low water use species.[3]
   B. Water application (% of average annual reference evapotranspiration, 77.56 inches)[1,6]
      1) High water use evergreen species 58.0%
      2) Medium water use evergreen species 35.5%
      3) LWU evergreen species (Mar.-Nov. ETo) 19.5%
   C. 4 foot average canopy diameter at maturity = water demand at 8 gallons/inch of ET_{plant}[6]
   D. Effective rainfall at 10% of annual average (10.65 inches, Mar.-Nov. average 7.12 inches)
   E. Irrigation efficiency =70%[7]
   F. *Calculation:*

77.56 inches * 58.0% = 44.98 inches
75.10 inches * 35.5% = 26.66 inches
68.40 inches * 19.5% = 13.34 inches
10.65 inches * 10% = 1.07 inches, 7.12 inches * 10% = 0.71 inch
44.98- 1.07 = 43.92 * 8 = 351 gallons * 1.02 shrubs = 357 gallons
26.66- 0.93 = 25.73 * 8 = 206 gallons * 12.43 shrubs = 2,558 gallons
13.34- 0.71 = 12.63 * 8 = 101 gallons * 9.86 shrubs = 996 gallons
3,910 gallons

3,910 gallons / 70% = **5,586 gallons**

Installation Rates[3]

1. 27.80% of respondents to survey of housing units built 1992-1995 in Tucson Water and Metro Water District service areas have turf.
2. 38.33% have a garden (flower, vegetable, herb).
3. 100% installation of average tree, accent, shrub and groundcover frequency is assumed.

APPENDIX 5F.4
EXTERIOR WATER USE MODEL FOR NEW RESIDENTIAL DEVELOPMENT
SINGLE FAMILY HOUSING UNITS
TUCSON ACTIVE MANAGEMENT AREA

LANDSCAPING

4. *Calculation:*

18,942 gallons/year * 27.80% =	5,265 gallons/year
8,674 gallons/year * 38.33% =	3,325 gallons/year
21,369 gallons/year * 100.00% =	21,369 gallons/year
5,586 gallons/year * 100.00% =	5,586 gallons/year
	35,544 gallons/year

Demand per Housing Unit per Day
35,544 gallons/year / 365 days/year = **97.38 GPHUD**

New Residential Exterior Water Use Model Summary

Swimming Pool	11.20 GPHUD
Spa	4.27 GPHUD
Evaporative Cooler	5.14 GPHUD
Landscaping	97.38 GPHUD
	118.00 GPHUD

(NOTE: All numbers in the exterior water use Appendices have been rounded to no more than two decimal places. Calculations were performed in a spreadsheet file at 15 decimal places. Performing the calculations at fewer decimal places may not result in the value shown in the Appendices.)

6 Pima County Cooperative Extension Service, Low4 Program, Landscape Water Conservation Workshop materials: "How to Develop a Drip Irigation Schedule" and "Plant Water Requirements Tucson, Arizona", unpublished.

7 "Landscape Water Management Principles", Irrigation Training and Research Center, California Polytechnic State University, San Luis Obispo, undated.

APPENDIX 5G
TOTAL GPCD CONSERVATION PROGRAM
TURF-RELATED FACILITIES SERVED GROUNDWATER BY MUNICIPAL PROVIDERS
AS OF JANUARY 1, 1990 AND MAXIMUM ANNUAL WATER ALLOTMENTS
TUCSON ACTIVE MANAGEMENT AREA

Water Provider - Turf-Related Facility	Allotment (acre-feet)
City of Tucson (COT)	
Christopher Columbus Park	121.4
El Rio Golf Course	467.5
Fort Lowell Park	132.9
Fred Enke Golf Course	416.0
Himmel Park	102.2
Jesse Owens Park	115.2
Joaquin Murrieta Park	98.4
Kennedy Park	182.8
Manzanita Park	65.8
McCormick Park	55.2
Mission Park	153.6
Palo Verde Park	98.0
Reid Park	356.8
Rodeo Park	151.5
Santa Rita Park	75.0
Sunnyside Park	138.0
Tucson Estates Golf Course	140.9
COT TOTAL	**2,871.2**
Davis-Monthan Air Force Base	
General Wm. Blanchard Golf Course	358.8
Flowing Wells Irrigation District (FWID)	
Flowing Wells High School	64.9
Flowing Wells Junior High School	84.2
FWID TOTAL	**149.1**
Forty-Niner Water Company	
Forty-Niner Golf Course	598.8
Green Valley Water Company (GVWC)	
Desert Hills Golf Course	482.7
Morry Canoa Hills Golf Course	475.4
San Ignacio Golf Course	428.5
GVWC TOTAL	**1,386.6**
Lago Del Oro Water Company	
SaddleBrooke Golf Course	628.1
Town of Oro Valley (TOV)	
Dennis Weaver Park	65.8
El Conquistador County Club	896.2
El Conquistador Resort Golf Course	173.3
Sun City Vistoso Golf Course	419.9
TOV TOTAL	**1,555.2**

APPENDIX 5H.1

RESIDENTIAL INTERIOR AND EXTERIOR STANDARD REASONABLE CONSERVATION MEASURES

RESIDENTIAL INTERIOR
STANDARD RCM

ORDINANCE OR CONDITION OF NEW SERVICE PROHIBITING INSTALLATION OR REPLACEMENT OF PLUMBING FIXTURES IN RESIDENTIAL HOUSING UNITS UNLESS FIXTURES MEET WATER SAVING STANDARDS

Description: *The provider adopts an ordinance or establishes conditions of new service prohibiting the installation of plumbing fixtures in new residential housing units and the replacement of plumbing fixtures in existing residential housing units unless the fixtures meet water efficiency standards. Plumbing fixtures to be covered and their respective maximum use rates are as follows:*

- *Faucets-kitchen and lavatory* — *3.0 gpm*
- *Replacement aerators - kitchen and lavatory* — *3.0 gpm*
- *Metering faucets* — *.25 gpc*
- *Toilets* — *1.6 gpf*
- *Showerheads* — *3.0 gpm*
- *Evaporative cooling systems/Decorative fountains must be equipped with water recycling or reuse systems*

Waivers may be available for unusual circumstances (e.g., historic buildings or areas where sanitation or health codes may conflict).

Implementation: *The provider shall adopt and enforce a plumbing ordinance or establish conditions of new service prohibiting the installation of plumbing fixtures in new housing units and the replacement of plumbing fixtures in existing housing units unless the fixtures meet the water savings performance standards outlined in the description above. Implementation of this RCM shall include a proactive inspection and enforcement program that ensures compliance with the applicable ordinance or conditions of service.*

Monitoring/Reporting: *The annual report required by A.R.S. § 45-632 shall include a copy of the current local plumbing ordinance or sample conditions of new service agreement that meet the implementation requirements for this RCM. This shall be submitted one time only (the first year of compliance with the Non-Per Capita Conservation Program) unless there is an amendment to the ordinance or agreement.*

In addition, the provider shall include in the annual report evidence of implementation of the applicable ordinance or conditions of service by reporting the number of certificates of occupancy issued in the service area, the number of permits issued for the replacement of plumbing fixtures in existing housing units, the number of housing units inspected, the number and type of plumbing fixture violations and any enforcement action taken.

A provider that is not a city or town shall also collect and examine all inspection records for new permits issued by governmental entities for the installation of original plumbing fixtures in new housing units and the replacement of plumbing fixtures in existing housing units within the provider's service area and report any plumbing code or plumbing ordinance violations that have not been enforced to the governing body of the entity charged with enforcing the code or ordinance.

Note: This documentation will be used to evaluate the effectiveness of the RCM. It will not be used to require any modification of the negotiated Non-Per Capita Conservation Program agreement.

RESIDENTIAL INTERIOR
STANDARD RCM

WATER AUDIT AND FIXTURE RETROFIT PROGRAM FOR EXISTING RESIDENTIAL CUSTOMERS

Description: *Water provider staff or hired consultants visit residences, or resident performs self-audit, to examine water use practices, detect leaks, make recommendations for improved efficiency and install retrofit devices. Water use reduction from installation of devices depends on the life of the device, for example toilet flapper normally last about five years.*

Implementation Levels: *Minimum Conservation Potential: The provider shall notify all existing residential customers of the availability of a self-audit and retrofit kit. The provider shall distribute a kit to all customers who request one. Moderate Conservation Potential: The provider shall perform minimum level requirement, plus a minimum of 10 percent of all pre-1980 housing units shall be audited and retrofitted, free of charge to the customer, by January 1, 2010 either by the homeowner or by a trained auditor. Maximum Conservation Potential: The provider shall perform minimum level requirement, plus a minimum of 20 percent of all pre-1980 housing units shall be audited and retrofitted, free of charge to the customer, by January 1, 2010 either by the homeowner or by a trained auditor.*

The self-audit and retrofit kit shall include, at a minimum, toilet leak detection dye tabs, instructions on measuring flow from fixtures, leak repair and fixture replacement instructions, advice on behavioral changes to save water, a toilet conservation device, a low flow showerhead and faucet aerators. The audit shall include measurement of flow rates from plumbing fixtures and a check for leaks.

The housing units audited or retrofitted to meet this requirement shall not include any housing unit that was audited or retrofitted prior to acceptance into this program for the third management period unless the water use of the housing unit is inefficient.

Monitoring and Reporting Requirements: *The Annual Report required by A.R.S. § 45-632 shall include a report containing information as agreed to at the time of acceptance into the Non-Per Capita Conservation Program sufficient to assess program effectiveness, including information on the method(s) used to contact customers, the annual number of audits and retrofits performed and self-audit kits sent out, and an estimate of the number and volume of leaks found and repaired.*

RESIDENTIAL EXTERIOR
STANDARD RCM

AUDIT PROGRAM FOR EXISTING RESIDENTIAL CUSTOMERS
Description: *Trained auditors visit residences to examine outdoor water use practices, or materials are supplied for a self-audit of outdoor water use practices. Areas of emphasis are irrigation scheduling advice, sprinkler and drip systems inspection, evaporative cooler inspection, information on improving water retaining capacity of the soil, information on Xeriscape™ concepts and swimming pool maintenance and evaporation control (i.e., pool covers). This program shall be designed to target those customers with the greatest conservation potential.*
Implementation Levels: *Minimum Conservation Potential: The provider shall notify all existing residential customers of the availability of an exterior water use self-audit packet. The packet shall include at a minimum information on checking irrigation systems for efficiency and leaks, information on checking evaporative coolers for efficiency and leaks, irrigation schedules, and information on Xeriscape™. The provider shall distribute a packet to all customers who request one. Moderate Conservation Potential: The provider shall implement the minimum level program plus 5 percent of total housing units in existence when the provider is accepted into this program shall be audited either by the homeowner or a trained auditor free of charge to the customer. Audits shall be completed by January 1, 2010. Maximum Conservation Potential: The provider shall implement the minimum level program plus 10 percent of total housing units in existence when the provider is accepted into this program shall be audited either by the homeowner or a trained auditor free of charge to the customer. The audits shall be completed by January 1, 2010.* *For both the moderate and maximum levels of implementation, the ratio of audited multifamily housing units to audited single family housing units shall be no greater than the ratio of total multifamily housing units to total single family housing units in the entire service area.* *The housing units audited to meet this requirement shall not include any housing unit that was audited prior to acceptance into this program for the third management period unless the water use of the housing unit is inefficient.*
Monitoring and Reporting Requirements: *The Annual Report required by A.R.S. § 45-632 shall include a report on the number of housing units audited, plus a follow-up survey of a statistically significant sample of those audited, as agreed to by the director, to determine if audited customers have implemented any changes in exterior use habits, irrigation system, or landscaping.*

LANDSCAPE WATERING ADVICE PROGRAM FOR EXISTING AND NEW RESIDENTIAL CUSTOMERS

Description: *Landscape watering advice helps existing and new homeowners to irrigate efficiently. The components of a landscape watering advice program may include guidelines for irrigation scheduling based on time of day or season and dissemination of weather-based watering information (e.g: ET rate based on solar radiation, temperature, rainfall and relative humidity). Programs that encourage watering only every other day and only at certain times of day have also been shown to save water.*

Implementation Levels: *Minimum Conservation Potential: The provider shall notify all existing and new residential customers of the availability of information from the provider regarding the general benefits of efficient landscape watering including water and cost savings. This notification shall be through water bill inserts printed directly on bills in a prominent manner, or some other mechanism approved by the director. The provider shall distribute the landscape watering information to all customers who request it. Moderate Conservation Potential: The provider shall mail the landscape watering information to all existing and new residential customers or make it available to the customers at local distribution centers such as schools, libraries, plant nurseries, or model homes and notify all residential customers of the location of the information. Maximum Conservation Potential: The provider shall implement the moderate level programs plus hold workshops on landscape irrigation and/or have a landscape advisor available for telephone advice to customers and/or develop a conservation goal-billing program designed to assist residential customers to determine the requirements for landscape water use. The provider shall hold at least one workshop annually for every 100,000 persons in the provider's service area. If there are less than 100,000 persons, the provider shall hold one workshop annually. If the telephone advice option is chosen, the provider shall publicize the telephone number at least once quarterly.*

Monitoring and Reporting Requirements: *The Annual Report required by A.R.S. § 45-632 shall include a report on the methods used to contact customers, the number of pamphlets/brochures distributed, the number of workshops conducted, and the number of phone calls taken to give landscape irrigation advice.*

ORDINANCE OR CONDITION OF NEW SERVICE FOR MODEL HOMES IN NEW RESIDENTIAL DEVELOPMENTS

Description: *Model homes in new developments are required to use low water use landscaping in front yards to set the tone for landscaping by homeowners. This measure helps to educate home buyers about the possibilities of appropriate landscaping for the area. Provision of information on low water use landscaping and/or landscape packages offered to new home buyers reinforces the message.*

Implementation: *The provider shall adopt and enforce an ordinance or establish conditions of new service requiring that new model homes meet water efficient standards. These include limitation of water-intensive landscaping to 10 percent of landscapable area, location of such landscaping where it is functionally useful, use of low water use plants from the Department's Low Water Use/Drought Tolerant Plant List (Appendix 5B) in the remaining area, and use of efficient irrigation systems in all areas. Information on low water use landscaping and/or landscape packages with low water use landscaping shall be made available and displayed in a prominent manner at the model home site. For purposes of this RCM, the term "water-intensive landscaped area" means an area of land that is watered with a permanent water application system and planted primarily with plants not listed in Appendix 5B (Low Water Use/Drought Tolerant Plant List), or any modifications to the list, and the total surface area of all water features (including swimming pools of any size, fountains, ponds, water courses, waterfalls, and other artificial water structures) filled or refilled with water from any source.*

Monitoring and Reporting Requirements: *The Annual Report required by A.R.S. § 45-632 shall include a copy of the ordinance or sample conditions of new service agreement used to meet the implementation requirements for this RCM. This shall be submitted one time only (the first year of compliance with the Non-Per Capita Conservation Program) unless there is an amendment to the ordinance or agreement. Each calendar year the provider shall submit a report on the number and location of model homes built during the reporting year.*

In addition to the annual reporting requirements, the provider shall maintain and submit to the Department upon request a copy of the landscape packages or landscape information provided by each developer to new home buyers.

RESIDENTIAL EXTERIOR
STANDARD RCM

PROHIBIT THE CREATION OF COVENANTS, CONDITIONS AND RESTRICTIONS THAT REQUIRE THE USE OF WATER-INTENSIVE LANDSCAPING OR WHICH PROHIBIT THE USE OF LOW WATER USE LANDSCAPING IN NEW RESIDENTIAL DEVELOPMENTS
Description: *In an effort to promote and facilitate installation of water conserving landscaping, the provider refuses to serve water to new subdivisions that have covenants, conditions and restrictions which require the use of water-intensive landscaping or prohibit low water use landscaping. This would not prohibit water-intensive landscaping, but would allow homeowners to install the landscaping of their choice.*
Implementation: *The provider shall adopt and enforce an ordinance or establish conditions of new service requiring that developers of new subdivisions neither forbid low water use landscaping nor require water-intensive landscaping through covenants, conditions and restrictions.*
Monitoring and Reporting Requirements: *The Annual Report required by A.R.S. § 45-632 shall include a copy of the ordinance or sample conditions of new service agreement used to meet the implementation requirements for this RCM. This shall be submitted one time only (the first year of compliance with the Non-Per Capita Conservation Program) unless there is an amendment to the ordinance or agreement.*

RESIDENTIAL EXTERIOR
STANDARD RCM (CHOICE 1 OF 3)

ORDINANCE OR CONDITION OF NEW SERVICE LIMITING USE OF TURF AND OTHER WATER-INTENSIVE LANDSCAPING IN NEW MULTIFAMILY DEVELOPMENTS
Description: *The provider adopts an ordinance or establishes conditions of new service that limit and set criteria for water-intensive landscaping in multifamily developments.*
Implementation: *The provider shall adopt and enforce an ordinance or establish conditions of new service requiring that new multifamily developments meet water conserving landscaping standards, including limitation of water-intensive landscaping to individual patio areas and those areas used for active recreational purposes, and prohibiting water-intensive landscaping in all other areas, including common areas not used for active recreational purposes. In addition, the ordinance or conditions of new service shall require the use of efficient irrigation systems.* ***This RCM can be chosen only by providers with significant conservation potential in the new multifamily sector.***
Monitoring and Reporting Requirements: *The Annual Report required by A.R.S. § 45-632 shall include a copy of the ordinance or sample conditions of new service agreement used to meet the implementation requirements for this RCM. This shall be submitted one time only (the first year of compliance with the Non-Per Capita Conservation Program) unless there is an amendment to the ordinance or agreement.*

RESIDENTIAL EXTERIOR
STANDARD RCM (CHOICE 2 OF 3)

ORDINANCE OR CONDITION OF NEW SERVICE LIMITING USE OF TURF AND OTHER WATER-INTENSIVE LANDSCAPING IN COMMON AREAS OF NEW SINGLE FAMILY AND MULTIFAMILY DEVELOPMENTS
Description: *The provider adopts an ordinance or establishes conditions of new service that limits turf and other water-intensive landscaping within common areas of new single family and multifamily developments.*
Implementation: *The provider shall adopt and enforce an ordinance or establish conditions of new service requiring that water-intensive landscaping within all common areas of new housing developments not exceed 10 percent of the total landscapable area of the common area. Those areas used for active recreational purposes shall not be included in calculating the common area.*
Monitoring and Reporting Requirements: *The Annual Report required by A.R.S. § 45-632 shall include a copy of the ordinance or sample conditions of new service agreement used to meet the implementation requirements for this RCM. This shall be submitted one time only (the first year of compliance with the Non-Per Capita Conservation Program) unless there is an amendment to the ordinance or agreement.*

RESIDENTIAL EXTERIOR
STANDARD RCM (CHOICE 3 OF 3)

REBATE PROGRAM FOR NEW RESIDENTIAL CUSTOMERS
Description: *A rebate is offered for new landscapes that are designed to be efficient in water use. The landscapes may be required to meet pre-established design, plant selection, installation, and maintenance standards.*
Implementation: *The provider shall offer all new residential customers a rebate for installing low water use landscaping. The rebate shall be in the form of cash, a reduction in water bills, or a waiver or rebate of the development (hookup) fee.*
Monitoring and Reporting Requirements: *The Annual Report required by A.R.S. § 45-632 shall include the number of rebates given, the amount of money distributed to participating customers and an estimate of water savings for the reporting year.*

APPENDIX 5H.2

NON-RESIDENTIAL INTERIOR AND EXTERIOR STANDARD REASONABLE CONSERVATION MEASURES

NON-RESIDENTIAL INTERIOR
STANDARD RCM

INTERIOR AUDIT PROGRAM FOR EXISTING FACILITIES

***Description**: The provider offers audits conducted by trained personnel or instructions for a self-audit to existing non-residential customers (excluding turf-related facilities, large scale cooling facilities, and landscaped public rights-of-way). These audits will be designed to include personal sanitation, cooling, and process water use as applicable for each facility. Audits for personal sanitation include visual leak detection, water budget analysis, recommendations for improved water use efficiency, staff education, and a retrofit analysis; cooling audits include education to determine system conductivity, maintenance practices, system operation, and design characteristics. Process water uses are audited where conservation potential exists. After the audit has been conducted the facility compiles information into a post-audit report to be submitted to the provider. Provider staff reviews and makes recommendations to improve water usage at the facility.*

Implementation:** The provider shall notify all existing non-residential customers (excluding turf-related facilities, large scale cooling facilities and landscaped public rights-of-way) of the availability of an audit performed on-site free of charge by staff or hired consultants, or a self-audit packet that at a minimum shall include information on how to conduct a self-audit and complete a post-audit report to be returned to the provider. The provider shall evaluate each analysis and make recommendations to the facility for water conservation potential. Existing non-residential customers that collectively receive at least 20 percent of the total non-residential water use in the provider's service area (excluding turf-related facilities, large scale cooling facilities, and landscaped public rights-of-way) shall be audited either by the non-residential customer or by trained personnel. The measurement of 20 percent of non-residential use shall be based on the most current water use records available when the provider enters the program. Annual progress requirements will be negotiated between the Department and the provider with the provider required to complete all the necessary audits by January 1, 2010.* ***This RCM shall be implemented in conjunction with the Exterior Audit for Existing Facilities.

***Monitoring/Reporting:** The Annual Report required by A.R.S. § 45-632 shall include the number of facilities audited by the provider and the number of facilities that conducted a self-audit and returned a post-audit report to the provider within the reporting year. The annual report shall include the name and type of facility audited and its annual water use for the previous year. The provider shall maintain and make available for the Department's inspection the name, address, phone number, contact person, and audit report for each facility audited.*

In addition to the annual reporting requirements, the provider shall collect, maintain and submit to the Department upon request information on selected facilities that utilize this program in order to allow an effective evaluation of the program. The number of records and type of data to be maintained will be determined at the time the provider enters the program. Note: This evaluation will be used to improve effectiveness of RCMs. It will not be used to require any modification of the negotiated Non-Per Capita Conservation Program agreement.

NON-RESIDENTIAL INTERIOR
STANDARD RCM

ORDINANCE OR CONDITION OF NEW SERVICE PROHIBITING INSTALLATION OR REPLACEMENT OF PLUMBING FIXTURES IN NON-RESIDENTIAL FACILITIES UNLESS FIXTURES MEET WATER SAVING STANDARDS

Description: *Provider adopts an ordinance or establishes conditions of new service prohibiting the installation of plumbing fixtures in new non-residential facilities and the replacement of plumbing fixtures in existing non-residential facilities unless the fixtures meet water efficiency standards. Plumbing fixtures to be covered and their respective maximum use rates are as follows:*

- *Faucets-kitchen and lavatory* — *3.0 gpm*
- *Replacement aerators - kitchen and lavatory* — *3.0 gpm*
- *Metering faucets* — *.25 gpc*
- *Gravity tank-type and flushometer toilets* — *1.6 gpf*
- *Electromechanical hydraulic toilets* — *1.6 gpf*
- *Blowout toilets* — *1.6 gpf*
- *Showerheads* — *3.0 gpm*
- *Urinals* — *1.0 gpm*
  (automatic, timed, and self-flushing urinals are prohibited)
- *Evaporative cooling systems/Decorative fountains must be equipped with water recycling or reuse systems*

Waivers may be available for unusual circumstances (e.g., hospitals and other areas where sanitation or health codes may conflict).

Implementation: *The provider shall adopt and enforce a plumbing ordinance or establish conditions of new service prohibiting the installation of plumbing fixtures in new non-residential facilities and the replacement fixtures in existing non-residential facilities unless the fixtures meet the water savings performance standards outlined in the description above. Implementation of this RCM shall include a proactive inspection and enforcement program that ensures compliance with the applicable ordinance or conditions of service.*

Monitoring/Reporting: *The annual report required by A.R.S. § 45-632 shall include a copy of the current local plumbing ordinance or sample conditions of new service agreement that meet the implementation requirements for this RCM. This shall be submitted one time only (the first year of compliance with the Non-Per Capita Conservation Program) unless there is an amendment to the ordinance or agreement.*

In addition, the provider shall include in the annual report, evidence of implementation of the applicable ordinance or conditions of service by reporting the number of certificates of occupancy issued in the service area, the number of permits issued for the replacement of plumbing fixtures in existing non-residential facilities, the number of non-residential facilities inspected, the number and type of plumbing fixture violations and any enforcement action taken.

A provider that is not a city or town shall also collect and examine all inspection records for new permits issued by governmental entities for the installation of original plumbing fixtures in new facilities and the replacement of plumbing fixtures in existing non-residential facilities within the provider's service area and report any plumbing code or plumbing ordinance violations that have not been enforced to the governing body of the entity charged with enforcing the code or ordinance.

Note: This documentation will be used to evaluate the effectiveness of the RCM. It will not be used to require any modification of the negotiated non-per capita conservation program agreement.

NON-RESIDENTIAL INTERIOR
STANDARD RCM

DISTRIBUTION OF CONSERVATION INFORMATION TO ALL NEW NON-RESIDENTIAL CUSTOMERS AND SUBMITTAL OF WATER USE PLAN BY NEW LARGE FACILITIES

Description: *Provider distributes a conservation packet to all new non-residential customers when an application is submitted for a building permit. The conservation packet includes educational material on the best commercially available technologies, current codes affecting water use at each facility, and a standard form approved by the Department to be filled out by the new customer. This form will function as the water use plan to be submitted by all new non-residential customers who may potentially use 10 acre-feet or more of water annually. Turf-related facilities, large scale cooling facilities, and new large produce processing facilities are excluded from the requirement to submit a water use plan as they are required in the Industrial Conservation Program to submit a water conservation plan. Utilization of the plan helps increase the awareness of best available technologies as they become available within each industry.*

The water use plan shall identify all water uses anticipated by the user and the water conservation measures to be utilized. The water use plan shall include at least the following information (where applicable):

- *Water conservation education/training for employees*
- *Use of alternative water sources (i.e., CAP, effluent, remediated groundwater, or other non-groundwater sources)*
- *Operating TDS or conductivity for cooling towers and total cooling capacity*
- *Use of best available technologies in accordance with existing process uses (i.e., recirculating systems for process water, alternative dust control methods, automatic shut-down devices to eliminate continual running of water)*
- *Any plans for the reuse of wastewater or process water at the facility*
- *Type of landscaping and irrigation system*

Implementation: *The provider shall distribute a conservation packet as described above to all new non-residential customers prior to construction when an application is submitted for a building permit (private water companies shall distribute a conservation packet when contacted for new service). As a condition of new service, those non-residential customers who will potentially use 10 acre-feet or more of water annually, excluding turf-related facilities, large scale cooling facilities, and new large produce processing facilities, shall be required to submit a water use plan as outlined in the description above to be reviewed by water provider staff. The Department will supply to the provider the necessary form and guidelines to complete the water use plan at the time the provider enters this program. Where necessary, provider staff shall make recommendations for efficient use of water to the new user.*

Monitoring/Reporting: *The Annual Report required by A.R.S. § 45-632 shall include a copy of the sample conditions of new service agreement used to meet the implementation requirements for this RCM. This shall be submitted one time only (the first year of compliance with the Non-Per Capita Conservation Program) unless there is an amendment to the agreement. The provider shall also include in the annual report the number of conservation packets distributed annually and the number of water use plans received during the reporting year.*

In addition to the annual reporting requirements, the provider shall maintain and submit to the Department upon request the water use plans submitted by non-residential customers.

NON-RESIDENTIAL INTERIOR
STANDARD RCM

EXTERIOR AUDIT PROGRAM FOR EXISTING NON-RESIDENTIAL CUSTOMERS
***Description**: Trained auditors visit existing non-residential customers (excluding turf-related facilities, large scale cooling facilities, and landscaped public rights-of-way) to examine outdoor water use practices, or materials are supplied for a self-audit of outdoor water use practices. These audits are designed for landscape water use and include a survey of water use practices or scheduling, a visual leak detection analysis, examination of the current irrigation system maintenance and efficiency, and an examination of existing employee education or training. After the audit has been conducted the facility compiles information into a post-audit report to be submitted to the provider. Provider staff reviews and makes recommendations to improve water usage at the facility.*
Implementation:** The provider shall notify all existing non-residential customers (excluding turf-related facilities, large scale cooling facilities, and public rights-of-way) of the availability of an audit performed on-site free of charge by staff or hired consultants, or a self-audit packet that shall include at a minimum information on how to conduct a self-audit and complete a post-audit report to be returned to the provider. The provider shall evaluate each post-audit report and make recommendations to the facility for water conservation potential. Existing non-residential customers that collectively receive at least 20 percent of the total non-residential water use in the provider's service area (excluding turf-related facilities, large scale cooling facilities, and landscaped public rights-of-way) shall be audited either by the non-residential customer or by a trained auditor. The measurement of 20 percent of non-residential use shall be based on the most current water use records available when the provider enters the program. Annual progress requirements will be negotiated between the Department and the provider with the provider required to complete all the necessary audits by January 1, 2010.* ***This RCM shall be implemented in conjunction with the Interior Audit for Existing Facilities.
***Monitoring/Reporting:** The Annual Report required by A.R.S. § 45-632 shall include the number of facilities audited by the provider and the number of facilities that conducted a self-audit and returned a post-audit report to the provider within the reporting year. The annual report shall include the name and type of facility audited and its annual water use for the previous year. The provider shall maintain and make available for the Department's inspection the name, address, phone number, contact person, and audit report for each facility audited.* *In addition to the annual reporting requirements, the provider shall collect and maintain information on selected facilities that utilize this program in order to make an effective evaluation of the program. The number of records and type of data to be maintained will be determined at the time the provider enters the program. Note: This evaluation will be used to improve effectiveness of RCMs. It will not be used to require any modification of the negotiated Non-Per Capita Conservation Program agreement.*

NON-RESIDENTIAL INTERIOR
STANDARD RCM

LANDSCAPE ORDINANCE OR CONDITION OF NEW SERVICE FOR NEW FACILITIES
Description: *Provider requires new non-residential customers to limit water-intensive landscaping, install efficient irrigation systems, and limit water features/fountains.*
Implementation: *The provider shall adopt and enforce an ordinance or establish conditions of new service requiring new non-residential customers with greater than or equal to 10,000 square feet of landscapable area to comply with the following, as applicable: (1) If the new non-residential customer is not a hotel or motel, the water-intensive landscaped area within the facility shall not exceed an area calculated by adding 10,000 square feet plus 20 percent of the facility's landscapable area in excess of 10,000 square feet. Schools, parks, cemeteries, golf courses, common areas of housing developments, and public recreational facilities with water-intensive landscaping greater than or equal to 10 acres are exempt from this provision, as they are regulated under the individual user requirements; (2) If the new non-residential customer is a hotel or motel, the water-intensive landscaped area within the facility shall not exceed an area calculated by adding 20,000 square feet plus 20 percent of the facility's landscapable area in excess of 20,000 square feet; (3) Only efficient irrigation systems shall be used; and (4) The use of water features and/or fountains shall be limited and shall be equipped with water recycling or reuse systems.*
Monitoring/Reporting: *The Annual Report required by A.R.S. § 45-632 shall include a copy of the ordinance or sample conditions of new service agreement used to meet the implementation requirements for this RCM. This shall be submitted one time only (the first year of compliance with the Non-Per Capita Conservation Program) unless there is an amendment to the ordinance or agreement.*

APPENDIX 5H.3

EDUCATION
STANDARD
REASONABLE CONSERVATION MEASURES

PUBLIC INFORMATION AND EDUCATION PROGRAM

Description: *Educating customers about the need for water conservation is essential to the success of any conservation program. There are many ways to educate and inform the public, including the distribution of information packets, brochures, pamphlets, bill inserts, newsletters, fact sheets, calendars, "tents" in restaurants, conducting "workshops," and radio and TV public service announcements (PSAs). Another method is the provision of information that allows customers to compare their current water use with the amount of water they used during the preceding billing period and the same billing period in the previous year. Water use tracking information may be effective because it is personalized and is updated and repeated with every billing cycle. Printed materials and PSAs can be effective for many months to the extent that they are heard, seen or read and acted upon.*

Implementation: *A minimum of once a year, the provider shall supply all customers with information on the following, using methods agreed to at the time of acceptance into the Non-Per Capita Conservation Program: 1) the significance and relevance of water conservation, and methods of conserving water, including information about conservation devices and behavioral changes that save water; and 2) how to participate in other conservation programs offered by the provider under the Non-Per Capita Conservation Program (e.g., audits, rebates, workshops). The provider shall also develop and distribute with every billing, conservation billing in either graphical or numerical format (i.e., graphs or numbers) showing current water use, the amount of water used during the preceding billing period and the same billing period in the previous year.*

Monitoring and Reporting Requirements: *The Annual Report required by A.R.S. § 45-632 shall include examples of the materials provided, a report on the methods used to contact customers, and the number of materials distributed in any form.*

APPENDIX 5H.4

SUBSTITUTE
REASONABLE CONSERVATION MEASURES

SUBSTITUTE REASONABLE CONSERVATION MEASURE LIST

The Substitute Reasonable Conservation Measure List for the Tucson AMA is filed in the Department's Tucson AMA office. A copy of the list effective as of the date of this Plan follows in this Appendix. Since the list may be amended in the manner described below, a current list is available upon request from the Tucson AMA office.

PROCEDURE FOR MODIFICATION OF SUBSTITUTE RCM LIST

1. *A municipal provider who seeks to add an RCM to the Substitute RCM List for the Tucson AMA may apply at any time to the director for a modification of the list. The application shall be made on a form prescribed and furnished by the director.*

2. *The director shall review each request for a modification of the Substitute RCM List. The director may request additional information from the applicant and may seek information from other sources as may be necessary to determine whether the list should be modified.*

3. *If the director approves the addition of an RCM to the Substitute RCM List, the director shall place the RCM on a supplemental list that shall be considered an addendum to the Substitute RCM List. The supplemental list shall be available upon request from the Tucson AMA office.*

4. *The director may add an RCM to the Substitute RCM List for the Tucson AMA on the director's own initiative if the director determines that implementation of the RCM, either by itself or in combination with one or more other RCMs on the Substitute RCM List, will result in a water use efficiency for the applicable water use category equivalent to the efficiency that would result from implementation of one or more of the required RCMs for that water use category.*

SUBSTITUTE REASONABLE CONSERVATION MEASURES

RCM	*Description*	*Implementation*
	Residential Interior	
Low Flow Plumbing Rebate Program for Existing Residential Customers	*Provider grants a financial rebate to residential homeowners who elect to replace existing high water use toilets, showerheads and faucets with low-flow devices, consistent with the AWEPA.*	*Negotiated and approved by the director.*
Toilet Leak Detection & Repair Program for Existing Residential Customers	*Provider supplies non-toxic dye tablets and instructions to conduct a toilet leak detection analysis and suggestions for leak repairs.*	*Negotiated and approved by the director.*
Landscape Retrofit Program for Existing Residential Customers	*Provider grants financial incentives, including rebates, to existing customers for conversion of existing high water use landscapes to low water use landscapes. Provider supplies examples of landscape plans, plant lists, irrigation methods, and information on soil amendments and preparation.*	*Negotiated and approved by the director.*
	Residential Exterior	
Effluent Reuse - Recycled Wastewater for Existing or New Residential Customers	*Provider develops an effluent reuse system for existing or new housing developments and provides incentives for the reuse of effluent at facilities capable of utilizing the resource.*	*Negotiated and approved by the director.*
Low Water Use Ordinance or Condition of New Service for New Residential Customers	*Provider develops conditions of new service or ordinances that limit turf and other water-intensive landscaping in all new developments consistent with the new single family and multifamily residential exterior water use models in the Third Management Plan for the provider's AMA.*	*Negotiated and approved by the director.*
	Non-Residential Interior	
Retrofit Distribution or Rebate Program	*Provider supplies retrofit kits or provides rebates to non-residential facilities that elect to retrofit existing high water using plumbing fixtures to low water using fixtures consistent with the AWEPA.*	*Negotiated and approved by the director.*
Process Water Conservation Program for New or Existing Facilities	*Provider develops a program that identifies the non-residential customers within the provider's service area with the greatest conservation potential and assigns conservation measures aimed at reducing water use in these facilities.*	*Negotiated and approved by the director.*

SUBSTITUTE REASONABLE CONSERVATION MEASURES

RCM	*Description*	*Implementation*
	Non-Residential Exterior	
Rebate Program for Low Water Use Landscaping & Irrigation System Improvements for Existing or New Facilities	*Provider offers financial incentives (e.g., rebates, reduced rates, wholesale prices on plant materials, or financing packages) to non-residential facilities to replace existing landscaping and irrigation system or installation of new landscaping or irrigation systems with low water use landscaping and efficient irrigation technologies.*	*Negotiated and approved by the director.*
Effluent and Wastewater Use Incentives for Existing and New Facilities	*Provider offers incentives for conversion of existing irrigation systems or installation of new irrigation systems capable of utilizing effluent or wastewater (includes all water discharged after an industrial or commercial use, excluding effluent) for landscape watering.*	*Negotiated and approved by the director.*
Ordinance or Condition of Service Requiring The Use of Effluent for New Public Recreation Facilities	*The provider adopts an ordinance or condition of service requiring the use of effluent in new public recreation facilities, including turf-related facilities and other facilities with a water-intensive landscaped area of 10 or more acres. The ordinance or condition of new service shall require the owner of the facility to demonstrate to the Department that the facility will be designed and operated in a manner that conserves water. Publicly owned rights-of-way are exempt from this requirement. For purposes of this RCM, "turf-related facility" and "water-intensive landscaped area" have the meanings prescribed by section 6-301 of Chapter 6.*	*Negotiated and approved by the director.*
	Education	
Training Opportunities	*Provider offers ongoing seminars, workshops, lectures, and videos to promote water conservation to residential or non-residential customers, employees, educators, or professional interest groups. Topics could include landscape design and maintenance, interior water conservation methods, or general background information on regional water supply issues.*	*Negotiated and approved by the director.*
Youth Programs	*Provider assists local school district(s) to provide water conservation and water supply information to students. Assistance can include classroom presentations, teacher education programs, curriculum, and field trips to water-related facilities.*	*Negotiated and approved by the director.*
Demonstration Sites and Exhibits	*Provider establishes, maintains and promotes facilities, sites, and exhibits that demonstrate water conservation including demonstration gardens, demonstration homes, conservation exhibits, and public activities.*	*Negotiated and approved by the director.*

SUBSTITUTE REASONABLE CONSERVATION MEASURES

RCM	*Description*	*Implementation*
Media-Related Outreach	*Provider to develop a media-outreach program focused on water conservation including news articles, features, and series, magazine stories, radio and television public service announcements, and television specials. Additionally, novelty items to promote local or regional conservation efforts can be distributed including buttons, posters, and bumper stickers.*	*Negotiated and approved by the director. Must include a method to evaluate effectiveness and market penetration.*
	System-Related Measures	
Water Audit Program	*Provider has an audit conducted by a trained auditor of the distribution system, accuracy of the water agency records, and systems control equipment. The audit should identify, quantify, and verify water and revenue losses to allow the provider to select and implement programs to reduce water and revenue losses. Such examination should be performed annually to update the results of earlier audits. The audit must include an analysis of the water audit results and possible corrective measures including resulting costs, feasibility, and savings.*	*Negotiated and approved by the director.*
Leak Detection Program	*Provider implements a leak detection program in conjunction with a water audit (see substitute RCM - Water Audit). The leak detection program must address losses due to leaks, unauthorized use (street, sewer, and fire departments), water department maintenance, and meter under-registration and must include repair, maintenance, and meter testing. Flushing frequency and exercise of valves should also be accounted for.*	*Negotiated and approved by the director.*
Conservation-Based Rate Structure	*Provider develops a water rate structure that results in slowing the increase in water consumption that traditionally accompanies increases in population and per capita income. Pricing structures that may result in conservation are: increasing block rate, lifeline rate, seasonal rate, and excess demand surcharge. To be effective, the rate structure must clearly send a conservation message. The rate structure established should ensure that customers receive the proper signal that allows them to make a choice as to whether or not to implement conservation measures. Additionally, the water rate revision should be accompanied by a public awareness campaign, a water conservation device distribution program, pamphlets on low water use landscaping, or other conservation measures to increase the effectiveness of the program.*	*Negotiated and approved by the director.*

SUBSTITUTE REASONABLE CONSERVATION MEASURES

RCM	***Description***	***Implementation***
Conservation Coordinator	*Provider employs a staff person whose sole responsibility is to ensure the implementation of effective water conservation programs. The employee would act to coordinate conservation efforts in conjunction with utility staff and be the primary contact for the public regarding conservation information. The coordinator could initiate an information campaign including: pamphlets, fact sheets, bill stuffers, public service announcements, and press releases. The coordinator can also coordinate direct conservation activities other than education.*	*Negotiated and approved by the director. Includes submittal of a complete job description for the position as well as annual goals and objectives for the program.*
Water Tampering and Water Waste	*Water provider adopts and enforces ordinances or implements policies regarding excessive and wasteful use of water. Meter reading staff and customers report water theft where ordinances are not applicable. Staff performs regular checks of water delivered and water used in distinct parts of the service areas where there is greater susceptibility to water theft.*	*Negotiated and approved by the director.*

APPENDIX 5I
ALTERNATIVE CONSERVATION PROGRAM
RESIDENTIAL CONSERVATION REQUIREMENT COMPONENT CALCULATION
TUCSON ACTIVE MANAGEMENT AREA

1. Existing Residential Allotment

   a. Determine the population in single family housing units as of July 1, 2000,
   Determine the population in multifamily housing units as of July 1, 2000,
   Add the Single Family and Multifamily Population to determine Year 2000 Residential Population;

   b. Multiply the year 2000 residential population by the provider's existing residential GPCD component (Appendix 5D), multiply this number by the number of days in the year, and divide the product by 325,851;

   c. The result is an annual volumetric allotment, in acre-feet, for existing residential uses. Reasonable reductions in GPCD are included in the annual target calculation.

2. New Single Family and Multifamily Residential Allotment:

   a. Determine the new single family housing units added since July 1, 2000,
   Determine the new single family population (post-7/1/00) for the calendar year,
   Determine the new multifamily housing units added since July 1, 2000,
   Determine the new multifamily population (post-7/1/00) for the calendar year;

   b. Multiply the new single family housing units and the new multifamily population by the exterior rates for new residential development:

   Single Family = 118 GPHUD
   Multifamily = 21 GPCD

   Add the products, multiply the result by the number of days in the year, and divide the product by 325,851;

   c. Multiply the sum of the new single family population and the new multifamily population by the interior rate for new residential development of 57 GPCD, multiply the result by the number of days in the year, and divide the product by 325,851;

   d. Add the results from subparagraphs 2.a and 2.b. The sum is an annual volumetric allotment, in acre-feet, for new residential uses.

3. Add the existing residential allotment from subparagraph 1.c and the new residential allotment from subparagraph 2.d. The sum is the TOTAL RESIDENTIAL ALLOTMENT for the calendar year.

APPENDIX 5J
CONSERVATION REQUIREMENTS FOR MUNICIPAL DISTRIBUTION SYSTEMS
LOST AND UNACCOUNTED FOR WATER
TUCSON ACTIVE MANAGEMENT AREA

Lost & Unaccounted For Includes:

Leaks:
- Distribution Lines
- Sewer Lines
- Storage Tanks
- Storage Ponds
- Hydrants
- Other

Breaks:
- Distribution Lines
- Sewer Lines
- Mains
- Hydrants
- Other

Measurement Errors:
- Meter Under-Registration
- Source Meter Errors
- Flume/Weir Errors

Evaporation

Illegal Connections/Water Theft

Phreatophyte Uses

Water System Uses Include:
- Residential Metered Deliveries
- Non-Residential Metered Deliveries
- Standpipe Uses
  - *(1)* Fire Flow
  - Hydrant Meter Reading
  - *(1)* Hydrant Flow Tests
  - *(1)* Fire Sprinkler System Flow Tests
  - *(1)* Construction
  - *(1)* Dust Control
  - *(1)* Line Flushing (distribution, sewer, or treatment facility)
  - *(1)* Street Cleaning
  - *(1)* Storm Drain Flushing
  - *(1)* Water Tests & Pressure Tests
  - Well Purging

(1) *These uses may be estimated using a method approved by the director. Documentation must be submitted with annual report.*

APPENDIX 5K
INCIDENTAL RECHARGE FACTOR CALCULATION
TUCSON ACTIVE MANAGEMENT AREA

Hydrologic Studies
The following information must be provided:

1. A copy of a hydrological study that demonstrates the amount of water supplied by the municipal provider for use within its service area during each of the preceding five years (prior to application to the Non-Per Capita Conservation Program) and the amount of incidental recharge as calculated below that occurred within the municipal provider's service area during each of those years.

2. A copy of a hydrological study that projects the average annual amount of water that the municipal provider will supply for use within its service area during the management period and the average annual amount of incidental recharge as calculated below that will occur within the municipal provider's service area during the management period.

Calculation of the Incidental Recharge and an Incidental Recharge Factor
The following information should be included in the hydrologic studies:

1. A map showing:
   a. Service area boundary.
   b. Location of turfed areas and/or unlined lakes greater than 10 acres where water is provided by the municipal provider applying for the Non-Per Capita Conservation Program.
   c. Location of areas that are served by septic systems.

2. For turfed and water acres:
   a. Combined actual turfed and water acres (of facilities greater than or equal to 10 acres).
   b. Plant consumptive use (actual or using consumptive use rate published in the Second Management Plan), or measured evaporation rates.
   c. Total annual volume of water applied to facility. If only a portion of the water used is supplied by the municipal provider, document the percentage supplied by the provider who is applying for the Non-Per Capita Conservation Program and from other sources.

3. For septic systems:
   a. The number of acres of lots served by septic systems and the number of septic tanks per acre.
   b. Volume of water supplied to that system and documentation of the volume of water incidentally recharged. If only a portion of the water used is supplied by the municipal provider, document the percentage supplied by the provider and from other sources.

4. Total annual volume of water supplied by a provider for use within its service area.

5. Any other data that contributes to incidental recharge within the service area. The Department will review the data and take them under consideration.

APPENDIX 5K
INCIDENTAL RECHARGE FACTOR CALCULATION
TUCSON ACTIVE MANAGEMENT AREA

Calculations

1. Turf

Annual Incidental Recharge (AF)	=	Total Annual Water Used (AF)	-	[Turfed Acres x Consumptive Use AF/Ac.]

2. Artificial Lakes

Annual Incidental Recharge (AF)	=	Total Annual Water Used (AF)	-	[Lake Acres x Evaporation Rate AF/Ac.]

3. Septic Systems

Annual Incidental (AF)	=	Total Acres of Septic System	x	Number of Septic Systems per Acre	x	Total Annual Water Use per Household(AF)	x	% Water Returned for Recharge

4. **Maximum Estimated Annual Incidental Recharge (AF)** = #1 + #2 + #3 + other data approved by ADWR

5. **Incidental Recharge Factor** = $\frac{\text{Annual Incidental Recharge (\#4)}}{\text{Total Annual Volume of Water Pumped and Received.}}$

APPENDIX 5L
LARGE MUNICIPAL PROVIDER EXISTING RESIDENTIAL CONSERVATION POTENTIAL
TUCSON ACTIVE MANAGEMENT AREA

Municipal Water Provider	Interior Conservation Potential	Exterior Conservation Potential
Arizona State Prison Complex - Tucson	Institutional Provider	Institutional Provider
Arizona Water Company - Oracle	No Reduction	No Reduction
Avra Water Coop	Minimum	Minimum
City of Tucson	Moderate	Minimum
Community Water Company of Green Valley	No Reduction	No Reduction
Davis-Monthan Air Force Base	Maximum	Moderate
Farmers Water Company	Minimum	Maximum
Flowing Wells Irrigation District	Moderate	Moderate
Forty-Niner Water Company	Maximum	Maximum
Green Valley Water Company	No Reduction	No Reduction
Lago del Oro Water Company	Minimum	Minimum
Las Quintas Serenas Water Company	No Reduction	Moderate
Marana Municipal Water System	No Reduction	Minimum
Marana Water Service	Minimum	Minimum
Metropolitan Domestic Water Improvement District	Moderate	Moderate
Town of Oro Valley	Minimum	Minimum
Ray Water Company	Minimum	Minimum
University of Arizona	No Reduction	No Reduction
Voyager Water Company	No Reduction	No Reduction

CHAPTER

6

Industrial Conservation Program

6.1 INTRODUCTION

This chapter contains the Arizona Department of Water Resources' (Department) conservation program for industrial users within the Tucson Active Management Area (AMA). The purpose of the Industrial Conservation Program is to move industrial water users within the AMA to the greatest level of efficiency economically attainable given use of the latest available water conservation technology. In addition to conservation, the replacement of groundwater sources with renewable water supplies during the third management period will ensure that industrial users make effective strides toward contributing to the AMA's statutorily mandated goal of safe-yield by the year 2025.

The Groundwater Code (Code) defines industrial use of water as "a non-irrigation use of water not supplied by a city, town, or private water company, including animal industry use and expanded animal industry use." A.R.S. § 45-561(5). An industrial user is a person who uses groundwater for an industrial use. In most cases industrial users withdraw groundwater from their own wells pursuant to Type 1 or Type 2 non-irrigation grandfathered rights or a groundwater withdrawal permit. These rights and permits (collectively referred to in this chapter as "industrial rights") have annual volumetric groundwater allotments. The total volume of Type 2 rights in the AMA was set at the time the Code was enacted. The total volume of water associated with Type 1 rights can increase over time as agricultural land with irrigation grandfathered rights is retired from production and the rights are converted to Type 1 non-irrigation grandfathered rights. General Industrial Use (GIU) permits are issued by the Department if water service cannot be secured from a municipal provider and if the use of surface water or effluent, or the purchase or lease of a grandfathered groundwater right, is not economically feasible. Permits expire after a specified period of years. (See the Glossary of Terms for a description of water rights and permits.)

An industrial user may also receive groundwater from an irrigation district. However, an industrial user may not receive groundwater from an irrigation district in excess of the amount it was entitled to receive on June 12, 1980 unless it has obtained a grandfathered right or a GIU permit. A.R.S. § 45-497(B).

There are also types of groundwater users that, although served by a municipal water provider, are subject to industrial program conservation requirements through the Municipal Conservation Program. These users include turf-related facilities and large-scale cooling facilities, and are referred to in the Municipal Conservation Program as "individual users."

Conservation is an important tool for reaching the AMA safe-yield goal. Industrial facilities generally use water efficiently due to pumping costs and industrial discharge limitations that require them to recycle water and contain water on-site. The allotment-based conservation requirements for the turf industry have required turf-related facilities to comply with declining application rates per acre since the First Management Plan became effective. This program has resulted in significant conservation savings through efficient use of water.

Industrial users have the legal authority to withdraw groundwater up to the annual allotment of their rights or permits subject to management plan conservation requirements. Because the cost of pumping groundwater is relatively low compared to the cost of other sources of water, there is no economic incentive for industrial users to switch to renewable water supplies. Because the Department does not have the authority to require holders of industrial rights to use renewable supplies in place of groundwater, it has tried to develop meaningful incentives to encourage use of renewable supplies.

Some industrial users use surface water, effluent, or industrial wastewater. However, the majority of industrial water use is groundwater. The industrial sector uses a smaller volume of renewable water supplies than either the agricultural or municipal sector. The industrial sector's contribution to safe-yield is therefore relatively small. The only industrial facilities that use effluent are turf-related facilities.

However, almost all of this use is by individual users, not industrial right holders. Industrial right holders used 782 acre-feet of effluent in 1995, while individual users used over 5,800 acre-feet.

Users in several industrial categories have indicated that they may be interested in using renewable water supplies if such supplies were available and comparable in cost to groundwater. However, there are many factors that impede the ability of industrial users to use renewable water supplies, including lack of proximity to renewable supplies, reliability, cost, supply ownership, and water quality issues. While there are no significant water quality problems associated with using effluent on turf-related facilities, use of this source by other industrial users could require additional treatment to remove salts and other constituents.

In all the AMAs, significant amounts of industrial right allocations are unused. These unused allocations represent a potential increase in groundwater pumpage allowable under statute and provide a means for the industrial sector to expand over time.

For the third management period, there are general conservation requirements that apply to all industrial users. In addition to these requirements, there are specific conservation requirements that apply to the following industrial users in the Tucson AMA:

- Turf-Related Facilities (≥10 acres)
- Sand and Gravel Facilities (>100 acre-feet/year)
- Metal Mining Facilities (>500 acre-feet/year)
- Large-Scale Power Plants (>25 megawatts)
- Large-Scale Cooling Facilities (>1,000 tons)
- Dairy Operations (monthly average ≥100 lactating cows/day)
- New Large Landscape Users (>10,000 square feet of water intensive landscape)
- New Large Industrial Users (>100 acre-feet/year)

Industrial uses of groundwater in the Tucson AMA consist primarily of industrial processing, cooling, and landscape watering. Industrial demand as a percentage of overall water use is higher in the Tucson AMA than in any other AMA due to metal mining operations. Industrial users with groundwater rights or permits accounted for almost 20 percent of the AMA water use in 1995, or about 60,000 acre-feet. Water use by industrial users is projected to increase to approximately 75,000 acre-feet by 2025. About 6 percent of this demand is anticipated to be met by effluent as compared to about 1 percent in 1995.

This chapter is organized as shown below. Following the Introduction, each Industrial Conservation Program is discussed under a separate subsection. In general, each of the subsections contain all or some of the following: (1) an introduction, (2) water use by the subsector, (3) First and Second Management Plan program development, (4) issues and Third Management Plan development, (5) program description, (6) non-regulatory efforts, (7) future directions, and (8) subsector conservation requirements.

6.1 Introduction
- Statutory Provisions
- Industrial Program Development
- Industrial Program Issues
- Non-Regulatory Efforts
- Future Directions

6.2 All Industrial Users
6.3 Turf-Related Facilities
6.4 Sand and Gravel Facilities
6.5 Metal Mining Facilities
6.6 Large-Scale Power Plants
6.7 Large-Scale Cooling Facilities

6.8 Dairy Operations
6.9 New Large Landscape Users
6.10 New Large Industrial Users

6.1.1 Statutory Provisions

6.1.1.1 Conservation Requirements

The Code requires that the management plan contain a conservation program for industrial users. For the third management period the director is required to establish for each plan:

> additional conservation requirements for all non-irrigation uses of groundwater to be achieved by the end of the third management period and may establish intermediate conservation requirements to be achieved at specified intervals during the third management period. . . . For industrial uses including industrial uses within the exterior boundaries of the service area of a city, town, private water company or irrigation district, the program in each plan shall require the use of or establish conservation requirements based on the use of the latest commercially available conservation technology consistent with reasonable economic return. A.R.S. § 45-566(A)(2).

6.1.1.2 Individual User Requirements

The Code also requires the establishment of additional conservation requirements for municipal uses in the Third Management Plan including "use of such other conservation measures as may be appropriate for individual users." A.R.S.§ 45-566(A)(2). (See Chapter 5). In the First Management Plan, only turf-related facilities receiving water from municipal providers were regulated as individual users. These facilities were subject to the requirements of the Industrial Program as if they were industrial users. Thus, regardless of the source of water, whether from a municipal provider or from the facility's own wells, all turf-related facilities were subject to the turf-related facility conservation requirements in the Industrial Program chapter of the First Management Plan.

Similarly, in the Second Management Plan, turf-related facilities receiving water from a municipal provider were regulated as individual users and were subject to the Second Management Plan's industrial program conservation requirements for turf-related facilities. In addition, new large cooling users, which are typically served by water providers, were also regulated as individual users in the Second Management Plan. These facilities were required to comply with the conservation requirements established for new large cooling users in the Industrial Program chapter.

6.1.2 Industrial Program Development

The Industrial Conservation Program has evolved into a more technically sophisticated program since the First Management Plan. This has been the result of considerable input and cooperation by the regulated community, as well as investigative efforts by the Department.

The First Management Plan requirements stressed water use efficiency and contained other general requirements. There were specific conservation programs only for metal mines, turf-related facilities, electric power plants, sand and gravel facilities, and other industrial users. As a result of consultant studies done for the Second Management Plan, additional conservation requirements were added for new large-scale cooling users, dairies, cattle feedlots, new large industrial users, and new large landscape users. In addition, there was a more specific effluent incentive provision for turf-related facilities.

Development of the Third Management Plan conservation requirements included extensive participation by a wide cross-section of industry representatives, including facility managers, consultants, municipal

representatives, vendors, land developers, and academic research specialists. The following Technical Advisory Committees (TACs) were formed for the development of specific conservation requirements found in the Industrial Conservation Program:

- Turf-related facilities (separate committees for the Tucson and Phoenix AMAs);
- Dairies/feedlots (a joint committee for the Tucson, Phoenix, and Pinal AMAs);
- Large-scale power plants and cooling facilities (a joint committee for the Tucson and Phoenix AMAs);
- Sand and gravel facilities (a joint committee for the Tucson, Phoenix, and Pinal AMAs); and
- Metal mining facilities (Tucson AMA only).

Collectively, over 30 meetings were held with the committees over a one and one-half year period. Committee members had an opportunity to help formulate and suggest conservation requirement alternatives, provide industry expertise, and review final programs.

In the Third Management Plan, separate industrial program categories have been created for large-scale cooling facilities, new large landscape users, and new large industrial user subsectors. These three industrial water use groups were included in the "all industrial users" category in the Second Management Plan, but have been separated out to more clearly present the water use characteristics and specific conservation requirements for the third management period. This results in a total of eight industrial program subsectors in the Third Management Plan for the Tucson AMA: (1) turf-related facilities, (2) large-scale cooling facilities, (3) large-scale power plants, (4) sand and gravel facilities, (5) metal mining facilities, (6) dairy operations, (7) new large landscape users, and (8) new large industrial users. There are industrial users in all of these categories in the Tucson AMA except for new large landscape users and new large industrial users. Some AMA management plans have a conservation program for cattle feedlot operations that have an average of 100 or more beef cattle per day. If a facility meeting this definition should be constructed in the Tucson AMA during the third management period, the management plan may be modified to include the cattle feedlot conservation program.

Industrial subsector requirements vary from allotment-based requirements to the implementation of specific conservation measures. In all cases, the requirements have been developed consistent with the statutory requirement to establish conservation requirements that require the use of, or are based on the use of, "the latest commercially available conservation technology consistent with reasonable economic return." A.R.S. § 45-566(A)(2).

For the Third Management Plan, the Department reviewed the existing subsector programs and tried to address any existing problems or deficiencies. In most instances, specific conservation requirements for the third management period are not significantly different from those in the Second Management Plan. Conservation requirements in the First and Second Management Plans have been effective in improving water use efficiency for certain industrial subsectors. In the Third Management Plan, a number of technical corrections have been made, requirements have been added, additional program alternatives have been included, and renewable supply use incentives have been added or adjusted to be more effective. The specific changes, issues, and renewable supply incentives that were considered in subsector program development are discussed in the subsector sections of this chapter.

6.1.3 Industrial Program Issues

The Department considered a number of issues associated with the Industrial Program as it developed the Third Management Plan. Several issues emerged that have long-term implications for industrial water use. Some issues can be addressed using existing statutory and regulatory mechanisms while others may require a statutory amendment. The Department will continue to pursue opportunities to address these issues.

6.1.3.1 Use of Renewable Supplies by Industrial Users

Use of renewable supplies by industrial users in the Tucson AMA is limited by physical, economic, and legal barriers. Physical access to renewable supplies is frequently limited because potential users are often far removed from Central Arizona Project (CAP) and effluent conveyance facilities. The cost of constructing delivery systems to the industrial users may be prohibitive. Because industrial users have legal authority to withdraw groundwater from their own wells at a cost consisting primarily of relatively low energy costs, there is no economic incentive to incur the additional expenses associated with the purchase, delivery, and possible treatment of an alternative supply. In addition, water quality regulations, such as wastewater reuse rules or aquifer protection permit rules, may also provide impediments to the use of CAP water or effluent by industrial users.

No industrial user in the Tucson AMA holds a CAP subcontract. Further, effluent supplies in the AMA are primarily controlled by the City of Tucson and Pima County. Thus, industrial users would need to enter contractual relationships with Central Arizona Water Conservation District, Tucson, or Pima County to obtain the legal right to use these supplies.

6.1.3.2 Matching Water Quality and Uses

Each industrial user category has its own water quality requirements related to the particular product or process involved. Although some users may require high quality water, others do not. For example, turf facilities are able to use effluent without any significant adverse impact and sand and gravel facilities can use effluent for aggregate washing. Remediated groundwater may be acceptable for certain industrial uses. One turf-related facility in the Tucson AMA uses groundwater that contains nitrate above the maximum contaminate level for drinking water. Use of industrial wastewater may also be a potential water supply and needs to be investigated. Constraints on use include location of the supply in relation to the facility, cost and pre-treatment needs.

In 1997, the Legislature enacted legislation significantly revising the Water Quality Assurance Revolving Fund (WQARF) program to provide incentives for the use of remediated groundwater to facilitate the treatment of contaminated groundwater. Among other things, the WQARF legislation provides that when determining compliance with management plan conservation requirements, the Department shall account for groundwater withdrawn pursuant to approved remedial action projects under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) or Title 49, Arizona Revised Statutes, consistent with the accounting for surface water. Laws 1997, Ch. 287, § 51(B). See Chapter 7, section 7.4.4.6.3. Groundwater withdrawn pursuant to an approved remedial action project retains its legal character as groundwater for all other purposes under Title 45, Arizona Revised Statutes, including all other laws regulating groundwater withdrawal and use such as the assessment of withdrawal fees pursuant to A.R.S. § 45-611 *et seq.*, as well as laws regulating water exchanges as set forth in A.R.S. § 45-1001 *et seq.*, the transportation of groundwater as set forth in A.R.S. § 45-541 *et seq.*, withdrawals of groundwater for transportation to active management areas as set forth in A.R.S. § 45-551 *et seq.*, and underground water storage, savings, and replenishment as set forth in Title 45, Chapter 3.1, Arizona Revised Statutes.

For each approved remedial action project, the annual amount of groundwater that is eligible for the remediated groundwater accounting incentive is the maximum annual volume of groundwater that may be withdrawn pursuant to the project, as specified in the consent decree or other document approved by the EPA or ADEQ. However, if the project was approved prior to June 15, 1999 and the maximum annual volume of groundwater that may be withdrawn pursuant to the project is not specified in a consent decree or other document approved by the EPA or ADEQ, the annual amount of groundwater that is eligible for the remediated groundwater accounting incentive is the highest annual use of groundwater withdrawn pursuant to the project prior to January 1, 1999. The director may modify the annual amount of groundwater that is eligible for the accounting incentive if an increase in withdrawals is necessary to

further the purpose of the project or if a change is made to the consent decree or other document approved by the EPA or ADEQ.

In order to qualify for the remediated groundwater accounting incentive, a person must notify the director in writing of the anticipated withdrawal of the groundwater prior to its withdrawal. The notification must include a copy of a document approved by ADEQ or the EPA such as the Remedial Action Plan (RAP), Record of Decision (ROD) or consent decree. Unless specified in the document, the notification must include the volume of groundwater that will be pumped annually pursuant to the project, the time period to which the document applies, and the annual authorized volume of groundwater that may be withdrawn pursuant to the project. The notification must also include the purpose for which the remediated groundwater will be used and the name and telephone number of a contact person. Additionally, at the time the notice is given, the person must be using remediated groundwater pursuant to the approved remedial action or must have agreed to do so through a consent decree or other document approved by ADEQ or the EPA. Remediated groundwater that qualifies for the accounting must be metered and reported separately from groundwater that does not qualify for the accounting. (See section 6-204 of the Conservation Requirements for All Industrial Users).

6.1.3.3 Unused Allotment

There is a large volume of unused groundwater right and permit allocations associated with the industrial sector. Rights and permits held by industrial users total nearly 193,000 acre-feet. In 1995, the unused portion was more than 132,000 acre-feet. This volume is slightly less than the estimated net natural and incidental recharge volume for the Tucson AMA. Some of the unused allotment may never actually be put to use and use predictions are difficult. However, industrial use is projected to be 73,300 acre-feet in 2010 and 75,400 acre-feet in 2025. If the entire unused allotment volume were pumped, it would be a serious hindrance to reaching safe-yield unless it were offset through replenishment with imported renewable supplies. Type 1 grandfathered rights and some Type 2 grandfathered rights may be extinguished for assured water supply credits (mineral extraction and electric power Type 2 rights may not be extinguished for this purpose). This mechanism provides an opportunity to permanently extinguish existing industrial rights.

6.1.3.4 General Industrial Use and Mineral Extraction Permits

GIU permits are issued under A.R.S.§ 45-515 for industrial uses located outside of water provider service area boundaries pursuant to certain conditions and are valid for a specified period of time. Permits may also be issued for mineral extraction and metallurgical processing under A.R.S. § 45-514. These permits allow groundwater pumping in addition to withdrawals pursuant to existing industrial rights. The total permitted GIU volume in the Tucson AMA in 1995 was 2,176 acre-feet, although the amount used was only 473 acre-feet. The number of permit applications may increase in the future as the availability of Type 2 grandfathered rights to serve industrial uses becomes more limited.

6.1.4 Non-Regulatory Efforts

During the first half of the second management period, over $106,000 in grant money was awarded to benefit industrial users in the Tucson AMA under the Department's Conservation Assistance Grant Program. Grants were awarded for research and education on turf water demand and management, evaluation of the conservation potential of metal mines, and development of a training program for water efficient cooling tower management. The Department is committed to continuing its effort to assist regulated industrial users in meeting their conservation requirements through direct staff assistance and through the grants program during the third management period. This effort could be in the form of technical assistance or the granting of monies to fund research on new water conservation technologies.

6.1.5 Future Directions

Maintaining water use efficiency, providing conservation and technical assistance, and developing opportunities for renewable resource use are the most likely future directions for the industrial sector. The future of industrial users in relation to the safe-yield goal is largely shaped by the potential for growth in groundwater use and existing constraints on replacing groundwater use with renewable supplies.

In order for the industrial sector to contribute more to the achievement of the AMA goal, there must be continuing and enhanced water use efficiency, meaningful incentives for the use of renewable water supplies, and viable administrative and physical renewable resource use mechanisms in place. The majority of effluent use in the third management period is projected to be used by municipally-served turf facilities through the Tucson Water regional reclaimed system. However, there may be potential for CAP and effluent use by sand and gravel facilities and CAP use by metal mines or other facilities in the future. In order for this to occur, there must be either regional infrastructure cost sharing opportunities for direct use that make it economically viable to use a renewable supply or low cost replenishment mechanisms whereby pumped groundwater would be replenished by a renewable supply elsewhere in the AMA under certain conditions.

Apart from the groundwater right retirement provision in the Code and the groundwater right extinguishment provisions in the Assured Water Supply Rules (AWS Rules), there is currently no regulatory authority that could reduce grandfathered groundwater rights. The Department has decided not to include a grandfathered right purchase and retirement program in the Third Management Plan at this time. The extent to which the extinguishment provisions in the AWS Rules will limit industrial use is impossible to predict. It may be necessary to explore groundwater replenishment approaches to offset a portion of industrial pumpage. Expanding the authority of the Central Arizona Groundwater Replenishment District (CAGRD) to recharge excess CAP water outside of the Assured Water Supply Program or establishing a separate replenishment authority for industrial users are possible mechanisms. Statutory change would be necessary to implement either mechanism.

The development of "critical area" programs within the AMAs will be a major focus of the Department's activities during the third management period. This may involve the development of water management strategies to address localized water conditions, promoting withdrawals in areas experiencing groundwater recharge and restricting withdrawals from areas experiencing severe declines. For industrial uses this could mean limiting new General Industrial Use permits and industrial users in critical areas, limiting Type 1 non-irrigation grandfathered right conversions or buying out or providing incentives for extinguishing existing grandfathered rights in specified areas.

Industrial water uses may change as new technologies are developed. Research may need to be conducted during the third management period to investigate water conserving opportunities associated with use of these technologies by certain industrial users. This research could be used to develop conservation requirements for the Fourth Management Plan.

6.2 ALL INDUSTRIAL USERS

6.2.1 Introduction

The conservation requirements in this section apply to all industrial water users. In addition to these requirements, certain industrial users are also required to comply with conservation requirements specific to their type of water use under other sections of this chapter. For example, a sand and gravel facility must comply with the requirement in this section to use low-flow plumbing devices at the facility to the maximum extent possible and, in addition, must comply with the conservation requirements in section 6.4.6 of this chapter.

The following industrial users are required to comply with the conservation requirements for all industrial users in this section, as well as conservation requirements for their specific type of water use in other sections of this chapter: turf-related facilities, sand and gravel facilities, metal mining facilities, large-scale power plants, large-scale cooling facilities, dairy operations, new large landscape users, and new large industrial users. All remaining industrial users are referred to in this section as "other industrial users" and are required to comply only with the conservation requirements for all industrial users in this section.

6.2.2 Water Use by "Other Industrial Users"

"Other industrial users" in the Tucson AMA used approximately 4,000 acre-feet of groundwater in 1995, which accounted for about 7 percent of the total industrial groundwater withdrawals in the AMA in that year. Of this amount, approximately 2,800 acre-feet was used by seven "large" users (more than 100 acre-feet per year). Many different types of commercial and manufacturing uses are included in this category. Some of the largest users include aerospace facilities, cement manufacturing plants, electronics plants, hospitals, bottling plants, shopping centers, and resorts. Water uses commonly include cooling, landscaping, sanitary, kitchen and industrial process uses.

There are about 400 water rights and permits associated with the "other industrial user" category in the Tucson AMA. The total annual groundwater right allotment associated with these rights is almost 91,000 acre-feet. Of that amount, over 52,000 acre-feet is held by the City of Tucson. An additional 14,000 acre-feet is associated with retired farmland in the Green Valley/Canoa Ranch area. Raytheon Aircraft holds over 17,000 acre-feet of allotment from rights and permits that are used to withdraw and treat contaminated groundwater.

The large volume of rights held by the City of Tucson will likely be used for municipal supply purposes in the future and not for industrial use. Similarly, the Green Valley area rights will likely be used for residential development purposes, although a substantial volume may be used for turf-related watering. It is anticipated that most future industrial development will be served by municipal providers because commercial and industrial development usually occurs within their service areas.

6.2.3 Program Development and Issues

In the First Management Plan, "other industrial users" were required to avoid waste and make efforts to recycle water. In addition, they were prohibited from using single-pass cooling or heating. These requirements and others were also included in the Second Management Plan for all industrial users.

Consultant studies done in preparation of the Second Management Plan investigated water use associated with landscaping, heating and cooling, and sanitary and kitchen water use practices. These studies identified areas of water conservation potential and appropriate water conservation techniques. The Department has determined that the findings from these studies still apply to current industrial use and practices. In addition, a 1996-97 Tucson AMA study, funded by a Department conservation assistance

grant, investigated water use practices at cooling towers and yielded additional information on water conservation potential for cooling towers.

The following techniques are recommended for achieving water conservation in the industrial sector:

- reusing or recycling water
- avoiding single-pass cooling unless the water is reused
- use of low flow plumbing fixtures
- use of low water use landscaping with efficient irrigation systems
- developing site-specific water conservation plans for large facilities

Most of these techniques are included in the conservation requirements for all industrial users detailed in section 6.2.5 and apply to "other industrial users" as well as industrial users subject to conservation requirements for their specific type of water use. The Third Management Plan requirements are intended to send a strong conservation message to all industrial users to use water efficiently.

The Department also inventoried the "other industrial user" category during the planning process for the Third Management Plan to determine if there were any user groups with sufficient usage and conservation potential to warrant specific conservation requirements. The diverse nature of water uses within this category make it difficult to formulate volumetric conservation requirements that address the various types of industries. There are, however, some opportunities for water conservation.

The greatest conservation potential within the "other industrial users" category is in cooling and landscape watering, which are uses common to most facilities. Commercial landscapes are usually maintained by contractors whose priority is a lush appearance and who may not adjust automatic irrigation controller clocks to match weather conditions. Smaller cooling towers may not be managed as efficiently as larger towers, nor with water conservation as a high priority.

6.2.4 All Industrial Users Conservation Program

The Third Management Plan conservation program for all industrial users is similar to the Second Management Plan program. All industrial users are required to avoid waste and make diligent efforts to recycle water. Single-pass cooling or heating is not allowed unless the water is reused, and low-flow plumbing fixtures must be used as required by the state or local plumbing code. Since January 1, 1994, the Arizona Statewide Plumbing Code has required the use of low-flow fixtures in new construction throughout the state and some local plumbing ordinances have even more stringent standards.

There are two new landscaping requirements in the Third Management Plan. Industrial users that are not regulated as a turf-related facility or as a new large landscape user are required to use low water use landscape plants where feasible and water with efficient irrigation systems. Improving irrigation efficiency can be a source of major water savings whether the plants have high or low water needs. The Department encourages all facilities to irrigate efficiently regardless of the type of vegetation planted. In addition, industrial users are prohibited from serving groundwater to vegetation planted in a public right-of-way after January 1, 2002 unless the plants are on the Low Water Use/Drought Tolerant Plant List for the AMA and are prohibited from serving groundwater to a water feature in the right-of-way if installed after January 1, 2002.

6.2.5 Industrial Conservation Requirements and Monitoring and Reporting Requirements for All Industrial Users

6-201. Definitions

In addition to the definitions set forth in Chapters 1 and 2 of Title 45 of the Arizona Revised Statutes, unless the context otherwise requires, the following words and phrases used in sections 6-202 through 6-203 of this chapter shall have the following meanings:

1. *"Industrial process purposes" means water that is used by an industrial user directly in the creation or manufacture of a product.*

2. *"Industrial use" means a non-irrigation use of water not supplied by a city, town, or private water company, including animal industry use and expanded animal industry use.*

3. *"Industrial user" means a person who uses water for industrial uses.*

4. *"Low-flow plumbing fixture" means a lavatory faucet, lavatory faucet replacement aerator, kitchen faucet, kitchen faucet replacement aerator, shower head, urinal, water closet, or evaporative cooler designed to meet the use rates specified in A.R.S. §§ 45-312 and 313 or the applicable county or city code, whichever is more restrictive.*

5. *"Single-pass cooling and heating" means the use of water without recirculation to increase or decrease the temperature of equipment, a stored liquid or a confined air space.*

6. *"Wastewater" means water that is discharged after an industrial or municipal use, excluding effluent.*

6-202. Conservation Requirements

Beginning on January 1, 2002 or upon commencement of water use, whichever is later, and continuing thereafter until the first compliance date for any substitute conservation requirement in the Fourth Management Plan, an industrial user shall comply with the following requirements:

1. *Avoid waste; use only the amount of water from any source, including effluent, reasonably required for each industrial use; and make diligent efforts to recycle water.*

2. *Do not use water for non-residential single-pass cooling or heating purposes unless the water is reused for other purposes.*

3. *Use low-flow plumbing fixtures as required by Title 45, Chapter 1, Article 12, Arizona Revised Statutes, or any applicable county or city code, whichever is more restrictive.*

4. *Use plants listed in Appendix 5B, Low Water Use/Drought Tolerant Plant List or any modifications to the list, for landscaping to the maximum extent feasible, and water with a water-efficient irrigation system. An industrial user regulated as a turf-related facility under sections 6-301, et seq., or as a new large landscape user under section 6-901, et seq., is exempt from this requirement.*

5. *Do not serve or use groundwater for the purpose of watering landscaping plants planted on or after January 1, 2002 within any publicly owned right-of-way of a highway, street, road, sidewalk, curb, or shoulder that is used for travel in any ordinary mode, including pedestrian travel, unless the plants are listed in Appendix 5B, Low Water Use/Drought Tolerant Plant List or any modifications to the list. The director may waive this requirement upon request from the industrial user if a waiver is in the public interest. This requirement does not apply to any portion of a residential lot that extends into a publicly owned right-of-way.*

6. *Do not serve or use groundwater for the purpose of maintaining water features, including fountains, waterfalls, ponds, water courses, and other artificial water structures, installed after January 1, 2002 within any publicly owned right-of-way of a highway, street, road, sidewalk, curb, or shoulder that is used for travel in any ordinary mode, including pedestrian travel. The director may waive this requirement upon request from the industrial user if a waiver is in the public interest. This requirement does not apply to any portion of a residential lot that extends into a publicly owned right-of-way.*

6-203. Monitoring and Reporting Requirements

A. Requirements

For calendar year 2002 or the calendar year in which the facility first begins to use water, whichever is later, and for each calendar year thereafter until the first compliance date for any substitute monitoring and reporting requirement in the Fourth Management Plan, an industrial user shall, except as provided for in subsection B of this section, include the following information in its annual report required by A.R.S. § 45-632:

1. *The total quantity of water by source, including effluent, withdrawn, diverted, or received during the reporting year for industrial process purposes, as measured with a measuring device in accordance with the Department's measuring device rules, A.A.C. R12-15-901, et. seq.*

2. *The total quantity of water by source, including effluent, withdrawn, diverted, or received during the reporting year for purposes other than industrial process purposes, listed in paragraph 1 of this subsection, as measured with a measuring device in accordance with the Department's measuring device rules, A.A.C. R12-15-901, et. seq.*

3. *An estimate of the quantity of wastewater generated during the reporting year.*

4. *An estimate of the quantity of wastewater recycled during the reporting year.*

5. *A description of the primary purposes for which water from any source, including effluent, is used.*

6. *The number of acres of land that were planted with low water use plants during the calendar year as a result of removal of plants not on the Low Water Use/Drought Tolerant Plant List for the Tucson AMA or any modifications to the list, if more than one acre, and the method of irrigation for those acres. An industrial user regulated as a turf-related facility under sections 6-301, et seq., or as a new large landscape user under section 6-901, et seq., is exempt from this requirement.*

B. Exemption

An industrial user who holds a Type 1 or Type 2 non-irrigation grandfathered right or a groundwater withdrawal permit in the amount of 10 or fewer acre-feet per year is exempt from the requirements set forth in subsection A of this section, unless the industrial user holds more than one such right or permit in the aggregate amount of more than 10 acre-feet per year and withdraws more than 10 acre-feet of water during the calendar year pursuant to those rights or permits.

6-204. Remediated Groundwater Accounting for Conservation Requirements

A. Accounting

Groundwater withdrawn pursuant to an approved remedial action project under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) or Title 49, Arizona Revised Statutes, and used by a person subject to a conservation requirement established under this chapter, shall be accounted for consistent with the accounting for surface water for purposes of determining the person's compliance with the conservation requirement, subject to the provisions of subsections B through D of this section.

B. Amount of Groundwater Eligible for Accounting

For each approved remedial action project, the annual amount of groundwater that is eligible for the remediated groundwater accounting provided in subsection A of this section is the project's annual authorized volume. The annual authorized volume for a remedial action project approved on or after June 15, 1999 is the maximum annual volume of groundwater that may be withdrawn pursuant to the project, as specified in a consent decree or other document approved by the United States Environmental Protection Agency (EPA) or the Arizona Department of Environmental Quality (ADEQ). The annual authorized volume for a project approved prior to June 15, 1999 is the highest annual use of groundwater withdrawn pursuant to the project prior to January 1, 1999, except that if a consent decree or other document approved by the EPA or ADEQ specifies the maximum annual volume of groundwater that may be withdrawn pursuant to the project, the project's annual authorized volume is the maximum annual volume of groundwater specified in that document. The director may modify the annual authorized volume for a remedial action project as follows:

1. *For an approved remedial action project associated with a treatment plant that was in operation prior to June 15, 1999, a person may request an increase in the annual authorized volume at the same time the notice is submitted pursuant to subsection C of this section. The director shall increase the annual authorized volume up to the maximum treatment capacity of the treatment plant if adequate documentation is submitted to the director demonstrating that an increase is necessary to further the purpose of the remedial action project and the increase is not in violation of the consent decree or other document approved by the EPA or ADEQ.*

2. *A person may request an increase in the annual authorized volume of an approved remedial action project at any time if it is necessary to withdraw groundwater in excess of the annual authorized volume to further the purpose of the project. The director shall increase the annual authorized volume up to the maximum volume needed to further the purpose of the project if adequate documentation justifying the increase is submitted to the director and the increase is not in violation of the consent decree or other document approved by the EPA or ADEQ.*

3. *The director shall modify the annual authorized volume of an approved remedial action project to conform to any change in the consent decree or other document approved by the EPA or ADEQ if the person desiring the modification gives the director written notice of the change within thirty days after the change. The notice shall include a copy of the legally binding agreement changing the consent decree or other document approved by the EPA or ADEQ.*

C. Notification

To qualify for the remediated groundwater accounting provided in subsection A of this section, the person desiring the accounting must notify the director in writing of the anticipated withdrawal of groundwater pursuant to an approved remedial action project under CERCLA or Title 49, Arizona Revised Statutes, prior to the withdrawal. At the time the notice is given, the person desiring the accounting must be using remediated groundwater pursuant to the approved remedial action project or must have agreed to do so through a consent decree or other document approved by the EPA or ADEQ. The notice required by this subsection shall include all of the following:

1. *A copy of a document approved by ADEQ or the EPA, such as the Remedial Action Plan (RAP), Record of Decision (ROD) or consent decree, authorizing the remediated groundwater project. Unless expressly specified in the document, the person shall include in the notice the volume of groundwater that will be pumped annually pursuant to the project, the time period to which the document applies, and the annual authorized volume of groundwater that may be withdrawn pursuant to the project.*

2. *The purpose for which the remediated groundwater will be used.*

3. *The name and telephone number of a contact person.*

4. *Any other information required by the director.*

D. Monitoring and Reporting Requirements

To qualify for the remediated groundwater accounting for conservation requirements as provided in subsection A of this section, groundwater withdrawn pursuant to the approved remedial action project must be metered separately from groundwater withdrawn in association with another groundwater withdrawal authority for the same or other end use. A person desiring the remediated groundwater accounting for conservation requirements shall indicate in its annual report under A.R.S. § 45-632 the volume of water withdrawn and used during the previous calendar year that qualifies for the accounting.

6.3 TURF-RELATED FACILITIES

6.3.1 Introduction

A turf-related facility is a facility with 10 or more acres of water-intensive landscaped area. Golf courses, parks, schools, cemeteries, and common areas within residential developments are examples of facilities that often qualify as turf-related facilities. Because "irrigation" is defined in the Code as water applied for the purpose of growing crops for sale or consumption, turf-related watering for recreational and aesthetic purposes is considered a non-irrigation water use rather than an irrigation use.

Turf-related facilities regulated under the Industrial Conservation Program obtain groundwater pursuant to Type 1 or Type 2 non-irrigation grandfathered rights or permits. In addition, a large number of turf-related facilities are served groundwater by municipal water providers and are also subject to the conservation requirements set forth in this section through provisions of the Municipal Conservation Program (See Chapter 5). These municipally-served facilities are called individual users.

Second Management Plan conservation requirements and other factors have led to changes in turf-related facilities. New facilities are typically designed with less water-intensive acreage, both existing and new facilities employ technology that applies water more efficiently, and facility management has become more cognizant of the need for water conservation.

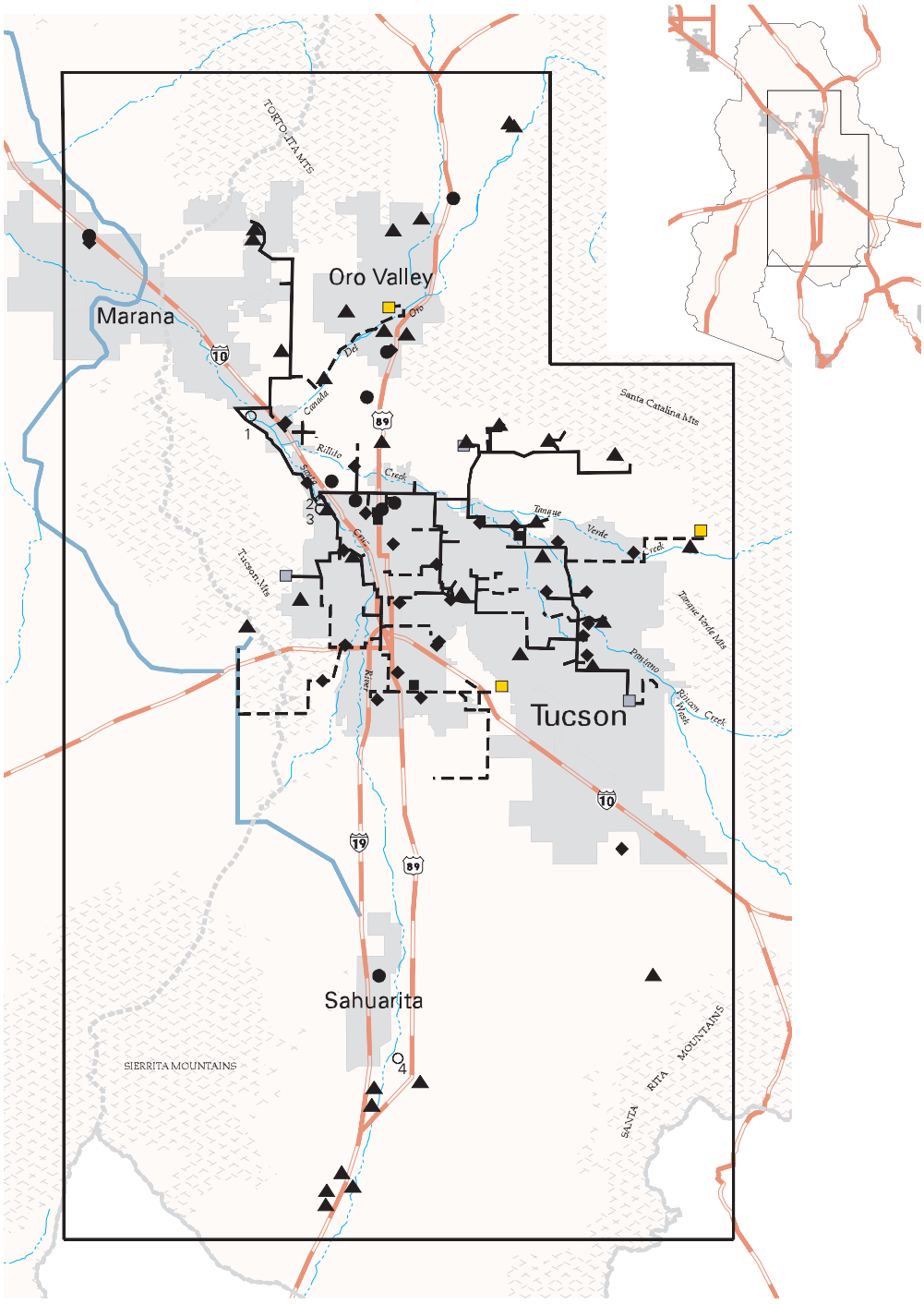
6.3.2 Water Use by Turf-Related Facilities

Turf-related facilities apply water for growing turfgrass and other landscaping plants and for filling and maintaining water levels in bodies of water. Water application efficiency is determined by the type of water application system that is utilized, maintenance of the system, water application scheduling, site topography, soil type, weather conditions, and water quality. There are 72 turf-related facilities in the Tucson AMA, including golf courses, parks, schools, and cemeteries. Common areas within residential subdivisions are subject to regulation as turf-related facilities if they have 10 or more acres of water-intensive landscaping, but none have been identified in the Tucson AMA. The location of Tucson AMA turf-related facilities and sources of effluent are shown in Figure 6-1.

There is a direct relationship between the number of acres of water-intensive landscaping maintained within a facility and the facility's water use. In 1995, turf-related facilities in the Tucson AMA encompassed a total of 4,215 acres of turf and 149 acres of water surface area. From 1987 through 1995, the average annual water application rate on turf acres within turf-related facilities has ranged between 4.3 and 4.7 acre-feet per acre. Golf courses tend to be the largest turf-related facilities, typically having at least 60 acres of turf. Parks make up the majority of the smaller turf-related facilities, usually having less than 40 turf acres.

The water use rate for maintaining bodies of water is higher than for turf and low water use landscaping because evaporation from the water surface (approximately 5.8 feet per year) is higher than the consumptive use and evaporation rates for plants. Unlined or inadequately sealed water holding basins can lose significant volumes of water through seepage. The bodies of water associated with turf-related facilities are most often constructed on golf courses, although a few parks feature recreational bodies of water.

In 1995, turf-related facilities in the Tucson AMA maintained a total of 232 acres of low water use landscaping that was irrigated with a permanent watering system, such as a drip irrigation system. Low water use landscaping water requirements tend to be highest during the first three years when new plants become established. Application rates for low water use landscaping are typically much lower than for turfgrass.



- Golf Course
- School
- Park
- Cemetery
- Water Treatment Site
- Existing Pipeline - Tucson reclaimed water distribution system
- Proposed Pipeline - Tucson reclaimed water distribution system
- Subbasins
- AMA Boundary
- Incorporated Areas
- Hardrock
- Proposed Reservoir
- Existing Reservoir

1 Ina Rd Water Pollution Control Facility
2 Roger Rd Wastewater Treatment Plant
3 Tucson Water Reclaimed Water Plant
4 Green Valley Wastewater Treatment Plant

Figure 6- 1

Location of Turf Related Facilities And Effluent Sources

0 1.8 3 5 7
Miles

North

ORIGINAL SOURCE

Arizona Department of Water Resources
Geographic Information System

"Water use efficiency" refers to the relationship between the physiological needs of the plants being watered and the amount of water actually applied. Turf-related watering is normally expressed in terms of acre-feet per acre per year. Average turf application rates at turf-related facilities may be estimated by subtracting the estimated water use for low water use landscaping acres and lake acres (calculated by multiplying the number of acres of low water use landscaping and water surface area by the application rates of 1.5 acre-feet per acre and 5.8 acre-feet per acre, respectively) from total water use. In 1995, the estimated turf application rates for different types of facilities in the Tucson AMA varied from 3.5 to 4.7 acre-feet per acre per year. This range is indicative of the broad spectrum of water use patterns among the types of turf-related facilities. Parks tend to have the lowest application rate, while golf courses tend to have the highest. Facility acreage attributes and water application rates are detailed in Table 6-1.

TABLE 6-1
1995 ACREAGE AND WATER USE BY TURF-RELATED FACILITIES
INDUSTRIAL USERS AND MUNICIPAL INDIVIDUAL USERS
TUCSON ACTIVE MANAGEMENT AREA

Turf-Related Facilities		Total Acreage			Water Application	
Type	Number	Turf	Total Water Surface Area	Low Water Use Landscaped Area	Total Water Use (acre-feet)	Application Rate for Turf Acres (acre-feet/acre)[1]
Golf Courses	32	3,251	101	208	16,154	4.9
Parks	26	602	48	0	2,380	3.5
Cemeteries	4	178	0	0	674	3.8
Schools	10	184	0	26	805	4.4
TOTAL[2]	**72**	**4,215**	**149**	**232**	**20,013**	**4.5**

[1] Average application rates for turf acres were derived by subtracting the estimated water for water surface area and low water use landscaped area from the reported 1995 water use and dividing by the number of turfed acres reported on 1995 water use reports.
[2] Numbers may not add up exactly due to rounding.

Turf-related facility water use in the Tucson AMA has increased from 17,900 acre-feet in 1987 to 20,013 acre-feet in 1995. While total water use has increased, it continues to be below the cumulative Second Management Plan maximum annual water allotment of 21,922 acre-feet for all turf-related facilities.

Turf-related facility water demand is met through various sources, including:

- Groundwater pumped pursuant to Type 1 and Type 2 non-irrigation grandfathered rights;
- Groundwater pumped pursuant to groundwater withdrawal permits;
- Groundwater served by municipal water providers;
- Effluent served via the City of Tucson's reclaimed water system;
- Effluent from Pima County wastewater treatment plants;
- Effluent from privately operated wastewater treatment plants; and
- Effluent or CAP water stored underground and recovered pursuant to water storage credits.

In 1995, 38 percent of the water used on turf-related facilities was groundwater withdrawn pursuant to industrial rights. The remaining 62 percent was water served by municipal providers. The volume of

groundwater served by municipal providers to turf-related facilities has remained fairly constant, while the volume of effluent being served has increased. Increased utilization of effluent by both existing and new turf-related facilities is due largely to the City of Tucson's commitment to the expansion of its reclaimed water distribution system. Water sources used in 1995 are detailed in Table 6-2.

TABLE 6-2
1995 TURF-RELATED FACILITY WATER USE BY SOURCE
TUCSON ACTIVE MANAGEMENT AREA

Type	Number of Facilities		Water Source (acre-feet)			
	Municipal	Industrial	Municipal		Industrial	
			Groundwater	Effluent	Groundwater	Effluent
Golf Courses	20	12	4,988	4,871	5,599	696
Parks	22	4	1,080	973	327	0
Cemeteries	0	4	0	0	589	86
Schools	2	8	141	0	664	0
TOTAL	**44**	**28**	**6,209**	**5,844**	**7,179**	**782**

Annual water demand by turf-related facilities is anticipated to reach 31,000 acre-feet by 2025. Golf course projections are based on information provided by specific development plans, development companies and public parks and recreation departments. Golf course construction is closely tied to development of golf-centered retirement communities. It is anticipated that 21 additional golf courses will be built in the Tucson AMA by 2025. Projections for parks, cemeteries, and schools assume that turfed acreage will increase commensurate with the regional population. The majority of new large turf-related facilities is expected to be golf courses. The current trend in the Tucson AMA to construct new schools, cemeteries, and parks with less than ten acres of water-intensive landscaped area is expected to continue.

Only about 12,000 acre-feet of the year 2025 turf-related facility water demand is expected to be met with groundwater withdrawn pursuant to industrial rights. The remaining 19,000 acre-feet of demand is anticipated to be served by municipal providers with the majority of it being met by effluent. Zoning code amendments passed by the Pima County Board of Supervisors in November, 1995 require that all new golf courses must use effluent or CAP water for turf-related watering, if available. Groundwater may be used if renewable supplies cannot reasonably be made available, but groundwater use must be offset by recharging CAP water. The City of Tucson has a policy that requires use of effluent by new turf-related facilities where feasible. Since 1983, all new golf courses served by Tucson Water have been connected to the reclaimed water system. This policy is expected to continue because of public opinion and because of the provision in the Municipal Conservation Program of the management plan that exempts direct effluent deliveries from a provider's GPCD calculation. The Town of Oro Valley is committed to serving renewable water to all turf-related facilities within its water service area by the year 2000. The Town of Marana has indicated that it will adopt similar zoning standards for new golf courses.

Compliance with GPCD conservation requirements usually prevents private water companies from serving new golf courses. Consequently, some developers have expressed their intent to participate in underground storage and recovery projects to generate storage credits. Stored water recovered by a turf-related facility from within a municipal provider's service area is not counted in the provider's GPCD usage rate, if the recovery is pursuant to a recovery well permit held by the turf-related facility.

6.3.2.1 Golf Courses

In the Tucson AMA, golf courses include par-three courses and 9, 18, 27, and 36 hole facilities. Non-regulation courses, those shorter than 6,200 yards in total length, have less turfed acres than regulation courses. Golf courses are composed of tees, greens, fairways, and roughs. The most frequently used types of warm season grass are common or hybrid bermuda grass (*Cynodon*) with hybrid bermuda or bent grass (*Agrostis*) used primarily on greens. All golf courses overseed their tees and greens with rye grass (*Lolium*) in winter unless they have bentgrass greens. During the 1990s, some golf courses began experimenting with using lower water use grass species such as buffalo grass (*Buchloe*), curly mesquite grass (*Hilaria*), and purple three-awn (*Aristida*) in rough areas as a water conservation measure.

A high proportion of resort golf courses overseed at least the fairways during the winter months. There is a great deal of variability in overseeding patterns on public and private courses. Some courses prefer to avoid the expense, maintenance problems and stress to the turf associated with overseeding fairways. Some golfers appreciate the better playability associated with dormant bermuda grass. Other facility managers feel strongly that a green appearance during the winter months is required to attract visitors to golf courses in Arizona. There is strong interest in turf appearance for all golf courses, particularly resort courses and courses associated with housing developments that emphasize aesthetics rather than maximum playability and water conservation during the winter.

Golf course water application systems are often more sophisticated than those at other turf-related facilities. Most have a system with a control panel and field satellites that can override the central controller. Computer-controlled watering systems and pump stations with flexibility in operating sprinkler heads are commonplace; newer systems provide much greater savings in energy and water costs than water delivery systems of ten years ago. Most of the newer systems can incorporate weather stations that assist in scheduling water application to more accurately replace the amount of water lost through evaporation and transpiration. Most courses apply water to greens and tees with spray heads; larger turf areas are watered with large radius heads. Water is typically pumped into the watering system from a reservoir or a storage tank.

Turf managers who are knowledgeable of water conservation technologies and practices are critical to program effectiveness. Taking advantage of a computerized system's ability for field-adjusting water distribution uniformity or the percentage of points within the area being watered that receive equivalent amounts of water, routine leveling of heads, and frequent verification of proper operation of all controllers and heads are examples of prudent management.

There were 32 golf courses in the Tucson AMA in 1995. These courses used 16,154 acre-feet of water in 1995, which was 81 percent of the water used by all turf-related facilities that year, and 27 percent of the water used by all users regulated under the Industrial Conservation Program that year including individual users. In 1995, golf courses used 5,599 acre-feet of groundwater withdrawn pursuant to industrial rights. This represents 9 percent of the total amount of groundwater withdrawn pursuant to such rights in 1995.

Golf course demand has remained fairly constant since 1987 even with the addition of five new courses. As expected, application rates increase proportionately to evapotranspiration rates in dry, hot years, although a less commensurate decrease in application rates has not been observed in wetter, cooler years. The average water application rate for turfed acreage was 4.7 acre-feet per acre in 1995.

6.3.2.2 Parks

Public parks maintain turf for playing surfaces, for aesthetic reasons, and for erosion control. Maintenance of public parks is usually coordinated through a central office without the presence of on-site staff on a daily basis. Parks commonly have inefficient water application systems, although newer parks are

installing more efficient systems, including drip irrigation and controllers that have water budgeting capacity. Large radius impact heads are frequently used. Vandalism is a significant problem, requiring specialized tamper-proof heads. Bermuda grass is the only species planted, with rye grass overseeding limited to only a few baseball fields. More relaxed turf appearance standards and lack of overseeding have resulted in much lower application rates than those achieved by golf courses, schools, and cemeteries.

Total water use for 26 parks was 2,380 acre-feet in 1995. The average water application rate for turf acreage was 3.5 acre-feet per acre. Only 17 percent of the park demand is served with groundwater withdrawn pursuant to industrial rights, the rest is served by municipal providers. About half of the municipally-served parks receive effluent as their sole water source for turf-related watering. Nearly a third of the parks in the AMA are under 20 acres in size. The largest, Reid Park, has just under 77 acres of water-intensive landscaped acreage with effluent being the only water source utilized for landscape watering and maintaining water levels in bodies of water within the park.

6.3.2.3 Schools

The main function of turf in school yards is to provide an appropriate surface for active play. School managers have determined that using low water application rates can save money without adversely impacting turf use. Bermuda grass is the only species used and is seldom overseeded. Although athletic fields tend to be maintained at a higher turf quality than the balance of school yards, more relaxed appearance standards and limited overseeding allow much lower application rates than those achieved by golf courses.

Water application systems at schools are usually relatively inflexible. In older schools, outdated equipment, including quick coupler systems, are common. Newer facilities have in-place sprinkler heads with manual or electromechanical control. Some schools have converted non-play areas to drip irrigation. Due to budget constraints, it is difficult for schools to install computerized controllers, and systems are frequently manually operated.

Turf acreage within schools is comparatively small. The largest facility is Marana Junior High School with 30 turf acres. Seven facilities are less than 20 acres in size. Water application rates for turf at schools are low, compared to other turf-related facilities, with an average of 3.7 acre-feet per acre. None of the schools regulated as turf-related facilities in the Tucson AMA receives effluent for turf-related watering. Tucson Unified School District is actively converting its turf-related watering to effluent at schools that have access to the City of Tucson's reclaimed water system, although none of these schools was regulated as a turf-related facility under the Second Management Plan.

6.3.2.4 Cemeteries

Cemeteries have several unique characteristics that affect water conservation potential. Cemeteries are developed in stages and are committed to maintaining grave sites in perpetuity in a manner acceptable to the public. Interment activities also cause problems in scheduling of water application. Cemeteries promote an image of a quiet, cool resting place so turf appearance is extremely important.

Water requirements of cemeteries are similar to those of golf courses, although less overseeding is practiced. Because cemeteries are developed in sections, additional water application systems are installed as new areas are opened. The water application system in older areas is often quite different from the system in more recently developed sections. The result is often a complex control system that is difficult to manage. Most cemeteries use electromechanical controllers with a large number of sprinkler heads on each controller. Large radius heads or raised spray heads are frequently used to allow watering around headstones. Several facilities have upgraded their systems and installed drip irrigation for trees and shrubs.

The trend through the 1990's in the Tucson AMA has been to design new cemeteries with a minimum of water-intensive landscaping. The public has accepted this new style of cemetery. An abundance of low water use trees creates a pleasantly shaded environment, low water use shrubs and groundcovers provide color during blooming seasons. None of the new cemeteries in the Tucson AMA is regulated as a turf-related facility.

6.3.3 First and Second Management Plan Program Development

The First Management Plan established a maximum annual water allotment for each turf-related facility and stressed water use efficiency. This was the first time golf course water use was regulated, and water management practices such as evapotranspiration-based water application scheduling was uncommon. The First Management Plan provided for adjustment of turf application rates if effluent was used.

The allotment approach permitted turf managers to consider characteristics of the facility, evaluate conservation alternatives, and decide how to most effectively apply the allotment to meet the facility's needs. A golf course requiring a lush, green appearance during the winter season could choose to reduce the amount of water applied to bermuda grass through the summer season, making a larger portion of the allotment available for extensive cool-season overseeding. Conversely, a golf course could emphasize the playability and lower maintenance of dormant bermuda grass and apply more of the allotment and maximize bermuda grass appearance during the summer season. A golf course that demanded a year-round lush appearance received sufficient allotment to do so, if state-of-the-art water application technologies and water management practices were employed.

The trend throughout the first management period was to convert turf-related facilities from groundwater to effluent use. This conversion was due in large part to City of Tucson policies that require effluent use and by an aggressive reclaimed water system construction program. These efforts continue to the present. The exclusion of direct effluent deliveries from the GPCD calculation in the Municipal Conservation Program also serves as an incentive for water providers to serve effluent to turf-related facilities when available.

Development of the Second Management Plan conservation requirements involved extensive data collection regarding water use patterns in Arizona and the conservation options available to turf-related facility managers. The Department relied heavily on input from the Turf Advisory Committees in the Tucson and Phoenix AMAs, which consisted of golf course, park, cemetery, and school turf managers, turf irrigation specialists, extension agents, and golf course designers.

The Department used consulting services to analyze the water conservation practices in use in the turf industry and the potential for future water conservation. The study evaluated technologies, including management practices and design alternatives associated with water conservation. A primary finding of the study was that management of the water application system, rather than the use of specific water application systems, is the most important factor in efficient landscape watering. The consultant and advisory committees concluded that a combination of good management and use of the latest water application systems was very effective in reducing water use.

For the Second Management Plan, the Department chose not to require specific conservation techniques wherever possible due to the widely varied nature of turf-related facilities. Instead, turf-related facilities continued to receive a maximum annual water allotment based on the use of conservation techniques. The allotment approaches of the First and Second Management Plans permitted turf managers to consider characteristics of the facility, evaluate conservation alternatives, and decide how to most effectively apply the allotment to meet each facility's needs.

The Second Management Plan included an overall decrease in application rates for all turf-related facilities, caps on maximum annual water allotments for new golf courses, and a limitation on the water-

intensive landscaped area within new cemeteries, plus a more specific effluent incentive. In setting the annual water allotments, factors considered included actual water use figures collected from over 400 turf-related facilities in all AMAs. Data on the consumptive use of the grass species most frequently used, water application efficiency achievable with available technologies, evaporative losses from bodies of water based on pond evaporation data, management practices and technologies currently in place, conservation potential associated with additional technologies, practices, and design alternatives, and germination requirements for establishing new turf were compiled and analyzed.

Based on these factors, the Department established final annual application rates in the Tucson AMA of 4.6 acre-feet per acre for turf acres, 5.8 acre-feet per acre for bodies of water and 1.5 acre-feet per acre for low water use landscaping. For golf courses that came into existence after 1984 the maximum annual water allotment could not exceed 23.8 acre-feet per hole. Adjustments to the application rates were provided for establishing new turf, using high salinity water, filling or refilling bodies of water, and revegetating acreage disturbed during construction.

The Department continued to encourage the use of effluent in the Second Management Plan. As an incentive, effluent use, if 50 percent or more of total water use, was discounted when determining a facility's compliance with its maximum annual water allotment.

A review of short-term weather data in the 1980s indicated that a three-year averaging method would adequately compensate for weather fluctuations when determining a facility's compliance with its allotment. A provision for finding a facility in compliance on either an annual or a three-year average basis was included in the Second Management Plan.

The Second Management Plan has proven most successful in changing the design of new facilities by reducing turfed acres without sacrificing functionality. Water use by turf-related facilities is highly correlated to the number of turfed acres within the facilities. Recent school and park designs usually eliminate turf except where essential for recreational purposes, reducing water use for turf. Most parks, schools, and cemeteries built during the second management period in the Tucson AMA have less than 10 acres of water-intensive landscaping and are not regulated as turf-related facilities. Golf course designers have been able to design lower acreage courses without affecting appearance and playability. Generally, improvements in water management and irrigation technology have allowed turf-related facilities to increase the percent of acreage that is overseeded, while maintaining efficient water application rates.

Table 6-3 compares changes in acres per hole for existing and new regulation size golf courses. Since 1985, under both the First and Second Management Plans, new courses have substantially less turf and body of water acres per hole.

Few turf-related facilities in the Tucson AMA have had difficulty complying with their maximum annual water allotments during the second management period. Facilities that have been out of compliance with the requirements have chosen to implement long-lasting conservation technologies and practices, such as relining leaking bodies of water, permanent removal of turf, or the renovation of aging, inefficient watering systems.

6.3.4 Issues and Third Management Plan Development

The Code provides that the conservation program for industrial users shall require the use of or establish conservation requirements based on the use of the latest commercially available and economically feasible water conservation technologies. For turf-related facilities, such technologies include: (1) the use of weather-based water application scheduling and water budgeting; (2) accurate, well-designed water application systems and computerized control mechanisms; (3) golf course design that concentrates water-intensive landscaping in areas that come into play; and (4) PVC liners for bodies of water. Using

TABLE 6-3
AVERAGE LANDSCAPED ACREAGE PER HOLE
EXISTING AND NEW GOLF COURSES
TUCSON ACTIVE MANAGEMENT AREA

Type of Acreage	Existing Golf Courses[1]	New Golf Courses[2]
Turf	5.4	4.7
Bodies of Water	0.17	0.15
Low Water Use Landscaping	0.14	0.81

[1]Existing courses are defined in the Second Management Plan as courses built or substantially commenced by December 26, 1984.
[2]New courses are defined in the Second Management Plan as courses built or substantially commenced after December 26, 1984

new low water use and drought tolerant turfgrasses, improving conservation knowledge and awareness by facility management, and converting industrial users to renewable supplies are ways turf-related facilities could further contribute to safe-yield.

Technical advisory committees (TACs) in the Phoenix and Tucson AMAs, consisting of golf course, park, school, and cemetery turf managers, golf course directors, golf course architects, industry association representatives, and land developers, have contributed to the development of the Third Management Plan conservation program for turf-related facilities. The committees aided the Department in identifying second management period water use efficiency, water supply and conservation program effectiveness issues, provided and reviewed data and information relevant to the issues, and participated in developing program alternatives for the third management period. The committees worked with the Department to review the merits of all alternatives and to strive for consensus on the program for the third management period. In some cases, subcommittees were formed to address a specific issue and to make a program recommendation to the committee as a whole. These committees and the Department identified the following issues of relevance:

- the allotment methodology
- application rates for turf
- weather adjustment
- renewable supply incentives

6.3.4.1 Allotment Methodology and Application Rates

The Second Management Plan final annual application rates of 4.6 acre-feet per acre for turf acreage, 5.8 acre-feet per acre for bodies of water and 1.5 acre-feet per acre for low-water use landscaping applied to all turf-related facilities. However, for most golf courses constructed after 1984, the maximum annual water allotment was limited to 23.8 acre-feet per hole.

During Third Management Plan development, some representatives of the golf industry argued that the Second Management Plan application rates for turf and the cap on the allotment for golf courses constructed after 1984 denied golf courses their legal right to sufficient groundwater to meet their actual needs consistent with their selected business practices. They felt that the Department's program unreasonably prevented the complete overseeding of golf courses, interfered with reasonable management of longer courses needed to attract high-visibility tournaments, and resulted in target-style courses that imposed unreasonable skill demands on inexperienced and older golfers. They asserted that the allocations were not supported by sufficient data. Other TAC members felt that Second Management Plan application rates and allotment limitations were supported by scientific research and, that while potentially challenging

to superintendents and designers, the allotments were adequate assuming the use of high-quality water application systems and conscientious water management practices.

Factors influencing turf watering needs include temperature, solar radiation, humidity, wind, and soil moisture. Based on research conducted at the University of Arizona Desert Turf Research Center (Brown, Gilbert, and Kopec, 1996) and 1988 to 1996 weather data from the Arizona Meteorological Network (AZMET) Tucson Station, high-quality turf with winter overseeding would need 4.5 to 5.2 acre-feet per acre per year of applied water depending upon the weather conditions of that year, not including rainfall. This research supports the adequacy of the Second Management Plan's 4.6 acre-feet per acre per year application rate for maintaining overseeded turf.

The parameters assumed in the research are conditions that may lead to a long-term root zone salt accumulation, depending upon the quality of the water applied to turf. Additional investigation is needed to determine if typical rainfall distribution will adequately flush accumulated salts beyond the turfgrasses' root zone or, if rainfall is not sufficient, if continuous water application at a slightly higher rate or periodic flushing at a much higher application rate would best balance salt management and water application efficiency.

Because regional variation in rainfall, wind speed during watering times, soil type, root zone depth, and course topography can all have potential negative impacts on turf water demand, application rates deemed sufficient for the majority of facilities may not be appropriate for all facilities. Individual facilities with special circumstances that could render these application rates unreasonable may seek relief through administrative review. A.R.S. § 45-575.

While the maximum annual water allotment provisions do not directly limit water-intensive acreage of new golf courses, acreage limitations are incorporated into the derivation of the 23 acre-foot per hole allotment cap for turf acres and low water use landscaped area and the 0.8 acre-foot per hole allotment cap for water surface acres. Among the conservation technologies currently available to golf course developers, minimizing water-intensive acreage is one of the most effective means of reducing water demand. Both the turf-related facility study conducted by the Department during development of the Second Management Plan and numerous articles in golf industry trade journals during the past 15 years point to smaller turfed areas as an effective means for golf courses to save water and reduce operating costs. Eighteen-hole golf courses with about 90 acres of turf were found to be more manageable while still being around 7,200 yards in length. Bodies of water with 2 to 3 acres of surface area allow for sufficient storage capacity to hold three to five days worth of peak facility water demand. The allotment cap is based on these acreage guidelines for an 18-hole course multiplied by the application rates for turfed and water surface area, expressed on a per hole basis. All of the golf courses constructed in the Tucson AMA since 1990 were designed with less than 90 acres of turf for 18 holes.

Historic water use and research in California indicates that the higher unirrigated perimeter to turfed acre ratios typical of target-style courses may result in higher water demand per acre than that of more traditionally-designed courses. Increased evapotranspiration may occur within 200 feet of perimeters adjacent to unwatered or low water use areas. On narrow fairways these zones may coincide, and water demand for the entire turfed area may increase on the order of 5 percent. In order to quantify this effect for possible inclusion in management plan requirements, additional research needs to be conducted in the desert regions of Arizona.

6.3.4.2 Weather Adjustment

Long-term weather data indicate that the mid-1980s and early 1990s represented a comparatively "wet" period. Historically, rainfall in the Tucson AMA tends to be cyclic with "dry" or "wet" periods that may last as long as four or five years. Wet years early in the second management period were followed by a

protracted period of hot summer weather combined with sparse or late summer rains. Consequently, in 1996 and 1997, an unusually large number of turf-related facilities began to experience difficulty in complying with their annual water allotments.

Alternatives were considered to the three-year averaging approach for determining compliance used in the Second Management Plan in order to compensate for weather fluctuations more effectively. These alternatives included a flexibility account and a five-year averaging provision. For the Third Management Plan, the Department chose not to extend the three-year averaging provision to five years. The length of a five-year averaging provision would result in a considerable lag between the time the annual allotment was exceeded and when corrective action could be taken. Instead, the Department opted for a flexibility account that contains both credit and debit limits. Credit and debit limits for the flexibility account have been set at 20 percent of the maximum annual water allotment based on an analysis of the 1988 through 1997 weather variations. The account will encourage and reward careful management through the accrual of credits.

6.3.4.3 Renewable Supply Incentives

While many new facilities are served alternative water sources by municipal providers, existing industrial users continue to pump groundwater. Conservation requirements strive for efficient use but cannot eliminate the contribution to overdraft by industrial users. The availability of Type 2 non-irrigation grandfathered rights through purchase or lease, the conversion of irrigation grandfathered rights to Type 1 non-irrigation grandfathered rights, the issuance of groundwater withdrawal permits, and the delivery of groundwater by municipal water providers are all prospects that could increase groundwater use by turf-related facilities in the future and further increase overdraft in the Tucson AMA.

The cost of using renewable water supplies is a major consideration for those turf-related facilities operating their own wells, because it is considerably cheaper to pump and use groundwater than to purchase effluent from the City of Tucson. In 1997, the cost of effluent served through the reclaimed water system was $462 per acre-foot. While this rate is less than potable water service from the City and most other municipal water providers, reclaimed water rates are partially subsidized by potable water sales and other revenue-generating activities. Extensions of the reclaimed water system to other water providers' service areas by the City of Tucson must be justified to the City's potable water ratepayers.

In the Second Management Plan, the effluent use incentive was structured so that if at least 50 percent of a facility's applied water was effluent, the volume of effluent used was discounted. The amount of the discount was 5 percent if up to 89 percent of the total water use was effluent and 10 percent if 90 percent or more of the total water use was effluent. Also, the cap placed on the allocation given for bodies of water within new golf courses did not apply to bodies of water filled entirely with effluent.

The cost and availability of effluent delivery and the policies of municipal water providers and local jurisdictions primarily determine effluent use for turf-related watering in the Tucson AMA. In addition to reserving high-quality groundwater for potable uses, serving effluent for turf-related watering provides further community benefits. Excluding direct deliveries of effluent from a municipal provider's gallons per capita per day conservation requirement makes effluent use attractive to water providers. Effluent reuse also eases peak demand impact on potable water systems. Avoidance of lengthy permitting processes and treatment costs incurred when effluent is discharged into public waterways makes reuse attractive to wastewater treatment authorities. Effluent reuse can also help to reduce groundwater pumping in areas experiencing substantial water level declines or land subsidence potential.

The Department and the Third Management Plan Turf TACs discussed several incentives that would further encourage effluent and CAP water utilization by both municipally provided facilities and industrial users in the Third Management Plan. Because effluent is an underutilized supply, the Department chose to

discount all direct effluent use by 30 percent. The discount will provide a significant incentive to encourage effluent use where supplies are expensive and will encourage the construction of wastewater treatment plants to produce effluent in new developments, where supplies may be limited until residential development nears completion. The incentive acknowledges the need for efficient use of all water supplies, while providing a higher potential application rate to facilities using higher percentages of effluent. Agronomic research has shown that high quality turfgrass can be maintained through application of approximately 75 percent of the measured evapotranspiration rate. As effluent use approaches 100 percent of a facility's total water use, the 30 percent effluent discount will allow a typical golf course to apply the full amount of water lost by turfgrass through evaporation and transpiration.

The Department and the TACs also explored options to allow a turf-related facility to mitigate water use in excess of the annual water conservation allotment. If more groundwater is used at a turf-related facility than allowed by its annual water allotment, a net benefit could be provided to the aquifer either through recharging without earning credits (known as storing "non-recoverable" water) or extinguishing existing recharge credits at a higher rate than the excess groundwater used at the facility. Issues considered included the rates of recharge required, conditions that would apply to ensure no wasteful practices are condoned, the effect on water conservation efforts, and the effect of excessive pumping upon localized groundwater conditions.

The Department determined that this option will not be included as a part of the conservation requirements for turf-related facilities during the third management period. In the meantime, the option of extinguishing recharge credits or storing non-recoverable water in particular areas as a compliance mechanism will be considered during the third management period, even in advance of a violation. Owners and operators of turf-related facilities who anticipate an allotment violation are encouraged to develop a proactive response program in cooperation with the Department (See Chapter 10).

6.3.5 Turf-Related Facilities Conservation Program

6.3.5.1 Maximum Annual Water Allotment

6.3.5.1.1 Base Allotment

The core of the conservation program for turf-related facilities is the maximum annual water allotment. The allotment is calculated differently for different types of facilities, but generally there is a direct relationship between the number of acres to which water is applied and the volume of the allotment. For all turf-related facilities, the annual application rate for turf acres is 4.6 acre-feet per acre, the application rate for water surface acres is 5.8 acre-feet per acre, and the application rate for low water use landscaped area is 1.5 acre-feet per acre.

For turf-related facilities other than golf courses, the allotment is calculated by determining the actual acreage within the facility in each of the three landscaping categories and then multiplying the number of acres by the appropriate application rate. The approach used for these facilities allows expansion of landscaped area. Beginning with the First Management Plan, the Department recognized that the latest conservation technology for golf courses includes course design that concentrates water-intensive landscaping into areas that come into play and water management practices that adjust water application schedules for weather conditions and seasons of highest play. The allotment for golf course acreage that came into existence after December 31, 1984 is therefore capped to encourage efficient design, construction, water application, and overseeding practices. These caps are described below.

Golf course acreage that came into existence from January 1, 1985 through December 31, 1991 - For golf courses, the allotment for any turf acres that came into existence from January 1, 1985 through December 31, 1991 is limited to an amount calculated by multiplying the number of holes within those acres by 23

acre-feet of water per hole, plus any allotment additions described later in this section. This cap is sufficient to water 5 acres of turf at 4.6 acre-feet per acre. If the turf acres planted during that period are in fact limited to 5 acres per hole, there is no cap on the allotment for any bodies of water that came into existence within the facility from January 1, 1985 through December 31, 1991. However, if the turf acres planted from January 1, 1985 through December 31, 1991 exceed 5 acres per hole, the allotment for any bodies of water that came into existence during that period and that are not filled and refilled entirely with direct use effluent or effluent recovered within the area of impact is limited to an amount calculated by multiplying the number of holes within those turf acres by 0.8 acre-feet of water, plus any allotment additions described later in this section.

Golf course acreage that came into existence after December 31, 1991 - For golf courses, the total allotment for turf acres and low water use landscaped area that came into existence after December 31, 1991 is limited to an amount calculated by multiplying the number of holes within those acres by 23 acre-feet of water, plus any allotment additions described later in this section. This cap is sufficient to water 5 acres of turf at 4.6 acre-feet per acre. If less than five acres of turf are planted per hole, the cap allows sufficient water for approximately 3 acres of low water use landscaping in place of each acre of turf not planted. The allotment for all bodies of water that came into existence after December 31, 1991 and that are not filled and refilled entirely with direct use effluent or effluent recovered within the area of impact is limited to an amount calculated by multiplying the number of holes within the turf acres that came into existence after December 31, 1991 by 0.8 acre-feet of water. This cap limits the allotment for such bodies of water to 0.14 acre of water surface per hole.

Golf courses may expand or develop any number of water-intensive landscaped acres and low water use landscaped area. However, water use must not exceed the maximum annual water allotment, which assumes acreage restrictions. Although the allotment is calculated on a per acre basis, the facility manager has discretion on how to apply the allotment within the facility.

6.3.5.1.2 Allotment Additions

Under certain circumstances, a turf-related facility is entitled to an addition to its base allotment. In some cases, the allotment addition is effective only for one year; in other cases, the allotment addition is effective for a longer period. The following are the allotment additions allowed in the Third Management Plan.

Reduction of Turfed Acreage

Conservation requirements for the third management period continue to provide an incentive to reduce landscaped area. When calculating the maximum annual water allotment for a turf-related facility, the amount of water allotted to pre-1985 turf, water surface acres, and low water use landscaping is based on the highest number of those acres in existence at the facility during the period from 1980 through 1984. Thus, removal of acreage planted during that period will not decrease the facility's allotment. All turf-related facilities are encouraged to minimize the water-intensive landscaping to areas consistent with the intended use and enjoyment of the facility.

Allotment Addition for Establishment of Newly Turfed Area

An allotment addition is given to turf-related facilities for the establishment of newly planted turf. The allotment addition is equal to 1.0 acre-feet per acre of newly turfed area, and is limited to the year in which the turf is planted. For golf courses, the allotment addition is limited to an amount calculated by multiplying the number of holes present within the newly turfed area by 5 acre-feet of water.

Allotment Addition for Revegetation

A revegetation allotment addition is available to facilities that want to establish low water use or other site-adapted landscaping plants that will need only temporary supplemental water application after construction of a new or renovated facility. This allotment addition of up to 1.5 acre-feet per acre for up to a maximum of three calendar years, is quantified and granted on an individual basis through an application process. The quantity and duration of the allotment adjustment is determined through the Department's evaluation of each application. This adjustment is separate from the low water use landscaping component included in the maximum annual water allotment calculation, and is not included in the allotment cap for new landscaped areas within golf courses.

Allotment Addition for Filling Bodies of Water

New turf-related facilities receive a one-time allotment addition to fill bodies of water within the facility. The allotment addition is equal to the volume used for initial filling of the body of water and is given only for the year in which the body of water is filled. Any facility may also apply for an allotment addition to refill a body of water that has been emptied for maintenance work to eliminate or reduce seepage losses. The allotment addition may be given only for the year in which the body of water is refilled.

Allotment Addition for Leaching

When high levels of total dissolved solids are present in the water supply, a turf-related facility may need an additional amount of water for leaching, or deep percolation, to prevent salts from accumulating in the root zone. If salts are allowed to accumulate in the soil, salinity may eventually reach levels toxic to turfgrass. Since most water supplies in the Tucson AMA are of a quality that does not require an additional leaching allowance, a leaching allowance was not included in the maximum annual water allotment calculation. However, if a facility's water supply has a concentration of 1,000 milligrams per liter of total dissolved solids (approximately 1.5 millimhos per centimeter of electrical conductivity) or greater, the turf-related facility may apply to the Department for an allotment addition for leaching.

6.3.5.2 Additional Conservation Requirements

All turf-related facilities are required to prepare and maintain a water conservation plan. The plan must outline the water management practices and technologies the facility will utilize to maximize water use efficiency. All turf-related facilities that are not golf courses are required to design, construct, and maintain grounds in a manner that will minimize water-intensive landscaped areas consistent with reasonable use and enjoyment of the facility. Golf courses have a capped maximum annual allotment that assumes water-efficient design and management.

A turf-related facility that is a cemetery must limit the water intensive landscaped area within any portion of the cemetery that came into existence after December 31, 1991, so that no more than 75 percent of the total cemetery area within that portion of the cemetery is landscaped with plants not listed on the Low Water Use/Drought Tolerant Plant List for the Tucson AMA (See Appendix 5B). This restriction does not apply to an expansion of a cemetery onto contiguous land that was under the same ownership as the cemetery as of December 31, 1984.

6.3.5.3 Effluent Use Adjustment

In the Tucson AMA, effluent is the only water supply that is expected to increase in availability throughout the third management period. Effluent's high nutrient content makes it an excellent supply for turf-related watering, as long as the nutrient load is carefully matched to plant needs and over-application of potential

groundwater pollutants is avoided. Despite the availability and suitability of effluent for turf watering, effluent is currently underutilized as a source of water for turf-related facilities.

To encourage the maximum use of effluent on turf-related facilities during the third management period, the Department has modified the effluent incentive offered in the Second Management Plan. While the maximum annual water allotment will not change, each acre-foot of effluent will be counted as 0.7 acre-foot when compliance with the maximum annual water allotment is determined. This adjustment does not apply to effluent stored in a storage facility pursuant to a water storage permit and recovered outside the area of impact of the stored water. In addition to the effluent adjustment, facilities using effluent may apply to the Department for an allotment addition to allow for leaching of salts below the root zone.

6.3.5.4 Flexibility Account

In order to compensate for fluctuating weather conditions, each turf-related facility will have a flexibility account with credit and debit limits. In wetter years or through careful management, facilities will be able to accrue a credit balance up to 20 percent of a facility's annual allotment. When weather conditions or water management decisions cause a facility's water use to exceed its allotment in any year, accrued credits are expended. If all credits are exhausted, a facility may accrue a debit balance up to 20 percent of the allotment. A violation will occur only when all credits have been exhausted and the debit maximum is exceeded. Prudent facility managers will take advantage of wet years and the latest conservation technologies to accumulate as many credits as allowed in order to compensate fluctuations in water demand during hot or dry years.

6.3.5.5 Monitoring and Reporting Requirements

The Third Management Plan includes monitoring and reporting requirements for all turf-related facilities. All turf-related facility water use will be assumed to be for landscape watering purposes unless other water uses are metered separately. For example, if water for domestic uses at a park is not metered, it will count against the facility's allotment. This provision encourages facilities to install enough meters to ensure that turf-related watering is accurately measured and reported.

6.3.6 Non-Regulatory Efforts

In 1991, the Department initiated a grants program for conservation assistance and augmentation of water supplies in the AMAs. Individual AMA programs focus on the areas of highest water conservation potential in each water use sector (municipal, industrial, and agricultural) based on total water usage, current water usage practices, and potential for implementation of new conservation technologies. Funding for the grants program comes from an annual withdrawal fee levied and collected from all regulated groundwater users in the AMAs. See Chapter 9 for a description of the Conservation Assistance Program for the third management period.

During the second management period, over $70,000 was awarded under the Conservation Assistance Grants Program to assist turf-related facilities through evaluation and implementation of conservation strategies. Funded projects include water application scheduling workshops for facility managers, a public school water application system audit and repair program, development of an electronic overwatering controller, and a water application field study that compared turf water demand under high- and low-traffic conditions. The Department is committed to continuing its efforts to assist turf-related facilities in meeting their conservation requirements through direct staff assistance and through the grants program.

Opportunities for future research abound in turf-related water conservation. Anecdotal evidence for golf courses in central and southern Arizona suggests that target-style courses may use more water due to the "edge effect." Further study is needed to quantify the potential water demand impacts of factors that may

be inherent in lower-acreage facility designs. New computer-controlled watering systems, which isolate watering needs of specific areas of turf, could prove to be a useful source of data for verifying this phenomenon. Many computer controlled irrigation systems have been introduced into the market during the last decade. How well turf-related facility managers understand and employ the latest commercially available water application technologies is not well documented.

The watering needs of low water use landscaping need to be more precisely quantified to determine whether the application rate of 1.5 acre-feet per acre is appropriate. Some evidence suggests the rate may be excessive, especially after the first few years when the plants have become established.

Because proper turf management is key to water conservation, the Department will continue to explore opportunities to provide training and assistance to turf managers through the Department's Conservation Assistance Program or other avenues.

Long-term use of water high in total dissolved solids, such as effluent and CAP water, may lead to the need for applying additional water to leach or flush salts below the root zone. Quantifying the long-term implications of using water high in total dissolved solids would enhance understanding the impacts on water application rates and aquifer water quality protection. Conservation assistance funds may be used during the third management period to address these research needs.

6.3.7 Future Directions

In order to achieve the safe-yield goal in the Tucson AMA, a reduction in groundwater use must occur. The current Code provisions limit the Department's ability to achieve this goal since they allow continuing withdrawal of groundwater by existing users, as well as some additional withdrawals by industrial users. Management plan conservation requirements can reduce groundwater pumping by industrial users only to the extent that the requirements are consistent with reasonable economic return. Increased utilization of renewable water supplies combined with efforts to maximize water application efficiency are key factors in meeting the active management area's water management goal. Renewable water supply use requirements similar to current City of Tucson and Pima County ordinances and policies or broader groundwater use prohibitions targeting specific water uses as in the "Lakes" Bill (A.R.S. § 45-131, *et seq.*) are possible legislative approaches. A change to the statutes that would allow the CAGRD to replenish mined groundwater not associated with the demonstration of an assured water supply, combined with a replenishment obligation for all or a portion of mined groundwater used by turf-related facilities, would facilitate greater utilization of renewable supplies and reduce groundwater overdraft.

The relationship of turf-related watering to groundwater overdraft has been evaluated and quantified. Approximately two-thirds of all turf-related water demand in 1995 was met with groundwater. At facilities served by industrial rights, nearly 90 percent of water demand was met with groundwater. Although some component of applied water may actually be incidentally recharged, deep percolation of water that may contain fertilizers, horticultural chemicals, or other potential pollutants could lead to serious water quality issues and should not be encouraged.

Stronger conservation-oriented technology and water management practice requirements should be considered from both a regulatory and non-regulatory perspective. From a regulatory perspective, application rates that determine the maximum annual groundwater allotments need to be further scrutinized under actual field conditions. Research will also need to be conducted to quantify the effects of increased evapotranspiration by turf adjacent to low water use areas. As a result of such research, fourth management period conservation requirements may include an allotment-based requirement that is different from the method used for the second and third management periods, incorporating application rates for turf and low water use landscaping that more closely resemble efficient water use needs for different types of landscaping in actual field conditions. Required use of conservation technologies and

practices should be further evaluated as a regulatory alternative to enforceable allotments. From a non-regulatory approach, legislation that increases funding for conservation, education, and augmentation could assist turf managers with implementing effective water management practices, evaluation of effective water conservation technology, and for construction of renewable water supply conveyance infrastructure.

Development of incentive programs in the context of achieving specific management goals should continue during subsequent management periods. If necessary, efforts to broaden participation in water storage and recovery options could continue as well as renewable supply utilization incentives. Providing additional assistance for education and increased water management efficiency must be a priority to reduce the demand side of the safe-yield equation. Ongoing regional cooperative efforts such as the CAP utilization study for the Green Valley area and the regional effluent planning task force that began in 1997 will be necessary to facilitate widespread use of these supplies by turf-related facilities.

6.3.8 Industrial Conservation Requirements and Monitoring and Reporting Requirements for Turf-Related Facilities

6-301. Definitions

In addition to the definitions set forth in Chapters 1 and 2 of Title 45 of the Arizona Revised Statutes, and section 6-201 of this chapter, the following words and phrases used in sections 6-301 through 6-305 of this chapter, unless the context otherwise requires, shall have the following meanings:

1. *"Body of water" means a constructed body of water or interconnected bodies of water, including a lake, pond, lagoon, or swimming pool, that has a surface area greater than 12,320 square feet when full and that is filled or refilled primarily for landscape, scenic, recreational purposes, or regulatory storage.*

2. *"Common area" means an area or areas that is owned and operated as a single integrated facility and that is used for recreational or open space purposes. A common area is maintained for the benefit of the residents of a housing development.*

3. *"Contiguous" means in contact at any point, or part of the same master planned community. Two parcels of land are contiguous even if they are separated by one or more of the following: a road, easement or right-of-way.*

4. *"Direct use effluent" means effluent transported directly from a facility regulated pursuant to Title 49, Chapter 2, Arizona Revised Statutes, to an end user. Direct use effluent does not include effluent that has been stored pursuant to Title 45, Chapter 3.1, Arizona Revised Statutes.*

5. *"Effluent recovered within the area of impact" means effluent that has been stored pursuant to Title 45, Chapter 3.1, Arizona Revised Statutes, and recovered within the stored effluent's area of impact. For purposes of this definition, "area of impact" has the same meaning as prescribed by A.R.S. § 45-802.01.*

6. *"First management period new acres" means a water-intensive landscaped area or a low water use landscaped area that came into existence or was substantially commenced after December 31, 1984 and before January 1, 1992, but that was not substantially commenced prior to January 1, 1985.*

7. *"First management period new turf acres" means turf acres that came into existence or were substantially commenced after December 31, 1984 and before January 1, 1992, but that was not substantially commenced prior to January 1, 1985.*

8. *"Golf course" means a turf-related facility used for playing golf with a minimum of nine holes and including any practice areas.*

9. *"Hole" means a component of a golf course consisting at a minimum of a tee and a green. A practice area or driving range is not a hole.*

10. *"Landscape watering" means the application of water from any source, including effluent, to a water-intensive landscaped area, a low water use landscaped area, or revegetation acres within a turf-related facility.*

11. *"Low water use landscaped area" means an area of land of at least one acre in aggregate, which is an integral part of a turf-related facility, which is watered by a permanent water application system and that is planted primarily with plants listed in Appendix 5B, Low Water Use/Drought Tolerant Plant List, or any modifications to the list. Mature vegetation planted in a low water use landscaped area must cover at least 50 percent of the area.*

12. *"Newly turfed area" means, for a calendar year, an area of land planted with a warm-season grass species that was not planted with a warm-season grass species during the preceding calendar year.*

13. *"Overseeded area" means, for a calendar year, an area of land planted with any cool-season grass species that grows over a dormant warm-season grass species during the fall-winter period.*

14. *"Post-1991 acres" means a water-intensive landscaped area or a low water use landscaped area that was neither in existence nor was substantially commenced as of December 31, 1991.*

15. *"Pre-1985 acres" means a water-intensive landscaped area or a low water use landscaped area that was either in existence or was substantially commenced as of December 31, 1984.*

16. *"Substantially commenced" means that all pre-construction permits and approvals required by federal, state, or local governments have been obtained or substantial capital investment has been made in the physical on-site construction.*

17. *"Total cemetery area" means an area of land being used for cemetery-related purposes, including any area of land covered by grave markers or by cemetery-related buildings, walks, pathways, and landscaping, but not including roads, parking lots, and any areas of land being held for future expansion of the cemetery.*

18. *"Turf acres" means an area of land that is watered with permanent water application system and planted primarily with plants not listed in Appendix 5B, Low Water Use/Drought Tolerant Plant List, or any modifications to the list.*

19. *"Turf-related facility" means any facility, including cemeteries, golf courses, parks, schools, or common areas within housing developments, with a water-intensive landscaped area of 10 or more acres. Turf-related facilities include, but are not limited to, those facilities listed in Appendix 6A.*

20. *"Water-intensive landscaped area" means, for a calendar year, the turf acres and the water surface acres within a turf-related facility.*

21. *"Water surface acres" means the total surface area of all bodies of water that are an integral part of the water-intensive landscaped area of a turf-related facility. Bodies of water used primarily for swimming purposes are not an integral part of the water-intensive landscaped area of a turf-related facility.*

6-302. Conservation Requirements for Turf-Related Facilities

A. Maximum Annual Water Allotment

Beginning with calendar year 2002 or the calendar year in which landscape watering commences, whichever is later, and for each calendar year thereafter until the first compliance date for any substitute conservation requirement in the Fourth Management Plan, an industrial user who uses water at a turf-related facility shall not withdraw, divert, or receive water for landscape watering purposes at the facility during a calendar year in an amount that exceeds the turf-related facility's maximum annual water allotment for the year as calculated in section 6-303.

B. Conservation Plan

No later than January 1, 2002 or 180 days after receiving official notice of conservation requirements, whichever occurs later, an industrial user who uses water at a turf-related facility shall have prepared a conservation plan for the facility that contains an accurate and detailed description of the conservation technologies, including management practices, that are applied at the facility when water is used for landscape watering purposes. The industrial user shall maintain the conservation plan until the first compliance date for any substitute requirement in the Fourth Management Plan.

C. Limiting Water-Intensive Landscaped Area

1. *Beginning on January 1, 2002 or upon commencement of landscape watering, whichever occurs later, and continuing until the first compliance date for any substitute requirement in the Fourth Management Plan, an industrial user who uses water at a turf-related facility that is not a cemetery or a golf course shall design, construct, and maintain the grounds of the facility in a manner that minimizes the water-intensive landscaped area of the facility consistent with the use of the facility. All of the facility's water-intensive landscaping shall be planted in those areas directly associated with the turf facility's primary purposes.*

2. *Beginning on January 1, 2002 or upon commencement of landscape watering, whichever occurs later, and continuing until the first compliance date for any substitute requirement in the Fourth Management Plan, an industrial user who uses water at a turf-related facility that is a cemetery shall limit the water-intensive landscaped area of post-1991 acres so that no more than 75 percent of the total cemetery area within the post-1991 acres is planted with plants not listed in Appendix 5B, Low Water Use/Drought Tolerant Plant List, or any modifications to the list, unless the post-1991 acres are an expansion of the cemetery onto contiguous land that was under the same ownership as the cemetery as of December 31, 1984.*

6-303. Calculation of Maximum Annual Water Allotment for Turf-Related Facilities

A. For each calendar year, the maximum annual water allotment for a turf-related facility shall be calculated by multiplying the number of acres in existence within the facility during the calendar year in each of the categories listed in Table 6-4 by the application rates listed in Table 6-4 and then adding together the products plus any allotment additions as determined under subsection B of this section. The maximum annual water allotment is subject to the conditions and restrictions set forth in Table 6-4.

TABLE 6-4
APPLICATION RATES, CONDITIONS, AND ALLOTMENT RESTRICTIONS
FOR TURF-RELATED FACILITIES
TUCSON ACTIVE MANAGEMENT AREA
From 2002 until the first compliance date for any substitute conservation requirement in the Fourth Management Plan

For All Facilities:	***Application Rate: (acre-feet per acre per calendar year)***
1. Pre-1985 Acres	
Turf Acres	*4.6*
Water Surface Acres	*5.8*
Low Water Use Landscaped Area	*1.5*
Conditions and Restrictions: *The allotment shall be calculated using the highest number of Pre-1985 acres in existence within the facility during any single calendar year after 1979.*	
2. First Management Period New Acres	
Turf Acres	*4.6*
Water Surface Acres	*5.8*
Low Water Use Landscaped Area	*1.5*
Conditions and Restrictions: *a. For golf courses, the allotment for first management period new turf acres shall not exceed an amount calculated by multiplying the number of holes within those acres by 23 acre-feet of water, plus any allotment additions as determined under subsection B of this section.* *b. For golf courses, if the first management period new turf acres exceed an area calculated by multiplying the number of holes within those acres by five acres, the allotment for all bodies of water within the first management period new acres not filled and refilled entirely with direct use effluent or effluent recovered within the area of impact shall not exceed an amount calculated by multiplying the number of holes within the first management period new turf acres by 0.8056 acre-foot of water, plus any allotment additions as determined under subsection B of this section. For purposes of this paragraph, any body of water allowed under an interim water use permit pursuant to A.R.S. § 45-133 shall be deemed to be filled and refilled entirely with direct use effluent or effluent recovered within the area of impact if the body of water will be filled and refilled entirely with direct use effluent or effluent recovered within the area of impact after the permit expires.*	
3. Post-1991 Acres	
Turf Acres	*4.6*
Total Water Surface Area	*5.8*
Low Water Use Landscaped Area	*1.5*

TABLE 6-4
APPLICATION RATES, CONDITIONS, AND ALLOTMENT RESTRICTIONS
FOR TURF-RELATED FACILITIES
TUCSON ACTIVE MANAGEMENT AREA
From 2002 until the first compliance date for any substitute conservation requirement in the Fourth Management Plan

For All Facilities:	***Application Rate: (acre-feet per acre per calendar year)***
Conditions and Restrictions: *a. For golf courses, the total allotment for post-1991 turf acres and post-1991 low water use landscaped area shall not exceed an amount calculated by multiplying the number of holes within the post-1991 acres by 23 acre-feet of water, plus any allotment additions as determined under subsection B of this section.* *b. For golf courses, the allotment for all bodies of water within the post-1991 acres not filled and refilled entirely with direct use effluent or effluent recovered within the area of impact shall not exceed an amount calculated by multiplying the number of holes within the post-1991 acres by 0.8056 acre-foot of water, plus any allotment additions as determined under subsection B of this section. For purposes of this paragraph, any body of water allowed under an interim water use permit pursuant to A.R.S. § 45-133 shall be deemed to be filled and refilled entirely with direct use effluent or effluent recovered within the area of impact if the body of water will be filled and refilled entirely with direct use effluent or effluent recovered within the area of impact after the permit expires.*	

B. Allotment Additions

1. *Newly Turfed Area Establishment Addition*

   For any year in which a warm-season turfgrass species is planted at a turf-related facility, the facility shall receive an allotment addition of 1.0 acre-foot of water per acre of newly turfed area. For golf courses, the newly turfed area establishment addition shall not exceed an amount calculated by multiplying the number of holes present within the newly turfed area by 5 acre-feet of water.

2. *Revegetation Addition*

   The owner or operator of a turf-related facility may apply to the director for an allotment addition to revegetate areas within or around the facility after initial construction or renovation of new acres. The director may allow up to an additional 1.5 acre-feet of water per acre for up to three years if the following conditions apply to the acres for which the revegetation addition is sought:

   a. *The plants that are planted within the revegetation area are listed in Appendix 5B, Low Water Use/Drought Tolerant Plant List, or any modifications to the list, or were adapted to the site prior to construction;*

   b. *The aggregate area to be watered exceeds one acre and has at least 50 percent vegetative cover at maturity;*

   c. *An allotment is not provided for the revegetation area under section 6-303.A; and*

   d. *All of the water applied to the revegetation area is measured and reported as part of the total water use of the facility.*

3. *Body of Water Fill and Refill Addition*

   a. *A turf-related facility shall receive a one-time body of water fill allotment addition equal to the volume of water used for the initial filling of any new body of water added after January 1, 2002 within the facility. The facility shall receive the allotment addition only for the calendar year in which the body of water is filled.*

   b. *If a body of water at a turf-related facility is drained or partially drained to allow for repairs to reduce water losses the owner or operator of the facility may apply to the director for an addition to the facility's maximum annual water allotment in the amount of water necessary to refill the body of water. The director shall grant the allotment addition if the director determines that drainage of the body of water was necessary to allow for repairs to reduce water losses. The facility shall receive the allotment addition only for the calendar year in which the body of water is filled.*

4. *Leaching Allotment Addition*

   The owner or operation of a turf-related facility may apply to the director for an allotment addition for leaching purposes. The director shall approve the application if the water supply used for landscape watering at the facility contains at least 1000 milligrams per liter of total dissolved solids. If the director approves an allotment

addition for leaching purposes, the director shall calculate the additional allotment as follows:

$$\textbf{Leaching Allotment Addition} = \left(\frac{1}{1 - \left(\frac{EC_w}{5EC_e - EC_w} \right)} - 1 \right) \times \frac{CU}{0.85}$$

Where: EC_w = *Electrical conductivity of water used*

EC_e = *Tolerance of the grass species grown to the soil salinity in electrical conductivity of the soil saturation extract*

CU = *Consumptive use requirement for the grass species*

Any allotment addition granted under this subsection shall remain in effect until the water supply used for landscape watering at the facility contains less than 1,000 milligrams per liter of total dissolved solids or until the first compliance date for the facility's conservation requirements in the Fourth Management Plan, whichever occurs first.

C. Combined Allotments for Contiguous Facilities

The maximum annual water allotments for contiguous turf-related facilities under one ownership or operation may be combined. All or a portion of the combined maximum water allotment may be applied to any part of the contiguous facilities.

D. *Nothing in this section shall be construed as authorizing use of more groundwater or surface water than may be used pursuant to any groundwater or appropriable water rights or permits associated with the use. Nor shall this section be construed as authorizing the use groundwater or surface water in any manner that violates Chapter 1 or Chapter 2 of Title 45, Arizona Revised Statutes.*

6-304. Compliance with Maximum Annual Water Allotment

A. Effluent Use Adjustment

For purposes of determining compliance with the maximum annual water allotment requirement, the director shall count each acre-foot of direct use effluent or effluent recovered within the area of impact used at the facility for landscape watering purposes during the calendar year as 0.7 acre-foot of water.

B. Flexibility Account

The director shall determine if a turf-related facility is in compliance with the maximum annual water allotment requirement through the maintenance of a flexibility account for the facility according to the following:

1. *Beginning with calendar year 2002 or the first full calendar year after the commencement of landscape watering, whichever is later, a flexibility account shall be established for a turf-related facility with a beginning balance of zero acre-feet.*

2. *Following each calendar year in which groundwater is withdrawn, diverted, or received for landscape watering purposes at the facility, the director shall adjust the turf-related facility's flexibility account as follows:*

   a. *Subtract the total volume of water from any source, including effluent, as adjusted under subsection A of this section, used by the facility for landscape watering purposes during that calendar year, from the facility's maximum annual water allotment for that year.*

   b. *If the result in subparagraph a of this paragraph is positive, credit the flexibility account by this volume.*

   c. *If the result in subparagraph a of this paragraph is negative, debit the flexibility account by this volume.*

3. *The account balance existing in a turf-related facility's flexibility account after the adjustment provided for in paragraph 2 of this subsection is made shall carry forward subject to the following limitations:*

   a. *The maximum positive account balance allowed in the flexibility account of a turf-related facility after any credits are registered pursuant to paragraph 2, subparagraph b of this subsection, shall be calculated by multiplying the facility's maximum annual water allotment for the calendar year for which the credits are registered by 0.2. If the account balance exceeds the maximum positive account balance after the credits are registered, the balance carried forward shall be equal to the maximum positive account balance.*

   b. *The maximum negative account balance allowed in the flexibility account of a turf-related facility after any debits are registered pursuant to paragraph 2, subparagraph c of this subsection, shall be calculated by multiplying the facility's maximum annual water allotment for the year for which the debits are registered by -0.2. If the account balance is less than the maximum negative account balance after the debits are registered, the balance carried forward shall be equal to the maximum negative account balance.*

C. Compliance Status

If the adjustment to a turf-related facility's flexibility account following a calendar year as provided for in subsection B, paragraph 2 of this section, causes the account to have a negative account balance less than the maximum negative account balance allowed in the flexibility account for the calendar year as calculated in paragraph 3, subparagraph b of this section, the industrial user who uses water at the facility is in violation of the facility's maximum annual water allotment for that calendar year in an amount equal to the difference between the facility's flexibility account balance and the maximum negative balance allowed in the facility's flexibility account.

6-305. Monitoring and Reporting Requirements

A. *An industrial user who uses water at a turf-related facility that commences landscape watering within post-1991 acres after January 1, 2002 shall submit to the director documentation of the new acreage within the facility no later than 90 days after commencing landscape watering within the new acres or receiving notice of these conservation requirements, whichever is later. The scale of the submitted documents, extent of turf acres, water surface acres, and low water use landscaped area must clearly be shown. Documentation may consist of one or more of the following:*

1. *As-built plans certified by a registered professional such a civil engineer, golf course designer, or landscape architect.*

2. *Aerial photography at a scale no smaller than 1"=200'.*

3. *A survey of the facility certified by a registered professional such a civil engineer or land surveyor.*

4. *Any other documentation upon approval by the director.*

B. *For calendar year 2002 or the calendar year in which landscape watering commences, whichever occurs later, and for each calendar year thereafter until the first compliance date for any substitute monitoring and reporting requirement in the Fourth Management Plan, an industrial user who uses water at a turf-related facility shall include in the annual report required by A.R.S. 45-632 the following information:*

1. *The total quantity of water by source, disaggregated by each source, withdrawn, diverted, or received during the calendar year for landscape watering purposes at the facility, as measured with a measuring device in accordance with the Department's measuring device rules, A.A.C. R12-15-901, et seq.*

2. *The amount of effluent, disaggregated by direct use effluent, effluent recovered within the area of impact, and effluent recovered outside the area of impact, that was withdrawn, diverted or received during the calendar year for landscape watering purposes as measured with a measuring device in accordance with the Department's measuring device rules, A.A.C. R12-15-901, et. seq.*

3. *The number of acres of turf acres within the facility during the calendar year, not including newly turfed area.*

4. *The number of water surface acres within the facility during the calendar year.*

5. *The number of acres of low water use landscaped area within the facility during the calendar year.*

6. *The number of acres of newly turfed area within the facility during the calendar year.*

7. *The number of turf acres removed within the facility during the calendar year.*

8. *The number of water surface acres added or removed within the facility during the calendar year.*

9. *The number of acres of low water use landscaped area added or removed within the facility during the calendar year.*

10. *If the facility is a golf course, the length of the course as measured from the back of each tee ground furthest from the associated green, then down the center line of the hole to the center of the green.*

11. *The number of acres approved by the director for a revegetation addition pursuant to section 6-303, subsection B, within the facility during the calendar year.*

12. *The quantity of water used to fill or refill a body of water within the facility during the calendar year for which an allotment addition is sought pursuant to section 6-303, subsection B.*

13. *The number of acres of overseeded area within the facility during the calendar year.*

14. *If the facility is a golf course, the number of holes within the facility during the calendar year.*

15. *If the facility is a golf course, the number of holes added within newly turfed area during the calendar year.*

16. *An estimate of the quantity of water from any source, including effluent, used for each purpose other than landscape watering purposes at the facility during the reporting year. Any water used at the facility that is not measured separately from the water used for landscape watering shall be counted by the director as water used by the facility for landscape watering for purposes of calculating the compliance with the maximum annual water allotment.*

C. *A single annual report may be filed for contiguous turf-related facilities that are under the same ownership or operation if the allotments for the contiguous facilities are combined pursuant to section 6-303, subsection C. The annual report shall report water use and landscaped areas of the contiguous facilities as required in subsection B of this section.*

6.4 SAND AND GRAVEL FACILITIES

6.4.1 Introduction

Sand and gravel facilities regulated under the Third Management Plan are facilities that produce sand and gravel and use more than 100 acre-feet of water from any source in a calendar year. Sand and gravel facilities include the activities of mining aggregate, mixing concrete, and producing asphaltic concrete.

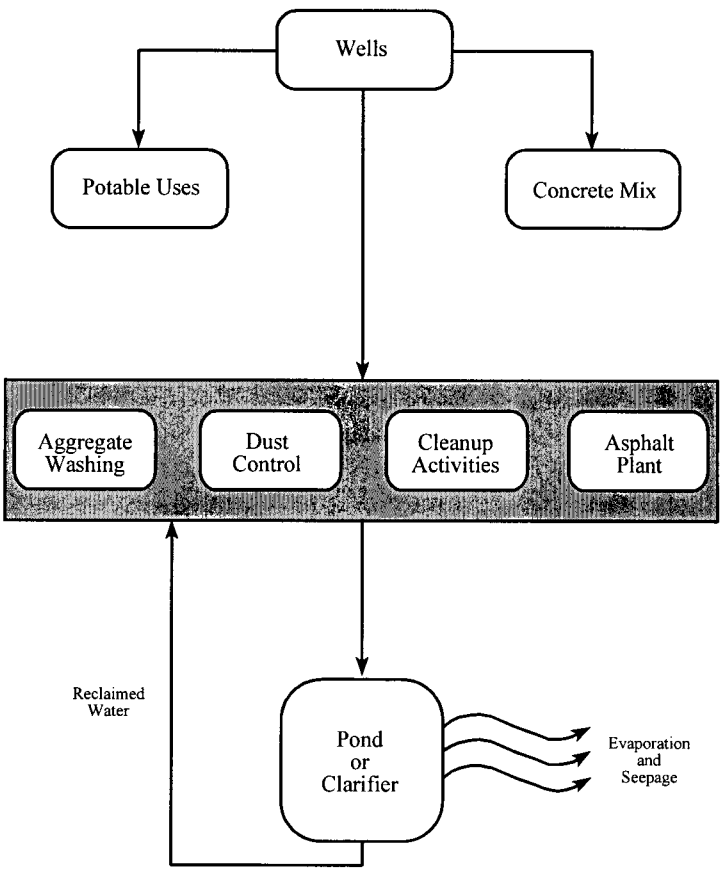
6.4.2 Water Use by Sand and Gravel Facilities

In the Tucson AMA, approximately 15 sand and gravel facilities are located along the banks of the Santa Cruz River or along older sand and gravel deposits in the Tucson, Green Valley, and Marana areas. These sand and gravel facilities pump groundwater pursuant to non-irrigation grandfathered rights or groundwater withdrawal permits. In 1995, sand and gravel facilities in the Tucson AMA held Type 1 and Type 2 non-irrigation grandfathered rights, and Type 2 mineral extraction rights and groundwater withdrawal permits with a combined annual allotment of around 17,000 acre-feet of groundwater.

Since adoption of the Second Management Plan, operators of sand and gravel operations have withdrawn between 2,300 acre-feet and 5,200 acre-feet of groundwater per year. It is projected that water use by sand and gravel facilities will grow commensurate with economic activity in the AMA, and will be approximately 7,000 acre-feet per year by 2025.

Sand and gravel facilities mine unconsolidated stream deposits to produce construction materials. The aggregate must be sorted according to grain size and washed to remove fine-grained particles. Aggregate washing accounts for the bulk of water use by sand and gravel facilities. In addition to using water for washing, water is used for the following purposes: (1) to produce ready-mix concrete, bricks, blocks, and asphaltic concrete; (2) to control dust; (3) to wash the outside of vehicles; (4) to wash the inside of mixer drums; (5) to wash other equipment; (6) to cool equipment; (7) to cool material; and (8) for domestic purposes. Figure 6-2 illustrates how water is cycled in a typical sand and gravel facility.

FIGURE 6-2
DIAGRAM OF WATERFLOW IN A TYPICAL SAND AND GRAVEL FACILITY



Most sand and gravel facilities recycle wash water using excavated pits called disposal ponds. Sediment-laden wash water is pumped or diverted into a pit or series of pits where sediment is allowed to settle out. After this sediment settles out, the water is recycled to the plant and used to wash more material. Water can also be pumped from the pond for dust control, truck washing, or other cleanup activities.

Geologic and hydrologic conditions at many facilities may result in a large amount of seepage loss incidentally returning to the aquifer from disposal ponds. Because most facilities are located along major riverbeds, depth to groundwater is usually relatively shallow. Some facilities even require dewatering to lower the water table to allow excavation to occur. A large portion of seepage loss may become a component of the groundwater pumped by sand and gravel facilities.

An alternative method of recycling wash water is the use of clarifiers. A clarifier is a device that accelerates the settling of sediment without creating the need for a large disposal pond. Chemical flocculants are usually used in conjunction with clarifiers to further enhance the removal of solid particles from the wash water.

Recycled water is not used for mixing concrete because the use of recycled water in the mixture may result in a product of inferior strength and quality. However, aggregate used in the concrete can be washed with recycled water without affecting concrete strength.

The ability of sand and gravel facilities to save water varies because of differences in geology, availability and cost of land and water, product demand and price, and other factors. It may therefore be economically feasible to use the latest commercially available conservation technology at some facilities but not at others.

Because recycled water can be used for most purposes at a sand and gravel facility, the maximum saving of water can occur in the recycling of wash water from aggregate washing and, to a lesser extent, the recycling of water used for wet scrubbers at asphalt plants.

There are a number of conservation techniques that may be employed to reduce the amount of water used to control dust raised by trucks traveling on haul roads. Binding agents, pavement, or other surface treatments may be used. Water uses for cleanup activities may be made more efficient by metering truck washing and by using alternative methods to clean truck mixer drums. Alternative methods can include the "rock out" method, which involves agitating rock inside the mixer drums for the purpose of cleaning excess concrete, or the use of chemical set-arresting agents, which prevent excess concrete from adhering to the mixer drums.

Sand and gravel facilities that have asphalt plants may have air emissions from the plant cleaned by either baghouses or wet scrubbers. Of these two methods, baghouses do not require water.

6.4.3 Program Development and Issues

The First Management Plan required sand and gravel facilities to recycle wash water using disposal ponds or clarifiers. This requirement ensures that sand and gravel facilities reduce their water use. The First Management Plan requirements were carried over into the second management period.

To identify the most economical conservation methods for each facility, sand and gravel facility operators were required during the second management period to evaluate specific water-saving methods and submit a conservation plan to the Department.

In addition to the conservation requirements identified in the First and Second Management Plans, there are a number of economically feasible ways water use for dust control and cleanup activities can be reduced. However, because conditions and characteristics at each facility vary, flexibility is needed to allow facility operators to select the requirements most appropriate for their facility.

6.4.4 Sand and Gravel Conservation Program

The First and Second Management Plan requirements for recycling wash water are included for the third management period because implementation of recycling improves water use efficiency. All sand and gravel operations can apply these techniques.

In addition to recycling wash water, sand and gravel facility operators must implement two additional conservation measures, one related to water used for dust control and the other related to cleanup activities. The facility operator must choose the conservation measure to be implemented in each category from a list of approved measures. The measures chosen must be the most appropriate for the facility for the third management period.

Similar to the Second Management Plan, sand and gravel operators will be required to evaluate specific water-saving methods and submit a conservation plan to the Department during the third management period. The conservation plan must be submitted to the director by January 1, 2002 or within 180 days after notification of the conservation requirements, whichever is later.

Implementation of water conservation practices or technologies can result in increased profits. Sand and gravel facility operators should analyze conservation methods to identify those that will result in a positive economic return. Operators will be required to perform an economic feasibility analysis of three potential conservation practices: disposal pond surface area reduction, use of clarifiers, and the use of an alternative water supply to groundwater. The following potential costs and savings may be analyzed in the economic feasibility analysis:

- Labor (including planning, construction, operation, maintenance, and management time);
- Equipment (values amortized over the projected life of the equipment);
- Land value (including value of mineral reserves);
- Water costs (including pumping costs, well maintenance, and withdrawal taxes);
- Costs for chemicals and raw materials;
- Fuel or energy costs;
- Industrial wastewater disposal costs;
- Changes in revenue caused by changing production rate, minimizing "down-time," or increasing the size of reserves; and
- Regulatory permitting costs.

6.4.5 Future Directions

In the Tucson AMA, sand and gravel facilities use water pursuant to non-irrigation grandfathered rights or groundwater withdrawal permits. Other potential water sources include CAP water, effluent and remediated groundwater. None of these sources are currently being used by the sand and gravel industry in the AMA. Effluent discharged to the Santa Cruz River could be a viable water source for facilities located along the River downgradient from the regional wastewater treatment plants. Secondary effluent is inexpensive and potentially available for use by sand and gravel facilities with the exception of use in concrete production. Several facilities are located in proximity to the CAP canal in the Marana area, however CAP water is significantly more expensive than groundwater. Groundwater pumping costs are low for most sand and gravel facility operators because the facilities are generally located where groundwater levels are close to the land surface. Incentives for use of effluent or CAP water could be considered in the Fourth Management Plan to address the potential for these facilities to use non-groundwater supplies.

6.4.6 Industrial Conservation Requirements and Monitoring and Reporting Requirements for Sand and Gravel Facilities

6-401. Definitions

In addition to the definitions set forth in Chapters 1 and 2 of Title 45 of the Arizona Revised Statutes, unless the context otherwise requires, the following words and phrases used in sections 6-402 through 6-404 of this chapter shall have the following meanings:

1. *"Alternative water supply" means a water source other than groundwater of drinking water quality.*

2. *"Sand and gravel facility" means a facility that produces sand and gravel and that uses more than 100 acre-feet of water from any source per calendar year. For purposes of this definition, the annual water use shall include all water used by the facility regardless of the nature of the use.*

3. *"Rock out method" means agitating rock inside concrete truck mixer drums for the purpose of cleaning excess concrete from the drums.*

4. *"Wash water" means water used for washing or sorting sand, gravel, or other aggregates.*

6-402. Conservation Requirements

A. Standard Conservation Requirements

Beginning on January 1, 2002 or upon commencement of water use, whichever occurs later, and continuing thereafter until the first compliance date for any substitute conservation requirements in the Fourth Management Plan, an industrial user who uses water at a sand and gravel facility shall comply with the following conservation requirements:

1. *If sufficient land area for construction and operation of disposal ponds is available at a reasonable price, the industrial user shall construct disposal ponds at the sand and gravel facility. All wash water, all water used for wet scrubbers at asphalt plants, all runoff from cleanup operations and all drainage from sand and gravel piles shall be discharged or diverted into the disposal ponds unless prohibited by state or federal environmental regulations. The disposal ponds shall contain a barge pump or sump pump of sufficient capacity, together with any necessary additional equipment, to assure the maximum reclamation of the water. The water shall be reclaimed and reused at the sand and gravel facility unless prohibited by state or federal regulations.*

2. *If sufficient land area for the construction and operation of disposal ponds is not available at a reasonable price, clarifiers shall be used at the sand and gravel facility for reclaiming wash water, all water used for wet scrubbers at asphalt plants, runoff from cleanup operations and all drainage from sand and gravel piles. The clarifiers shall be designed and operated to assure the maximum reclamation of water. The water shall be reclaimed and reused at the sand and gravel facility unless prohibited by state or federal regulations.*

3. *At least one of the following techniques or technologies designed to reduce water use for dust control shall be implemented at the sand and gravel facility:*

   a. *The placement of binding agents on all haul roads;*

   b. *The paving of all haul roads;*

   c. *The placement of recycled asphalt on all haul roads;*

   d. *The placement of medium sized aggregate or "pea gravel" on all haul roads; or*

   e. *A technology or technique designed to reduce water use for dust control not included in subparagraphs a through d of this paragraph that demonstrates water savings equivalent to any of the technologies or techniques listed in subparagraphs a through d, and that has been approved by the director.*

   The industrial user shall have sole discretion in determining whether to implement more than one of the above technologies.

4. *At least one of the following techniques or technologies designed to reduce water use for cleaning shall be implemented at the sand and gravel facility:*

   a. *Use of metered timers for truck washing and other cleanup activities;*

   b. *Use of the "rock out method" of cleaning concrete from truck mixer drums;*

   c. *Use of concrete set-arresting agent chemical applications to clean concrete from truck mixer drums; or*

   d. *A technology or technique designed to reduce water use for cleaning that is not included in subparagraphs a through c of this paragraph that demonstrates water savings equivalent to any of the measures listed in subparagraphs a through c and that has been approved by the director.*

   The industrial user shall have sole discretion in determining whether to implement more than one of the above technologies.

B. Substitute Conservation Requirements

1. *An industrial user who uses water at a sand and gravel facility may apply to the director to use conservation technologies other than the standard conservation requirements prescribed in subsection A of this section. The director may approve the use of substitute conservation technologies if both of the following apply:*

   a. *The industrial user has submitted a detailed description of the proposed substitute technologies and the water savings that can be achieved by the use of those technologies, and;*

   b. *The director determines that the proposed substitute conservation technologies will result in a water savings equal to or greater than the savings that would be achieved by the standard conservation requirements prescribed in section 6-402.*

2. *If the director approves an industrial user's request to use conservation technologies other than the standard conservation requirements prescribed in subsection A of this section, the industrial user shall comply with the substitute conservation technologies approved by the director beginning on the date determined by the director and continuing until the first compliance date for any substitute conservation requirement in the Fourth Management Plan.*

C. Conservation Plan

Not later than January 1, 2002 or within 180 days after receiving notice of these conservation requirements, whichever is later, an industrial user who uses water at a sand and gravel facility, including an industrial user who acquires ownership of an existing sand and gravel facility after January 1, 2002, shall submit to the director a plan to improve the efficiency of water use at the facility on a form provided by the director. The plan shall analyze the economic feasibility of implementing all of the following at the facility:

1. *Disposal pond surface area reduction;*

2. *The use of clarifiers for recycling water;*

3. *Use of an alternative water supply if such a supply is available within a one mile radius of the facility.*

6-403. Monitoring and Reporting Requirements

For calendar year 2002 or the calendar year in which the sand and gravel facility first commences using water, whichever is later, and for each calendar year thereafter until the first compliance date for any substitute monitoring and reporting requirement in the Fourth Management Plan, an industrial user who uses water at a sand and gravel facility shall include the following information in its annual report required by A.R.S. § 45-632:

1. *The quantity of water reclaimed from disposal ponds or clarifiers during the calendar year, as measured with a measuring device in accordance with the Department's measuring device rules, A.A.C. R12-15-901, et seq.*

2. *The quantity of water from any source, including effluent, supplied to the wash plant during the calendar year, as measured with a measuring device in accordance with the Department's measuring device rules, A.A.C. R12-15-901, et seq.*

3. *The quantity of water from any source, including effluent, supplied to the asphalt plant during the calendar year, as measured with a measuring device in accordance with the Department's measuring device rules, A.A.C. R12-15-901, et seq.*

4. *The aggregate surface area of any disposal ponds.*

5. *The average depth of any disposal ponds.*

6. *The estimated quantity of water from any source, including effluent, used during the calendar year for:*

a. *Industrial process purposes. Water used for industrial process purposes includes water used for sanitary waste disposal but does not include water used for cooling and cleaning purposes.*

b. *Non-domestic cooling purposes.*

c. *Non-domestic cleaning purposes. Water use for non-domestic purposes includes truck washing, truck mixer drum washing, or other non-domestic cleaning purposes.*

d. *Road dust control.*

e. *Landscape watering.*

f. *Other purposes.*

7. *The tonnage of material washed during the calendar year.*

6.5 METAL MINING FACILITIES

6.5.1 Introduction

The Department regulates mining facilities that mine and process metallic ores and use or have the potential to use more than 500 acre-feet of water per year. Copper and molybdenum are the primary products of the metal mines of the Tucson AMA. Two mining techniques are used in the AMA. Open-pit mining followed by milling and flotation is the predominant mining technique. Leaching followed by solvent extraction and electrowinning (SX/EW) is also used at some locations. Water is used in almost all steps of the mining process. Conservation requirements address specific process steps to reduce overall water use.

6.5.2 Water Use by Metal Mining Facilities

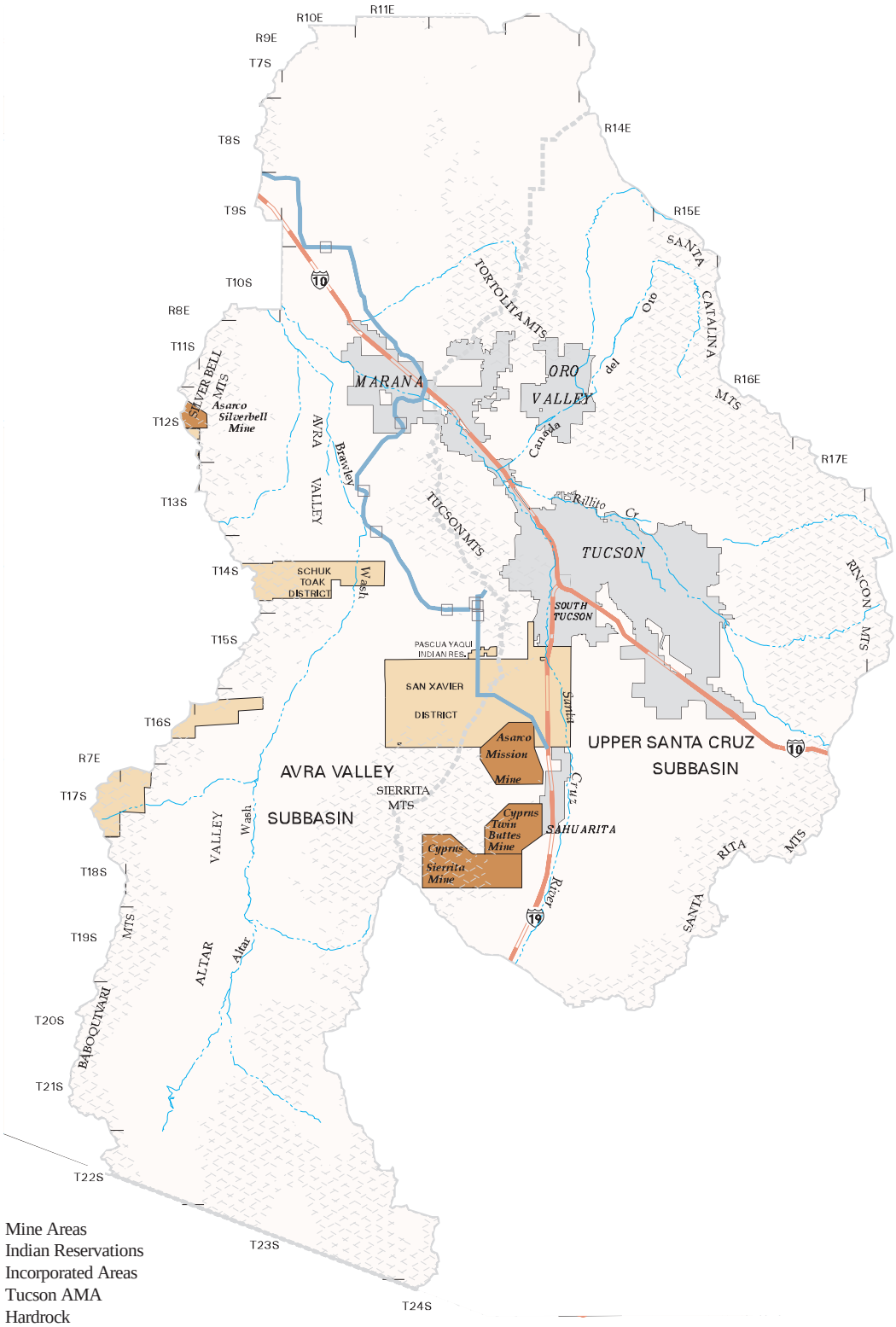
Metal mines used 41,359 acre-feet of groundwater in 1995, constituting the largest industrial water use sector in the AMA. Currently mines have rights to pump around 62,000 acre-feet of groundwater per year pursuant to Type 1 and Type 2 non-irrigation grandfathered rights and groundwater withdrawal permits. Withdrawals vary substantially from year to year due to fluctuations in copper market conditions.

Four metal mines are currently operating in the Tucson AMA: Cyprus Sierrita, Cyprus Twin Buttes, ASARCO Mission, and ASARCO Silver Bell. Cyprus Sierrita and Cyprus Twin Buttes Mines are located 26 miles south of Tucson, west of the Sahuarita/Green Valley area (Figure 6-3). The Cyprus Sierrita and Twin Buttes mines hold groundwater rights and permits totaling 37,382 acre-feet per year. In 1995, the two mines used a total of 27,390 acre-feet of groundwater pursuant to those rights and permits (Table 6-5).

TABLE 6-5
1995 GROUNDWATER RIGHTS AND WITHDRAWAL PERMITS AND 1987 TO 1995 GROUNDWATER WITHDRAWALS FROM METAL MINES TUCSON ACTIVE MANAGEMENT AREA

	ASARCO Mission Complex		ASARCO Silver Bell Mine	Cyprus Sierrita Mine	Cyprus Twin Buttes Mine
Volume of Groundwater Rights and Permits (AF/YR)	17,585		6,703	23,366	14,016
1995 Withdrawals (AF)	10,771[1]	2,982[2]	217	22,066	5,324
1994 Withdrawals (AF)	10,038[1]	4,684[2]	182	22,674	5,946
1993 Withdrawals (AF)	9,440[1]	4,250[2]	80	18,880	6,071
1992 Withdrawals (AF)	9,023[1]	3,705[2]	234	16,953	6,920
1991 Withdrawals (AF)	7,925[1]	1,466[2]	437	23,900	5,877
1990 Withdrawals (AF)	7,086[1]	1,428[2]	406	17,887	5,636
1989 Withdrawals (AF)	6,876[1]	2007[2]	532	18,684	3,499
1988 Withdrawals (AF)	6,034[1]	821[2]	262	16,566	205
1987 Withdrawals (AF)	5,322[1]	732[2]	351	15,838	60

AF = acre-feet
[1] Withdrawals from ASARCO property that are pursuant to groundwater right and permits
[2] Withdrawals from San Xavier District for ASARCO use that are not pursuant to groundwater rights and permits



- Mine Areas
- Indian Reservations
- Incorporated Areas
- Tucson AMA
- Hardrock
- Rivers and Streams
- Roads and Highways
- Subbasins
- CAP Canal
- CAP Pumping Stations

Figure 6- 3

Approximate Areas of Metal Mines

0 3 6 9 12
Miles

North

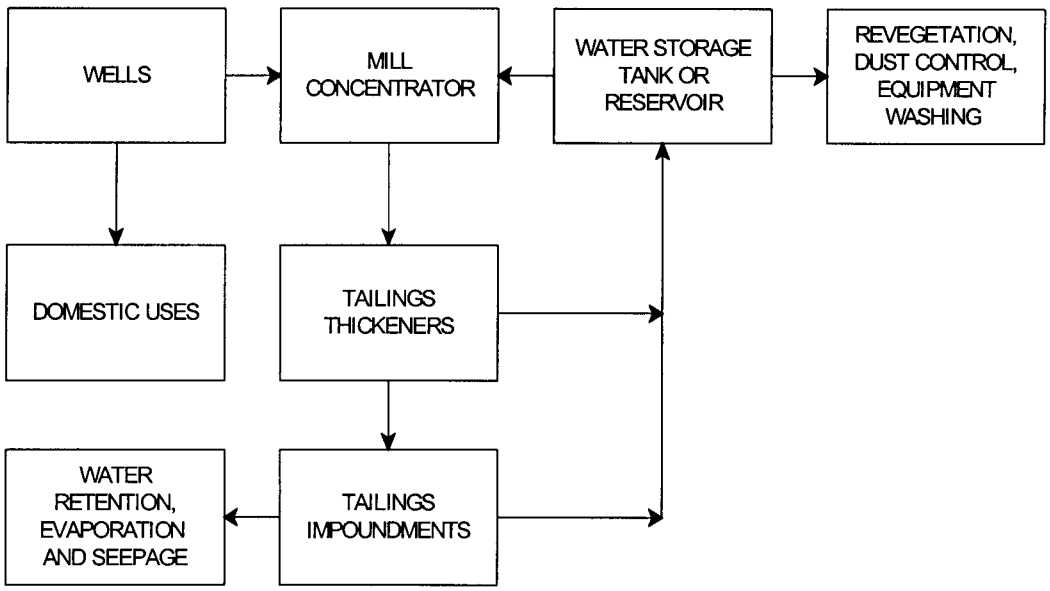
ORIGINAL SOURCE
Arizona Department of Water Resources
Geographic Information System

ASARCO Mission Complex is located 16 miles south of Tucson, along the southern boundary of the San Xavier District of the Tohono O'odham Nation. It holds groundwater rights and permits totaling 17,585 acre-feet per year. In 1995, this facility used 10,771 acre-feet of groundwater pursuant to its rights and permits. In addition, the Mission Complex pumped 2,982 acre-feet of groundwater from the San Xavier District by agreement with the District, bringing total groundwater use to 13,753 acre-feet. Groundwater withdrawn from the District is not subject to state reporting and management requirements for groundwater.

ASARCO Silver Bell Mine is in the northwest portion of the Tucson AMA and straddles the Tucson and Pinal AMAs. Because the mine's production wells are located east of the facility within the Tucson AMA boundary, water use at the entire facility is regulated by the Tucson AMA. Silver Bell Mine used only 217 acre-feet of groundwater in 1995, but has constructed a new SX/EW plant at the site that will lead to increased copper production and water use. It holds groundwater rights and permits totaling 6,703 acre-feet per year.

Open-pit mining followed by milling and flotation steps is widely used to recover copper and molybdenum from metallic ore in Tucson AMA mines. Figure 6-4 is a simplified diagram of water flow at a typical copper mine using a mill and flotation process. In the mill concentrator, water is added to ore that is crushed and milled to a powder-like form. The crushed ore/water mixture is discharged into a series of flotation cells where the copper and molybdenum-bearing minerals are physically removed. This flotation is accomplished by adding chemicals to the mixture that cause the valuable minerals to float to the surface of the tanks where they are skimmed off and recovered.

FIGURE 6-4
DIAGRAM OF WATER FLOW IN A TYPICAL COPPER MINE USING A MILL AND FLOTATION PROCESS TO RECOVER COPPER



The milled rock material remaining in the mill flotation cells is moved to large thickener tanks where solids are allowed to settle to the bottom. After the solids settle, water is recovered from the top of the thickener tanks and recycled back to the mill concentrator. The thickened slurry of water and solids that settles to the bottom of the thickener tanks is known as tailings. Tailings are transported via pipeline from the bottom of the thickener tanks to tailings impoundments for final disposal. Groundwater can be conserved in the tailings transport process by maintaining the tailings slurry at a high density, by transporting tailings in smooth high density polyethylene piping to reduce friction loss in the pipes, and by pumping tailings to the tailings impoundments rather than gravity-feeding them.

Once transported, the tailings slurry is distributed on the surface of the tailings impoundment through spigots arrayed around the perimeter of the impoundment. The solid tailings settle to the bottom of the tailings impoundment leaving standing water in "stilling basins." This water is "decanted" or skimmed off using decant towers or barge pumps then returned to the mill concentrator for reuse. Evaporation from tailings impoundments is the largest consumptive use of water by the mines. Evaporation can be reduced by carefully managing tailings deposition to minimize the surface area of stilling basins and by installing multiple decant towers when possible, to decant water more quickly.

Some water is permanently retained in the fine-grained tailings material deposited in the impoundments. The amount of water retained in subsurface tailings is a function of the fine-grained texture of this material and is largely beyond the control of mine operators. Water also seeps out below the tailing impoundments. This seepage can be reduced by depositing fine-grained tailings (slimes) on top of native soils before delivering full tailings loads to these areas.

In addition to open-pit mining techniques, copper-bearing minerals can be leached at land surface from some types of ore-bearing rocks. Surface leaching is conducted by distributing a dilute solution of sulfuric acid over ore-bearing rocks that have been heaped or dumped on native bedrock. This solution is typically applied using a sprinkler system, resulting in some evaporative water loss. Drip lines can also be used to apply water in some cases. As the solution slowly passes through the ore-bearing rock, copper minerals are dissolved. Copper-rich water (leachate) is then collected from the bottom of the leach pile. Leachate is piped to an SX/EW facility for recovery of the copper. At this facility, the copper is transferred from the leach solution to a rich electrolyte solution then transported to vats where an electrical current draws copper out of solution onto solid copper plates. The leach solution left after the copper is removed is re-acidified and returned to the leach piles for reuse, thus conserving water use in the leach circuit. Water use may be further reduced by converting, if feasible, to delivery methods other than sprinkler systems.

An innovative form of leaching that has recently come into use is known as "in situ" or "in place" mining. This process uses an injection well to introduce a dilute solution of sulfuric acid into subsurface fractures in copper-bearing rock. As the solution circulates in the fractures, copper is dissolved. The copper-rich solution is recovered using extraction wells arranged around the injection well. At the surface, the copper-rich solution is piped to an SX/EW plant where the copper is extracted from the solution. The acid/water solution is continuously recycled through the copper deposit and the SX/EW plant, minimizing water use. In situ mining has been successfully conducted on a pilot scale in the Pinal AMA. If proven to be economically successful, in situ mining may be used in full-scale commercial mining operations in the future.

Leaching followed by an SX/EW process uses less water to produce copper than the flotation process. However, only selected types of ore will yield copper using leaching processes. The majority of ores in Tucson AMA mines must be recovered using open pit mining and the flotation process. Other water uses at metal mines include dust control, equipment washing, revegetation of tailings, and domestic needs.

Mineral output at Tucson AMA metal mines has recovered in recent years. The mining industry is expected to continue to operate in the AMA, with a slight increase in water use. It is projected that total groundwater withdrawals by metal mines will be 47,500 acre-feet per year by 2025.

6.5.3 Program Development and Issues

First Management Plan requirements for metal mines largely reflected mining practices in place at the time the regulations were written. Key requirements for metal mining facilities included:

- Transport tailings at a minimum average density of 40 percent solids by weight
- Reduce leakage from tailings impoundments by compacting tailings up slope from the free water surface in impoundments or by installing interceptor wells
- Manage tailings impoundments to minimize free water surface, maximize water depth, create stilling basins, and recover decant water
- Recover and recycle tailings impoundment water
- Cap abandoned tailings impoundments to minimize water used for dust control
- Comply with monitoring and reporting requirements

The First Management Plan also required mining facilities built after 1984 to achieve the greatest feasible tailings density, install any new wells so they would intercept tailings seepage, and equip any new tailings facilities with decant towers and interceptor wells to reclaim water from tailings impoundments and intercept seepage. In the First Management Plan, facilities could apply for alternative conservation programs or obtain temporary stays from conservation requirements.

First Management Plan requirements were modified in the Second Management Plan to require tailings densities of 45 percent for mines in operation by the end of 1984 and 50 percent for mines that went into operation after 1984. In addition, all mines were required to prepare long-range conservation plans in which they were to evaluate the feasibility of increasing tailings density to 55 percent, using alternative water sources, reducing tailings evaporation, and minimizing water use for dust control.

While water is actively recycled at area metal mines, there is some potential for additional groundwater conservation. This potential is addressed in the Third Management Plan with increased tailings density requirements and the addition of a menu of conservation strategies. Requirements have also been updated to reflect current mining practices and to integrate water conservation regulations with other environmental requirements.

Each 1 percent increase in the tailings density achieved during transport to tailings impoundments results in 500 to 800 acre-feet of water savings per year at the large open pit mines in the Tucson AMA. Improved conservation technologies have enabled mines to achieve tailings densities ranging from 46 to 52 percent at various portions of their facilities. In the Third Management Plan, tailings density requirements for mining facilities in operation by the end of 1984 have been increased from the Second Management Plan annual average density requirement of 45 percent to a three-year running average of 48 percent. This change reflects the increasing ability of the mines to maintain higher tailings transport densities. Lower densities will be temporarily allowed in cases where, because of equipment malfunctions or due to the density of ore being mined, the 48 percent densities cannot be achieved. Mines that began operation after 1984 are required to achieve an average annual tailings density of 50 percent.

In the Third Management Plan, the 50 percent tailings density requirement for mines that began operation after 1984 has been linked to construction of new mill concentrator facilities because constraints at the mill concentrator and thickeners largely control the maximum density that can be achieved in tailings transport. Conservation plan requirements for mines have shifted emphasis from providing site evaluation data to analyzing the latest available conservation technologies consistent with reasonable economic return.

Stilling basins are areas of free-standing water created in tailings impoundments when the solids in deposited tailings settle out. The Second Management Plan required that mining facilities manage tailings impoundments to minimize free water surface, maximize water depth, and create stilling basins. Third Management Plan specifications have been simplified to require that stilling basins be created and that their surface area be minimized.

To reduce seepage underneath tailings impoundments, the First and Second Management Plans required that impoundments be "preslimed" with fine-grained tailings and that these preslimed deposits be compacted. Because freshly deposited tailing slimes cannot support the weight of compaction equipment, Third Management Plan requirements have been modified to require facilities to preslime without compaction. An alternative to presliming is to install interceptor wells downgradient from each tailings impoundment to intercept seepage water from the impoundment.

To address further conservation potential at the mines, the Third Management Plan requires mining facilities to implement three additional conservation measures from a list of eight measures. These measures address aspects of tailings impoundment management, piping material, leach water delivery, dust control, site drainage, and revegetation.

The Second Management Plan requirement that wells constructed at mining facilities built after 1984 be placed to intercept the maximum possible amount of seepage has been deleted in the Third Management Plan because new wells may be needed to replace existing wells, to pump water from remote well fields, or to supply potable water. These needs may not be compatible with maximizing seepage interception. Facilities are required to use alternative water supplies to the extent practicable to minimize pumping of groundwater of drinking water quality. Alternative water supplies may include the use of groundwater supplies that do not meet drinking water standards. Additionally, facilities may use either decant towers or pumps to recover water and are required to minimize seepage from tailings impoundments.

In the Third Management Plan, surface leach operations and in situ leaching facilities are required to minimize water use to the extent practicable. In addition, a provision has been added in the Third Management Plan to address possible overlaps or conflicts between water conservation requirements and other environmental regulations. In determining compliance with mine conservation requirements, the director must ensure this compliance does not result in violating other local, state, or federal environmental regulations. Environmental regulations may include Best Available Demonstrated Control Technologies specified by the Arizona Department of Environmental Quality in their mine Aquifer Protection Permit requirements, mine closure requirements specified in Aquifer Protection Permits, mine closure requirements specified in the Mine Reclamation Act, air quality standards, federal Clean Water Act provisions, and others.

6.5.4 Metal Mine Conservation Program

Third Management Plan requirements for metal mines include the following provisions:

- Transport tailings at an average density of 48 percent solids by weight over a three-year running average at pre-1985 mines and at an average annual density of 50 percent at facilities built after 1984
- Reduce water loss from tailings impoundments by depositing tailings up slope from the free water surface in impoundments to reduce seepage or by installing interceptor wells down gradient of impoundments to intercept seepage at pre-1985 mines
- Manage tailings impoundments to minimize the free water surface of stilling basins and recover decant water
- Recover and recycle tailings impoundment water
- Cap abandoned tailings impoundments to minimize water used for dust control

- Minimize water use in leaching processes
- Implement three of eight specified additional conservation techniques
- Comply with monitoring and reporting requirements

In the third management period, metal mines will be required to evaluate water conservation practices and technologies that may be implemented at their facility and submit these evaluations to the Department in a long-range conservation plan.

6.5.5 Non-Regulatory Efforts

A study funded by the Department and by a Tucson AMA Conservation Assistance Grant was conducted by a consultant to determine the potential for additional groundwater conservation and the potential to use CAP water at Tucson area metal mines (Southwest Ground-water Consultants, Inc., 1997 *Conservation and CAP Use Potential of Tucson AMA Mines.* Prepared for the Arizona Department of Water Resources, Tucson AMA). In addition to providing data for development of the Third Management Plan conservation requirements for the mines, the results of the study have stimulated a more extensive and informed dialog between the mines, communities, and water suppliers on issues related to CAP conversion.

The mines currently rely entirely on groundwater for their water supply. Use of renewable supplies at Tucson AMA metal mines is likely to be limited to the use of CAP water because of the great distance between the mines and the large municipal effluent sources in Tucson. Use of CAP water by the mines is theoretically possible because the CAP delivery pipeline terminates at Pima Mine Road in the vicinity of ASARCO's Mission Mine (Figure 6-3). However, because the mines have sufficient groundwater rights to support planned mining activities well into the future, conversion to CAP water may need to be subsidized by other water users.

To make conversion to CAP water feasible, a number of issues would need to be addressed and resolved including finding a CAP source, constructing distribution lines to the mines, addressing the interruptability of the CAP supply, and addressing the impacts of CAP water quality on mineral extraction processes. The consultant's report addresses these issues and estimates costs for possible conversions. The Department continues to encourage conversion to renewable supplies by the mines due to the large volume of groundwater projected to be used and the potential acceptability of alternative sources.

6.5.6 Future Directions

The potential for additional groundwater conservation is somewhat limited at mines due to the current level of conservation and recycling being practiced and the need to continue to transport and dispose of tailings. Conversion to CAP water offers the best alternative to continued large scale groundwater use. Establishing meaningful incentives for such a conversion, facilitating communication and cooperation between possible partners, and continuing to add to the information base about CAP options are tasks the Department can undertake to improve the likelihood of conversion. The AMA has begun work on these efforts through its participation in regional recharge planning efforts. The potential for use of CAP water at mines through groundwater savings arrangements was one of a number of recharge approaches evaluated in this planning effort. The AMA has funded a study of the feasibility of delivering CAP water to mines and other potential users in the Sahuarita/Green Valley area. The Upper Santa Cruz Water Users Group is likely to use the information from the feasibility study as a basis for further exploration of the feasibility of funding and constructing a pipeline system to convey CAP water from the CAP canal terminus to water users in the Sahuarita-Green Valley area.

6.5.7 Industrial Conservation Requirements and Monitoring and Reporting Requirements for Metal Mining Facilities

6-501. Definitions

In addition to the definitions set forth in Chapters 1 and 2 of Title 45 of the Arizona Revised Statutes, unless the context otherwise requires, the following words and phrases shall have the following meanings:

1. *"Abandoned tailings impoundment" means a tailings impoundment that the owner/operator of a metal mining facility does not plan to use for additional disposal of tailings.*

2. *"Alternative water supply" means a water source other than groundwater of drinking water quality.*

3. *"Decant water" means water removed from the stilling basin of a tailings impoundment either by gravity flow into a decant tower or by pumping.*

4. *"Heap and dump leaching" means the extraction of minerals using acid solutions applied to metallic ores that have been removed from their original location and heaped or dumped in a new location.*

5. *"In situ leaching" means the extraction of metallic ores using acid leaching of ores that are not moved from their original natural location.*

6. *"In situ leaching sites" mean those portions of metal mining facilities at which in situ leaching and associated copper recovery operations occur, including surface applications of acid leaching solutions and deep well injection of acid leaching solutions.*

7. *"Large-scale metal mining and processing facility" means an industrial facility at which mining and processing of metallic ores is conducted and that uses or has the potential to use more than 500 acre-feet of water per reporting year. For the purposes of this definition, the annual water use or potential annual water use includes all water from any source, including effluent, used or projected to be used within or by the facility, regardless of the nature of the use.*

8. *"Mill concentrator" means the structure at open-pit metal mines within which metallic ore is crushed and the flotation process is used to remove minerals.*

9. *"Mill circuit" means the flow of water used in the process of crushing ore, recovering copper at the mill concentrator, and transporting and disposing of tailings, and includes recovery of water at the tailings impoundments for reuse in the mill concentrator.*

10. *"Post-1984 metal mining facility" means either:*

    a. *A large-scale metal mining and processing facility that does not qualify as a pre-1985 metal mining facility, including any expanded or modified portion of the facility, or*

    b. *Any expanded or modified portion of a pre-1985 metal mining facility if the expansion or modification includes one or more new tailings impoundments, new mill circuits,*

or new leaching facilities, and was not substantially commenced as of December 31, 1984.

11. *"Pre-1985 metal mining facility" means a large-scale metal mining and processing facility at which the mining and processing of metallic ores was occurring as of December 31, 1984, or that was substantially commenced as of December 31, 1984, and includes any expanded or modified portion of such a facility if the expansion or modification includes one or more new tailings impoundments, new mill concentrator circuits, or new wells, and was substantially commenced as of December 31, 1984.*

12. *"Seepage water" means water that has infiltrated from tailings impoundments into the material underlying the tailings impoundments.*

13. *"Substantially commenced as of December 31, 1984" means, with regard to the construction, expansion, or modification of a large-scale metal mining and processing facility, that the owner or operator of the facility had obtained all pre-construction permits and approvals required by federal, state, or local governments for the construction, expansion, or modification of the facility by December 31, 1984, or had made a substantial capital investment in the physical on-site construction of the project in the 12 months prior to December 31, 1984.*

14. *"Tailings" mean the slurry of water and fine-grained waste rock material remaining after minerals have been removed in the mill concentrator and excess water has been recovered and returned to the mill concentrator.*

15. *"Tailings impoundment" means the final disposal site for tailings generated in the milling circuit.*

6-502. Conservation Requirements for Pre-1985 Metal Mining Facilities

Beginning on January 1, 2002 and continuing thereafter until the first compliance date for any substitute conservation requirement in the Fourth Management Plan, an industrial user who uses water at a pre-1985 metal mining facility shall comply with the following requirements:

A. Management of Tailings Density

The industrial user shall transport tailings to the tailings impoundment area at the maximum density possible consistent with reasonable economic return; but, beginning with calender year 2002, the average density of the tailings during transport shall be 48 percent solids by weight or greater during the period consisting of the reporting year and the previous two years. The director may reduce the density required for a period of time determined by the director if the industrial user demonstrates that, due to the shut down of ore processing or tailings transport equipment or due to the density of ore being mined, a three-year average density of 48 percent or greater cannot be achieved.

B. Management of Presliming/Interceptor Wells

The industrial user shall comply with one of the following:

1. *Deposit a layer of tailings immediately up-slope from the free water level in each tailings impoundment. The tailings layer shall be 12 inches or more in thickness and shall minimize soil surface permeability.*

2. *Drill interceptor wells down-gradient from each tailings impoundment. The interceptor wells shall be designed, located and operated in such a manner as to intercept the maximum amount of seepage water possible from each tailings impoundment. Water recovered from the interceptor wells shall be reused at the mining facility.*

C. Management of Water in Tailings Impoundments

The industrial user shall minimize the free water surface area in each tailings impoundment by complying with all of the following:

1. *Manipulate tailings that have been disposed of in a tailings impoundment, and manage new disposal of tailings in an impoundment, to create stilling basins that increase the rate of recovery of decant water from the stilling basins, and to minimize the free water surface area of stilling basins.*

2. *Use decant towers, barge pumps, or sump pumps to recycle water from each tailings impoundment back to the mill concentrator.*

3. *Expand decant tower barge pumping capacity where necessary to increase the capacity to recycle water from each tailings impoundment back to the mill concentrator.*

4. *Use, to the maximum extent possible, tailings impoundment water, rather than pumping additional groundwater.*

D. Capping Abandoned Tailings Impoundments

The industrial user shall cap each abandoned tailings impoundment in a manner that minimizes the quantity of water used for dust control purposes and/or revegetation.

E. Heap and Dump Leaching

The industrial user shall apply water to heap and dump leaching operations in a manner that minimizes water use to the extent practicable, consistent with reasonable economic return.

F. Additional Conservation Measures

An industrial user who uses water at a metal mining facility shall comply with three of the following eight conservation measures at those portions of the facility that do not qualify as in situ leaching sites:

1. *When revegetating abandoned mine-related areas, utilize drought-tolerant vegetation.*

2. *Utilize multiple decant towers in single impoundments to increase decant rate.*

3. *Convert piping to high density polyethylene piping to increase density of transported tailings.*

4. *Harvest and reuse storm water runoff on site.*

5. *Reuse pit dewatering water.*

6. *Reduce evaporation from free-standing water surfaces in addition to evaporation reduction from stilling basins.*

7. *Reduce water used for dust control by reducing the number and extent of haul trips, using road binders, converting to conveyors for material transport, or using another dust control measure that reduces water use.*

8. *Reduce water used for delivery of acid/water solution for heap or dump leaching operations by using delivery methods that use less water than sprinkler delivery.*

6-503. Conservation Requirements for Post-1984 Metal Mining Facilities

Beginning on January 1, 2002 or upon commencement of operations at the facility, whichever is later, and continuing thereafter until the first compliance date for any substitute conservation requirement in the Fourth Management Plan, an industrial user who uses water at a post-1984 metal mining facility shall comply with conservation requirements applicable to pre-1985 metal mining facilities as prescribed in section 6-502, subsections C through F, and the following additional requirements:

A. Management of Tailings Impoundments

The industrial user shall design and construct any post-1984 tailings impoundments to maximize recovery of water from the stilling basins and to minimize seepage water. Any interceptor wells down gradient of tailings impoundments shall be constructed to maximize recovery of seepage water.

B. Management of Tailings Density

The industrial user shall design, construct, and operate any post-1984 mill concentrators and their associated tailings transport systems to achieve the maximum tailings densities possible consistent with reasonable economic return, but the average annual density of tailings during transport shall not be less than 50 percent solids by weight.

C. Management of In Situ Leaching

The industrial user shall utilize water for in situ leaching in a manner that minimizes water use to the extent practicable, consistent with reasonable economic return.

6-504. Alternative Conservation Program

An industrial user who uses water at a metal mining facility may apply to the director to use conservation technologies other than the technologies prescribed in sections 6-502 and 6-503, whichever is applicable. The director may approve the use of alternative conservation technologies if the director determines that both of the following apply:

1. *The industrial user has filed a detailed description of the proposed alternative technologies and the water savings that can be achieved by the use of these technologies with the director.*

2. *The industrial user has demonstrated to the satisfaction of the director that the latest commercially available conservation technology consistent with reasonable economic return will be used.*

6-505. Modification of Conservation Requirements for Metal Mining Facilities

A. *An industrial user who uses water at a metal mining facility may apply to the director to modify conservation requirements prescribed in sections 6-502 and 6-503, whichever is applicable, for any year in which compliance with the conservation requirements would likely result in violation of any federal, state, or local environmental standards or regulations. To apply for a modification of conservation requirements, an industrial user shall submit a request in writing to the director that includes the following information:*

1. *Documentation describing the conservation requirement(s) for which compliance with this requirement is likely to result in violation of environmental standards, and the environmental standards that are likely to be violated.*

2. *The proposed modification to the conservation requirements.*

B. *The director shall grant a request for modification of conservation requirements if the director determines that compliance with the conservation requirements prescribed in sections 6-502 and 6-503, whichever is applicable, would likely result in a violation of any federal, state, or local environmental standards or regulations.*

6-506. Preparation of a Long-Range Conservation Plan for Metal Mining Facilities

By January 1, 2002 or three months prior to commencement of operations at the facility, whichever is later, an industrial user who uses water at a metal mining facility shall submit to the director a long-range water conservation plan that describes the existing or planned design, construction and operation of the facility, including a description of the ore type, method of mining, and method of metal extraction. The plan shall include an evaluation of the use of the latest commercially available conservation technology consistent with reasonable economic return. Prior to submitting the plan, the industrial user shall analyze the feasibility of applying the following conservation practices or technologies at the mine and shall report the results in the plan:

1. *Using alternative water sources for mining and metallurgical needs, including determining the source and volume of the alternative water sources being analyzed.*

2. *Reducing tailings impoundment evaporation through the application of the latest commercially available technologies for minimizing evaporation from the impoundments and through the application of improved tailings management.*

3. *Minimizing water use for dust suppression through the use of road binders, conveyors, paved haul roads, and other available dust control mechanisms.*

4. *Increasing tailings densities to 55 percent solids or greater by weight.*

The industrial user may include any additional conservation techniques or technologies in the plan. The plan shall include a schedule of the approximate dates for implementation of any conservation practices or technologies that the industrial user intends to implement.

6-507. Monitoring and Reporting Requirements for Metal Mining Facilities

A. Water Measurement and Reporting

For calendar year 2002 or the calendar year in which the facility commences operation, whichever is later, and for each calendar year thereafter until the first compliance date for any substitute requirement in the Fourth Management Plan, an industrial user who uses water at a metal mining facility shall include in its annual report required by A.R.S. § 45-632 the following information:

1. *The quantity of water from any source, including effluent, used during the calendar year for each of the following purposes: dust control, tailings revegetation, domestic use, and transportation of tailings to tailings impoundments. The quantity of water used for dust control and tailings revegetation shall be separately measured with a measuring device in accordance with the Department's measuring device rules, A.A.C. R12-15-901, et seq. The quantity of water used for domestic use and transportation of tailings to tailings impoundments may be estimated.*

2. *The quantity of make-up water from any source, including effluent, used during the calender year for each of the following purposes: equipment washing, leaching operations, and milling operations, as separately measured with a measuring device in accordance with the Department's measuring device rules, A.A.C. R12-15-901, et seq.*

3. *The quantity of water from any source, including effluent, reclaimed during the calendar year from each of the following: tailings impoundments and pit dewatering. These quantities shall be separately measured with a measuring device in accordance with the Department's measuring device rules, A.A.C. R-12-15-901, et seq.*

4. *The tons of ore milled during the calendar year.*

5. *The tons of ore stacked to heap and/or dump leach during the calendar year.*

6. *The tons of ore vat leached during the calendar year.*

7. *The tons of material mined during the calendar year.*

8. *The tons of mineral produced from mill circuits and from leach circuits during the calendar year.*

9. *The average gallons of water consumed per ton of mineral produced during the calendar year.*

10. *The average percentage of solids by weight in tailings transported to the tailings impoundments during the calendar year and in each of the previous two years.*

11. *The average annual depth of water at the deepest portion of the stilling basin(s).*

12. *Copies of aerial photos of tailings impoundments, with scale indicated, for use by the Department in determining the wetted surface area of the tailings impoundments.*

13. *A description of the additional conservation measures applied at the metal mining facility as prescribed in section 6-502, subsection F.*

B. Contiguous Facilities

A single annual report may be filed for a pre-1985 metal mining facility and a post-1984 metal mining facility that are contiguous and owned by the same owner. The combined operations of the metal mining facilities shall be described pursuant to reporting requirements specified in subsection A of this section.

6.6 LARGE-SCALE POWER PLANTS

6.6.1 Introduction

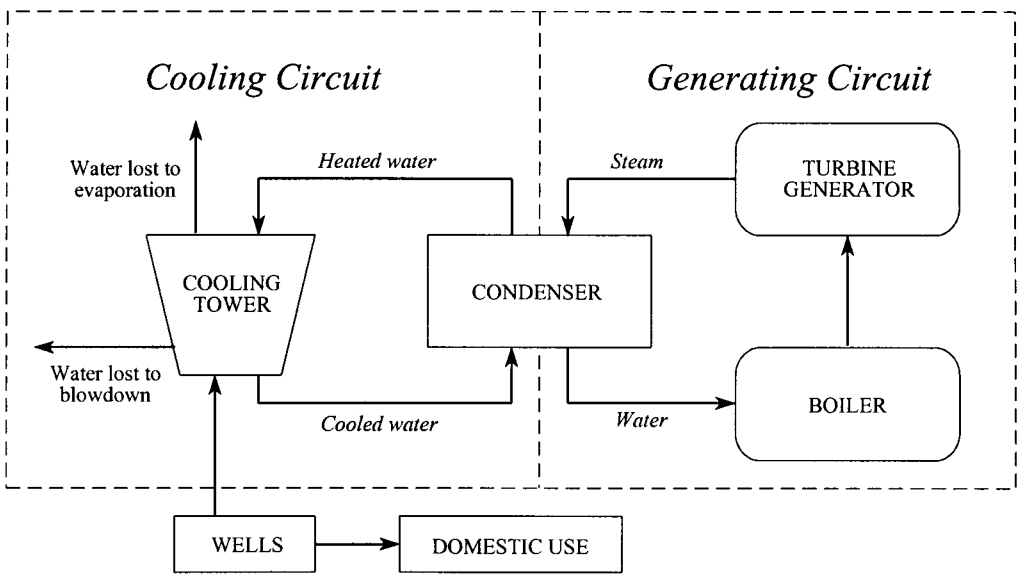
The Department regulates power plants that produce or are designed to produce more than 25 megawatts of electricity. The electric power industry uses cooling towers to dissipate excess heat that builds up in the electrical generation process. The major consumptive use of water at these facilities is evaporation from cooling towers. Because of the large volume of water used in towers, conservation requirements for the electric power industry require facilities to achieve a high level of efficiency in cooling tower operation.

6.6.2 Water Use by Large-Scale Power Plants

The electric power industry in the Tucson AMA currently holds water rights to over 10,000 acre-feet of groundwater per year pursuant to Type 2 non-irrigation grandfathered rights limited to use for electric power generation. Two large-scale power plants currently operate in the Tucson AMA. The Tucson Electric Power plant operates year round and is located at Irvington Road and Interstate 10 in the southeast area of Tucson. Water use averaged 1,700 acre-feet per year at this plant between 1987 and 1995. It is projected that water demand at this plant will reach 1,900 acre-feet per year by the year 2025. An Arizona Public Service plant is located in the northwest portion of the AMA near Picacho. This peaking plant operates only during high demand periods in the hotter months of the year. Water use averaged 350 acre-feet per year at this plant between 1987 and 1995, and is projected to reach 600 acre-feet per year by 2025. Groundwater used by these plants is not projected to parallel population growth because the electric power needed to meet increasing demand is likely to be imported, rather than generated within the AMA.

Most electric power plants have two water use circuits, referred to as the generating circuit and the cooling circuit. Figure 6-5 illustrates water flow in a typical electrical power plant. In the generating circuit, water is heated in the boiler to form steam that turns the turbines. The turbines in turn drive the generators that create electricity. The steam must be cooled and condensed into water before being recycled back to the boiler. The conversion of water to steam and back to water in the generating circuit is completed in a closed system, so water is efficiently recycled with little loss.

FIGURE 6-5
DIAGRAM OF WATER FLOW IN A TYPICAL POWER PLANT



At the condenser, heat is transferred from the steam in the generating circuit to the cooled water in the cooling circuit. Because this heat exchange occurs through the walls of the condenser piping, water in the two circuits does not mix. The heated water in the cooling circuit is pumped to a cooling tower where it is cooled by evaporation. The cooled water is then recirculated back to the condenser. Evaporation losses in the cooling tower constitute the main consumptive use of water at large-scale power plants. As a portion of the cooling circuit water evaporates in the cooling tower, dissolved minerals become more concentrated in the remaining water. Due to the high mineral concentrations, corrosion, mineral deposition, and biological fouling can result and can lead to reduced cooling efficiency and equipment damage. Use of chemical treatments can prolong water use in a tower, but periodically, mineral-laden water must be discharged or "blown down" to prevent minerals from precipitating on equipment. Replacement water, known as "make-up water," is added to replace water lost to evaporation and blowdown.

The "cycles of concentration" or "concentration ratio" achieved in a tower indicate how efficiently water is being used. Cooling towers that are consistently operated at higher cycles of concentration consume less water than towers consistently operated at lower cycles of concentration. Cycles of concentration can be determined by dividing the concentration of a constituent in the blowdown water by the concentration of this same constituent in the make-up water. Total dissolved solids content is one commonly used constituent for calculating the cycles of concentration. For example, if the total dissolved solids concentration in blowdown water is 1,500 milligrams per liter (mg/l), and the total dissolved solids content of make-up water is 300 mg/l, the tower is operating at 5 cycles of concentration. Cycles of concentration can also be calculated using electrical conductivity measurements, water volumes, and other conservative mineral constituents (mineral constituents whose concentrations are not altered by precipitation, loss to the atmosphere, or the addition of treatment chemicals).

6.6.3 Program Development and Issues

Conservation requirements for the electric power industry were generally the same in the First and Second Management Plans. Facilities in operation by the end of 1984 were required to reach 7 cycles of concentration in cooling towers before blowing down water. Facilities that went into operation after 1984 were required to reach 15 cycles of concentration. For large-scale power facilities in operation by the end of 1984, achieving 7 cycles of concentration is a realistic ceiling on water use efficiency. Above 7 cycles of concentration, the potential for additional water savings decreases while the potential for equipment damage and the cost of chemical additives both increase. Large-scale power facilities can be designed to achieve 15 cycles of concentration, but the technology to accomplish this needs to be built into the plant from the outset and represents an additional expense.

Third Management Plan regulations keep the core requirements from earlier management periods with some modifications to address cooling tower operational time periods and periods of changing water quality. In the Third Management Plan, the cycles of concentration requirement has been revised to apply only when cooling towers are in full operational mode dissipating heat created during the generation of electricity. Some large-scale power plants generate electricity only during summer months when demand for electric power peaks. During non-generating months, compliance with the cycles of concentration requirements may not be possible because even though water is recirculated to keep tower surfaces wetted, tower evaporation fans are turned off to reduce electricity use. This reduces the normal rate of evaporation. When the recirculating water eventually becomes stagnant, it needs to be blown down even if 7 (or 15) cycles of concentration have not been reached.

Individual cooling towers are periodically shut down and rebuilt. New structural pieces may be installed in towers during this process. If chemically treated lumber is used, concentrations of arsenic, copper, or chromium can build up in tower water. This water needs to be discharged before these concentrations exceed environmental standards even if 7 (or 15) cycles of concentration have not been reached. As groundwater is withdrawn from greater depths, mineral and trace metal concentrations can increase. When

this groundwater is used to provide make-up water to cooling towers, concentrated minerals in the recirculating water can precipitate and cause equipment damage. There is also a potential for trace metals to build up in recirculating water and exceed sewer system discharge standards for Publicly-Owned Treatment Works or exceed National Pollutant Discharge Elimination System standards. In the Third Management Plan, the director may adjust the 7 (or 15) cycles of concentration requirement for cooling towers at large-scale power plants in cases where, because of leaching from new tower components, deterioration of make-up water supplies, or other reasons, facilities are likely to experience equipment damage or come into conflict with environmental discharge regulations if they comply with the cycles of concentration requirement. A facility must submit documentation of potential problems to support its request to have the cycles of concentration requirement reduced.

Use of effluent in cooling towers is encouraged as an alternative to groundwater use. The feasibility of this use depends on a number of factors including, among others, the availability of effluent, the volume and timing of water demand at the towers, water quality considerations, cost, any constraints on groundwater supplies, and site-specific factors such as other on-site uses for the effluent. The chemical composition of this renewable water source can vary seasonally and even daily depending on the quality, volume and source of wastewater flowing into wastewater treatment facilities. In the Third Management Plan, cooling towers at power plants are exempted from cycles of concentration requirements for the first 12 months in which effluent constitutes more than 50 percent of a tower's water supply. During this period, the power plant operator can collect data on the concentration and variability of constituents in the effluent-served cooling towers that may limit the cycles of concentration that can safely be reached and maintained. After the 12-month exemption period, the facility must either comply with the required cycles of concentration standards or propose an alternative cycles of concentration standard for effluent-served towers based on the data collected during that year.

Several additional changes have been made to the Third Management Plan to more accurately reflect facility operations. The definition of "continuous blowdown and make-up" has been revised to clarify that this term refers to continuous blowdown and make-up or frequent periodic blowdown and make-up of recirculating water. Monitoring and reporting requirements have been revised to allow total dissolved solids, other conservative mineral constituents, or electrical conductivity to be used to determine cycles of concentration. Monitoring and reporting requirements have also been revised to allow monitoring in time increments consistent with operational periods for cooling towers.

6.6.4 Large-Scale Power Plant Conservation Program

The Third Management Plan requires that power plants in operation as of the end of 1984 achieve an annual average of 7 cycles of concentration in cooling towers, while facilities that went into operation after 1984 are required to achieve an annual average of 15 cycles of concentration in their cooling towers. The cycles of concentration requirement applies only during periods when facilities are generating electricity and applies only to fully operational towers that are dissipating heat from the power generation process. In addition to achieving 7 (or 15) cycles of concentration, facilities must discharge blowdown water and add make-up water to cooling towers on a continuous basis and divert the maximum possible volume of on-site wastewater (other than blowdown water and sanitary wastewater) to the cooling process.

Facilities may be granted adjustments to their full cycles of concentration requirements in cases where, due to the quality of recirculating water, adhering to the 7 (or 15) cycles of concentration standard is likely to result in equipment damage or blowdown water exceeding environmental discharge standards. Cooling towers at power plants are exempted from cycles of concentration requirements during the first 12 months in which effluent constitutes more than 50 percent of tower water supply. After this period, facilities may request an adjustment to full cycles of concentration requirements for effluent-served towers based on the water quality of the effluent supply.

Facilities may apply to the director to use alternative conservation technologies in place of achieving 7 (or 15) cycles of concentration if the use of the proposed alternative technologies will result in equal or greater water savings. Facilities may also request a waiver from conservation requirements on the basis that cooling tower blowdown water is completely reused. Facilities must periodically measure and annually report blowdown water volumes, make-up water volumes, and the chemical concentration of blowdown and make-up water. In addition, facilities must report the amount of electricity generated, periods when they are not generating electricity, and the volume of water used for purposes other than electric power generation.

6.6.5 Non-Regulatory Efforts

Conservation assistance funds in the Tucson AMA are supporting a study of the tolerance of common landscape plants to cooling tower blowdown water from an electric power plant. The goal of this study is to determine whether landscapes can successfully be watered with blowdown water rather than groundwater. An experimental project in the Phoenix AMA uses cooling tower blowdown water from a large-scale power plant to grow halophytes (salt tolerant plants) that are being used to vegetate an urban wildlife refuge adjacent to the facility. Depending on the results of these studies, cooling tower blowdown water may be useful for replacing the use of groundwater to water existing vegetation at some locations.

6.6.6 Future Directions

In the Tucson AMA, large-scale power facilities are supplied by Type 2 non-irrigation grandfathered rights limited to use for electric power generation. Other potential water sources include CAP water and effluent, but neither of these are currently being used by the electric power industry in the AMA. The Third Management Plan includes a temporary exemption from the cycles of concentration requirements for towers using at least 50 percent effluent, with the option to adjust cycles of concentration requirements if needed to make long-term use of effluent viable. If this option is used by power plants during the third management period, the information gained can be used to direct research and regulatory directions in the fourth management period. Reuse of industrial wastewater in cooling towers and use of cooling tower blowdown water for landscape watering should continue to be examined to determine the advantages and constraints of these conservation strategies.

6.6.7 Industrial Conservation Requirements and Monitoring and Reporting Requirements for Large-Scale Power Plants

6-601. Definitions

In addition to the definitions set forth in Chapters 1 and 2 of Title 45 of the Arizona Revised Statutes, unless the context otherwise requires, the following words and phrases shall have the following meanings:

1. *"Blowdown water" means water discharged from a cooling tower recirculating water stream to control the buildup of minerals or other impurities in the recirculating water.*

2. *"Conservative mineral constituent" means a component of recirculating water in a cooling tower, the concentration of which is not significantly modified by precipitation, loss to the atmosphere or the addition of treatment chemicals.*

3. *"Continuous blowdown and make-up" means patterns in cooling tower operation that include continuous blowdown and make-up or frequent periodic blowdown and make-up of recirculating water.*

4. *"Cycles of concentration" means the ratio of the concentration of total dissolved solids, other conservative mineral constituent or electrical conductivity in the blowdown water to the concentration of this same constituent or electrical conductivity in the make-up water.*

5. *"Effluent-served cooling tower" means a cooling tower served by a make-up water supply that on an annual average basis consists of 50 percent or more effluent.*

6. *"Fully operational cooling tower" means a cooling tower that is functioning to dissipate heat from a large-scale power plant that is generating electricity.*

7. *"Large-scale power plant" means an industrial facility that produces or is designed to produce more than 25 megawatts of electricity.*

8. *"Limiting constituent" means a chemical, physical, or biological constituent present in recirculating cooling tower water that, due to potential physical or biological factors or due to potential exceedence of any federal, state, or local environmental standards upon discharge as blowdown, should not be allowed to accumulate in recirculating cooling tower water above a certain concentration.*

9. *"Make-up water" means the water added back into the cooling tower recirculating water stream to replace water lost to evaporation, blowdown, or other mechanisms of water loss.*

10. *"Post-1984 power plant" means either:*

    a. *A large-scale power plant that does not qualify as a pre-1985 power plant and includes any expanded or modified portion of the power plant if the expansion or modification includes the construction or modification of one or more cooling towers; or*

b. Any expanded or modified portion of a pre-1985 power plant if the expansion or modification includes the construction or modification of one or more cooling towers and was not substantially commenced as of December 31, 1984.

11. "Pre-1985 power plant" means a large-scale power plant that either produced electric power as of December 31, 1984 or was substantially commenced as of December 31, 1984 and includes any expanded or modified portion of such a power plant if the expansion or modification was substantially commenced as of December 31, 1984 and included the modification or construction of one or more cooling towers.

12. "Substantially commenced as of December 31, 1984" means, with regard to the construction, expansion, or modification of a large-scale power plant, that all preconstruction permits and approvals required by federal, state, or local governments for the construction, expansion, or modification of the plant were obtained by December 31, 1984, or that a substantial capital investment in the physical on-site construction of the project was made within the 12 months prior to December 31, 1984.

6-602. Conservation Requirements for Pre-1985 Power Plants

Beginning on January 1, 2002 and continuing thereafter until the first compliance date for any substitute conservation requirement in the Fourth Management Plan, an industrial user who uses water at a pre-1985 power plant shall comply with the following requirements:

1. An annual average of 7 or more cycles of concentration shall be achieved at fully operational cooling towers during periods when the power plant is generating electricity.

2. Blowdown water shall be discharged on a continuous basis, and make-up water shall be provided on a continuous basis.

3. The maximum amount of wastewater feasible, excluding blowdown water and sanitary wastewater, shall be diverted to the cooling process.

6-603. Conservation Requirements for Post-1984 Power Plants

Beginning on January 1, 2002 or upon commencement of water use, whichever occurs later, and continuing thereafter until the first compliance date for any substitute conservation requirement in the Fourth Management Plan, an industrial user who uses water at a post-1984 power plant shall comply with the following requirements:

1. An annual average of 15 or more cycles of concentration shall be achieved at fully operational cooling towers during periods when the power plant is generating electricity.

2. Blowdown water shall be discharged on a continuous basis, and make-up water shall be provided on a continuous basis.

3. The maximum amount of wastewater feasible, excluding blowdown water and sanitary wastewater, shall be diverted to the cooling process.

6-604. Cycles of Concentration Adjustment Due to the Quality of Recirculating Water

A. *An industrial user who uses water at a large-scale power plant may apply to the director for an adjustment to the cycles of concentration requirements set forth in section 6-602 or section*

6-603, whichever is applicable, if compliance with the cycles of concentration requirements would likely result in damage to cooling towers or associated equipment or exceedence of federal, state or local environmental discharge standards because of the quality of recirculating water. To apply for an adjustment to the cycles of concentration requirements based on recirculating water quality, an industrial user shall submit a request in writing to the director that includes the following information:

1. *Historic, current and projected water quality data for the relevant constituent(s).*

2. *Documentation describing the potential damage to cooling towers or associated equipment, or documentation of environmental standards that are likely to be exceeded, whichever applies.*

B. *The director shall grant the request if the director determines that compliance with the cycles of concentration requirements set forth in section 6-602 or section 6-603, whichever is applicable, would likely result in damage to cooling towers or associated equipment or exceedence of federal, state, or local environmental discharge standards because of the quality of recirculating water.*

6-605. Exemption and Cycles of Concentration Adjustment Due to the Quality of Effluent Make-up Water Supplies

A. *The cycles of concentration requirements set forth in sections 6-602 and 6-603 do not apply to any effluent-served cooling tower at a large-scale power plant during the first 12 consecutive months in which more than 50 percent of the water supplied to the cooling tower is effluent.*

B. *After the 12-month exemption period expires, the industrial user who uses water at the large-scale power plant may apply to the director for a cycles of concentration adjustment to lower the cycles of concentration requirement for the effluent-served cooling tower if compliance with the requirement would not be possible due to the presence of a limiting constituent in the effluent supplying the tower. To apply for an alternative cycles of concentration requirement to address such a limiting constituent, an industrial user shall submit a request in writing to the director that includes the following information:*

1. *The limiting constituent that is present in the effluent supplying the tower that results in the need to blow down a greater annual volume of water than that required in section 6-602 or section 6-603, whichever is applicable.*

2. *Documentation describing the concentration at which this limiting constituent should be blown down and the reason for the alternative blowdown level.*

The director shall grant the request if the director determines that the presence of a limiting constituent in the effluent supplying the cooling tower results in the need to blow down a greater annual volume of water than that required in section 6-602 or section 6-603, whichever is applicable. Any cycles of concentration adjustment granted pursuant to this paragraph shall apply only while the tower qualifies as an effluent-served cooling tower.

6-606. Alternative Conservation Program

An industrial user who uses water at a large-scale power plant may apply to the director to use conservation technologies other than those prescribed in section 6-602 or section 6-603,

whichever is applicable. The director shall approve the use of alternative conservation technologies if both of the following apply:

1. *The industrial user files with the director a detailed description of the proposed alternative technologies and the water savings that can be achieved by the use of the alternative technologies.*

2. *The director determines that the alternative conservation technologies will result in water savings equal to or greater than the savings that would be achieved by the applicable conservation technologies prescribed in section 6-602 or section 6-603.*

6-607. Waiver

A. *An industrial user who uses water at a large-scale power plant may apply to the director for a waiver of any applicable conservation requirement in section 6-602 or section 6-603 by submitting a detailed, long-term plan for beneficial reuse of 100 percent of blowdown water outside the cooling circuit, including an implementation schedule. Reuse of blowdown water includes the discharge of blowdown water into pipes, canals, or other means of conveyance if the discharged water is transported to another location at the plant or off the plant for reuse.*

B. *The director shall grant a waiver request if the director determines that implementation of the plan will result in the beneficial reuse of 100 percent of blowdown water outside the cooling circuit. If a waiver request is granted, the industrial user shall implement the plan in accordance with the implementation schedule submitted to and approved by the director.*

6-608. Monitoring and Reporting Requirements

A. *For calendar year 2002 or the calendar year in which water use first commences, whichever is later, and for each calendar year thereafter until the first compliance date for any substitute requirement in the Fourth Management Plan, an industrial user who uses water at a large-scale power plant shall include in its annual report required by A.R.S. § 45-632 the following information:*

1. *Cooling capacity in tons of each cooling tower at the facility.*

2. *Frequency of use of each cooling tower at the facility.*

3. *Source of water providing make-up water to each cooling tower at the facility.*

4. *For each cooling tower at the facility that is exempt from cycles of concentration requirements pursuant to section 6-605, subsection A, or for which a cycles of concentration adjustment was granted pursuant to section 6-605, subsection B, the percentage of water served to the tower during the year that was effluent.*

5. *For all fully operational cooling towers subject to cycles of concentration requirements under section 6-602 or section 6-603:*

    a. *The total quantity of blowdown water discharged from the cooling towers for each month or partial month when the facility was generating electricity during the calendar year.*

b. *The total quantity of make-up water used at cooling towers for each month or partial month when the facility was generating electricity during the calendar year.*

c. *The weighted average concentration of total dissolved solids or other conservative mineral constituent in make-up water and blowdown water at the cooling towers for each month or partial month when the facility was generating electricity during the calendar year, either:*

1) *Determined by direct analysis, or*

2) *Calculated based on average monthly electrical conductivity readings if the following conditions have been met: (a) correlations between electrical conductivity and total dissolved solids or between electrical conductivity and another conservative mineral constituent have been established over a period of one year or more in make-up and blowdown water and (b) documentation of these correlations has been provided to the director.*

6. *For each fully operational cooling tower that is exempt from cycles of concentration requirements pursuant to section 6-605, subsection A, or for which an adjusted cycles of concentration requirement was granted pursuant to section 6-604 or section 6-605, subsection B:*

a. *The total quantity of blowdown water discharged from the cooling tower for each month or partial month when the facility was generating electricity during the calendar year.*

b. *The total quantity of make-up water used at the cooling tower for each month or partial month when the facility was generating electricity during the calendar year.*

c. *The weighted average concentration of total dissolved solids or other conservative mineral constituent in make-up water and blowdown water at the cooling tower for each month or partial month when the facility was generating electricity during the calendar year, either:*

1) *Determined by direct analysis, or*

2) *Calculated based on average monthly electrical conductivity readings if the following conditions have been met: (a) correlations between electrical conductivity and total dissolved solids or between electrical conductivity and another conservative mineral constituent have been established over a period of one year or more in make-up and blowdown water and (b) documentation of these correlation has been provided to the director.*

7. *All time periods when the facility was not generating electricity.*

8. *The amount of electricity generated each month or each partial month when the facility was generating electricity during the calendar year.*

9. *The estimated quantity of water from any source, including effluent, used during the calendar year for each purpose other than electric power generation purposes.*

B. *A single annual report shall be filed for a pre-1985 power plant and a post-1984 power plant that are contiguous and owned by the same owner. The report shall describe the combined operations of the pre-1985 and post-1984 power plants as required in subsection A of this section.*

C. *All water measurements required in this section shall be made with a measuring device in accordance with the Department's measuring device rules, A.A.C. R12-15-901, et. seq.*

6.7 LARGE-SCALE COOLING FACILITIES

6.7.1 Introduction

The purpose of cooling tower operation is to cool water that has absorbed the heat load of a heat-generating process. Cooling towers are present at a variety of commercial, industrial, and institutional facilities. Large-scale cooling facilities are defined as facilities with an aggregate cooling capacity of 1,000 tons or more. The minimum cooling unit which is added to create the aggregate total of 1,000 tons is 250 tons in size. Most large-scale cooling facilities are served by municipal water providers. These facilities are termed individual users. Water providers are responsible for the individual users' compliance with industrial conservation requirements unless they have notified the Department of the existence of the individual user as provided in section 5-111 of the Municipal Conservation Requirements (Chapter 5), in which case the individual user is responsible for compliance. Large-scale cooling facilities served by their own wells are regulated directly by the Department and are responsible for complying with industrial conservation requirements.

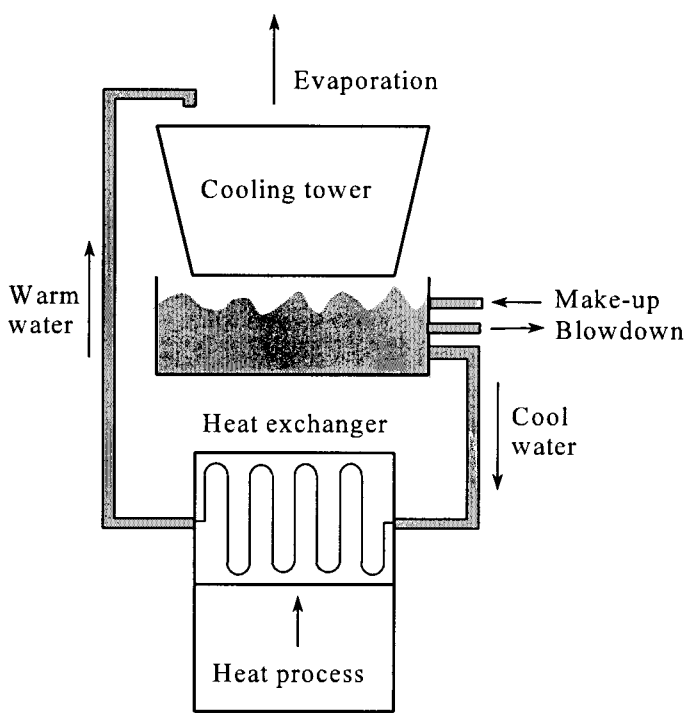
6.7.2 Water Use by Large-Scale Cooling Facilities

The main use of water in a cooling tower is to absorb heat from a heat-generating process and dissipate this heat through evaporation, as shown in Figure 6-6. Because a portion of the recirculating water is lost through evaporation, this is considered an "open" recirculating cooling loop.

The equipment served by a cooling tower varies from industry to industry, the most common is equipment used to reject heat from a large Heating, Ventilation, and Air Conditioning system (known as an HVAC system). Various equipment configurations are used to transfer heat from its source to the cooled water stream coming from the cooling tower. This transfer typically occurs inside a heat exchanger (Figure 6-6).

As a portion of cooling tower water evaporates, dissolved minerals become concentrated in the remaining water. Problems such as corrosion, mineral deposition, and biological fouling can result. These conditions reduce cooling efficiency and damage equipment. Chemical treatments including biocides, scale inhibitors, corrosion inhibitors, and addition of sulfuric acid can prolong the time mineral-laden water can safely be recirculated in towers. Mineral-laden water must periodically be discharged to prevent the excessive buildup of minerals and possible precipitation of these minerals onto equipment surfaces. This discharge is known as "blowdown." Replacement water, known as "make-up water" is added back to the tower's recirculating water stream to replace the water lost to evaporation and blowdown.

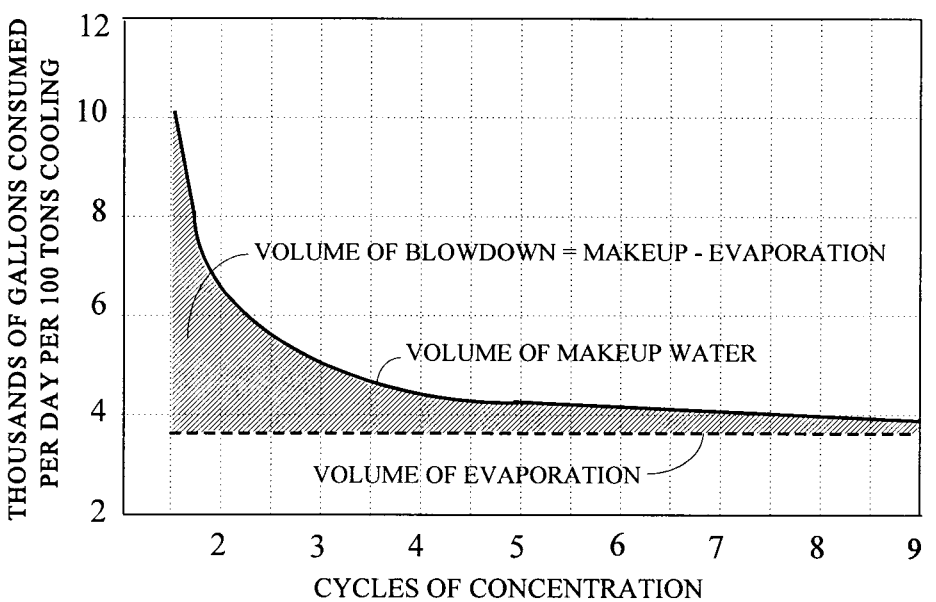
FIGURE 6-6
AN OPEN RECIRCULATING COOLING LOOP



The "cycles of concentration" or "concentration ratio" achieved in a tower indicate how efficiently water is being used in the tower. Cycles of concentration can be determined by dividing the concentration of a constituent in the blowdown water by the concentration of this same constituent in the make-up water. The concentration of total dissolved solids, a measure of the overall dissolved mineral content in water, is one commonly used constituent for calculating the cycles of concentration. For example, if the total dissolved solids concentration in blowdown water is 1,500 mg/l and the total dissolved solids content of make-up water is 300 mg/l, the tower is operating at 5 cycles of concentration. Cycles of concentration can also be calculated using electrical conductivity measurements, water volumes, and other conservative constituents (mineral constituents whose concentrations are not altered by precipitation, loss to the atmosphere, or the addition of treatment chemicals).

Figure 6-7 illustrates the relationship between the cycles of concentration achieved in a tower and the volume of water lost through evaporation and blowdown and replaced by make-up water. At lower concentration cycles, the tower loses water through both evaporation and blowdown. At higher cycles of concentration, the rate of water consumption levels off until almost all water loss is due to evaporation. Evaporation cannot be reduced since this is the mechanism that provides the cooling function of the tower. However, blowdown can be minimized by operating the tower at optimal efficiency. The larger a tower is, the more water will be saved as the cycles of concentration increase.

FIGURE 6-7
RELATIONSHIP BETWEEN THE CYCLES OF CONCENTRATION AND THE AMOUNT OF WATER CONSUMED BY A COOLING TOWER



Cooling tower water use cannot be determined directly from water supply records because water supplies to large facilities serve a number of water needs besides cooling towers. In the absence of direct records, water use at cooling towers has been based on an estimation of the number, size and efficiency of towers in the Tucson AMA. Lists of large water customers served by municipal water providers were reviewed to locate hospitals, manufacturing plants, commercial buildings, department stores, grocery stores, schools, and other facilities with large cooling demands. Questionnaires were sent to these facilities to determine tower size and water use efficiency. Based on the lists of large water customers and survey results, it is estimated there are about 750 towers of all sizes in the Tucson AMA.

The size or cooling capacity of a tower is often described in units of tons. Cooling capacity tonnage indicates the rate at which the cooling tower can reject heat. Cooling tower capacities can range from as little as 50 tons to 1,000 tons or more. Large industrial or commercial facilities may have several large towers. As discussed in section 6.7.3, Third Management Plan regulations apply to facilities with a total cooling capacity of 1,000 tons or more. Based on the survey results, approximately 100 facilities may fit into this regulatory category. Assuming towers at these facilities average 1,000 tons in capacity and operate 24-hours a day at 3 cycles of concentration, they would use around 5,700 acre-feet of water annually. These estimates need to be confirmed with additional field data.

Future water use by regulated cooling towers will depend on the size and number of newly constructed facilities and the cycles of concentration achieved at all regulated towers. Assuming cooling tower construction parallels population growth, the number of towers in the Tucson AMA could double by 2025. At three cycles of concentration, facilities subject to Third Management Plan regulations could use 11,400 acre-feet by 2025.

6.7.3 Program Development and Issues

There were no conservation requirements in the First Management Plan for cooling towers other than for towers serving the electric power industry (section 6.6 of this chapter). Beginning in the Second Management Plan, regulations went into effect for "new large cooling users," defined as facilities with an aggregate tower capacity in excess of 250 tons that went into operation after January 1, 1990. Cooling towers at facilities in this category were required to achieve a concentration of 2,000 mg/l of total dissolved solids in recirculating water before blowing it down. The cutoff date of January 1, 1990 was intended to focus on new facilities with cooling towers, which could be identified as they established hook-ups with water providers. This identification process has proved to be difficult, and a complete list of facilities subject to Second Management Plan requirements has not been developed.

The Third Management Plan includes several changes intended to increase the effectiveness of conservation requirements for cooling towers. The facilities subject to regulation have been expanded from "new" facilities to facilities of all ages, because cooling technology has not changed significantly over time, and age alone does not preclude towers at facilities from achieving water use efficiency. At the same time, the size of regulated facilities has been shifted upwards to include only those facilities with an aggregate cooling capacity of 1,000 tons or more. In determining the aggregate cooling capacity of a facility, only cooling towers that are 250 tons or more in size are considered and only towers of this size or larger have specific blowdown requirements. This size cutoff excludes small capacity towers at which it may not be cost effective to conduct monitoring and install chemical feed equipment. Eliminating the January 1, 1990 cutoff date increases the number of facilities subject to regulation and increases the potential water savings. Identifying facilities subject to Third Management Plan requirements should be facilitated by concentrating on larger scale industries, commercial buildings, and institutions that need 1,000 tons or more of cooling capacity.

In the Second Management Plan, facilities were required to achieve a recirculating water concentration of 2,000 mg/l of total dissolved solids in cooling towers before blowing down. Blowdown standards in the Third Management Plan have been shifted from total dissolved solids to silica- and hardness-based standards. While the concentration of total dissolved solids is relatively easy to estimate using electrical conductivity as a surrogate and the 2,000 mg/l cutoff level addresses to some extent the water quality variations in make-up water supplies, silica and total hardness are more useful as indicators of the maximum concentration cycles that can safely be achieved in a tower. Silica can build up in recirculating water and damage equipment by precipitating a layer of "glass" inside piping. This silica layer reduces heat transfer and requires expensive repairs. The total hardness of water is a measure of the presence of calcium and magnesium salts, which can precipitate to form scale inside cooling towers and associated piping.

The purpose of Third Management Plan regulations is to effectively move large-scale cooling facilities toward more water conserving management practices while operating within a range that safely avoids mineral precipitation in cooling towers and associated piping. As required in the Code, conservation requirements for industrial users must be based on the use of the latest commercially available conservation technology consistent with reasonable economic return. Conservation requirements in the Third Management Plan focus on standards that can be achieved using conventional chemical treatment to extend cycles of concentration in cooling towers. This is the most efficient proven conservation technology currently available without major capital outlays. Several new commercially available technologies for tower operation and maintenance are available but have drawbacks because they are unproven technologies, have high initial capital costs, or do not work efficiently at high desert temperatures.

In the Third Management Plan, large-scale cooling facilities must achieve concentrations of either 120 mg/l of silica or 1,200 mg/l of total hardness, whichever is reached first, before blowing down the recirculating water from towers with 250 tons or more of cooling capacity. The solubility limit of silica in water is around 150 mg/l. Allowing facilities to discharge water when silica reaches 120 mg/l provides a margin of safety against costly equipment damage. The solubility limit of total hardness is a function of the chemical treatment used in a tower. Large cooling towers can generally operate safely at concentrations of around 1,200 mg/l total hardness in the recirculating water so this was selected as the Third Management Plan total hardness standard. Total hardness is typically expressed as an equivalent concentration of calcium carbonate ("hardness as calcium carbonate"), though both calcium and magnesium salts are included in this expression.

Third Management Plan cooling tower blowdown requirements apply only when towers are functioning to dissipate heat. Some towers are operated periodically based on seasonal or workload patterns, rather than being operated continuously. During periods when they are not dissipating heat, water may still need to be recirculated through towers to keep surfaces wetted, but evaporation fans may be turned off to reduce electricity use. This reduces the normal rate of evaporation. When the recirculating water becomes stagnant, it needs to be blown down whether or not blowdown standards have been met.

Use of effluent in cooling towers is encouraged as an alternative to groundwater use. The feasibility of this use depends on a number of factors including the availability of effluent, the volume and timing of water demand at the towers, water quality considerations, cost, any constraints on groundwater supplies, and site-specific factors such as other on-site uses for the effluent. The chemical composition of this renewable water source can vary seasonally and even daily depending on the quality, volume, and source of wastewater flowing into wastewater treatment facilities. In the Third Management Plan, a cooling tower at a large-scale cooling facility is exempt from cooling tower blowdown requirements for the first 12 months in which effluent constitutes 50 percent or more of the water supply to the tower. During this period, the facility operator will collect data on the concentration and variability of constituents in make-up water that may limit the cycles of concentration that can safely be reached and maintained. After the 12-month exemption period, the facility must either comply with the silica/total hardness blowdown standards for the tower or propose an alternative blowdown standard based on the data collected during that year.

For all facilities subject to Third Management Plan requirements, in cases where the build up of constituents other than silica or total hardness in cooling tower recirculating water is likely to result in damage to cooling towers or is likely to result in exceeding environmental discharge standards, facilities may apply to use an alternative blowdown standard.

6.7.4 Large-Scale Cooling Facility Conservation Program

Large-scale cooling facilities are facilities with a total cooling capacity of 1,000 tons or more. The following Third Management Plan conservation requirements apply to cooling towers that are located at large-scale cooling facilities and that have 250 tons or more of cooling capacity.

- Fully operational cooling towers with 250 tons or more of cooling capacity must achieve either 120 mg/l of silica or 1,200 mg/l of total hardness in recirculating water, whichever is reached first, before blowing down.
- If needed, a facility may apply for an alternative blowdown standard for any tower using effluent. During the initial 12-month period during which 50 percent or more of the water used by a tower is effluent, the tower is exempt from blowdown standards.
- If needed, a facility may apply for an alternative blowdown standard for any tower if compliance with blowdown requirements would likely result in damage or exceedence of environmental discharge standards because of the accumulation of a limiting constituent other than silica or total hardness.
- Facilities must record monthly and report annually the volumes of tower make-up water and blowdown water and the concentrations of silica, total hardness or approved alternative constituent in both make-up water and blowdown water.

6.7.5 Non-Regulatory Efforts

To encourage water conservation in facilities of all sizes, a cooling tower training video has been prepared that describes how water can be conserved by improving the efficiency of tower maintenance. The video and an accompanying workbook were prepared through a Tucson AMA conservation assistance grant. Copies of this instructional set are available from the Department, water providers, Pima Community College, and the public library. Tower operators are asked to fill out a survey on their water use practices in conjunction with viewing the video and return the survey to the Department so data can be compiled on the size, water use patterns, and management practices of cooling towers in the AMA. This training material will be available throughout the third management period.

6.7.6 Future Directions

Identification of the regulated community and wide distribution of the cooling tower maintenance video and workbook are high priorities for the cooling tower program during the third management period. During this period, data on the number, size, and efficiency of cooling towers will be collected under both the regulatory and conservation assistance programs. Based on the collected data, the effectiveness of these programs will be determined. Fourth management period requirements may be adjusted accordingly. New cooling tower maintenance technologies will continue to be investigated and can be incorporated into future conservation requirements.

Experiences gained by facilities converting to effluent use in the third management period can be used to direct research and regulatory directions in the fourth management period. Reuse of industrial wastewater in cooling towers and use of cooling tower blowdown water for landscape watering should continue to be examined to determine the advantages and constraints of these approaches. The potential for future direct use of CAP water in the Tucson AMA has not been determined; but, if it occurs, the impacts on tower operation will be examined.

6.7.7 Industrial Conservation Requirements and Monitoring and Reporting Requirements for Large-Scale Cooling Facilities

6-701. Definitions

In addition to the definitions set forth in Chapters 1 and 2 of Title 45 of the Arizona Revised Statutes, unless the context otherwise requires, the following words and phrases shall have the following meanings:

1. *"Blowdown water" means water discharged from a cooling tower recirculating water stream to control the buildup of minerals or other impurities in the recirculating water.*

2. *"Conservative mineral constituent" means a component of recirculating water in a cooling tower, the concentration of which is not significantly modified by precipitation, loss to the atmosphere, or the addition of treatment chemicals.*

3. *"Cycles of concentration" means the ratio of the concentration of a conservative mineral constituent or electrical conductivity in the blowdown water to the concentration of this same constituent or electrical conductivity in the make-up water.*

4. *"Effluent-served cooling tower"means a cooling tower served by a make-up water supply that on an annual average basis consists of 50 percent or more effluent.*

5. *"Fully operational cooling tower" means a cooling tower that is functioning to dissipate heat.*

6. *"Large-scale cooling facility" means a facility that has control over cooling operations with a total combined cooling capacity greater than or equal to 1,000 tons. For the purposes of this definition, the minimum cooling tower size that shall be used to determine total facility cooling capacity is 250 tons. A large-scale cooling facility does not include a large-scale power plant that utilizes cooling towers to dissipate heat.*

7. *"Large-scale power plant" means an industrial facility that produces or is designed to produce more than 25 megawatts of electricity.*

8. *"Limiting constituent" means a chemical, physical, or biological constituent present in recirculating cooling tower water that, due to potential physical or biological factors or due to potential exceedence of any federal, state, or local environmental standards upon discharge as blowdown, should not be allowed to accumulate in recirculating cooling tower water above a certain concentration.*

9. *"Make-up water" means the water added back into the cooling tower recirculating water stream to replace water lost to evaporation, blowdown, or other mechanisms of water loss.*

6-702. Conservation Requirements

A. Conservation Requirements

Beginning on January 1, 2002 or upon commencement of water use, whichever occurs later, and continuing thereafter until the first compliance date for any substitute conservation

requirement in the Fourth Management Plan, an industrial user who uses water at a large-scale cooling facility shall comply with the following requirement:

Each fully operational cooling tower with greater than or equal to 250 tons of cooling capacity at the facility shall achieve a cycles of concentration level that results in blowdown water being discharged at an average annual minimum of either 120 mg/l silica or 1,200 mg/l total hardness, whichever is reached first.

B. Exemptions and Alternative Blowdown Standards

1. *The requirement set forth in subsection A of this section does not apply to a large-scale cooling facility in any year in which 100 percent of facility blowdown water is beneficially reused.*

2. *The requirement set forth in subsection A of this section does not apply to any effluent-served cooling tower at a large-scale cooling facility during the first 12 consecutive months in which more than 50 percent of the water supplied to the cooling tower is effluent. After the 12-month period expires, the person using water at the effluent-served cooling tower may apply to the director to use an alternative blowdown level from that required in subsection A of this section if compliance with the blowdown requirement would not be possible due to the presence of a limiting constituent other than silica or total hardness in the effluent supplying the tower. To apply for an alternative blowdown level to address such a limiting constituent, an industrial user shall submit a request in writing to the director that includes the following information:*

   a. *The limiting constituent other than silica or total hardness that is present in the effluent supplying the tower that results in the need to blow down a greater annual volume of water than that required under subsection A of this section.*

   b. *Documentation describing the concentration at which this limiting constituent should be blown down and the reason for the alternative blowdown level.*

   The director shall grant the request if the director determines that the presence of a limiting constituent other than silica or total hardness in the effluent supplying the cooling tower results in the need to blow down a greater annual volume of water than that required under subsection A of this section. Any alternative blowdown level granted pursuant to this paragraph shall apply only while the tower qualifies as an effluent-served cooling tower.

3. *An industrial user may apply to the director to use an alternative blowdown level from that required in subsection A of this section if compliance with the blowdown requirement would likely result in damage to cooling towers or associated equipment or exceedence of federal, state, or local environmental discharge standards because of the accumulation of a limiting constituent other than silica or total hardness in recirculating water. To apply for an alternative blowdown level for such a limiting constituent, an industrial user shall submit a request in writing to the director that includes the following information:*

   a. *Historic, current, and projected water quality data for the relevant limiting constituent(s).*

b. Documentation describing the potential damage to cooling towers or associated equipment, or documentation of environmental standards that are likely to be exceeded, whichever applies.

The director shall grant the request if the director determines that compliance with the blowdown level set forth in subsection A of this section would likely result in damage to cooling towers or associated equipment or exceedence of federal, state, or local environmental discharge standards because of the accumulation of a limiting constituent other than silica or total hardness in recirculating water.

6-703. Monitoring and Reporting Requirements

For calendar year 2002 or the calendar year in which water use first commences, whichever is later, and for each calendar year thereafter until the first compliance date for any substitute monitoring and reporting requirement in the Fourth Management Plan, an industrial user who uses water at a large-scale cooling facility shall include in its annual report required by A.R.S. § 45-632 the following information for all cooling towers with 250 tons or more of cooling capacity at the facility:

1. Capacity in tons of each cooling tower.

2. Number of days per month that each cooling tower was fully operational.

3. For each cooling tower that is exempt from cycles of concentration requirements or for which an alternative blowdown level has been granted, pursuant to section 6-702, subsection B, paragraph 2, the percentage of water served to the tower during the year that was effluent.

4. The quantity of water from any source, specified by source, that was used for make-up water on a monthly basis during the calendar year as measured with a measuring device in accordance with the Department's measuring device rules, A.A.C. R12-15-901, et seq.

5. The quantity of water that was blown down on a monthly basis during the calendar year as measured with a measuring device in accordance with the Department's measuring device rules, A.A.C. R12-15-901, et seq.

6. The average monthly concentrations of silica, total hardness or other approved limiting constituent established under section 6-702, subsection B, paragraph 2 or 3, in make-up and blowdown water for those portions of each month when cooling towers were fully operational during the calendar year, reported in mg/l or other measurement units established under section 6-702, subsection B, paragraph 2 or 3, and either:

a. Determined by direct analysis; or

b. Calculated based on average monthly electrical conductivity readings for those portions of each month when cooling towers were fully operational if the following conditions have been met: (a) correlations between electrical conductivity and silica, between electrical conductivity and total hardness, or between electrical conductivity and another approved limiting constituent established pursuant to section 6-702 subsection B, paragraph 2 or 3, have been established over a period of one year or more in make-up and blowdown water; and (b) documentation of these correlations has been provided to the director.

6.8 DAIRY OPERATIONS

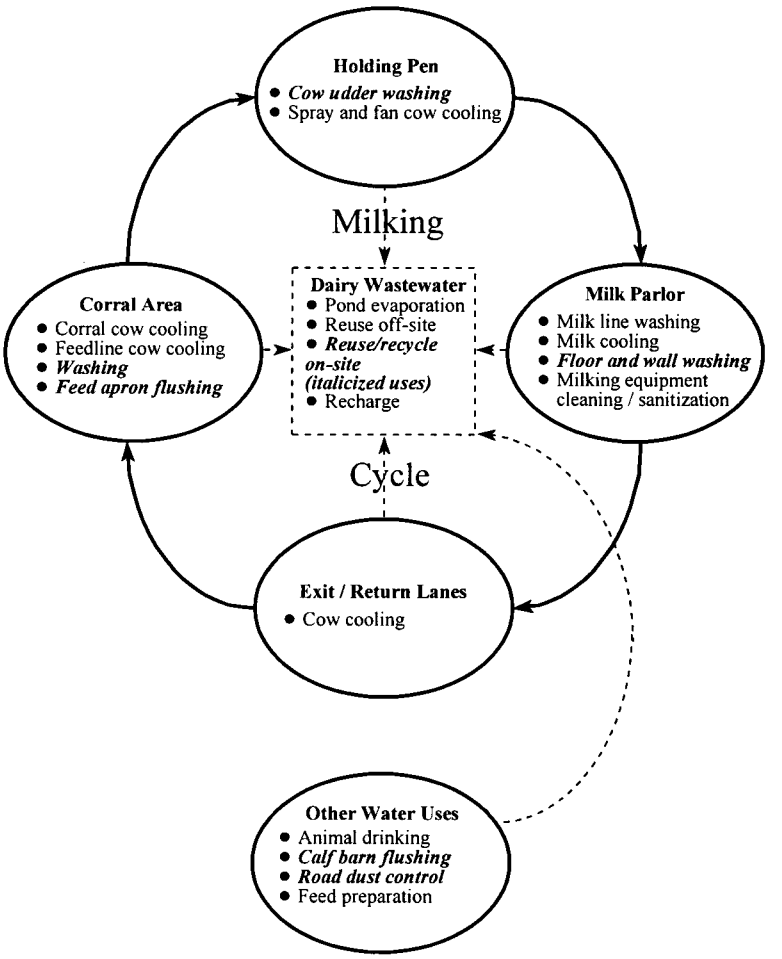
6.8.1 Introduction

The Department regulates dairy operations that annually house a monthly average of 100 or more lactating cows per day. The majority of water use at dairies occurs for animal drinking needs, udder washing, barn cleanup, and animal cooling.

6.8.2 Water Use by Dairy Operations

The dairy industry is a small industrial water use sector in the Tucson AMA. Water use at Tucson AMA dairies ranged between 45 and 73 acre-feet per year from 1987 through 1995. Two of the AMA's three dairies went out of production during the second management period. The remaining active dairy is located in the Marana area and is undergoing expansion. This dairy holds a Type 2 non-irrigation grandfathered right that allows withdrawal of up to 210 acre-feet of groundwater per year. Water use at this dairy was 73 acre-feet in 1995. Water use is projected to increase to around 200 acre-feet per year due to expansion and continue at this level through 2025. Many of Arizona's large dairies are located in the Phoenix AMA. However, due to rapid urbanization, dairies may relocate to a more rural environment such as that found in the Pinal AMA. It is not anticipated that additional dairies will be constructed in the Tucson AMA.

FIGURE 6-8
WATER USE AT A TYPICAL DAIRY OPERATION



Italized items can use reused and/or recycled water
Not all water uses shown on this chart exist at every dairy

Figure 6-8 shows how water is used at a dairy. A significant amount of water is used for the milking cycle. The first step in the milking cycle at most dairies is moving the cows into a holding pen, where the udders are washed before milking. Sprinklers, arranged in a grid pattern on the floor of the pen, are turned on to wash the udders. The cows may be cooled during udder washing to enhance milk production. The animals are then moved to the milking parlor for milking after which they are returned to the corral area through return lanes. Each time the cycle is completed, the holding pen and parlor areas are cleaned, milk lines are cleaned and sanitized, milking equipment is cleaned, and manure is removed.

There are a number of dairy management decisions that affect water use. Animal cooling to reduce heat stress and enhance milk production is an increasingly common management practice. Cooling is usually done when temperatures exceed 85 to 90 degrees Fahrenheit and may be done at various locations, including the holding pen corral, at the parlor exit, along the fenceline feeding area, or in the corral area.

During the warm season, virtually all dairies in the AMAs cool their cows during some portion of the day. Cooling practices have increased during the past decade and are expected to continue to increase in the future. Whereas at many existing dairies lactating cows are often cooled at only one or two of the possible locations, newly designed dairies incorporate cooling wherever possible.

Milking frequency is another management decision that will affect water use. Cows may be milked two, three, or even four times daily. Increasing the milking frequency per day will increase water use. Dairy managers evaluate the benefits of milking two or three times per day based upon parlor capacity, milk yield, staffing, and other economic factors. If future market demands require increasing pounds of milk production per cow, milking up to four times a day could become commonplace.

Aside from milking, water is used for drinking needs, controlling dust, and, at the majority of dairies, feed preparation. Water used for drinking needs varies depending upon whether the animal present at the facility is a lactating cow (a cow producing milk) or a non-lactating animal (calves, heifers, dry cows, bulls, and steers). A lactating cow drinks an average of 30 gallons of water per day, and a non-lactating animal drinks an average of 15 gallons per day, with some seasonal variation.

Whether non-lactating animals are housed on or off-site can significantly affect water use. Each dairy keeps lactating and mature dry cows on-site at a ratio that remains relatively constant throughout the year, with some variation due to weather and breeding. Another management decision is whether animals such as calves and heifers are housed on-site. Approximately 40 percent of Arizona dairies raise calves and heifers off-site or do not raise them at all.

Within the milking cycle, the dairy industry practices that have the most significant water conservation potential are the udder washing process, the practice of water recycling, and, to a lesser extent, cleaning and sanitization. The typical udder washing cycle consists of a one minute washing, a two minute break, followed by a three minute washing. Many dairies have invested in automatic timers to manage the udder wash system. Timers reduce the potential for excessive manual washing, provided the timer is used appropriately. Proper management is the best way to control water waste, and the use of automatic timers can result in significant water savings. Other factors affect the amount of water used for udder washing. Regular and frequent washing of the feed apron, milking parlor, and holding pen areas reduces the potential for soiled udders and thus reduces wash water needs. Periods of wet weather result in muddy corrals, requiring longer udder washing periods or increased washing of corral walkways and milking areas.

Another important water conservation practice for dairies is recycling of wastewater generated by the dairy. Wastewater may be conveyed to a lagoon where it evaporates, delivered off-site for non-dairy uses (such as irrigating certain crops), or recycled and reused at the dairy. There are many opportunities for recycling at a dairy. Milk cooling using vacuum pumps produces discharged water that can be captured and used in the udder washing cycle or for certain other washing and cleaning purposes. At some facilities, and depending upon how the recycled water is used initially, this water can be captured a second time and used again. For example, recycled water used for udder washing may be recycled again to wash corral walkways. Recycling offers the dairy manager several benefits, including: lower water costs, less wastewater to dispose of, less free-standing water, drier conditions, and cleaner cows. Recycling should be evaluated and implemented wherever feasible in new dairies. Health and sanitary requirements may prohibit the use of recycled water for certain water uses at a dairy.

At many dairies, the amount of water used for cleaning and sanitizing the holding pen, milking parlor, and milk transport lines after each milking increases during the summer months, though no increase may be warranted. Summer water use for this purpose can easily be reduced with little or no additional management or equipment costs.

6.8.3 Program Development and Issues

During the first management period, dairy operations did not have any specific conservation requirements. When the Second Management Plan was developed, the Department conducted a study to identify dairy water use patterns, processes, and associated water use to determine conservation potential for dairy operations. Several dairies were visited during the study. Experts from the University of Arizona reviewed and supplemented the study and provided significant input to the conservation requirements. Conservation requirements for the second management period established a maximum annual water allotment for dairies effective beginning in the year 2000. The maximum annual water allotment was determined using the per animal water use needs for lactating cows and non-lactating animals and could vary depending upon the number of animals at the facility. Upon application, the Department could approve an additional allocation of water for a dairy operation above its annual allotment if the dairy operation demonstrated that milking, sanitary, or cooling needs would require more water.

During the second management period, rapid changes in cooling technologies and the increased diversity in dairy size and design made it difficult for some dairies to conform to an allotment based conservation requirement like that included in the Second Management Plan. In an effort to have higher milk production efficiency, newer dairies tend to employ more cooling practices and incorporate more methods to recycle or reuse water.

The Department was informed by the Dairy Technical Advisory Committee that future dairy facilities will have to be larger and utilize these new cooling technologies in order to be economically competitive. These practices are designed to increase the milk yield per lactating cow, and will require more water than historical use indicates. The conservation program for the third management period provides dairies the opportunity to choose one of two conservation programs. Dairies may continue to be regulated under an allotment-based program identical to Second Management Plan requirements, or dairies may apply for conservation requirements that are specified "best management practices."

6.8.4 Dairy Operation Conservation Program

6.8.4.1 Allotment Based Requirements

The amount of water required by a dairy depends upon the number of cows and non-lactating animals housed at the dairy, the breed of cow, dairy management practices, and the type and water use efficiency of the technology employed. Table 6-6 summarizes daily water needs for each dairy process, assuming use of appropriate water conservation technology and practices.

The water needs listed are based on two assumptions: (1) milking is done three times per day per lactating animal and (2) cooling is done during the summer for at least a portion of the herd.

The assumptions of Table 6-6 are the basis for the annual water allotments for dairies. When calculating the total annual allotment, lactating cows are allotted 105 gallons per animal per day (GAD) while non-lactating animals are allotted 20 GAD. The allotment is calculated annually and will vary with the monthly average of lactating cows and non-lactating animals per day present at the dairy each year.

Upon application, the Department may approve an additional allocation of water for a dairy operation above its annual allotment if the dairy operation demonstrates that one or more of the following conditions exist:

- Milking is being done more than three times daily;
- Technologies that are designed to achieve industry health and sanitation objectives, such as the recommended pre-milking sanitation method, are being used;
- Animal cooling technologies designed to increase milk production are being used.

In consideration of weather variability, the Department has included a three-year averaging provision in the maximum annual water allotments in the third management period. The water use of three consecutive years can be averaged to determine if compliance with the Third Management Plan allotment has been achieved.

TABLE 6-6
WATER NEEDS AT A TYPICAL DAIRY

Operation	Water Use Allocation (gallons per day)	
	Lactating Cow	Non-Lactating Animal
Drinking needs[1]	30	15
Udder washing - based on 72 minutes/day at 8 gallons/minute; 16 cows per milking (two per group). Varies with number of milkings per day.[1]	35	0
Barn cleanup and sanitizing. Varies with number of milkings per day.[1]	20	0
Animal cooling management option, site-specific	10	0
Calf barn cleanup	0	5
Milk cooling tower (if present)	5	0
Miscellaneous	5	0
Total	105	20

[1] Assumes three milkings per day

6.8.4.2 Best Management Practices Requirements

As an alternative to the annual allotment requirement, a dairy may submit an application to the director to be regulated under the Best Management Practices Program (BMP Program). This program requires implementation of conservation and management practices to maximize efficiency in the following water use categories:

- Delivery of drinking water for dairy animals;
- Udder washing and milk parlor cleaning;
- Corral design and maintenance;
- Cleaning and sanitizing milking equipment;
- Dust control, calf housing cleaning, and feed apron flushing;
- Dairy animal cooling; and
- Dairy animal feed preparation.

Implementation of all the standard BMPs listed in Appendix 6B will have a specific measurable result. While most of the standard BMPs are applicable to all dairies, the water use activities associated with some of the standard BMPs may not exist at all dairies. If a dairy cannot implement a standard BMP, the dairy may apply to implement a substitute BMP with a specific measurable result that demonstrates a water

savings equivalent to the water savings associated with the standard BMP. If a substitute BMP is not possible, the dairy may apply for a waiver of the standard BMP. The director may grant a waiver only for the following standard BMPs: (1) BMP 2.1.2 (Udder Wash System); (2) BMP 2.2.2 (Milking Parlor Floor and Wall Washing); (3) BMP 4.1.1 (Milk Cooling and Vacuum Pump); (4) all of the standard BMPs in Water Use Category No. 5 (Dust Control, Calf Housing Cleaning, and Feed Apron Flushing); (5) all of the standard BMPs in Water Use Category No. 6 (Dairy Animal Cooling); and (6) all of the standard BMPs in Water Use Category No. 7 (Dairy Animal Feed Preparation).

Five years after a dairy is accepted for regulation under the BMP Program, the director will review the dairy's BMPs to determine if they are still appropriate. If the BMPs are no longer appropriate due to an expansion of the dairy or a change in management practices, the director will require a modification to the BMPs.

6.8.5 Non-Regulatory Efforts

Dairies stand to benefit from a conservation assistance grant that supported the construction and study of an on-site demonstration of dairy wastewater treatment through constructed wetlands in the Phoenix AMA. Wastewater from cow barns (cow washing, etc.) will be collected and solids will be removed. The wastewater will be cycled through a series of wetlands cells. The quality of water obtained from this process will be closely monitored. This treatment facility will attempt to assess the ability of constructed wetlands to produce water suitable for reuse in the dairy or for recharge.

Research is needed to further investigate the quantity of water required for various processes at a dairy operation. This should include the water use of new technologies designed to increase milk production.

6.8.6 Future Directions

Although newer dairies tend to use more water for cow cooling than older dairies by employing more cooling technologies and practices, thoughtful design will allow dairies to reuse and recycle more water than they have in the past. The latest "state of the art" dairies even collect and use rainfall. Fourth management period conservation requirements may need to be adjusted with the increased utilization of more water intensive technologies. Any adjustment to current allotments must be based on reliable data from a verifiable study. Alterations to allotments or to BMPs must be based on additional research that quantifies the water requirements associated with these new technologies or provides new information on existing technologies.

6.8.7 Industrial Conservation Requirements and Monitoring and Reporting Requirements for Dairy Operations

6-801. Definitions

In addition to the definitions set forth in Chapters 1 and 2 of Title 45 of the Arizona Revised Statutes, unless the context otherwise requires, the following words and phrases used in sections 6-802 through 6-805 of this chapter shall have the following meanings:

1. *"Dairy animal" means a lactating cow or a non-lactating animal present at a dairy operation.*

2. *"Dairy operation" means a facility that houses an average of 100 or more lactating cows per day during a calendar year as calculated in section 6-802.*

3. *"Dairy wastewater" means any water that has been put to a beneficial use at the dairy operation, including water containing dairy animal wastes.*

4. *"Lactating cow" means any cow that is producing milk that is present on-site at a dairy operation and receives water through the dairy operation's watering system.*

5. *"Non-lactating animal" means a calf, heifer, mature dry cow, bull, or steer that is present on-site at a dairy operation and receives water through the dairy operation's watering system.*

6-802. Maximum Annual Water Allotment Conservation Requirements

A. Maximum Annual Water Allotment

Beginning on January 1, 2002 or upon commencement of water use, whichever is later, and continuing thereafter until the first compliance date for any substitute conservation requirement in the Fourth Management Plan, an industrial user shall not withdraw, divert or receive water for use at a dairy operation during a calendar year in a total amount that exceeds the dairy operation's maximum annual water allotment for the year as calculated in subsection B below, unless the industrial user applies for and is accepted into the Best Management Practices Program described in section 6-804.

B. Calculation of Maximum Annual Water Allotment

A dairy operation's maximum annual water allotment for a calendar year shall be determined as follows:

1. *Calculate the average daily number of lactating cows and non-lactating animals that are present during the calendar year. The average daily number of lactating cows and non-lactating animals present during the calendar year shall be calculated as follows:*

    a. *Determine the total number of lactating cows and non-lactating animals present at the dairy operation on the last day of each month during the calendar year.*

    b. *For each category of animal, add together the total number of such animals present at the dairy operation on the last day of each month during the year in question and*

then divide the result by 12. The quotient is the average daily number of lactating cows and non-lactating animals present during the calendar year.

2. *Calculate the dairy operation's maximum annual water allotment for the calendar year as follows:*

   a. *Multiply the average daily number of lactating cows present during the calendar year by 105 gallons per animal per day (GAD) and then convert to acre-feet per year as follows:*

$$C_L \times \frac{105\ GAD}{325{,}851\ g/af} \times d/yr = \text{Maximum annual water allotment for lactating cows (acre-feet per year)}$$

Where: C_L = *Average daily number of lactating cows*
GAD = *Gallons per animal per day*
g/af = *Gallons per acre-foot*
d/yr = *Days in the year*

The result is the dairy operation's maximum annual water allotment for lactating cows for the calendar year.

   b. *Multiply the average daily number of non-lactating animals present during the calendar year by 20 gallons per animal per day (GAD) and then convert to acre-feet per year as follows:*

$$A_N \times \frac{20\ GAD}{325{,}851\ g/af} \times d/yr = \text{Maximum annual water allotment for non-lactating animals (acre-feet per year)}$$

Where: A_N = *Average daily number of non-lactating animals*
GAD = *Gallons per animal per day*
g/af = *Gallons per acre-foot*
d/yr = *Days per year*

The result is the dairy operation's maximum annual water allotment for non-lactating animals for the calendar year.

   c. *Add the dairy operation's maximum annual water allotment for non-lactating animals for the calendar year as calculated in subparagraph b of this paragraph and the dairy operation's maximum annual water allotment for lactating cows for the calendar year as calculated in subparagraph a of this paragraph. The sum is the maximum annual water allotment for the dairy operation for the calendar year, except as provided in subparagraph d of this paragraph.*

   d. *Upon application, the director may approve an additional allocation of water for the dairy operation consistent with industry health and sanitation objectives if the dairy operation requires more than its maximum annual water allotment because of one or more of the following:*

1) milkings per lactating cow occur more than three times daily,

2) technologies are used to achieve industry health and sanitation objectives that require additional water use, or

3) technologies are designed and/or implemented for cooling lactating cows and non-lactating animals that increase milk production.

3. Nothing in this section shall be construed to authorize a person to use more water from any source than the person is entitled to use pursuant to a groundwater or appropriable water right or permit held by the person. Nor shall this section be construed to authorize a person to use water from any source in a manner that violates Chapter 1 or Chapter 2 of Title 45, Arizona Revised Statutes.

6-803. Compliance with Maximum Annual Water Allotment

An industrial user who uses water at a dairy operation is in compliance for a calendar year with the dairy operation's maximum annual water allotment if the director determines that either of the following applies:

1. The volume of water withdrawn, diverted, or received during the calendar year for use at the dairy operation, less the volume of dairy wastewater delivered from the dairy operation to the holder of a grandfathered groundwater right for a beneficial use, is equal to or less than the dairy operation's maximum annual water allotment for the calendar year; or

2. The three-year average volume of water withdrawn, diverted, or received for use at the dairy operation during that calendar year and the preceding two calendar years is equal to or less than the dairy operation's three-year average maximum annual water allotment for that calendar year and the preceding two calendar years. In calculating the three-year average volume of water withdrawn, diverted or received for use at the dairy operation, the volume of dairy wastewater delivered from the dairy operation to the holder of a grandfathered right for a beneficial use shall not be counted.

6-804. Best Management Practices Program Conservation Requirements

A. Criteria for Approval of Application

An industrial user who uses water at a dairy operation may apply for regulation under the Best Management Practices Program (BMP Program) by submitting an application on a form provided by the director. The director shall approve a complete and correct application for regulation under the BMP Program if the director determines that the applicant will implement all of the standard best management practices (BMPs) described in Appendix 6B, unless the director approves a substitution of a standard BMP under subsection D of this section or a waiver of a standard BMP under subsection E of this section. If the director approves a substitution of a standard BMP, the director shall approve the application if the director determines that the applicant will implement the substitute BMP or BMPs in addition to any remaining standard BMPs.

B. Exemption from Maximum Annual Water Allotment Conservation Requirements

An industrial user accepted for regulation under the BMP Program is exempt from the maximum annual water allotment conservation requirements set forth in section 6-802 beginning on January 1 of the first calendar year after the industrial user's application for the BMP Program is approved, unless the director approves an earlier date.

C. Compliance with Best Management Practices Program

Beginning on a date established by the director and continuing thereafter until the first compliance date for any substitute conservation requirement established in the Fourth Management Plan, an industrial user accepted for regulation under the BMP Program shall comply with all standard BMPs listed in Appendix 6B, unless the director approves a substitution of a standard BMP under subsection D of this section, or a waiver of a standard BMP under subsection E of this section. If the director approves a substitution of a standard BMP the industrial user shall comply with the substitute BMP or BMPs in addition to any remaining standard BMPs. The standard BMPs listed in Appendix 6B are broken into the following seven categories: (1) delivery of drinking water for dairy animals; (2) udder washing and milking parlor cleaning; (3) corral design and maintenance; (4) cleaning and sanitizing milking equipment; (5) dust control, calf housing cleaning, and feed apron flushing; (6) dairy animal cooling; and (7) dairy animal feed preparation.

D. Substitution of Best Management Practices

1. *The director may allow an industrial user applying for the BMP Program to replace a standard BMP listed in Appendix 6B with a substitute BMP if the director determines that the standard BMP cannot be achieved and that implementation of the substitute BMP will result in water use efficiency equivalent to that of the standard BMP. To apply for a substitution of a standard BMP, the industrial user shall include in its application for the BMP Program an explanation of why the standard BMP is not achievable and a description of how the substitute BMP will result in water use efficiency equivalent to that of the standard BMP.*

2. *An industrial user regulated under the BMP Program may apply to the director for a substitution of an existing BMP that is no longer appropriate for the industrial user's dairy operation. The director may allow the industrial user to replace the existing BMP with a substitute BMP if the director determines that the substitute BMP will result in water use efficiency equivalent to that of the existing BMP.*

E. Waiver of Best Management Practices

1. *The director may waive a standard BMP listed in paragraph 3 of this subsection if the director determines that the standard BMP cannot be achieved and that no substitute BMP is appropriate. To apply for a waiver of a standard BMP listed in paragraph 3, the industrial user shall include in its application for the BMP Program an explanation of why the standard BMP is not achievable and why no substitute BMP is appropriate.*

2. *An industrial user regulated under the BMP Program may apply to the director for a waiver of an existing BMP listed in paragraph 3 of this subsection if the BMP is no longer appropriate for the industrial user's dairy operation. The director may waive the existing BMP if the director determines that the existing BMP is no longer appropriate for the industrial user's dairy operation and the that no substitute BMP is appropriate.*

3. *Only the following standard BMPs may be waived by the director under this subsection: (1) BMP 2.1.2 (Udder Wash System); (2) BMP 2.2.2 (Milking Parlor Floor and Wall Washing); (3) BMP 4.1.1 (Milk Cooling and Vacuum Pump); (4) all of the standard BMPs in Water Use Category No. 5 (Dust Control, Calf Housing Cleaning, and Feed Apron Flushing); (5) all of the standard BMPs in Water Use Category No. 6 (Dairy Animal Cooling); and (6) all of the standard BMPs in Water Use Category No. 7 (Dairy Animal Feed Preparation).*

F. Five Year Review of Best Management Practices

Five years after an industrial user is accepted for regulation under the BMP Program, the director shall review the industrial user's BMPs to determine whether any changes in the BMPs are warranted. If the director determines that any of the existing BMPs are no longer appropriate due to an expansion of the dairy operation or a change in management practices at the operation, the director shall notify the industrial user in writing of that determination and the director and the industrial user shall make a good faith effort to stipulate to a modification of the BMPs so that they are appropriate for the expanded operation or the change in management practices.

If the director and the industrial user are unable to stipulate to a modification to the BMPs within 180 days after the director notifies the industrial user of the determination that one or more of the existing BMPs are no longer appropriate or such longer time as the director may agree to, the industrial user shall no longer be regulated under the BMP Program but shall thereafter be required to comply with the maximum annual water allotment conservation requirements set forth in section 6-802.

If the director and the industrial user stipulate to a modification of the BMPs, the industrial user shall comply with the modified BMPs by a date agreed upon by the director and the industrial user and shall continue complying with the modified BMPs until the first compliance date for any substitute conservation requirement in the Fourth Management Plan.

G. Change in Ownership of Dairy Operation

1. *If an industrial user regulated under the BMP Program sells or conveys the dairy operation to which the BMPs apply, the new owner of the dairy operation shall continue to be regulated under the BMP Program until January 1 of the first calendar year after acquiring ownership of the dairy operation. Except as provided in paragraph 2 of this section, beginning on January 1 of the first calendar year after acquiring ownership of the dairy operation, the new owner shall comply with the maximum annual water allotment conservation requirements set forth in section 6-802. The new owner may at any time apply for regulation under the BMP Program.*

2. *If the new owner submits a complete and correct application for regulation under the BMP Program prior to January 1 of the first calendar year after acquiring ownership the of the dairy operation, the new owner shall continue to be regulated under the BMP Program until the director makes a determination on the application. If the director denies the application, the new owner shall be required to comply with the maximum annual water allotment conservation requirements set forth in section 6-802 immediately upon notification of the denial or January 1 of the first calendar year after acquiring ownership of the dairy, whichever is later. If the director approves the application, the new owner shall continue to be regulated under the BMP Program until the first*

compliance date for any substitute conservation requirement in the Fourth Management Plan.

6-805. Monitoring and Reporting Requirements

For the calendar year 2002 or the calendar year in which water use is commenced at the dairy operation, whichever occurs later, and for each calendar year thereafter until the first compliance date for any substitute monitoring and reporting requirements in the Fourth Management Plan, an industrial user who uses water at a dairy operation shall include the following information in its annual report required by A.R.S. § 45-632:

1. *The total quantity of water from any source, including effluent, withdrawn, diverted, or received during the calendar year for use by the dairy operation, as measured with a measuring device in accordance with the Department's measuring device rules, A.A.C. R12-15-901, et seq.*

2. *The total quantity of water delivered during the calendar year to any uses other than the dairy operation from the well or wells that serve the dairy operation, as measured with a measuring device in accordance with the Department's measuring device rules, A.A.C. R12-15-901, et seq.*

3. *The total quantity of dairy wastewater delivered to grandfathered rights other than the dairy operation, as measured with a measuring device in accordance with the Department's measuring device rules, A.A.C. R-12-15-901, et seq.*

4. *The total number of lactating cows and non-lactating animals that were present on-site at the dairy operation on the last day of each month during the calendar year.*

5. *If the dairy operation is regulated under the BMP Program, any documentation as required by the director that demonstrates compliance with the program.*

6.9 NEW LARGE LANDSCAPE USERS

6.9.1 Introduction

New large landscape users are industrial users with substantial water-intensive landscaped area that was planted after January 1, 1990. The conservation program differentiates between two types of new large landscape users: non-residential facilities that are hotels or motels and non-residential facilities that are not hotels or motels. If the facility is not a hotel or motel, conservation requirements apply to landscapable areas in excess of 10,000 square feet. If the facility is a hotel or motel, requirements apply to landscapable areas in excess of 20,000 square feet. If a facility has 10 or more acres of water-intensive landscaped area it is defined as a turf-related facility and is subject to specific conservation requirements discussed in section 6.3 of this chapter.

6.9.2 Water Use by New Large Landscape Users

Water use associated with landscaping is directly related to the size of the landscaped area, the types of vegetation, and the efficiency of the irrigation method used. Although low water use residential landscaping is common in Tucson, significant water use may be associated with the landscaping of industrial parks, and large commercial and institutional facilities. A 9-acre hotel landscape could use more than 40 acre-feet per year if it was planted entirely with water-intensive plants. This is enough water to supply about 130 households per year. By restricting lush plantings and water features to those areas that may be used for recreation or near areas that receive the most visitation, considerable water savings may be realized. Under the Third Management Plan requirements, this same facility would use about 10 acre-feet per year to meet its landscaping needs while still maintaining an esthetically pleasing and lush landscape.

Both the City of Tucson and Pima County have ordinances that place some restrictions on new non-residential landscaping in these jurisdictions. While these ordinances have multiple objectives, they also have provisions that address water conservation. Some of these provisions include the placement of plants based on their water needs, planting of low water use plants in certain areas and preservation of native vegetation.

No new large landscape users served by their own wells, rather than by a municipal water provider, were identified during the second management period. While many large resorts and commercial facilities are constructed within water provider service areas, the potential exists for new facilities to be served by their own wells, particularly those that are associated with development on retired farmland in outlying areas of the AMA. It is difficult to predict the extent of growth possible in this subsector, but the potential for future facility construction and for corresponding significant water use does exist as the Tucson area grows.

6.9.3 Program Development and Issues

Consultant studies done for the Second Management Plan indicated that significant reductions in landscape water use can be achieved using the following techniques:

- Improving water application efficiency through proper irrigation scheduling, use of more sophisticated control systems, conversion to drip irrigation, and grouping plants with similar water needs.
- Reducing the size and perimeter of turfed areas and limiting the placement of turfed areas to functional use areas and areas of high visual impact.
- Using drought-resistant plant species adapted to the desert.
- Using proper planting, fertilization, and maintenance techniques.

- Grading sites to direct rainfall into planted areas.
- Avoiding the use of water-intensive plants within rights-of-way thus emphasizing the community's commitment to low water use designs.

The findings from these studies still apply for the third management period. Attractive landscapes can be maintained solely with rainfall. However, a lush, colorful, low water use landscape, watered by a permanent drip irrigation system, is considered more desirable for commercial and industrial landscape applications. This type of landscape results in water savings of 50 to 75 percent of the amount used by a well-maintained turf (water-intensive) landscape.

The distinction in the program between hotel or motel landscapes and landscapes that are associated with facilities that are not hotels or motels is intended to address the contention by the lodging industry that for certain hotel and motel developments there is an economic benefit from planting high water using landscape plant material, thus economically justifying a larger water-intensive area.

6.9.4 New Large Landscape User Conservation Program

The new large landscape user program for the Third Management Plan is similar to that in the Second Management Plan. In addition to the requirements that apply to all industrial users, new large landscape users must limit the percentage of water-intensive landscaped area above a specified square footage. The facility must limit its water-intensive landscaped area to the greater of the following: 1) 10,000 square feet (20,000 square feet for hotels and motels) plus twenty percent of the area in excess of 10,000 square feet (20,000 square feet for hotels and motels); and 2) the total surface area of all bodies of water within the facility that qualify as water intensive landscaped area.

Water-intensive landscaping includes not only high water using plants such as turf, but also bodies of water such as ponds. However, it does not include any area of land watered exclusively with direct use effluent or effluent recovered within the area of impact, bodies of water used primarily for swimming, bodies of water filled and refilled exclusively with direct use effluent or effluent recovered within the area of impact, and bodies of water allowed under an interim water use permit pursuant to the Lakes Bill if the body of water will be filled and refilled exclusively with direct use effluent or effluent recovered within the area of impact after the permit expires. If 100 percent wastewater is used to water the landscape, the requirements do not apply. For example, if there is sufficient cooling tower blowdown water and greywater available from the operations of a hotel, this wastewater could be used to water any amount of water-intensive landscaped area up to 10 acres. Once a water-intensive landscaped area equals or exceeds 10 acres in size, it is defined as a turf-related facility and is subject to regulation under that program.

6.9.5 Industrial Conservation Requirements and Monitoring and Reporting Requirements for New Large Landscape Users

6-901. Definitions

In addition to the definitions set forth in Chapters 1 and 2 of Title 45 of the Arizona Revised Statutes and section 6-201 of this chapter, unless the context otherwise requires, the following words and phrases used in sections 6-902 and 6-903 of this chapter shall have the following meanings:

1. *"Direct use effluent" means effluent transported directly from a facility regulated pursuant to Title 49, Chapter 2, Arizona Revised Statutes, to an end user. Direct use effluent does not include effluent that has been stored pursuant to Title 45, Chapter 3.1, Arizona Revised Statutes.*

2. *"Effluent recovered within the area of impact" means effluent that has been stored pursuant to Title 45, Chapter 3.1, Arizona Revised Statutes, and recovered within the stored effluent's area of impact. For purposes of this definition, "area of impact" has the same meaning as prescribed by A.R.S. § 45-802.01.*

3. *"Landscapable area" means the entire area of a lot less any areas covered by structures, parking lots, roads, or any other area not physically capable of being landscaped.*

4. *"New large landscape user" means a non-residential facility that has a water-intensive landscaped area in excess of 10,000 square feet and that has landscaping planted and maintained after January 1, 1990 or bodies of water, other than bodies of water used primarily for swimming purposes, filled and maintained after January 1, 1990, or both. Turf-related facilities as defined in section 6-301 of this chapter are excluded from this definition.*

5. *"Water-intensive landscaped area" means, for the calendar year in question, all of the following areas within a non-residential facility:*

    a. *Any area of land that is planted primarily with plants not listed in Appendix 5B, Low Water Use/Drought Tolerant Plant List, or any modifications to the list, and watered with a permanent water application system, except any area of land that is watered exclusively with direct use effluent or effluent recovered within the area of impact.*

    b. *The total water surface area of all bodies of water within the facility, except bodies of water used primarily for swimming purposes, bodies of water filled and refilled exclusively with direct use effluent or effluent recovered within the area of impact, and bodies of water allowed under an interim water use permit pursuant to A.R.S. § 45-133 if the bodies of water will be filled and refilled exclusively with direct use effluent or effluent recovered within the area of impact after the permit expires.*

6-902. Conservation Requirements

A. Conservation Requirements for New Large Landscape Users that are not Hotels or Motels

Beginning on January 1, 2002 and continuing thereafter until the first compliance date for any substitute conservation requirement in the Fourth Management Plan, the water-

intensive landscaped area within a new large landscape user that is not a hotel or motel shall not exceed the greater of the following: 1) an area calculated by adding 10,000 square feet plus 20 percent of the facility's landscapable area in excess of 10,000 square feet; and 2) the total water surface area of all bodies of water within the facility that are allowed under A.R.S. § 45-131, et seq., and that qualify as water-intensive landscaped area.

B. Conservation Requirements for New Large Landscape Users that are Hotels or Motels

Beginning on January 1, 2002 and continuing thereafter until the first compliance date for any substitute conservation requirement in the Fourth Management Plan, the water-intensive landscaped area within a new large landscape user that is a hotel or motel shall not exceed the greater of the following: 1) an area calculated by adding 20,000 square feet plus 20 percent of the facility's landscapable area in excess of 20,000 square feet; and 2) the total water surface area of all bodies of water within the facility that are allowed under A.R.S. § 45-131, et seq., and that qualify as water-intensive landscaped area.

C. Waiver of Conservation Requirements for the Use of 100 Percent Wastewater

The conservation requirements set forth in subsections A and B of this section shall not apply to a new large landscape user in any year in which all of the water used for landscaping purposes within the facility is wastewater.

6-903. Monitoring and Reporting Requirements

For calendar year 2002 or the calendar year in which the facility first begins to use water, whichever is later, and for each calendar year thereafter until the first compliance date for any substitute monitoring and reporting requirement in the Fourth Management Plan, an industrial user that applies water to a new large landscape user shall include the following information in its annual report required by A.R.S. § 45-632:

1. *The total quantity of water from any source, including effluent, withdrawn, diverted, or received for use on the facility during the calendar year for landscape watering purposes, including bodies of water filled or refilled during the calendar year, as measured with a measuring device in accordance with the Department's measuring device rules. A.A.C. R12-15-901, et seq.*

2. *The total amount of landscapable area within the facility.*

3. *The total amount of water-intensive landscaped area at the facility broken down into the area planted primarily with plants not on the Low Water Use/Drought Tolerant Plant List, or any modifications to the list (except any area watered exclusively with direct use effluent or effluent recovered within the area of impact) and the surface area of all bodies of water (except bodies of water used primarily for swimming purposes, bodies of water filled and refilled exclusively with direct use effluent or effluent recovered within the area of impact, and bodies of water allowed under an interim water use permit if the bodies of water will be filled and refilled exclusively with direct use effluent or effluent recovered within the area of impact after the permit expires).*

6.10 NEW LARGE INDUSTRIAL USERS

6.10.1 Introduction

New large industrial users are industrial users that use in excess of 100 acre-feet of water per year and commence use after January 1, 2000. In the Second Management Plan, new large industrial users were defined as industrial users that use in excess of 100 acre-feet per year and commenced use after January 1, 1990. As of 1999, all of the new large industrial users identified in the Tucson AMA were industrial users subject to specific conservation requirements discussed elsewhere in this chapter (e.g., metal mines, turf-related facilities, etc.).

6.10.2 Water Use by New Large Industrial Users

In 1995, there were seven industrial facilities in the Tucson AMA, other than metal mines, sand and gravel facilities, turf-related facilities, electric power plants, and dairy operations, that individually used more than 100 acre-feet of water during the year. The combined water use of these facilities during 1995 was approximately 2,800 acre-feet. However, none of these facilities qualified as a new industrial user under the Second Management Plan because each commenced water use prior to January 1, 1990. These facilities use groundwater pursuant to 14 Type 2 non-irrigation grandfathered rights and permits with allotments totaling 12,616 acre-feet. The facilities include cement plants, electronics industries, hospitals, and others. There are an additional 36 rights and permits with allotments of over 100 acre-feet per year, these rights are either being used to withdraw less than 100 acre-feet per year or are not being used at all. The allotments for these thirty six rights and permits total over 71,000 acre-feet, most of which is held by the City of Tucson and others for municipal uses. Although some of this large volume could potentially be used to serve new large industrial users, growth potential is difficult to predict. New large commercial or manufacturing facilities are often constructed within water company service areas and are customers of the water provider.

6.10.3 Program Development and Issues

There were no requirements for new industrial users in the First Management Plan. In addition to the conservation requirements for all industrial users, the Second Management Plan contains a specific conservation requirement for new industrial users that use over 100 acre-feet of water per year. In the Second Management Plan, new industrial users were required to prepare and submit a water conservation plan addressing the water conservation opportunities at the facility. The user was required to develop a plan that:

- describes the level of water conservation that can be achieved,
- identifies the water uses and conservation opportunities within the facility,
- describes an ongoing water conservation education program for employees, and
- includes an implementation schedule.

The Department has determined that submitting a conservation plan is a reasonable requirement to continue for the Third Management Plan considering the large volume of unused allotments that could be used for new large industrial uses and the corresponding opportunity to design water conservation into new or expanding facilities. When facilities expand, even after operation has commenced, there are additional water conservation opportunities associated with being able to "build in" water conserving designs. This is typically more economical and more feasible than retrofitting a facility that is not expanding.

6.10.4 New Large Industrial User Conservation Program

The new large industrial user program for the Third Management Plan is identical to that of the Second Management Plan. In addition to the requirements that apply to All Industrial Users, new large industrial users must prepare and submit a water conservation plan to the director. However, if the user is required to submit a conservation plan under another section of this chapter, it can combine the plans and submit one plan.

The water conservation plan must show how much water conservation can be achieved at the facility. It must identify how water is used at the facility and what can be done to conserve in major water use areas. The plan must also detail an employee water conservation education program at the facility and describe when conservation measures will be implemented.

6.10.5 Industrial Conservation Requirements and Monitoring and Reporting Requirements for New Large Industrial Users

6-1001. Definitions

In addition to the definitions set forth in Chapters 1 and 2 of Title 45 of the Arizona Revised Statutes and section 6-201 of this chapter, "new large industrial user" means an industrial user that begins using more than 100 acre-feet of water per year for industrial purposes after January 1, 2000.

6-1002. Conservation Requirements

A. *Not later than January 1, 2002 or within 180 days after the end of the first calendar year in which the facility first uses more than 100 acre-feet of water for industrial purposes, whichever is later, a new large industrial user shall submit to the director a plan to improve the efficiency of water use by the facility. The plan shall:*

1. *Specify the level of water conservation that can be achieved assuming the use of the latest commercially available technology consistent with reasonable economic return;*

2. *Identify water uses and conservation opportunities within the facility, addressing water used for the following categories as appropriate: landscaping; space cooling; process-related water use, including recycling; and sanitary and kitchen uses;*

3. *Describe an ongoing water conservation education program for employees; and*

4. *Include an implementation schedule.*

B. *If a person required to submit a plan under subsection A of this section is required to submit a conservation plan under another section of this chapter, the person may combine the plans into a single conservation plan.*

REFERENCES

Brown, P., Gilbert, J., and D. Kopec, 1996. *Final Report to the Arizona Department of Water Resources, Turfgrass Irrigation Scheduling Using Weather Based Estimates of Evapotranspiration for High and Low Traffic Turfs*. Contract No. CA94TU103-00, May 31, 1996.

APPENDIX 6A
TURF-RELATED FACILITIES
TUCSON ACTIVE MANAGEMENT AREA

Facility Name	Water Source	Water Supply	Right Number
CEMETERIES			
East Lawn Cemetery	City of Tucson	Effluent	56-000001
Evergreen Cemetery	Type 2 GFR	Groundwater	58-109101
Holy Hope Cemetery	Type 2 GFR	Groundwater	58-108519
South Lawn Cemetery	Type 2 GFR	Groundwater	58-109112
GOLF COURSES			
Arthur Pack GC	Pima County	Effluent	NA
Cliff Valley GC	Type 2 GFR	Groundwater	58-100274
CC of Green Valley	Type 2 GFR	Groundwater	58-101735
Dell Urich GC	City of Tucson	Effluent	56-000001
Desert Hills GC	Green Valley WC	Groundwater	56-000302
Dorado CC	Type 2 GFR	Groundwater	58-108946
El Conquistador CC	Town of Oro Valley	Groundwater	56-000368
El Conquistador Resort GC	Town of Oro Valley	Groundwater	56-000368
El Rio GC	City of Tucson	Effluent	56-000001
Forty-Niner GC	Forty-Niner WC	Groundwater	56-000088
Fred Enke GC	City of Tucson	Effluent	56-000001
The Gallery at Dove Mountain	City of Tucson	Effluent	56-000001
Gen. Wm Blanchard GC	Davis-Monthan AFB	Groundwater	56-000058
The Golf Club at Vistoso	Town of Oro Valley	Groundwater	56-000368
Haven GC	Type 2 GFR	Groundwater	58-104567
Heritage Highlands GC	City of Tucson	Effluent	56-000001
La Paloma GC	City of Tucson	Effluent	56-000001
The Links at Continental Ranch	Type 1 / Type 2 GFRs	Groundwater	58-160014
Morry Canoa Hills GC	Green Valley WC	Groundwater	56-000302
Mountain View GC	Lago del Oro WC	Groundwater	56-000245
Oro Valley CC	Type 2 GFR	Groundwater	58-101530
Quail Creek CC	Type 1 GFR	Groundwater	58-105292
Randolph GC	City of Tucson	Effluent	56-000001
Raven GC at Sabino Springs	City of Tucson	Effluent	56-000001
Rolling Hills CC	Type 2 GFR	Groundwater	58-112457
SaddleBrooke GC	Lago del Oro WC	Groundwater & Effluent	56-000245
San Ignacio GC	Green Valley WC	Groundwater	56-000302
Santa Rita CC	Type 2 GFR	Groundwater	58-107119
Silverbell GC	City of Tucson	Effluent	56-000001
Skyline CC	City of Tucson	Effluent	56-000001
StarrPass GC	City of Tucson	Effluent	56-000001
Sun City Vistoso GC	Town of Oro Valley	Groundwater	56-000368
Torres Blancas GC	Type 1 / Type 2 GFRs	Groundwater	58-101963
Tucson CC	Type 2 GFR / City of Tucson	Groundwater & Effluent	58-106007
Tucson Estates GC	City of Tucson	Groundwater	56-000001
Tucson National GC	Type 2 GFR	Groundwater	58-102307
Ventana Canyon GC	City of Tucson	Effluent	56-000001

APPENDIX 6A
TURF-RELATED FACILITIES
TUCSON ACTIVE MANAGEMENT AREA

Facility Name	Water Source	Water Supply	Right Number
PARKS			
Dennis Weaver Park	Metropolitan DWID	Groundwater	56-000349
Christopher Columbus Pk	City of Tucson	Groundwater	56-000001
Fort Lowell Park	City of Tucson	Effluent	56-000001
Golf Links Sports Complex	City of Tucson	Effluent	56-000001
Himmel Park	City of Tucson	Effluent	56-000001
Jack Conrad's Golf Practice Range	Type 2 GFR	Groundwater	58-113289
Jacobs Park	City of Tucson	Effluent	56-000001
Jesse Owens Park	City of Tucson	Effluent	56-000001
Kennedy Park	City of Tucson	Groundwater	56-000001
Lakeside Park	City of Tucson	Effluent	56-000001
The Club at La Mariposa	Type 1 GFR	Groundwater	58-109720
Lincoln Park	City of Tucson	Effluent	56-000001
Mansfield Park	City of Tucson	Groundwater	56-000001
Manzanita Park	City of Tucson	Groundwater	56-000001
Marana Park	Town of Marana	Groundwater	56-000107
McCormick Park	City of Tucson	Effluent	56-000001
Mission Park	City of Tucson	Groundwater	56-000001
Joaquin Murrieta Park	City of Tucson	Effluent	56-000001
Palo Verde Park	City of Tucson	Effluent	56-000001
Pima County Fairgrounds	Type 2 GFR	Groundwater	58-100381
The Practice Tee	City of Tucson	Groundwater	56-000001
Reid Park	City of Tucson	Effluent	56-000001
Rodeo Park	City of Tucson	Groundwater	56-000001
Sam Lena Park	City of Tucson	Groundwater	56-000001
Santa Rita Park	City of Tucson	Groundwater	56-000001
Sunnyside Park	City of Tucson	Groundwater	56-000001
Udall Park	City of Tucson	Effluent	56-000001
SCHOOLS			
Amphitheater HS	Type 2 GFR	Groundwater	58-112278
Amphitheater JHS	Type 2 GFR	Groundwater	58-112278
Apollo Middle School	City of Tucson	Groundwater	56-000001
Canyon del Oro HS	Type 2 GFR	Groundwater	58-112278
Catalina HS	City of Tucson	Groundwater	56-000001
Catalina Foothills HS	City of Tucson	Groundwater	56-000001
Chaparral Middle School	City of Tucson	Groundwater	56-000001
Cherry Field	City of Tucson	Groundwater	56-000001
Cholla HS	City of Tucson	Groundwater	56-000001
Coronado School	Type 2 GFR	Groundwater	58-112278
Cross Middle School	Type 2 GFR	Groundwater	58-112278
Desert View HS	City of Tucson	Groundwater	56-000001
Doolen Middle School	City of Tucson	Groundwater	56-000001
Duffy/Gump Schools	City of Tucson	Groundwater	56-000001
Esperero Middle School	City of Tucson	Groundwater	56-000001
Fickett Middle School	City of Tucson	Groundwater	56-000001
Flowing Wells JHS	Flowing Wells ID	Groundwater	56-000084

APPENDIX 6A
TURF-RELATED FACILITIES
TUCSON ACTIVE MANAGEMENT AREA

Facility Name	Water Source	Water Supply	Right Number
Flowing Wells HS	Flowing Wells ID	Groundwater	56-000084
Gridley Middle School	City of Tucson	Groundwater	56-000001
Magee Middle School	City of Tucson	Groundwater	56-000001
Marana JHS	Type 2 GFR	Groundwater	58-111064
Marana HS	Type 2 GFR	Groundwater	58-111066
Naylor Middle School	City of Tucson	Groundwater	56-000001
Orange Grove Middle School	City of Tucson	Groundwater	56-000001
Palo Verde HS	City of Tucson	Groundwater	56-000001
Pistor Middle School	City of Tucson	Groundwater	56-000001
Pueblo HS	City of Tucson	Groundwater	56-000001
Rincon HS	City of Tucson	Groundwater	56-000001
Sabino HS	City of Tucson	Groundwater	56-000001
Sahuarita School	Withdrawal Permit	Groundwater	59-509091
Sahuaro HS	City of Tucson	Groundwater	56-000001
Santa Rita HS	City of Tucson	Groundwater	56-000001
Secrist Middle School	City of Tucson	Groundwater	56-000001
Sierra Middle School	City of Tucson	Groundwater	56-000001
Townsend Middle School	City of Tucson	Groundwater	56-000001
Tucson HS	City of Tucson	Groundwater	56-000001
Utterback Middle School	City of Tucson	Groundwater	56-000001
Vail Middle School	City of Tucson	Groundwater	56-000001

APPENDIX 6B
DAIRY OPERATION BEST MANAGEMENT PRACTICES PROGRAM
STANDARD BEST MANAGEMENT PRACTICES

WATER USE CATEGORY 1. DELIVERY OF DRINKING WATER FOR DAIRY ANIMALS **Description:** The level of milk production, season of year and type of dairy animal housing has a significant effect on the water intake of a dairy animal. The drinking water needs of a lactating cow will vary from 25 to 45 gallons per day. As milk production per cow per day increases, drinking water intake will also increase. Conservation of dairy animal drinking water could best be accomplished by preventing and promptly repairing leaks in the drinking water system.	
BMP 1.1	Install and maintain valves and floats throughout the drinking water system to allow for the isolation of leaks in lines and tanks. The Annual Report required by A.R.S. § 45-632 shall include a water system map of the dairy facility showing the location of all valves and floats. This map shall be submitted one time only (the first annual report following acceptance into the BMP Program) unless there is a change in the location of the valves or floats.
BMP 1.2	Inspect the drinking water system for leaks daily to ensure that leaks are promptly identified and repaired to prevent water loss. If a leak occurs, stop water flow by isolating the area of the leak and/or repair the leak within 72 hours.
WATER USE CATEGORY 2. UDDER WASHING AND MILKING PARLOR CLEANING **Description:** Udder washing and milking parlor cleaning is the single largest water use at a dairy operation. Floor and wall wash and sanitation of the milking area is necessary for producing a safe product. These systems can be either manual or semi-automatic. The amount of water used also depends on weather conditions. Udder washing and milking parlor cleaning offer the greatest conservation potential at a dairy through management of the system.	
2.1 <u>UDDER WASH SYSTEM</u>	
BMP 2.1.1	Install and operate the udder washing system with automatic timers. When udder washing, use a maximum of one minute of water for the soak cycle followed by a minimum of two minutes off and a maximum of three minutes of water for the wash cycle followed by one minute off. Repeat with a second wash cycle if needed.
BMP 2.1.2	Install a grid no larger than six feet by five feet between sprinkler heads on wash pens installed or renovated after January 1, 2002. The Annual Report required by A.R.S. § 45-632 shall include a water system map of the dairy facility showing the location of all sprinkler heads and the dimensions of the wash pens. This map shall be submitted one time only (the first annual report following acceptance into the BMP Program) unless there is a change to the location of the sprinkler heads or to the dimensions of the wash pens.

BMP 2.1.3	Install lock-out devices so that the wash system can be used only once per group of cows unless exceptional conditions require an override of the lock-out device. The Annual Report required by A.R.S. § 45-632 shall include a water system map of the dairy facility showing the location of all lock-out devices. This map shall be submitted one time only (the first annual report following acceptance into the BMP Program) unless there is a change to the location of the lock-out devices.
BMP 2.1.4	Establish and implement an inspection schedule to properly maintain and replace spray heads and timing devices. Inspect all spray heads and timing devices daily to ensure that they are operating correctly. If a device is found to be malfunctioning, repair or replace the device within 72 hours.
2.2	**MILKING PARLOR FLOOR AND WALL WASHING**
BMP 2.2.1	Equip all parlor hoses with shut-off valves. Inspect all hoses and valves daily. If a leak occurs, stop water flow by isolating the area of the leak and/or repair the leak within 72 hours.
BMP 2.2.2	If a semi-automatic floor flush system is used, it must be equipped with a timing device to limit the duration of cleaning and be designed to use no more water than necessary unless the water used is water recycled within the dairy operation. The Annual Report required by A.R.S. § 45-632 shall include a description of the flush system that includes the flush schedule and the amount of water used for each flush. This information shall be submitted one time only (the first annual report following acceptance into the BMP Program) unless there is a change to the timing device.
WATER USE CATEGORY 3. CORRAL DESIGN AND MAINTENANCE **Description:** Proper corral design and maintenance will reduce water use in the cow wash pen prior to milking by reducing the amount of wash time necessary to clean the cow. Sloping and maintaining the corral in a dry condition keeps the cow in a cleaner condition.	
BMP 3.1	Slope corrals to prevent standing water and to promote drainage to the wastewater system. The Annual Report required by A.R.S. § 45-632 shall include a dairy facility map that shows the corral design and the direction of slope. This map shall be submitted one time only (the first annual report following acceptance into the BMP Program) unless there is a change to corral design.

BMP 3.2	Scrape, harrow or drag corrals to eliminate holes and maintain corrals in a dry condition. The Annual Report required by A.R.S. § 45-632 shall include a description of corral maintenance for wet and dry conditions and a maintenance schedule. This information shall be submitted one time only (the first annual report following acceptance into the BMP Program) unless there is a change in corral maintenance.
WATER USE CATEGORY 4. CLEANING AND SANITIZING MILKING EQUIPMENT **Description:** Cleaning and sanitizing milking equipment is necessary to provide a safe dairy product. Water is also used in pre-coolers and vacuum pumps during the milking operation. Water used for this purpose is usually between 5-10 percent of the total water use at the dairy operation. This water can be recycled for other uses at the dairy.	
4.1	**MILK COOLING AND VACUUM PUMP**
BMP 4.1.1	If the milk cooling and vacuum pump system is water-cooled and is not a closed system, reuse water from the system to wash cow udders or pens, or for any other uses, consistent with state and federal sanitary codes. The Annual Report required by A.R.S. § 45-632 shall include a description and diagram of how water is reused from the milk cooling and vacuum pump system. This information shall be submitted one time only (the first annual report following acceptance into the BMP Program) unless there is a change in how water is reused from the milk cooling and vacuum pump system.
4.2	**MILK LINE WASHING**
BMP 4.2.1	Install and operate the milk line washing system with an automatic or semi-automatic timing device. The Annual Report required by A.R.S. § 45-632 shall include a description of how the milk line washing system operates. The description shall include the number of cycles per washing and the amount of water used per washing. This information shall be submitted one time only (the first annual report following acceptance into the BMP Program) unless there is a change in the number of cycles per washing and the amount of water used per washing.
4.3	**BACK-FLUSH SYSTEMS**
BMP 4.3.1	Maintain and service all back-flush systems in accordance with the manufacturer's design specifications and maintenance schedule. The Annual Report required by A.R.S. § 45-632 shall include the manufacturer's design specifications and a maintenance schedule. This information shall be submitted one time only (the first annual report following acceptance into the BMP Program) unless there is a change to the back flush system.

APPENDIX 6B
DAIRY OPERATION BEST MANAGEMENT PRACTICES PROGRAM
STANDARD BEST MANAGEMENT PRACTICES

WATER USE CATEGORY 5. DUST CONTROL, CALF HOUSING CLEANING AND FEED APRON FLUSHING **Description:** Control of dust, wastes and feed residues is necessary for fly control, sanitation and animal health. This requires water for cleaning and flushing feed aprons and calf housing and for wetting roadways. Conservation potential in this category includes recycling and reusing water, avoiding waste, and employing simple technologies that can reduce the amount of water needed for dust control.	
BMP 5.1	If the dairy flushes the cow feed apron, design the systems to recycle water from the cow udder wash system or to pump wastewater and recycle it from the lagoon or wetland area. The Annual Report required by A.R.S. § 45-632 shall include a description of how water is recycled at the operation, an estimate of the amount of water recycled, and the method of estimation. This information shall be submitted one time only (the first annual report following acceptance into the BMP Program) unless there is a change to how water is recycled.
BMP 5.2	If the calf housing utilizes a flush system to remove animal wastes, design and manage the system so that it uses only the minimum amount necessary and equip with a timer to minimize the duration of each flush. The Annual Report required by A.R.S. § 45-632 shall include a description of how the system is designed and managed to minimize water use, the length of time of each flush and the number of times per day on average that the system is in operation, and a water system map of the facility showing the location of the timer. This information shall be submitted one time only (the first annual report following acceptance into the BMP Program) unless there is a change to the design or operation of the flush system.
BMP 5.3	If dust control practices are used at the facility, the following dust control methods should be used: paving, aggregate, chemical binding agents or dairy wastewater if consistent with state and federal standards. If potable water is used for dust control it must be used as efficiently as possible. The Annual Report required by A.R.S. § 45-632 shall include a description of the dust control technology(ies) used and the area on which dust control is practiced, and the amount of water used for dust control. If water use is estimated, provide a description of how water use is estimated. This information shall be submitted one time only (the first annual report following acceptance into the BMP Program) unless there is a change to dust control practices.

APPENDIX 6B
DAIRY OPERATION BEST MANAGEMENT PRACTICES PROGRAM
STANDARD BEST MANAGEMENT PRACTICES

WATER USE CATEGORY 6. DAIRY ANIMAL COOLING

Description: Dairy animal cooling is an effective method to improve milk production per cow and reproductive efficiency, which are important factors in dairy profitability. Animal cooling is also an important factor in improving animal health. The amount of water required depends on the type of method or methods used to cool cows, on the maintenance practices for the system and on the hours of usage. Methods to conserve water for each cooling system are available to dairy farm management.

6.1 HOLDING PEN COOLING

BMP 6.1.1 Design and operate independent fan and spray systems to ensure that water is used efficiently under all weather conditions.

The Annual Report required by A.R.S. § 45-632 shall include a diagram demonstrating that fans and spray systems are used independently and provide information on how the system is managed depending on weather conditions. This information shall be submitted one time only (the first annual report following acceptance into the BMP Program) unless there is a change to the fan and spray systems.

6.2 COW EXIT AND RETURN LANES COOLING

BMP 6.2.1 Use leaf gate, wand switch, electric eye or motion (proximity) indicators to automatically activate the water valve.

The Annual Report required by A.R.S. § 45-632 shall include a description of the activation device used at the dairy operation and how it operates, including the length of time the water valve is in operation and the amount of water used, and include the average number of times per day that the device is activated in a year. This information shall be submitted one time only (the first annual report following acceptance into the BMP Program) unless there is a change in activation device.

6.3 FEED LINE COOLING

BMP 6.3.1 Locate the feed line cooling system to take advantage of prevailing winds in order to place water directly on the dairy animal. Equip the system with timers to control the duration of use.

The Annual Report required by A.R.S. § 45-632 shall include a water system map of the dairy facility showing the location of all timers and the direction of prevailing winds. Report the length of time the timer is in operation and the average number of times per day that the system is in operation in a year. This information shall be submitted one time only (the first annual report following acceptance into the BMP Program) unless there is a change in the feed line cooling system or timers.

6.4	CORRAL SHADE COOLERS
BMP 6.4.1	Equip corral shade coolers with thermostats or timers to control operation time. The Annual Report required by A.R.S. § 45-632 shall include a water system map of the dairy facility showing the location of all thermostats or timers and report the average daily length of time the coolers are in operation in a year. This information shall be submitted one time only (the first annual report following acceptance into the BMP Program) unless there is a change in the thermostats or timers.
BMP 6.4.2	Establish an inspection schedule to ensure regular maintenance of nozzles and water filter systems. The Annual Report required by A.R.S. § 45-632 shall include an inspection and maintenance schedule. This schedule shall be submitted one time only (the first annual report following acceptance into the BMP Program) unless there is a change in the maintenance schedule.
WATER USE CATEGORY 7. DAIRY ANIMAL FEED PREPARATION **Description:** Water is used in the preparation of dairy animal feed at dairy operations to pre-soak cereal grain for processing, (rolling and flaking). A large use of water in feed preparation is its addition to the total mixed ration to improve feed intake. The amount of water needed depends on the dryness of the feed in the ration. The total amount of water added to the feed could equal 20 percent of the ration. The greatest conservation potential for feed preparation rests with leak detection and prevention.	
BMP 7.1	Install shut-off valves at each water source used for feed preparation to allow for the isolation of leaks. If a leak occurs, isolate the area of the leak and/or repair the leak within 72 hours. The Annual Report required by A.R.S. § 45-632 shall include a water system map of the facility showing the location of all valves. This map shall be submitted one time only (the first annual report following acceptance into the BMP Program) unless there is a change in the location of the valves.

CHAPTER

7

Groundwater Quality Management Program

7.1 INTRODUCTION

Water quality is an important component in the management of the water supply in the Tucson Active Management Area (AMA). The role of the Arizona Department of Water Resources (Department) in water quality relates to the impacts of water quality on available water supplies. Protecting and managing water quality maximizes the overall quantity of usable water. This chapter defines the Department's role and authority in groundwater quality management during the third management period and addresses water quality impacts on the management of water supplies in the Tucson AMA.

The Department's water quality responsibilities include enhancement of groundwater quality protection programs, assistance in the cleanup of contaminated areas, and assistance in matching water quality with the highest beneficial use. In the third management period, the Department will play a greater role in water quality issues because of increased responsibilities and funding for water quality management activities provided for in the 1997 Water Quality Assurance Revolving Fund (WQARF) Program reform legislation. Laws 1997, Ch. 287. Furthermore, the utilization of renewable supplies such as Central Arizona Project (CAP) water and effluent as well as the designation of end uses for remediated groundwater will play a larger role in water supply decisions during the third management period.

In general, groundwater in the Tucson AMA is of acceptable quality for most uses. Most of the groundwater resources meet federal and state drinking water standards, though contaminant levels exceed primary safe drinking water standards in a few areas. Groundwater withdrawals from wells within these identified areas have been discontinued or are in the process of being cleaned up through remedial activities. Other areas of known contamination that are not being remediated are monitored to ensure that contaminants do not spread.

In this chapter, the following topics are discussed in the order listed:

- Goals and Objectives
- Statutory Provisions
- Regulation of Groundwater Quality in Arizona
- Water Quality Assessment
- Third Management Plan Program Summary
- Future Directions

7.2 GOALS AND OBJECTIVES

The Department's goals and objectives for groundwater quality management for the third management period are complicated due to the Department's dual responsibilities to achieve reductions in withdrawals of groundwater and to facilitate remediation of contaminated groundwater by implementing incentives for the use of remediated groundwater. The WQARF reform legislation of 1997 creates several incentives for the use of remediated groundwater. In response to the fact that many sites with groundwater contamination have not been cleaned up, the Legislature mandated incentives for remediated groundwater use that could result in a significant increase in groundwater withdrawals. These incentives to use remediated groundwater present a unique groundwater management problem because they may be in conflict with an underlying objective of the Groundwater Code (Code), which is to "achieve reductions in withdrawals of groundwater" in order to attain the management goal of each AMA.

The Department recognizes that the goal of remediating contaminated groundwater is important and intends to facilitate such remediation by implementing incentives for remediated groundwater use. However, as the agency entrusted with the responsibility of managing and conserving Arizona's long-term water supplies, the Department also has the responsibility to ensure that the minimum amount of groundwater necessary to achieve remedial action objectives is pumped and to ensure that, where practicable, new groundwater uses are not created and groundwater supplies are conserved. While the Department believes that it is possible to both achieve reductions in withdrawals of groundwater and provide incentives for the use of remediated groundwater, it recognizes that there is a delicate balance between the two responsibilities that will involve coordinated efforts between the Arizona Department of Environmental Quality (ADEQ) and the Department to ensure that, on a case-by-case basis, no more groundwater is withdrawn than is necessary.

To implement its groundwater quality management challenge, the Department will "coordinate and confer" with ADEQ regarding "water plans, water resource planning, water management, wells, water rights and permits, and other appropriate provisions of [title 45] pertaining to remedial investigations, feasibility studies, site prioritization, selection of remedies and implementation of the [WQARF] program pursuant to title 49, chapter 2, article 5." Arizona Revised Statute (A.R.S.) § 45-105(B)(4)(c). A Memorandum of Understanding between the Department and ADEQ will be developed to address this cooperative effort.

The Department's goals and objectives for groundwater quality management for the third management period are as follows:

- to ensure that remediation of contaminated groundwater uses the least amount of groundwater necessary to facilitate the objectives of each remedial action project.

- to ensure that end uses of remediated groundwater minimize groundwater withdrawals and are consistent with the safe-yield goal.

- to ensure that water quality considerations affecting Department programs that extend beyond the scope of the WQARF program are also addressed in order to preserve groundwater quality and quantity. Some of these considerations include well construction and abandonment standards, well spacing, assured water supply, recharge, and groundwater withdrawal permits.

Pursuant to the WQARF Program, the Department will respond first to the highest ranked sites on the WQARF site registry. The Department's objectives are to ensure that remedial action projects are not an impediment to achieving the management goals for each AMA, and that cleanups are performed in a prudent and efficient manner from a water management perspective.

7.3 STATUTORY PROVISIONS

ADEQ is the agency primarily responsible for regulating water quality. The Department also has some limited responsibilities in this area. Statutory provisions pertaining to the Department's limited authority to regulate groundwater quality are discussed below.

The Code grants the Department authority to regulate groundwater. Under the Code, the Department has the following authority and responsibilities relating to water quality:

- "[T]he director may . . . [f]ormulate plans and develop programs for the practical and economical development, management, conservation and use of surface water, groundwater and the watersheds in this state, including the management of water quantity and quality." A.R.S. § 45-105(A)(1).

- "[T]he director may . . . [c]onduct feasibility studies and remedial investigations relating to groundwater quality and enter into contracts and cooperative agreements under § 104 of the comprehensive environmental response, compensation, and liability act [CERCLA] of 1980 (P.L. 96-510) to conduct such studies and investigations." A.R.S. § 45-105(A)(16).

- For the third management period, the director "shall, in cooperation with the department of environmental quality, include in each [management] plan an assessment of groundwater quality in the active management area and any proposed program for groundwater quality protection. Any such program shall be submitted to the Legislature for any necessary enabling legislation or coordination with existing programs of the department of environmental quality." A.R.S. § 45-566(A)(7).

- "[T]he director shall consult with the department of environmental quality on water quality considerations in developing and implementing management plans under this article." A.R.S. § 45-573.

The WQARF legislation, as revised in 1997, expands the Department's role in water quality management. The Department's responsibilities and authority under WQARF, which will be explained in greater detail later in this chapter, include the following:

- "[T]he director of water resources, in consultation with the director of environmental quality, may inspect wells for vertical cross-contamination of groundwater by hazardous substances and may take appropriate remedial actions to prevent or mitigate the cross-contamination. . . ." A.R.S. § 45-605(A).

- "[T]he director [of water resources] shall notify an applicant for a permit or a person who files a notice of intent to drill a new or replacement well if the location of the proposed well is within a subbasin where there is a site [with existing or future groundwater contamination presenting a risk of vertical cross-contamination by the well]." The director is also required to adopt rules relating to vertical cross-contamination and new or replacement wells. A.R.S. § 45-605(E).

- "[T]he director of environmental quality and the director of water resources shall coordinate their efforts to expedite remedial actions, including obtaining information pertinent to site investigations, remedial investigations, site management and beneficial use of remediated water." A.R.S. § 49-290.01(C).

- The director of water resources may waive permits, approvals or authorizations if they "unreasonably limit the completion of a remedial action." A.R.S. § 49-290.01(A). The director of water resources may also waive any regulatory requirement under Title 45 if the requirement conflicts with the selected remedy in a remedial action as long as the waiver does not "result in adverse impacts to other land and water users." A.R.S. § 49-290.01(D).

- "The department of water resources shall include in its management plans . . . provisions to encourage the beneficial use of groundwater that is withdrawn pursuant to approved remedial action projects. . . ." Laws 1997, Ch. 287, § 51. In order to encourage the beneficial use of remediated groundwater, "the department of water resources shall account for groundwater withdrawn pursuant to approved remedial action projects under CERCLA or Title 49, Arizona Revised Statutes, consistent with the accounting for surface water" for purposes of determining compliance with management plan conservation requirements. Laws 1997, Ch. 287, § 51(B).

- "For each calendar year until 2025, the use of up to an aggregate of sixty-five thousand acre-feet of groundwater withdrawn within all active management areas pursuant to approved remedial action

projects under CERCLA or Title 49, Arizona Revised Statutes, shall be considered consistent with the management goal of the active management area as prescribed in section 45-576, subsection I, paragraph 2, Arizona Revised Statutes." Additionally, in the third management period, 50 percent of the total volume of groundwater withdrawn pursuant to remedial action projects and in excess of the aggregate volume of 65,000 acre-feet shall be considered consistent with the management goal of the AMA. Laws 1997, Ch. 287, § 52.

- "The department of environmental quality and the department of water resources shall develop a method of sharing data, including cooperative data base development and integration between the departments, that will provide the departments with the information necessary to protect the resources of the state." Laws 1997, Ch. 287, § 53.

- "The directors of environmental quality and water resources shall enter into an agreement to coordinate the well inspection and remediation programs and to rank wells within an area of contamination according to each well's potential to act as a conduit to spread contamination and to determine the appropriate remedial action regarding the wells with a potential to act as a conduit, including well reconstruction, well abandonment or no action." Laws 1997, Ch. 287, § 54.

7.4 THE REGULATION OF GROUNDWATER QUALITY IN ARIZONA

To understand the Department's role in regulating groundwater quality, it is important to understand the broad framework of laws and programs impacting both groundwater and surface water quality. Since groundwater quantity and quality issues are so interrelated, ADEQ and the Department work together to prevent and mitigate groundwater quality and quantity problems. ADEQ has the lead role in protecting the state's groundwater and surface water quality, while the Department secondarily manages groundwater quality concerns. This section discusses the regulatory agencies responsible for administering laws impacting groundwater and surface water quality as well as the federal laws and state programs impacting groundwater and secondarily surface water quality.

7.4.1 Water Quality Regulatory Agencies

Water quality protection programs in Arizona are based on both federal and state law and are primarily administered by either ADEQ or the United States Environmental Protection Agency (EPA) Region IX. ADEQ has the responsibility to administer state water quality programs pursuant to state statutes and to administer federal water quality programs for which the EPA has delegated its authority to the state, sometimes referred to as state primacy. EPA has the responsibility to administer federal water quality programs pursuant to federal statutes, but may delegate its authority to states that demonstrate the ability to administer such programs.

ADEQ has authority pursuant to the Arizona Environmental Quality Act (EQA) of 1986 to set water quality standards and to regulate discharges that may impact the quality of groundwater by requiring dischargers to obtain Aquifer Protection Permits (APPs). ADEQ also has authority over remediation of contaminated groundwater under WQARF. ADEQ has authority under the Clean Water Act (CWA) to set Arizona's surface water quality standards and to certify that discharges subject to federal permits do not violate state water quality standards. Moreover, ADEQ has authority to regulate drinking water under the Safe Drinking Water Act (SDWA) and hazardous waste under the Resource Conservation and Recovery Act (RCRA).

EPA Region IX retains authority to administer the CWA National Pollutant Discharge Elimination System (NPDES) permits and the pretreatment program, while the United States Army Corps of Engineers, Los Angeles District, has authority to administer CWA permits for the discharge of dredge or fill materials in

Arizona's waters. EPA Region IX also has authority to require groundwater monitoring and remediation in accordance with CERCLA.

7.4.2 Federal Laws Impacting Groundwater Quality

The SDWA is the primary federal law regulating groundwater quality. In particular, it regulates drinking water from all sources including groundwater. The CWA, which regulates surface water, also impacts groundwater quality. CERCLA and RCRA impact groundwater management through the regulation of hazardous waste and sites contaminated by hazardous waste. Following is a brief overview of these federal laws and their impacts on the Department's water quality management.

7.4.2.1 Safe Drinking Water Act

The SDWA was enacted in 1974 to regulate drinking water. ADEQ has been delegated authority by the EPA to implement the SDWA and "to ensure that all potable water distributed or sold to the public through public and semipublic water systems is free from unwholesome, poisonous, deleterious, or other foreign substances and filth or disease causing substances or organisms." A.R.S. § 49-351(A).

There are two types of standards set by the SDWA: national primary drinking water standards and national secondary drinking water standards. National primary drinking water standards may either be primary Maximum Contaminant Levels (MCLs) or Treatment Techniques (TT) requirements. Primary MCLs are the maximum permissible level of a constituent in a public water system and constitute the enforceable standard for safe drinking water. TT requirements set action levels for constituents such as lead and copper that cannot be directly detected or removed by water systems. National secondary drinking water regulations, referred to as secondary Maximum Contaminant Levels, set non-enforceable numeric standards for the aesthetic quality of water, such as taste, odor, or color. Water with contaminants above the secondary MCLs are not typically expected to cause health problems. ADEQ has adopted the EPA MCLs as state Drinking Water Standards and has the authority to adopt more stringent standards as well.

Although the Department does not directly regulate drinking water quality, the presence of contaminants that exceed federal and state standards impacts the regulation of municipal providers and poses significant water management issues for drinking water systems.

7.4.2.2 Clean Water Act

The CWA, first passed in 1972, is the comprehensive federal statute regulating surface water quality. The CWA contains six major elements: (1) the NPDES permit program, which regulates discharges of pollutants by any person to the nation's waters and is designed to protect the chemical and biological integrity of the nation's waters, (2) technology-based effluent standards that apply to the quality of a facility discharge, (3) state ambient water quality standards, (4) dredge and fill permits designed to protect the physical and biological integrity of the nation's waters, (5) oil and hazardous substance spill liability, and (6) federal grant programs for improvement of municipal water treatment.

Under the NPDES permit program, all point source dischargers of pollutants into "waters of the United States" must obtain a permit. The jurisdictional reach of the CWA extends to "navigable waters" that are defined as "waters of the United States, including the territorial seas." 33 U.S.C. § 1362(7). EPA and the Corps define "waters of the United States" to include interstate waters; waters that are used, were used in the past, or may be susceptible to use in interstate or foreign commerce; waters the use, degradation, or destruction of which would or could affect interstate or foreign commerce; tributaries to such waters; the territorial sea and wetlands. 40 C.F.R. § 122.2; 33 C.F.R. § 328.3(a). A frequently cited definition of "waters of the United States" is:

> any waterway within the United States also including normally dry arroyos through which water may flow, where such water will ultimately end up in public waters such as a river or stream, tributary to a river or stream, lake, reservoir, bay, gulf, sea, or ocean within or adjacent to the United States. U.S. v. Phelps Dodge Corp., 391 F. Supp. 1181 (D. Ariz. 1975).

Based on this "tributary rule," the CWA has potential application to dry land that drains into a water of the United States. Additionally, EPA interprets waters of the United States to include wetlands, areas susceptible to use as habitat by migratory wildfowl, and areas where industries engaged in interstate commerce discharge. 44 Fed. Reg. 32854, 32858 (June 7, 1979); 51 Fed. Reg. 41206, 41217 (Nov. 13, 1986). "Point source" means:

> any discernible, confined, and discrete conveyance including but not limited to any pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock, concentrated animal feeding operation, or vessel or other floating craft, from which pollutants are or may be discharged. 33 U.S.C. § 1362(11).

"Pollutant" includes dredged spoil, solid waste, incinerator residue, sewage, garbage, sewage sludge, munitions, chemical wastes, biological materials, radioactive materials, heat, wrecked or discarded equipment, rock, sand, cellar dirt, and industrial, municipal, and agricultural waste discharged into water. 33 U.S.C. § 1362(6). Based on the expansive definitions of "waters of the U.S.," "point source," and "pollutant," the jurisdictional reach of the CWA NPDES Program is quite broad. The EPA has also implemented a NPDES storm water permit program that regulates municipal and industrial runoff that eventually discharges to waters of the United States.

NPDES permits that allow discharges to canals or river systems as a result of remedial projects or by wastewater treatment facilities are important to the Department's overall water management strategy. As a result, the Department provides input on related reports and draft NPDES permits that may impact the water management activities in the state. Furthermore, non-point source contamination of groundwater by such substances as nitrate, sulfate, and dissolved solids can render large volumes of groundwater unusable for many purposes and pose serious water management problems. Therefore, the Department monitors statutory and programmatic developments as well as permits and reports related to non-point source discharges under the CWA.

The CWA also provides for area-wide long-range planning processes to mitigate water quality control problems in selected areas that result from urban and industrial wastewater. Because such planning processes include a comprehensive review of wastewater treatment and reuse options, the Department participates in this planning process and provides technical assistance to the local councils of government administering the plans.

7.4.2.3 Comprehensive Environmental Response, Compensation and Liability Act

CERCLA and the Superfund Amendments and Reauthorization Act, commonly referred to as the federal Superfund program, authorize the investigation and remediation of groundwater contaminated by releases of hazardous substances. Groundwater remediation may be required to comply with primary MCL standards, although less stringent standards may be approved by EPA on a case-by-case basis through a technical waiver process. In Arizona, CERCLA establishes a comprehensive response program that is administered by ADEQ in cooperation with the EPA. The Department also plays an advisory role in this process.

Under Section 105 of CERCLA, the EPA is required to annually update the National Priority List (NPL) of Superfund sites. Sites are proposed for inclusion on the NPL after being assessed as to the release of

hazardous substances that threaten public health and the environment. Two significant components in the Superfund process are site investigation (Remedial Investigation) and evaluation of possible cleanup alternatives (Feasibility Study). During the Remedial Investigation, information is gathered to determine the general nature, extent, and sources of contamination at a site. Once the final cleanup plan has been selected, EPA formalizes this decision by signing a "Record of Decision" (ROD). The ROD also contains a Responsiveness Summary, which is EPA's response to public comments on the Remedial Investigation, Feasibility Study, and Proposed Plan. Design and actual cleanup activities (Remedial Design and Remedial Action) can then proceed.

The Department regularly participates in CERCLA Program activities, primarily for sites located within AMA boundaries. The Department's concern at CERCLA sites is that any groundwater withdrawn and remediated be put to reasonable and beneficial use. The Department participates on CERCLA technical committees and serves in an advisory capacity for monitoring and extraction well installation, source control projects, and permitting.

7.4.2.4 Resource Conservation and Recovery Act

The RCRA established a national hazardous waste management program in 1976. Under RCRA, hazardous waste permits are issued for the treatment, storage, and disposal of hazardous wastes. Individual permits issued to these facilities specify design, performance, and operational standards that include groundwater monitoring. Hazardous waste facilities also undergo a closure process once operations are reduced or terminated. Moreover, corrective action may be required at treatment, storage, and disposal facilities and may include groundwater monitoring.

ADEQ has been delegated authority for the implementation of RCRA requirements in Arizona. The Department's participation at RCRA sites is important for water management activities, particularly in regard to well siting, use permits, and end use issues.

7.4.3 <u>ADEQ Groundwater Programs</u>

The EQA (A.R.S. § 49-101, *et seq.*) established the ADEQ and created a strong and comprehensive water quality management structure. ADEQ's programs that protect groundwater resources include water quality assessments, groundwater monitoring, pollutant discharge monitoring, permitting activities, and remediation activities. The following are selected water quality protection programs that fall under the jurisdiction of ADEQ and have a direct impact on Department activities.

7.4.3.1 Aquifer Water Quality Standards

Arizona's Aquifer Water Quality Standards (AWQSs) are the cornerstone of the state's groundwater protection program. Arizona has adopted the federal primary MCLs, established under SDWA, as numeric AWQSs. A.A.C. R18-11-406. These standards apply to aquifers that are classified and protected for drinking water use. Because all aquifers in Arizona are classified and protected for drinking water use, Arizona's AWQSs are enforceable water quality standards in all of Arizona's aquifers. A.R.S. § 49-224(B).

ADEQ may reclassify an aquifer within an AMA, upon consultation with the appropriate Groundwater Users Advisory Council and upon conducting a public hearing, for a projected use other than drinking water if the identified aquifer is hydrologically isolated from other aquifers or other portions of the same aquifer, water from the identified aquifer is not being used as drinking water, and the benefits to the public of the resulting water quality degradation outweigh the costs. A.R.S. § 49-224(c).

Arizona has also adopted narrative AWQSs to regulate pollutant discharges for which no numeric standards have been developed. Arizona's narrative AWQSs include the following: (1) a discharge shall not cause a pollutant to be present in an aquifer classified for a drinking-water-protected use in a concentration that endangers human health, (2) a discharge shall not cause or contribute to a violation of a surface water quality standard established for a navigable water of the state, and (3) a discharge shall not cause a pollutant to be present in an aquifer that impairs existing or reasonably foreseeable uses of water in an aquifer. A.A.C. R18-11-405.

7.4.3.2 Aquifer Protection Program

The most comprehensive ADEQ groundwater protection program is the Aquifer Protection Permit (APP) system, established by the EQA in 1986 and implemented by rule in 1989. An individual or general permit is required for any person who discharges or who owns or operates a facility that discharges a pollutant from a facility either directly into an aquifer or to the land surface or the vadose zone in such a manner that there is a reasonable probability that the pollutant will reach an aquifer. A.R.S. §§ 49-201(11) and 49-241. Discharging facilities that require either an individual or general permit to operate include: surface impoundments; solid waste disposal facilities; injection wells; land treatment facilities; facilities that add a pollutant to salt formations, dry well, underground cave or mine; mine tailings piles and ponds; mine leaching operations; large septic tank systems; effluent recharge projects; point source discharges to waters of the United States; sewage or sludge ponds; and wastewater treatment facilities. A.R.S. § 49-241(B). Classes or categories of facilities that are exempted from APP requirements are identified in A.R.S. § 49-250. General permits are issued by rule while individual permits must be applied for on a facility by facility basis.

APPs require a demonstration that AWQSs are maintained and the Best Available Demonstrated Control Technology (BADCT) is applied. For individual APPs, compliance with AWQSs is measured at a designated point of compliance. BADCT requirements ensure that the greatest degree of discharge reduction is achieved through an evaluation of site-specific engineering, environmental, and economic criteria.

APPs may require compliance with best management practices (BMPs). BMPs are typically site design techniques used to protect water quality. BMPs may be adopted to manage urban runoff, storm sewers, silvicultural activities, and septic tank systems. Agricultural general permits require compliance with BMPs for nitrogen fertilizer application and concentrated animal feeding operations. ADEQ is required to monitor compliance with established BMPs and to measure BMPs effectiveness.

Department staff receives and reviews all APPs for any impacts on Departmental programs and water management. In particular, the Department coordinates with ADEQ to review APP applications for potential harmful water quality impacts on groundwater conditions. Pursuant to A.A.C. R18-9-109, ADEQ advises the Department of each APP application received for a facility that is a recharge project or an underground storage and recovery project. One of the conditions for the issuance of an underground storage facility permit is that ADEQ must determine that the facility is not in a location that will result in pollutants being leached to the groundwater table so as to cause unreasonable harm. A.R.S. § 45-811.01(C). Facilities exempt from APP provisions may be required by the Department, in consultation with ADEQ, to meet other requirements to mitigate harmful water quality impacts to the aquifer.

7.4.3.3 Wellhead Protection Program

ADEQ's Wellhead Protection Program is an important supplement to the groundwater quality protection provided by the Department's well construction standards and well driller licensing programs. The Wellhead Protection Program fulfills federal requirements of Section 1428 of the SDWA by designating

Wellhead Protection Areas around public drinking water systems. The Wellhead Protection Program is a voluntary program that encourages the protection of all wells, not just public drinking water system wells. Local entities that have the authority to control land use and exercise other management options can also implement wellhead protection, therefore encouraging the creation of local programs.

7.4.3.4 Reuse Permits

Reuse permits are issued to facilities that provide wastewater for reuse. A reuse permit specifies the amount of effluent to be reused and its chemical quality. ADEQ wastewater reuse rules (A.A.C. R18-9-701, *et seq.*) set the criteria for the use of treated effluent, or reclaimed water, for purposes such as agricultural irrigation, turf irrigation, and recharge. The current reuse rules prescribe numeric reclaimed water quality criteria and monitoring requirements for specific reuse applications. In general, these rules prescribe allowable limits for pH, total fecal coliform, turbidity, enteric viruses, and certain parasites. Reuse may be limited depending on the quality of source water and the intended use.

Wastewater reuse rules undergo periodic updating through ADEQ's rule-making process. The Department reviews any proposed changes to the wastewater reuse rules to ensure the protection of public health and groundwater supplies while maximizing the use of a significant renewable water supply. The Department evaluates effluent reuse permits issued by ADEQ and encourages the use of effluent where appropriate.

7.4.3.5 Underground Storage Tanks

ADEQ'S Underground Storage Tank (UST) Program was developed to ensure the proper operation of USTs and to prevent and remediate releases. Under state regulation and RCRA amendments, the UST Program consists of notification requirements, technical standards for new and existing USTs, leak detection and closure criteria, corrective actions for remediation and financial responsibility demonstrations. Leaking USTs in a concentrated area can have detrimental impacts on groundwater quality and supplies.

The Department has the authority to issue poor quality groundwater withdrawal permits for water contaminated by USTs. The Department can provide guidance for UST site remediation projects to ensure the beneficial use of remediated water.

7.4.3.6 Water Quality Assurance Revolving Fund

The WQARF Program, sometimes referred to as the state Superfund program, was created as part of the EQA. WQARF monies are used to protect the waters of the state against hazardous substances and may be used in conjunction with federal funds. Funds can be used for statewide water quality monitoring, health and risk assessment studies, and remediating hazardous substances that threaten the waters of the state. Mitigation of non-hazardous substances is also allowed under specified conditions. A.R.S. § 49-286. Each year, ADEQ develops a priority list of environmentally threatened sites that qualify for WQARF monies, based in part on the degree of risk to the environment and other available funding sources. Funds are used at those sites to mitigate existing contamination or to prevent further spread of pollutants that may threaten water supplies.

Some of the key legislative changes made in the 1997 WQARF reform package include: (1) establishment of a proportional share liability for cost allocation to responsible parties; (2) creation of a neutral party arbitration process, with incentives to encourage early settlements and disincentives to responsible parties who do not enroll in the neutral party arbitration process; (3) new ADEQ funding mechanisms designed to protect existing wells against migrating contamination from WQARF sites; (4) the creation of a comprehensive WQARF site registry, which consolidates a number of separate lists that were previously

used; the inclusion of petroleum releases in the WQARF Program under some circumstances; and (5) increased flexibility in the selection of groundwater remedies.

ADEQ follows a process for management and cleanup of WQARF sites that consists of site identification and characterization, site prioritization, remedy selection, identification of end uses, implementation and monitoring, and closure. The criteria used to evaluate response actions include practicability, risk, cost, and benefit. This process also includes a comparison of alternatives based on established statutory criteria, developing a Remedial Action Plan (RAP), obtaining public comment, and issuing a ROD. The Department will actively coordinate with ADEQ in the planning and implementation of groundwater cleanup actions under WQARF.

7.4.3.7 Water Infrastructure Finance Authority

In 1989, the Arizona Legislature created the Wastewater Management Authority to administer funds granted to the state pursuant to the federal SDWA. These funds, which required a 20 percent state match, were loaned to wastewater treatment facilities for assistance in meeting the SDWA requirements. The ADEQ made loans for this purpose from monies in the ADEQ wastewater treatment revolving fund.

In 1997, this administrative body was amended by the Legislature and renamed the Water Infrastructure Finance Authority (WIFA). The authority of WIFA was expanded to make loans available to drinking water systems in addition to wastewater treatment systems for assistance in meeting requirements of the SDWA. The state funding source was also changed so that monies made available to these systems are now derived from the drinking water revolving fund. The Department participates on the advisory board that oversees WIFA and has an interest in the viability of water systems and SDWA compliance.

7.4.4 <u>The Department's Programs Related to Groundwater Quality</u>

The Department protects groundwater quality by considering groundwater quality issues in its permitting process and water quantity management programs. As a result of WQARF reform legislation of 1997, the Department has increased its responsibility in the program to coordinate and provide assistance to WQARF activities. Among other things, the bill provides for:

- annual funding for Department WQARF activities;
- database development and coordination with ADEQ;
- groundwater withdrawn pursuant to certain cleanups to be accounted for in the same manner as surface water for the purpose of determining compliance with conservation requirements;
- amendment of the Assured Water Supply Rules (AWS Rules);
- active involvement by the Department in all phases of site assessment, remediation, management, operation, and planning strategies;
- a WQARF Advisory Board on which the Department has a seat; and
- a well inspection program through which wells that are contributing to vertical cross-contamination of aquifers may be identified and modified.

The Department's existing permits and programs that involve groundwater quality issues, as well as its new programs for groundwater quality protection based on the WQARF legislation, are discussed in the following subsections.

7.4.4.1 Poor Quality Groundwater Withdrawal Permits

Appropriate use of poor quality groundwater conserves the existing supply of potable groundwater. The Department issues poor quality groundwater withdrawal permits to allow the withdrawal of groundwater that, because of its quality, has no other beneficial use at the present time. A.R.S. § 45-516. Withdrawal

permits are issued by the Department, and the withdrawal must be consistent with the AMA management plan. Permits are usually issued in conjunction with CERCLA, WQARF, or leaking UST sites for pump and treat operations. To increase the appropriate uses of poor quality groundwater during the third management period, the Department will continue to encourage matching poor quality groundwater with beneficial uses within the AMA.

7.4.4.2 Assured Water Supply Program

The Assured Water Supply Program (AWS Program) is a consumer protection program that ensures that new subdivisions have a secure supply of water with adequate quality for at least 100 years. The AWS Program is described in detail in Chapter 5, section 5.3.

In assessing the quality of a water supply pledged for assured water supply purposes, the Department works closely with ADEQ to determine whether the water supply meets ADEQ standards for the purposes for which the water is pledged. If the water is not of adequate quality, the applicant may need to find alternative water sources or to expend additional resources treating the water to meet the ADEQ standards.

7.4.4.3 Underground Water Storage and Recovery

Underground water storage, also known as recharge, will play an important role in achieving the Tucson AMA's goal of safe-yield. The underground water storage program is administered by the Department and described in detail in Chapter 8, section 8.7.2. Permits must be obtained from the Department prior to undertaking recharge activities. The Department coordinates closely with ADEQ to ensure that underground water storage does not adversely impact existing aquifer water quality and does not cause movement of existing groundwater contamination. If effluent is stored underground, the applicant must obtain an APP from ADEQ, in addition to the underground storage permits required from the Department. CAP water that is recharged is exempt from the APP process.

7.4.4.4 Well Spacing/Impact Analysis

A.R.S. § 45-598 and the Department's temporary Well Spacing and Well Impact Rules require well impact studies to evaluate the potential for new non-exempt wells and new withdrawals to damage land and other water users, particularly existing well operations. The Department conducts the impact studies for wells with a maximum discharge of 500 gallons per minute (gpm) or less. For wells with a maximum discharge rate exceeding 500 gpm, the permit applicant must submit a hydrological study of projected water level declines due to the operation of the proposed well. The study must also assess potential adverse impacts from the migration of poor quality groundwater. The well permit application may be denied if the Department determines the proposed well would cause an unreasonable and adverse impact on surrounding wells, additional regional land subsidence, or migration of poor quality groundwater. Wells that withdraw less than 35 gpm are currently exempt from these requirements.

7.4.4.5 Well Construction and Abandonment Requirements and Licensing of Well Drillers

If wells are not constructed, sealed, or abandoned properly, they can act as conduits for contaminant flow from the surface to groundwater or between aquifers. The Department's rules governing well construction, abandonment, and driller licensing, set forth at A.A.C. R12-15-801, *et seq.*, are summarized below.

- Minimum well construction and abandonment requirements prevent entry of fluids at and near the surface and minimize the possibilities of migration and inadvertent withdrawal of poor quality groundwater. These requirements also prohibit the use of hazardous materials in the construction of wells.

- Installation, modification, abandonment, or repair of wells in Arizona must be performed by a driller licensed by the Department. The licensing procedure includes the administration of written examinations to test the applicant's knowledge of state regulations, hydrologic concepts, and well construction principles and practices.

- Disposal site restriction prevents the use of wells as disposal facilities for any material that may pollute groundwater.

- Special standards may be required by the Department if the minimum well construction requirements do not adequately protect the aquifer or other water users.

- Open wells must be capped with a water-tight steel plate.

- Except for monitor and piezometer wells, no well shall be drilled within 100 feet of any septic tank system, sewage disposal area, landfill, hazardous waste facility or storage area, or petroleum storage areas and tanks, unless authorized by the director.

Wells drilled prior to the enactment of the well construction rules (effective March 5, 1984) were not required to be constructed in accordance with minimum well construction standards. If a pre-rule well is replaced or modified, however, the new or modified well must meet the current well construction standards. See A.R.S. § 45-594.

7.4.4.6 The Department's Role in the WQARF Program

The Department's involvement in groundwater remediation has been redefined in the WQARF reform bill as a result of recommendations made by the Groundwater Task Force, which conducted an extensive series of stakeholder negotiations designed to expedite groundwater cleanup and groundwater quality management activities at remedial sites. Involvement in this development process was widespread and representative of a varied group of private and public interests.

7.4.4.6.1 Department Activities in the WQARF Site Cleanup and Management Process

ADEQ's WQARF site cleanup and management process and the Department's role in that process are described in the following discussion.

<u>Site Identification and Characterization</u>

Existing WQARF sites have been identified and are being managed by ADEQ. Additional sites may be identified in the future based on a preliminary investigation by ADEQ to determine the potential risk to public health, welfare, or the environment. The Department will further assist ADEQ in this process by providing resource data that includes well location and pumpage records, water rights information, and any other appropriate data recorded by the Department.

Characterization of sites is important because the nature and extent of contamination must be understood before remedies can be selected and implemented. An important part of site characterization is an evaluation of how contamination impacts current and future groundwater uses. The Department's role may include such activities as site inspections and evaluations, review of investigations, field work such as well inspection and water quality sampling, identification of potential water management issues, and any other characterization as appropriate. Department computer models may be useful in characterizing groundwater flow patterns.

Site Prioritization

The results of the preliminary investigation will be used by ADEQ for site scoring using a method to be established in rules adopted by the ADEQ director. The completed preliminary investigation will be used by ADEQ to either make a determination of no further action on a site, or to prepare the site for inclusion on the Site Registry. In this latter case, a Site Registry report is prepared containing a description of the site, with its geographical boundaries indicated, and a score in accordance with the site scoring method to be established in rules and adopted by the ADEQ. The Department will assist ADEQ by sharing pertinent water resource information.

Remedy Selection

ADEQ has established a list of response actions to be considered when managing a site. Based on the potential impact on current and future water uses, remedial action options must be evaluated and a RAP developed. Each RAP is site-specific. The Department will assist in defining potential remedies to ensure the remedial approach is consistent with Department water management objectives and sound groundwater management practices that are publicly acceptable. The Department's level of assistance will vary based on the remedy selected. Possible remedies include:

- Plume Remediation

Plume remediation, or aquifer restoration, means achieving appropriate water quality standards for groundwater throughout the affected area. Source control and monitoring will likely be essential elements of this strategy. This remedy may be more effective for smaller plumes that can be remedied within reasonable time frames.

- Physical Containment

Physical containment refers to an approach that contains contaminants within defined boundaries. This strategy could consist of plume control and coordination of groundwater pumpage and recharge to ensure that contamination is confined within a defined area. Source control and monitoring are also likely elements of this strategy. Physical containment may be appropriate in cases where potable water supplies are threatened by contaminant migration and where containment is technically feasible, however, it may require extensive groundwater management to implement.

- Controlled Migration

This strategy aims to control but not necessarily contain contaminant migration. Source control and monitoring are likely elements of this strategy. Control of contaminants can include control and/or coordination of pumpage that affects contaminant migration and any other measures taken to control contaminant migration. Controlled migration may be appropriate for larger plumes that cannot be practically remediated or contained.

- Source Control

Source control is a reduction of continuing contaminant sources such as soil contamination or areas of high concentrations of Volatile Organic Compounds (VOCs) or other contaminants. Dense non-aqueous phase liquids (DNAPLs), which are contaminants (such as VOCs) of such high concentrations that they are not dissolved in groundwater but exist as free phase liquids, are an example of contaminant sources. Source control is a remedial action that often results in the highest volume of contaminants removed per unit cost.

This strategy employs controlling the pollutant at the source to ensure that aquifer contamination does not migrate due to uncontrolled contaminant releases. Monitoring is a likely component of this strategy. Source control can include, but is not limited to, the remediation of sorbed or free-phase contaminants, pumpage of groundwater to contain or control significant sources of contaminants, and the removal of contributing contaminant sources.

- Monitoring

Monitoring water quality conditions, instead of implementing actual cleanup activities, can be a remedy applied to sites with low risk to human health or the environment. Monitoring sites is also an important part of many remediation plans to assess the extent of contamination and the effectiveness of remedial activities. Computer groundwater models may be used to predict contaminant movement, to monitor well locations, and to develop contingency plans for more aggressive remedies, if necessary.

- No Action

This alternative consists of taking no action at a site. The site is not monitored nor are any remedial actions performed. This strategy is normally included as a baseline condition for comparison purposes in a remedial investigation feasibility study, but may be a viable alternative in limited cases. Generally, this alternative would only be chosen for sites that are geographically isolated from populated areas, do not pose a significant threat to drinking water supplies, or would be used for comparative purposes to other sites.

Identification of Beneficial End Uses

The Department is committed to the beneficial use of groundwater withdrawn and treated at WQARF sites, along with other areas that have degraded groundwater quality. The Department will assist ADEQ with the identification and facilitation of designated end uses for remedial projects. These end uses should be consistent with those determined for existing sites as well as the development of new end uses to match the intended use.

Implementation and Monitoring

The implementation and monitoring phase of a site activity includes construction, startup, monitoring, operation and maintenance, and any other appropriate activities. The Department will assist ADEQ in this phase through the following activities where appropriate: field work, review of groundwater analyses, pertinent groundwater and assured water supply accounting, and any other appropriate activities.

Site Closure

ADEQ must certify that site goals have been attained in order to discontinue cleanup activities. Department staff will assist in evaluation of sites and certification of site closure. The Department may need to identify alternative water sources to replace remediated water when sites are closed.

7.4.4.6.2 The Department Policies for WQARF Site Cleanup and Management

In general, site cleanup plans should be consistent with the management goal of the AMA in which the site is located. A.R.S. §§ 49-282.06(F) and 45-105(B)(4)(c). Therefore, the Department will implement policies during the third management period for the management and cleanup of remedial sites in cooperation with ADEQ. These policies will ensure that AMA goals are addressed when remedial actions are planned. The Department supports proposed remedial projects when they are appropriate, but believes

that RAPs must make sense from a groundwater management perspective. The principles that will be used to formulate these policies are described below.

Water should be used consistent with water allocation concepts in Title 45

This policy requires that entities using water withdrawn pursuant to cleanups, whether under CERCLA, WQARF, RCRA, voluntary, or other sites possess appropriate authorities for the use of groundwater (such as permits or water rights).

The Department supports source control cleanups to protect water sources

Source control, which controls pollution at its source, can be the most cost effective and practicable approach to cleanups. Source control projects to protect wells that are threatened by contaminant migration are generally supported by the Department. Pollution prevention is also a significant component of mitigating contaminant migration.

Any groundwater withdrawn must be put to reasonable and beneficial use

Reasonable and beneficial use of groundwater is a policy that applies to all groundwater remediation efforts. Any withdrawals of 100 acre-feet or less per year may qualify for de minimis status and be exempted from beneficial use requirements, but the Department will evaluate de minimis exemptions from this policy on a case-by-case basis. In the case of leaking UST sites, the Department generally exempts sites that annually pump less than 10 to 15 acre-feet. The de minimus policy also facilitates the handling of small volumes of water pumped for the collection of groundwater sampling.

Contaminated groundwater represents a resource that has future importance

Contaminated groundwater is a resource that may be used for both potable and nonpotable uses. Potable uses must meet state and federal standards that regulate public consumption of drinking water. ADEQ and the Department of Health Services intend to develop end use standards for non-potable uses that, if implemented, will make large volumes of contaminated groundwater usable for specific purposes. The Department will cooperate in the development of nonpotable end use standards and will develop policies for appropriate end uses based on the new standards.

Containment remedies that involve massive groundwater withdrawals to achieve regional groundwater flow control are generally inappropriate and will not be supported by the Department

In some cases, massive groundwater withdrawals of uncontaminated or only slightly contaminated water may be considered to control migration of contaminant plumes or for other purposes. In general, the Department considers these kinds of proposed remedies to be wasteful of groundwater and not cost-effective.

7.4.4.6.3 Statutory Mandates for the Department's Involvement in the WQARF Program

The 1997 WQARF reform legislation mandates that the Department implement certain water quality programs and provides for expanded Department involvement in water quality management. New Department programs and responsibilities based on the 1997 WQARF reform legislation include the following:

Remediated Groundwater Incentives

The WQARF reform legislation of 1997 directs the Department to include in the management plans developed pursuant to A.R.S. § 45-566 (the Third Management Plans) provisions to encourage the beneficial use of groundwater that is withdrawn pursuant to approved remedial action projects under CERCLA or Title 49, Arizona Revised Statutes. Laws 1997, Ch. 287, § 51(A).

- Remediated Groundwater Incentive for Conservation Requirement Accounting

In order to encourage the beneficial use of remediated groundwater, the Legislature specifically mandated:

> In determining compliance with applicable conservation requirements adopted pursuant to sections 45-566, 45-567 and 45-568, Arizona Revised Statutes, the department of water resources shall account for groundwater withdrawn pursuant to approved remedial action projects under CERCLA or Title 49, Arizona Revised Statutes, consistent with the accounting for surface water.

Laws 1997, Ch. 287, § 51(B).

- Remediated Groundwater Incentive for Assured Water Supply Accounting

In addition, the WQARF reform legislation of 1997 directs the Department to consider specified amounts of groundwater withdrawn pursuant to approved remedial action projects as consistent with the management goal of the active management area from which it is withdrawn for purposes of the Department's AWS Program. Laws 1997, Ch. 287, § 52. The Legislature mandated that:

> For each calendar year until 2025, the use of up to an aggregate of sixty-five thousand acre-feet of groundwater withdrawn within all active management areas pursuant to approved remedial action projects under CERCLA or Title 49, Arizona Revised Statutes, shall be considered consistent with the management goal of the active management area.

Laws 1997, Ch. 287, § 52(A).

Once the aggregate volume of 65,000 acre-feet of remediated groundwater use by all users in all active management areas is reached in a year, the use of an additional amount of remediated groundwater is consistent with the management goal of the active management area based on a sliding scale. In the third management period, fifty percent of the total volume withdrawn in excess of the 65,000 acre-feet will be consistent with the management goal. Laws 1997, Ch. 287, § 52(B). By the year 2025, the remediated groundwater incentive for assured water supply accounting decreases to zero.

A municipal provider must apply for a remediated groundwater accounting for an assured water supply determination prior to January 1, 2010. The amount of groundwater determined to be consistent with the management goal cannot exceed the amount that the municipal provider is legally obligated to withdraw or use and does not extend beyond 2025. Laws 1997, Ch. 287, § 52(C).

Annual groundwater withdrawals of 250 acre-feet or less that are withdrawn pursuant to an approved remedial action project shall not be debited against the water provider's assured water supply mined groundwater account and shall not be subject to a replenishment obligation. The water provider must notify the Department of its compliance with the exemption. Annual withdrawals of 250 acre-feet or less of remediated groundwater will not count against the 65,000 acre-feet per year total volume. Laws 1997, Ch. 287, § 52(E).

- Coordination with ADEQ in Evaluating Proposed Remedial Actions

Pursuant to A.R.S. § 45-105(B)(4)(c), the Department is required to actively coordinate and confer with ADEQ in evaluating proposed remedial actions to provide ADEQ with information regarding water resource considerations. The Department will coordinate and confer with ADEQ prior to ADEQ's approval or denial of a proposed remedial action project. Once a remedial action project is approved by ADEQ or the EPA pursuant to CERCLA or Title 49, Arizona Revised Statutes, the Department will account for remediated groundwater in accordance with Laws 1997, Ch. 287, §§ 51 and 52. Among other things, the Department will consider the following factors relating to proposed remedial actions in its recommendations to ADEQ:

- Volume of remediated groundwater to be withdrawn

The Department will encourage remedial actions that use the least amount of groundwater necessary to facilitate a project's remedial goal and will discourage remedial actions that are not prudent and efficient from a groundwater management perspective.

- End uses to which remediated groundwater will be put

The Department will encourage end uses that minimize groundwater withdrawals and that are consistent with the safe-yield goal because they will result in no change in groundwater storage. Where remediated groundwater cannot be practicably or cost effectively re-injected or recharged, the Department will encourage replacing existing groundwater uses with remediated groundwater and preventing new permanent uses that would not have occurred without the incentive to use remediated groundwater and that would continue to rely on groundwater after the remediated groundwater is no longer available.

While individualized circumstances will be evaluated on a case-by-case basis, generally, the Department's beneficial end use preferences are the following, listed in order from most to least preferred based on impacts to the AMAs management goal and the amount of groundwater in storage:

<u>Neutral to local aquifer</u>

a. Re-inject or recharge in the same local area.
b. Replace existing groundwater uses in same local area.

<u>Neutral to groundwater basin</u>

c. Re-inject or recharge in the same AMA.
d. Replace existing groundwater uses in the same AMA.

<u>Reduce groundwater in storage</u>

e. Replace existing non-groundwater use in the same AMA.
f. Beneficial uses of water for new purposes.
g. Artificial wetlands or artificial lakes.
h. Dispose to the sewer (unless the resulting effluent is re-injected, recharged or replaces an existing groundwater use).

- Achievement of maximum beneficial use of waters and viability of proposed remedial action

Remedial actions must assure the protection of public health and welfare and the environment; to the extent practicable, provide for the control, management or cleanup of hazardous substances so as to allow the maximum beneficial use of the waters of the state; and be reasonable, necessary, cost-effective and technically feasible. A.R.S. § 49-282.06(A).

- Consistency with Title 45

Groundwater withdrawn pursuant to an approved remedial action must be withdrawn and used consistent with Title 45, Arizona Revised Statutes.

Well Inspection, Modification, or Replacement

The Department is required by the 1997 WQARF legislation to develop rules for well inspections. An evaluation of the extent of the cross-contamination problems will be performed by the Department in cooperation with ADEQ and other stakeholders.

Construction of New Wells In and Near WQARF Sites

The 1997 WQARF legislation mandates that the Department ensure that new or replacement wells located in areas of known groundwater contamination are constructed in such a manner that cross-contamination does not occur. Department staff will screen Notices of Intent to Drill that are submitted to help ensure that wells are properly constructed. The Department will establish policies and procedures to implement this directive, including procedures to effectively communicate with well owners and drillers.

Abandonment of Wells In and Near WQARF Sites

Department staff will review and evaluate Notices of Intent to Abandon to ensure that abandonment of wells is done in accordance with Department rules and that potential for cross-contamination is minimized.

7.5 WATER QUALITY ASSESSMENT

A water quality assessment must be included in management plans pursuant to the Code. The assessment provides an overview of water quality concerns in the Tucson AMA. The following sections discuss the assessment goals and objectives, water quality of renewable and groundwater supplies, constituents of concern in the Tucson AMA and their impact on water management, and specific contamination areas in the Tucson AMA.

7.5.1 Assessment Goals and Objectives

The primary goal of the Third Management Plan Water Quality Assessment is to provide a general evaluation of groundwater and surface water quality conditions in the Tucson AMA and to identify the interface of water quality concerns with the regional water supply. The impact of water quality on water resource management has become more important in recent years due to such factors as stringent water quality standards, conjunctive use of water supplies, groundwater management at remediation sites, and increasing levels of public concern.

The municipal, agricultural, and industrial sectors have distinctive demand patterns and water quality requirements. For example, state law prohibits direct use of treated effluent for potable use, but treated effluent is used for turf irrigation, agricultural irrigation, cooling towers, and groundwater recharge. Water high in total dissolved solids (TDS) may be inappropriate for agricultural irrigation, but may be usable for some industrial applications. Water high in nitrate could provide a suitable end use for agriculture, but does not meet potable standards. During the third management period the Department will evaluate matching water quality characteristics with appropriate end uses while ensuring compliance with applicable laws and rules for each end use.

7.5.2 Renewable Water Supplies

The primary renewable water supplies available for use in the Tucson AMA are CAP water and effluent. Other than imported CAP water, the volume of natural surface water supplies in the Tucson AMA available for direct use is small. The quality of these waters is discussed in the following sections.

7.5.2.1 Central Arizona Project Water

The largest surface water supply available in the Tucson AMA is CAP water, which is diverted and conveyed from the Colorado River primarily in an open canal. The direct delivery of CAP water for municipal water supply has been met with much controversy in the Tucson AMA. The City of Tucson, the largest municipal CAP subcontractor in the state, has been faced with many obstacles in their attempt to utilize their CAP allocation. The utilization of CAP water as a direct supply for drinking water has been an issue since the City began delivery of treated CAP water in November 1992. Customer complaints of colored water, corrosion, bad taste and odor, and other problems led to the Mayor and Council's decision to discontinue deliveries of treated CAP water. Since then, many of the causes for these water quality problems have been identified and control methods are being developed. Some of these problems were caused by changes in pH, pressure fluctuations, hydraulic flow reversals, and the deteriorated condition of part of the existing water distribution system.

Disinfectants are used in public water supplies to avoid outbreaks of water-borne diseases and pathogens such as giardia and cryptosporidium. Scientists currently believe that the health risks of these diseases far outweigh the risk associated with disinfection by-products. However, research is being done to evaluate issues related to disinfection by-products.

There has been considerable controversy concerning the potential harmful health effects of disinfection by-products associated with surface water treatment, especially trihalomethanes (THMs). THMs, including chloroform, are known cancer-causing agents in animals and are produced as a by-product when chlorine disinfectants are used in source water containing naturally occurring organic matter.

The EPA published new federal regulations in December 1998 for disinfectants, disinfectant by-products, and microbial contaminants. The phase in of these new standards will regulate water constituents such as haloacetic acids and individual THMs. This action may affect water supply management decisions and create additional issues regarding the treatment and direct use of CAP water.

A combination of ozone and chloramine was chosen by the City of Tucson for CAP water treatment because it produces fewer THMs compared to chlorine, the disinfectant used by most water treatment facilities. Ozone is used to kill all viruses and bacteria in a single "shock" treatment. Ozone does not leave any residuals. Chloramine is a combination of chlorine and ammonia and is added in the final stages of treatment as a residual disinfectant to keep microorganisms from growing in the distribution system. For the Hayden-Udall CAP water treatment plant, the City set a disinfectant by-product standard of 20 micrograms per liter (μg/l) THMs as compared to the current EPA standard of 100 μg/l. The EPA has promulgated the Stage 1 Disinfectants/Disinfection By-products Rule in December 1998, which are more stringent than the current standards. Compliance dates for these rules begin three to five years after promulgation depending on the type of water system being regulated.

Many CAP water use alternatives have been recommended and include blending treated CAP water with groundwater, enhanced treatment of CAP water using membrane filtration, and implementing larger-scale recharge programs. Levels of TDS in CAP water range from about 650 to 750 milligrams per liter (mg/l), which is typically higher than TDS found in groundwater currently being pumped in most locations of the Tucson AMA. These and other alternatives raise significant technical and economic issues that will continue to be studied.

7.5.2.2 Effluent

Effluent is defined by A.R.S. § 45-101(4) as "water that has been collected in a sanitary sewer for subsequent treatment in a facility that is regulated pursuant to A.R.S. §§ 49-361 and 49-362. Such water remains effluent until it acquires the characteristics of groundwater or surface water." Sanitary sewers are comprised of any pipe or other enclosed conduit that carries any waterborne human wastes from residential, commercial, and industrial facilities. A.R.S. § 45-101(8).

Effluent treated at municipal wastewater treatment plants is a significant source of renewable water supply in the Tucson AMA. Although not suitable for human consumption without advanced treatment, effluent is suitable for turf irrigation, agricultural irrigation, sand and gravel washing, and several other industrial applications.

There are currently two wastewater treatment facilities that discharge effluent into the Santa Cruz River within the Tucson AMA boundaries. These facilities are the Roger Road Wastewater Treatment Facility and Ina Road Water Pollution Control Facility and are operated by the Pima County Wastewater Department. Segments of the Santa Cruz River downstream from the effluent discharges have perennial or continuous flows as a result of these discharges. Wastewater discharges to waters of the United States require an NPDES permit and an APP to ensure that water quality standards are being met.

Secondary effluent, which is treated to NPDES permit standards, usually contains TDS, nitrate, sulfate, metals, and bacteria at concentrations higher than those present in public water supply systems with groundwater sources. A portion of the secondary effluent is treated to a higher standard by filtering and disinfection and is directly delivered for non-potable uses in the Tucson AMA. Wastewater reuse rules are developed by ADEQ and establish parameters for wastewater reuse options.

Constructed wetlands can be developed to further enhance the treatment of effluent and to pretreat water prior to recharge or reuse. Vegetation and microbial activity in wetlands along with filtration of effluent through the vadose zone (soil aquifer treatment) improves the quality of water containing high concentrations of nitrate and organic carbon. Constructed wetlands are occasionally used as a treatment for lower quality surface waters and agricultural return flows. Wetland projects are also being evaluated to determine their effectiveness as an enhanced TT to bring effluent discharges into compliance with potentially more stringent NPDES permit requirements. In addition to improving water quality, wetlands enhance wildlife habitat and serve as an educational and recreational resource for the community.

7.5.2.3 Surface Water Other Than CAP Water

Most streams in the Tucson AMA are ephemeral or intermittent. Because in-stream channel flows are typically short-term and occur in response to runoff from precipitation events, the direct use of surface water is limited. The surface water supplies other than CAP are an important source of natural aquifer recharge in the Tucson AMA. Although relatively few surface water quality samples have been taken, water from this source often contains bacteria, parasites, and/or viruses. Municipal and industrial storm water runoff may also contribute to surface water contamination. In order to address contaminants in storm water runoff, the NPDES storm water program was developed to specifically control the amount of storm water pollutant discharges to waters of the United States.

7.5.3 Groundwater Supplies

Groundwater is one of the most important sources of water in Arizona. Most of the groundwater supplies in the Tucson AMA are of acceptable quality for most uses. However, some groundwater areas have been degraded as a result of contamination.

The introduction of contaminants into aquifer systems degrades groundwater quality and threatens public health and the environment. Contaminants can migrate into areas of potable groundwater supplies due to groundwater pumping or regional groundwater flow patterns. Many areas of the Tucson AMA are projected to remain dependent on groundwater pumping, thereby potentially causing migration of contaminants. The Department's role in managing potential contaminant migration is through involvement in site-specific and non site-specific water quality management.

Groundwater that has been degraded has limited beneficial uses due to chemical, biological, or radiological contamination and may have high treatment and delivery costs associated with its use. Despite these limitations, the Department considers poor quality groundwater to be a valuable resource for future water management and encourages appropriate uses of this water supply. Matching the highest beneficial use with poor quality groundwater is an important aspect of water management. Frequently, poor quality groundwater is remediated and re-injected into the aquifer because it is not economically feasible to convey the treated water to another location for a higher beneficial use.

The Central Arizona Groundwater Replenishment District, the Arizona Water Banking Authority (AWBA), and other entities are actively pursuing recharge of excess CAP water within the Phoenix, Pinal, and Tucson AMAs. The impacts of CAP water recharge on existing groundwater quality are not fully understood at this time. Recognizing that there may be groundwater quality impacts resulting from surface water recharge, the EPA requires states to develop a rule for groundwater under the influence of surface water. ADEQ has proposed a rule (A.A.C. R18-11-405), currently under public review, which would require that groundwater under the direct influence of surface water withdrawn from recharge facilities undergo more extensive treatment than groundwater. These filtering and disinfection requirements are cost factors for the development and operation of underground water storage facilities. See Chapter 8, section 8.3.4, for further discussion of recharge water quality issues.

7.5.4 Groundwater Constituents and Their Impacts on Water Quality Management

The management of water resources requires an understanding of how water quality impacts aquifer conditions and potential uses. Drinking water quality regulations are developed to ensure that the intended use will not have harmful impacts on human health. The Department and ADEQ evaluate water quality based on ADEQ's numeric and narrative AWQSs as well as EPA's primary and secondary MCLs, commonly expressed as mg/l or µg/l. Appendix 7A provides a detailed list of the primary MCLs for VOCs, pesticides, inorganic metals, radiochemicals regulated under the Arizona Drinking Water Rules, and other selected contaminants. Appendix 7A also includes a brief description of the potential human health effects and sources of these contaminants in drinking water. Appendix 7B lists the secondary MCLs for selected contaminants. Secondary MCLs are non-enforceable aesthetic standards.

The following sections briefly describe the impact of selected constituents on groundwater management and public health. ADEQ's Arizona Water Quality Assessment was used as a reference for descriptions of the limitations on uses, present and planned remedial activities, and potential uses of poor quality groundwater for each constituent. Other sources used in the presentation of contaminant concentrations include the Department's Second Management Plan for the Tucson AMA, CAP water quality reports prepared by the Central Arizona Water Conservation District, Groundwater Reclamation Project Reports prepare for Air Force Plant Number 44 (AFP 44), and data contained in the 1994 Pima Association of Government's State of the Region Water Quality Report.

For most constituents, a corresponding map is provided that displays available water quality data for well locations sampled in the Tucson AMA since 1990. Well sites that produced test results within drinking water quality standards and in exceedance of current drinking water quality standards are displayed for each selected constituent. If multiple samples were taken at a monitor site, the most recent sample analyzed since 1990 is displayed.

The groundwater quality maps are the result of an interagency effort between the Department and the ADEQ. An interagency team retrieved and analyzed data from a variety of sources including the Department's Registry of Groundwater Rights and Groundwater Site Inventory databases, the ADEQ Groundwater Quality database, and a number of WQARF site project reports.

Other ADEQ databases, such as the Underground Storage Tank and Drinking Water Quality databases, were not used because they could not be integrated with the Department's databases. Consequently, the groundwater quality maps depicted in this section were made from the information that was available and compatible with the Department's well identification system.

The groundwater quality maps provide a general overview of water quality conditions within the AMA. These maps are provided for informational purposes and should not be referenced for site-specific groundwater quality conditions. Other reports that are published by the ADEQ and other sources may contain additional data that are not reflected on these maps.

7.5.4.1 Nitrate

Nitrates are salts formed from nitrogen compounds and are one of the most common groundwater contaminants detected in Arizona. Low nitrate concentrations in groundwater may originate from natural sources such as organic acids. Elevated nitrate levels are generally attributed to current and historic industrial sources, wastewater treatment plants, septic tanks and leach fields, agricultural fertilizers, and animal impoundments such as stockyards.

The primary MCL for nitrate can be expressed in two different ways. When nitrate is expressed as a concentration of nitrogen (N) in water, the primary MCL is 10 mg/l and it is termed nitrate-nitrogen. When nitrate is expressed as a concentration of nitrate (NO_3) in water, the primary MCL is 45 mg/l and is termed simply "nitrate." The primary MCLs of 10 mg/l of nitrate-nitrogen and 45 mg/l of nitrate are equivalent. Water containing high levels of nitrate cannot be delivered as a drinking water supply unless it is equal to or reduced below the primary MCL of 10 mg/l for nitrate-nitrogen. Adults can tolerate high levels of nitrate, although water containing more than several hundred mg/l of nitrate-nitrogen can cause gastrointestinal irritation. Water that contains nitrate in concentrations in excess of the primary MCL can be harmful to infants. Nitrate may also be harmful to livestock at levels exceeding several thousand mg/l.

Nitrate stimulates plant growth and is typically regarded as a desirable constituent for most agricultural and irrigated turf applications. For this reason, effluent is often sought as a source of irrigation water. Nitrogen fertilizer application rates may be reduced or eliminated if irrigation water contains elevated nitrate levels.

Figure 7-1 displays selected nitrate groundwater sample test data from sources as described in section 7.5.4. In the Tucson AMA, nitrate concentrations above the EPA primary MCL of 10 mg/l of nitrate-nitrogen (equivalent to 45 mg/l of nitrate) can be found in localized areas along the Santa Cruz River near Green Valley, Sahuarita, and northwest of Marana. In the Upper Santa Cruz Valley Subbasin, nitrate concentrations are lowest in aquifers underlying undeveloped desert. In the Avra Valley Subbasin, nitrate concentrations are lowest in the southern portion, in aquifers underlying undeveloped desert. Nitrate concentrations are highest in the northern portion of the subbasin along the Brawley Wash.

7.5.4.2 Sulfate

Sulfate can occur as a natural inorganic constituent of groundwater that originates from the natural dissolution of minerals in aquifers. Elevated concentrations can result from the leaching of industrial wastes and agricultural fertilizers. High sulfate concentrations are often found in aquifers underlying current or historic agricultural lands, mining areas, and areas of natural mineralization.

Figure 7-2 shows some of the locations of elevated sulfate conditions in the Tucson AMA, based on data collected as described in Section 7.5.4. Elevated sulfate levels, (which are not displayed), have also been detected in groundwater west of the Santa Cruz River near Green Valley where copper mine operations and natural mineralization occurs. The sulfate level for raw CAP water typically averages 242 mg/l, whereas the average groundwater concentration in the AMA is 48 mg/l.

The EPA has not established a primary MCL for sulfate. The EPA is scheduled to complete studies of the human health effects of sulfate and to decide whether to establish a drinking water MCL in August 2002. The secondary MCL for sulfate is 250 mg/l.

Elevated sulfate concentrations in drinking water supplies can cause problems due to taste and laxative effects and can lead to scale formation in evaporative cooling systems. The diverse nature of industrial water quality requirements creates specific needs for different industries. Some industries require very low sulfate levels while others can use water with elevated sulfate levels. High sulfate concentrations in groundwater do not commonly limit agricultural water use.

7.5.4.3 Total Dissolved Solids

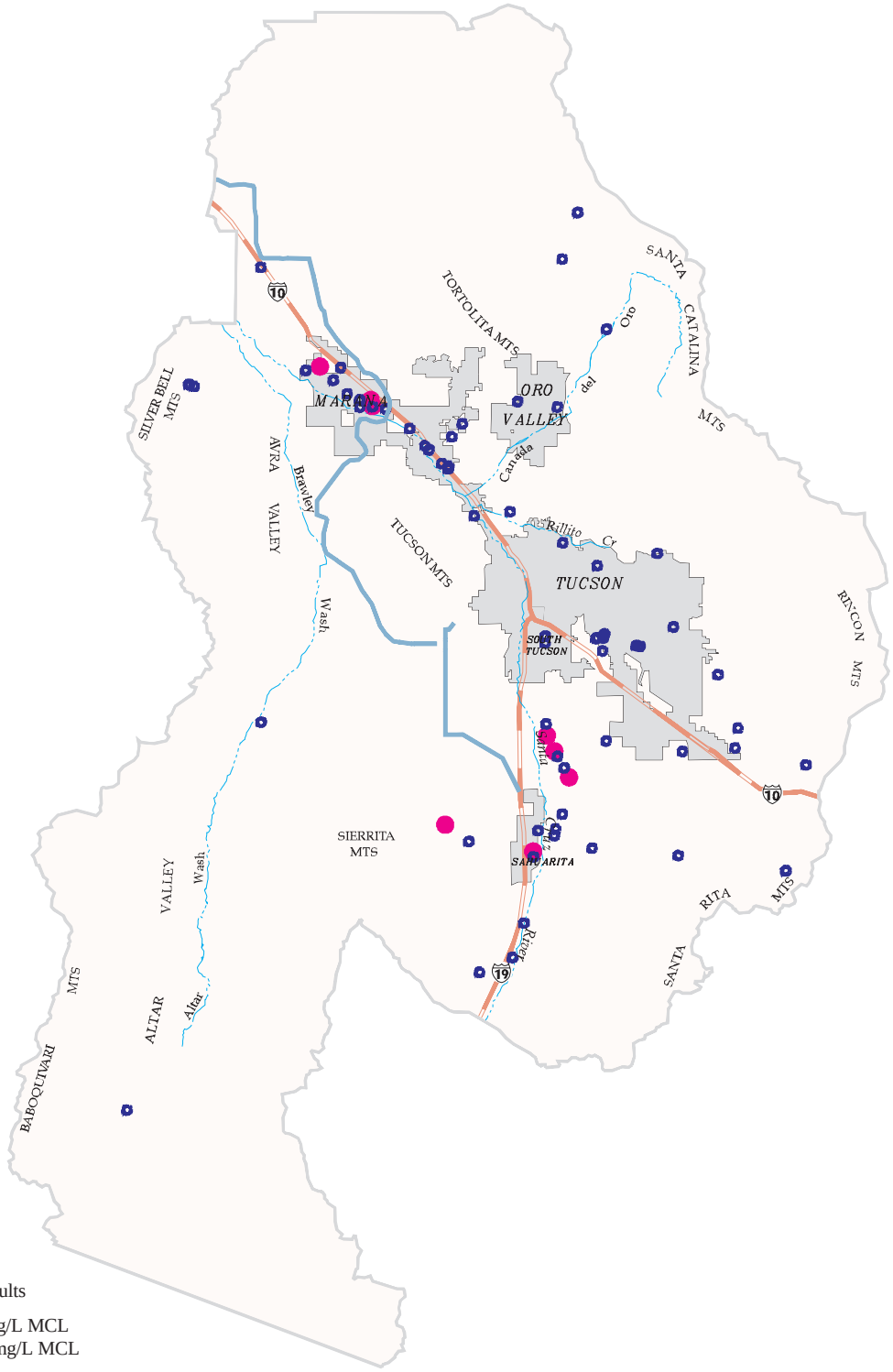
TDS content is a measure of the dissolved minerals present in water and is a general indication of inorganic water quality. Components of TDS include inorganic compounds such as calcium, magnesium, sodium, potassium, sulfate, bicarbonate, chloride, and silica. In most areas, the primary components of TDS are derived naturally as groundwater dissolves minerals present in aquifers. TDS concentrations can also be elevated by agriculture, industry, and wastewater treatment facility discharges.

The EPA has established a secondary MCL of 500 mg/l for TDS. High TDS concentrations, which result in scaling and mineral accumulation, can have an adverse economic impact on water distribution systems and household plumbing and appliances. Though no permanent harmful effects have been observed from drinking high TDS water, some people may find the taste of this water to be less desirable than lower TDS water.

TDS concentrations in the Tucson AMA are depicted in Figure 7-3. TDS levels up to 2,500 mg/l have been detected in groundwater near Green Valley and the mines and levels up to 600 mg/l have been detected downstream of agricultural activities in the northern portion of the Avra Valley Subbasin along Brawley Wash. The TDS content of most groundwater in the Tucson AMA is below or near the secondary MCL. TDS concentrations in the groundwater currently being withdrawn typically ranges from 200 mg/l to about 500 mg/l. Such concentrations present little restriction in the use of the potable groundwater supplies.

TDS concentrations in CAP water imported into the Tucson AMA range from about 650 to 750 mg/l. This has become an issue in the Tucson AMA because the concentration of TDS in CAP water is higher than the concentration detected in much of the current groundwater supply. As discussed in Chapter 8, there is concern about the potential impacts of CAP water on existing groundwater quality due to aquifer recharge and underground storage of CAP water.

The concentration of TDS that limits water use varies widely among industries. High TDS water is a primary concern of a few industries (such as the semiconductor industry) that require water so pure they must treat almost any source water to obtain the necessary quality. Other industries, such as sand and gravel operations, can use water with very high TDS concentrations. The application of water containing high concentrations of TDS on turf facilities can impact turf quality and clog irrigation sprinkler heads if proper management techniques are not followed.



Sample Test Results

- < 10 mg/L MCL
- >= 10 mg/L MCL

- Tucson AMA
- Incorporated Areas
- Roads and Highways
- Rivers and Streams
- CAP Canal

Figure 7- 1

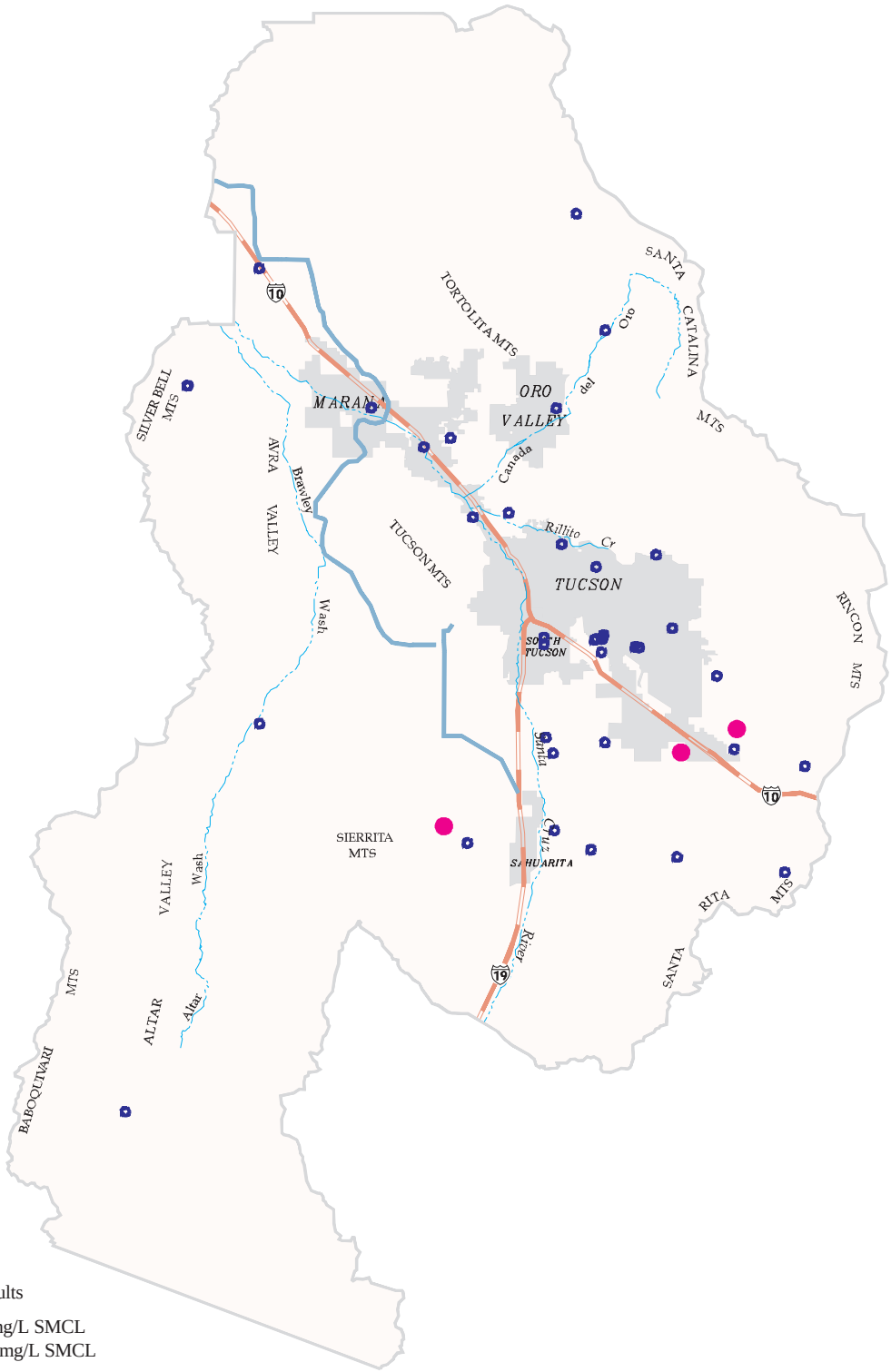
Water Quality Sample Test Results
Nitrate Nitrogen and Nitrite Plus Nitrate

0 3 6 9 12
Miles

North

ORIGINAL SOURCE

Arizona Dept of Environmental Quality:
Water Quality Database
Selected Well Locations and Water Quality Samples since 1990



Sample Test Results

- < 250 mg/L SMCL
- >= 250 mg/L SMCL

- Tucson AMA
- Incorporated Areas
- Streets and Highways
- Rivers and Streams
- CAP Canal

Figure 7- 2

Water Quality Sample Test Results

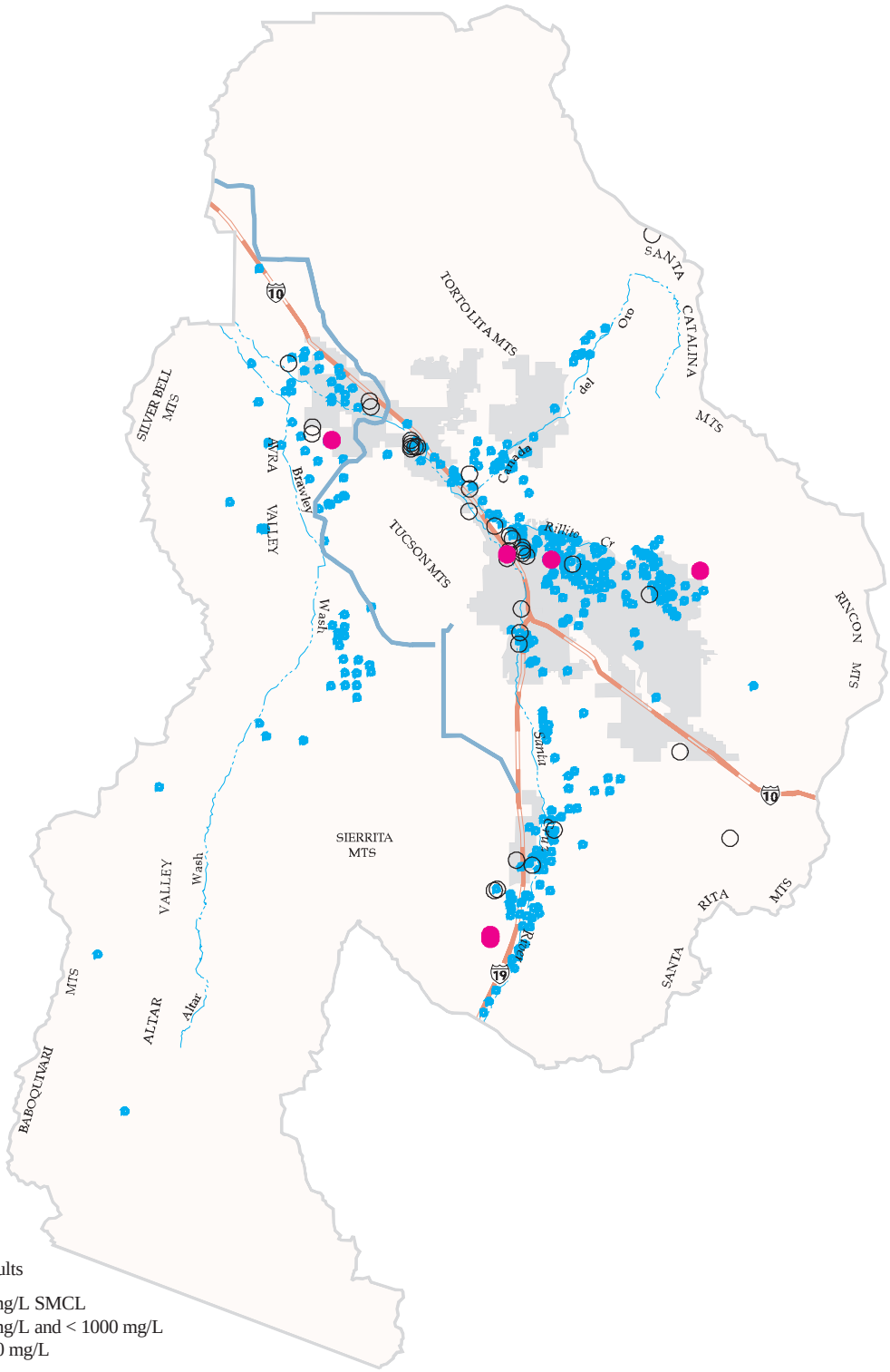
Sulfate

0 3 6 9 12
Miles

North

ORIGINAL SOURCE

Arizona Dept of Environmental Quality:
Water Quality Database
Selected Well Locations and Water Quality Samples since 1990



Sample Test Results

- < 500 mg/L SMCL
- > 500 mg/L and < 1000 mg/L
- >= 1000 mg/L

- Tucson AMA
- Incorporated Areas
- Streets and Highways
- Rivers and Streams
- CAP Canal

Figure 7- 3

Water Quality Sample Test Results
Total Dissolved Solids

0 3 6 9 12
Miles

North

ORIGINAL SOURCE

Arizona Department of Water Resources:
GWSI Well Locations
Selected Water Quality Samples since 1990

Calculated from Specific Conductivity

7.5.4.4 Metals

The EPA has designated 13 priority pollutant metals and has established primary MCLs for nine of the metals that occur in drinking water: antimony, arsenic, barium, beryllium, cadmium, chromium, mercury, selenium, and thallium. The primary MCL for nickel has recently been remanded for further review by the EPA. The EPA promulgated primary MCL goals and National Primary Drinking Water Rules for lead and copper in June of 1991. High concentrations of metals in groundwater are typically associated with industrial wastes. Some metals naturally occur in groundwater, depending on the geology of the aquifer and the geochemical equilibrium between aquifer materials and groundwater.

Most metals detected from groundwater samples in the Tucson AMA are naturally occurring and found in low concentrations. Figure 7-4 summarizes metal concentrations in the Tucson AMA based on the ADEQ Groundwater Quality Database as described in section 7.5.4. A few metals have been detected in groundwater samples associated with industrial waste disposal sites, airports, and mining areas. Silver, cadmium, chromium, lead, and selenium are present in high concentrations in the upper Santa Cruz Valley Subbasin in several isolated areas. Chromium above the primary MCL has been detected in the vicinity of the Tucson Airport and the Raytheon (formerly Hughes) Aircraft facility and has been decreasing with ongoing remedial activity. Concentrations of metals in exceedence of the primary MCLs have also been found in groundwater samples from a few wells in areas along the Santa Cruz River in the northern portion of the Santa Cruz Valley Subbasin.

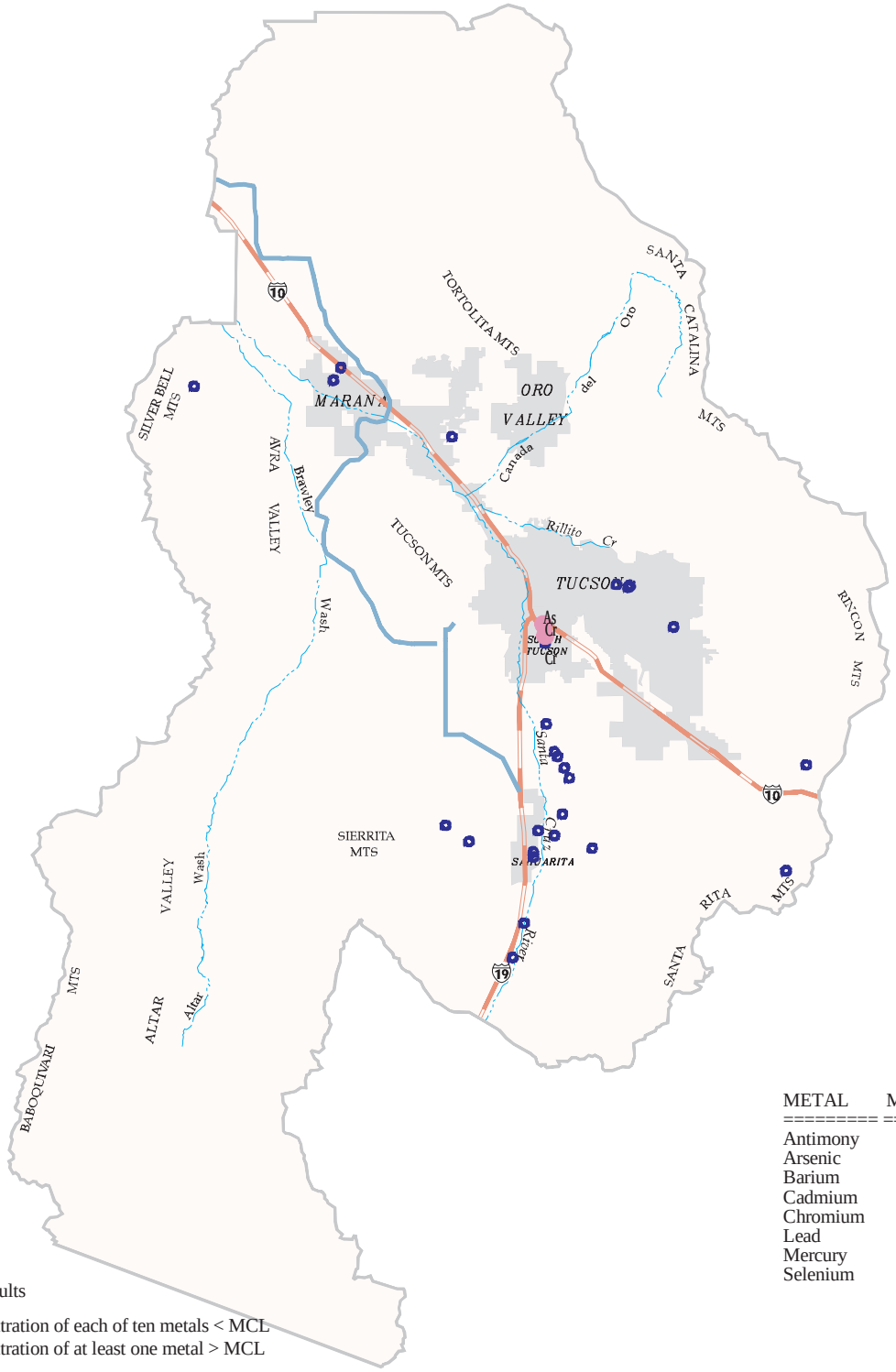
The health effects associated with exposure to metals vary depending on the constituent and concentrations. Some metals such as selenium and chromium are known to be essential for human nutrition and are beneficial in certain concentrations. Others, such as lead, have no known beneficial effects on human or animal development and are harmful in high concentrations. Limitations on industrial and agricultural use of water with high concentrations of metals varies considerably depending on the contaminant and the associated use.

7.5.4.5 Volatile Organic Compounds

VOCs, such as trichloroethylene (TCE) and tetrachloroethylene (PCE), are chemicals that evaporate easily but do not readily dissolve in water. Other common VOCs include acetone, vinyl chloride, 1,2-dichloroethane, benzene, 1,1-dichloroethylene, 1,1-dichloroethane, chloroform, toluene, and methylene chloride. VOCs are present in or are used for the manufacturing of many substances including degreasers, solvents, plastics, paint, varnish, finish removers, detergent, medicine, and gasoline. When found in groundwater, VOCs are usually associated with industrial areas, landfills, and other sites used for the improper disposal of chemicals.

Older landfills that were developed in gravel pits and other unsuitable sites are more likely to have leachate and VOC migration problems than modern landfills that are properly sited, constructed, operated, and closed. It is generally accepted that the transport of VOCs associated with older landfills is primarily caused by the downward percolation of leachate through the vadose zone to groundwater. However, recent work performed by the City of Tucson's Office of Environmental Management indicates that in arid landfills vapor transport of VOCs to groundwater also occurs. Continued research on this condition will be necessary to understand VOC transport and for determining appropriate remedial strategies.

VOC contamination has been found near the CERCLA and WQARF sites in the Tucson AMA. The largest area of known VOC contamination is located at the Tucson International Airport Area (TIAA) CERCLA site south of Tucson. This area is described further in section 7.5.5.7. Figure 7-5 displays VOC concentrations within the Tucson AMA.



METAL	MCL	
Antimony	6	g/l
Arsenic	50	g/l
Barium	2000	g/l
Cadmium	5	g/l
Chromium	100	g/l
Lead	15	g/l
Mercury	2	g/l
Selenium	50	g/l

Sample Test Results

- Concentration of each of ten metals < MCL
- Concentration of at least one metal > MCL

- Tucson AMA
- Incorporated Areas
- Streets and Highways
- Rivers and Streams
- CAP Canal

Figure 7- 4

Water Quality Sample Test Results

Metals

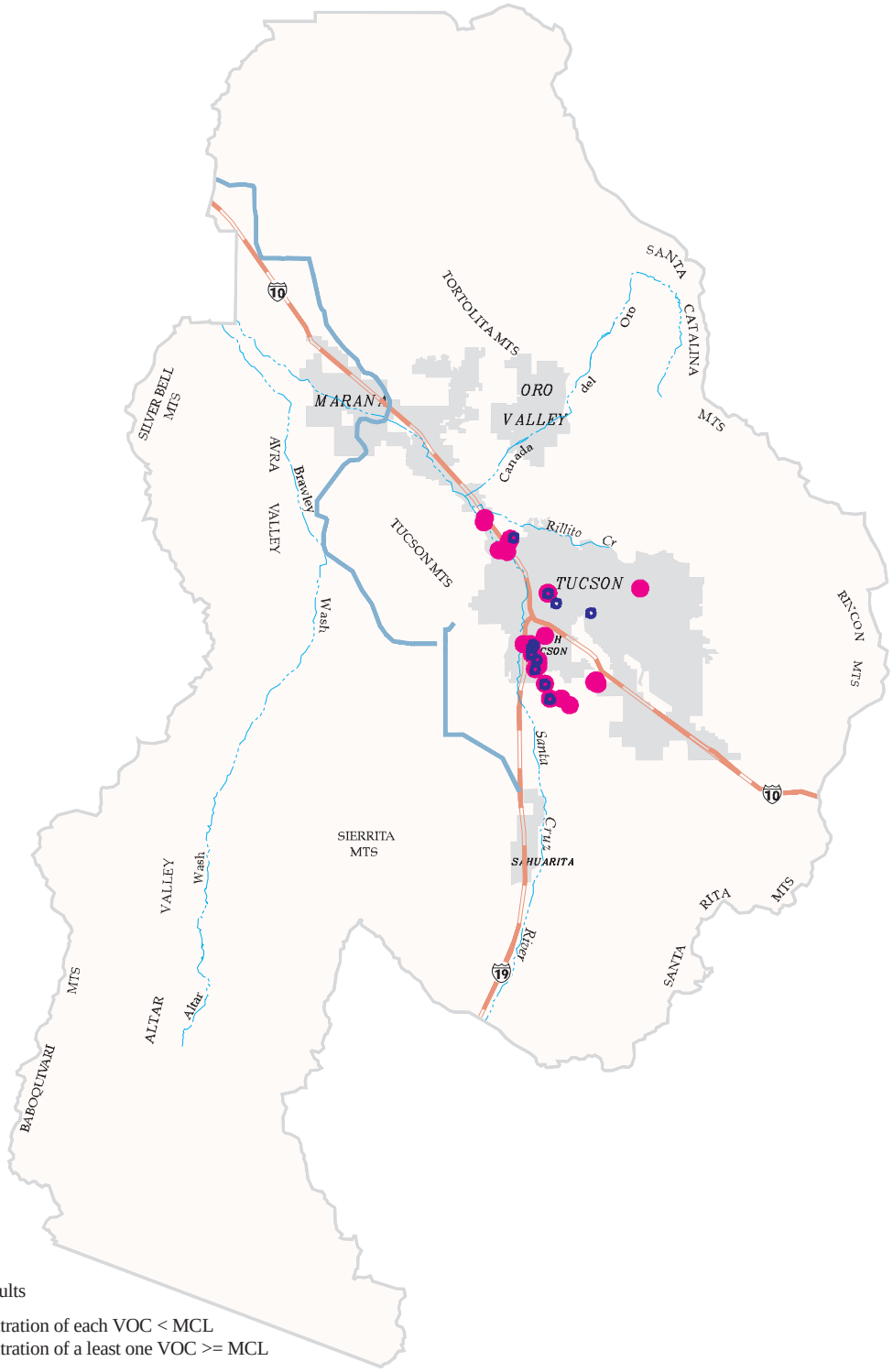
0 3 6 9 12 Miles

North

ORIGINAL SOURCE

Arizona Dept of Environmental Quality: Water Quality Database

Selected Well Locations and Water Quality Samples Since 1990



Sample Test Results

- Concentration of each VOC < MCL
- Concentration of a least one VOC >= MCL

- Tucson AMA
- Incorporated Areas
- Streets and Highways
- Rivers and Streams
- CAP Canal

Figure 7- 5

Water Quality Sample Test Results
Volatile Organic Compounds

0 3 6 9 12
Miles

North

ORIGINAL SOURCE

Arizona Department of Water Resources:
Registered Well Locations

Arizona Dept of Environmental Quality:
Water Quality Database
Selected water quality samples since 1990

Health effects associated with VOCs in drinking water are complex and vary with the types of compounds and concentrations present. Some VOCs, such as TCE, are suspected human carcinogens while others have been associated with damage to internal organs. Drinking water supplies that exceed primary MCLs for VOCs must be treated prior to use.

The use of water containing VOCs for industrial and agricultural applications must be examined on an individual basis. Treatment processes for the removal of VOCs must be adequate to meet the intended use of the remediated water. Air quality regulations also need to be considered prior to the use of water contaminated with VOCs.

7.5.4.6 Petroleum Hydrocarbons

This class of contaminants includes non-halogenated hydrocarbons such as benzene, toluene, ethylbenzene, and xylenes, which are ingredients of gasoline and other fuels. These constituents are incorporated into the VOC concentrations in Figure 7-5. Primary MCLs have been established for the main ingredients in gasoline and other fuels.

Leaking underground fuel storage tanks and distribution systems are a common source of groundwater contamination by petroleum hydrocarbons. According to ADEQ, there are over 5,700 reported leaking UST systems in Arizona. Many of these leaking USTs have been investigated and remediated.

Contaminants from leaking USTs in the Tucson AMA are usually detected in the soil area above the aquifer and only a small percentage of these sites have caused groundwater contamination. Furthermore, petroleum hydrocarbons in groundwater may naturally reduce over time depending on the physical, chemical, and microbiological conditions in the aquifer.

In 1998, there were 445 registered active UST facilities in Pima County. Many other UST facilities have been closed. ADEQ's database for Pima County indicates that, of these 445 sites, there are approximately 312 open investigation cases of reported releases from UST systems. Most of these reported release sites are located within the Tucson AMA. Many of the reported releases have been discovered during closure or upgrade of older UST systems. The risk of groundwater contamination from UST system releases will decrease significantly as UST systems come into compliance with federal regulations for system construction, inventory monitoring, and leak detection, and as the older systems are closed.

As of 1996, there were 37 leaking UST sites identified as contributing to groundwater contamination in the Tucson AMA. Most of these leaking systems are associated with gasoline stations and with commercial and industrial sites. The sites identified have varying degrees of groundwater contamination and are in various stages of remediation.

7.5.4.7 Pesticides

Pesticides are synthetic and natural organic chemicals that are used as insecticides, rodenticides, and herbicides. Pesticides may be detected in groundwater underlying areas irrigated for agriculture and turf grass. Municipal water providers were required by the SDWA to begin quarterly testing for pesticides in 1994 for a period of one year. Testing for pesticides is repeated every three years. This process has shown minimal pesticide detections, and to date, pesticide contamination of groundwater has not been a major concern in the Tucson AMA. Although pesticide sampling has been limited, better analysis of the occurrences of pesticides in groundwater will be made as more data becomes available. Many pesticides have low mobility and are usually contained near the ground surface of soil profiles.

The health effects of pesticide exposure in water are varied and complex, depending on both the pesticide's inert and active ingredients and reaction with substances contained in the water. The presence of pesticides can restrict some industrial and agricultural water uses such as animal-based industries and vegetable production because elevated concentrations of pesticides may bioaccumulate (accumulate in living tissue) as they are passed through the food chain.

7.5.4.8 Fluoride

Fluorides are compounds found in rocks and soil and some industrial waste products. Fluorides are used primarily in manufacturing and as a drinking water additive for the prevention of tooth decay. Fluoride occurs naturally in groundwater; however, the acceptability of water containing fluoride for domestic or municipal use depends on the concentration level.

The average fluoride level in Tucson area groundwater is about 0.4 mg/l and in CAP water it is about 0.3 mg/l. Fluoride concentrations in the Tucson AMA are shown in Figure 7-6. An optimal fluoride concentration of 0.8 mg/l in drinking water is recommended for the prevention of tooth decay. However, elevated concentrations can cause mottling of teeth and skeletal effects. Fluoride is not currently added to Tucson area water supplies. The EPA primary MCL for fluoride is 4.0 mg/l and the recommended secondary MCL is 2.0 mg/l to prevent mottling of teeth.

7.5.4.9 Radiochemicals

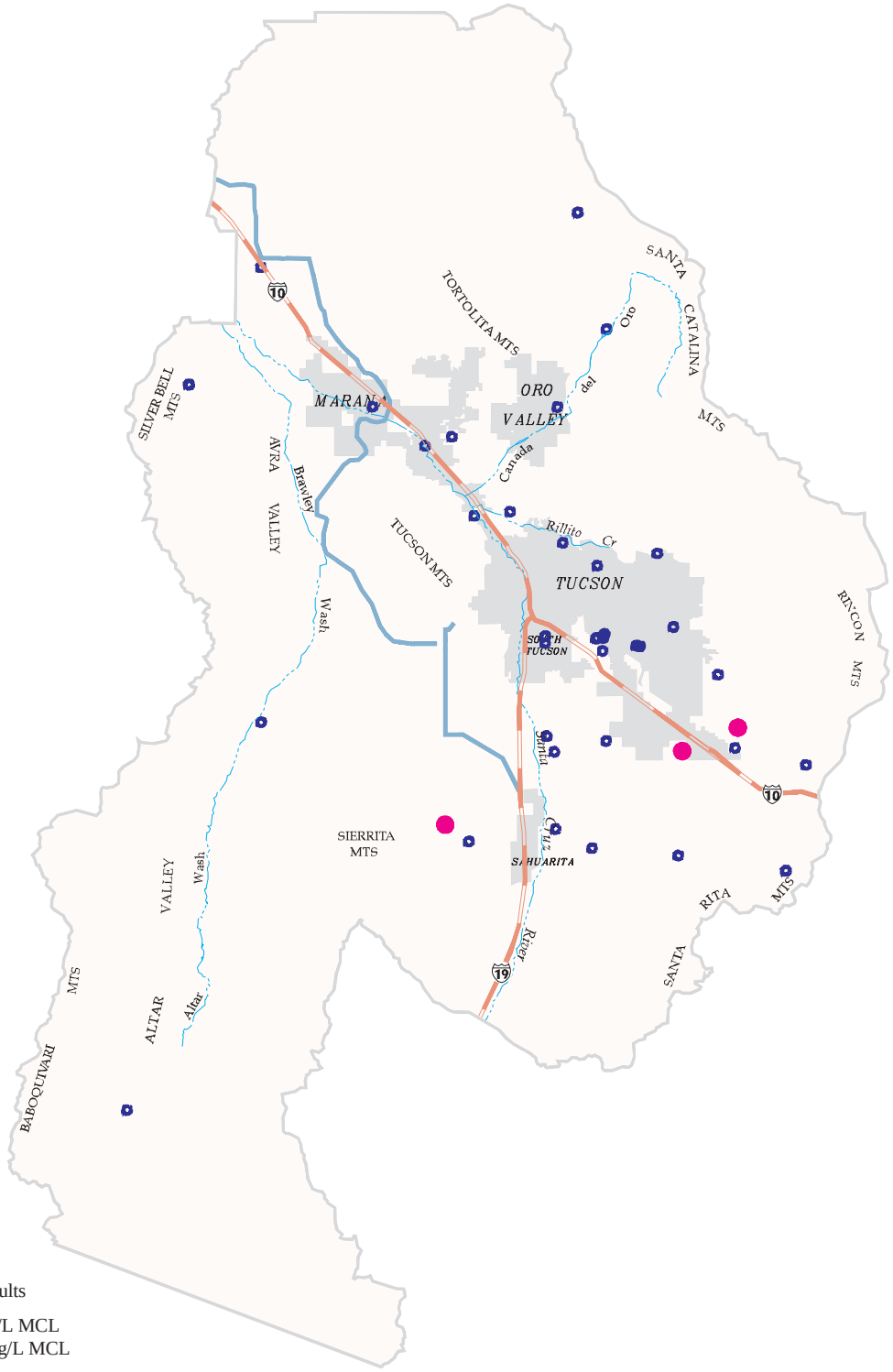
Radioactive elements such as uranium, radon, and radium occur naturally in soil and water at locations throughout Arizona. The federally proposed primary MCL for radon is 300 picocuries per liter, but radon in groundwater is not regulated at this time. The EPA is currently collecting data on radon occurrences and conducting a health effects study prior to promulgating a radon standard for drinking water. Inhalation of radon may be harmful when it is released to the air from a contaminated water source. The primary concern when using radon-contaminated water is to ensure that emissions are below air quality standards when processes such as cooling towers, construction aggregate washing, and sprinkler irrigation are used.

Radon occurrences in the Tucson AMA are primarily a result of naturally occurring uranium-rich lacustrine limestone deposits. In areas south of Tucson, radon at 200 to 1800 picocuries per liter have been detected in 87 wells according to ADEQ. Ranges from 500 to 1400 picocuries per liter has been detected in the central Tucson groundwater basin. Since regional data were not available for radiochemicals, groundwater quality maps depicting these concentrations were not produced for this chapter.

7.5.5 <u>Specific Contamination Areas</u>

This section contains a description of some of the specific groundwater contamination areas that have been identified in the Tucson AMA. Unless otherwise indicated, each of these sites are listed on the WQARF Priority List or the NPL. Figure 7-7 shows WQARF, CERCLA, or Department of Defense remedial site boundaries located within the Tucson AMA. It should be noted that the areas shown on this map are the designated site boundaries and do not necessarily indicate the extent of groundwater contamination.

WQARF sites throughout the state have been scored based on criteria developed by ADEQ. In the Tucson AMA, the El Camino del Cerro area, Miracle Mile Interchange area (including Silverbell Jail Annex), Park-Euclid site (Mission Linen), and the Broadway-Pantano site have each been ranked in the top ten sites statewide. The scores assigned to WQARF sites may change as more site-specific information becomes available and is evaluated by ADEQ. A summary of individual remedial sites in the Tucson AMA is



Sample Test Results

- < 4 mg/L MCL
- >= 4 mg/L MCL

- Tucson AMA
- Incorporated Areas
- Streets and Highways
- Rivers and Streams
- CAP Canal

Figure 7- 6

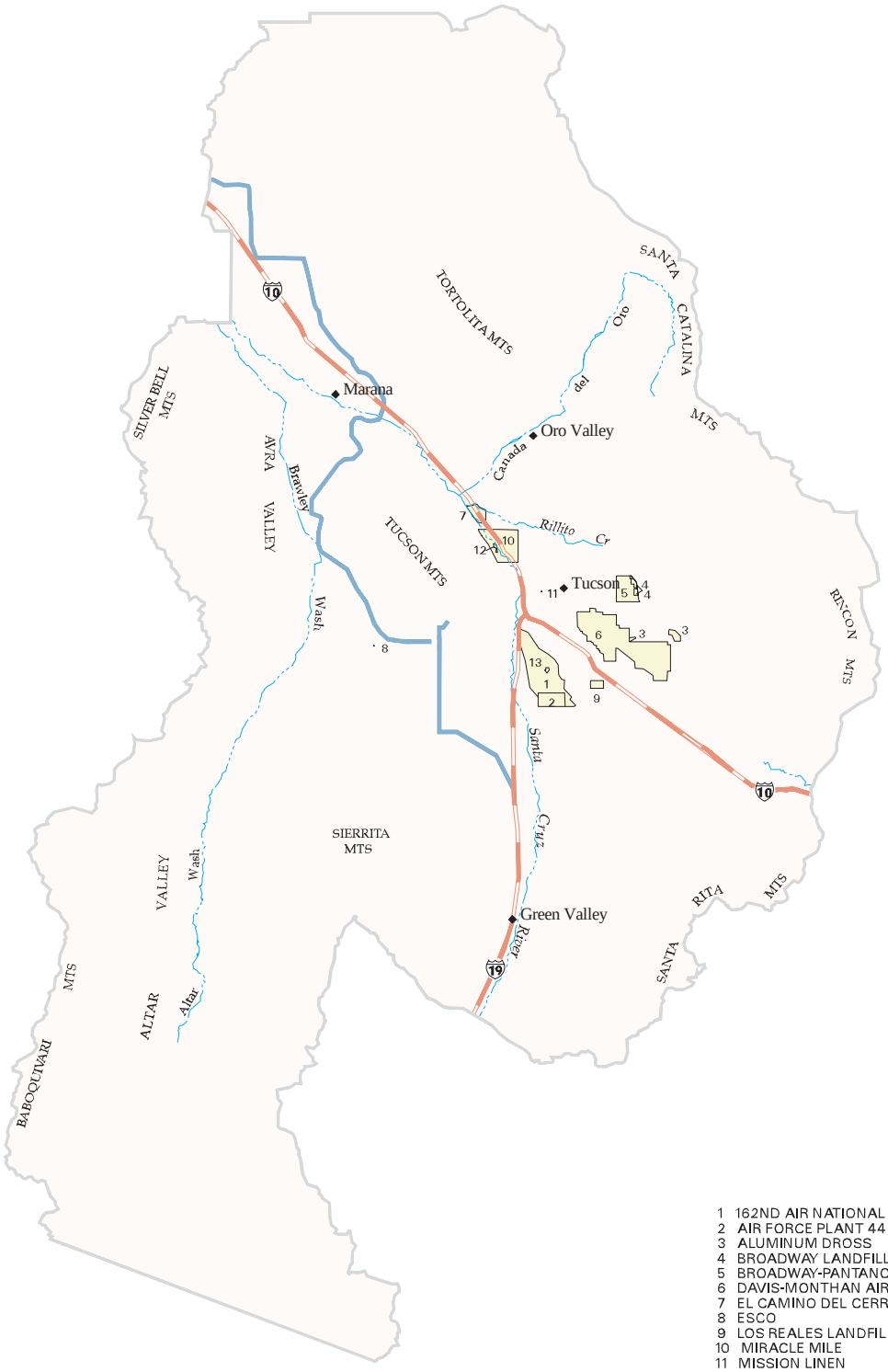
Water Quality Sample Test Results
Fluoride

0 3 6 9 12
Miles

North

ORIGINAL SOURCE

Arizona Dept of Environmental Quality:
Water Quality Database
Selected Well Locations and Water Quality Samples since 1990



1 162ND AIR NATIONAL GUARD
2 AIR FORCE PLANT 44
3 ALUMINUM DROSS
4 BROADWAY LANDFILL TUCSON
5 BROADWAY-PANTANO AREA
6 DAVIS-MONTHAN AIR FORCE BASE
7 EL CAMINO DEL CERRO AREA
8 ESCO
9 LOS REALES LANDFILL
10 MIRACLE MILE
11 MISSION LINEN
12 SILVERBELL LANDFILL
13 TUCSON INTERNATIONAL AIRPORT AREA

Tucson WQARF Sites
Tucson AMA
Interstate Highways
Rivers and Streams
CAP Canal
Cities

Figure 7- 7

Selected Water Quality Study Areas

0 3 6 9 12
Miles

North

ORIGINAL SOURCE
Arizona Dept of Environmental Quality

provided below. Information on the description and status of remedial sites was obtained from ADEQ's Southern Regional Office, City of Tucson's Office of Environmental Management, Davis-Monthan Air Force Base's Management Action Plan, and the Pima Association of Government's 1994 State of the Region Water Quality Report.

7.5.5.1 El Camino Del Cerro Area

The El Camino del Cerro Study Area is located in northwest Tucson between the Santa Cruz River on the west, Shannon Road on the east, the Rillito River on the north, and El Camino del Cerro Road on the south. The El Camino del Cerro Study Area Landfill occupies approximately 20 acres of land located on the southwest corner of the study area. This site was placed on the WQARF Priority List on May 23, 1995.

VOC contamination has been detected in several wells used for domestic, commercial, industrial, and public drinking water supplies. These wells are located north and northeast of the site and are no longer used for drinking water supplies. Approximately 23 different VOCs and several trace metals have been detected in groundwater around the site. Pima County has been conducting groundwater monitoring in the El Camino del Cerro Study Area for VOCs, trace metals, and general minerals. Eight of the 25 wells sampled in January of 1998 indicated VOC levels above the primary MCL. PCE was detected as high as 160 μg/l and TCE as high as 85 μg/l. The primary MCLs for PCE and TCE are each 5 μg/l.

In addition to groundwater sampling, data are being collected within the El Camino del Cerro Study Area from soil vapor sampling probes and will be used to evaluate potential contamination sources and remedial actions.

7.5.5.2 Miracle Mile Interchange Area/Silverbell Jail Annex Landfill

The Pima County Health Department discovered VOCs in groundwater near the Miracle Mile/Interstate 10 interchange during the fall of 1983. The southern boundary of the VOC contamination is just south of Miracle Mile Road and the northern limit is slightly over two miles to the northwest (downgradient), near Wetmore Road. In the vicinity of Prince Road, the east-west width of the contamination is approximately two miles. ADEQ is monitoring this site quarterly and as of the third quarter of 1996, results indicated that VOCs and metals were present above the primary MCLs in several wells. The highest detected contamination was TCE at 17 μg/l, and chromium at 200 μg/l. The primary MCL for TCE is 5 μg/l and is 100 μg/l for chromium. The Miracle Mile site was placed on the WQARF Priority List on November 13, 1987.

Inorganic groundwater quality in the Miracle Mile interchange area is apparently naturally poor. High TDS, sulfate, and chloride concentrations have been present at least since the 1920s. The area also has had an elevated nitrate zone since the 1950s.

There are eight identified possible contamination sources in the southern plume area including six industrial sites and two landfills. The Silverbell Jail Annex landfill was owned and operated by the City of Tucson between 1966 and 1977. The landfill appears to have contributed to VOC contamination of the groundwater. Another landfill was operated by the University of Arizona at the Agricultural Center on the east side of the Santa Cruz River and is a potential source of PCE and freons found in groundwater. The Miracle Mile contamination has affected two public-supply wells serving mobile home parks. Groundwater samples taken in this area in November, 1997, had concentrations of PCE as high as 16 μg/l and TCE at 13 μg/l. No other wells tested detected levels above the primary MCLs for PCE and TCE. Benzene and chromium above the primary MCL have each been detected in the study area.

The City of Tucson has completed a pilot study on the effectiveness of a vertical circulation well for the removal of chlorinated hydrocarbons in the groundwater at the Silverbell Jail Annex. This method eliminates the need to pump the contaminated groundwater to the surface for treatment and disposal, thereby preventing unnecessary groundwater depletion. This process is currently being reviewed to determine if a vertical circulation system should be implemented in place of the pump and treat system originally proposed in the 1995 RAP.

7.5.5.3 Tucson Urban Study Area

Groundwater investigations by the Arizona Department of Transportation and ADEQ in the vicinity of downtown Tucson have produced evidence of wide-spread petroleum contamination and VOC contamination in some wells. Diesel fuel was found in 1964 during the drilling of two Tucson Water wells just north of the downtown area. There is concern that some of the existing wells could be providing a conduit between the perched and regional aquifers creating a pathway for contaminant migration. Additional assessment and investigation work needs to be completed to determine the extent of the contamination.

Diesel fuel is the most widespread contaminant in the Downtown area and appears to be generally confined to the perched aquifer. However, diesel has been found in the regional aquifer at the Mission Linen dry-cleaning facility and in three Tucson Water wells. ADEQ has indicated that Southern Pacific Transportation Company (presently owned by Union Pacific) is a likely source of the diesel contamination. Other sources include the Continental Trailways bus station, which was reported to have a leaking UST.

Chlorinated VOCs such as TCE and PCE are present in more localized areas. The highest concentrations of chlorinated VOCs in the regional aquifer were found in a well at Mission Linen. Concentrations of PCE were reported up to 11,000 µg/l. Benzene, trichloroethane (TCA), and other VOCs were also detected. The extent of contamination is still under investigation. PCE has been detected in the deeper aquifer and new monitoring wells indicate concentrations of PCE up to 630 µg/l and lower levels of TCE and dichloroethylene (DCE) in the uppermost regional aquifer.

Other areas noted to have groundwater contamination include gasoline in the perched groundwater and soils near the Yellow Cab facility (411 N. 5th Avenue) and benzene, toluene, and ethylbenzene detected from two monitor wells in the perched aquifer downgradient from the former Continental Trailways bus station (5th and Broadway).

7.5.5.4 Broadway - Pantano Study Area

The Broadway Landfill area is located on the City of Tucson's east side, north and south of Broadway Boulevard at Kolb Road. The Broadway Landfill was operated between 1959 and 1974 as a municipal sanitary landfill and is now closed. VOCs were detected in the groundwater in 1983. Analysis of groundwater samples collected at this site and downgradient of the landfill has detected concentrations of PCE and TCE.

In June 1995, the City of Tucson began monthly water quality monitoring in this area. In December, 1997, and January, 1998, TCE and PCE levels were detected above the 5 µg/l primary MCL in several of the area's wells. A Remedial Investigation to characterize the landfill and investigate potential sources of groundwater contamination in the vicinity of the Broadway North Landfill has been completed. Field investigation activities included a soil gas survey, soil borings, and the installation of three permanent deep soil vapor probes. Three groundwater monitoring wells were also installed and equipped with deep soil gas vapor probes. The final report identifies the landfill as a source of groundwater contamination and gas phase transport as the mechanism by which the VOCs moved from the landfill downward 325 feet to the regional aquifer.

7.5.5.5 Los Reales Landfill

Los Reales Landfill, owned and operated by the City of Tucson, is an active municipal sanitary landfill consisting of approximately 320 acres in southeast Tucson. The landfill site has been in operation since the early 1970s. Approximately five acres in the southeast corner of the landfill were designated for hazardous waste disposal from 1977 to 1980. The hazardous waste area has been closed, leveled, and fenced in.

Analyses of water samples collected from monitor wells installed at the site as part of the remedial investigation detected several VOCs including PCE, TCE, dichloroethane, DCE, methylene chloride, and dichlorodifluoromethane (freon-12). PCE and TCE concentrations from these test sites have exceeded the primary MCLs for drinking water standards. Groundwater quality samples taken in 1997 from downgradient monitor wells (located northwest of the landfill) contained PCE concentrations as high as 30.8 μg/l and TCE at 14 μg/l. Water samples taken from upgradient wells have not had detectable levels of VOCs.

Studies conducted by the City of Tucson have indicated that the contamination at the landfill site exists primarily in the upper portion of the aquifer. The City's Conceptual Design Plan for the landfill remediation was approved by ADEQ in September, 1997. The preferred remedial alternative is to pump, treat, and re-inject the treated water upgradient of the Los Reales Landfill. The final plan design is scheduled to be submitted to ADEQ in 1998.

No public-supply wells have been impacted by this plume. However, wells supplying drinking water to the Town and Country Mobile Home Park and the Ray Water Company are located 1.5 miles downgradient from the landfill.

7.5.5.6 Price Service Center

The City of Tucson's Thomas O. Price Service Center is located south of downtown Tucson, near the intersection of Park Avenue and Ajo Way. Petroleum-related contamination of soil and groundwater has been detected at this site where gasoline and diesel fuel were stored in 23 USTs. Employees at the facility discovered leaks in the storage system in 1989, and the tanks were emptied. The City refilled six of the tanks in 1991 but emptied them again when a tank was punctured and leaked about 8,000 gallons of diesel fuel. All of the tanks were removed in October of 1992.

The soil and shallow groundwater were sampled by the City in the fall of 1992. Contaminants found included benzene, toluene, and xylene, which are all common gasoline constituents. Benzene was detected in concentrations as high as 30,000 μg/l in one of the shallow monitoring wells containing fuel. The area of soil contamination is approximately 400 by 600 feet.

Numerous soil borings and monitor wells have been installed at this site. A corrective action plan has been submitted by the City to ADEQ addressing soil contamination and plans will be submitted to address shallow and deep groundwater contamination.

7.5.5.7 Tucson International Airport Area

The TIAA CERCLA site is the only federal Superfund site in the Tucson AMA. The TIAA consists of a number of major project areas with groundwater contamination, particularly VOCs. Groundwater contamination in the TIAA is characterized as one major plume and two smaller plumes. The major plume is more than four miles long and one-half mile wide and extends from the United States AFP 44 facility to slightly north of Irvington Road. The plume is oriented along the groundwater flow gradient to the north-

northwest. The two smaller plumes are located east of the major plume north of the Tucson International Airport. Both of these plumes are less than one-half mile in diameter and length.

The regional aquifer in the area is divided into an upper zone and a lower zone separated by a 100 to 160-foot thick clay aquitard that impedes the flow of water between the two zones. The aquitard pinches out in the northwest, resulting in an undivided regional aquifer. Most of the contamination in the major plume is within the upper zone of the regional aquifer, although in the northwest area of the plume the contamination has spread beyond the edge of the clay aquitard and into the undivided regional aquifer. The two smaller plumes are primarily confined to the upper zone of the regional aquifer. Soil contamination is present in both areas.

TCE is the major detected contaminant in the plumes and other contaminants include 1,1-dichloroethylene; chloroform; benzene; xylene; and chromium. TCE has been detected in the main aquifer in concentrations as high as 2,700 µg/l near the AFP 44 site and 350 µg/l in the portion of the plume at the Tucson International Airport (north of Los Reales Road). In a 1992 Wellhead Protection study done by the Pima Association of Governments, 15 public-supply wells were identified as either closed or requiring treatment due to TCE contamination.

7.5.5.7.1 Tucson Airport Remediation Project

The Tucson Airport Remediation Project plume is being remediated through a pump-and-treat system that began operation in September of 1994. The 5,800 gallon per minute facility removes TCE from the water and distributes the treated water to the City of Tucson water system where it is blended with other groundwater supplies and delivered to Tucson's west side and downtown areas. This treatment process has been very effective, with no detections of TCE in the blended water supply since the City of Tucson began delivering remediated water to customers. Although the Water Consumer Protection Act of 1995 precludes delivery of this water for potable purposes, no alternative use has been identified that is acceptable to all parties and consistent with the federal ROD required for this CERCLA site.

7.5.5.7.2 United States Air Force Plant 44 (Raytheon Aircraft Corporation)

The AFP 44 is located within the boundaries of the TIAA CERCLA site and is a subsite of the TIAA Superfund Site. AFP 44, which was operated by the Hughes Aircraft Corporation until 1997 and is currently operated by the Raytheon Aircraft Corporation, is a Department of Defense Installation Restoration Program (IRP) site. The groundwater investigation and ongoing groundwater cleanup are regulated under CERCLA. The RCRA Program has the regulatory lead in the soils investigation and remedial design for soil cleanup activities at the site. The EPA, in coordination with the ADEQ and the Department has initiated a Federal Facilities Agreement for AFP 44 to consolidate the regulatory requirements for soil and groundwater remediation.

Groundwater contamination was first detected in 1981 when the EPA conducted a preliminary investigation of groundwater conditions underlying AFP 44 that revealed elevated levels of several VOCs, including TCE. It is suspected that groundwater contamination by VOCs was present in this area as early as the 1950s as a result of historical waste management and disposal practices. The investigation revealed that the perched zone, which is located above and separated from the regional aquifer, contained levels of chromium, manganese, arsenic, iron, zinc, TCA, TCE, and DCE that were above background levels and in general above applicable EPA primary drinking water standards. The upper zone of the regional aquifer contained similar levels of these constituents. However, manganese, arsenic, and zinc concentrations did not exceed drinking water standards.

The remediation process used at AFP 44 is a "pump and treat" method followed by injection of the treated water back into the aquifer. The project includes a reclamation well field, a treatment plant, and a

monitoring program. The reclamation well field consists of 20 upper zone extraction wells, four lower zone extraction wells, and 19 injection (recharge) wells. Water is pumped from the extraction wells in the center of the plume and transported to the treatment plant, where metals and organics are removed using an air stripping process. When elevated chromium levels were detected in groundwater samples, the water was treated by ion exchange prior to going to the air strippers to remove the chromium. The ion exchange system was placed on standby in November, 1994 because chromium concentrations in all of the extraction wells were below the primary MCL of 0.1 mg/l. The treated water is recharged by well injection to the aquifer along the margins of the plume.

A Dual Phase Extraction (DPE) project began in August 1994. The DPE system is used with the groundwater pump-and-treat system to enhance the groundwater remediation program. The DPE system uses a vapor extraction blower unit to pull air under vacuum from the casing of a pumping, groundwater extraction well. The vacuum causes VOC's present in the soils just above the water table and in the dewatering section of the aquifer to evaporate and be removed with the air stream.

7.5.5.7.3 Arizona Air National Guard

The Arizona Air National Guard is currently treating a small groundwater plume at its Tucson facility. This site, also known as the 162nd Tactical Fighter Group, is a Department of Defense Facility. The plume has affected the facility's well. Groundwater sampled from this well was detected to have 14 μg/l TCE and a private well just off-site to the north was sampled at 7 μg/l TCE. A groundwater pump, treat, and re-injection system has been operating at this site since the spring of 1997.

7.5.5.7.4 Burr-Brown

The Burr-Brown site is located north of the airport and includes the property owned by Burr-Brown, an area immediately adjacent to the Burr-Brown property, and the area between the northern boundary of the property and Valencia Road. Groundwater extraction and treatment at the facility began in 1992 and uses air stripping technology. TCE contaminated groundwater is extracted at about 40 gpm and treated. The treated water is used at the facility for irrigation and industrial uses.

7.5.5.7.5 West-Cap

The former West-Cap of Arizona facility is located near the Burr-Brown site northeast of the Tucson Airport in an industrial and commercial area at 2204 East Elvira Road. Elevated levels of TCE and PCE were detected from an off-site source during groundwater monitoring efforts at the Burr-Brown and Arizona Air National Guard facilities. EPA investigations determined that the off-site source is from the former West-Cap of Arizona facility. Contaminant migration will be controlled through groundwater extraction at the West-Cap site. Current remedial plans include the installation of one extraction well and two monitoring wells. The extracted groundwater will be connected to the groundwater treatment plant at the Burr-Brown facility. Groundwater monitoring and investigations will continue at this site to determine the extent of contamination.

7.5.5.7.6 Soils Restoration Program

The Soils Restoration Program is ongoing at six IRP sites within AFP 44. Soil Vapor Extraction (SVE) is being used at three of these sites to remove VOCs in the soils. Soil excavation techniques are being used at the other three sites to remove heavy metal contaminants, which are disposed off-site at a RCRA landfill.

7.5.5.8 Davis-Monthan Air Force Base

Davis-Monthan Air Force Base began its IRP investigations and site assessments in the early 1980s. As a result, 47 sites at the base were identified as areas of concern. Subsequent investigations have indicated that many of these sites have no confirmed contamination or have been evaluated and determined to be of no significant threat to humans or the environment. Some of these sites may be revisited prior to ADEQ granting final site closure. Current concerns have been narrowed to approximately four activities that are described in more detail below.

Long-term monitoring is being conducted to confirm that there are no significant groundwater quality problems associated with various sites within the base. Monitor wells located in proximity to sites that are under a "no action status" are also being closely monitored.

A jet fuel leak was detected at the J3 Pumphouse (Site 35) in March 1985 and the pipe leak was repaired in June of that year. Nine groundwater monitoring wells were installed and sampled. Levels of petroleum compounds in excess of the federal primary MCLs were detected in water samples collected from two of these wells. The groundwater level in this area is about 300 feet below land surface and both the soil and groundwater have been contaminated by the fuel. In 1990, the groundwater contamination extended approximately 60 feet to the northeast of the leak. The contamination has not affected public supply wells. Remedial activities are operating at Site 35 and includes the operation of a groundwater treatment system, an SVE system, and bioventing. Long-term operation of this remedial site is expected.

The Site 1 Landfill, which was used from the early 1940s to 1976, covers approximately 17 acres in a 35-foot deep pit. The landfill was used for the disposal of household garbage, metals, cars and aircraft, thinners, solvents, pesticides, and other items. The pit was filled to about 20 feet below grade and covered with soil. The remedial plan for this site is to cap the landfill to prevent leaching.

Site 47, referred to as the DRMO (Defense Reutilization and Marketing Office) yard consists of two waste pits and a french drain. The waste pits contain approximately 100 cubic yards of contaminated soil, waste and ash and the french drain contains approximately 50 cubic yards. It is believed that the wastes at this site were from aircraft recycling. An Interim Removal Action to cap the waste in place was completed in August of 1997. No further remedial action is expected at this site.

7.6 THIRD MANAGEMENT PLAN PROGRAM SUMMARY

Most groundwater supplies in the Tucson AMA are of acceptable quality for most uses. However, human activity and natural processes have resulted in the degradation of groundwater quality in some areas to the extent that it is unusable for many purposes. The extent and type of contamination varies by location and land use activities. In general, contaminated groundwater in the Tucson AMA is caused by human activity. VOCs are a predominant contaminant in the Tucson AMA and limit the direct use of some groundwater. Remedial processes are used to treat VOC contaminated water to drinking water quality standards making this water available for either current or future direct potable use. Water supplies contaminated with other constituents must also be properly treated prior to use for drinking water supplies. Beneficial end uses of lower quality water can be identified but must be economically feasible.

As WQARF activities progress, addressing water management issues such as available supply and reuse options will become essential to ensure a long-term water supply of adequate quality. The ability to recognize specific groundwater management requirements for contaminated and degraded aquifer conditions will also become increasingly important as the demand for water increases.

During the first and second management periods, ADEQ emphasized pump and treat remedies to cleanup poor quality groundwater in aquifers within the AMA. Success was limited, however, due to lengthy

periods of litigation that have restricted actual cleanup activities. With the advent of the WQARF reform package of 1997, a new approach emphasizing incentives to cleanup and flexibility in the selection of remedies was developed to improve the likelihood that sites will actually be remediated.

The 1997 WQARF reform legislation creates an incentive for the use of groundwater withdrawn in accordance with approved remedial action projects pursuant to Title 49, Arizona Revised Statutes, or CERCLA. It provides that such groundwater must be accounted for consistent with accounting procedures used for surface water conservation requirements and that the use of certain volumes of such groundwater is consistent with achievement of the management goal of the AMA until the year 2025. During the third management period, the Department will amend its AWS Rules to conform to these provisions. Additionally, permanent rules regarding well spacing and impact will be promulgated by the Department during the third management period. The Department also intends to integrate water quality concerns more fully into its underground water storage programs.

During the third management period, the Department intends to enact and implement the provisions outlined in this chapter. This commitment will encompass the new provisions and activities summarized below.

- An ongoing groundwater quality assessment in cooperation with ADEQ will assist with the evaluation of existing rules and provisions and provide better data to the public.

- Integration of groundwater quality management into recharge planning and permitting, and development of incentives to use remediated groundwater where appropriate.

- Formal permit coordination with ADEQ to cooperate on both Title 45 and Title 49 permits. Basin-wide or non-site-specific tracking and coordination of all permits will provide both agencies with a more complete picture of contaminant distribution, groundwater withdrawals, and releases to groundwater and surface water on a basin-scale perspective.

- Evaluation of the need for additional incentives to withdraw and use remediated groundwater in an effort to match quality with beneficial use. This evaluation will include groundwater that may be contaminated with hazardous, non-hazardous, and naturally occurring substances. Incentives may involve amendments to Title 45, Arizona Revised Statutes, Department rules and policies, or a modification of the management plans.

- The Department and ADEQ will develop and enter into Memorandums of Understanding, as necessary, to establish, among other things, the division of responsibilities for the implementation of the reformed WQARF Program, development of common scopes of work for WQARF sites and other groundwater contamination sites, and database development and exchange.

The Department's Water Quality Section, which was established with funding provided by the 1997 WQARF reform legislation, will allow the Department to strengthen its commitment to work closely with ADEQ to resolve groundwater quantity and quality issues throughout Arizona. The Department's Water Quality Section will provide support to the Tucson AMA on issues related to WQARF cleanup activities.

Other remedial activities and management action plans such as those associated with Superfund sites will continue to include the Department's direct involvement. This will ensure that remedial activities meet the Department's water management objectives and are consistent with the AMA's safe-yield goal.

7.7 FUTURE DIRECTIONS

The Department's long-range plans for groundwater quality management will focus on two areas: (1) evaluation of groundwater quality issues on a site and non-site-specific level to understand the impact of broader groundwater quality issues on water resource management; and (2) preservation of AMA management goals and interests while implementing incentives to use remediated groundwater.

7.7.1 Non-Site-Specific Water Quality Management

Non-site-specific groundwater quality management refers to groundwater quality management activities that may occur in general areas located outside of an identified WQARF or CERCLA boundary. To address and mitigate dispersed contamination over large areas, a broader management strategy is needed. Areas that may need more intensive management can include those where public or private supply wells have been or may be affected by contamination. For instance, areas that are in the vicinity of major population centers or agricultural areas can be affected by contamination, especially if large volumes of groundwater are pumped, creating cones of depression.

Issues related to changes in groundwater levels will be monitored during the third management period to reduce the possibility of degrading aquifer conditions. Managing rising water levels in areas of known landfills or other areas that have suspended contaminants in the vadose zone (e.g. leaking USTs), will mitigate the potential of contaminant migration. Aquifers experiencing declining groundwater levels also need to be monitored for impacts on aquifer water quality. In addition, proper planning will ensure that the impacts of groundwater recharge projects do not contribute to the degradation of aquifer conditions.

The concept of groundwater quality management on a non-site-specific scale will be developed to enhance water management activities in critical areas. The identification of source groundwater quality and the development of area-specific plans to match water quality with the intended use will become an important aspect in the third management period. The Department intends to study the development of area-specific plans that could employ a combination of strategies to evaluate and mitigate the effects of contamination in critical areas. These plans should be developed in coordination with ADEQ and with affected stakeholders. Any contaminant management on a non-site-specific scale will be voluntary and will not affect rights to groundwater, well ownership, delivery responsibilities, or existing permits.

7.7.2 Preservation of AMA Management Goals

The WQARF reform package of 1997 was designed to encourage the remediation of groundwater that has limited or no use due to contamination. Pump and treat groundwater remediation activities are anticipated to increase substantially during the third management period as a result of the remediated groundwater use incentives provided in the WQARF reform package. As a result, previously unavailable sources of groundwater from contaminated areas may be put to beneficial use.

Remediated groundwater withdrawals associated with WQARF, CERCLA, Department of Defense, RCRA, and voluntary site cleanups are expected to increase. Estimates of annual remediated groundwater withdrawals, provided by ADEQ and its contractors for existing remedial sites within the Tucson AMA range from about 14,000 acre-feet to approximately 23,000 acre-feet. Such withdrawals may occur as part of aquifer restoration or plume containment. These estimates merely represent preliminary projections based on data from only a portion of the existing sites within the Tucson AMA. These estimates may be conservative due to the potential detection of unknown sites and because remedial activities on known contaminated areas are in different stages of development.

In the third management period, the Department will monitor water levels, subsidence, and effects on local water providers at remedial project sites in areas of intensive pumping. While the Department supports the

remediation of contaminated groundwater, it also seeks to preserve the management goal of safe-yield in the Tucson AMA. Water quality management is a lengthy process that is expected to continue far beyond the scope of the third management period. Continued remedial activities over the long-term will likely result in considerable volumes of groundwater being pumped, treated, and subsequently used.

The net effect of continued remediated groundwater withdrawals could result in a substantial increase in the overall volume of groundwater used within the Tucson AMA. Proper water quantity and water quality management will be required to ensure that groundwater use created as a result of remedial projects does not negatively impact the goal of safe-yield in the Tucson AMA. Remediated groundwater is not a renewable water supply and therefore must be managed as a diminishing resource. Consequently, the Department will seek to preserve the intent of the Code and the AMA management goals while cooperating with EPA, ADEQ, and other water resource agencies to promote groundwater quality management.

APPENDIX 7A
DRINKING WATER STANDARDS AND HEALTH EFFECTS
TUCSON ACTIVE MANAGEMENT AREA

Contaminant	Primary MCL (mg/l)[1]	Potential Health Effects from Ingestion of Water	Sources of Contaminant in Drinking Water
Inorganics			
Antimony	0.006	Cancer	Fire retardants, ceramics, electronics, fireworks, solder
Arsenic	0.05	Skin, nervous system toxicity	Natural deposits; smelters, glass, electronics waste
Asbestos	7.0 MFL[2]	Cancer	Natural deposits, asbestos cement in water systems
Barium	2.0	Circulatory system effects	Natural deposits, pigments, epoxy sealants, spent coal
Beryllium	0.004	Bone, lung damage	Electrical, aerospace, defense industries
Cadmium	0.005	Kidney effects	Galvanized pipe corrosion; natural deposits, batteries, paints
Chromium (total)	0.1	Liver, kidney, circulatory disorders	Natural deposits; mining, electroplating, pigments
Cyanide (as free cyanide)	0.2	Thyroid, nervous system damage	Electroplating, steel, plastics, mining, fertilizer
Fluoride[3]	4.0	Skeletal and dental fluorosis	Natural deposits; fertilizer, aluminum industries
Mercury	0.002	Kidney, nervous system disorders	Crop runoff; natural deposits; batteries, electrical switches
Nickel	Remanded	Gastrointestinal distress, skin irritation, respiratory congestion	Food, water, and metal alloys
Nitrate (as N)	10.0	Methemoglobulinemia	Animal waste, fertilizer, sewage, natural deposits, septic tanks
Nitrite (as N)	1.0	Methemoglobulinemia	Same as nitrate; rapidly converted to nitrate
Total nitrate/nitrite	10.0	Same as nitrate	Same as nitrate
Selenium	0.05	Liver Damage	Natural deposits; mining, smelting, coal/oil combustion
Thallium	0.002	Kidney, liver, brain, intestinal	Electronics, drugs, alloys, glass

APPENDIX 7A
DRINKING WATER STANDARDS AND HEALTH EFFECTS
TUCSON ACTIVE MANAGEMENT AREA

Contaminant	Primary MCL (mg/l)[1]	Potential Health Effects from Ingestion of Water	Sources of Contaminant in Drinking Water
Volatile Organic Chemicals			
Benzene	0.005	Cancer	Some foods; gas, drugs, paint, pesticides, plastic industries
Carbon tetrachloride	0.005	Cancer	Solvents and degradation by-products
ortho-Dichlorobenzene	0.6	Liver, kidney, blood cell damage	Paints, dyes, engine cleaning compounds, chemical wastes
para-Dichlorobenzene	0.075	Cancer	Room and water deodorants, and mothballs
1,2-Dichloroethane	0.005	Cancer	Leaded gasoline, fumigants, paints
1,1-Dichloroethylene	0.007	Cancer	Plastics, dyes, perfumes, paints
cis-1,2-Dichloroethylene	0.07	Liver, kidney, nervous, circulatory	Waste industrial extraction solvents
trans-1,2-Dichloroethylene	0.1	Liver, kidney, nervous, circulatory	Waste industrial extraction solvents
Dichloromethane	0.005	Cancer	Paint stripper, metal degreaser, propellant, extraction
1,2-Dichloropropane	0.005	Liver, kidney effects; cancer	Soil fumigant; waste industrial solvents
Ethylbenzene	0.7	Liver, kidney, nervous system	Gasoline; insecticides; chemical manufacturing wastes
Monochlorobenzene	0.1	Nervous system and liver effects	Waste solvent from metal degreasing process
Styrene	0.1	Liver, nervous system damage	Plastics, rubber, resin, drug industries; landfill leachate
Tetrachloroethylene	0.005	Cancer	Improper disposal of dry cleaning and other solvents
Toluene	1.0	Liver, kidney, nervous, circulatory	Manufacturing and solvent operations, gasoline additive
1,2,4-Trichlorobenzene	0.07	Liver, kidney damage	Herbicide production, dye carrier
1,1,1-Trichloroethane	0.2	Liver, nervous system effects	Adhesives, aerosols, textiles, paints, inks, metal degreasers
1,1,2-Trichloroethane	0.005	Kidney, liver, nervous system	Solvent in rubber, other organic products; chemical production wastes
Trichloroethlylene	0.005	Cancer	Textiles, adhesives, and metal degreasers

APPENDIX 7A
DRINKING WATER STANDARDS AND HEALTH EFFECTS
TUCSON ACTIVE MANAGEMENT AREA

Contaminant	Primary MCL (mg/l)[1]	Potential Health Effects from Ingestion of Water	Sources of Contaminant in Drinking Water
Vinyl chloride	0.002	Cancer	May leach from PVC pipe; formed by solvent breakdown
Xylenes (total)	10.0	Liver, kidney, nervous system	By-product of gasoline refining; paints, inks, detergents
Synthetic Organic Chemicals			
Alachlor	0.002	Cancer	Runoff from herbicides applied to crops
Atrazine	0.003	Mammary gland tumors	Runoff from herbicides used on crops and non-cropland
Benzo(a)pyrene	0.0002	Cancer	Fossil fuels, burning organic matter, coal tar coatings, volcanics
Carbofuran	0.04	Nervous, reproductive system effects	Soil fumigant; some area restrictions apply
Chlordane	0.002	Cancer	Leaching from soil treatment for termites
2,4-D	0.07	Liver and kidney damage	Runoff from herbicides applied to crops, rangelands, and lawns
Dalapon	0.2	Liver and kidney effects	Herbicide on orchards, crops, lawns, road/railways
Dibromochloropropane	0.0002	Cancer	soil fumigant
Di(2-ethylhexyl)adipate	0.4	Decreased body weight	Synthetic rubber, food packaging, cosmetics
Di(2-ethylhexyl)phthalate	0.006	Cancer	PVC and other plastics
Dinoseb	0.007	Thyroid, reproductive organ damage	Runoff of herbicide from crop and non-crop applications
Diquat	0.02	Liver, kidney, eye effects	Runoff of herbicide on land and aquatic weeds
Endothall	0.1	Liver, kidney, gastrointestinal	Herbicide on crops, land/aquatic weeds; rapidly degraded
Endrin	0.002	Liver, kidney, heart damage	Pesticide on insects, rodents, birds; restricted since 1980
Ethylene dibromide	0.00005	Cancer	Leaded gasoline additives; leaching of soil fumigant
Glyphosate	0.7	Liver, kidney damage	Herbicide on grasses, weeds, brush
Heptachlor	0.0004	Cancer	Leaching of insecticide for termites and very few crops
Heptachlor epoxide	0.0002	Cancer	Biodegradation of heptachlor
Hexachlorobenzene	0.001	Cancer	Pesticide production waste by-product

APPENDIX 7A
DRINKING WATER STANDARDS AND HEALTH EFFECTS
TUCSON ACTIVE MANAGEMENT AREA

Contaminant	Primary MCL (mg/l)[1]	Potential Health Effects from Ingestion of Water	Sources of Contaminant in Drinking Water
Hexachlorocyclopentadiene	0.05	Kidney, stomach damage	Pesticide production intermediate
Lindane	0.0002	Liver, kidney, nervous, immune circulatory	Insecticide on cattle, lumber, gardens; restricted in 1983
Methoxychlor	0.04	Growth, liver, kidney, nerve effects	Insecticide for fruits, vegetables, alfalfa, livestock, pets
Oxamyl (Vydate)	0.2	Kidney damage	Insecticide on apples, potatoes, tomatoes
Pentachlorophenol	0.001	Cancer, liver and kidney effects	Wood preservatives, herbicide, cooling tower wastes
Picloram	0.5	Kidney, liver damage	Herbicide on grass sod, some crops, aquatic algae
Polychlorinated biphenyls	0.0005	Cancer	Coolant oils from electrical transformers; plasticizers
Simazine	0.004	Cancer	Herbicide on grass sod, some crops, aquatic algae
2,3,7,8-TCDD (Dioxin)	3×10^{-8}	Cancer	Chemical production by-product; impurity in herbicides
Toxaphene	0.003	Cancer	Insecticide on cattle, cotton, soybeans; canceled in 1982
2,4,5-TP (Silvex)	0.05	Liver and kidney damage	Herbicide on crops, right-of-way, golf courses; canceled in 1983
Radionuclides			
Combined Radium-226 and Radium-228	5 pCi/l[4]	Bone Cancer	Natural deposits
Gross Alpha[5]	15 pCi/l	Cancer	Decay or radionuclides in natural deposits
Gross beta	4 mrem/yr[6]	Cancer	Decay of radionuclides in natural and man-made deposits
Radon-222 (Proposed)	300 pCi/l	Cancer	Natural sources
Uranium (Proposed)	20 µg/l[7]	Cancer	Natural sources

APPENDIX 7A
DRINKING WATER STANDARDS AND HEALTH EFFECTS
TUCSON ACTIVE MANAGEMENT AREA

Contaminant	Primary MCL (mg/l)[1]	Potential Health Effects from Ingestion of Water	Sources of Contaminant in Drinking Water
Microbiology			
Giardia lamblia	TT[8]	Gastroenteric disease	Human and animal fecal waste
Legionella	TT	Legionnaire's disease	Indigenous to natural waters; can grow in water heating systems
Standard Plate Count	TT	Indicates water quality, effectiveness of treatment	
Total Coliform	[9]	Indicates gastroenteric pathogens	Human and animal fecal waste
Turbidity	[9]	Interferes with disinfection, filtration	Soil runoff
Viruses	TT	Gastroenteric disease	Human and animal fecal waste
Total Trihalomethanes	0.1	Cancer	Drinking water chlorination by-products

1 mg/l = milligrams per liter (all MCLs are in mg/l unless otherwise indicated)
2 "MFL" means million fibers per liter greater than ten microns
3 The MCL for fluoride applies to community water systems only
4 pCi/l = picocuries per liter (30pCi/l is equivalent to 20 µg/l)
5 Gross particle activity, including Radium-226 but excluding Radon and Uranium
6 mrem/yr = millirem per year, see ADEQ, Drinking Water Rules source (1) for more information
7 µg/l = micrograms per liter
8 Treatment Technology (refer to source (1) for more information)
9 Refer to source (1) for more information

Sources:
1. Arizona Department of Environmental Quality, Arizona Drinking Water Rules, April 28, 1995
2. United States Environmental Protection Agency, Office of Water 4304, EPA 822-B-96-002, October 1996
3. United States Environmental Protection Agency, National Primary Drinking Water Regulations, Appendix A: National Primary Drinking Water Standards (Modified 1/14/98)

APPENDIX 7B
SECONDARY DRINKING WATER STANDARDS[1]
TUCSON ACTIVE MANAGEMENT AREA

Constituents	SMCLs (mg/l)[2]
Aluminum	0.05 to 0.2
Chloride	250
Color	15 color units
Copper	1.0
Corrosivity	non-corrosive
Fluoride	2.0
Foaming agents	0.5
Iron	0.3
Manganese	0.05
Odor	3 threshold odor numbers
pH	6.5 - 8.5
Silver	0.1
Sulfate	250
Total dissolved solids	500
Zinc	5

[1] Secondary Drinking Water Standards are unenforceable federal guidelines regarding taste, odor, color and certain other non-aesthetic effects of drinking water. States may adopt their own enforceable regulations governing these concerns.

[2] Secondary Maximum Contaminant Levels (SMCLs) units are in milligrams per liter (mg/l) unless otherwise indicated.

Source:
United States Environmental Protection Agency, Office of Water 4304, EPA 822-B-96-002, October 1996.

CHAPTER

8

Augmentation and Recharge Program

8.1 INTRODUCTION

The purpose of the Augmentation and Recharge Program is to encourage the development, delivery, storage, and use of renewable water supplies now and in the future. The water supply Augmentation and Recharge Program, in combination with conservation program efforts, is intended to support achievement of the safe-yield management goal for the Tucson Active Management Area (AMA). Increasing the use of renewable water supplies, particularly Central Arizona Project (CAP) water and effluent instead of using groundwater, is a key component of achieving safe-yield.

For the purposes of this chapter, "supply augmentation" means increasing the availability and use of renewable water supplies such as CAP water and effluent instead of groundwater. "Recharge" means storage of water supplies for future use pursuant to the Underground Water Storage, Savings and Replenishment Act. A.R.S. § 45-801, *et seq.*

Although achieving basin-wide safe-yield remains the Tucson AMA's groundwater management goal, the objectives of the Augmentation and Recharge Program in the third management period reflect an increased awareness and improved understanding of the importance of water resource management on a smaller scale. Since the development of the Second Management Plan, new information has been obtained on the physical availability and distribution of water supplies and the potential for subsidence. Recent United States Geological Survey (USGS) publications have heightened concern regarding the potential for subsidence, particularly in Tucson's Central Wellfield. A basin-wide "paper balance" between supply and demand for groundwater does not address the concerns of the public and many groundwater users about the effects of ongoing depletions in some areas and water level rises elsewhere in the AMA. The Third Management Plan incorporates a new focus on site-specific or "critical area" water management.

In the Tucson AMA, development of alternative supplies and recharge are key elements in meeting water management needs at the local or subregional level. The Arizona Department of Water Resources (Department) will work in cooperation with AMA water users to address critical area needs and attain the regional and local water supply management goals of the AMA. The specific goals and objectives of the Augmentation and Recharge Program are described in section 8.6.

The emphasis of the Department's supply augmentation program will be to encourage and facilitate the replacement of groundwater use with the efficient use of the currently available renewable supplies. The Department will continue to explore other potential water supply augmentation alternatives, such as importing additional surface water through the CAP canal. However, the primary focus for the third management period will be to take advantage of the current availability of excess CAP water and the growing effluent supply.

Although the Colorado River is currently in a surplus condition and some municipal entities do not have enough annual demand or the physical access necessary to use their CAP water allocations directly, these conditions are likely to change in the relatively near future. Future shortages are anticipated on the Colorado River system when the Upper Basin States (Colorado, New Mexico, Wyoming, and Utah) use more of their allocations and in periods of drought. In the short term, the Department is providing incentive programs to encourage development and use of alternative supplies; nevertheless, conservation activities will continue to play an important role in achieving safe-yield. Efficient use of all water supplies will be necessary to supply our future water demand.

The state's Underground Water Storage, Savings, and Replenishment (UWS) Program is an important component of the Third Management Plan Augmentation and Recharge Program. Recharge provides a cost-effective means of storing water that is currently available in the AMA but that has no direct use. Additionally, the program can be an effective tool in helping to mitigate problems due to changes in water levels, depending upon where storage and recovery occurs.

While the Department and the Arizona Water Banking Authority (AWBA) will support local efforts to augment the AMA's water supplies, the Department recognizes that the principal responsibility for developing and storing water supplies remains with the region's water providers. The Department will work with the community to encourage use and storage of renewable supplies and facilitate these activities when possible. The current scope of the Department's activities in supply augmentation includes the following:

- Director's Roles and Authorities. In addition to other statutory roles and authorities, the director of the Department is designated as the representative of the State of Arizona in Colorado River and interstate water issues; advisor to the Secretary of the Interior in allocating water among users; coordinator of Arizona's review and comments on water development proposals by the United States Army Corps of Engineers, Secretary of the Interior and Secretary of Agriculture; and manager of the state's water rights to ensure achievement of water management objectives. The director is also the Chairperson of the AWBA and serves on the Arizona Water Protection Fund (AWPF) Commission.

- Regulatory and permitting authority. The Department's regulatory and permitting authority regarding use of groundwater rights and development of underground storage and recovery projects helps to ensure that these uses of water are consistent with water management objectives.

- Staff support to the Arizona Water Banking Authority and the Arizona Water Protection Fund. The Department's staff assist the AWBA and the AWPF Commission in carrying out their mandates. Both entities are operated in close coordination with Departmental activities.

- Regulatory incentives. Regulatory incentives established in the Agricultural, Municipal, and Industrial Conservation Programs of the management plans are designed to facilitate the implementation of water supply augmentation activities by water users.

- Technical assistance. The Department provides various kinds of technical assistance to the public, for example: (1) assisting with permits and water rights issues; (2) participating in research and feasibility studies; (3) supporting hydrologic investigations; (4) providing review of proposals, applications, and draft permits; and (5) participating in legislative activities.

- Financial assistance. The augmentation, conservation assistance, and monitoring fund, as well as specifically budgeted appropriations, provide financial assistance to entities implementing augmentation projects or studies that contribute to achieving the AMA's management goals or resolving regional water management issues.

- Data management and public information. The Department's responsibility for accumulation and dissemination of water use and water supply data provides the information necessary to develop water management plans, implement augmentation projects, and conduct research related to resolving water management issues.

- Facilitation and coordination. The facilitation and coordination of augmentation and recharge activities, particularly between jurisdictions and multiple regulatory agencies, is an important component of the Department's statewide and regional water planning responsibilities.

The remainder of this chapter is organized as follows:

- Assessment of Physical Conditions and Use of Renewable Supplies
- Status of Supply Augmentation and Artificial Recharge in the Tucson AMA
- Assessment of Second Management Plan Augmentation Program Activities

- Augmentation and Recharge Issues
- Augmentation and Recharge Program Goals and Objectives
- Third Management Plan Augmentation and Recharge Program
- Future Directions

This chapter describes the Department's role in water supply augmentation and summarizes why augmentation, recharge, and reuse are important in the Tucson AMA based on current and projected water use patterns, the physical effects of groundwater overdraft, and the availability and use of renewable supplies in the AMA. Regulatory and institutional factors and permitting considerations affect augmentation and recharge efforts. An evaluation of the Second Management Plan program shows both the success of the Department's programs in responding to changing conditions and the need to develop new management tools. Assessment of the status of supply augmentation and recharge efforts in the AMA helps reveal the scope of the water resource management problem. Statutorily required elements and regulatory provisions are addressed in the Third Management Plan Augmentation and Recharge Program, section 8.7. The Future Directions section focuses primarily on changes in the Groundwater Code (Code) and Assured Water Supply Rules (AWS Rules) that could assist in achieving safe-yield.

8.2 ASSESSMENT OF PHYSICAL CONDITIONS AND USE OF RENEWABLE SUPPLIES

8.2.1 Groundwater Supply and Use

The following section summarizes current water use patterns, the physical effects of groundwater overdraft, and the current availability and use of alternative supplies.

8.2.1.1 Groundwater Overdraft and Limits of Physical Supply

Total water use in the AMA was approximately 317,400 acre-feet in 1995. About 97 percent of this demand, 307,000 acre-feet, was met by groundwater. However, annual natural and incidental recharge was estimated to be only 143,100 acre-feet in 1995. The 1995 groundwater overdraft was therefore approximately 163,900 acre-feet. Thus, the Tucson AMA has been using groundwater at twice the rate of aquifer replenishment.

The demand for water is increasing as the population of the AMA grows. Projections indicate the AMA population may be almost 1.3 million by 2025, a 65 percent increase above the 1995 figure. The statutory goal of reaching safe-yield by 2025 cannot be achieved and maintained without both significant water conservation and supply augmentation.

8.2.1.2 Consequences of Groundwater Overdraft

As described in Chapter 2, groundwater overdraft is reflected in groundwater level declines. Figure 2-7 shows historical water level changes between approximately 1940 and 1995. During this time period, maximum water level declines were approximately 200 feet in the Tucson Central Wellfield, 150 feet in the vicinity of the ASARCO wellfield near Sahuarita, and 150 feet in Avra Valley.

Sustained groundwater mining in the AMA has had negative consequences and is expected to result in more problems if it continues. Over the past 50 years, lower water levels have destroyed riparian habitat, caused erosion, displaced existing water users, and reduced stream flows. Furthermore, because the most productive portion of the aquifer is being depleted, decreased well productivity and increased pumping costs are expected over time. Tucson Water has observed decreased productivity in many of its wells since the 1970s (Tucson Water, 1997). Because the salinity of groundwater tends to increase with depth, the quality of groundwater pumped is also expected to decrease as older groundwater from deeper parts of the aquifer is pumped.

The depletion of the groundwater supplies within Tucson Water's service area threatens the City's demonstration of assured water supply. Section 5.3 describes the Assured Water Supply Program (AWS Program) and requirements for Designations of Assured Water Supply. Tucson Water will not continue to meet the criteria in the AWS Rules unless renewable supplies are physically available within their service area in the near term. Renewable supplies, whether recharged and recovered or delivered directly, must physically be usable within the service area to relieve demands on the Central Wellfield. The Central Avra Valley Storage and Recovery Project (CAVSARP) is designed to meet these requirements.

Differential subsidence in developed areas can cause considerable damage to well casings, foundations, structures, underground utility lines, storm water drains, and sewage systems. A USGS report on subsidence potential (Hanson and Benedict, 1994) estimates that the land surface elevation in Tucson in the vicinity of downtown could subside between 1 and 12 feet by the year 2025 if pumping in the region continues at 1986 rates. Because dense development characterizes the land use in this area, the potential for infrastructure and other property damage is significant. USGS models also indicate there is potential for up to 4 feet of subsidence in the vicinity of the City of Tucson's Santa Cruz Wellfield (located north of Sahuarita) by the year 2025 (Hanson and Benedict, 1994).

In the Tucson AMA, there is already some evidence of aquifer compaction and associated land subsidence attributed to rapid aquifer dewatering. Fissuring, aquifer compaction, and subsidence have been observed in the Upper Santa Cruz Basin, especially in northern Avra Valley. In 1988, an earth fissure in Avra Valley damaged the CAP aqueduct in Pima County, costing about $50,000 in repairs (Slaff, 1993). The USGS has estimated that potential maximum subsidence from 1985 to 2024 could reach 14.7 feet in northern Avra Valley if 1970s pumpage rates were to continue (Hansen, Anderson, and Pool, 1990). Although a direct link to groundwater overdraft has not been proven, 1,700 sink holes have been reported in the San Xavier District (Hoffmann, Pool, Konieczki, and Carpenter, 1997). See Chapter 2, section 2.6, and Figure 2-9 for a more complete discussion of observed subsidence and potential for further subsidence in the AMA.

Because there is potential for significant damage due to subsidence in the Tucson AMA, mitigation of groundwater overdraft in subsidence-prone areas is one of the Department's primary groundwater management objectives.

8.2.1.3 Responsibility for Overdraft

Both historic use and recent growth are responsible for the decline in groundwater levels in the AMA. Though not all are currently being used, existing water rights (irrigation, Type 1, and Type 2 grandfathered rights) and withdrawal permits exceed natural and incidental recharge by a factor of about 2.8. All water use sectors contribute to achieving safe-yield through conservation programs, but opportunities for further conservation are limited. Water supply augmentation, increased substitution of renewable supplies for groundwater use, retirement of existing rights, and management of new uses are needed to mitigate groundwater overdraft in the AMA.

Of the agricultural, industrial, and municipal sectors, only new municipal use is legally required to utilize renewable supplies through acquisition of a Designation of Assured Water Supply or a Certificate of Assured Water Supply. All new subdivisions must demonstrate the use of renewable supplies (through direct use or storage and recovery) or join the Central Arizona Groundwater Replenishment District (CAGRD) so their groundwater pumpage will be replenished. Municipal providers with Designations of Assured Water Supply have been allocated a limited amount of groundwater that can be used at any time, either during times of shortage in CAP water deliveries or during the phase-in period of use of renewable supplies. Thus, municipal entities may continue to use groundwater to serve a percentage of their demand, potentially causing water levels to continue to decline even after the safe-yield goal is attained. The

flexibility of the AWS Program means it is difficult to project with certainty when providers will use their groundwater allocations and at what rate they will store CAP water for future use.

In terms of their Designation of Assured Water Supply, Tucson Water has the legal right to pump approximately 3.5 million acre-feet. Due to their program to purchase and retire agricultural land in the late 1970s and early 1980s in Avra Valley, the City of Tucson has a legislative appropriation of up to 2 million acre-feet of groundwater credits in addition to their assured water supply groundwater allocation of approximately 1.5 million acre-feet. However, due to the overdrafted condition of the City's wellfields, it may be difficult for them to continue to prove physical availability of groundwater to serve their customers, unless CAP water is used for direct potable delivery or is recharged and recovered for delivery in their service area.

Voluntary use of renewable supplies by many users is limited by economic disincentives. Without subsidies, the cost to deliver and use renewable supplies is generally higher than the cost to pump and use groundwater. Although state law mandates that no new land may be brought into agricultural production in the AMA, agricultural groundwater use could increase if more of the acreage with irrigation grandfathered rights (IGFR) is farmed. Industrial water users may acquire new groundwater withdrawal permits (e.g., general industrial use permits) and may obtain, through purchase or lease, currently unused non-irrigation grandfathered rights to pump groundwater. Current industrial rights and withdrawal permits alone exceed the annual volume of natural and incidental recharge in the AMA. Of particular concern in the Tucson AMA is the long-term groundwater demand of the copper mining industry, which is projected to remain a major groundwater user for the foreseeable future. There is no regulatory authority at this time to require industrial water users to convert to renewable supplies.

Beyond the needs defined by the AWS Program, augmentation is needed to offset continued agricultural and industrial demand, as well as the existing pumpage by municipal providers that do not have designations. At this time, the Department has not projected the magnitude of agricultural and industrial pumpage beyond 2025. However, based on the projections in Chapter 11, safe-yield may not be achieved by the year 2025. After 2025, it will become increasingly difficult to maintain a balance between groundwater supply and demand. Further overdraft (beyond that allowed through the AWS Program) will occur unless existing users switch to renewable supplies, new water users do not use groundwater, and additional conservation measures are implemented. Changes to existing groundwater management legislation and rules may be necessary to limit further groundwater overdraft and protect critical areas.

8.2.2 Renewable Supplies and Use in the AMA

The primary renewable supplies in the Tucson AMA are Colorado River water delivered via the CAP and effluent. Using CAP water is the primary alternative to groundwater use. Recycling effluent stretches the water supply and has other benefits related to water quality. The surface water resources in the AMA are a less significant renewable supply because much of the water that flows during storm events already naturally recharges within the AMA. Interbasin water transfers, cloud seeding, and watershed management are not likely to occur in the Tucson AMA during the third management period. The following section describes the major water supplies and how they are currently used in the AMA. For a broader discussion of renewable supplies in the AMA, see Chapter 2, section 2.8.

8.2.2.1 Colorado River Water and the Central Arizona Project

In 1964, the United States Supreme Court issued a final decree in the case of Arizona v. California, 376 U.S. 340 (1964) granting Arizona rights to 2.8 million acre-feet of mainstream Colorado River water for use within the state, to the extent that the water was available within the system. In 1968, Congress passed the Colorado River Basin Project Act which authorized construction of the CAP. Figure 1-1 shows the location of the CAP canal and terminal pipeline within the AMA. CAP water is the largest volume

renewable supply available for augmentation in the AMA. Economic, geographic, technical, political, and institutional factors affect the management, distribution, and use of this supply. The following sections describe the AMA's CAP water supply, current use by water use sectors, and supply reliability issues related to allocation priorities, Tucson's location at the end of the CAP line, and water user needs. Additional discussion of CAP water use issues may be found in chapters 2, 5, and 6 and in Appendix 8A.

8.2.2.1.1 Central Arizona Project Water Supply

The CAP is the most important source of renewable water supplies in the Tucson AMA. Annual CAP water allocations for the Tucson AMA total 215,333 acre-feet. Of this total, approximately 38,300 acre-feet are currently subcontracted to the Tohono O'odham and Pascua Yaqui Indians, and the remaining 177,033 acre-feet consists mostly of municipal subcontracts. Additional CAP water may be allocated as a result of the Southern Arizona Water Rights Settlement Act.

A list of existing CAP water allocations/contracts is presented in Table 8-1. Agricultural and copper mining water users declined CAP water subcontracts. In the Tucson AMA, CAP water use by non-Indian agriculture has been limited to groundwater savings facilities (GSF). Agricultural water use in the AMA is likely to decline with urbanization. Mines and other industrial users have expressed reluctance to pursue CAP water subcontracts because of water quality constraints, the costs associated with pretreatment, and limits on conversion to urban uses.

TABLE 8-1
CURRENT AND PENDING CENTRAL ARIZONA PROJECT CONTRACTS
TUCSON ACTIVE MANAGEMENT AREA

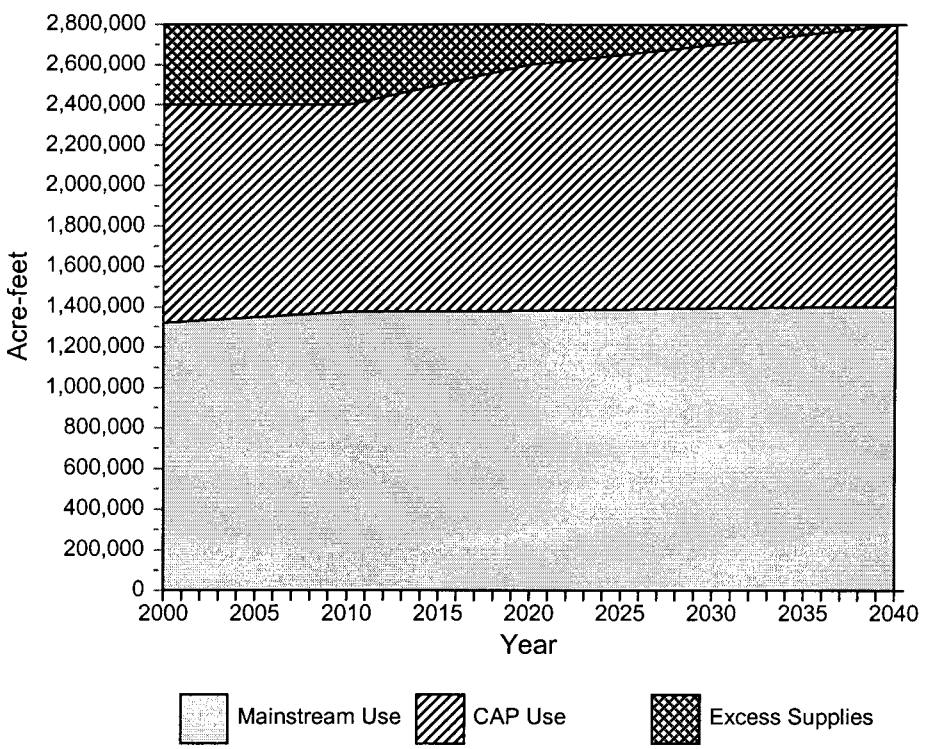
Entity	Allocation (acre-feet)
MUNICIPAL AND INDUSTRIAL SUBCONTRACTS	
City of Tucson	138,920
Arizona State Land Department	14,000
Metropolitan Domestic Water Improvement District [1]	8,858
Flowing Wells Irrigation District	4,354
Spanish Trail Water Company	3,037
Green Valley Water Company	1,900
Town of Oro Valley [2]	2,294
Midvale Farms	1,500
Community Water Company of Green Valley	1,337
Vail Water Company (formerly Del Lago Water Company)	786
Town of Marana [3]	47
INDIAN SUBCONTRACTS	
San Xavier (Tohono O'odham)	27,000
Schuk Toak (Tohono O'odham)	10,800
Pascua Yaqui	500
TOTAL	**215,333**

[1] Allocation transferred from Tucson Water
[2] Includes 1,652 acre-feet of allocation transferred from Canada Hills and 642 acre-feet of allocation transferred from Tucson Water
[3] Allocation transferred from Cortaro Water Users Association

In the short term, unused entitlements and surplus Colorado River supplies provide an opportunity to bring additional CAP water supplies into the AMA beyond existing allocations. Each year the Secretary of the Interior evaluates the Colorado River water supply and determines if it is a normal, surplus, or shortage water year. Unused entitlements (either surplus supplies or subcontracted water that is not ordered and used) can be contracted to other users on an annual basis. This provides an opportunity for the AWBA, the CAGRD, and users who would like to order CAP water in excess of their contract to acquire CAP water. The unused entitlements are a temporary resource, because as the Colorado River becomes more heavily utilized, less excess water will be available. Shortages due to increased use are anticipated on the Colorado River after 2015. Lower than average precipitation on the Colorado River watershed may also result in shortages. Because Arizona has a low priority right to Colorado River water, Arizona's full 2,800,000 acre-foot entitlement may not be available in drought years.

In anticipation of future shortages, the Department expects that renewable supplies will be recharged in the early years, while supplies are available and relatively inexpensive. The Department's projection of the maximum potentially available excess CAP water supplies is illustrated in Figure 8-1. This storage activity may cause temporary rises in water levels in some areas, which should not be confused with achieving and maintaining AMA-wide safe-yield over the long term. If this stored water will be recovered within the area of impact and used in future years to meet demand, it does not result in a permanent change in water levels.

FIGURE 8-1
ARIZONA PROJECTED MAXIMUM EXCESS COLORADO RIVER SUPPLIES



In addition to long-term storage and recovery, CAP water may be utilized through annual storage and recovery. This mechanism, although it involves recharge, is analogous to direct use because no long-term storage credits are generated.

8.2.2.1.2 Municipal Use of Central Arizona Project Water

The municipal sector has the largest allocations of CAP water in the Tucson AMA and offers the greatest opportunities for use of this source. The City of Tucson is the largest provider in the AMA, serves 78 percent of the population in the AMA, and holds the largest municipal CAP water contract in the state (138,920 acre-feet). The City of Tucson adopted a 110-year water resources plan in 1989 which envisioned that direct CAP water utilization (after filtration and disinfection) would serve 95 percent of the population by 1995. This was not achieved due to technical and public relations problems in delivery implementation.

In 1992, Tucson Water began direct delivery of treated CAP water to approximately 60 percent of its municipal customers. Direct delivery was discontinued to areas with older plumbing in 1993 due to problems with older plumbing systems, resulting in odor, discolored water, and damage to household appliances. Most of the "brown water" problems have been attributed to loosening of corrosion coatings in old cast iron water mains, galvanized steel water mains, and household plumbing due to changes in flow patterns through the distribution system, pH differences, and other inorganic chemical factors in the delivered CAP water. Tucson Water found in subsequent investigations that most of these problems can be eliminated by replacement of the older pipelines and changes in management of Tucson's treatment plant and distribution system.

In May of 1994, the City initiated a study to evaluate various alternative options for utilization of CAP water supplies. The options ranged from leasing or exchanging the water to treating with advanced membrane filtration to remove salinity and organic material. In October 1994, the CAP system was shut down statewide for siphon repairs on the canal, and in January 1995, the Tucson City Council voted not to return to direct deliveries until the water quality problems in the delivery system were addressed. Total CAP water use by Tucson in 1995 was consequently only about 10,200 acre-feet, primarily in the form of groundwater savings.

In response to water quality problems experienced when Tucson Water began direct distribution of treated CAP water, Tucson citizens approved an initiative which has had significant impacts on the management of water supplies in Tucson and throughout the AMA. The 1995 Water Consumer Protection Act (WCPA) amends the City of Tucson Code for a minimum of five years. After five years, portions of the Act will remain in effect until the citizens vote to repeal or amend it.

Among other provisions, the WCPA requires that CAP water only be used for sale, exchange or recharge, and to replace groundwater used by agriculture, industry, and landscape irrigation. In the City of Tucson, CAP water to be delivered for potable supply must be treated to concentrations equal or below the salinity, hardness, and dissolved organic concentrations of groundwater from the City's Avra Valley Wellfield. These standards are more stringent than the United States Environmental Protection Agency (EPA) drinking water standards. The groundwater from the Avra Valley Wellfield is relatively high quality. No decision has been made at this time when, or if, the City will return to direct delivery. Because the treatment requirements under the WCPA are expensive and may not be technologically feasible at the scale needed, a return to direct delivery of CAP water in the Tucson Water service area is not likely in the short term.

Although the WCPA directs the City of Tucson to address overdraft in the Central Wellfield through recharge, the WCPA effectively prohibits injection recharge, which may be the most promising technique given the limited availability of suitable surface recharge sites in the Central Wellfield. In the City of

Tucson, CAP water may not be recharged by direct injection unless the water is treated to the quality of Avra Valley groundwater and contains no detectable concentrations of disinfection by-products.

Passage of the WCPA substantially changed the City's CAP water utilization options from those envisioned at the time the Second Management Plan was prepared. Rather than an emphasis on direct delivery, Tucson Water is now expanding recharge activities. The Third Management Plan CAP water use assumptions are based on an all-recharge option. However, Tucson Water is participating in a pilot project with the United States Bureau of Reclamation (USBR) to investigate enhanced membrane filtration as a treatment method for CAP water in order to meet the water quality requirements of the WCPA. The possibility of direct potable use of CAP water for municipal supply in the future will depend on whether a treatment process can be identified and improvements made in the distribution system which will make the water quality acceptable to water customers at a cost that they are willing to pay.

Although the provisions and restrictions of the WCPA only apply to the City of Tucson, other municipal providers in the AMA have been reluctant to initiate direct delivery and injection projects and appear likely to use their CAP water allocations primarily through storage and recovery mechanisms in the near term. Metropolitan Domestic Water Improvement District (MDWID) has recharged CAP water at the Avra Valley Recharge Project since 1996. Several providers, including MDWID, Spanish Trail Water Company, Community Water Company of Green Valley, the Town of Oro Valley, and Green Valley Water Company, have been storing water at the Tucson AMA's four GSFs. Storage at the GSFs began in 1995. Furthermore, the Tucson region risks losing federal funding for a reservoir to increase the reliability of CAP water supply delivery because CAP water is not being used directly. See chapters 2 and 5 for additional information on CAP water use by municipal users. See Chapter 7 for additional information on water quality issues.

8.2.2.1.3 Agricultural Use of Central Arizona Project Water

Agricultural entities in the Tucson AMA, which include the Cortaro Marana Irrigation District (CMID), Avra Valley Irrigation District (AVID), and Farmers Investment Company (FICO), declined their CAP water allocations. Decisions not to sign a CAP water subcontract were made primarily due to CAP water costs. In the cases of AVID and FICO, infrastructure costs for the conveyance of CAP water to their farms was also an issue.

Agricultural use of CAP water in the Tucson AMA has been made possible by the Department's Groundwater Savings Program, which allows a water storer to earn storage credits for providing an alternative water supply to a water user who would have otherwise used groundwater. The cost of CAP water to a farmer operating a GSF varies depending on the CAP water provider and specific conditions of the storage agreement; however, GSF storage agreements typically provide CAP water to farmers at a cost lower than any other water source available to them. Through this program, there is an economic incentive for the farmer to use CAP water instead of groundwater. The entities supplying CAP water earn long-term storage credits. Because much of the agricultural land is close to the CAP canal, using CAP water through a GSF also minimizes the distribution costs for the water storer.

In 1997, agricultural use of CAP water in the Tucson AMA was approximately 25,000 acre-feet. This number is expected to increase in the short term but decrease over time as the demand for direct municipal use increases and as direct recharge facilities are developed. See Chapter 4 for further discussion of agricultural CAP water use and section 8.7.3 for current program incentives to encourage CAP water use.

8.2.2.1.4 Industrial Use of Central Arizona Project Water

There are limited opportunities for CAP water use by industrial users in the Tucson AMA. The cost of CAP water compared to groundwater, the lack of physical access to the CAP water supply, and institutional and water quality concerns constrain the economic use of CAP water by industry. The mines are the largest-volume industrial water user group in the AMA. Lack of delivery infrastructure, costs associated with CAP water quality as it affects mineral recovery, and the cost of CAP water compared to groundwater may preclude direct CAP water use. However, participation in groundwater savings projects may improve the economics of CAP water utilization for copper mining. Incentives to encourage CAP water use by industrial users are included in this plan in section 8.7.3. See Chapter 6 for further discussion of current and potential CAP water use by industrial users.

8.2.2.1.5 Central Arizona Project Water Supply Reliability

The reliability of CAP water supplies and the scheduling of deliveries has implications for the planning and operation of some recharge facilities and direct delivery for municipal use within the AMA. Arizona's CAP water has the lowest allocation priority among the Lower Division states of the Colorado River Basin. The Tucson AMA's location at the terminus of the project, the current lack of terminal storage facilities, and Tucson's lack of other surface water supplies increase the importance of CAP water supply reliability and scheduling.

The USBR conducted the Tucson Aqueduct System Reliability Investigation (TASRI). The focus of the TASRI study was to identify and evaluate methods to bring projected CAP water delivery reliability in the Tucson metropolitan area up to the same level as in the Phoenix metropolitan area. There were differing perceptions of the level of reliability needed, ranging from the need to eliminate water delivery interruptions due to CAP maintenance to providing storage for short-term emergency outages of up to 47 days. The USBR concluded a surface terminal storage reservoir with 15,000 acre-feet of usable storage capacity constructed at Black Wash near the Pascua Yaqui Indian Reservation would meet system reliability needs (USBR, undated). Independent local actions were proposed to provide the additional level of reliability required in the Tucson AMA.

Federal support for construction of the terminal storage reservoir is jeopardized due to changes in the City of Tucson's approach to using its CAP water allocation to meet the requirements of the City's 1995 WCPA. The absence of terminal storage may limit the opportunity to return to direct delivery.

Other municipal water users, the Tohono O'odham Nation, and some industrial water users are also concerned about delivery reliability. Design and operation of recharge facilities is affected by the likelihood of delivery delays and interruptions. Currently, the Southern Arizona Water Resources Settlement Act (SAWRSA) obligates the Secretary of the Interior to pay damages for failure to deliver CAP water to the Tohono O'odham Nation. Reliability is a key issue if the mines in the AMA are to utilize CAP water, because their processes operate 24 hours a day and maintaining the groundwater supply infrastructure as a back-up in case the CAP water supply is interrupted is a significant cost factor.

8.2.2.2 Effluent

Approximately 69,000 acre-feet of effluent were produced in 1995 within the Tucson AMA. Of this amount, only about 10,000 acre-feet, or 15 percent, was reused on turf facilities or delivered to agricultural users. About 56,000 acre-feet, or 81 percent, of the effluent produced was discharged to the Santa Cruz River bed. It is estimated that approximately 10 percent of the discharged effluent evaporates or supports riparian habitat. Because most of the effluent discharged to the river recharges the groundwater aquifer within the AMA, direct use of this effluent provides a limited but important increase in the total water

supply available to the AMA. There are several benefits to increasing direct use of effluent. The primary benefit is reserving high quality groundwater for potable use. Other benefits include the following:

- As more effluent is discharged to the Santa Cruz River, the chances increase that it could leave the AMA as surface water or groundwater outflow.

- Use of effluent for turf irrigation improves the quality of the water that is incidentally recharged because turf takes up nitrogen and phosphorus.

- When CAP water is the original source, effluent reuse increases the benefit of the CAP supply because the original potable use of the CAP water replaces a groundwater use and use of the resulting effluent also replaces a groundwater use.

- A potential localized benefit is the mitigation of subsidence impacts caused by overpumping of groundwater.

- Regulations governing the discharge of effluent to streambeds are expected to become more stringent. As this happens, direct use of effluent will prevent the need to upgrade wastewater treatment facilities.

Direct use or storage that results in keeping the effluent near where it was generated or moving the effluent back upstream increases the likelihood that it will benefit more users. Effluent could also be recharged or used in critical groundwater water level decline areas.

Management of the effluent supply is complicated by institutional factors. The decisions and policies of the jurisdictions controlling the supply and distribution of effluent will affect the use of effluent during the third management period. It should be noted that effluent could cease to be discharged to the Santa Cruz River if alternative plans for the effluent's use are developed. If this happens, the recharge that results from the current discharges will also cease. The effect on safe-yield will depend upon the decrease in groundwater pumping associated with the use that the effluent replaces.

Pima County owns and operates the wastewater system in the Tucson AMA but controls little of the effluent produced. Under an agreement related to the SAWRSA settlement, the Secretary of the Interior is assigned 28,200 acre-feet per year of the effluent discharged from the County's metropolitan wastewater treatment facilities. The City of Tucson controls 90 percent of the remaining effluent produced by County facilities under a 1979 intergovernmental agreement (IGA) and ten percent is controlled by Pima County.

The City of Tucson owns and operates a distribution system for reclaimed water (post-secondary-treated wastewater). The system is primarily used for turf irrigation. The Sweetwater Recharge Facility provides temporary underground storage and filtration to meet demands of the reclaimed water system. The facility uses spreading basins to recharge excess effluent during the winter. The effluent can be extracted via on-site recovery wells for use in the hotter months when irrigation demands are higher. A proposed in-channel effluent storage and recovery project will increase the volume of water that can be delivered through the reclaimed system in the future.

The proposed in-channel or managed effluent storage project may be expanded in the future to include the entire quantity of effluent discharged from the Ina and Roger Road plants that is controlled by the City of Tucson and the Secretary of the Interior. Although this type of credit cannot be used as a demonstration of assured water supply and credits are limited to 50 percent of the water stored, the manner and timing of the storage and recovery of these credits impacts the water budget for the Tucson AMA and may have local implications for water levels.

Although the supply of effluent is increasing with population and offers opportunities for augmenting the water supply, there are conditions in the Tucson AMA that could restrict effluent use:

- Expanding Tucson's reclaimed water distribution system would be costly.
- There is currently no distribution system that could make effluent available to many of the large agricultural users such as BKW Farms, AVID, and FICO.
- Chemical incompatibility of effluent and reclaimed water with metallurgical processes makes the use of effluent in mining operations problematic. Costs associated with constructing, operating, and maintaining a conveyance system to deliver the water to the mines is also prohibitive.
- Institutional/jurisdictional issues associated with using effluent pursuant to the 1979 IGA between the City of Tucson and Pima County have limited effluent use. The 1979 IGA is the subject of ongoing disputes between the City and County and other water providers.
- The SAWRSA settlement, which entitles the Secretary of the Interior to 28,200 acre-feet of effluent annually to settle Indian water rights claims will not be fully implemented until several lawsuits are resolved. Although various proposals are being investigated, the Tohono O'odham Nation has indicated that it does not want to use effluent directly, and no distribution or marketing mechanism for the Indian effluent allocation has been implemented to date.
- There are currently few proposed or developed sites situated for recharging effluent. Pima County has evaluated potential sites for effluent recharge, and both the City of Tucson and the County are in the process of developing small wetland effluent treatment and recharge projects. However, the capacity of the proposed wetland treatment and recharge projects is very limited.

Cooperative regional planning could help address some of the institutional, financial, and regulatory barriers to efficient effluent supply management and effluent use. A regional effluent management planning process began in 1997 with funding from the USBR in cooperation with the Tucson Regional Water Council. The mission of the Regional Effluent Planning Project (REPP) is to develop and implement a coordinated long-range effluent utilization plan and to construct projects in the Tucson AMA. This plan could address water supply needs of critical areas, water quality concerns, and ways to prevent water supplies from migrating out of the AMA.

8.2.2.3 Surface Water

In the upper stream reaches in the Santa Catalina Mountains and a few other areas in the AMA, surface water often flows year-round. Because the surface water eventually percolates to the groundwater aquifer as mountain front and stream bed recharge, this surface water is not a potential new source of renewable supply.

Because most of the intermittent storm-water run-off in the Tucson AMA already recharges naturally along the mountain fronts and in the washes of the AMA, storm-water run-off is also not a significant new source of renewable supply. Impacts to downstream surface water right holders must be taken into account if a storm water recharge project has the potential to affect downstream flows. In order to accrue recharge credits for recharge of storm water, one must demonstrate that the water recharged would have otherwise left the AMA.

Changing the distribution of storm-water recharge in the basin may help meet local water management objectives. Large-scale recharge projects designed solely to recharge storm water are often not cost-effective due to the small number of days of flow during each year. Some small-scale, multiple-use

projects incorporating storm-water recharge have been proposed in the Tucson AMA. A large number of households retaining storm water by harvesting runoff in swales, microcatchments, and tanks could cumulatively result in significant reductions in municipal demand for outdoor use. Retaining storm water in the soil and applying tank-stored storm water to landscaping reduces the need to use groundwater, imported CAP water, or effluent to meet this demand.

8.3 STATUS OF SUPPLY AUGMENTATION AND ARTIFICIAL RECHARGE IN THE TUCSON AMA

This section summarizes direct recharge and groundwater savings project activity; highlights some of the factors affecting recharge, including siting limitations and water quality issues; and gives an overview of how artificial recharge meets other water management objectives.

8.3.1 Recent Direct Recharge Activity - Underground Storage Facilities

Capacity to store renewable supplies in the Tucson AMA is relatively limited, although it has been increasing rapidly. Table 8-2 describes underground storage facilities (USF) permitted as of August 1998, and lists approximate storage volumes for each year from 1995-1997. As of August 1998, there were three USF projects with permits to store CAP water and one permitted project for effluent storage. Because some pilot permits have a maximum volume limit over the life of the permit and full-scale permits have limits on an annual basis, the volume of recharge under the permits may vary significantly from year to year. The calculated volume of credits accrued in USFs through 1997 was 13,856 acre-feet. The locations of projects with permits as of August 1998, projects with pending permits, and proposed sites are shown on Figure 8-2. Brief descriptions of the currently permitted projects are in Table 8-2. The project numbers used in the table are designations used by the Regional Recharge Committee (RRC). This committee of 22 hydrologists and engineers assessed recharge issues and opportunities in the Tucson area and published a report in 1996.

8.3.2 Recent Groundwater Savings Facility (In-Lieu) Activity

A GSF uses a renewable water supply "on a gallon-for-gallon substitute basis" in lieu of the groundwater it would otherwise have pumped. A.R.S. § 45-812.01(B). GSF permits have been obtained to replace groundwater used for irrigated agriculture with CAP water. In order to obtain a GSF permit, the applicant must demonstrate, among other things: (1) that the groundwater to be replaced would have otherwise been pumped; (2) that no other source of water, other than groundwater withdrawn within the AMA, is reasonably available; and (3) that the recipient of the renewable water could not reasonably be expected to use the renewable supply without the added benefits of operating a GSF.

The permit application also must show what evidence will be submitted with annual reports to prove the amount of groundwater saved. A.R.S. § 45-812.01(B) provides guidance on the kinds of information that should be included as evidence.

In the Tucson AMA, as of August 1998, there were four permitted GSFs. Their combined permitted capacity was 52,544 acre-feet per year. Applications for additional permits with a combined capacity of 8,441 acre-feet were pending. Table 8-3 describes the facilities, permitted storage volumes, and volume stored each year from 1995-1997. Figure 8-2 shows the locations of existing and proposed sites. A total of 53,967 acre-feet were stored in GSF's in the Tucson AMA between inception of the program and the end of 1997.

TABLE 8-2
PERMITTED UNDERGROUND STORAGE FACILITIES
TUCSON ACTIVE MANAGEMENT AREA

Facility Description and Status	Storage Permittee	Maximum Volume	Expires	1995 Storage AF	1996 Storage AF	1997 Storage AF
Avra Valley Airport USF - CAP Consists of four off-channel constructed shallow spreading basins. Facility is located northeast of the airport, less than one mile south of Tangerine Road and about one mile east of Sanders Road. CAWCD's pilot permit was for 8,300 AF. The 11,000 AFA full-scale facility permit expires in 2018. Facility is fully operational. RRC project #3.	CAWCD	over 2 years 8,300 AF	1998	NP	0.0	0.0
	MDWID	over 2 years 8,300 AF	1998	NP	2,794.1	3,435.0
	AWBA	8,000 AFA	1998	NP	NP	2,121.0
Pima Mine Road USF - CAP Consists of two off-channel shallow constructed spreading basins, each comprised of four cells. Facility is North of Pima Mine Road, along the Old Nogales Highway. CAWCD's 10,000 AF facility permit expires in 1999. Full-scale project is expected to have capacity of 30,000 AFA. RRC project #4.	CAWCD	over 2 years 10,000 AF	1999	NP	NP	0.0
	Tucson Water	over 2 years 10,000 AF	1999	NP	NP	0.0
Central Avra Valley Storage and Recovery Project USF - CAP Consists of three off-channel shallow spreading basins. Facility is located north of Mile Wide Road a mile west of Sanders Road. CAVSARP Pilot #1: Tucson Water's 500 AF facility permit expired in 1997. CAVSARP Pilot #2: Tucson Water's 10,000 AF facility permit expires in 1999. Application for a 5-year 15,000 AFA permit has been submitted. Full-scale capacity projected to be 60,000 AFA. Facility is fully-funded but expansion depends on results of pilot studies. RRC project #5.	Tucson Water	over 6 months 500 AF	1997	NP	153.6	202.0
	Tucson Water	over 2 years 10,000 AF	1999	NP	NP	1,007.0
	AWBA	over 2 years 10,000 AF	1999	NP	NP	1,000.0
Sweetwater USF- Effluent Consists of seven off-channel basins. Annual storage and recovery facility operated in association with Tucson's reclaimed water system. Facility is located along the Santa Cruz River near Roger Road. Tucson Water's 6,500 AFA facility permit expires in 2008. RRC did not evaluate this site in detail.	Tucson Water	6,500 AFA	2008	2,654	2,572.0	3,207.0
TOTAL				**2,654**	**5,519.7**	**10,972.0**

Losses (evaporation and cut to the aquifer) have not been subtracted from the storage volumes.
AF = acre-feet
AFA = acre-feet annually
AWBA = Arizona Water Banking Authority
CAP = Central Arizona Project
CAWCD=Central Arizona Water Conservation District
CAVSARP = Central Avra Valley Storage and Recovery Project
MDWID = Metropolitan Domestic Water Improvement District
NP = no permit in effect during this year
RRC = Regional Recharge Committee
USF = Underground Storage Facility

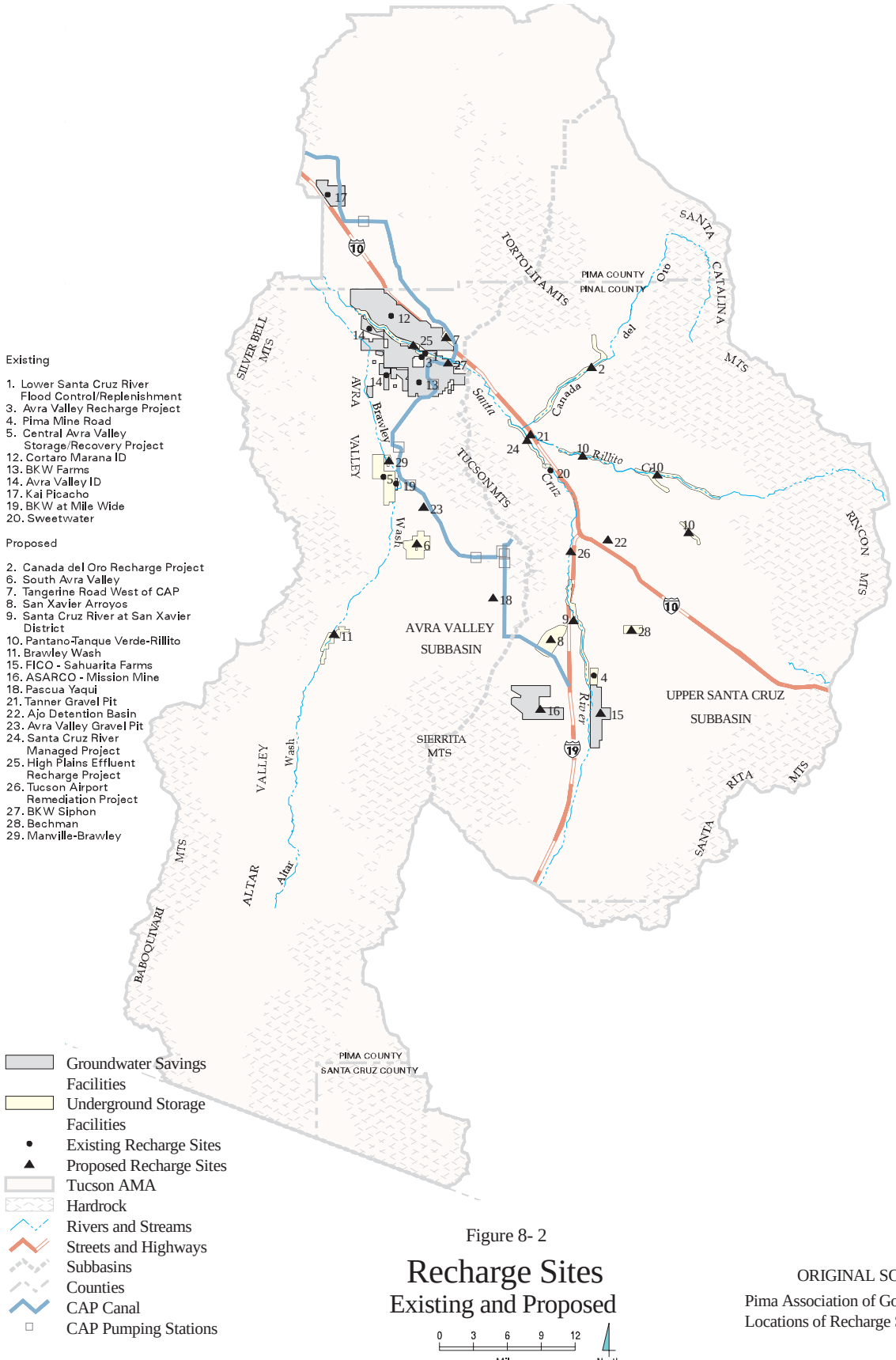


Figure 8- 2

Recharge Sites

Existing and Proposed

ORIGINAL SOURCE

Pima Association of Governments
Locations of Recharge Sites are Approximate

GSFs tend to be less expensive than USFs because very little construction is required for facilities located near the CAP canal. However, the benefits of GSFs and the opportunities for their use as a water management tool are mostly short-term. GSF storage capacity is likely to increase in the third management period, while unused CAP water allocations, excess CAP water, and storage sites close to existing conveyance infrastructure are available. In the long term, the volume of water used on irrigated agriculture is expected to decline due to urbanization of farmland and decreasing availability of CAP water.

GSFs are perceived by some local water interests as a postponement of groundwater level declines, because after the GSF contracts are completed, water users are likely to resume pumping groundwater in the area of storage. Temporary supply substitution through GSFs without extinguishment of some groundwater rights or other reduction in use will not solve local overdraft problems. Although GSFs were not originally conceived as a tool to address water management problems in critical areas, they can be used to address areas of overdraft, if the credits generated are recovered in locations where water supply availability is less critical. The relative benefits of USFs compared to GSFs must be analyzed on a site-by-site basis.

8.3.3 Limitations on Availability of Recharge Sites

Availability of suitable recharge sites affects direct recharge efforts in the Tucson AMA. The City of Tucson, Pima County, Metropolitan Domestic Water Improvement District (MDWID), Marana, Oro Valley, Central Arizona Water Conservation District (CAWCD), the Department, and others have participated in hydrogeological and other feasibility investigations of sites that may be suitable for recharge. The RRC and IPAG, in developing a regional recharge plan for the Tucson AMA, screened the available data for 37 proposed recharge project sites for project feasibility and potential to meet regional groundwater management objectives. More information about the planning process is in section 8.4.5.3.

Physical factors affecting recharge feasibility include infiltration rates, permeability, geochemistry, available storage, and the existence and extent of lower permeability or impermeable layers in the vadose zone. Although there are many locations within the AMA suitable for recharge, there are few single sites capable of accepting as large a volume of water as the Granite Reef Underground Storage Project site in the Phoenix AMA, which is likely to store approximately 75,000 acre-feet annually.

Availability of sites for basin or in-channel recharge is also limited by areas of existing contamination and potential contaminant sources. Some reaches of stream channels in the Tucson AMA are not suitable sites for developing surface recharge, because closed and active landfills and dumps and other land uses that could be sources of contaminants are located too close to the channels. The Department will not issue a permit for a proposed facility that may cause unreasonable harm based on evaluation of the application data.

Well injection recharge can be particularly useful in urban areas where there is insufficient space to develop a surface recharge site or land costs are too high for surface recharge to be economically viable. The cost to meet injection recharge water quality requirements under the 1995 WCPA discourages use of injection recharge methods within the City of Tucson.

Proximity to source water is a significant economic feasibility factor for siting effluent and CAP water projects because of the cost to construct and operate conveyance and distribution systems. Hydrogeologically suitable sites for recharge in some of the critical water level decline areas may be too far from existing effluent and reclaimed water delivery systems and the CAP canal to economically develop the sites. Use of the existing potable water supply system for CAP water deliveries could improve the economic viability of some recharge sites.

TABLE 8-3
PERMITTED GROUNDWATER SAVINGS FACILITIES
TUCSON ACTIVE MANAGEMENT AREA

Facility Description and Status	Water Storage Permittee	Maximum Volume AFA	Expires	1995 Storage AF	1996 Storage AF	1997 Storage AF
Cortaro Marana Irrigation District GSF Receives CAP water in lieu of pumping groundwater. Facility roughly located from Tangerine Road north to the Pima/Pinal County border and southwest of I-10 to one mile west of Trico Road. CAWCD's 10,000 AFA facility permit was conveyed to CMID. CMID's modified 20,000 AFA permit expires in 2008. The facility is fully-funded and currently operating. RRC #12.	CAWCD	10,000	2008	0	0	0
	Tucson Water	10,000	2003	5,902	9,581	6,327
	Spanish Trail	10,000	2003	NP	NP	3,419
	Community Water Company of Green Valley	10,000	2003	NP	NP	0
BKW Farms GSF Receives CAP water in lieu of pumping groundwater. Facility located south of Santa Cruz River to Emigh Road between Trico Road and Silverbell Road. CAWCD's 8,800 AFA facility permit expires in 2002. Facility is fully-funded. Application for expansion to 16,614 AFA has been submitted. RRC #13.	CAWCD	8,800	2002	1,000	0	0
	Community Water Company of Green Valley	8,800	2002	NP	NP	2,000
	Tucson Water	8,800	2002	3,235	5,080	6,648
	MDWID	2,000	2002	NP	2,000	0
Herb Kai Red Rock GSF Receives CAP water in lieu of pumping groundwater. Located in Pinal County, east of the Town of Red Rock, south of Neuman Peak Road to Park Link Road, and between I-10 and Pecan Road. Herb Kai's 11,231 AFA facility permit expires in 2006. The facility is operating. RRC #17.	MDWID	11,231	2006	NP	NP	1,136
	CAWCD	11,231	2006	NP	NP	0
	Spanish Trail	11,231	2006	NP	NP	3,915
	Town of Oro Valley	6,000	2006	NP	NP	1,150
	Green Valley Water Co.	500	1999	NP	NP	500
	Tucson Water	11,231	2006	NP	NP	0
Avra Valley Irrigation District GSF Receives CAP water in lieu of pumping groundwater. Located between Trico and Sanders Roads, on either side of Avra Valley Road, west of the Santa Cruz River. Herb Kai's 12,513 AFA permit expires in 2008. RRC #14.	MDWID	12,513	2008	NP	NP	NP
TOTAL				**10,137**	**16,661**	**25,095**

AF= acre-feet
AFA= acre-feet annually
CAP = Central Arizona Project
CAWCD= Central Arizona Water Conservation District
CMID= Cortaro Marana Irrigation District
GSF= Groundwater Savings Facility
MDWID= Metropolitan Domestic Water Improvement District
NP= no permit effective in this year.
RRC = Regional Recharge Committee

Recharge to help mitigate overdraft in the Central Wellfield is particularly constrained by these site availability issues. The critical area of water level decline primarily underlies densely urbanized areas of Tucson. Potential contamination sources, local regulations, and conveyance issues affect the feasibility of recharge in this area.

Recovery considerations are another constraint on potential recharge site development. Some of the concerns include where the facility is located with respect to the final use, whether the recovered water is determined to be groundwater under the influence of surface water and will therefore require filtering and disinfection, and whether the proposed recovery will be feasible under recovery permit requirements in areas of severe groundwater overdraft and high subsidence risk.

Additional discussion about the opportunities and limitations associated with siting direct recharge facilities can be found in the *Regional Recharge Plan* developed by the Tucson AMA Institutional Policy Advisory Group (IPAG) in 1998.

8.3.4 Water Quality Issues

Protecting and managing groundwater quality and matching water supplies of different quality to user needs maximizes the amount and utility of water available to the AMA. The Arizona Department of Environmental Quality (ADEQ) is the lead state agency in protecting and monitoring groundwater quality conditions (see Chapter 7 and Appendix 8A.4 for more information about ADEQ authorities). The Department is involved with water quality management through wellhead protection; well construction standards; permitting; and review, planning, and other activities associated with the ADEQ Water Quality Assurance Revolving Fund (WQARF) Program. Chapter 7 describes the Department's Water Quality Management Program in detail. This section focuses on water quality issues with respect to augmentation of water supplies.

Most of the groundwater supplies in the Tucson AMA meet all EPA and state drinking water standards. However, groundwater from some areas has contaminant levels that exceed the primary safe drinking water standards. There are concerns that remediation efforts to date have been inadequate at many sites. Substantial public education efforts are also needed. Chapter 7 describes many of the areas where groundwater quality is a concern in the Tucson AMA.

Tucson's 1995 Water Consumer Protection Act prohibits delivery of groundwater that has been treated by Tucson Water to remove contaminants, even if the resulting water quality meets all federal and state drinking water standards. Within the Tucson Water service area, use of treated groundwater supplies and achievement of maximum beneficial use of treated groundwater produced by mandated clean-ups are complicated by this provision.

Water quality considerations regarding recharge are site-specific. They are related to the ambient groundwater quality (which varies across the AMA), the soil chemistry, the quantity of water to be recharged, the degree of mixing with the ambient groundwater, past land-use practices, percolation rates, and residence time. The location, volume, and timing of recovery activities are also important in assessing water quality impacts.

Water withdrawn in the vicinity of a recharge site is often a mixture of the recharged water and ambient groundwater. In some areas of the AMA, recharge of CAP water would improve the quality of the ambient groundwater. In other areas, there may be increases in the concentration of total dissolved solids (TDS). TDS concentration is one of several parameters that affect the aesthetic qualities of drinking water. The typical concentration of TDS in CAP water is higher than the concentrations of TDS found in the groundwater currently being withdrawn from most areas of the AMA. Generally, artificial recharge processes, including percolation of water from surface basins through vadose zone soils, do not remove

TDS from recharging water. Older groundwater supplies in deeper parts of the aquifer than those layers that are currently being tapped are also likely to have higher concentrations of TDS and other inorganic parameters than the groundwater currently being supplied. See Chapter 7 for a more detailed discussion.

The impact of the implementation problems Tucson Water experienced with direct delivery has affected CAP water use plans beyond the City of Tucson. Public perception of CAP water quality, which was an issue even before direct delivery, has been affected regionally, and other communities in the AMA are reluctant to consider direct delivery of CAP water in the short term.

ADEQ is developing new rules to govern "groundwater under the influence of surface water." How ADEQ will interpret and enforce the surface water disinfection rules when the recharged CAP water and ambient groundwater is withdrawn from wells for potable use is a water quality issue for CAP water recharge projects statewide. If the recovered water is deemed to be groundwater under the influence of surface water, then both filtration and disinfection may be required, resulting in substantial increases in recovery costs. Whether the effects of soil aquifer treatment will be taken into consideration on a case-by-case basis has not been determined yet. (See Appendix 8A, section 8A.4.2, for more information regarding this requirement.)

Augmentation funds have been used to assess potential water quality impacts of recharge activities. The Department funded a study of selected disinfection by-product issues related to the recharge and recovery of CAP water. The Department also funded a water quality impacts evaluation as part of a study to assess the feasibility of delivering CAP water to water users in the Sahuarita-Green Valley Area. These projects are described further in chapters 7 and 9.

8.3.5 Integrating Artificial Recharge with Other Groundwater Management Objectives

Artificial recharge can play a role in meeting multiple planning objectives. Some artificial recharge projects may provide side benefits involving storage, flood control, groundwater quality management, subsidence prevention, infrastructure utilization, open space and recreation, and riparian habitat maintenance. The Department recognizes that multiple-purpose projects can provide significant benefits to the community. However, to be permitted as a USF and accrue long-term storage credits, the recharge project's primary purpose must be water storage (see section 8.7.2.2). The design focus of a USF should be to maximize recharge.

8.3.6 Regulatory and Institutional Setting for Recharge

The regulatory and institutional framework for recharge activities is complex. Statutory provisions and permitting considerations for USF facilities provide background for the USF Program section and explain certain policy considerations (see section 8.7.2). Other Department activities that affect the Augmentation and Recharge Program include the use of the augmentation, conservation assistance, and monitoring fund; AWPF grants; the AWS Program; and well spacing rules (see Appendix 8A).

The AWBA, the CAWCD, and the CAGRD play significant roles in water supply augmentation and recharge. An understanding of the roles, authority, programs, and policies of these institutions is essential for understanding CAP water availability, use, and reliability in the Tucson AMA.

Federal, state, and local regulations and policies and the actions of other institutions and agencies have significant impacts on recharge and supply augmentation efforts. Key factors include:

- Indian water rights settlements;
- ADEQ regulations and programs including aquifer protection permits (APP), water disinfection rules for groundwater under the direct influence of surface water, aquifer water quality standards (AWQS), and wastewater reuse permits;
- Federal Clean Water Act requirements including National Pollutant Discharge Elimination System (NPDES) permits (administered through ADEQ), and section 404 permits (administered by the United States Army Corps of Engineers);
- United States Fish and Wildlife Service (USFWS) activities and Endangered Species Act (ESA) requirements;
- The State Historic Preservation Act and local requirements for archaeological surveys;
- USBR activities and requirements of the Reclamation Reform Act (RRA);
- Local zoning and flood control regulations; and
- City of Tucson 1995 Water Consumer Protection Act.

The implications of several of these programs and policies are discussed in detail elsewhere in this chapter. Background information on many of the listed factors is in Appendix 8A.

8.4 ASSESSMENT OF SECOND MANAGEMENT PLAN AUGMENTATION PROGRAM ACTIVITIES

The Second Management Plan contained a thorough review of opportunities to supplement the water supplies of the AMA. It focused on six objectives that were thought to be most useful in supporting the augmentation efforts of the AMA. The following section is a review of the Second Management Plan program objectives and progress in meeting those objectives. Each subsection refers to an objective listed in the Second Management Plan.

8.4.1 Second Management Plan Objective 1: Maximum Use of Tucson AMA Central Arizona Project Allocations

Problems with utilization of the AMA's CAP water allocation relate to both allocation and distribution issues. Some entities hold subcontracts and are currently unable to use them. Other entities would like to use CAP water but have no way to physically access the water. Use of the City of Tucson's annual subcontract, the largest allocation in the state, has been delayed due to direct delivery problems as described in section 8.2.2.1.2.

The lack of conveyance structures to transport CAP water from the canal or the City of Tucson delivery system to other water providers and users in the AMA, and CAP water delivery reliability issues also inhibit use of CAP water subcontracts. The mines and agricultural users have declined CAP water subcontracts as discussed previously.

8.4.2 Second Management Plan Objective 2: Optimize Use of Central Arizona Project Canal System to Enable Delivery of "Surplus" Colorado River Water and Other Water to the AMA

The GSF program has utilized some excess CAP water and some CAP contract water. The AWBA now provides an opportunity to bring more surplus water into the region while it is available. The CAWCD operated the CAP canal at full capacity during parts of 1997, and the canal is expected to be at capacity at least during the summer months in the future. Although statewide CAP water deliveries have been near capacity, deliveries to the Tucson AMA have been limited primarily by the factors previously discussed. Opportunities to bring other water sources into the AMA via the canal have not been investigated by the Department.

8.4.3 Second Management Plan Objective 3: Maximize Recharge of Alternative Supplies to Groundwater

Several steps were taken toward achieving this objective, including recharge feasibility assessments; pilot projects which were designed, built, and operated in the second management period; and regional planning activities. Most of the recharge activity has been near the CAP canal.

Annual storage and recovery of effluent at Tucson's Sweetwater facility has occurred since 1987. An application for a facility permit for managed in-channel recharge of effluent in the Santa Cruz River is pending.

The Town of Marana and Pima County Flood Control District have submitted an application for a facility permit to recharge effluent and also effluent that is accounted for as surface water at the proposed High Plains recharge project. The application is for a two-year pilot to recharge 600 acre-feet. The facility would consist of five basins, with a total area of approximately four acres located along the south bank of the Santa Cruz River about 250 feet from the main channel.

The Department initiated a regional recharge planning effort in 1995. The planning process has provided a more complete picture of the geographical, political, institutional, legal, and technical issues associated with the development and implementation of recharge projects (see section 8.4.5.3).

Additional effluent recharge options have been identified in various forums, including the Regional Effluent Planning Process which was initiated in 1997 (see section 8.2.2.2).

8.4.4 Second Management Plan Objective 4: Augment Supplies Through Inter-regional Water Transfers and Exchanges

No inter-regional water transfers or exchanges were completed in the second management period. However, the 1992 Water Exchange Act may facilitate future exchanges.

8.4.5 Second Management Plan Objective 5: Resolve Technical, Institutional, Legal, and Environmental Constraints that Inhibit the Development of Beneficial Use of Alternative Supplies

The augmentation discussion presented in the Second Management Plan identified some legal and institutional issues which needed to be resolved before augmentation projects could be undertaken on a large scale. Examples of the issues identified include questions regarding ownership of rights to augmented water supplies, questions regarding liability for potential damages resulting from augmentation projects, and the need for laws or Department rules to provide incentives for water supply augmentation efforts. The following sections describe efforts during the second management period to respond to these issues.

8.4.5.1 Legislative Changes

Substantial legislative changes have been sponsored or supported by the Department to facilitate the augmentation of water supplies in the AMAs. In 1996, legislation established the AWBA for the purposes of increasing utilization of excess Colorado River supplies, primarily through recharge in the Phoenix, Pinal, and Tucson AMAs. For more information about the AWBA see section 8.4.5.2, section 8.7.1, and Appendix 8A.

In 1994, passage of the Underground Water Storage, Savings, and Replenishment Act integrated the various underground water storage programs adopted since 1986 into a single, unified program. This more

streamlined process was intended to facilitate development of recharge projects. The legislation also improved the recharge permitting system, addressed the assignability of long-term storage credits, and established accounting mechanisms for replenishment districts and conservation districts.

Legislation was also passed in 1994 to address recommendations by the Governor's CAP Advisory Committee for increasing the state's use of CAP water supplies. To encourage earlier use of CAP water, the legislation moved back the statutory date by which cities and towns with CAP allocations would have to prove an assured water supply from 2001 to 1998. The AWPF was established in 1994 to issue grants to water users for implementing projects to protect the state's rivers and streams, including the use of excess CAP water for riparian enhancement.

Other legislation has been enacted since adoption of the Second Management Plan that enhances the ability of water users to undertake augmentation projects. In 1993, legislation was enacted that created the CAGRD (administered by the CAWCD) to utilize excess CAP water to replenish groundwater used by district members in excess of their mined groundwater allocations under the Assured Water Supply Rules. The CAGRD allows water companies and subdivisions to meet the renewable water supply requirements of the AWS Rules.

The 1992 Water Exchange Act allows for the trade of any water supplies for any other water supplies between water users, as long as each water user has the legal right to use the water it gives in trade. This facilitates conjunctive use of surface water, groundwater, and effluent, and is particularly useful in the Phoenix AMA.

Although the 1991 Groundwater Transportation Act severely restricts the ability of municipal water providers to transfer groundwater from rural basins to urban areas, the act nonetheless provides a legal framework for certain interbasin transfers of groundwater supplies to assist in demonstrating an assured water supply. The Act reduces the conflict between rural and urban interests over importation of groundwater. This Act laid important groundwork for development of the AWS Rules, which are instrumental in ensuring the use of renewable water supplies in the AMAs.

Other legislation initiated since the adoption of the Second Management Plan provides additional incentives for the use of CAP water by reducing the level of conservation required for users who limit groundwater use to 30 percent or less of their total use and by allowing for the extinguishment of recharge credits to gain compliance with the municipal gallons-per-capita-per-day water use requirement.

8.4.5.2 Arizona Water Banking Authority

Arizona does not currently use its full annual 2.8 million acre-foot share of Colorado River water established through the court opinion in *Arizona v. California*, 373 US 546 (1963). Any of Arizona's apportionment that is not diverted from the mainstream of the river by Arizona is available for use in California or Nevada. The AWBA was established in 1996 as a means to increase the utilization of Arizona's Colorado River apportionment and to store unused Colorado River water to meet Arizona's future water supply needs. As Arizona directly uses more of its Colorado River apportionment, the amount of "excess" CAP water available to the AWBA for storage is expected to decrease over time. Arizona has the lowest priority right of the Lower Division states of the Colorado River basin. The availability of "excess" water would be less during periods of shortages, when Arizona is not allowed to divert the full 2.8 million acre-feet per year.

The objectives of the AWBA include: (1) protecting municipal and industrial users of CAP water from shortages or disruptions of the CAP system, (2) assisting in meeting the management objectives of the state Code, (3) assisting in the settlement of Indian water rights claims, (4) exchanging water to assist Arizona's Colorado River communities, and (5) exploring opportunities for interstate water banking with Nevada and

California. Although the AWBA has been working closely with the AMAs to identify storage opportunities that would also help support the water management objectives of each AMA, some of the recharge projects that are ideally located to meet some of these AWBA objectives may not assist the AMAs in meeting their specific water management goals.

Annual funding for the AWBA comes from four sources: an ad valorem property tax of four cents per $100 assessed valuation in the three-county CAP service area; $2.50 per acre-foot of the $3.00 per acre-foot groundwater withdrawal fee in the Tucson, Phoenix, and Pinal AMAs; general fund appropriations; and the proceeds of interstate banking activities. A.R.S. § 45-2425 describes how the water banking fund is collected, and A.R.S. § 45-2457 describes how each fund component may be used. The ad valorem tax collected for the AWBA in Pima County is estimated to be $1.4 million for 1998. The groundwater withdrawal fee should generate $700,000 in 1998.

Long-term storage credits accrued with general fund appropriations may be used by the AWBA only as follows: (1) to make water available to municipal and industrial users of Colorado River water in this state that are outside the CAWCD service area and to CAWCD for the purpose of meeting the demands of its municipal and industrial subcontractors (both are limited to situations when there are water shortages and require reimbursement), (2) to implement Indian water rights settlements, and (3) to fulfill the water management objectives of the Code.

Credits accrued with the withdrawal fees may only be used for the benefit of the AMA in which the monies were collected. These credits may be used for Indian water rights settlements or to meet the water management objectives of the Code. These funds can be used to store credits for future use or to store credits for extinguishment.

Credits accrued with the ad valorem tax may only be used to benefit the county in which the funds were collected. The AWBA is required to transfer the credits to CAWCD to meet the demands of CAWCD's municipal and industrial subcontractors during times of shortage.

Credits accrued with monies paid by California or Nevada agencies pursuant to the interstate banking provisions must be associated with a plan for forbearance from taking Colorado River water in the future. The AWBA, under certain conditions, is authorized to enter into interstate banking agreements with entities in Nevada and California. Under these agreements, the out-of-state entity would finance the storage of Colorado River water in Arizona. Later, when that entity needed additional water supplies, the AWBA would provide for the recovery of the previously stored water. The recovered water would be used in place of diverting Arizona's full mainstream Colorado River apportionment. The additional water left on the mainstream would be used by the participating out-of state entity. To the extent interstate water is stored in the Tucson AMA, the AMA would receive a short-term benefit of additional water supplies being imported into the AMA in advance, perhaps by decades, of when those supplies would be needed for direct use.

The AWBA is expected to play an important role in the Tucson AMA's water management plans for the third management period. The AWBA will bring additional CAP water into the AMA that would otherwise have been unavailable, and is expected to participate in developing additional water storage opportunities that will benefit the AMA. The Institutional Policy Advisory Group (IPAG) estimated in the November 1997 Report to the AWBA that the total recharge capacity that could be utilized by the bank in the Tucson AMA is 30,000 to 42,000 acre-feet per year, based on AWBA costs of $50 to $70 per acre-foot of CAP water, which may be optimistic.

The AWBA developed a Storage Facilities Inventory for the Phoenix, Pinal, and Tucson AMAs and published the results in March 1997. The AWBA inventory identified 18 proposed and existing recharge facilities in the Tucson AMA, including underground storage, groundwater savings, and effluent recharge

projects, but determined that much of this capacity might not be available to the AWBA because of existing storage obligations to other users and due to other factors. The AWBA concluded that of the three AMAs, only the Tucson AMA had inadequate storage facility capacity to meet the needs of the AWBA for the next ten years. Consequently, under the requirements of A.R.S. § 45-2453(A), the AWBA must develop and implement a plan for additional storage facilities in the Tucson AMA.

In developing and implementing the Facilities Plan, the AWBA is working with the Tucson AMA's regional recharge planning process. The AWBA stated in the Storage Facilities Inventory that the Facilities Plan should complement the Tucson AMA's Regional Recharge Plan to the greatest extent possible. Through this planning relationship, the Department anticipates that most of the AWBA's activities in the AMA will be consistent with local water management objectives. The plans of the AWBA to conduct recharge in the Tucson AMA in both 1997 and 1998 were limited by the slower than anticipated development of certain facilities. The Tucson AMA's specific recommendations to the AWBA regarding siting of storage facilities and contributions to water management appear in section 8.7.1

8.4.5.3 Regional Recharge Planning

Starting in 1995, with the support of the Groundwater Users Advisory Council (GUAC), the Tucson AMA initiated a voluntary planning process for development of the Regional Recharge Plan. Separate technical and policy committees were formed so that political and institutional considerations would not impede evaluation of the technical feasibility of recharge. In 1996, the RRC met to resolve technical issues and provide objective analysis of available data for the use of the political and institutional participants of the IPAG in developing the plan.

The RRC addressed several issues and developed consensus opinions on each issue. Thirty-four potential recharge projects, including seven GSFs, were identified and evaluated. The RRC selected 16 of the projects for a more detailed evaluation, which included a conceptual design and cost analysis. Projects were evaluated for their ability to maximize short-term (five year) recharge volume and long-term regional benefits. Figure 8-2 shows the approximate location of the direct recharge and groundwater savings sites the RRC evaluated in detail and locations of other sites. The RRC's findings were summarized in the September 5, 1996 Department report, "Regional Recharge Committee Technical Report."

IPAG defined the objectives and principles of the Regional Recharge Plan, assessed the recharge-related needs of water users through interviews, identified and described key policy issues, identified and ranked recharge objectives based on the needs assessment data, and developed project evaluation criteria based on these objectives. Physical evaluation criteria and technical data from the RRC were incorporated in the project evaluation criteria.

In November, 1997 IPAG developed a report that focused on storage opportunities for the AWBA, "Report to the Arizona Water Banking Authority." IPAG and Department staff completed the Regional Recharge Plan in 1998. The Regional Recharge Plan includes projections of regional recharge needs under various conditions, project combinations and options under various recharge demand scenarios that fulfill the regional plan criteria, available capacity and potential storage opportunities for the AWBA and other regional interests. It identified data gaps and project needs to address specific problem areas and water management needs such as subsidence risk in the City of Tucson's Central Wellfield and areas of poor water quality.

Implementation of the plan depends on the cooperation of the community, water providers, and political entities, and the willingness of these parties to address regional water management issues. The AWBA used information from the Regional Recharge Plan to develop the AWBA's Facility Plan for the Tucson AMA.

While legal and institutional barriers to augmentation efforts in the AMAs still exist, it is clear that many barriers that were present when the Second Management Plan was adopted have been removed as a result of the efforts of the Department, regulated water users, and other interested parties.

8.4.5.4 Santa Cruz Valley Water District

The Department assisted in the development of 1990 legislation which authorized the creation of a regional water district within the Tucson AMA. The Santa Cruz Valley Water District (SCVWD) was established in June 1991 to facilitate water resource management, especially access to renewable water supplies. Originally the SCVWD was known as the Tucson AMA Augmentation Authority. The scope of duties and authorized activities included the following: construction of water conveyance and recharge projects, facilitation of policy coordination and cooperation between government entities, issuance of revenue bonds, groundwater replenishment responsibilities, contracts and agreements to acquire water supplies for water exchanges and deliveries, provision of technical or financial assistance for developing water supplies to help meet water management goals, development of a comprehensive water resource augmentation plan, coordination of water conservation efforts, provision of miscellaneous water management services, and collaboration on regional recharge and augmentation studies (Santa Cruz Valley Water District, 1993).

SCVWD was funded by groundwater withdrawal fees for a 30-month study period. In December of 1993, although a majority of the board voted to continue, a veto from one member resulted in termination of the District, primarily because issues of governance could not be resolved. Some of the roles envisioned for SCVWD have been incorporated in Department and CAGRD programs.

8.4.5.5 Cooperative Efforts to Encourage Use of Renewable Supplies

The Department has also been actively involved in groups that have formed to facilitate use of renewable supplies within specific regions of the AMA. Department staff have participated in the Northwest Replenishment Program, which is a cooperative effort by multiple political jurisdictions, water districts, and water providers to use artificial recharge of CAP water and effluent for supply augmentation, wildlife and vegetation enhancement, recreation, and flood control. The Upper Santa Cruz Water Users Group (USCWUG) provides a forum to evaluate the feasibility of bringing CAP water to users in the southern part of the AMA, south of the CAP terminus. The regional recharge planning and effluent use planning efforts have also provided a means to share information, identify and resolve problems, and coordinate efforts. Section 8.7.4 provides information on continuing planning efforts.

8.4.6 Second Management Plan Objective 6: Identify Potential Augmentation Measures for Future Implementation

During the second management period, energy was focused on resolving conflicts related to CAP water and effluent use through regional recharge planning efforts and the attempt to establish a regional augmentation authority. The Department's focus has been on maximizing utilization and storage of CAP water, and efforts to take advantage of the surplus Colorado River water while it exists. The Department focused less on developing more remote, future alternative supply augmentation concepts such as cloud seeding or importing other water resources from outside the AMA.

8.4.7 The Second Management Plan Augmentation Assistance Program

The Second Management Plan contained specific criteria for evaluating augmentation grant applications and the Department's proposals for program expenditures. The Augmentation Assistance Program has since been expanded to include technical services contracts and intergovernmental agreements (IGAs) for monitoring of the AMA's water supply conditions. The Tucson AMA augmentation grants financed programs ranging from the Feasibility Study for the Rillito Recharge Project and the establishment of the

SCVWD, to staff support for the Regional Recharge Plan. In addition, a total of six grants supporting specific recharge projects, several IGAs, and three technical contracts have been issued. All of the grants, contracts, and IGAs have been written and managed by Tucson AMA staff. This program is described more specifically in Chapter 9, and the augmentation expenditures are listed in Appendix 9B.

8.4.8 Summary of Program Effectiveness

Overall, the implementation of the Second Management Plan Augmentation Program for the Tucson AMA has been effective. The most successful aspects of the program have been the legislative and rule changes that support the management goal, including: (1) the AWS Rules; (2) the passage of the Underground Storage, Savings and Replenishment Act; and (3) the establishment of the AWBA. In addition, activities supported by the Augmentation Fund have received substantial support from the public and the technical community. These activities include the development of the Regional Recharge Plan and of various specific recharge and feasibility studies. The Department has emerged as a major source of technical assistance and has put significant effort into coordination and facilitation of augmentation efforts.

However, utilization of renewable supplies has not progressed as quickly as was anticipated, due primarily to economic and institutional constraints. It is also not clear that the regulatory incentives included in the Second Management Plan have been effective in increasing use of CAP water and effluent.

8.5 AUGMENTATION AND RECHARGE ISSUES

The Department has planning tools and the regulatory authority to support achievement of safe-yield and the Tucson AMA's groundwater management objectives. The Department also has many opportunities to influence and/or contribute to the efforts of others to facilitate supply augmentation and management. However, the decisions and actions of many governments, institutions, and individuals are required to achieve safe-yield. Consequently, there are many factors affecting augmentation programs and implementation of programs that are beyond the control of the Department. Some of these factors are discussed in previous sections and Appendix 8A.

The programs developed for the third management period focus on elements of water-supply management problems and strategies that are within the authority of the Department and are feasible with the anticipated available agency resources. The program discussion and future directions sections of this chapter and Chapter 12 highlight some of the potential opportunities for the agency to acquire additional tools and authorities or to contribute indirectly to the efforts of others to address the water management problems facing this community. Major water supply augmentation challenges facing the Tucson AMA include:

(1) Existing grandfathered right allocations (irrigation, Type 1, and Type 2) exceed net natural recharge by a factor of about 2.8.

(2) Current failure to directly use or store the majority of the Tucson AMA CAP water allocations, the most important source of alternative supply available to the AMA.

(3) The local consequences of overdraft, including subsidence, decreases in well productivity, decreases in water quality, and loss of riparian habitat, are inadequately addressed by existing Code authorities, which focus on a basin-wide balance. Implications include difficulties for the City of Tucson in meeting the physical availability criteria for an assured water supply designation.

(4) Regional conflicts over water policy, including interjurisdictional conflict and factions that have evolved within the community, hinder appropriate use of renewable supplies.

(5) Inability to maximize the use of effluent in place of potable groundwater. If effluent discharges into the Santa Cruz River from the regional wastewater treatment plants continue to increase, this could result in eventual losses of effluent from the AMA through surface water or groundwater outflow.

(6) The effects of in-stream or "managed" effluent storage projects may require additional study.

(7) Lack of economic incentives to "do the right thing." Because groundwater pricing does not reflect the cost of the next available supply, and because the impacts of individual actions are obscured in long-term and regional effects, there is little sense of ownership of the consequences. Groundwater remains the cheapest, and in most cases, the highest quality source of supply.

(8) Local water supply management needs include delivery of alternative supplies to Tucson Water's Central Wellfield and to the rapidly developing portions of the AMA that are not directly adjacent to Tucson Water's reclaimed water system or a CAP delivery system. Distance from renewable supply sources increases the cost and difficulty of utilizing supplies.

(9) It is possible that the groundwater allocations provided through the AWS Rules and the Avra Valley groundwater credit provisions for the City of Tucson may provide too much flexibility for water providers and result in lower utilization of CAP water than would otherwise have occurred during the second and third management periods.

(10) There is a need to maximize the benefits of recharge by locating recharge facilities in places where multiple objectives can be achieved without jeopardizing the efficiency of the recharge component.

8.6 AUGMENTATION AND RECHARGE PROGRAM GOALS AND OBJECTIVES

Since the development of the Second Management Plan, new data about the distribution of water resources, hydrogeologic conditions, and subsidence potential have been published, and there have been significant changes in the institutional and regulatory setting for supply augmentation and recharge. The goals and objectives of the augmentation and recharge program in the third management period reflect an updated understanding of the scope of the AMA's groundwater management problems and the need to develop additional tools to address them.

The primary goals of the AMA's Third Management Plan augmentation program are to:

- Encourage and facilitate the replacement of groundwater use with the efficient use of renewable supplies throughout the AMA.
- Improve or maintain groundwater conditions in areas of the AMA experiencing or projected to experience significant negative impacts due to changes in water levels.
- Initiate a planning process to consider the "critical area" concept.
- Maximize storage of CAP water to offset future shortages.

During the third management period the Department will work to:

- Maximize the beneficial use of Colorado River water and effluent to reduce groundwater overdraft and ensure a safe, long-term, reliable water supply.

- Support efforts to utilize the CAP canal system to the fullest extent possible, to deliver "surplus" Colorado River water and other water to the AMA while these supplies are available, and develop opportunities to maximize interstate banking within the AMA through the AWBA.

- Support development of local water management, supply augmentation, and recharge plans consistent with groundwater management objectives.

- Develop groundwater monitoring programs, improve databases, and expand public information programs to support planning and management activities.

- Integrate water quality and quantity programs, and coordinate groundwater replenishment, AWBA activities, assured water supply activities, and related activities to facilitate achievement of groundwater management goals. These goals include ensuring that recharge activities protect the quality and storage capacity of the aquifer, and that facilities are sited in a manner that maximizes benefits and provides for future recovery as required.

- Resolve legal and institutional constraints that hinder comprehensive regional water management and inhibit the development and beneficial use of alternative supplies.

- Develop incentives for augmentation of water supplies, especially incentives that promote efficient use of renewable supplies.

- Continue to identify and assess feasibility of potential future water supply augmentation measures.

- Facilitate the settlement of Indian water rights claims, particularly the Southern Arizona Water Rights Settlement for the Tohono O'odham Nation.

- Evaluate the need for establishing a purchase and retirement program for groundwater rights in the AMA, and evaluate other possible incentives to retire existing groundwater rights.

- Develop programs and/or support new legislation and rules to reduce recovery in critical areas where water levels are declining rapidly. This is needed to mitigate existing and potential negative consequences including subsidence due to compaction of dewatered sediments, water quality problems, and increased costs to supply water.

- Develop new well-spacing rules that better protect existing land and water users and limit damage that can be caused by additional groundwater withdrawals.

8.7 THIRD MANAGEMENT PLAN AUGMENTATION AND RECHARGE PROGRAM

The Department is required to include in the Third Management Plan "a program for additional augmentation of the water supply of the active management area, if feasible, including incentives for artificial groundwater recharge." A.R.S. § 45-566(A)(6). "Augmentation" in this context is statutorily defined to mean "to supplement the water supply of an active management area and may include the importation of water into the active management area, storage of water or storage of water pursuant to chapter 3.1 of this title." A.R.S. § 45-561(2). As described in the introduction to this chapter, the Department must remain consistent with this statute, but for purposes of this chapter we have drawn a finer distinction: *augmentation* means increasing the availability and use of renewable supplies such as CAP water and effluent in lieu of groundwater; and *recharge* means storage of water pursuant to Title 45, Chapter 3.1, the Underground Water Storage, Savings and Replenishment Act. Therefore the augmentation program includes provisions addressing the development of additional water supplies for the

AMA, maximizing the use of renewable supplies, and for the storage of renewable water, either above ground or underground.

A.R.S. § 45-566(A) also requires the Third Management Plan to include a number of other provisions related to augmenting the AMA's water supplies. Paragraph 9 of that subsection provides that the Third Management Plan may include a plan for the purchase and retirement of grandfathered rights beginning no earlier than January 1, 2006. Paragraph 13 requires that the plan include recommendations to the AWBA regarding:

(a) Whether additional water storage in the AMA would help to achieve the management goal for the AMA.

(b) Where additional water storage in the AMA would be most useful to achieve the management goal for the AMA.

(c) Whether the extinguishment of long-term storage credits accrued or to be accrued by the AWBA would help to achieve the management goal for the AMA.

The Augmentation and Recharge Program for the third management period contains these required elements.

The principal responsibility for developing water supplies and for storing that water for future uses lies with the AMA's water users. The Department's responsibility under A.R.S. § 45-566(A) is to design an augmentation program that encourages and facilitates the efforts of those water users. The program should particularly encourage augmentation and storage of water where groundwater supplies are limited. However, the augmentation program must also allow the Department to use its authority to prevent unreasonable harm to third parties and to avoid exacerbating existing local water supply problems.

The Third Management Plan Recharge Program derives from A.R.S.§ 45-801.01, *et seq.*, the Underground Water Storage, Savings and Replenishment Act, which details the statutory requirements for storing and recovering water within an AMA. The key statutory provisions for storage facilities relate to hydrologic feasibility, A.R.S. § 45-811.01(C)(2); protection from unreasonable harm to land and other water users, A.R.S. § 45-811.01(C)(3); and avoidance of water quality impacts, A.R.S. § 45-811.01(C)(5). Although this Act contains requirements for water storage and recovery, it also includes requirements linking storage and recovery to the management plan goals. The provision that affects non-recoverable storage is found in A.R.S. § 45-833.01(A), with a requirement that non-recoverable water storage must be consistent with the AMA's augmentation program. The provisions that affect recovery are found in A.R.S. § 45-834.01. They include a requirement for consistency with the management plan in the case of recovery outside the area of impact (AOI) of the water storage. A.R.S. § 45-834.01(A)(2)(b).

The Department has developed the Augmentation and Recharge Program for the Third Management Plan based on the statutory authorities and tools available to it to address the goals and objectives identified in the previous section. The program components will be presented in the order listed:

- Recommendations to the AWBA (section 8.7.1)
- UWS Program (section 8.7.2)
- Regulatory Incentives for the Use of Renewable Supplies (section 8.7.3)
- Technical Assistance, Coordination, and Facilitation of Efforts (section 8.7.4)
- Financial Assistance (section 8.7.5)
- Purchase and Retirement of Grandfathered Rights (section 8.7.6)
- Resolution of Institutional and Legal Barriers (section 8.7.7)

8.7.1 Recommendations to the Arizona Water Banking Authority

As previously discussed in section 8.4.5.2, the AWBA was created in 1996 for the purpose of conveying and storing the unused part of Arizona's Colorado River water apportionment and surplus Colorado River water supplies. One of the stated purposes of the legislation is to "store water brought into this state through the CAP to fulfill the water management objectives of this state set forth in chapter 2 of this title." A.R.S. § 45-2401(F)(3). The AWBA is also required to coordinate with the director of the Department, who serves as chair of the AWBA Commission, in the "storage of water and distribution and extinguishment of long-term storage credits . . . in accordance with the water management objectives set forth in chapter 2 of this title [the Code]." A.R.S. § 45-2423(A)(3).

The statutory requirements to incorporate water management objectives in AWBA plans result in the need for the Department to provide specific advice to the AWBA as to how to incorporate such objectives in the AWBA's activities. The Code requires that the Department include in the Third Management Plan recommendations to the AWBA on whether additional storage in the AMA helps to achieve the goals of the AMA, where the storage would be most useful, and whether the extinguishment of credits would assist in achieving the goals. The Department provides the following recommendations to the AWBA for water storage in the AMA.

8.7.1.1 Advice to the AWBA on Additional Storage Needs in the AMA

In March of 1997, when the AWBA prepared its storage facility inventory for the Tucson AMA pursuant to A.R.S. § 45-2452, it was determined that the facilities available in the AMA were inadequate for the AWBA's needs for the following ten years. In making this determination, the AWBA was required to consider whether the facilities to be used by the AWBA promote the water management objectives of the AMA. In preparing the Facility Plan for the Tucson AMA as required by A.R.S. § 45-2453, the AWBA must consider the advice of the Department as to where storage would most contribute to meeting AMA water management objectives. The draft Facility Plan and each year's operating plan must be reviewed by the GUAC prior to adoption. A.R.S. §§ 45-2453(C)(1) and 45-2456(C)(1).

Evaluations of the storage capacity for CAP water in the Tucson AMA have been performed by both the RRC and the IPAG as part of the regional recharge planning process in the Tucson AMA (see section 8.4.5.3). Given current institutional limitations on the direct potable use of CAP water by the City of Tucson, as well as the need to utilize the subcontracts of various other entities that are not currently able to use CAP water directly, there is a substantial need for additional recharge facilities in the Tucson AMA. The IPAG report to the AWBA, using relatively conservative "high end" assumptions in the scenario development, concluded that the necessary storage capacity in the year 2000 could be 158,000 acre-feet, and by 2007, 173,500 acre-feet. Current permitted maximum annual capacity, counting both USFs and GSFs, is less than 100,000 acre-feet.

It is clear that there is a role for the AWBA to assist development of additional storage facilities, particularly those that would help meet water management objectives, through cooperative efforts as authorized by law.

8.7.1.2 Advice to the AWBA on the Location of Water Storage in the AMA

The location of recharge that is intended to firm up the supplies for municipal and industrial (M & I) subcontractors during periods of drought is extremely important, since it is imperative that the stored water be recoverable. In many cases, the AWBA may be able to select sites for recharge that are either in the vicinity of the subcontractor's wellfields, or that would hydrologically benefit such wellfields. The AWBA has evaluated recoverability issues. The key concept that should be incorporated in the AWBA's plans is that recharge siting decisions made annually and in the AWBA's ten-year Facilities Plan

must result in water being stored in locations that are consistent with the CAP subcontractor's long-range plans. Siting criteria are likely to be different, or at least weighted differently, to evaluate facilities that will serve different users and/or objectives. Optimal siting depends on the purpose of the recharge (e.g., for firming supplies for CAP M & I subcontractors, water management, Indian settlements, or interstate banking).

In many cases, it may be possible to store water to help meet local water management objectives as well as the AWBA's objectives. The AWBA may store water in an area that is experiencing, or is at high risk of experiencing, negative impacts from a rapid groundwater level decline rate, while developing a program to recover water in other parts of the basin that have more stable groundwater levels and are at less risk. The Department recommends close cooperation with AMA staff and local water users and distribution of draft facility and operation plans for review in advance of development of the AWBA's Annual Plan of Operation. This will maximize the opportunities to incorporate consideration of the AMA's water management objectives in the AWBA's actions. Furthermore, in any year in which Colorado River water supplies are limited, the AWBA should generate and distribute its storage credits in a manner that protects the interests of the water users in the AMAs.

The Tucson AMA has identified three geographic areas where additional storage may substantially increase the likelihood of attaining groundwater management objectives: (1) the Tucson Central Wellfield where historic groundwater declines have caused physical availability problems and where recharge could help mitigate the risk of subsidence; (2) the Cañada del Oro area where groundwater levels are relatively stable but significant increases in water demand are projected; and (3) the Sahuarita/Green Valley area where water levels are declining, increases in water demand are projected, and there are significant concerns associated with protecting the water supplies within the San Xavier District. The Department anticipates an ongoing exchange of planning information and advice with the AWBA. Additional critical areas may be identified in the future.

Although currently the most serious water management concerns in the AMA are associated with the City of Tucson's Central Wellfield, it is anticipated that a reduction in pumping in the Central Wellfield through the development of the CAVSARP, the development of proposed in-stream recharge projects, and ongoing conservation efforts will reduce these concerns. The AWBA's participation in CAVSARP indirectly contributes to the effort to address water management problems in the Central Wellfield. The AWBA could potentially store water supplies to offset future shortages in locations that would directly mitigate water level decline problems in the City's Central Wellfield. However, in the short term, it may be difficult for the AWBA to overcome political and jurisdictional considerations, and the logistical and cost issues related to the distance from the CAP canal to suitable recharge sites.

The AWBA could also help meet water management objectives in the Cañada del Oro area, a rapidly developing area of the AMA. There have been ongoing investigations of the feasibility and options for direct recharge in this area, primarily because of projected increases in demand. At this time, the groundwater table is largely stable, except in the lower reaches of the watershed. However, bringing "wet water" to the region is a top priority for MDWID and the Town of Oro Valley. Current investigations involve both CAP water and effluent (reclaimed water) deliveries. Both sources require significant capital investment because pumping stations and up to 16 miles of pipelines may be required. The AWBA could assist with financing through a long-term lease for recharge capacity in the proposed Cañada del Oro Recharge and Recovery project.

In the Green Valley/Sahuarita area, potential GSFs and USFs, in addition to the Pima Mine Road project, were evaluated by the USCWUG as part of a broader effort to develop a pipeline system from the CAP terminus to water users in the area. This area is generally up gradient from the majority of the pumpers in the AMA. There may be significant potential for AWBA activities in this location, including both GSFs and USFs. The most promising project in the short term may be the FICO GSF that is proposed for the

Sahuarita Farm. It may be possible for the AWBA to participate in recharge projects in the San Xavier District as well.

8.7.1.3 Advice to the AWBA on Water Storage and Storage Credit Extinguishment

Recharge of renewable supplies followed by extinguishment of the associated long-term storage credits is a key water management tool that is expected to assist with reducing overdraft in the Tucson AMA. Credits generated by the AWBA using groundwater withdrawal fees should be dedicated to reducing groundwater level declines in the AMA and stored in areas that provide other water management benefits, if possible. If this volume of water is recharged with consideration of water management opportunities and in critical areas, the AWBA could make a valuable contribution to stabilizing water levels and mitigating local water management concerns. Extinguishment of credits, which has the same effect as non-recoverable storage, would be most desirable in the Green Valley/Sahuarita area, Central Avra Valley, or Tucson's Central Wellfield.

It is recommended that the AWBA develop a program in cooperation with AMA water users and interested parties to store non-recoverable water and/or extinguish storage credits specifically in areas of ongoing overdraft that are likely to experience subsidence or other significant consequences of overdraft. This program could be incorporated in an amendment to the facilities plan.

8.7.1.4 AWBA Incorporation of Water Management Objectives

As discussed in the previous section, AWBA recharge and groundwater savings activities, particularly extinguishment of long-term credits using funding from either the general fund or the Tucson AMA withdrawal fees, can contribute to attainment of the AMA's water management objectives. There is also potential that the credits generated in an interstate water storage agreement could assist in meeting such objectives, if the forbearance plan is consistent with water management objectives. The following section addresses specific ways in which AWBA activities could further assist the Tucson AMA in meeting water management objectives.

It has been estimated by the AWBA Study Commission in the 1997 Interim Report of the Planning and Modeling Assumptions Subcommittee that 750,000 acre-feet of storage credits will be needed to firm up the predicted shortages for municipal CAP water subcontractors in the Tucson AMA over the next 100 years (AWBA, 1997). This is based on a series of assumptions regarding river operations; Upper Basin, Lower Basin, and Mexican demands; historic flows; 100-year projected deliveries to the CAP; and shortage criteria in the master contract and the 1983 Record of Decision regarding shortage sharing among subcontractors.

As of 1997, the AWBA had only recharged 3,100 acre-feet of CAP water in the Tucson AMA, for which the AWBA received 2,391.9 acre-feet of credits after adjustment for evaporation and the cut to the aquifer. In contrast, the AWBA had accrued hundreds of thousands of acre-feet of credits through direct recharge in USFs and indirect recharge in GSFs in the Pinal and Phoenix AMAs. The AWBA did not store as much water in the Tucson AMA primarily because of the lack of permitted storage capacity. It is imperative that more facilities be developed, so that sufficient capacity exists for local AMA recharge needs as well as for the AWBA. The AWBA could also increase indirect recharge quantities in the AMA by developing a pricing policy that makes groundwater savings in the Tucson AMA economically feasible. Current pricing policy and the lack of available capacity have, to date, precluded the AWBA's involvement in GSFs in the Tucson AMA.

It is imperative that the AWBA and others take advantage of the opportunity to store water in the early years while surplus volumes of CAP water and financial resources to pay for the storage are available.

This form of conjunctive management may cause local water levels to rise in early years, but this trend will be eliminated as stored supplies are used in the future during shortages.

8.7.2 Underground Water Storage, Savings, and Replenishment Program

Due to various factors that have been described in previous sections, underground water storage is an increasingly important tool for water management in the Tucson AMA. Underground storage provides an additional benefit of restoring or preserving groundwater in areas where groundwater levels have declined. The UWS Program is, therefore, a significant component of the Augmentation and Recharge Program.

Arizona's UWS Program is a regulatory program under which water may be stored underground and rights to recover may be accrued. The statutes and policies of the UWS or "recharge" program establish a number of objectives. The objectives include the following:

- to protect the general economy and welfare of the state by encouraging the use of renewable water supplies, especially Colorado River water, instead of groundwater through a flexible and effective regulatory program for the underground storage, savings, and replenishment of water;
- to allow the use of direct storage facilities to aid with filtration and to develop an accounting system which allows "recovery" of renewable supplies without the expense of expanding physical distribution systems;
- to further the conjunctive management of the water resources of this state to reduce the overdraft and achieve the management goals of the AMAs;
- to store water underground for seasonal peak demand use and for use during years of shortage; and
- to augment the water supply for future growth and development.

Since its inception in 1986, the recharge program has become increasingly flexible over time with regard to storage and recovery locations and the number and types of programs available. With the increased flexibility has come increased complexity and an increased potential for recharge projects to aggravate, as well as mitigate, local water problems. Water levels, water quality, physical availability, and third-party impacts are all conditions that can be impacted positively or negatively by recharge facilities. Thus, the regulation of the program to maximize benefits and minimize harm is crucial to an effective program.

This section includes: (1) a brief overview of the UWS programs; (2) the definition of what is, and what is not, considered a storage facility; and (3) the storage and recovery location criteria that determine whether a recharge project is considered "consistent with the management plan and achievement of the management goal" of the AMA.

8.7.2.1 Overview of the Underground Water Storage, Savings, and Replenishment Program

Persons who want to undertake recharge activities are required to obtain permits from the Department. There are three types of permits: (1) storage facility permits, which may be constructed USF permits, managed USF permits, or GSF permits; (2) water storage permits; and (3) recovery well permits.

8.7.2.1.1 Storage Facility Permits

Storage facility permits allow the holder to construct, develop and operate a storage facility. If storage is to occur at a facility that will use constructed basins or wells to add water to an aquifer, a constructed USF permit is required. If the storage will utilize the natural channel of a river or stream to add water to an

aquifer, a managed USF permit is required. At a GSF, a groundwater user who would otherwise have pumped groundwater is provided an alternative supply of water by a water storer. The alternative supply is then used in lieu of the groundwater, thus preserving the groundwater.

8.7.2.1.2 Water Storage Permits

Water storage permits are always affiliated with a particular storage facility where the storage will occur. The holder of the water storage permit is authorized to store water at the affiliated storage facility. Rights to recover water under the UWS Program always accrue to the holder of the water storage permit.

8.7.2.1.3 Recovery Well Permits

Recovery well permits allow the holder to recover water stored pursuant to the UWS Program. The storer of the water may always recover the water stored within the AOI of water storage. The AOI of water storage is defined as follows: "as projected on the land surface, the area where the stored water has migrated or is stored." A.R.S. § 45-802.01(2). Under a number of conditions, some of which are discussed in detail later in this chapter, recovery can also occur outside the AOI. Theoretically, if these recovery conditions are met, recovery of water stored in the Tucson AMA could occur anywhere within the AMA. Under no circumstance, however, can water be recovered in the AMA if it was stored outside the AMA.

8.7.2.1.4 Other Key Components of the Underground Water Storage, Savings, and Replenishment Program

There are a number of other key components of the UWS Program. Rights to recover water may be exercised annually or long-term. Almost any water stored can be recovered within the same year in which it was stored. If a number of conditions are met, stored water will be credited to a long-term storage account which allows the account holder to recover the water at any point in the future. These conditions assist the achievement of water management goals by preventing an entity from storing water and earning long-term storage credits if the water could be put to direct use. The statutes define which source waters cannot be put to direct use and therefore may be eligible for long-term storage credits. A.R.S. § 45-802.01(21). In general, if an entity stores effluent prior to 2025, it is determined that the effluent cannot be reasonably put to direct use, and is therefore eligible to earn long-term storage credits. Additionally, CAP water is considered water that cannot be put to direct use if the storer is *not* simultaneously mining groundwater. In other words, if the storer continues to mine groundwater, then credits may be earned only if the entity stores an additional amount of CAP water to offset the groundwater pumpage. (An exception is made for designated providers that are pumping groundwater pursuant to their assured water supply groundwater allocation.) The obvious intent of this provision is to discourage groundwater mining and avoid giving long-term storage credits in cases where there is no net storage in the aquifer. It should be reemphasized that while a given storer may not be eligible for long-term storage credits, the water stored is eligible to be recovered on an annual basis, and is treated as a direct use for all intents and purposes.

There is no time limit on the right to recover long-term storage credits. Long-term storage credits may be assigned to another entity, if that entity could meet the same provisions for earning credits as the storer. In addition, once the water is recovered, it retains the same legal characteristics it had before storage. For example, if CAP water is stored, the water, when recovered, may be used in any legal manner CAP water can be used, even if the recovery occurs outside the AOI of the stored water.

The UWS Program is also the mechanism by which the CAGRD replenishes water on behalf of its members. The CAGRD may store water and accrue long-term storage credits or obtain credits already accrued by other storers. At the CAGRD's request, the Department will transfer credits from the CAGRD's long-term storage account to its replenishment account, termed a "conservation district account"

by statute, to offset the CAGRD replenishment obligations. A.R.S. § 45-859.01. Once the credits are transferred to the replenishment account, they may not be recovered, assigned, or moved back to the long-term storage account.

8.7.2.2 Underground Water Storage, Savings, and Replenishment Program Issues

The Department must issue permits only to legitimate storage facilities. With regard to USFs, A.R.S. § 45-815.01 specifically lists a number of water-related facilities that are categorically excluded. These include aqueducts, irrigation canals and other man-made water conveyance systems. In addition, incidental recharge from any agricultural, municipal, or industrial use is precluded from qualifying for a USF permit.

A.R.S. § 45-815.01(1) also specifically references "body[ies] of water," stating that they do not qualify for USF permits unless they "have been designed, constructed or altered so that water storage is a principal purpose of the body of water." In addition, Arizona law generally prohibits artificial "bodies of water" constructed for landscape, scenic or recreational purposes, unless the body of water is "unsealed and an integral part of an underground storage facility." A.R.S. § 45-132(B)(6). Thus, the law does allow for a body of water to be both a USF and a recreational lake. The Department, however, will not issue a permit for a facility if the facility appears to be designed to evade the prohibition on recreational lakes by designating a facility as a USF. Thus, if the purpose of the facility is primarily recreational or aesthetic, it does not qualify as a USF. However, if the facility meets the goals and requirements of the USF Program while serving other uses as well, it may qualify for a USF permit.

Usually, the storage efficiency of a USF is related to its purpose. If a permit applicant's *primary* intent is to store water, achieving high efficiency at the facility is an important goal for the applicant, and the design and operation of the facility will minimize evaporation and transpiration. If storage is not a primary purpose, efficiency is likely to be less important.

As the AMA becomes more reliant upon renewable supplies, as is required under the AWS Rules, efficient storage and use of all water supplies will become even more important. The recharge program will continue to encourage efficient use of water. Every effort will be made in the future to retain the integrity of the program goals and to maximize the efficiency of recharge at permitted facilities. The Department examines projected efficiency of a USF as a part of its review to determine whether a project is hydrologically feasible, which must be established before a USF permit will be issued. A.R.S. § 45-811.01(C)(2). The less efficient a proposed project is, the more likely the Department will be concerned about its legitimacy as a USF. The Department will consider a number of factors when evaluating a facility for efficiency as a component of hydrologic feasibility, including the following:

- whether the facility has the *potential* to store water and the quantity of that potential storage;
- whether the facility is designed, constructed, or altered so that water storage is a principal purpose;
- whether other regulatory agencies apply standards to a facility that are inconsistent with the Department's program objectives (e.g., ADEQ containment standards in a treatment wetland);
- whether the facility will be maintained (e.g., wet-dry cycles, scraping, etc.) to ensure and/or enhance infiltration;
- if a facility serves multiple purposes, whether purposes other than recharge would not be legal or would be regulated if it was not associated with a recharge facility; and
- whether potential water storers at the facility are subject to conservation requirements and lost-and-unaccounted-for water limits under the management plan.

The Department is also concerned about potential abuses in applications for GSF permits. The statutes make clear that not every instance where groundwater use is replaced with a renewable water resource qualifies for a GSF permit. Therefore, the Department will not issue a GSF permit unless a legitimate "groundwater savings" will occur. Only where the use of the renewable resource would not have occurred

without the operation of the GSF and where there is no other reasonably available alternative source should a GSF be permitted. A.R.S. § 812.01(B).

The groundwater savings program is an important tool in achieving the water management objectives of increasing use of Colorado River water and preserving groundwater supplies. However, it should be noted that the recipients of the alternative supplies at GSFs retain their right to pump groundwater in the future. Therefore, the physical water that is saved at a GSF may be pumped once the recipient returns to using groundwater and the long term storage credits that are earned at the GSF may also be pumped. The groundwater savings program can be, in effect, a deferred groundwater pumping program and should not be confused with the conversion of an existing groundwater use to a renewable supply, which provides a permanent savings of groundwater and a direct contribution to the achievement of safe-yield. However, storage at USFs also result in long term storage credits that may be pumped in the future. Consequently, the benefits of any recharge facility must be evaluated on a case by case basis to determine whether the facility will result in water management benefits.

8.7.2.3 Need for Revised Storage and Recovery Criteria for the Third Management Plan

The Second Management Plan anticipated that CAP water utilization in the Tucson AMA would be met primarily through direct potable delivery. Water users' CAP water utilization plans have changed dramatically. The Third Management Plan assumes no direct potable use in the water budget scenarios in Chapter 11, and instead assumes all CAP water use will be through recharge and groundwater savings. Although there is no way of knowing how CAP water will actually be used in future years, this change from direct delivery to underground water storage and groundwater savings leads to new issues for the Department's recharge program. The potential for large amounts of water to be stored in some areas while the groundwater in other areas is seriously depleted has become a major concern in the Tucson AMA.

The siting criteria for storage of non-recoverable water and for recovery wells are currently one of the Department's few tools to address local groundwater management problems within the AMA. Stronger siting criteria are needed for the third management period to strategically address the negative consequences of further dewatering in critical areas of the AMA. Consequences of further dewatering may include: (1) loss of riparian habitat; (2) local increases in cost to supply groundwater due to decreasing well productivity, the need to drill deeper wells, and increasing pumping costs; (3) impacts on physical availability of supplies for future use; and (4) subsidence which can cause damage to structures and infrastructure (see sections 2.6 and 8.2.1.2).

In the Tucson AMA, the areas with high rates of aquifer dewatering are generally also areas at risk for subsidence and other negative impacts. The average rate of water level decline over a recent time period could serve as a proxy for the definition of "critical areas" within which additional withdrawals should be discouraged. Stricter recovery well average decline rate siting criteria may mitigate some of the local impacts of groundwater level declines while advancing progress on achieving AMA-wide safe-yield.

Recovery well siting criteria can be changed after recovery permits are issued, especially by adoption of new management plans. Although there is a need for the Department to be able to respond quickly to changing aquifer conditions, the Department recognizes there is also a need for regulatory certainty (including adequate noticing provisions) so that investments that are made in infrastructure to utilize or store renewable supplies are not reduced in value by subsequent changes in recovery permit criteria. Currently, recovery well permits can be reviewed at any time to ensure that wells listed on the permit continue to meet the recovery criteria. In theory, wells could lose their eligibility to be used for recovery and then regain this eligibility if the rate of water level decline in the area changes. To increase certainty regarding investments in recovery infrastructure, the Department may establish a period before a recovery well permit is subject to review.

The IPAG for the Regional Recharge Plan concluded that the storage and recovery siting criteria need to be strengthened as a step towards achieving safe-yield and addressing local groundwater supply problems. However, IPAG also recommended that stricter criteria be contingent on increasing the equity in applying the management plan siting requirements to both non-CAGRD and CAGRD pumpage. Water users who are storing and recovering CAP water themselves (non-CAGRD pumpage) are subject to the recovery criteria. Currently CAGRD members can pump groundwater, even in areas with high rates of decline, without being affected by the recovery criteria, because they are not recovering "stored" water as defined by current law. The CAGRD replenishes excess groundwater use with CAP water recharge, after the groundwater use has occurred. To require CAGRD pumpage to meet the same recovery siting criteria as those recovering stored water would require legislative action.

IPAG also supported the development of well spacing rules that incorporate concerns regarding localized areas of groundwater decline and supported the development of a critical areas program, including discussion of legislation to provide increased regulatory tools to address such areas.

8.7.2.4 Decline Rate Methodology

In evaluating an application for a proposed recovery well permit, the Department considers many factors in determining consistency with the average water-level decline rate recovery well siting criteria. The time frame for which the average is calculated may vary based on data availability and the hydrologic characteristics of the area. Major trends in water supply utilization over time, trends in precipitation, hydrogeologic data, and modeling of projected impacts may be factors in evaluating this rate. Other considerations may also be appropriate depending on the location of the proposed recovery well.

Typically, the Department examines the historic static water level data for the period of record for wells located in the section in which the proposed recovery well is located and in the adjacent eight sections. The specific area examined and the data that are used depend on the availability and quality of water level data and the hydrogeology of the area. Bedrock outcrops, large pumping centers, and other features may affect determination of which data are pertinent. Generally, wells which are screened in the aquifer of concern and regularly monitored using consistent methods for static water level data are good reference points (such as the Department's statewide network of regularly monitored index wells). The Department examines the well hydrographs (plots of static water levels over time) and evaluates the slope of the curve for the time period of interest. The slope indicates whether the static water level in the monitoring well has risen or fallen over time. A horizontal line indicates water levels remained stable over time. The Department identifies what activities may have caused any groundwater changes over time, to see whether the activity still exists, or has reduced or increased over time.

This approach provides more flexibility and protection of the groundwater resource than would be provided by a simplistic evaluation of water level decline rates calculated for all water level data within a set radius and the entire period of record. For example, if a recovery well is proposed for an area in which historically there was a rapid decline in groundwater levels due to activities that no longer exist (e.g., retirement of agriculture after heavy agricultural use in the 1940s and 1950s) and if the proposed area is not at high risk for subsidence, the proposed recovery well might be deemed consistent with the average decline rate criteria by looking at the period of time after the historic change in use. Similarly, if for decades water levels in the vicinity of the proposed recovery well were very stable but recently a new use has caused rapid rates of decline, the proposed recovery well may be deemed inconsistent with the criteria.

The Department's groundwater models may be used to regionally project future water levels and decline rates. Modeling may assist the permittee in evaluating recovery options. Where there are sufficient data, a model may give an indication of how long recovery within a region may remain permitable based on the current average decline rate criteria.

The most current procedures for establishing the average groundwater level decline rate in the vicinity of a proposed recovery well will be published in the Department's Recovery Well application packet.

8.7.2.5 Storage and Recovery Siting Criteria

The benefits to water management through the recharge program depend upon the location where water is stored and where it is recovered (unless the water stored is non-recoverable or the credits are extinguished). A.R.S. § 45-833.01(A) specifically states that non-recoverable water storage must be consistent with the AMA's augmentation program. To date, there has been very little water stored with a "non-recoverable" designation.

For storage and recovery, A.R.S. § 45-834.01(A) clarifies that unless stored water is recovered by the storer within the AOI of water storage, the recovery is only allowed "if the director determines that recovery at the proposed location is consistent with the management plan and achievement of the management goal for the active management area." Additionally, recovery of stored water within the AOI of the stored water is always considered consistent with the management plan.

Although the statute ties recovery outside the AOI to the consistency requirements of the plan, the locations of storage and recovery of water are inherently linked and must *both* be considered when determining whether the future recovery meets the consistency requirements and management goals of the AMA. Outside the AOI, it cannot be determined whether recovery is consistent with water management objectives of the AMA unless the storage location is also considered. Water management benefits to the AMA depend greatly on whether credits recovered from an existing well were accrued through storage in a remote area of the AMA or in a large pumping center of the AMA. Therefore, the criteria to determine whether a recovery location is consistent with the management plan and goal for the AMA must also consider where water was stored.

The locations of storage and recovery are important factors in addressing local and regional supply problems, particularly in critical areas, and attempting to balance the supplies in the AMAs during the third management period. For example, the useful water supplies of the AMA may be diminished if water storage occurs in a location where there is no future demand for the stored water and recovery occurs outside the AOI of storage. In addition, recovery away from the AOI of water storage could aggravate problems if the area of recovery was experiencing rapidly dropping groundwater levels or if the groundwater supplies were already fully committed under the AWS Program. On the other hand, if storage occurs in an area experiencing high water levels and recovery occurs away from the AOI, the water storage may cause damage through water logging. If dewatering is required as a *direct* result of water storage or savings, either the storage facility's operational plan should be adjusted to minimize impacts, which may include strategic recovery locations to mitigate impacts, or the storer may not be issued credits.

Thus, while the Second Management Plan siting criteria provided no protection of groundwater supplies already committed under the AWS Program, the new Third Management Plan criteria protect groundwater supplies that are already committed for an assured water supply from an entity who wishes to recover water *outside* of the AOI.

The Third Management Plan criteria also link future use benefits to determinations under the AWS Program. If storage occurs in a remote area, but one that has a committed and projected demand through a Designation or Certificate of Assured Water Supply, then it is deemed to contribute to groundwater supplies that will be used in the future. If the storage does not meet this criterion, it must otherwise be beneficial to the AMA if recovery is to occur outside the AOI of storage. If a storage facility does not meet the criteria, this concern would be incorporated in the permit as a notice to potential water storers that future recovery may only be allowed inside the AOI.

Recovery from within the AOI is not required to meet management plan consistency requirements. A.R.S. § 45-834.01(A) states that recovery may occur *outside* the AOI of the storage only if the director determines that the recovery location is consistent with the management plan. Therefore, recovery must continue to be consistent with management plan criteria, even after the recovery well permit has been issued. Existing, previously permitted recovery wells are subject to the criteria of the Third Management Plan and future management plans.

8-101. Storage and Recovery Siting Criteria

During the third management period, for the purposes of A.R.S. § 45-834.01(A)(2)(b), recovery of stored water at a location is consistent with the management plan and achievement of the management goal for the AMA:

A. *If recovery will occur within the area of impact (AOI), regardless of whether the recovery well permit applicant was the storer of the water; or*

B. *If recovery will occur outside of the AOI, all of the following three criteria are met:*

1. *The water storage that resulted in the right to recover water:*

   a. *Is contributing to groundwater supplies that are accessible to current groundwater users or that have been committed to establish a Designation, Certificate, or Analysis of Assured Water Supply pursuant to A.R.S. § 45-576 or rules adopted thereunder; or*

   b. *Is a component of a remedial action project under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) or Title 49, Arizona Revised Statutes, and the director has determined that the remedial action will contribute to the objectives of this chapter or the achievement of the management goal for the AMA; or*

   c. *Is otherwise determined by the director to have contributed to the objectives of this chapter or the achievement of the management goal for the AMA.*

2. *Either:*

   a. *At the time of the application, the maximum projected depth to water at the location of the recovery well after 100 years does not exceed the general 100-year depth-to-static water level for the AMA specified by A.A.C. R12-15-703 after considering: (1) the maximum proposed withdrawals from the recovery well; (2) withdrawals for current, committed, and projected demands associated with determinations made under A.R.S. § 45-576 that are reliant on the water which the recovery well will withdraw; and (3) withdrawals for other current or projected demands that are reliant on the water which the recovery well will withdraw; or*

   b. *The recovery will be undertaken within the applicant's service area and the applicant is a municipal provider designated as having an assured water supply.*

3. *The recovery well is:*

   a. *Located in an area experiencing an average annual rate of decline that is less than 4.0 feet per year for the years 2000 through 2004, and 3.0 feet per year for the years 2005 until any subsequent management plan provision. The three feet per year*

criterion will go into effect in the year 2005 only if all stored water withdrawals and groundwater reported as excess groundwater to a water conservation district serving as a groundwater replenishment district are subject to the same restriction, as established through a legislative amendment. Otherwise, the four feet per year criterion will continue until the effective date of any subsequent management plan provision; or

b. A component of a remedial action project under CERCLA or Title 49, Arizona Revised Statutes, and the director has determined that the remedial action will contribute to the objectives of this chapter or the achievement of the management goal for the AMA; or

c. Likely to contribute to the water management objectives of the geographic area in which the well is located, as determined by the director.

8.7.2.6 Criteria for Storage of Non-Recoverable Water

A.R.S. § 45-833.01(A) provides that "the director may designate a water storage permit as storing non-recoverable water. If the water storage occurs within an active management area, the water storage permit may be designated in this manner only if the storage is consistent with the active management area's augmentation program." Water that is stored under a non-recoverable water storage permit may not be recovered on an annual basis, may not be credited to a long-term storage account, and may not be used for replenishment purposes associated with the CAGRD. The same considerations discussed in the preceding section that shaped the criteria for recovery location have shaped the criteria for siting non-recoverable storage.

As of August, 1998, no applications for permits to store non-recoverable water had been filed in the Tucson AMA. During the third management period, non-recoverable water storage may result from enforcement actions for non-compliance with conservation requirements (see Chapter 10).

8-201. Storage of Non-Recoverable Water

During the third management period, water storage that is designated as non-recoverable is consistent with the AMA's augmentation program if one of the following criteria is met:

The water storage:

1. Is contributing to groundwater supplies that are accessible to current groundwater users or that have been committed to establish a Designation, Certificate, or Analysis of Assured Water Supply pursuant to A.R.S. § 45-576 or rules adopted thereunder so long as the areas in which water is stored are not experiencing problems associated with shallow depth to water; or

2. Is a component of a remedial action project under CERCLA or Title 49, Arizona Revised Statutes, and the director has determined that the remedial action will contribute to the objectives of this chapter or the achievement of the management goal for the AMA; or

3. Is otherwise determined by the director to contribute to the objectives of this chapter or the achievement of the management goal for the AMA.

8.7.3 Regulatory Incentives for the Use of Renewable Supplies

Provisions established in the Agricultural, Municipal, and Industrial Conservation Programs of this management plan provide incentives for water users to implement augmentation measures. The inclusion of augmentation incentives as a trade-off for conservation requirements is controversial. The program to increase the use of renewable water supplies should not be perceived as an alternative to conservation.

Although Arizona is not currently using its full Colorado River apportionment, and some municipal entities do not have enough annual demand to use their allotments, these conditions are likely to change in the relatively near future. Shortages are anticipated on the Colorado River system 35 out of the next 100 years. The Code (particularly through the assured water supply provisions) and the management plans require a long-term perspective on supply and demand. In the long-term, efficient use of *all* water supplies will be necessary. The distinctions that are now being made between sources of water, including incentives that allow increased use of certain renewable sources, may seem ill-advised in hindsight. In fact, shortages are anticipated on the Colorado River system 35 out of the next 100 years. It is important to build a conservation ethic into the structure of our communities even as we move towards the use of renewable supplies.

There are some uses of water that can be identified as "structural" and others that are "discretionary." Structural uses are part of the base water use requirement; for example, once a swimming pool is built, it is likely to be filled with water. However, the decision to overseed a lawn or a golf course in a particular year is discretionary. As incentives have been designed for inclusion in this plan, the Department has emphasized that increased utilization of renewable supplies should be for nonstructural purposes, so that the use can be scaled back as renewable supplies become more scarce.

Achievement of our water management goals over the long term is only possible in the context of serious, long-term conservation efforts and increased utilization of renewable supplies. The debate is not between conservation and augmentation, but rather, whether the concept of "efficient use" can be integrated into the regulatory system and the community ethic. Matching the demand to the supply in the context of a surface-water dominated water picture will require more sophisticated management, including conjunctive management of groundwater and surface water, than has been the norm in Arizona in the past. It is difficult to design incentives that are administratively workable without causing equity problems and weakening the conservation message.

Incentives should be limited to applications where the desired response, such as substitution of use of renewable supplies for groundwater use or improved water conservation, would not otherwise have happened.

Table 8-4 lists the Third Management Plan incentives to use alternative supplies. Some of these incentives were established in the Second Management Plan. Because many of these incentives encourage use of alternative supplies at the expense of conservation, the augmentation incentives may need to be scaled back in the future in order to achieve safe-yield.

Although the need to include specialized incentives to address subregional conditions has been identified, to date the only regulatory tool for addressing localized areas of decline is the limitation on recovery of recharged water if it is recovered outside the area of hydrologic impact. The compliance approach described in Chapter 10 may encourage recharge in specific locations to address local hydrologic concerns in critical areas.

Additional incentives to encourage use of remediated groundwater in lieu of high quality supplies are provided in the AWS Rules and through legislative requirements in the WQARF Program (see Chapter 7).

TABLE 8-4
RENEWABLE WATER SUPPLY USE INCENTIVES
TUCSON ACTIVE MANAGEMENT AREA

Municipal
Delivery of effluent by a municipal water provider does not count against the gallons per capita per day (GPCD) requirement, unless it is effluent that is recharged in one location and recovered outside the AOI. This is an incentive for municipal providers to invest in effluent systems (see section 5-103(A)). The Alternative Conservation Program removes the non-residential portion of the GPCD requirement for providers who have a Designation of Assured Water Supply or limit their groundwater use to the highest annual use between specific years, utilize renewable supplies for their remaining demand, and implement specific conservation measures for non-residential customers. This program also includes an incentive to extinguish existing grandfathered rights (see section 5-105). The Non-Per Capita Conservation Program removes the GPCD rate entirely as a regulatory tool in exchange for implementation of specified conservation measures. A "best management practices" approach is designed to achieve the same level of efficiency as the GPCD, but the point of compliance is implementation of the programs, not the level of water use. To qualify, water providers must phase out groundwater use or have a Designation of Assured Water Supply (see section 5-104). CAP water which is delivered by a municipal provider to a non-residential water user is excluded from the provider's total GPCD requirements for up to ten years if it is shown that the delivery will expedite the development of infrastructure to deliver reclaimed effluent to the user in the future (see section 5-103(E)).
Industrial
Turf-Related Facilities Effluent use is discounted when calculating compliance with the annual allotment for each facility. For the Third Management Plan, the incentive has been increased to a 30 percent discount (the Second Management Plan discount was a maximum of ten percent (see section 6-304(A))).
Large-Scale Cooling Facilities Cooling towers that recycle 100 percent of their blowdown water are exempt from meeting the blowdown concentration requirements (see section 6-702 (B)(1)). Cooling towers that convert to at least 50 percent effluent are exempt from the blowdown concentration requirements for one full year. If it is shown that they cannot meet the requirements if they use effluent, reduced blowdown concentration levels may be requested and approved (new incentive in the Third Management Plan (see section 6-702 (B)(2))).
Large-Scale Power Plants Electric power generating facilities that recycle 100 percent of their blowdown water are exempt from meeting the blowdown concentration requirements (see section 6-607). Electric power generating facilities that convert to at least 50 percent effluent are exempt from the blowdown concentration requirements for one full year. If it is shown that they cannot meet the requirements if they use effluent, reduced blowdown concentration levels may be requested and approved (new incentive in the Third Management Plan (see section 6-605)).

TABLE 8-4
RENEWABLE WATER SUPPLY USE INCENTIVES
TUCSON ACTIVE MANAGEMENT AREA

Agricultural
Pursuant to A.R.S. § 45- 467, effluent use cannot contribute to a farm exceeding its allotment in any year. In determining whether a farm exceeds its maximum annual groundwater allotment for a year, total water use, including groundwater, effluent, and surface water, is counted. Then any effluent used that year is subtracted from the amount of water that otherwise would have exceeded the farm's allotment (see section 4.7.1).
All Users
The Department's compliance approach for the third management period may allow regulated groundwater users, under certain specified conditions, to voluntarily enter a stipulated agreement to extinguish recharge credits or store non-recoverable water in specified locations to offset their overuse prior to the end of the year in which the over utilization occurred. This program cannot be used to offset a permanent, structural increase or for any other long-term physical changes (see section 10.7.3). If 100 percent of the water used at a facility is legally non-groundwater, the user is not subject to compliance with management plan conservation requirements.

In response to comments received during the development of the Third Management Plan, the Department will be establishing one or more task forces to address incentive development in the context of local water management objectives. The task force concept is developed more fully in Chapter 12.

8.7.4 Technical Assistance, Coordination, and Facilitation of Efforts

The Department will continue to support augmentation project construction, planning, modeling, and research activities during the third management period. Technical assistance will be provided to water users in assessing the need for augmentation projects, determining project feasibility, and reviewing project impacts. Department staff will participate on oversight committees, provide data, and review planning and feasibility study reports. To facilitate research projects, the Department will assist users by initiating research activities, assisting in study design, providing data, reviewing results, and disseminating information.

The Department's current Technical Services Contract provides for a facilitated contracting process to address technical issues associated with recharge. The focus of this effort is to evaluate technical concerns associated with developing recharge projects, and to facilitate construction of projects that are consistent with the AMA's management goals. A similar contract may be developed during the third management period. In addition, the Department may assess opportunities for additional funding.

Cooperative efforts among many government agencies, water users, and other groups will allow the development of larger, more effective projects and studies. The Department will continue to work with water utilities, government agencies, and other organizations to coordinate and facilitate augmentation activities. For example, during the second management period, the Department: (1) conducted studies in 1992 and 1993 on the underutilization of CAP water in the state for the Governor's CAP Advisory Committee, (2) coordinated the assessment of the feasibility of weather modification along the Mogollon Rim, (3) assisted in establishing the SCVWD, and (4) initiated the Regional Recharge Planning Process in the Tucson AMA. The Regional Recharge Planning Process (further described in section 8.4.5.3) has established a means for the sharing of information and coordination of efforts. As technical coordinator for

recharge permit applications, AMA staff assist in streamlining the permitting process and ensuring timely processing and good communication within the Department and between agencies and applicants.

The Tucson AMA staff will also continue to provide planning support and technical assistance to facilitate the following local efforts: the SAWRSA negotiations; the Regional Effluent Planning Process; the City of Tucson Pilot Membrane Filtration Study; the USCWUG, which is investigating the feasibility of CAP water delivery to the Green Valley-Sahuarita area; the Northwest Replenishment Study; and the Southern Arizona Regional Water Management Study. The Department will participate in other water supply augmentation-related projects as they arise.

8.7.5 Financial Assistance

The Department's Augmentation Assistance Program is described in Chapter 9. This is a significant program that provides funding for augmentation and recharge projects through grants, contracts, and IGAs.

Funds for the Augmentation Assistance Program, the Conservation Assistance Program, and monitoring activities are provided to the Department through the groundwater withdrawal fee which is levied within the AMAs pursuant to A.R.S. § 45-611 which provides in part that:

> The director shall set the actual amount of the fee as follows:
>
> 2. Through 2016, for augmentation of the water supply of the active management area, conservation assistance to water users within the active management area and monitoring and assessing water availability within the active management area, an amount of not more than fifty cents per acre-foot per year, and after 2016, an amount of not more than two dollars per acre-foot per year.
>
> 4. For purchasing and retiring grandfathered rights, an amount of not more than two dollars per acre-foot per year. The initial fee for purchasing and retiring grandfathered rights shall be levied in the first year in which the director develops and implements a program for the purchase and retirement of grandfathered rights as part of the management plan for the active management area, but not earlier than January 1, 2006.

Additional funds may be received for augmentation and conservation assistance and for purchase and retirement of grandfathered rights through fees assessed for the temporary use of groundwater in artificial lakes as described in A.R.S. § 45-133(E). The Department may seek additional funding and cooperative efforts for water supply monitoring and assessment.

8.7.6 Purchase and Retirement of Grandfathered Rights

A.R.S. § 45-566(A)(9) authorizes the Department to develop a program for the purchase and retirement of grandfathered rights to begin no earlier than January 1, 2006. An annual groundwater withdrawal fee of up to $2.00 per acre-foot can be collected for this program; however, the fee cannot be levied until the management plan contains a program for the purpose of purchase and retirement. A.R.S. § 45-611(C)(4). If the management plan were modified to include a grandfathered rights purchase and retirement program, it would provide the Tucson AMA with another method to reduce groundwater overdraft and to achieve the management goal. The purpose of this section is to evaluate the feasibility of developing and implementing a purchase and retirement program in the Tucson AMA.

8.7.6.1 Program Concept

The focus of this analysis is on the purchase and retirement of Irrigation Grandfathered Rights (IGFRs). Although a purchase and retirement program could also legally include Type 1 and Type 2 grandfathered rights, these rights may be more expensive to retire, and purchase and retirement of these rights could possibly be offset by increases in general industrial use permits, thereby defeating the objective of reducing groundwater demand. At a minimum, the program should be limited to those IGFRs that use groundwater exclusively and do not lie in the path of urban development. In addition, IGFRs that would be targeted for purchase and retirement should be required to meet one or more of the following secondary criteria: (1) high water duties, (2) recent history or current use of high consumptive use crops, (3) recent history or current use of high proportion of cropped acres, or (4) located in areas historically exhibiting high groundwater decline rates.

8.7.6.2 Potential Groundwater Savings

To analyze the potential groundwater savings that could be realized from an IGFR purchase and retirement program in the Tucson AMA, an estimate was first made of the total withdrawal fees that could be collected by the Department in 2006 assuming: (1) use of a $2.00 per acre-foot withdrawal fee for purchase and retirement, and (2) groundwater and in-lieu water use equivalent to the AMA's average annual groundwater and in-lieu water use from 1990 through 1996. An estimate was next made of the amount of farmland that could be purchased by the Department assuming: (1) use of all of the collected fees, and (2) a purchase cost for farmland equivalent to the representative 1996-1997 price for an acre of farmland in those areas of the AMA that best meet the proposed minimum program criteria. The groundwater savings were then estimated by assuming: (1) a historic groundwater use for the retired farmland equivalent to the representative annual groundwater use per acre for those IGFRs in the AMA that grow high consumptive use crops and have high land utilization rates, and (2) a 20-year benefit period for the groundwater savings, beginning in 2006 and lasting through the end of the fifth management period in 2025. It should also be noted that the potential groundwater savings assumes that the farmland would not be offset by inactive IGFRs in the AMA being brought back into production. While this information, which is shown in Table 8-5, is useful for analytical purposes, it is unrealistic to assume that the Department would implement an IGFR purchase and retirement program for just one year. Therefore, using the same basic assumptions, the potential groundwater savings that could be realized from continued IGFR purchase and retirement programs implemented for 5, 10, 15, and 20 years were also analyzed.

As shown in Table 8-5, the potential groundwater savings for a five-year program, which would be implemented in 2006 and terminated at the end of the third management period in 2010, are estimated to average 2,201 acre-feet per year, and the average cost associated with the groundwater savings is estimated to be $65 per acre-foot. It should be noted that this cost reflects only the Department's costs for purchasing farmland and assumes that: (1) 163 acres of farmland would be purchased each year using $572,000 of withdrawal fees that were collected during that year, and (2) the 489 acre-feet of groundwater savings resulting from the purchase would continue to accrue on an annual basis from the year of purchase through 2025. Adding the accrued groundwater savings from each year's purchase of farmland results in total groundwater savings of 44,010 acre-feet by 2025. The total costs from 2006 to 2010 for purchasing the farmland equals $2,860,000 (or $572,000 x 5 years). Therefore, the average cost of groundwater savings is $65 (or $2,860,000 ÷ 44,010 acre-feet).

While possible, it is unlikely that the Department would terminate a purchase and retirement program at the end of the third management period. A more realistic assumption is that the program would be continued for the fourth and fifth management periods. Assuming no change in the price for farmland or the amount of withdrawal fees collected, the potential groundwater savings for a 20-year purchase and retirement program are estimated to average 5,135 acre-feet per year, with purchase costs averaging $111 per acre-foot.

TABLE 8-5
POTENTIAL GROUNDWATER SAVINGS AND ASSOCIATED IMPACTS
IGFR PURCHASE AND RETIREMENT PROGRAM
TUCSON ACTIVE MANAGEMENT AREA

Program Duration (Years)	Total Withdrawal Fees Collected [1]	Total Farmland Purchased and Retired [2] (Acres)	Total Groundwater Savings [3] (Acre-feet)	Average Groundwater Savings[4] (Acre-feet per year)	Cost of Groundwater Savings [5] (Per acre-foot)
1	$572,000	163	9,780	489	$58
5	$2,860,000	815	44,010	2,201	$65
10	$5,720,000	1,630	75,795	3,790	$75
15	$8,580,000	2,445	95,355	4,768	$90
20	$11,440,000	3,260	102,690	5,135	$111

[1] Assumes a $2.00 per acre-foot withdrawal fee for purchase and retirement and 286,000 acre-feet per year of groundwater and in-lieu water use.
[2] Assumes purchase of the farmland in the year the fees are collected and a $3,500 per acre purchase cost.
[3] Assumes 3.00 acre-feet per acre of historic groundwater use and groundwater savings accruing annually through 2025.
[4] Annual savings equals total groundwater savings divided by 20 years.
[5] Average cost equals total withdrawal fees collected divided by total groundwater savings.

It is likely, however, that the price for farmland will increase and the amount of withdrawal fees collected will decrease before 2025. Changing the assumptions used above has a significant impact on the conclusions that can be drawn about the effectiveness of the program. If the volume of groundwater and in-lieu water used declines incrementally from 286,000 acre-feet in 2006 to 187,000 acre-feet in 2025 (as is projected in the TMP scenario water budget in Chapter 11, Table 11-12), the total water savings from a twenty year program is 85,774 acre-feet. If the purchase price of farmland increases incrementally from $3,500 per acre in 2006 to $7,000 per acre in 2025, the total water savings from a twenty year program is 79,891 acre-feet. Under a scenario where both of these variables change simultaneously, a twenty year program will result in a total groundwater savings of 71,914 acre-feet by 2025 and an annual average savings of 3,596 acre-feet. The total cost of the program is $9,460,000 and the average cost of groundwater savings is $132 per acre-foot.

8.7.6.3 Land Management and Maintenance Issues

Before a purchase and retirement program could be developed and implemented in the Tucson AMA, issues involving land management and maintenance would need to be addressed. These issues include, but are not limited to, the following:

- Funding for staff and other resources needed to manage the retired farmland
- Liability claims
- Impacts of removing the land from the county and local property tax base
- Control of noxious weeds and dust on the land

8.7.6.4 Program Development Decision

Even without considering the costs to manage and maintain the retired farmland, it is clear that saving groundwater in the Tucson AMA through the purchase of irrigated land and retirement of the irrigation rights would be expensive. Other augmentation or demand reduction measures may be more cost effective

to implement. Although at this time the Department has decided to not develop an IGFR retirement program, the Third Management Plan can be modified in the future to incorporate such a program if the concerns listed in the section above are addressed. Many issues could be avoided if a program were developed that extinguished the water right without purchasing the land.

8.7.7 Resolution of Institutional and Legal Barriers

The Department will continue to work with interested parties in the AMAs and around the state to draft rules and propose legislation that will resolve legal and institutional barriers to water supply augmentation projects. Among the barriers are difficulties with the permitting process, jurisdictional issues, and conflicting objectives of various regulatory programs. There are some problems that the Department can address with existing tools and authorities, such as revision of well-spacing and impact rules. The Department can indirectly influence progress in some areas through support of legislation, education, and the regional planning process. For some issues, new tools and authorities may be necessary, as described at the end of this chapter and Chapter 12.

8.8 FUTURE DIRECTIONS

There are a number of issues that will have to be addressed in order to facilitate achievement of safe-yield and other objectives discussed in this chapter. There is a growing recognition that the regulatory and non-regulatory tools that are available may not be sufficient to meet the AMA management objectives. As has been discussed, there are numerous factors that impact water use patterns, many of which are not affected by the Department's programs. Although some Code provisions are directly linked to achieving the management goal, there are many ways in which water management tools could be improved. An evaluation of the roles and responsibilities of all groundwater users in reducing groundwater mining will be initiated as described in Chapter 12. A key consideration in evaluating the need for stronger regulatory programs is whether economic conditions alone can substantially reduce groundwater use in the agricultural and copper mining sectors. If these sectors reduce their groundwater pumpage substantially, the need to offset their groundwater pumpage will diminish.

Critical area management strategies are being considered for formulation during the third management period to attempt to move beyond the AMA-wide goal and address water management problems in specific geographic areas of the AMA. If a critical area program is developed, it will focus on problems associated with groundwater pumping, such as large cones of depression, subsidence, earth fissures, reduction in aquifer storage capacity, and the reduced physical availability of supplies. These efforts will require partnerships with entities from the areas in question who are willing to make necessary changes, and support more stringent requirements to improve groundwater conditions.

It may be necessary to reexamine the AWS Rules provision that allows groundwater up to 1,000 feet below the land surface to be determined physically available. Allowing groundwater levels to fall this much will exacerbate subsidence, water quality problems, and problems with well productivity. Evaluation of the results from the subsidence monitoring and gravity studies conducted by the Department and the USGS in the context of the AMA groundwater flow model will provide information that can be used to amend the AWS Rules if changes are warranted. The total volume of allowable mined groundwater under the AWS program may also need to be reevaluated in order to reach physical safe-yield. See Chapter 11, section 11.5 for further explanation of the effect of allowable mined groundwater on the water budget.

Further examination of the purchase and retirement of grandfathered rights will be conducted. Issues such as whether the current withdrawal fee would be sufficient to successfully carry out this program will be evaluated and whether or not the Department will consider the extinguishment of rights separately from the lands will be considered.

Community support is the key component to developing new programs. The quality and quantity of the water supply is a major concern for the citizens of the Tucson AMA. Changes to the water rights system and the relative responsibilities of various water use sectors will require substantial public input and opportunities for comment. If larger public policy issues are included in the evaluation, such as quality of life, water quality objectives, riparian habitat, and wetland treatment opportunities, the public input effort may require significant staff resources.

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APPENDIX 8
REGULATORY AND INSTITUTIONAL FACTORS AFFECTING RECHARGE AND/OR WATER SUPPLY AUGMENTATION

The following policies, programs, and regulations have a significant impact on the Department's water supply augmentation program.

8A.1 CENTRAL ARIZONA WATER CONSERVATION DISTRICT POLICIES

The CAWCD was established to contract with the federal government for the repayment of the CAP. CAWCD operates the CAP and repays the federal construction debt for the project. In addition to these responsibilities, CAWCD has been assigned recharge-related functions, including operation of State Demonstration Projects (A.R.S. § 45-891.01) and replenishment projects. The CAWCD is directed by a fifteen-member elected board from the three member counties (Pima, Pinal, and Maricopa). Pima County has four members. The Board sets policy for the CAP, which the CAWCD implements. CAWCD policies regarding CAP water pricing, use of State Demonstration Project monies, and delivery scheduling priorities may affect the direct use of CAP water as well as the development and operation of some recharge projects in the Tucson AMA.

8A.1.1 Central Arizona Project Water Pricing

The CAWCD charges a "postage stamp rate" for all CAP water delivered to subcontractors in the CAP service area. This pricing policy is critical to the Tucson AMA's augmentation efforts, since higher delivery costs in the Tucson AMA would make CAP water utilization far less attractive.

The price of CAP water affects utilization rates. In particular, the cost of CAP water for the AWBA has a direct effect on augmentation in the Tucson AMA. The amount of money available to finance the AWBA's activities is limited, so higher water costs will reduce the amount of water recharged. The postage stamp rate is a key consideration in AWBA cost, and it is hoped that the AWBA will continue to be subject to this pricing policy. Also, decisions regarding participation in GSFs will affect the volume of water that can be recharged in the Tucson AMA.

In 1993, CAWCD established an agricultural pool pricing program as an incentive to keep the agricultural sector participating in the CAP and increase its use of CAP water. This pricing program has had little impact in the Tucson AMA because the majority of agricultural CAP water use has been through GSFs. CAWCD also offers incentive priced water for recharge to municipal and industrial subcontractors. This is excess water that is priced below subcontract water to supply permitted recharge projects only. CAWCD has approved this program only through 1999. CAWCD will need to reevaluate the program and pricing for future years. See section 8.2.2.1.3 for further discussion of CAP water pricing and agriculture. A schedule for annually increasing capital charges for municipal and industrial CAP water allocations has been established by CAWCD.

8A.1.2 State Demonstration Fund

Funding for State Demonstration Projects or recharge of excess CAP water was provided from ad valorem taxes levied by CAWCD at a rate of four cents per $100 secondary assessed valuation in Maricopa and Pima Counties between 1991 and 1996. Monies are no longer being added to the fund for state demonstration projects, and most of the fund for the Tucson AMA has been encumbered. In 1996, new legislation established the AWBA. The monies raised from the tax are now provided to the AWBA to recharge excess CAP water in the county from which the monies originated, unless CAWCD determines that it must be used to support CAWCD's repayment obligation to the federal government.

Three projects in the Tucson AMA have, or will, receive State Demonstration Project funds for construction: the Pima Mine Road Recharge Project, Avra Valley Recharge Project, and Lower Santa Cruz Replenishment Project. After completion, these State Demonstration Projects can be used by CAWCD, CAGRD, AWBA or others to store water for various purposes.

8A.1.3 Delivery Policy

As operator of the CAP, the CAWCD established an administrative system to take orders, schedule deliveries, collect charges and handle contingencies. Each year the CAWCD estimates the amount of water that will be available to customers and accepts orders on the basis of that estimate. As long as more CAP water exists than is ordered by subcontractors, the CAWCD will schedule orders for excess water. Orders for scheduled water deliveries must be made by October 1 for the next calendar year. Additional water may be purchased on demand as long as excess CAP water supplies and excess canal capacity exist. The CAWCD maintains an informal working relationship with its CAP water customers for flexibility in meeting system needs.

Annual priorities for delivery of CAP water, as established in law, assign the highest priority to Indian and municipal subcontractors. The lowest priority is assigned to non-Indian agriculture. This means that if scheduled deliveries must be curtailed in any year, deliveries to non-Indian agricultural subcontractors will be cut first. The priority of daily deliveries is assigned by CAWCD taking into account the operational flexibility of its customers. As currently implemented, daily operating priorities place direct municipal uses first, but place agricultural uses before municipal recharge projects, on the rationale that timing of deliveries is more important to agriculture than to recharge. This policy may be revisited due to the concerns of some municipal subcontractors that it could shift the burden of supply reliability away from agriculture and towards municipal and industrial users.

8A.2 CENTRAL ARIZONA GROUNDWATER REPLENISHMENT DISTRICT

Legislation enacted in 1993 established the CAGRD as an operating unit of CAWCD. As currently constituted, the CAGRD exists solely to provide municipal providers or subdivisions a means to replenish groundwater that is withdrawn in excess of the amount of groundwater that is allocated to them under the Department's AWS Rules. Membership in the CAGRD is voluntary. The CAGRD may offer economic benefits to members through the collective bargaining power of the district and the economies of scale in development of cooperative regional projects.

The CAGRD service area includes those portions of Maricopa, Pinal, and Pima Counties which are located within the Phoenix, Pinal, and Tucson AMAs. The CAGRD provides replenishment services to members who agree to the terms of a membership contract. The CAGRD may meet its replenishment obligations using CAP water or any other source of water except groundwater withdrawn within an AMA. In addition, the CAGRD may construct and operate recharge projects, enter into leases or water exchanges, purchase and retire water rights, and levy and collect fees from its members to finance replenishment activities.

The amount of excess groundwater reported can vary at the discretion of the provider from a minimum, calculated on the basis of a formula in the replenishment statute, to the total amount of groundwater delivered in any year. The contractual minimum replenishment obligation formula begins in 1999 at 1/30 of the groundwater delivered in that year and increases by 1/30 each year until 2014 for most member service areas in the Tucson AMA. A special contract was negotiated with Tucson Water because under the standard contract Tucson's demand for replenishment could have varied from near zero to over 100,000 acre-feet from one year to the next. The special contract addresses uncertainty and costs of maintaining redundant recharge capacity.

The CAGRD maintains a replenishment account for each member. It computes each member's replenishment obligation yearly based on the member's annual report and debits the account by the calculated amount. Members can build limited credit in the account by purchasing replenishment services. Members' accounts are balanced annually, and members with a debit balance must pay the CAGRD to replenish the amount of over-drafted groundwater and bring the balance at least to zero. A member also may transfer to the CAGRD storage credits accrued or purchased elsewhere to offset a debit balance. The CAGRD has three years to replenish excess groundwater used by a member.

Because of the flexibility of the system, it is difficult to predict the volume of replenishment which will be provided by the CAGRD in any given year beyond the statutory minimum replenishment obligation. Because the minimum replenishment obligation increases over time, the impact of the CAGRD's activities on the Tucson AMA's water supply will increase over time.

The water used for replenishment may be acquired by the CAGRD or a member. According to the CAGRD's first 20-year plan of operation adopted in 1994 in the Tucson AMA, the CAGRD intends to fulfill contractual obligations using excess CAP water.

8A.3 DEPARTMENTAL REGULATIONS AND PROGRAMS RELATED TO AUGMENTATION

8A.3.1 Augmentation and Conservation Assistance Fund

The Department's Augmentation Assistance Program is one of the ways in which the Department provides technical assistance to the community. Conveyance, storage, and/or direct use of alternative water supplies are facilitated through grants and contracts for feasibility studies, monitoring studies, routing studies, and other projects. Fund monies may be used to advance development of specific projects, or to resolve technical issues with broader applications. Chapter 9 describes the Augmentation Assistance Program more fully, including a summary of specific grants and projects completed during the second management period.

The Department's augmentation and conservation assistance activities are funded by groundwater withdrawal fees. The potential of the program to affect the Tucson AMA's augmentation activity depends on the amount of funds available and how strategically the funds are used. In 1996, when most of the available augmentation funding was diverted to the development and support of the AWBA, the Department initiated a proposal and contracting process to target high priority groundwater management issues and information needs with the remaining funds. In 1997, to help reduce the time required to procure technical consultants for augmentation projects, the Department developed a general technical services contract that is renewable for up to three years. Cost-sharing projects broaden the effectiveness of the program.

8A.3.2 Water Protection Fund Grants

Legislation establishing the AWPF was passed in 1994. The purpose of the AWPF is to provide grant monies for implementing projects to protect or restore the state's rivers and streams, including the purchase of CAP water or effluent for riparian enhancement. The Legislature appropriated $4 million for the AWPF from the state general fund in 1994 and $6 million in 1995. The Commission awarded 53 AWPF grants totaling $12,289,923 in the 1995 and 1996 funding cycles.

AWPF grants could impact future augmentation activities in the Tucson AMA by providing funds to develop riparian enhancement projects which would utilize excess CAP water or effluent. AWPF grants issued for the City of Tucson's Atturbury Wash Project and the San Xavier District's Arroyos Project are

associated with recharge facilities. However, few of the applications filed to date in the Tucson AMA have proposed acquisition of renewable supplies.

8A.3.3 Assured Water Supply Program

In February of 1995, the Department adopted the Assured and Adequate Water Supply Rules. These rules are a primary tool in achieving the AMA's management goals and ensuring sufficient water supplies for new development. The rules require that developers of new subdivisions demonstrate the availability of renewable, non-mined groundwater supplies that are sufficient to meet the demand of the development for 100 years, either by obtaining a Certificate of Assured Water Supply or by receiving service from a water provider with a Designation of Assured Water Supply. While new subdivisions and designated providers must limit their overall use of mined groundwater, a specified amount of mined groundwater is allocated to them. Any groundwater use above the mined groundwater allocation must be replenished. If a certificate applicant or water provider does not have access to a renewable water supply, the development or service area may be enrolled in the CAGRD to satisfy its replenishment obligation. If a municipal provider is a member service area, or a subdivision is a member land of the CAGRD, any groundwater withdrawn in excess of the mined groundwater allocation must be replenished within the AMA by the CAGRD within three years.

Municipal water use accounts for nearly half of all water used in the Tucson AMA. In addition, a significant portion of the population falls within service areas that have assured water supply designations. Once a provider has joined the CAGRD, the CAGRD is committed in perpetuity to replenish the demand that existed within that service area during the membership period in addition to the demand of new developments. Therefore, the AWS Program should significantly influence the use of renewable water supplies in the AMA.

Most private water companies have chosen not to be designated. Vail Water Company (formerly Del Lago) and Spanish Trail Water Company are the only private water companies in the Tucson AMA with designations as of December 1999. Several companies which formerly held assured water supply designations have decided not to reapply (see Chapter 5). New developments in undesignated providers' service areas must have a Certificate of Assured Water Supply, but undesignated water providers are expected to continue to pump groundwater to serve their existing customers. This ongoing use of mined groundwater jeopardizes the ability of the AMA to reach safe-yield.

Table 8A-1 shows the status of provider assured water supply designations. Tucson Water, the largest municipal provider in the AMA, has applied for and received a designation under the AWS Rules. In order to maintain a designation under the new requirements, Tucson Water needs to resolve some of the limitations on municipal CAP water use described in section 8.2.2.1.2 because there are limits to the amount of groundwater physically available within their service area. All of the designated providers listed below are, or will be, members of the CAGRD.

As of December 1999, there were 19 large (serving more than 250 acre-feet) and approximately 132 small undesignated providers in the Tucson AMA. Some of these undesignated providers could be targets for augmentation efforts; their current groundwater use is 23,600 acre-feet. Efforts to encourage use of renewable water supplies in this sector merit further attention as a component of the augmentation program in the Tucson AMA.

TABLE 8A-1
ASSURED WATER SUPPLY STATUS
TUCSON ACTIVE MANAGEMENT AREA

Provider	1996 Population	1996 Water Use (acre-feet)	Assured Water Supply Status
Marana Municipal Water System	533	88	Designation granted
Metropolitan Domestic Water Improvement District	42,861	9,109	Designation granted
Spanish Trail Water Company	551	133	Designation granted
Town of Oro Valley (formerly Canada Hills and Rancho Vistoso Water Companies)	23,229	6,457	Designation granted
Tucson Water	599,602	114,548	Designation granted
Vail Water Company (formerly Del Lago Water Company)	1,275	202	Designation granted
TOTAL DESIGNATIONS	**668,051**	**130,537**	
Community Water Company of Green Valley	12,819	2,145	Expired
Farmers Water Company	686	280	Expired
Forty-Niner Water Company	872	862	Expired
Green Valley Water Company	4,203	2,355	Expired
New Pueblo Water Company (purchased by Community W.C. of Green Valley)	841	122	Expired
Ray Water Company	4,617	667	Expired
TOTAL EXPIRED	**24,038**	**6,431**	
TOTAL OTHER UNDESIGNATED PROVIDERS	**80,788**	**17,180**	
GRAND TOTAL	**772,877**	**154,148**	

8A.3.4 Well Spacing Rules

The Code states that the director shall adopt rules governing well locations (A.R.S. § 45-598(A)) and may adopt rules governing pumping patterns (A.R.S. § 45-601) to minimize damage to adjacent land and water users. The Department is currently operating under temporary well-spacing and well-impact rules (A.A.C. R12-15-830 adopted in 1983) and intends to develop new rules to address this complex program. These rules could be developed not only to address the statutory requirements of protection but also as a management tool in conjunction with recharge and augmentation programs to better control localized aquifer conditions.

8A.4 ARIZONA DEPARTMENT OF ENVIRONMENTAL QUALITY REGULATIONS AND PROGRAMS RELATED TO AUGMENTATION

ADEQ activities and regulations that affect supply augmentation and/or recharge include Aquifer Protection Permits (APP), disinfection rules, Aquifer Water Quality Standards (AWQS), and the Wastewater Reuse Rules. For further information on ADEQ programs and regulations, contact the ADEQ Southern Regional Office (520) 628-6734.

8A.4.1 Aquifer Protection Permits

ADEQ has responsibilities for protecting the quality of water resources in the state. Unless otherwise exempted, discharge that has the potential to degrade water quality in an aquifer must receive an APP from ADEQ certifying that specified measures have been or will be taken to prevent pollution of the aquifer.

The APP rules include special provisions for underground storage and recovery. They also require ADEQ to advise the Department of permit applications received for individual APPs for facilities which are recharge projects. An APP is not required for recharge projects using CAP water. However, ADEQ statutorily is required to review applications for USF permits regardless of their exemption from APP requirements. ADEQ assesses whether a facility is in a location that will promote either the migration of a contaminant plume or the migration of a remediated groundwater area so as to cause unreasonable harm, or is in a location that will result in pollutants being leached to the groundwater table so as to cause unreasonable harm. A.R.S. § 45-811.01(C)(5). The Department, after consultation with ADEQ, may include in its permit any requirements deemed necessary to protect aquifer water quality.

Recharge projects using effluent must be issued an APP by ADEQ. In general, effluent must meet primary drinking water quality standards before an APP will be issued for its discharge to the aquifer, although other standards and exceptions can apply. Recharge projects employing spreading basins, stream channels or injection methods would all be considered discharge to the aquifer. To discharge CAP water to a river bed, an entity must have either an APP or a recharge permit.

APP rules include numeric and narrative water quality standards. There are numeric AWQSs for certain inorganic and organic chemicals, radionuclides, and microbiological pollutants which may not be exceeded within the aquifer. These standards are generally the same as the Maximum Contaminant Levels (MCL) set by the EPA for drinking water. ADEQ has one year to adopt a new AWQS after EPA adopts an MCL for a groundwater constituent. Sometimes when EPA eliminates an MCL standard, ADEQ retains the correlating AWQS for that constituent. ADEQ narrative standards include that a discharge shall:

- Not cause a pollutant to be present in an aquifer classified for a drinking water protected use in a concentration which endangers human health.

- Not cause or contribute to a violation of a surface water quality standard established for a navigable water of the state.

- Not cause a pollutant to be present in an aquifer which impairs existing or reasonably foreseeable uses of water in an aquifer.

Changes or additions to the numeric standards list and interpretation of the narrative standards could significantly affect future augmentation activities in the Tucson AMA. For example, the recharge of effluent could become constrained if numeric standards for TDS were added to the list. Conversely, this could lead to increased direct use of effluent.

8A.4.2 Groundwater Under the Direct Influence of Surface Water Disinfection Requirements

The ADEQ is the designated agency of the state to administer the federal Safe Drinking Water Act. In this capacity, ADEQ must promulgate rules for determining on a case-by-case basis whether water recovered from CAP water recharge projects is considered "groundwater under the direct influence of surface water." Such water must be treated according to the drinking water rules that apply to surface water, while groundwater need not be treated unless it fails to meet primary drinking water standards. (A national groundwater disinfection rule is currently being contemplated which could change this.) If water recovered from a recharge project is determined to be "groundwater under the direct influence of surface water," filtration and disinfection could be required before the water enters the distribution system. This treatment could add significantly to project costs. Rules on this subject were adopted effective April 19, 1999.

For public water systems using a well within 500 feet lateral distance from a surface water body, the ADEQ requires a determination of whether the well is pumping "groundwater under the direct influence of surface water." ADEQ's Drinking Water Program currently regards recharge basins, in-channel recharge facilities, injection wells, or virtually any other mode of discharge of CAP water into wells or an aquifer as a "surface water body." Thus, if a recharge facility is designed with recovery wells that are within 500 feet, or utilizes existing wells within 500 feet of the facility, a determination would be required. ADEQ will first try to assess the vulnerability of the well to the direct influence of surface water using existing hydrogeologic and well construction data. ADEQ may determine that the groundwater source is sufficiently separated from the surface water source and is, therefore, not under the direct influence of surface water. However, if there is insufficient data available or it is determined that the groundwater source has a high vulnerability to influence the surface water source, then the water system will be required to determine through testing whether it is pumping "groundwater under the direct influence of surface water."

While a recharge project's recovery wells may qualify for testing, they do not need filtration and disinfection treatment unless the tests confirm a direct surface water influence. The required test is Microscopic Particulate Analysis (MPA), which looks for insect fragments, leaf parts, etc., that have not been filtered out by aquifer materials.

This is a new and evolving program. Because ADEQ is currently reviewing and revising procedures and requirements for this program, the Department recommends contacting ADEQ for the latest information on this rule.

8A.4.3 Aquifer Water Quality Standards

Under Title 49, ADEQ has adopted rules (A.A.C. R18-11-401, *et seq.*) which set both numeric and narrative AWQSs as well as Health Based Guidance Levels (HBGL). Numeric AWQSs are equivalent to the Federal primary drinking water standards while narrative standards may be set on a "case by case" basis utilizing HBGLs or other technical information to protect human health or current and future aquifer use.

Although recharge of CAP water and other non-effluent waters is exempt from APP requirements (A.R.S. § 49-250(B)(12) and (13)) if a permit to operate is secured under Title 45, any discharge must still comply with AWQSs. This exemption from the APP program should expedite recharge permitting of non-effluent water while still providing ample protection to the aquifer through the Department's permit and monitoring requirements.

8A.4.4 Wastewater Reuse Permits

Wastewater reuse is an important component of the Tucson AMA augmentation program. Direct use of treated wastewater (effluent and industrial wastewater) may occur only if a wastewater reuse permit is granted by ADEQ. A wastewater reuse permit is intended to ensure that the use of treated wastewater will not adversely affect human health, water supplies, or the environment. For example, a wastewater treatment plant operator or the user of the effluent must apply for a permit from ADEQ before effluent can be released from the treatment plant for reuse. The treatment plant operator or the user of the effluent is responsible for meeting the conditions of the wastewater reuse permit, as set forth in a legally enforceable contract between them.

The reuse rules specifically prohibit the use of treated wastewater for direct human consumption. However, there are reuse standards established for orchards, fiberseed and forage, pastures, livestock watering, processed food, landscaped areas, food consumed raw, incidental human contact and full body contact uses, gray water uses, wetlands marshes, and industrial reuse. Depending upon the use and disposal of the wastewater, an APP, or a National Pollutant Discharge Elimination System (NPDES) permit may also be required.

The ADEQ is currently revising the reuse rules, A.A.C. R18-9-701, *et seq.* The revised rules may impact augmentation activities in the Tucson AMA by expanding the options for direct use of effluent.

In the Tucson AMA, Tucson Water holds a reuse permit for its reclaimed water system. Individual reclaimed water customers who agree to operate within the criteria set forth in the City's blanket reuse permit are not required to obtain individual permits from ADEQ.

8A.5 STATE HISTORIC PRESERVATION ACT

Recharge projects are frequently located along riverbeds, which are the areas where archaeologic sites are most frequently identified. Under Arizona's State Historic Preservation Act, an archaeologic survey is required wherever the land surface will be excavated and/or inundated for a storage project. The survey is done to ensure that no historic or prehistoric sites will be disturbed. If no archaeologic remains are found, a clearance is issued. If archaeologic or paleontologic items are found on state, county, or municipal lands, it is necessary to contact the director of the Arizona State Museum. It also is necessary to contact the director of the Arizona State Museum if funerary remains are found on private lands. Other agencies that should be contacted if archaeologic remains are found include the Tucson Historic Preservation Office and/or the Pima County Historic Preservation Office.

8A.6 FEDERAL REGULATIONS PROGRAMS AND ISSUES

Federal activities affecting supply augmentation and/or artificial recharge include compliance with: the NPDES and dredge and fill sections of the Clean Water Act, the Endangered Species Act (ESA), the Reclamation Reform Act (RRA), Colorado River Law, and SAWRSA.

8A.6.1 National Pollutant Discharge Elimination System Permits

Pursuant to section 402 of the Clean Water Act, ADEQ administers the certification of NPDES permits for the EPA. The NPDES Permit for Point Sources of Pollution, as defined by ADEQ, protects the waters of the state from pollutants discharged from a point source. The waters of the state include all perennial or intermittent streams, lakes, ponds, impounding reservoirs, marshes, watercourses, waterways, wells, aquifers, springs, irrigation systems, drainage systems, and other bodies or accumulations of surface, underground, natural, artificial, public, or private water situated wholly or partly in or bordering on the state.

A NPDES storm water permit may also be required for certain industrial and construction activities that discharge storm water. NPDES permits are usually required for effluent or industrial wastewater being disposed of by discharge to the waters of the state. However, when wastewater is proposed for a reuse application, such as recharge, the ADEQ wastewater reuse and APP rules are applied.

8A.6.2 Section 404 Clean Water Act Dredge and Fill Permits

Section 404 (Wetlands) of the Clean Water Act requires that the United States Army Corps of Engineers, with the concurrence of EPA, issue or deny permits for activities that result in the discharge of dredge or fill material into the waters of the United States. For the purposes of this section, waters of the United States include most streams, stream channels, and wetlands in Arizona. Intended to prevent the unlawful filling of wetlands, this section would apply to most channel modifications made for in-channel recharge projects. Section 404 permits must be certified by ADEQ, under section 401 of the same Clean Water Act. Certification depends on a review "solely to determine whether the effect of the discharge will comply with the water quality standards for navigable waters . . . ." A.R.S. § 49-202(C).

8A.6.3 Endangered Species Act

The ESA could have a major impact on siting and developing recharge facilities in the Tucson AMA. The United States Fish and Wildlife Service (USFWS) must be consulted when a recharge project involving a federal government action is planned. The USFWS issues a Biological Opinion on whether a project is likely to jeopardize endangered or threatened species. If the USFWS determines the project is likely to jeopardize such species, the project's sponsors must consult with the USFWS on ways to avoid or mitigate the project's negative impact. In the Tucson AMA, projects that involve the USBR, rights-of-way on federal land, or similar federal participation may require consultation with the USFWS.

The mitigation requirements can be extensive. In 1994, USFWS released a Biological Opinion under section VII of the ESA identifying the potential of the CAP delivery system to transport, introduce, and spread non-native aquatic species to the Gila River Basin. Although this 1994 Gila River Basin Biological Opinion did not consider CAP impacts to most of the Santa Cruz River Subbasin, it provides precedents that may affect other federal agency decisions and indirectly the development of recharge projects in the Tucson AMA. The Reasonable and Prudent Alternatives developed to minimize potential jeopardy to endangered native species included: (1) construction of physical fish barriers and maintenance of existing electrical fish barriers, (2) development and implementation of a program to monitor fish populations in the CAP aqueduct and selected contiguous waters, (3) funding for threatened and endangered fish conservation, (4) funding for control activities of non-native fishes, and (5) development and implementation of an information and education program on non-native species introductions into native aquatic communities.

As of 1999, GSFs using CAP water have gone forward in the Santa Cruz River Basin without formal USFWS consultation based on an agreement between the USFWS and the USBR on protective measures. The USFWS mitigation requirements for the Santa Cruz River sub-basin included construction of fish

barriers. However, because the CAWCD requested that 1996 and subsequent funds for endangered species mitigation be deleted from the congressional appropriation, protective structures were not built; and several issues disputed by the USBR, the USFWS, and the CAWCD are being resolved through litigation.

Currently it is unclear if the construction of the CAP system itself can be considered the federal action used as a basis for applying certain provisions of the ESA to recharge projects involving use of CAP water, even though the recharge project has no other direct federal involvement.

Many areas along rivers and washes in the Tucson AMA have been identified as potential ferruginous pygmy owl habitat. Construction in and near the owl habitat may be affected by this determination. ESA compliance may block or inhibit development of some of the proposed in-channel and off-channel recharge projects located within or near critical owl habitat.

Determination of the applicability of USFWS formal consultation and mitigation requirements under the ESA to recharge projects involving CAP water may range from limited to extensive impact on the cost of development and operation of many proposed recharge projects in the Tucson AMA. If resolution of the dispute results in requirements for formal consultation with the USFWS on endangered species protection and addition of protective structures to recharge project designs for all CAP water recharge projects located in or near the Santa Cruz River bed and tributaries, ESA compliance could become a significant disincentive to recharge.

The ESA may also affect recharge projects in the Tucson AMA if an endangered species should come to depend on habitat created or sustained by a project. The Southwest Center for Biological Diversity has filed suits requesting that Hoover and Roosevelt Dams be operated in a way that protects the habitat of the endangered southwestern willow flycatcher, which exists around the margins of the reservoirs created by the dams. If a facility can be compelled to protect habitat it incidentally creates or sustains, then the design and operation of some recharge projects may be legally constrained for endangered species protection. Injection recharge projects and basin recharge projects operated to maximize recharge through wet/dry cycles and disking are less likely to create incidental habitat than multi-purpose projects incorporating riparian features and recreation.

8A.6.4 Reclamation Reform Act

The RRA was passed by Congress in 1982. The RRA established strict limits on the amount of acreage that landowners may irrigate with reclamation water delivered by irrigation districts which have water service contracts with the USBR. In most cases, the limit is 960 acres, including leased lands. Land owned in excess of 960 acres must be put under recordable contract with the Secretary of Interior and disposed of within 10 years of the date of first water service to the land. Excess lands not placed under recordable contract must pay full cost for reclamation water.

The Impact of the RRA on CAP water use in the Tucson AMA was initially thought to be significant; however, the groundwater savings program has provided an avenue to avoid the RRA CAP water use restrictions for agriculture.

8A.7 INDIAN WATER RIGHTS SETTLEMENTS

Indian water rights claims involve a large portion of the water supplies available in the state. Through an initial allocation by the Secretary of the Interior in 1982 and subsequent water rights settlements, Indian CAP water allocations totaled approximately 455,600 acre-feet by 1996, or 483,800 acre-feet if the 28,200 acre-feet of SAWRSA exchange water is included. Recent CAP repayment proposals affect the

distribution of CAP water between Indian and non-Indian users. It is expected that Indian water rights settlements will play a major role in water supply availability within the AMAs.

In the Tucson AMA, amendments to the SAWRSA being proposed as settlement to pending litigation may have significant water supply management implications. The Tohono O'odham Nation, the United States, and two Indian allottees initiated a lawsuit in 1975 suing the City of Tucson and other water users in the AMA claiming damages and seeking to enjoin pumping of groundwater. Although a settlement was reached in 1982, most provisions have not been implemented because an ongoing dispute between the Nation and the San Xavier District allottees regarding distribution of assets included in the settlement thwarted dismissal of the pending litigation. In 1993, the allottees filed two new lawsuits. All three lawsuits are in abeyance during ongoing negotiations for a legislative solution. Settlement negotiations are ongoing. The 1996 version of the proposed SAWRSA Amendments settlement is summarized in Table 8A-2.

TABLE 8A-2
INDIAN WATER SUPPLIES IF SAWRSA AMENDMENTS ARE ENACTED
TUCSON ACTIVE MANAGEMENT AREA

	San Xavier District	Eastern Schuk Toak District	Total
CAP water	27,000 AF	10,800 AF	37,800 AF
Groundwater	10,000 AF	3,200 AF	13,200 AF
Additional CAP water (effluent exchange)	23,000 AF	5,200 AF	28,200 AF
Initial Groundwater Credits	50,000 AF	16,000 AF	66,000 AF
Annual Maximum Credit Recovered*	10,000 AF	3,200 AF	13,200 AF
10 Year Maximum Credit Recovered*	50,000 AF	16,000 AF	66,000 AF

*The annual maximum recovered credit would be in addition to the annual groundwater allotment. This means the San Xavier District Allottees could pump up to 20,000 acre-feet per year, as long as there were credits in their account, and they did not exceed the 10-year maximum. Because they could recover a maximum of 50,000 acre-feet of credits in any 10-year period, they could potentially pump an average of 15,000 acre-feet per year in any 10-year period.

AF = acre-feet

The USBR is responsible for executing the federal government's responsibilities (other than trust responsibilities) in the SAWRSA. The USBR has assisted the San Xavier District of the Tohono O'odham Nation by helping to deliver CAP water to the Arroyos Project.

The SAWRSA amendments are anticipated to resolve the Tohono O'odham Nation's "Winters Doctrine" water claims in the Tucson AMA, as well as claims for damages resulting from groundwater overdraft. In separate efforts, the Tohono O'odham Nation is also seeking water rights for the Sif Oidak District located within the Pinal AMA.

CHAPTER

9

Water Management Assistance Program

9.1 INTRODUCTION

The Arizona Department of Water Resources' (Department) Water Management Assistance Program (WMAP) is intended to provide financial and technical resources to assist water users in meeting their conservation requirements, facilitate renewable water supply utilization, and obtain information on hydrologic conditions and water availability in the Active Management Area (AMA). This program is funded primarily through a portion of the groundwater withdrawal fees paid annually by persons withdrawing groundwater in the AMA. The WMAP consists of the following: the Conservation Assistance Program, the Augmentation Assistance Program, and the Monitoring and Assessment Program. Conservation and augmentation assistance, and information on hydrologic conditions acquired through monitoring and assessing water availability, are essential tools in achieving the Department's water management goals. These goals include the efficient use of all water supplies and meeting the AMA safe-yield goal.

Conservation assistance is provided primarily in the form of financial assistance. However, it also includes planning and technical support and information and education services. Conservation assistance will continue to serve as a balance to enforcement actions during the third management period.

Augmentation assistance involves providing funds for projects that supplement the water supply of the AMA or that provide information to resolve technical feasibility issues or to optimize operation of recharge projects. Assistance includes studies initiated or conducted by the Department, cost sharing grants for augmentation projects, and studies initiated or conducted by others. Assistance may also include planning and technical support for AMA-wide and local area water management strategies.

Monitoring and assessment activities include providing staff assistance and funds for water supply and subsidence monitoring studies.

This chapter includes the following sections:

- Statutory Provisions
- Department's Role in the Water Management Assistance Program
- Second Management Plan Program Summary and Assessment
- Third Management Plan Program Goals and Objectives
- Allocation of Program Funds
- Future Program Direction

9.2 STATUTORY PROVISIONS

9.2.1 Program Authorization and Funding

The Groundwater Code (Code) requires that the Third Management Plan include a program for "additional augmentation of the water supply of the active management area, if feasible, including incentives for artificial groundwater recharge" and "a program for conservation assistance to water users within the active management area." A.R.S. § 45-566(A)(6) and (8). Funding for these programs comes primarily from groundwater withdrawal fees levied and collected pursuant to A.R.S. § 45-611(C). Other sources of funding include one-half of the annual surcharge collected by the director from persons holding a permit for interim groundwater use in bodies of water within the AMA and application fees for underground

storage facility permits, groundwater savings facility permits, water storage permits, and recovery well permits. A.R.S. §§ 45-133(E) and 45-871.01(A).

All fees received by the Department for the WMAP must be transmitted to the state treasurer. A.R.S. § 45-615. The state treasurer is required to hold the fees in a separate fund, and to maintain within the fund, separate accounts for each AMA. A.R.S. § 45-615(1). Monies held in the fund for an AMA may be used only to finance the augmentation and conservation assistance programs that are part of the management plan for the AMA, and to fund any projects that are authorized by the director for monitoring and assessing water availability within the AMA. A.R.S. § 45-613(A).

The director is authorized to provide monies from the fund, through grants rather than through the state's Procurement Code, for augmentation or conservation assistance projects that will benefit the AMA in which the monies were collected. A.R.S. § 45-617. However, the director has no authority to grant monies from the fund for monitoring and assessing water availability. Thus, if the Department elects to contract with an outside party to perform work on a monitoring project, the Department must either comply with the Procurement Code or enter into an intergovernmental agreement (IGA) with another governmental entity.

9.2.2 Groundwater Withdrawal Fees

The groundwater withdrawal fee is levied and collected from each person who withdraws groundwater from a non-exempt well within the AMA, except persons who withdraw groundwater for use on a farm with ten or fewer irrigation acres. No later than October 1 of each year, the director is required to set the groundwater withdrawal fee for an AMA for the following year. A.R.S. § 45-614(A). Prior to setting the fee, the Groundwater Users Advisory Council (GUAC) for the AMA recommends to the director how the fee should be set within the statutory limit.

Within 30 days after setting the fee, the director is required to give written notice of the fee to all counties, cities, towns, private water companies, political subdivisions, and holders of groundwater withdrawal permits in the AMA. A.R.S. § 45-614(C). The fee is required to be paid to the Department at the time the person withdrawing the water files an annual report pursuant to A.R.S. § 45-632. A.R.S. § 45-614(E).

Groundwater withdrawal fees for administration and enforcement of the Code have been collected since 1984. The Tucson AMA began levying an augmentation fee in 1986 as authorized in a 1984 amendment to the Code and for conservation assistance in 1991 through a 1990 Code amendment. Prior to 1996, up to $2.00 per acre-foot could be collected for augmentation and conservation assistance programs. The Legislature amended the Code in 1996 to provide that a portion of the fee could also be used for monitoring and assessing water availability in the AMA. A.R.S. § 45-611(A)(2). Also in 1996, the Legislature reduced the maximum amount that could be collected for WMAP purposes to $.50 per acre-foot, while providing for $2.50 per acre-foot to be collected to support the activities of the Arizona Water Banking Authority (AWBA). In 2017, the fee for Arizona water banking purposes will expire, and the fee for augmentation, conservation assistance, and monitoring and assessing water availability will revert to a maximum of $2.00 per acre-foot per year. Table 9-1 provides withdrawal fee information in the Tucson AMA since 1984. Total available funding for the programs varies from year to year depending on the amount of groundwater withdrawn and any carry-over of funds from previous years. The total expenditures from these funds are itemized in Appendices 9A and 9B.

TABLE 9-1
ANNUAL WITHDRAWAL FEE SUMMARY
TUCSON ACTIVE MANAGEMENT AREA

Year	Admin/ Enforcement ($/acre-foot)	Augmentation ($/acre-foot)	Conservation Assistance ($/acre-foot)	Legislative Studies ($/acre-foot)	Total ($/acre-foot)
1984	.50				.50
1985	.75				.75
1986	1.00	.50			1.50
1987	1.00	.50			1.50
1988	1.00	.50			1.50
1989	1.00	.50			1.50
1990	1.00	1.00			2.00
1991	1.00	1.50	.25	.15	2.90*
1992	1.00	1.50	.35	.15	3.00*
1993	1.00	1.50	.50	.15	3.15*
1994	1.00	1.50	.50		3.00*
1995**	1.00	2.00			3.00*
1996**	1.00	2.00			3.00*
1997**	2.50 for AWBA	.50			3.00*
1998**	2.50 for AWBA	.50			3.00*

* Water Quality Assurance Revolving Fund (WQARF) money collected from Type 1 and Type 2 grandfathered rights and withdrawal permits for the Arizona Department of Environmental Quality resulted in a total of $5.02 for 1991; $5.12 for 1992; $5.27 for 1993; and $5.12 for 1994, 1995, 1996, 1997, and 1998 for these users.

** In 1995, the Augmentation and Conservation Assistance Funds were combined. In 1996, the law was changed to allow this fund to also be used to monitor and assess water supply availability.
AWBA = Arizona Water Banking Authority

9.3 THE DEPARTMENT'S ROLE IN THE WATER MANAGEMENT ASSISTANCE PROGRAM

The Department's role in the WMAP is to:

- Review and provide input on project proposals
- Develop project proposals
- Implement Department projects
- Prioritize projects that best meet the AMA management objectives
- Provide technical and field assistance
- Provide information and educational services
- Promote the exchange of information among entities implementing the projects
- Administer IGAs, contracts, and grants as described in this chapter

A complete description of how projects are prioritized and selected, and how funds are allocated is found in section 9.6.

9.3.1 Fund Management and Administration

Fund management and administration of grants and contracts are coordinated between the Department's Administrative Services Division and the AMA. The centralized functions include management of the separate funds for each AMA and contract administration. The AMA staff initiate and support the grant application and review process and serve as the technical administrators for most grants and contracts.

9.3.2 Contract Development, Monitoring, and Support

Each applicant proposal accepted for funding must enter into a contractual agreement with the Department. Contracts are prepared by Department staff, consistent with the applicant's proposal and scope development. The contract describes what tasks are to be accomplished and sets deadlines for task completion and fund disbursements. Department staff track progress and review deliverables for compliance with contract requirements. The Department authorizes and issues payments, modifies contracts as needed, and provides other legal and administrative support.

9.3.3 Information and Education Service

The Department's Web site will serve as an information clearinghouse and the primary public venue for dissemination of current information on the WMAP programs. Information gained through Department sponsored programs, which are deemed to be regionally, statewide, and/or nationally transferable, will be placed on the Department's Web site and updated regularly. An additional focus will be linking the Department's Web site to other pertinent Web sites. This will assist users in finding water conservation, water supply, and augmentation information from other sources. In addition to a computer-based information clearinghouse, a centralized clearinghouse could include a library of conservation and augmentation literature as well as detailed information on grants and contracts funded and could provide centralized water conservation outreach activities.

The AMA office is responsible for developing water conservation information materials, educational curricula and displays, and programs specific to water users within the AMA. These materials may be developed independently, with conservation assistance funding (e.g., grants or contractual agreements with consultants), in cooperation with other AMAs, or through partnerships with other government agencies, community groups, or utilities.

The AMA office is also responsible for maintaining inventories of information and educational materials for distribution to water users within the AMA. Conservation-related presentations to schools, civic and other groups, and participation at local events are generally the responsibility of the AMA staff.

9.3.4 Assistance Activities

The Tucson AMA provides direct conservation assistance to individual water users to promote compliance with management plan conservation requirements. Assistance activities may include providing general or specific advice, performing research, assisting in the development of conservation and water management programs, and providing field or other technical support. AMA staff also provide support for augmentation and recharge activities including technical assistance and facilitation of regional planning efforts.

9.4 SECOND MANAGEMENT PLAN PROGRAM SUMMARY AND ASSESSMENT

The fees collected during the second management period were used to fund conservation and augmentation assistance grants and to fund program administration and conservation and augmentation assistance staff in the Tucson AMA. Typically, the Department advertised the availability of funds for grants each year,

evaluated the grant proposals received, and awarded funds to projects that best met the program objectives. Beginning in 1996, a change from the augmentation grant system to a proposal process was initiated as discussed in section 9.4.2.

9.4.1 Second Management Plan Conservation Assistance Program

The following four separate conservation assistance programs were identified for funding in the Second Management Plan: (1) Information and Education Program, (2) Agricultural Users Program, (3) Municipal Users Program, and (4) Industrial Users Program.

By the end of the 1998 conservation grant cycle, the Tucson AMA had funded conservation programs totaling $1,210,101. The program subtotals are shown in Table 9-2. A detailed summary of conservation assistance expenditures can be found in Appendix 9A. The information and education category includes funding for municipal and industrial programs and five years of funding for a water conservation specialist position in the Tucson AMA office to provide administrative and technical support for the Conservation Assistance Program.

TABLE 9-2
CONSERVATION ASSISTANCE GRANTS FUNDED 1992-1998
TUCSON ACTIVE MANAGEMENT AREA

Program	Number of Grants	Expenditures
Information and Education	32	$521,173
Agricultural Users	9	$243,350
Municipal Users	26	$308,134
Industrial Users	12	$137,444
TOTAL	79	$1,210,101

The types of programs funded included:

Information and Education/Youth Education Programs: teacher training and production of a teacher's resource guide; a monthly water education article and program in a regional children's newspaper; a transportable water conservation maze; and groundwater models with accompanying 5-8th grade water conservation curriculum

Information and Education/General Programs: full-time water conservation specialist position in the Tucson AMA office; brochures on water conservation requirements, water harvesting, and conservation design and technology for developers; landscape workshops; interactive educational displays; video and outreach at Casa del Agua; a desert landscaping interactive multimedia CD-ROM; a water conservation booklet and display at the Arizona Sonora Desert Museum; and a regional water supply and demand brochure and video

Agricultural Programs: irrigation scheduling assistance program for farmers; effluent utilization plan development; and a bilingual video on efficient irrigation for agriculture

Municipal Programs: plumbing retrofit, water audit, leak detection, education, and toilet and faucet aerator rebate programs in several service areas; production of a conservation video public service announcement; a regional water supply and demand brochure; installation and monitoring

of waterless urinals; pilot irrigation central controller system; outdoor water use training workshops; analysis of water conservation potential of front loading washing machines; and a landscape irrigation system analyst position to provide recommendations on improving irrigation system efficiency at high water use sites

Industrial Programs: interior and exterior hotel water audits; video and training manual on water conservation techniques for cooling tower operation; submetering and displays at the Arizona Sonoran Desert Museum; feasibility study on Central Arizona Project (CAP) water use by metal mines; subsurface drip irrigation feasibility study; potential for use of high total dissolved solids (TDS) cooling tower blowdown water for plant irrigation; training workshops for turf irrigation; turf irrigation audit and repair program; turf irrigation efficiency study; and development and field testing of a turf overwatering controller

Appendix 9A contains a complete listing of conservation assistance grants funded in the Tucson AMA from 1992 through 1997. In addition, chapters 4, 5, and 6 contain discussions of grants for these sectors in the "Non-Regulatory Efforts" sections. Detailed information on conservation assistance grants is available through the Tucson AMA office, including project final reports. By the year 2000, information should also be available through the Department's website.

9.4.2 Second Management Plan Augmentation Assistance Program

Prior to the establishment of the augmentation grants program, the Tucson AMA initiated the Rillito Recharge Project, a multi-source, multi-agency cooperative project that was expected to be constructed between Craycroft and Swan Roads on the Rillito River. Pima County and the City of Tucson worked jointly with the Department on preparation of a feasibility study, development of the hydrologic database, preliminary design work, and the preparation of a transferable technologies report. The Department's contribution from the augmentation fund was $173,933. Although the project was discontinued in 1992 after the City of Tucson ended its participation, renewed interest in the feasibility of recharge in the Rillito has resulted in an extensive hydrologic modeling effort by the Department and the United States Geological Survey (USGS) to evaluate recharge feasibility and direction of flow.

From 1990 through 1993, augmentation assistance monies totaling $798,190 were used to fund the Santa Cruz Valley Water District, a regional district established through legislation to facilitate access to renewable water supplies (see section 8.4.5.4 of Chapter 8).

During the second management period, the Tucson AMA awarded augmentation grants and contracts totaling approximately $1,347,000 through March 1999. These grants and contracts are summarized below. A more detailed summary of augmentation fund projects and expenditures is found in Appendix 9B. Complete information on augmentation grants is available through the Tucson AMA office, and by the year 2000, should also be available through the Department's website.

- Sahuarita School District Pilot Wetlands Project to treat wastewater generated at the site and serve as an educational resource

- A feasibility study on conversion of a turf irrigation system from groundwater to reclaimed water for 12 Tucson Unified School District sites

- Irrigation ditch improvements at BKW farms to allow for greater volumes of CAP water to be delivered to farms

- Two grants to Metropolitan Domestic Water Improvement District for feasibility studies for recharging CAP water in the Cañada del Oro Wash

- At the request of the Upper Santa Cruz Water Users Group (USCWUG), a study of the feasibility of bringing CAP water from the current CAP terminus to water users in the Green Valley-Sahuarita area

- A contract for a literature search to evaluate selected disinfection by-product issues related to the recharge and recovery of CAP water

- A grant to Pima County for archaeological, geotechnical, geochemical, and hydrogeological feasibility studies of the proposed Lower Santa Cruz Recharge Project and the proposed Cañada del Oro Recharge and Recovery Project to determine the projected long-term geochemical impacts of recharging CAP water and effluent on recharge rates and groundwater quality

- A contract to complete hydrological characterization and technical recharge feasibility assessment of the proposed Cañada del Oro Recharge and Recovery project. A variably saturated flow model of the vadose zone will be used in lieu of a pilot test to evaluate the long-term recharge potential of the site and whether mounding will be significant

- An IGA with the U.S. Geological Survey for a recharge feasibility study of a 12 mile reach of the Rillito River. A model will be developed and used to evaluate several infiltration scenarios to determine the timing and location of recharge and the recharge benefit to Tucson's Central Well Field

Almost $2.5 million was spent on augmentation-related projects and staff in the Tucson AMA since 1987.

9.4.3 Second Management Plan Program for Monitoring and Assessment

In early 1998, the Department worked with the USGS, Pima County, and the City of Tucson to develop a cooperative subsidence and aquifer monitoring program in the Tucson area. The monitoring program has expanded to include the Tucson, Phoenix, and Pinal AMAs. This cooperative effort entails the acquisition of monitoring equipment, development of a research protocol, and ongoing measurement of changes in land surface elevation and aquifer storage.

Changes in the land surface elevation for the Tucson Basin and Avra Valley will be estimated on the basis of repeated Global Positioning System (GPS) surveys. Changes in aquifer storage will be monitored based on microgravity surveys at a network of stations. Differential GPS surveys can be used to monitor changes in vertical position of the land surface with an accuracy of 2 centimeters or better. The GPS and gravity surveys will use an existing network of vertical extensometers and benchmarks, as well as an additional 20 sites that will be added to the network, to obtain representative coverage of the region. Changes measured in gravity readings at the stations over specific time intervals will be integrated across the area to produce a total change in aquifer storage for the network area. The combination of data on land surface changes and aquifer storage will yield valuable information on existing subsidence rates, changes in the ability of the aquifer to store water, and future subsidence potential. This data is needed to make informed water management decisions and to provide inputs for groundwater modeling activities.

The three-year project is funded at a total of $137,000 per year with funds contributed by the Tucson AMA, Tucson Water, and the USGS. Pima County is participating by providing in-kind contributions of equipment and personnel for monitoring activities.

9.4.4 Second Management Plan Program Assessment

The Conservation Assistance Program in the Tucson AMA has been very successful, with virtually all grants resulting in the completion of high quality products or deliverables. Applications have exceeded the

amount of money available every year, the quality of applications has been high, and the selection process has been competitive. As is illustrated by the project summaries in Appendix 9A, the availability of funds has generated innovation and collaboration in the community. Although the quantity of water saved is not measurable for all projects, in some cases (such as the agricultural irrigation conservation assistance program with reported savings of almost 7,500 acre-feet over four years), quantified water savings are directly attributable to grant-related activities.

The augmentation assistance funds have been used for grants, IGAs, contracts with consulting firms, and AMA staffing for contract management and the regional recharge planning process. As with the conservation program, there is a high degree of satisfaction with the assistance that has been provided and the quality of work products. Activities associated with the regional recharge planning process have resulted in the establishment of a regional forum to address the highly politicized issues associated with recharge. (See section 8.4.5.3 of Chapter 8.) Augmentation funds have supported the direct use of CAP water and effluent, helped develop new techniques for assessing recharge feasibility, and addressed water quality management questions related to the operation of recharge facilities.

9.5 THIRD MANAGEMENT PLAN PROGRAM GOALS AND OBJECTIVES

As incoming funds for the WMAP decline as a result of reduction in the amount of the groundwater withdrawal fee that may be levied and reductions in groundwater pumping due to renewable supply use during the third management period, the remaining funds will need to be further focused on projects that provide maximum benefit to the AMA. This section discusses the goals and objectives of each of the Water Management Assistance Programs for the third management period.

9.5.1 Third Management Plan Conservation Assistance Program

Goals of the Conservation Assistance Program for the third management period include the following:

- Increasing efficiency of all water use
- Assisting regulated water users in meeting their conservation requirements
- Maximizing the effectiveness of conservation programs through cooperative activities and transferability of grant products
- Providing outreach activities
- Targeting the water using sectors with the greatest conservation potential
- Funding research in areas where more information is needed

During the third management period, the Department, with input from the GUAC and others, may take a more active role in directing how funds are utilized. This may include compiling a list of projects that need to be funded through requests for proposals (RFP), in addition to or in place of using the current grant-based approach. Assessment of program effectiveness in saving water and transferability of information are particularly important as the monies available for conservation assistance decline. Conservation assistance activities are an integral part of achieving the Tucson AMA safe-yield goal and the Department intends to continue to allocate staff resources for education and assistance efforts.

9.5.2 Third Management Plan Augmentation Assistance Program

The Third Management Plan objectives of the Augmentation Assistance Program are to continue to use augmentation funds for research and planning assistance activities that expedite the utilization of renewable water supplies to replace groundwater use, as well as facilitating regional cooperative efforts. The Augmentation Assistance Program may be more Department directed during the third management period because of reduced funding. The AMA is developing a more site-specific local resource management approach to address concerns about localized negative impacts of groundwater level changes.

The goals and objectives of the Augmentation Program are listed in section 8.6 of the Augmentation Program Chapter.

9.5.3 Third Management Plan Program for Monitoring and Assessment

Understanding hydrologic conditions is integral to water resource planning. The goal of the Third Management Plan Monitoring and Assessment Program is to collect data about hydrologic conditions in the Tucson AMA on an ongoing basis. These data will be used to determine aquifer storage and subsidence impacts, and to support the safe-yield goal through the Department's water management activities and groundwater modeling efforts.

9.6 ALLOCATION OF PROGRAM FUNDS

During the third management period, the director will continue to allocate the WMAP fund between the conservation assistance, augmentation assistance and monitoring programs based on the need to implement particular projects for the benefit of the AMA. The GUAC will initially make a recommendation to the director on how the WMAP funds should be allocated among the three programs. The director will then make the final decision on the allocation.

While funds were reduced for the WMAP in 1997, there was a substantial amount of unspent monies in the original augmentation assistance fund. This allowed for a continued high level of funding for augmentation projects and allowed the incoming monies ($.50 per acre-foot) to be spent on conservation assistance programs. As the monies in the original augmentation assistance fund diminish, the AMA will need to develop an allocation method that provides the greatest cost/benefit to the AMA. This section discusses the types of programs that might be funded, the project selection methodology for each program, and project implementation methods.

9.6.1 Fund Categories

9.6.1.1 Conservation Assistance Program

The following types of conservation assistance could be provided through grants, contracts, or direct staff assistance:

Planning, Research, Feasibility, and Follow-up Studies

- Analyze water savings and water use efficiency potential among water use sectors
- Analyze the effectiveness of individual programs or technologies
- Promote cooperative research efforts between the Department and water users
- Identify future research and implementation needs

Technical Assistance

- Assist users in implementing conservation programs
- Assist users in managing their systems or facilities for maximum efficiency
- Provide information, training, and water use assessments and recommendations
- Perform water use audits
- Develop grant applications and contracts

Information and Education Materials

- Acquire and/or develop information and education materials for distribution at libraries, AMA offices, water utility offices, and throughout the community
- Assist in developing materials that can be used by multiple AMAs whenever appropriate

Conservation Devices and Technology

- Research and promote water efficient plumbing fixtures, appliances, water reuse systems and other technologies (e.g., front loading clothes washers, hot water heater recirculation loops, grey water filtration systems and others as developed)
- Assist local governments to amend or develop ordinances, incentives, and design guidelines to incorporate new water conservation technologies that promote water use reductions or increased water use efficiency

Testing and Monitoring Equipment

- Acquire testing and monitoring equipment for irrigation system analysis, soil moisture probes, leak detectors, or other measuring devices. As appropriate, make the equipment available for use by staff or interested water users.

9.6.1.2 Augmentation Assistance Program

Monies allocated for augmentation assistance will be used for projects that have as their primary goal the increase of water supplies or water storage. The monies may support staff members engaged in augmentation and recharge support activities. The monies may also be used for planning, research, and feasibility studies to help determine what augmentation activities are suitable for future construction and implementation projects. Types of studies could include those designed to assess the feasibility of new technologies, to identify future sites for augmentation projects, to collect data, to resolve institutional issues, and to otherwise facilitate future augmentation activities. The monies may also be used to finance pilot and demonstration projects, construct facilities, and fund other activities that increase water supplies.

9.6.1.3 Monitoring and Assessment Program

The monitoring program may include various activities depending on the types of hydrologic information needed to be gathered or monitored. The following are possible funding categories that could be considered:

Monitoring and Measurement

The Department may fund the purchase of monitoring equipment to measure subsidence, groundwater and surface water flow, recharge and water levels, as well as for use in ongoing monitoring activities of hydrologic conditions in the AMA. This could include providing monies to pay for personnel to conduct measurements, develop reports, and acquire and analyze data.

Research Activities

Research activities could include developing innovative monitoring techniques for aquifer water storage or other hydrologic information, assessing the feasibility of new monitoring technologies, supporting the AMA groundwater modeling efforts, or other research and planning activities related to water availability and subsidence.

9.6.2 Project Selection

While all efforts that lead to conservation and augmentation of water resources are encouraged, the efforts selected to receive WMAP funds depend on many factors. These factors will determine how funds are allocated to: (1) projects in various sectors, (2) the Department for the administration of the programs, and (3) projects initiated by the Department.

The decision-making process for project selection must be flexible. During the third management period, changes may occur in water use patterns, technology, social values, institutional constraints, and the economic viability of conservation or efficiency measures. Due to this potential for change, it is impractical at this time to determine the types of projects that will merit funding in the future. The second management period project selection process has proven flexible as well as politically and publicly responsive. This has been accomplished by full participation of the GUAC. The GUAC's regularly scheduled meetings provide an excellent forum for public review and comment on projects and proposals. Joint GUAC meetings, which involve the GUACs from all the AMAs, can also provide an opportunity to discuss changing circumstances or priorities. This process will be continued for the third management period.

In 1996, the Tucson AMA initiated an augmentation contract process to supplement the grant system. The purpose of the change was to focus on priority projects that target prominent regional recharge needs, and to make strategic use of dwindling augmentation program funds. Although the amount of the fee levied to fund the Augmentation and Conservation Assistance Program was significantly reduced by the 1996 legislation that created the AWBA, the balance remaining in the original augmentation account is available to fund augmentation projects. To simplify the procurement process and shorten the delay in contracting for technical expertise, the Tucson AMA developed a general technical services contract through the Arizona Department of Administration. The Department and the AWBA anticipate using this contract for a wide range of augmentation and recharge feasibility-related projects.

If the Department determines that grants will be available in a given funding cycle, it will then provide notice to water users and other interested parties of the procedures that will be used for soliciting grant project proposals. The Department may also submit its own projects for consideration. The evaluation criteria that will be used by the GUAC and the director in selecting projects to be funded will be determined prior to commencing the selection process. Using the evaluation criteria below and others selected by the GUAC, the proposals will be reviewed by AMA staff, the GUAC, and outside reviewers as appropriate. The GUAC will then recommend projects to the director for funding. If the GUAC recommends a project proposed by the Department, the GUAC may also recommend whether the project should be implemented by the Department or another entity, based on an evaluation of efficiency, effectiveness and short-term and long-term benefits to the AMA. The director will make the final decision on what projects to fund.

9.6.2.1 Conservation Assistance Proposal Selection Criteria

The selection criteria to be used in the Tucson AMA by the GUAC and the director to evaluate conservation assistance proposals are listed below. Certain criteria may be given greater weight, and any weighted system will be applied consistently to each application. There are three mandatory evaluation criteria and additional criteria that may be used in project selection.

Mandatory Evaluation Selection Criteria

1. Compliance of the project with applicable laws and administrative regulations. In the case of regulated water users, the extent to which this project helps to reach Third Management Plan conservation requirements.

2. Cost effectiveness of the project. Ability to combine the project with proposed or ongoing projects resulting in cost and human resource savings. Ability of the applicant to obtain matching funds for the project. Extent to which the applicant is contributing to the cost of the project (e.g., in-kind or cash). Predicted water demand reduction - extent and duration of reduction relative to project costs.

3. Compatibility of the project with the Department's policies and programs and the management goal of the Tucson AMA.

Additional Evaluation Selection Criteria

4. Extent to which the type of project is applicable to other users, other sectors, and other AMAs.

5. Likelihood of community support for the project. Demonstrated sector commitment to participate in the project.

6. Significance of the project's potential economic, environmental, and social impacts.

7. Extent to which the type of project has previously been proven feasible and effective, or extent to which implementation of the project will provide information on feasibility and effectiveness if not previously proven.

8. Demonstrated need–is it likely the project would not be implemented without conservation assistance funding?

9. Ability to monitor demand reductions during and after implementation of the project. Ability to produce documented comparisons of pre- and post-project water savings, scientific data collection and reporting methods, or pre- and post-program surveys to verify project results.

10. Past performance of the applicant with regard to implementing conservation projects. Whether the applicant has experience and past successes with similar projects.

11. Effectiveness of proposal–includes factors such as a clear statement of purpose, goals, methodology, and list of deliverables (data collection, interim and final reports, etc.). Contains background on current and historic water use if applicable. Whether the proposal is innovative and includes sufficiently researched budget information to determine if the requested funding amount is warranted (e.g., salary costs and benefits, retrofit device costs, equipment purchases, and supplies).

Special Preference Points

The director may choose to give special preference points to certain sectors or types of projects prior to the initiation of the grant process. These special categories may change from year to year. For example, preference points may be given for projects that result in measurable water savings, involve technology transfer and/or cooperative efforts, or that involve cost sharing between water providers or regulated water users.

9.6.2.2 Augmentation Assistance Proposal Project Selection

Each augmentation assistance project grant proposal will be evaluated according to the criteria established by the director in consultation with the GUAC. Evaluation criteria may include, but are not limited to the following:

- Compatibility with current Department programs and policies, and consistency with the management goal of the Tucson AMA
- Significance of the project's potential economic, environmental, and social impacts
- Compliance with applicable federal, state, and local regulations
- Technical feasibility and timely realization of alternative renewable water supplies
- Promotion of efficient use of the alternative water supplies
- Potential to contribute to regional water management solutions
- Likelihood of developing transferable information
- Capability of the applicant to successfully implement the project
- The potential to contribute to critical area management solutions

Augmentation projects and proposals other than grants may be initiated at any time by the Department at the request of the GUAC, a public or private entity, or at the Department's own initiative. The GUAC and Department staff will analyze these proposals for consistency with the AMA's augmentation assistance objectives and the evaluation criteria, as applicable. The director will make the final decision on whether to fund a proposal.

The Department may coordinate with other agencies and organizations involved in water quality regulation and issues, in addition to the Arizona Department of Environmental Quality, through a review and comment process or other means, to ensure that these agencies and organizations are aware of the proposed project and are allowed time to assess any impact the proposed project may have.

9.6.2.3 Monitoring and Assessment Project Selection

Monitoring projects will likely be developed in cooperation with other government agencies or educational institutions through an IGA or will be initiated by the Department and funded through RFPs. There is no statutory provision that authorizes the director to grant monies for monitoring and assessing water availability, unless it is tied to augmentation. Thus, the Department must comply with the Procurement Code if the Department contracts with a private entity to conduct monitoring. Project development and selection will be based on the AMA's monitoring and assessment needs in consultation with the GUAC.

9.6.3 Project Implementation Methods

Once a conservation, augmentation, or monitoring project has been selected to receive monies from the fund, the method that will be used to implement the project will depend on the type of applicant. If the project is to be implemented by a private entity, the Department will either allocate the money through a grant contract to the entity proposing the project or seek bids from private contractors under the provisions of Arizona's Procurement Code. A.R.S. § 41-2501, *et seq*. If bids are sought, all bids received by the advertised deadline will be evaluated by the Department. A contract will then be executed with that entity whose bid best meets the applicable contract guidelines. All grant contracts contain enforceable performance provisions to ensure high quality and timeliness of products and deliverables. If the project is to be implemented by a public agency, board, or commission, the Department will either allocate the money to the entity through a grant contract or execute an IGA pursuant to A.R.S. § 11-952. If the project is to be implemented by the Department, monies will be withdrawn from the fund for payment of the costs of the project as they accrue.

General master contracts may be developed in the third management period similar to the technical services contract that was established in the second management period for recharge related studies and projects. For projects that require technical expertise or other services beyond the scope provided by the general services contractors, the Arizona Department of Administration RFP process can be used.

9.7 FUTURE PROGRAM DIRECTION

There are several issues that affect the future of the WMAP including reduced program funding, the Department's changing planning and management priorities, and research and assistance needs identified by the community and the Department.

9.7.1 Reduced Program Funding

Due to the establishment of the Arizona Water Banking Authority in 1996, the conservation assistance, augmentation assistance, and monitoring programs will have less funding available for financial assistance during the third management period. Estimates are that revenues collected for augmentation, conservation, and monitoring programs will drop from approximately $500,000 per year to $150,000 per year beginning in 1998.

The prospect of reduced funding presents a challenge to meet the growing need to develop recharge projects, to evaluate new approaches to implementing conservation assistance programs, and to provide assistance to resolve technical obstacles or issues related to augmentation and recharge.

The Department will continue to participate in financial or in-kind partnerships with other agencies, municipalities, businesses, and utilities. This participation will allow the Department to continue to promote conservation, augmentation, and monitoring activities with fewer funds available. The Department may also need to look to other sources of funding, such as legislative appropriations for special studies and projects. The AMA may need to reevaluate the level of assistance it has provided in the past and focus primarily on providing seed money for projects and target funds to low-cost demonstration or feasibility projects with regional and transferable benefits or projects that address high-priority local water management problems. The Department could direct funds towards a very limited number of priority projects and defer grant disbursal in some years in order to build up sufficient funds to support key projects.

Staff positions in the AMA funded from WMAP funds have been critical to the success of the program by providing program administration, direct conservation assistance to regulated water users, facilitation of regional planning efforts, technical assistance, conservation information exchange and education, and facilitation of cooperatively funded efforts. The AMA will need to evaluate future program expenditures in the context of program staffing needs.

9.7.2 Relationship of Assistance Programs to AMA Program Goals and Planning Efforts

As the Department continues its efforts to facilitate increased utilization of renewable water supplies in concert with water conservation, funds could be allocated to promote the goals and objectives of its regulatory programs. The "Future Directions" sections of chapters 4, 5, 6, 7, and 12 identify specific needs that could be addressed with assistance funds. These research and assistance needs are summarized in this section.

The municipal, agricultural, and industrial programs all demonstrate the need for assistance in expanding utilization of renewable water supplies and for funds for continued conservation assistance and education as described below.

- Municipal program needs include evaluation of the effectiveness of conservation programs and funding of programs that result in significant long-term savings. This may involve focusing funds on conservation research or evaluation projects and implementation programs.

- Agricultural program needs include irrigation water management assistance to farmers, installation of efficient irrigation systems and infrastructure to convey renewable supplies to farms. Other agricultural needs are monitoring crop and water use patterns, and evaluating the impact of market conditions and regulatory programs on farming operations.

- Industrial needs include developing opportunities and planning assistance for renewable supply use. For turf-related facilities, research needs include evaluation of the application rate and of new irrigation technologies. For cooling towers, needs include further research on the impact of effluent and CAP water on cooling tower operation, the use of blowdown water for irrigation, and further investigation of cooling tower maintenance technologies.

9.7.3 Conservation Assistance Program

The Department will continue to strengthen its commitment to conservation through outreach activities in the third management period. All sectors have the potential for further conservation savings, and ongoing education is essential to maintaining and enhancing conservation efforts. As AMA funds diminish, other sources of funding may be needed to supplement the conservation assistance funds or multi-AMA efforts may be developed. On a local or statewide basis, an outreach program could include a media campaign (TV/Radio Public Service Announcements), a Department Conservation and Augmentation Newsletter and an expanded Web site. Research is needed on residential exterior water use and conservation measures and on predicting the success of potential conservation programs. Continuing efforts to promote cooperative regional water conservation programs are necessary in order to reach the widest audience at the lowest cost possible.

9.7.4 Augmentation Assistance Program

In the second management period the Department, the Regional Recharge Committee, and the GUAC identified several general and specific project priorities to facilitate recharge of alternative water supplies. During the third management period, the Department will continue to define project priorities with the assistance of the GUAC and possibly other advisory groups. Chapter 8 identified many institutional, economic, and regulatory factors that influence the ability of area water users to obtain and store or directly use renewable supplies. Because many of these factors will change over time, the specific priorities for project selection are likely to change during the third management period.

During the third management period, the Department may choose to adjust its funding mechanism to fit project priorities and needs. For example, the Department could initiate another grant cycle, in addition to the current process for augmentation assistance, as a means to generate innovative project concepts from a wide variety of sources.

Some of the second management period augmentation assistance program contracts were for activities that are part of longer-term regional efforts. This may result in follow-up activities by the Department during the third management period. One example is continued evaluation and development of a conveyance project to bring CAP water south from the CAP terminus to water users in the Green Valley-Sahuarita area. There is also interest in a further, targeted, cost-effective study of the implications of proposed new stricter federal drinking water standards for disinfection by-products on the design and operation of surface water recharge and recovery operations. The Department could continue to facilitate dissemination of new data and study results into the third management period. If there is ongoing support for the Cañada del Oro project by the project sponsors, and the project continues to meet water management objectives of the AMA, the Department could provide further assistance. Such activities may include participation in the Northwest Augmentation Program, regional planning, review of plans and reports, and coordination support.

9.7.5 Monitoring and Assessment Program

Monies in the WMAP fund allocated for monitoring projects will be used to support a better understanding of the aquifer and the impact of groundwater depletion on surface subsidence. Funds could be used to support development of the hydrologic model for the Tucson AMA that would aid in evaluating impacts on groundwater movement, mining, recharge, and volumes in storage. Monitoring and assessment activities are also critical to developing water management strategies that take more localized water conditions into account and in the revision of the well spacing and impact rules. More information is critical to effectively manage the groundwater resource through development of augmentation and conservation strategies.

APPENDIX 9A
1992 CONSERVATION ASSISTANCE GRANT EXPENDITURES
TUCSON ACTIVE MANAGEMENT AREA

Grant Number – Grantee	Funding Amount
CA92TUE03-00 (INFO/ED) Arizona Department of Water Resources, Tucson AMA–Produced the Second Management Plan Conservation Requirements Brochure.	$1,503.32
CA92TUE05-00 (INFO/ED) Arizona Department of Water Resources, Tucson AMA–Water Resource Specialist II–Position and Equipment. Funds a full-time conservation assistance employee in the Tucson AMA whose main objective is to assist the regulated community in meeting their conservation targets.	$25,798.54 Salary/ benefits /expenses
CA92TUE(M)08-00 (MUNI) Community Water of Green Valley, Green Valley Water Company, and Las Quintas Serenas Water Company–Assisted water companies serving the Green Valley area in implementing a unified water conservation program by conducting an educational campaign and residential interior water audits and plumbing retrofits.	$6,500.00
CA92TUM-IGA (MUNI) Arizona Department of Water Resources, Tucson AMA–Provided tuition to a two day water audit training workshop for 12 irrigators from large turf facilities (golf courses, parks and schools) located within the Tucson AMA but outside the Tucson Water service area. The Department worked in conjunction with Tucson Water's existing turf irrigation training program. Funds were also provided to purchase an irrigation audit kit to allow Tucson AMA staff to conduct audits or loan the kit to interested irrigators within the AMA.	$3,271.88
Total 1992 Expenditures	**$37,073.74**

APPENDIX 9A
1993 CONSERVATION ASSISTANCE GRANT EXPENDITURES
TUCSON ACTIVE MANAGEMENT AREA

Grant Number – Grantee	Funding Amount
CA93TUA20-00 (AG) Pima Natural Resource Conservation District (NRCD) Irrigation Conservation Assistance Program (ICAP)–Assisted farmers with irrigation scheduling and water management techniques in order to reduce agricultural water use while maintaining crop yields.	$36,000.00 Year 1
CA93TUE05-00 (INFO/ED) Arizona Department of Water Resources, Tucson AMA–Water Resource Specialist II–Position and Equipment. Funded a full-time conservation assistance employee in the Tucson AMA to assist the regulated community in meeting their conservation requirements.	$33,826.61 Salary/ benefits /expenses
CA93TUE07-00 (INFO/ED) Bear Essential News for Kids, HydroSmarts Program– Educated grades 1-8 on water conservation through the monthly "HydroSmarts" program in a children's newspaper.	$8,900.00 Year 1
CA93TUI03-00 (IND) University of Arizona, Plant Sciences– Determined the effect of water application rates on the visual quality and health of low and high traffic (compacted) turf areas. Multiple crop coefficients (from weather based evapotranspiration model) and multiple irrigation scheduling techniques were used.	$10,000.00
CA93TUI06-00 (IND) Southern Arizona Innkeepers Association–Funding was provided to conduct professional interior and exterior water audits at two commercial lodging facilities.	$4,000.00
CA93TUM15-00 (MUNI) Tucson Unified School District (TUSD)–Quantified the value of applied water audit training at six comparable TUSD school sites using both potable and reclaimed water systems with separate irrigation meters over a two year period.	$8,250.00 Year 1
Total 1993 Expenditures	**$100,976.61**

APPENDIX 9A
1994 CONSERVATION ASSISTANCE GRANT EXPENDITURES
TUCSON ACTIVE MANAGEMENT AREA

Grant Number - Grantee	Funding Amount
CA94TUA20-00 (AG) Pima Natural Resource Conservation District (NRCD) Irrigation Conservation Assistance Program (ICAP)–Assisted farmers with irrigation scheduling and water management techniques in order to reduce agricultural water use while maintaining crop yields.	$36,000.00 Year 2
CA94TUE02-01 (INFO/ED) University of Arizona, Arizona Water Education for Teachers (WET)–Provided K-6 educators, youth group leaders, museum staff and others who work with youth with information on past and present water use in the AMAs to foster an awareness of AMA specific water issues through design and construction of a unique, area specific, water conservation maze.	$3,717.00
CA94TUE05-00 (INFO/ED) Arizona Department of Water Resources, Tucson AMA–Water Resource Specialist III– Position and Equipment. Funded a full-time conservation assistance employee in the Tucson AMA to assist the regulated community in meeting their conservation requirements.	$35,868.46 Salary/ benefits /expenses
CA94TUE01-00 (INFO/ED) Bear Essential News for Kids, HydroSmarts Program–Educated grades 1-8 on water conservation through the monthly "HydroSmarts" program in a children's newspaper.	$10,000.00 Year 2
CA94TUI03-00 (IND) University of Arizona, Plant Sciences–Determined the effect of water application rates on the visual quality and health of low and high traffic (compacted) turf areas. Multiple crop coefficients (from weather based evapotranspiration model) and multiple irrigation scheduling techniques were used.	$10,000.00
CA94TUM15-00 (MUNI) Tucson Unified School District (TUSD)–Quantified the value of applied water audit training at six comparable TUSD school sites using both potable and reclaimed water systems with separate irrigation meters over a two year period.	$8,250.00 Year 2
Total 1994 Expenditures	**$103,835.46**

APPENDIX 9A
1995 CONSERVATION ASSISTANCE GRANT EXPENDITURES
TUCSON ACTIVE MANAGEMENT AREA

Grant Number – Grantee	Funding Amount
CA95TU(E)A05-00 (AG) SWCA, Inc. Environmental Consultants–Prepared the script and story board for a bilingual (Spanish and English) instructional video on uniform and efficient irrigation for agricultural irrigators.	$12,000.00 Year 1
CA95TUA20-00 (AG) Pima Natural Resource Conservation District (NRCD) Irrigation Conservation Assistance Program (ICAP)–Assisted farmers with irrigation scheduling and water management techniques in order to reduce agricultural water use while maintaining crop yields.	$36,000.00 Year 3
CA95TUE04-00 (INFO/ED) Arizona Hydrological Society–Prepared a hydrology curriculum for 5th-8th graders, sponsored a career day for elementary school teachers and students, and constructed 200 "hands-on" groundwater models for use in local schools.	$5,100.00
CA95TUE05-00 (INFO/ED) Arizona Department of Water Resources, Tucson AMA–Water Resource Specialist III– Position and Equipment. Funded a full-time conservation assistance employee in the Tucson AMA to assist the regulated community in meeting their conservation requirements.	$38,451.40 Salary/ benefits /expenses
CA95TUE17-00 (INFO/ED) University of Arizona, Water Resources Research Center–Developed an interactive multi-media database on CD-ROM of Xeriscape™ plants for the desert Southwest entitled "Desert Landscaping, Plants for a Water-Scarce Environment."	$20,091.00
CA95TUE18-04 (INFO/ED) University of Arizona, Office of Arid Lands Studies–Upgraded educational displays at Casa del Agua and provided part-time staffing to accommodate group tours and regional outreach and promotion of local water-related programs and information.	$15,250.00 Year 1
CA95TUE20-00 (INFO/ED) Bear Essential News for Kids, HydroSmarts Program–Educated grades 1-8 on water conservation through the monthly "HydroSmarts" program in children's newspaper.	$10,920.00 Year 3
CA95TUI03-00 (IND) Arizona Sonora Desert Museum–Devised and constructed water conservation strategies including sub-metering and public displays on water conservation at the Desert Museum.	$4,800.00
CA95TU(E)I16-00 (IND) Pima Community College–Developed a video and manual to train present and future facility managers and cooling tower operators on efficient cooling tower operation with a focus on conserving water.	$9,330.00
CA95TU(M)I14-00 (IND) University of Arizona, Ag/Biosystems Engineering–Tested ease of use and reliability of a device developed by the Grantee, called the "over-watering controller," for schools, parks, homes and commercial facilities. The savings of irrigation water at the study sites resulting from installing the over-watering controllers was determined by comparison with control sites to determine the number of times irrigations were skipped.	$11,074.00 Year 1

APPENDIX 9A
1995 CONSERVATION ASSISTANCE GRANT EXPENDITURES
TUCSON ACTIVE MANAGEMENT AREA

Grant Number – Grantee	Funding Amount
CA95TUM01-00 (MUNI) Metropolitan Domestic Water Improvement District (MDWID)–Provided funding for additional customers to participate in MDWID's toilet rebate program for replacement of high volume toilets with 1.6 gallon per flush toilets to help reduce water consumption in the District.	$10,000.00
CA95TUM06-00 (MUNI) Dan Dorsey–Developed and constructed two types of low-cost, easily assembled water cisterns to allow residential water customers to collect and store rainwater from their roof surfaces for later use on their landscapes.	$975.00
CA95TU(E)M07-00 (MUNI) University of Arizona, Cooperative Extension, Low 4–Provided maintenance and repair training for school district turf irrigators. Each workshop was tailored to meet the needs of individual Tucson AMA school districts.	$10,000.00
CA95TU(E)M08-00 (MUNI) University of Arizona, Cooperative Extension, Low 4–Provided exterior water conservation "Smartscape" workshops for professionals and "Water$mart" workshops for homeowners. Smartscape is a training program for nursery and landscape professionals designed to encourage horticultural practices consistent with water conservation objectives in the Tucson AMA. Water$mart is a program of free workshops offered throughout the Tucson AMA and designed to reduce residential landscape water use.	$28,781.00 Year 1
CA95TU(E)M10-00 (MUNI) City of Tucson, Tucson Water–Developed a unified regional summer water conservation message in video format to be promoted by southern Arizona water companies.	$10,000.00
Total 1995 Expenditures	**$222,772.40**

APPENDIX 9A
1996 CONSERVATION ASSISTANCE GRANT EXPENDITURES
TUCSON ACTIVE MANAGEMENT AREA

Grant Number – Grantee	Funding Amount
CA96TU(E)A05-00 (AG) SWCA, Inc. Environmental Consultants–Produced a bilingual (Spanish and English) training video on uniform and efficient irrigation for agricultural irrigators.	$9,680.00 Year 2
CA96TUA24-00 (AG) Pima Natural Resource Conservation District (NRCD) Irrigation Conservation Assistance Program (ICAP)–Assisted farmers with irrigation scheduling and water management techniques in order to reduce agricultural water use while maintaining crop yields.	$36,000.00 Year 4
CA96TUE05-00 (INFO/ED) Arizona Department of Water Resources, Tucson AMA–Water Resource Specialist III–Position and Equipment. Funded a full-time conservation assistance employee in the Tucson AMA to assist the regulated community in meeting their conservation requirements.	$41,649.09 Salary/ benefits /expenses
CA96TUE17-00 (INFO/ED) University of Arizona, Water Resources Research Center– Developed three interactive, touch screen kiosks for use with the Desert Landscaping CD ROM (CA95TUE17-00) in the Tucson AMA.	$16,032.00
CA96TUE18-00 (INFO/ED) University of Arizona, Office of Arid Lands Studies –Upgraded educational displays at Casa del Agua and provided part-time staffing to accommodate group tours and a school outreach program.	$16,037.00 Year 2 unspent field trip funds carried over to 1997
CA96TUE20-00 (INFO/ED) Kids View Communications/Bear Essential News for Kids–Educated grades 1-8 on water conservation through the monthly "HydroSmarts" program in a children's newspaper.	$11,855.00 Year 4
CA96TUE61-00 (INFO/ED) University of Arizona, Project Water Education for Teachers (WET)–Provided funding for National Project WET teacher training throughout the Tucson AMA.	$3,739.00
CA96TUE62-00 (INFO/ED) University of Arizona, Project Water Education for Teachers (WET)–Provided financial support for maintaining and transporting the water conservation maze (CA94TUE02-01) to schools and provided a cooperative outreach component for water education resources.	$6,452.00 Year 1
CA96TUE63-00 (INFO/ED) University of Arizona, Coop. Extension, Low 4–Produced a water harvesting booklet explaining simple and complex water harvesting techniques for residential and commercial buildings.	$5,000.00
CA96TUE65-00 (INFO/ED) SAWARA–Produced a 15 minute video "Our Water, Our Choice: The Tucson Basin and its Future" promoting increased awareness of Tucson AMA water supply, demand, natural and artificial recharge, subsidence and general hydrologic principles for use by staff, educators, media and service groups.	$25,000.00
CA96TUE68-00 (INFO/ED) Tucson Resource Center for Environmental Education (TREE)–Developed and printed a K-12 teachers resource guide "Water Education Curricula: A Compendium of Resources Specific to Tucson and Southern Arizona" and a regional water education outreach plan.	$5,300.00

APPENDIX 9A
1996 CONSERVATION ASSISTANCE GRANT EXPENDITURES
TUCSON ACTIVE MANAGEMENT AREA

Grant Number – Grantee	Funding Amount
CA96TUE69-00 (INFO/ED) Arizona Sonora Desert Museum–Developed and published a booklet entitled "Desert Waters" and designed related displays on water conservation at the Desert Museum (2 year project).	$28,985.00 2 year funding
96TUI01-00 (IND) Arizona Department of Water Resources, Tucson AMA–Evaluated conservation potential and the potential for CAP utilization at metal mines in the Tucson AMA. Matching funds provided through the Department's General Fund were used to support the consultant's study.	$20,648.00
CA96TU(M)I14-00 (IND) University of Arizona, Ag/Biosystems Engineering–Tested ease of use and reliability of a device developed by the Grantee, called the "over-watering controller," for schools, parks, homes and commercial facilities. The savings of irrigation water at the study sites resulting from installing the over-watering controllers was determined by comparison with control sites to determine the number of times irrigations were skipped.	$10,128.00 Year 2
CA96TU(E)M11-00 (MUNI) University of Arizona, Coop. Extension, Low 4–Developed and produced a brochure for developers focusing on water saving design, equipment/technology, greywater, etc.	$10,000.00
CA96TU(E)M12-00 (MUNI) Pioneer Plumbing–Installed and monitored water savings from waterless urinals in schools and public buildings in comparison to standard flush urinals.	$17,100.00
CA96TUM51-00 (MUNI) MDWID–Provided funding for a low flow toilet (1.6 gal) and faucet aerator rebate program to reduce groundwater use by District customers.	$14,616.54
CA96TUM53-00 (MUNI)–Avra Water Co-op Inc.–Provided retrofit devices for a customer plumbing retrofit and home audit program.	$7,380.00
CA96TUM54-00 (MUNI)–Town of Oro Valley Water Utility–Developed and printed a brochure on regional water supply, demand and conservation opportunities to serve as a companion piece to the video on Tucson water resources "Our Water, Our Choice: The Tucson Basin and its Future."	$2,000.00
CA96TU(E)M58-00 (MUNI) University of Arizona, Coop. Extension, Low 4–Provided exterior water conservation "Smartscape" workshops for professionals and "Water$mart" for homeowners. Smartscape is a training program for nursery and landscape professionals designed to encourage horticultural practices consistent with water conservation objectives in the Tucson AMA. Water$mart is a program of free workshops offered throughout the Tucson AMA and designed to reduce residential landscape water use.	$22,362.00 Year 2
Total 1996 Expenditures	**$309,963.63**

APPENDIX 9A
1997 CONSERVATION ASSISTANCE GRANT EXPENDITURES
TUCSON ACTIVE MANAGEMENT AREA

Grant Number – Grantee	Funding Amount
CA97TUA24-00 (AG) Pima Natural Resource Conservation District (NRCD) ICAP–Assisted farmers with irrigation scheduling and water management techniques in order to reduce agricultural water use while maintaining crop yields.	$18,000.00 Year 5
CA97TUA26-00 (AG) Westland Resources, Inc.–Developed an effluent utilization plan, environmental analysis, preliminary design and cost estimates for delivery of effluent to the Avra Valley Irrigation District and Cortaro Marana Irrigation District.	$23,670.00
CA97TUE05-00 (INFO/ED) Arizona Department of Water Resources, Tucson AMA–Water Resource Specialist III–Position and Equipment. Funded a full-time conservation assistance employee in the Tucson AMA to assist the regulated community in meeting their conservation requirements.	$38,101.91 Salary/ benefits /expenses
CA97TUE18-00 (INFO/ED) University of Arizona, Office of Arid Lands Studies–Upgraded educational displays at Casa del Agua and provided part-time staffing to accommodate group tours and regional outreach and promotion of local water related programs and information.	$14,782.00 Year 3
CA97TUE20-00 (INFO/ED) Kids View Communications/Bear Essential News for Kids–Educated grades 1-8 on water conservation through the monthly "HydroSmarts" program in children's newspaper.	$10,920.00 Year 5
CA97TUE62-00 (INFO/ED) University of Arizona, Project Water Education for Teachers (WET)–Provided support for the water conservation maze and cooperative outreach component for area resources for water education.	$6,452.00 Year 2
CA97TUE70-00 (INFO/ED) City of Tucson, Stormwater Section–Developed and provided educational materials highlighting water harvesting at the City's Southeast Branch Library and Educational Resource Center.	$11,700.00
CA97TUI16-00 (IND) University of Arizona, Ag/Biosystems Engineering–Provided funding for a research project to determine whether sub-surface drip irrigation is a viable water conservation option on turf using reclaimed water.	$11,288.00 Year 1
CA97TUI19-00 (IND) University of Arizona, Environmental Research Lab–Developed best management practices for the reuse of high-TDS cooling tower blowdown water on trees, shrubs and groundcovers typically planted in landscapes near large cooling towers in the Tucson area.	$14,960.00 Year 1
CA97TUM58-00 (MUNI) University of Arizona, Coop. Extension, Low 4–Provided funding for two exterior water conservation "SmartScape" workshop series for professionals and 30 "Water$mart" workshops for homeowners.	$22,362.00 Year 3
CA97TUM80-00 (MUNI) City of Tucson, Tucson Water–Provided funding to develop a landscape water budget methodology and support materials for distribution through the Zanjero Program that provides residential water audits to Tucson Water customers. (Cancelled at grantees request)	$3,006.00

APPENDIX 9A
1997 CONSERVATION ASSISTANCE GRANT EXPENDITURES
TUCSON ACTIVE MANAGEMENT AREA

Grant Number – Grantee	Funding Amount
CA97TUM82-00 (MUNI) Tucson Unified School District (TUSD)–Implemented a pilot central irrigation controller system for water conservation and irrigation management at TUSD schools.	$3,337.00
CA97TUM83-00 (MUNI) University of Arizona, Water Resources Research Center–Evaluated water providers' service areas to determine what residential exterior water conservation measures would be most effective for individual service areas and looked for opportunities for providers to cooperatively develop conservation programs.	$13,255.00
CA97TUM85-00 (MUNI) Arizona Department of Water Resources, Tucson AMA–Evaluated the water conservation potential of horizontal axis (tumble action, front loading) washing machines within the Tucson AMA through a feasibility/market research study.	$1,642.67 Year 1
CA97TUM87-00 (MUNI) University of Arizona, Coop. Extension, Low 4–Funded a irrigation system analyst position in the Low 4 Office to provide irrigation system evaluations to water providers in the Tucson AMA (outside the Tucson Water service area) of large residential, multifamily, and commercial turf facilities.	$35,018.00
Total 1997 Expenditures	**$228,493.58**

APPENDIX 9A
1998 CONSERVATION ASSISTANCE GRANT EXPENDITURES
TUCSON ACTIVE MANAGEMENT AREA

Grant Number-Grantee	Funding Amount
CA98TUA24-00 (AG) Pima Natural Resource Conservation District (NRCD) Irrigation Conservation Assistance Program (ICAP)– Assisted farmers with irrigation scheduling and water management techniques in order to reduce agricultural water use while maintaining crop yields.	$36,000.00 Year 6
CA98TUE05-00 (INFO/ED) ADWR, TAMA–Water Resource Specialist III-Position & Equipment. Funded a full time conservation assistance employee in the Tucson AMA to assist the regulated community in meeting their conservation requirements.	$38,101.91 Salary/ benefits /expenses
CA98TUE18-00 (INFO/ED) University of Arizona Office of Arid Lands Studies– Upgraded educational displays at Casa del Agua and provided part-time staffing to accommodate group tours and regional outreach and promotion of local water related programs and information.	$10,000.00 Year 4
CA98TUE20-00 (INFO/ED) Kids View Communications/Bear Essential News for Kids–Educated grades 1-8 on water conservation through the monthly "HydroSmarts" program in children's newspaper.	$11,340.00 Year 6
CA98TUE71-00 (INFO/ED) Environmental Education Exchange–Developed water conservation education materials for use by middle school students.	$8,000.00
CA98TUE72-00 (INFO/ED) The League of Women Voters of Greater Tucson Produced and distributed a fact sheet on the issues raised by CAP water recharge.	$2,000.00
CA98TUI16-00 (IND) U of A - Ag/Biosystems Engineering–Determined whether sub-surface drip irrigation using reclaimed water is a viable water conservation option on turf.	$16,269.00 Year 2
CA98TUI19-00 (IND) U of A Environmental Research Lab–Developed best management practice for the reuse of high-TDS cooling tower blowdown water on trees, shrubs and groundcovers typically planted in landscapes near large cooling towers in the Tucson area.	$14,947.00 Year 2
CA98TUM58-00 (MUNI) U of A Coop. Extension, Low 4–Provided funding for two exterior water conservation "Smartscape" workshop series for professionals and 15 "Water Smart" workshops for homeowners.	$23,134.00 Year 4

APPENDIX 9A
1998 CONSERVATION ASSISTANCE GRANT EXPENDITURES
TUCSON ACTIVE MANAGEMENT AREA

Grant Number - Grantee	Funding Amount
CA98TUM85-00 (MUNI) ADWR, Tucson AMA–Developed and implemented an educational/ media campaign and possible rebate or incentive program to encourage the use of horizontal axis washers that save 40% of the water used by standard washers.	$ 15,358.33 Year 2 includes carry over of $ 5,358.33 in unspent funds from year one
CA98TUM90-01, (MUNI), U of A, P.C. Coop Extension/Low 4 Program Developed three new workshops for the Water Smart series on water harvesting, hands on drip irrigation installation and low water use plant selection.	$11,050.00
CA98TU(E)M92-00 (MUNI) WestLand Resources, Inc. Developed a "step by step" guide that will allow a homeowner to easily design and permit a residential greywater system in Pima County.	$5,490.00
CA98TUM94-00 (MUNI) U of A Water Conservation Alliance of So. Arizona Assessed the current use of residential greywater in terms of water quality, water savings and additional conservation potential. Determined whether current regulations can be simplified to enable greater use of greywater to reduce groundwater use outdoors.	$15,295.00
Total 1998 Expenditures	**$206,985.24**

APPENDIX 9B
AUGMENTATION PROGRAM EXPENDITURES 1987-1999
GRANTS, CONTRACTS, IGAs, AND LEGISLATIVE INITIATIVES
TUCSON ACTIVE MANAGEMENT AREA

Grant/Contract Number – Grantee/Consultant	Funding Amount
IGA Arizona Department of Water Resources, Tucson AMA–A cooperative project initiated by the Department with Pima County Flood Control District and Tucson Water to develop a multi-source recharge facility in the Swan to Craycroft reach of the Rillito. Original concept incorporated (1) increased flood storage, (2) enhanced recharge of runoff water, (3) artificial recharge of CAP water and effluent, and (4) recreational and interpretive components. **Phase A**–Feasibility of the Rillito Recharge Project was effective from August 18, 1987 to December 31, 1989. **Phase B**–The second IGA between City of Tucson, Pima County Flood Control District, and the Department, effective from May 28, 1991 to December 31, 1992, combined the participants' resources to fund a separate contract between the Department and CH2M Hill to complete the Phase B activities. Under this phase, two conceptual designs were developed for the project, one using CAP water, reclaimed water and storm water, and the second using only storm water.	$173,933.43
1990-1993 Santa Cruz Valley Water District (originally named the Tucson AMA Water Augmentation Authority)–The Tucson AMA Water Augmentation Authority was authorized by adoption of Senate Bill 1556 to assist in the effort to attain safe-yield for the Tucson AMA. The Authority was later renamed the Santa Cruz Valley Water District as part of legislative amendments passed in 1992.	$798,190.00
TUCAUG94-2-2 Sahuarita Unified School District–Conducted a feasibility study to evaluate replacing the School District's current wastewater leaching system with a constructed wetland system.	$24,550.00
TUCAUG94-4-1 Metropolitan Domestic Water Improvement District–TUCAUG94-4B, Assessed the feasibility of recharging CAP water within the Cañada del Oro (CDO) drainage basin. Technical assessments of recharge feasibility were performed for recharge basins at the proposed Big Wash and Oasis recharge sites and within the channel of the nine-mile-long reach of the CDO Wash between the sites.	$21,250.00
Fiscal Year 1995 Arizona Department of Water Resources, Tucson AMA–Water Resource Specialist III–Funded a full-time augmentation assistance employee to facilitate augmentation and use of renewable water supplies within the Tucson AMA.	$10,256.21 Salary/benefits /expenses

APPENDIX 9B
AUGMENTATION PROGRAM EXPENDITURES 1987-1999
GRANTS, CONTRACTS, IGAs, AND LEGISLATIVE INITIATIVES
TUCSON ACTIVE MANAGEMENT AREA

Grant/Contract Number – Grantee/Consultant	Funding Amount
AUGTU95-1 Pima County Flood Control District–Conducted a study to determine the recharge suitability of near-surface soils at the Lower Santa Cruz River (LSCR) site and the suitability of the vadose zone at the Cañada Del Oro (CDO) site to transmit recharged water. Determined the chemical compatibility of CAP water with the alluvial deposits and aquifer underlying the LSCR and CDO sites, and treated effluent with the alluvial deposits and aquifers underlying the LSCR site.	$296,000.00
AUGTU95-2 Tucson Unified School District (TUSD)–Study and report on the feasibility of converting the irrigation systems from a potable groundwater source to a reclaimed water source at twelve TUSD schools.	$15,000.00
AUGTU95-3 Metropolitan Domestic Water Improvement District–Collected data on groundwater storage conditions in the Lower Cañada Del Oro (CDO) basin to allow local water users to better assess groundwater augmentation needs. Provided information about primary areas that are conducive to artificial recharge and rates of recharge along the CDO Wash.	$53,500.00
AUGTU95-4 BKW Farms–Removal and construction of 9,400 feet of ditch pad and lining to increase the capacity of irrigation ditches and laterals. Allows for the delivery of greater volumes of CAP water to agricultural lands owned by the grantee in Avra Valley.	$51,700.00
Fiscal Year 1996 Arizona Department of Water Resources, Tucson AMA–Water Resource Specialist III– Funded a full-time augmentation assistance employee to facilitate augmentation and use of renewable water supplies within the Tucson AMA.	$33,401.88 Salary/benefits /expenses
Fiscal Year 1997 Arizona Department of Water Resources, Tucson AMA–Water Resource Specialist III– Funded a full-time augmentation assistance employee to facilitate augmentation and use of renewable water supplies within the Tucson AMA.	$32,810.31 Salary/benefits /expenses
Fiscal Year 1997 Arizona Department of Water Resources, Tucson AMA–Water Resource Specialist III– Funded a temporary, full-time planner devoted to facilitate regional recharge activities within the Tucson AMA.	$29,180.15 Salary/benefits /expenses
A7-0093 Malcolm Pirnie, Sahuarita, Green Valley Area CAP Water Use Feasibility Analysis and Delivery System Optimization Study–The study scope was developed by the USCWUG and the Department to assess the feasibility of delivering CAP water from the CAP Terminus to users in the Sahuarita-Green Valley area. The study included an assessment of projected water use needs; an assessment of feasible routes and a conceptual design of nine alignment segments; an optimization of the system to deliver the most CAP water at least cost to area water users; a preliminary design of the optimal system; and financial analysis of project costs. The data may be used by USCWUG as the basis for further work to develop the project.	$296,995.00

APPENDIX 9B
AUGMENTATION PROGRAM EXPENDITURES 1987-1999
GRANTS, CONTRACTS, IGAs, AND LEGISLATIVE INITIATIVES
TUCSON ACTIVE MANAGEMENT AREA

Grant/Contract Number – Grantee/Consultant	Funding Amount
A7-0077-005-97-2220 GeoSystems Analysis, Inc., Disinfection By-Product Issues Study–Through literature review and interviews, with input from an advisory committee, the consultant investigated disinfection by-products (DBP) and DBP precursors as affected by the recharge and recovery of CAP water. The consultant summarized relevant information about the organic quality of CAP water served in the Tucson AMA, DBP transport and fate mechanisms, water quality management, and contributions by algal blooms. They also identified and prioritized data gaps; identified opportunities for cooperative studies and outside funding; and recommended a strategy to address water providers' research needs. Sixty copies of the April 29, 1998 final report were distributed.	$21,160.00
Fiscal Year 1998 Arizona Department of Water Resources, Tucson AMA–Water Resource Specialist III–Funded a full-time augmentation assistance employee to facilitate augmentation and use of renewable water supplies within the Tucson AMA.	$38,644.09 Salary/benefits /expenses
Fiscal Year 1998 Arizona Department of Water Resources, Tucson AMA–Water Resource Specialist III–Funded a temporary, full-time planner devoted to facilitate regional recharge activities within the Tucson AMA.	$19,663.25 Salary/benefits /expenses
IGA-99-2256 Town of Oro Valley and Metropolitan Domestic Water Improvement District. A7-0077-005-99 GeoSystems Analysis, Inc., Cañada del Oro Supplemental Recharge Feasibility Investigation–A cooperative project to complete hydrogeological investigations of the proposed Cañada del Oro Recharge and Recovery Project site. Variably saturated flow modeling will be used to simulate recharge in lieu of conducting a pilot test. Sonic drilling to obtain continuous cores; detailed mapping, sampling and analysis of surface outcrops; permeability testing; and geostatistical analysis of surface and borehole data are being used to characterize key parameters.	$250,000.00
IGA 99-2267 Agreement No. 3 United States Geological Survey, The Development of Methods to Estimate Groundwater Recharge, Rillito Creek, Tucson, Arizona–A cooperative study to evaluate recharge feasibility along a 12-mile reach of the Rillito Creek between Craycroft Road and the confluence with the Santa Cruz River. Saturated and variably saturated flow models will be developed to simulate the results of several infiltration scenarios.	$317,000.00 thru 3/02
Total of Augmentation Grant/Contract Expenditures	**$2,483,234.34**

CHAPTER

10

Plan Implementation

10.1 INTRODUCTION

This chapter describes the process the Arizona Department of Water Resources (Department) will follow when implementing, determining compliance with, and enforcing compliance with the Third Management Plan requirements. These plan elements will be carried out in accordance with the Department's overall regulatory approach, which is described in the preface to Section II, Regulatory Programs. The following topics are discussed in the order listed:

- Notice of Conservation Requirements - Compliance Dates
- Variance and Administrative Review Process
- Plan Modification Procedures
- Groundwater Use Reporting Requirements
- Monitoring and Audit Procedures
- Compliance Approach

10.2 NOTICE OF CONSERVATION REQUIREMENTS - COMPLIANCE DATES

Within 30 days of adoption of the Third Management Plan, the Department will mail written notice of the irrigation water duties and conservation requirements established in the plan to the persons required to comply with the requirements. A.R.S. § 45-566(B). The written notice will set forth the final irrigation water duty or conservation requirement that will become effective on January 1, 2010, and any intermediate conservation requirements that must be complied with prior to that time. Two years before the compliance date for an irrigation water duty or conservation requirement established in the Third Management Plan, the Department will give additional written notice of the requirement to the person required to comply. A.R.S. § 45-566(B).

A person who receives notice of an irrigation water duty or conservation requirement established in the Third Management Plan must begin complying with the requirement by the date specified in the notice, unless the person applies for and is granted a variance, as explained in section 10.3. A.R.S. § 45-566(C). The person must continue complying with the requirement until the effective date of any substitute irrigation water duty or conservation requirement established in the Third or Fourth Management Plans. If a person receives notice of a Third Management Plan irrigation water duty or conservation requirement that replaces an irrigation water duty or conservation requirement established for the person in the Second Management Plan, the person must continue complying with the Second Management Plan irrigation water duty or conservation requirement until the effective date of the Third Management Plan requirement.

The director may give written notice of a conservation requirement at any time to a person with a right or permit to withdraw, distribute, or use groundwater that was not in existence when the management plan was adopted. The person given written notice must comply with the conservation requirement not later than the compliance date specified in the notice, unless the person applies for and is granted a variance. A.R.S. § 45-571.01(B) and (C).

10.3 VARIANCE AND ADMINISTRATIVE REVIEW PROCESS

Upon receipt of a notice of a Third Management Plan irrigation water duty or conservation requirement, a person may apply for a variance from or seek administrative review of the water duty or conservation requirement. In general, a variance gives a person additional time to comply with an irrigation water duty

or conservation requirement, while an administrative review can result in an adjustment to the requirement for that management period. Each of these processes is described below.

10.3.1 Variance

If a person requires additional time to comply with a new irrigation water duty or conservation requirement, the person may apply for a variance. An application for a variance must be filed within 90 days of the date of the notice of the irrigation water duty or conservation requirement given two years prior to the compliance date for the requirement. A.R.S. § 45-574(A). The director may grant a variance for up to five years upon a showing that "compelling economic circumstances" will prevent the person from complying with the new irrigation water duty or conservation requirement by the compliance date specified in the notice. A person granted a variance must continue complying with any existing irrigation water duty or conservation requirement during the variance period, unless the director establishes a schedule of intermediate water duties or conservation requirements to be reached at specified intervals during the variance period. A.R.S. § 45-574(C).

10.3.2 Administrative Review

If a person believes that an error or omission was made in calculating the person's irrigation water duty or conservation requirement, the person may request an administrative review of the irrigation water duty or conservation requirement. If granted, an administrative review can result in a permanent adjustment to the irrigation water duty or conservation requirement. An application for administrative review must be filed within 90 days of the date of the notice of the irrigation water duty or conservation requirement given within 30 days of adoption of the management plan, if the application is based on circumstances in existence as of the date of the notice. A.R.S. § 45-575(A).

At any time during the third management period, a person may seek administrative review of the person's irrigation water duty or conservation requirement based on a claim that "extraordinary circumstances not in existence as of the date of notice that was given thirty days after adoption of the management plan" justify revision of the irrigation water duty or conservation requirement. The director may revise the irrigation water duty or conservation requirement based on clear and convincing evidence that extraordinary circumstances not in existence as of the date of notice make it unreasonable to require compliance with the irrigation water duty or conservation requirement. A.R.S. § 45-575(B).

In determining whether extraordinary circumstances exist that render an irrigation water duty or conservation requirement unreasonable, the director will consider, among other things, whether actual conditions that came into existence after the date of notice are significantly different from those conditions in effect at the date of notice.

Examples of extraordinary circumstances may include the following situations: changes in water quality that necessitate altering water application rates for irrigation grandfathered rights; changes in technology or economics that are significantly different from the Department's projections or assumptions; and changes in federal, state, and local laws and regulations that prevent compliance with irrigation water duties or conservation requirements.

Additionally, a municipal provider that is subject to the Non-Per Capita Conservation Program (NPCCP) may seek administrative review of a conservation requirement, other than a conservation requirement for an individual user, only if the municipal provider claims at any time that "significant circumstances that did not exist when the municipal provider's application for the NPCCP was approved by the director" justify the modification. The director may modify the conservation requirement upon clear and convincing evidence that significant circumstances that did not exist when the application was approved by the director make it unreasonable to require compliance. A.R.S. § 45-575(C).

10.4 PLAN MODIFICATION PROCEDURES

At any time after the Third Management Plan is adopted, the plan may be modified pursuant to the same public hearing and comment procedures required for adoption of the plan. A.R.S. § 45-572(A). Further, the director may modify an irrigation water duty or conservation requirement established in the plan "only if the director determines that extraordinary circumstances, errors, or mistakes justify the modification." A.R.S. § 45-572(A).

Within 30 days of a modification of an irrigation water duty or conservation requirement, the Department must give written notice of the modification to the person required to comply with the modified requirement. The person may request a variance from or an administrative review of the modified irrigation water duty or conservation requirement within 90 days of the date of the notice. A.R.S. § 45-572(B) and (C).

10.5 GROUNDWATER USE REPORTING REQUIREMENTS

The Groundwater Code (Code) contains a number of provisions that enable the Department to acquire needed information on water use. This information is used to evaluate compliance with the Code and Department rules, permits, and management plans. The water use monitoring and reporting requirements, which are summarized below, are also designed to give water users the data needed to assess their progress in attaining conservation requirements.

10.5.1 Water Measurement

The Code requires persons withdrawing groundwater from non-exempt wells in Active Management Areas to measure those withdrawals using a water measuring device approved by the director. A.R.S. § 45-604. However, some small irrigation and non-irrigation users are exempt from the measuring device requirements. The Department has adopted rules requiring the use of an approved device, or a combination of devices and methods, for measuring rates and volumes of groundwater withdrawals for the calculation of the total annual volume of groundwater withdrawn. A.A.C. R12-15-901, *et seq.* Persons subject to the measuring device requirements must maintain the accuracy of the device within specific standards.

10.5.2 Records and Annual Reports

The Code requires most persons who own or lease a right or permit to withdraw, receive, or use groundwater to file an Annual Water Withdrawal and Use Report with the director for each right or permit they hold. All persons required to file annual reports must maintain current and accurate records of water withdrawn, delivered, received, and used. A.R.S. § 45-632.

Persons withdrawing groundwater from exempt wells and most non-irrigation customers of cities, towns, private water companies, and irrigation districts are exempt from record keeping and reporting requirements. Persons receiving water pursuant to a grandfathered right or a groundwater withdrawal permit and persons assigned and noticed of individual user requirements must meet the record keeping and reporting requirements, although certain small right holders are exempted from those provisions.

10.6 MONITORING AND AUDIT PROCEDURES

The Department has the authority to determine compliance with Code, management plan, and rule requirements. This authority is described below.

10.6.1 Measuring Devices

The Department monitors compliance with the measuring device requirements, as required by A.A.C. R12-15-901, *et seq.*, through review of Annual Water Withdrawal and Use Reports, field investigations, and evaluations of energy usage. Before field visits, the Department generally contacts well owners to ask for their cooperation and presence during the inspection. Standardized procedures and equipment are used to test the accuracy of measuring devices. The Department checks a significant percentage of the wells in the Tucson Active Management Area (AMA) for accuracy each year.

10.6.2 Irrigation Acreage and Water Use Monitoring

The Department monitors irrigated acreage and irrigation water use in the Tucson AMA using annual reports, crop records, energy use records, aerial photography, and satellite-based remote sensing data. These procedures are also used to determine the accuracy of annual water use reports and to detect illegal irrigation. The Department investigates any potential discrepancies or violations identified using these methods.

10.6.3 Annual Report Reviews and Audits

The Department reviews all annual water withdrawal and use reports. This is the Department's primary means for determining compliance with conservation requirements, measuring requirements, and groundwater use limitations.

Each year, the Department conducts official audits of a significant number of annual reports to check the accuracy of the reports and to verify suspected problems. An audit is a detailed review by Department staff of a person's water use records. Each person audited is requested to attend the audit. Audits ensure overall compliance with the Code and the management plan for the Tucson AMA.

10.6.4 Inspections

The Code allows the Department to enter property where facilities are located that are used for the withdrawal, transportation, or use of groundwater. This authority allows the Department to inspect facilities and lands subject to Code provisions and obtain data or access to records relating to the withdrawal, use, or transportation of groundwater. A.R.S. § 45-633.

The Department is generally required to give persons reasonable notice of inspections or investigations unless entry is sought solely to inspect a measuring device. Notice is not required in the rare cases in which there is reason to believe that notice would impede enforcement efforts.

10.7 COMPLIANCE APPROACH

The Department has developed a compliance program approach that includes education, assistance, and flexibility.

10.7.1 Education and Assistance

The Department informs water users of their conservation and reporting requirements as described in section 10.2 of this chapter. The Department also educates water users by explaining how the requirements were derived and how the user can achieve those requirements. This is done through advisory committees, detailed program descriptions contained in reports and issue papers, public presentations, the publication of this management plan, and individual meetings with interested users.

Annual flexibility account balance statements are sent to all affected users allowing them to monitor their compliance status. Irrigation grandfathered right holders who have exceeded the debit limits of their flex accounts, or who are close to exceeding them are notified of their status and given the opportunity to reduce water usage or purchase flex credits to avoid an enforcement action. However, irrigation grandfathered right holders regulated under the Historic Cropping Program may not purchase flex credits.

Financial and technical assistance is available to water users to assist them in meeting their conservation requirements. This assistance is more fully described in Chapter 9.

10.7.2 Determination of Compliance

The mandatory conservation programs in the Third Management Plan are designed to achieve reductions in groundwater withdrawals and use. Consequently, the persons given notice of irrigation water duties and conservation requirements established in the plan are required to comply with those irrigation water duties and conservation requirements only in those years in which they withdraw, distribute, or receive groundwater. The following two sections describe how the Department determines compliance with conservation requirements when groundwater is used.

10.7.2.1 Maximum Annual Water Allotments and Gallons Per Capita Per Day Requirements

The Third Management Plan establishes maximum annual water allotments for irrigation grandfathered rights, turf-related facilities, dairies, and cattle feedlots. Municipal providers regulated under the Total GPCD Program and the Alternative Conservation Program are required to comply with gallons per capita per day (GPCD) requirements. The requirements are similar to maximum annual water allotments in that they limit the amount of water that may be used during a year to a predetermined amount. A person's compliance with a maximum annual water allotment or GPCD requirement is generally determined by comparing the total amount of water used by the person during the year with the amount of water allowed by the allotment or GPCD requirement. However, the use of water in excess of the allotment or GPCD requirement during a year does not necessarily mean that the person is out of compliance for the year. To account for weather variations and other factors that may result in the use of more water in some years than others, the Department determines compliance either through the operation of a flexibility account or through a three year averaging method, depending on the type of use.

Flexibility accounts are used to determine compliance for municipal providers subject to GPCD requirements, turf-related facilities, and irrigation grandfathered rights. The total water use reported by the user for the year is compared with the amount of water the user was entitled to use during the year. Generally, if the total amount of water used during the year is less than the allotment for the year, the flexibility account is credited with the difference. If the water use exceeds the allotment, the flexibility account is debited with the difference. A user is out of compliance with its allotment or GPCD requirement in any year in which its flexibility account is debited with an amount of water that causes the account balance to exceed the maximum negative balance allowed for the use.

For dairies and cattle feedlots subject to maximum annual water allotments, compliance is determined through a three year averaging method. Under this method, the user will be in compliance with its allotment for any year in which its water use exceeds its allotment if the total amount of water used during that year and the previous two years does not exceed the sum of allotments for those three years.

If an irrigation grandfathered right, turf-related facility, or municipal provider uses water during a year in an amount that causes its flexibility account to exceed its maximum negative account balance, or if a dairy or cattle feedlot uses water during a three year period in an amount that exceeds the sum of the allotments for those three years, a violation occurs, but only to the extent of the groundwater included in excess. The Department determines the amount of groundwater in the excess by a process known as "stacking."

Under the stacking process, water from all sources used by a person during a year, with certain exceptions, is counted when comparing the person's water use to the maximum annual water allotment or GPCD requirement. However, groundwater is counted last. The process of counting groundwater last is called stacking because the groundwater is added to, or stacked on top of, the non-groundwater sources. Because groundwater use is counted last, the amount of any water used by a person in excess of its allotment or GPCD requirement will be comprised, at least partially, of groundwater.

10.7.2.2 Specific Conservation Measures

Municipal providers regulated under the NPCCP are required to comply with specific conservation measures instead of GPCD requirements. The following industrial users are required to comply with conservation measures specific to their type of use instead of maximum annual water allotments: dairies regulated under the Best Management Practices Program, sand and gravel facilities, metal mines, electrical power plants, large-scale cooling facilities and new large landscape users. For these municipal providers and industrial users, compliance will be determined by ascertaining whether they implemented their specific conservation measures in the manner required by the management plan, rather than by comparing their water use to a volumetric allotment. They are out of compliance if they fail to implement the conservation measures in the required manner.

All industrial users, including those subject to maximum annual water allotments, are required to comply with the conservation measures established for All Industrial Users in section 6-202 of Chapter 6. These conservation requirements include general requirements to avoid waste and make efforts to recycle water. They also include more specific requirements relating to low water use landscaping, landscaping and water features in publicly-owned rights of way, single pass heating and cooling, and low flow plumbing fixtures. In addition to these requirements, section 6-1002 of Chapter 6 requires that all new large industrial users submit a water conservation plan to the director.

10.7.3 <u>The Enforcement Process</u>

When the Department's monitoring program identifies a potential violation or when third party complaints are received about the activities of another user, an investigation is conducted to obtain the facts.

An investigation may involve a field inspection by Department staff or an audit at the Department's office after notice to the potential violator. The Department may request that the individual produce relevant records for the inspection or audit. Based on the investigation, the Department will determine whether there has been a violation and, if so, what course of action to take.

Where the violation is minor and does not require corrective action, the Department may bring the compliance action to a close with an advisory letter upon discontinuance of the violation. For more serious violations where there is reason to believe a person is violating or has violated a statute, permit, rule, or management plan provision, enforcement action will be taken by the Department.

During the first and second management periods, the Department took a non-traditional approach to enforcement. Given the recent introduction of the Code and management plans, a high level of tolerance was employed. Fines were set at low levels and probationary provisions and advisory notices were widely used. Usually, for unintentional violations of management plan requirements such as GPCD limits and maximum turf or irrigation grandfathered right allotments, the Department deferred any monetary penalties. Instead, it allowed the violator to develop or expand conservation measures designed to help the violator reduce water use. The Department felt that the long-term benefits of a properly designed and implemented conservation program, tightly structured and closely monitored, would exceed the benefits of a traditional monetary penalty program.

For a management plan violation, the violator was given the following options:

- Contest the enforcement action by requesting a hearing, or
- Pay a predetermined monetary penalty, generally based on the amount of groundwater used in excess of the requirement, or
- Negotiate a mitigation program with the Department designed to develop or expand conservation programs intended to assist the violator in achieving future compliance.

The results of this enforcement strategy have been mixed. Some mitigation programs developed under this approach have been successful in increasing water use efficiency, while others have been less effective. In most cases, significant and sometimes disproportionate amounts of time and resources have been invested by both the violators and the Department.

The Third Management Plan approach to enforcement will exercise flexibility on a more limited scale. The arguments of "newness and complexity" will be less compelling in this management period. Previous violations will be considered in determining the appropriate compliance approach. In addition, the Department may consider new compliance approaches during the management period for Code and management plan violations. One possible provision would employ a groundwater replenishment option. This may involve storage of renewable water designated as nonrecoverable, as defined by A.R.S. § 45-833.01, in a volume that would adequately compensate for the violation. A related approach may allow the purchase and extinguishment of long-term storage credits to offset a violation. The result of these approaches is a penalty that compensates for a violation and results in a positive water resource activity. If a water user anticipates a violation and informs the Department of this expectation before receiving a notice of noncompliance, the director may consider this voluntary disclosure to be a mitigating factor in determining the appropriate enforcement action.

The Department may consider a more aggressive level of compensation for certain violations as part of its forthcoming "critical area strategy."

Additional enforcement mechanisms are generally reserved for violators not amenable to the previously mentioned approaches. They include contested hearings, cease and desist orders, and civil penalties of up to $10,000 per day for violations directly related to illegal withdrawals, transportation, or use of groundwater. A.R.S. §§ 45-634 and 45-635.

Extremely serious cases may also be referred for criminal prosecution if persons knowingly violate or refuse to comply with the Code or with a permit, rule, or order issued or adopted under the Code.

SECTION

III

Future Conditions and Directions

Chapter 11 Water Budgets and Projections

Chapter 12 Future Directions

Preface

Sections I and II have described water resource conditions within the Tucson Active Management Area (AMA) and the regulatory programs designed to cause efficient use of groundwater and increasing use of renewable water supplies. The Arizona Department of Water Resources' (Department) regulatory program for the third management period, described in Section II, represents the midpoint in our overall management strategy to implement water management programs which ultimately will lead to the achievement of the AMA's management goal by the year 2025.

Section III describes projected future conditions within the Tucson AMA, as well as the directions the Department proposes to take in developing additional water management programs during the third management period.

Alternative future water supply and demand conditions are described in Chapter 11. The Department's supply and demand conditions, also known as "water budgets," are designed to illustrate a range of supply and demand possibilities for consideration as we develop our management programs. Both Tucson AMA scenarios exhibit overdraft conditions. Chapter 11 projects continued overdraft even under optimistic conditions, indicating that mid-course changes in direction may be necessary if we are to achieve safe-yield by 2025.

Chapter 12 describes some options for the future looking towards ultimately achieving the AMA management goal through increasingly stringent requirements for the conservation of groundwater along with the augmentation of water supplies. Chapter 12 summarizes existing water management problems, identifies the obstacles to safe-yield, and describes the actions the Department expects to take to remove these obstacles during the Third Management Period and beyond.

CHAPTER

11

Water Budgets and Projections

11.1 INTRODUCTION

The basic goals and structure of the water budget are described in the following sections. Terminology and concepts used throughout this chapter that apply to agricultural, municipal, and industrial sector water use are described in chapters 4, 5, and 6, respectively. Terminology and concepts that apply to the recharge and recovery of renewable water supplies are described in Chapter 8. Detailed information on the data sources and projection calculations used in this chapter is compiled in the Third Management Plan Administrative Record.

11.1.1 Use of Water Budgets and Sensitivity Analysis

The Arizona Department of Water Resources (Department) uses detailed water budgets to evaluate the current imbalance between water demands and supplies and to forecast progress toward meeting the Tucson Active Management Area (AMA) goal of achieving safe-yield in the AMA by 2025. Water demand and supply projections and water budget scenarios are prepared based on many assumptions. Two primary water budget scenarios are discussed below. Progress toward meeting safe-yield is tabulated for these budgets in five-year increments through 2025. In addition, sensitivity analyses were performed on selected variables in the water budget to determine the relative impact of these variables on water use in 2025.

11.1.2 Water Accounting Approach Used in the Water Budget

Water is a physical resource and, as such, can be tracked and understood in purely physical terms. However, water management is becoming increasingly tied to legal accounting mechanisms for water supply and demand. The water budgets and sensitivity analyses presented in this chapter incorporate the water accounting approaches used to track the recharge and recovery of Central Arizona Project (CAP) water and effluent, the use of "allowable mined groundwater" under the Assured Water Supply Rules (AWS Rules), and the use of remediated groundwater under the Water Quality Assurance Revolving Fund (WQARF) legislation.

This accounting-oriented water budget, which includes estimates of both "actual" and "accounting" overdraft, does not yield the same estimates of overdraft as would result from a strict hydrologic water budget because in both "actual" and "accounting" overdraft calculations, CAP and effluent recharge volumes are entered as supplies in the water budget only in those years in which they are recovered, even though the water may physically be recharged before this time period and in larger volumes than are recovered. This approach prevents an underestimate of groundwater mining in the early years when recharge may exceed credit recovery and prevents an overestimate of groundwater mining in later years when recovery of credits may exceed recharge.

After "actual overdraft" is calculated, "accounting overdraft" is determined by subtracting the volume of allowable mined groundwater and remediated groundwater projected to be used in a given year from actual overdraft. The various types of mined groundwater, including allowable mined groundwater and remediated groundwater, are described in section 11.4.1.2.

When groundwater is pumped as a means to recover CAP or effluent recharge credits, it is shown as CAP water or effluent in the water budget. For example, under the Groundwater Savings Program, CAP water is applied directly to agricultural land in place of the groundwater the farmer otherwise would have used. CAP credits are accrued by the entity (a water provider, Central Arizona Water Conservation District (CAWCD), Central Arizona Groundwater Replenishment District (CAGRD), Arizona Water Banking Authority (AWBA), etc.) that supplies CAP water to the farmer at a subsidized cost. For Department water accounting purposes, the farmer who applies CAP water to his fields is still considered to be using groundwater, so his use is shown as groundwater in the water budget. When the CAP credits are recovered

in the future through the process of pumping groundwater, this water is shown as CAP water in the water budget.

The water budget does not reflect the impacts of recharge and pumping on water levels in the AMA. The Department is developing a computer model that will make it possible to map areas of projected water level rises and declines in order to show the impacts of recharge and pumping inside the AMA.

11.1.3 The Third Management Plan and the Water Budget in the Context of Longer-Term Water Management

The overdraft values shown in the water budget represent AMA-wide balances at given points in time. The third management period constitutes one ten-year increment of the 35-year time period represented in the water budget. Both the management plan and the water budget are affected by the requirements and implications of the Assured Water Supply Program (AWS Program) and need to be understood in the context of the 100-year planning time frame addressed by the AWS Program. Many of the decisions water providers will make between now and 2025 will be made in the context of water management needs during this 100-year time frame. Likewise, decisions the Department makes on water management policy are framed in this larger context, including the decision to allow a certain volume of groundwater mining by water providers.

11.1.4 Complexity of Supply and Demand Components in the Water Budget

The major components of water supply and demand in the Tucson AMA are illustrated in Figure 11-1. The water budget must account for a variety of supply and demand components and a number of complicating factors including time lags between CAP and effluent storage and recovery, allocations of water to the aquifer (cuts to the aquifer) as a result of CAP and effluent recharge, and multiple categories of groundwater use that are accounted for differently in the budget. Supply and demand components are described in detail in this chapter.

11.2 WATER BUDGET SCENARIOS

Two water budget scenarios are presented in this plan. These scenarios were selected from numerous scenarios prepared by the Department to illustrate possible water demand and supply conditions and to demonstrate the projected effects of Third Management Plan conservation requirements on reducing water use in the Tucson AMA. The water budget scenarios are as follow:

- **Base Scenario**: Assumes that, while the municipal population and the number of industrial facilities grow through 2025, the municipal gallons per capita per day (GPCD) water use rates and industrial water use practices present in 1995 continue through the year 2025.

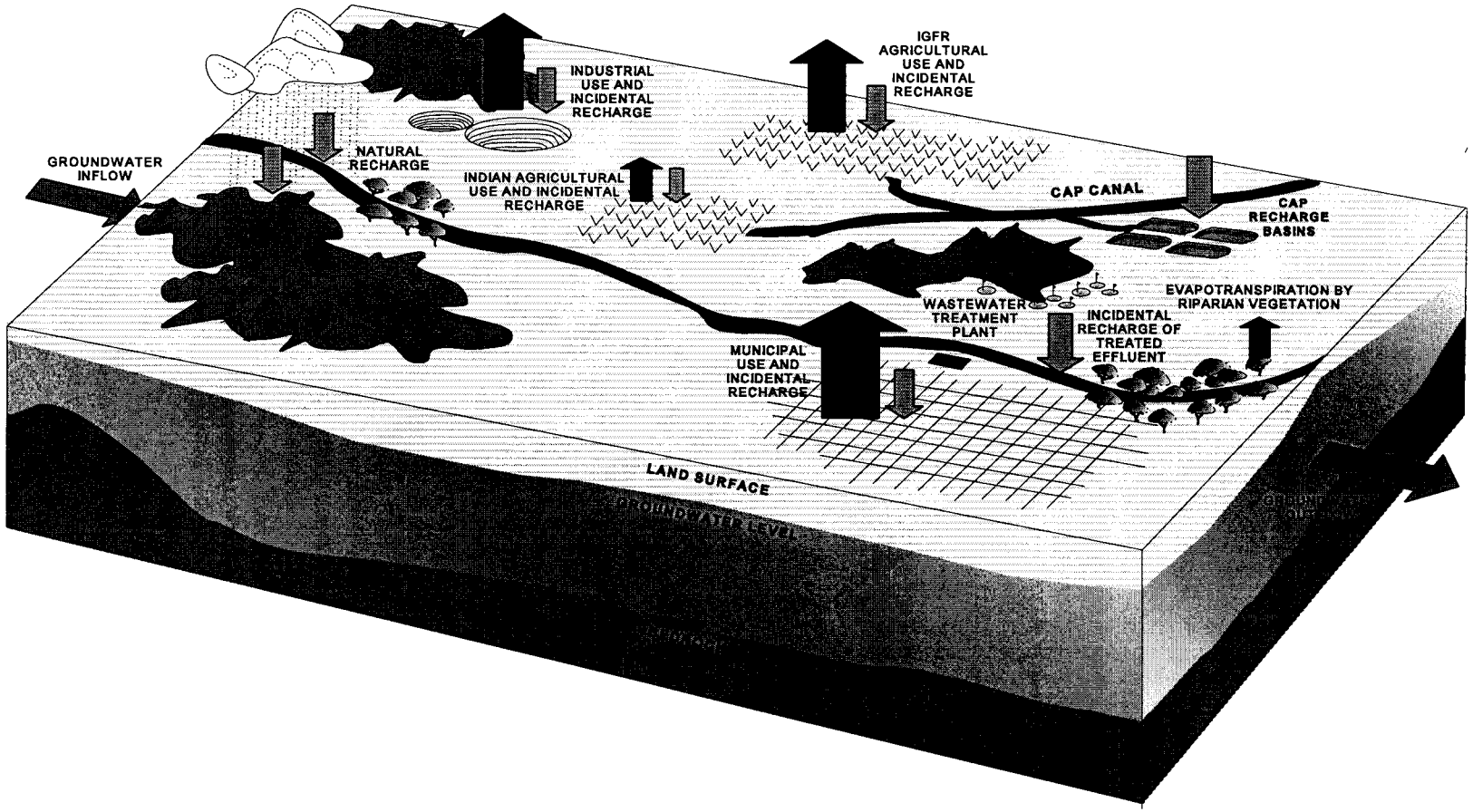
- **Third Management Plan Scenario (TMP Scenario)**: Assumes that, while the municipal population and the number of industrial facilities grow through 2025, municipal and industrial demand levels are reduced to meet Third Management Plan conservation requirements and these reduced demand levels continue through 2025. This scenario also assumes that some AWBA CAP recharge credits are extinguished to benefit the aquifer.

The following general assumptions apply to both water budget scenarios:

- Tucson AMA population projections are based on Department of Economic Security projections.

- Turf-related facility demand served by municipal providers increases over time based on projected expansion of existing facilities and projected construction of new facilities.

FIGURE 11-1
SCHEMATIC ILLUSTRATION OF DEMAND AND SUPPLY VARIABLES
IN THE WATER BUDGET
TUCSON ACTIVE MANAGEMENT AREA



- Agricultural demand decreases over time as a result of a reduction in irrigation acres as agricultural lands are retired to other uses; agricultural water use efficiency increases as a result of implementation of improved water management practices that are not related to Third Management Plan requirements.

- Industrial water demand increases on an industry-by-industry basis through 2025 based on one or more of the following factors: (1) past history of growth, (2) growth projections provided by the industrial water users and evaluated by the Department, and (3) parallels to population growth.

- The volume of CAP recharge tallied in water budget scenarios in any given year is equal to the sum of the annual storage and recovery credits projected to be recovered that year, the long-term storage credits projected to be recovered that year, the CAGRD replenishment obligations incurred that year, and a 5 percent cut to the aquifer associated with long-term storage credits and replenishment obligations. CAP recharge does not appear in the budget if it results in the accumulation of long-term storage credits that are not recovered by 2025.

- A portion of effluent discharged from Pima County's regional wastewater treatment plants into the Santa Cruz River is stored through managed in-channel effluent recharge projects by the City of Tucson and the United States Secretary of the Interior, and a portion of these credits are recovered.

Groundwater pumped within the AMA on Indian reservations is not regulated by the Department but is tracked in the water budget. Specific demand and supply assumptions used in water budget scenarios are described in the following sections.

11.3 PROJECTED DEMAND BY SECTOR

Water demand in the Tucson AMA is divided into municipal, agricultural, and industrial sectors for analysis and management purposes.

11.3.1 Agricultural Demand Assumptions

Agricultural water demand on non-Indian lands is a function of the land actually cultivated in a given year as it relates to the total acreage that can legally be irrigated (the cropped-acreage ratio). Non-Indian irrigated acreage is served by groundwater, with the exception of a small volume of effluent use each year. Cultivation on Indian lands is not subject to the legal restrictions on irrigable acreage that apply on non-Indian lands. Indian irrigation is expected to be served by importation of CAP water. Water demand for irrigation both on and off Indian lands is affected by the efficiency of water use and the average consumptive use of crops. Components of agricultural demand for each water budget scenario are shown in Table 11-1. More information on agricultural water use and explanations for the terms used here are contained in Chapters 3 and 4.

Agricultural water use variables and assumptions stay constant for both scenarios, and include the following:

- Irrigation grandfathered right (IGFR) acreage decreases by 50 percent from 1995 to 2025
- Irrigation efficiency increases from 75 percent to 80 percent starting in 2010 for non-Indian agriculture
- Cropped acreage ratio increases to 65 percent by 2005 for non-Indian agriculture
- Agricultural effluent use averages 3,000 acre-feet per year from 2000 to 2025 for non-Indian agriculture
- Canal loss of 7 percent for Cortaro Marana Irrigation District (CMID) canals
- Average consumptive use of 3.6 acre-feet/acre for both Indian and non-Indian agriculture

- Demand for 10,300 acre-feet/year of CAP water by 2005 and 15,800 acre-feet/year of CAP water by 2010 to irrigate lands on the San Xavier and Schuk Toak Districts of the Tohono O'odham Nation
- 75 percent irrigation efficiency for Indian agriculture
- Cropped acreage ratio of 100 percent for Indian agriculture

TABLE 11-1
AGRICULTURAL DEMAND ASSUMPTIONS FOR WATER BUDGET SCENARIOS
TUCSON ACTIVE MANAGEMENT AREA

Factors	Agricultural Water Use Projections							
	1990	1995	2000	2005	2010	2015	2020	2025
Non-Indian Irrigation								
Total IGFR Irrigation Demand (AF)[1]	93,800	98,000	103,600	107,400	91,700	81,200	69,200	54,200
IGFR Acreage (acres)	40,000	36,100	35,100	33,600	30,600	27,100	23,100	18,100
Cropped Acreage Ratio	47%	55%	60%	65%	65%	65%	65%	65%
Consumptive Use Factor (AF/acre)	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6
Irrigation Efficiency	75%	75%	75%	75%	80%	80%	80%	80%
Agricultural Effluent Use (AF)	4,000	1,800	3,000	3,000	3,000	3,000	3,000	3,000
Irrigation District Canal losses (AF)	3,000	3,400	2,600	2,700	2,300	2,100	1,700	1,400
Indian Irrigation								
Total Indian Irrigation Demand (AF)	0	0	1,100	10,300	15,800	15,800	15,800	15,800
Total Indian Irrigation Acreage (acres)	0	0	220	2,150	3,300	3,300	3,300	3,300
San Xavier	0	0	220	1,000	1,000	1,000	1,000	1,000
Schuk Toak	0	0	0	1,150	2,300	2,300	2,300	2,300
Cropped Acreage Ratio	100%	100%	100%	100%	100%	100%	100%	100%
Consumptive Use Factor (AF/acre)	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6
Indian Irrigation Efficiency	75%	75%	75%	75%	75%	75%	75%	75%

[1]Total IGFR irrigation demand includes canal losses and irrigation use by exempt small rights
IGFR = Irrigation Grandfathered Right
AF = acre-feet

A finite number of IGFR acres exist in the Tucson AMA, limited by the Groundwater Code (Code) to the acreage that was irrigated from 1975 to 1980. Maximum irrigable acreage is projected to decrease by approximately 50 percent between 1995 and 2025 as agricultural land shifts to other types of use and development. A previous large reduction in irrigated acreage occurred on 16,000 acres of farmland bought and retired by the City of Tucson between 1975 and 1986 to obtain the associated water rights. Shifts away from agricultural use in the future could occur in several areas of the AMA. In the northern Marana area, shifts away from agricultural land use are likely due to improved flood control protection along the Santa Cruz River, which will allow urban development of formerly flood-prone agricultural land. Shifts away from agricultural land use could also occur due to development of portions of Farmers Investment

Company acreage in the Green Valley/Sahuarita area and development of some remaining agricultural acreage along the Interstate 10 corridor east of the Tucson Mountains.

The cropped acreage ratio for IGFRs is assumed to increase from 47 percent in 1990 to 65 percent by 2005 and to continue at 65 percent through 2025. The increasing cropped acreage ratio reflects several factors including the phasing out of government subsidies to reduce acreage in production and increases in irrigation that may result from other economic conditions. As the number of IGFRs decrease in the AMA, it is assumed that a larger percent of the remaining farmland will be kept in production. This projected increase in the cropped acreage ratio results in an increase in agricultural demand in 2000 and 2005, even though IGFR acreage is projected to decrease during this period.

It is estimated that groundwater irrigation will serve approximately 220 acres of farmland on the San Xavier District of the Tohono O'odham Nation by the year 2000. By 2005, it is projected that CAP water will replace this groundwater use and additional acreage will be brought into production, reaching a total of approximately 1,000 acres. The Schuk Toak District of the Tohono O'odham Nation is projected to be irrigating approximately 1,150 acres of land with CAP water by 2005 and 2,300 acres by 2010, continuing through 2025. Total Indian agricultural water use is projected to increase from around 10,300 acre-feet in 2005 to 15,800 acre-feet in 2010.

The consumptive use value is the volume of water used by plants for growth and transpiration. A consumptive use value of 3.6 acre-feet/acre/year is used for both Indian and non-Indian agriculture in the water budgets. This is an average value based on existing consumptive use values in the AMA and is assumed to apply to all crops for all years in the water budget.

Second and Third Management Plan conservation requirements for irrigation right holders are generally based on an assigned irrigation efficiency that is used to determine a maximum annual groundwater allotment. The allotments are based on the crops historically grown and the highest number of acres planted in any one year from 1975 to 1980. The Department does not require farmers to operate at their assigned irrigation efficiency. However, they must meet their assigned maximum annual groundwater allotment.

For purposes of the water budget, an assumed irrigation efficiency of 75 percent is projected to increase to 80 percent by 2010 and continue at this level through 2025 for non-Indian agriculture. This increase is expected to result from several factors. Water management assistance programs provided by the Department through avenues other than the management plans will assist farmers in improving irrigation efficiency. In addition, the relationship between the cost to use water and profit margins will act as an incentive to improve efficiencies. It is assumed that Indian irrigation water use efficiency will remain at 75 percent through 2025. The Department's agricultural conservation requirements and the flexibility account provisions associated with IGFRs are not applicable to Indian agricultural systems.

The average use of effluent since 1988 by the agriculture sector has been around 3,000 acre-feet per year. Although this could change if new effluent delivery projects are implemented, current assumptions are that this level of use will continue through 2025. A canal loss of approximately 7 percent is applied to water used in the CMID, which relies on extensive distribution canals to supply water to a number of farms. This value is added to on-farm water use to derive total irrigation demand.

11.3.2 Municipal Demand Assumptions

Population and per capita water consumption are the primary factors influencing municipal demand. Total municipal demand is composed of potable and non-potable water use by AMA water providers, domestic well owners, and Indian reservation populations. Municipal demand is currently met by groundwater and by effluent, some of which is delivered through the City of Tucson's reclaimed water system to municipal

turf-related facilities (golf courses, parks, cemeteries, school yards, etc.). In the Third Management Plan, future demands are assumed to be met with decreasing amounts of groundwater and with increasing amounts of directly used effluent, recharged and recovered effluent, and recharged and recovered CAP water. Components of municipal demand for each water budget scenario are shown in Table 11-2. Additional information on municipal water use is contained in chapters 3 and 5.

Municipal water use factors that stay constant for both scenarios are:

- Projections of AMA population
- Demand of 50 GPCD on the San Xavier District and the portion of the Schuk Toak District that is within the Tucson AMA
- Municipal demand for secondary effluent and reclaimed water

The municipal water use factor that changes between the two scenarios is average non-Indian municipal demand. The assumptions about this factor are:

- Demand of 172 GPCD in 1995 in the Base Scenario continuing through 2025
- Demand of 172 GPCD in 1995 decreasing to 161 GPCD by 2010 and to 158 GPCD by 2025 in the TMP Scenario

Total municipal demand in 1995 was 155,500 acre-feet (Table 11-2). In the Base Scenario, it is projected that total municipal demand will reach 267,100 acre-feet in 2025. In the TMP Scenario, municipal demand is projected to reach 247,300 acre-feet in 2025. The population of the AMA, with the exception of Indian districts, was approximately 766,500 in 1995 and is expected to reach around 1,262,900 by 2025 based on Department of Economic Security projections. The population on the San Xavier District and the portion of the Schuk Toak District that is within the AMA was approximately 1,500 in 1995 and is expected to reach approximately 3,600 by 2025 based on an assumed growth rate of 3 percent per year. The population of the Pascua Yaqui Reservation is included in non-Indian AMA population estimates because this area is served by Tucson Water.

It is assumed in the Base Scenario that municipal GPCD conditions present in 1995 remain in place through 2025. It should be noted that under the Second Management Plan requirements, municipal GPCD would continue to decrease through 2025 as it does under the Third Management Plan requirements. Municipal water demand averaged 172 GPCD in 1995. Municipal water demand in 2010 is projected to average 172 GPCD under the Base Scenario and 161 GPCD under the TMP Scenario reflecting reduced use due to Third Management Plan conservation requirements. Because Third Management Plan conservation requirements specify that new municipal water users meet a lower GPCD rate than existing users, the total GPCD for the TMP Scenario continues to go down after 2010. The GPCD reaches 158 in 2025 reflecting the effect of newly added population.

Municipal demand projections are based on the average GPCD rates that would need to be achieved under the Total GPCD Municipal Conservation Program. Several large water providers including Tucson Water have requested transfer out of the Total GPCD Program and into the Non-Per Capita Program. In the Non-Per Capita Program, GPCD targets are not specified for water providers, but water conservation strategies should result in savings equivalent to those in the Total GPCD Program. The components that are used to calculate average GPCD are residential, non-residential, and lost and unaccounted for water use. Residential use applies to single and multifamily homes and apartments. Non-residential use applies to industries, turf-related facilities, and other non-residential users served by water providers. Lost and unaccounted for water results from leaking pipes, hydrant use, and other losses.

TABLE 11-2
MUNICIPAL DEMAND ASSUMPTIONS FOR WATER BUDGET SCENARIOS
TUCSON ACTIVE MANAGEMENT AREA

Factors	Municipal Water Use Projections							
	1990	1995	2000	2005	2010	2015	2020	2025
Total Municipal Demand, Base Scenario (AF)[1]	130,100	155,500	172,900	193,500	212,200	232,000	249,700	267,100
Total Municipal Demand, TMP Scenario (AF)[1]	130,100	155,500	172,900	188,300	199,800	218,600	233,900	247,300
AMA Population Off-Reservation	653,700	766,500	836,600	919,000	1,003,000	1,089,600	1,176,100	1,262,900
Indian Reservation Population	1,300	1,500	1,700	2,000	2,300	2,700	3,100	3,600
Municipal Demand (GPCD)								
Base Scenario	169	172	172	172	172	172	172	172
TMP Scenario	169	172	172	167	161	161	160	158
Indian Reservation Demand (GPCD)	50	50	50	50	50	50	50	50
Municipal Secondary Effluent/Reclaimed Demand (AF)	6,300	7,700	11,600	16,300	18,800	21,900	23,000	23,600

[1]Municipal demand includes pumpage from exempt wells
AF = acre-feet
TMP = Third Management Plan
AMA = Active Management Area
GPCD = gallons per capita per day
Note: Indian Reservation population includes the San Xavier District, and the portion of the Schuk Toak District within the AMA boundary. It does not include the Pascua Yaqui Reservation population, which is served by Tucson Water and is included in the AMA off-reservation population.

Exempt well users are included in the municipal population estimates. Since exempt well use (wells with pump capacities of <35 gallons/minute) is not reported to the state, it is assumed for purposes of the water budget that exempt well water use per person is the same as the average municipal water use rate. Water demand on the Schuk Toak and San Xavier Districts was approximately 50 GPCD in 1995 and is projected to continue at this level through 2025.

In 1995, 7,700 acre-feet of secondary effluent and reclaimed water were used to meet municipal sector demands primarily for turf-related facility use. Municipal demand for effluent is projected to reach 23,600 acre-feet by 2025. Because this municipal effluent demand is not a component of the GPCD calculations made by the Department, municipal demand for secondary effluent and reclaimed water is tabulated separately from the GPCD-based demand in the water budget and then added to GPCD-based demand to determine total municipal demand.

Shortly after the year 2000, managed in-channel recharge of effluent is projected to commence. The effluent proposed for recharge is controlled by the City of Tucson and the United States Secretary of the Interior. Managed effluent recharge is proposed in the bed of the Santa Cruz River. Credits accrued from this process are anticipated to be recovered to meet a portion of the City's reclaimed water system demand and to support the settlement of Indian water rights claims of the Tohono O'odham Nation. Recovery of effluent credits to meet a portion of the City's reclaimed system demand is incorporated in secondary effluent and reclaimed demand estimates shown in Table 11-2. Additional credits are anticipated to be recovered by water providers, who would recover credits by pumping groundwater from other locations of the AMA. It is assumed that, for these water providers, recovered effluent credits would replace a portion

of their use of recovered CAP credits. Projections of the accrual and recovery of effluent credits and the impact of this recharge effort on incidental recharge in the river are discussed and tabulated in section 11.4.2.

11.3.3 Industrial Demand Assumptions

For purposes of the water budget, all water demand for industrial facilities served completely or partially by Type 1 or Type 2 non-irrigation groundwater rights and groundwater withdrawal permits is tallied under the industrial sector. This includes secondary effluent and reclaimed water demand at those industrial facilities that have converted or are projected to convert from groundwater to effluent supplies. Components of industrial demand are shown in Table 11-3 for industrial turf-related facilities, metal mining facilities, and the combined use of other industrial facilities. More information on industrial water use is contained in Chapters 3 and 6.

TABLE 11-3
INDUSTRIAL DEMAND ASSUMPTIONS FOR WATER BUDGET SCENARIOS
TUCSON ACTIVE MANAGEMENT AREA

Factors	Industrial Water Use Projections (acre-feet)							
	1990	1995	2000	2005	2010	2015	2020	2025
Industrial Turf-related Facilities								
Both Scenarios -Groundwater	6,300	7,200	8,100	8,100	7,800	6,000	5,900	5,800
Both Scenarios - Effluent	800	800	1,100	1,300	2,300	2,800	3,200	3,500
Metal Mining								
Base Scenario - Groundwater	32,400	41,400	47,500	47,500	47,500	47,500	47,500	47,500
TMP Scenario - Groundwater	32,400	41,400	47,500	47,500	47,000	47,000	47,000	47,000
Other Industrial								
Base Scenario - Groundwater	9,200	10,900	14,100	14,860	15,610	16,370	17,170	17,940
TMP Scenario - Groundwater	9,200	10,900	14,100	14,860	15,560	16,310	17,110	17,870
Both Scenarios - Effluent	0	0	200	400	600	800	1,000	1,200

TMP = Third Management Plan

Conservation requirements for turf-related facilities and large-scale cooling facilities apply to facilities in both the municipal and industrial sectors. Water demand for turf-related facilities and large-scale cooling facilities served exclusively by municipal providers is tallied under municipal demand.

Industrial demand projections vary depending on conservation requirements and the rate of growth projected for industrial categories. In the Base Scenario, demand for groundwater by metal mines was 41,400 acre-feet in 1995 and is projected to increase to 47,500 acre-feet by 2000 and continue at this level through 2025. Water use by the metal mining industry could vary substantially from projected use because the industry is subject to changes in the world copper market and innovations in copper extraction technologies. The mining industry currently holds allotments for around 62,000 acre-feet of groundwater per year and could obtain additional groundwater withdrawal authority through purchase of groundwater rights or requests for groundwater withdrawal permits, if needed. For purposes of the water budget, conservation requirements in the Third Management Plan are projected to result in a one percent savings in mine water use in the TMP Scenario. These savings begin in 2010 and continue through 2025, when mine water use is projected to be around 47,000 acre-feet per year.

Groundwater use by industrial turf-related facilities was approximately 7,200 acre-feet in 1995. Annual groundwater use is projected to temporarily increase during the years 2000 to 2010 as turf-related facility demand increases, then decrease to around 5,800 acre-feet by 2025 as increasing numbers of turf-related

facilities convert from groundwater to effluent water sources. Effluent use by these industrial facilities is projected to increase from around 800 acre-feet in 1995 to around 3,500 acre-feet in 2025, due to the combination of the expansion of existing facilities already using effluent and the conversion from groundwater to effluent at other facilities. Because water allotments for turf-related facilities specified in the Second Management Plan are being maintained in the Third Management Plan, these projections apply to both scenarios.

In the Base Scenario, the combined groundwater use of sand and gravel facilities, electric power plants, and other industrial facilities besides mines and turf-related facilities increases from 10,900 acre-feet in 1995 to a projected 17,940 acre-feet in 2025. Overall, water demand increases due to growth in the size and number of industrial facilities. In the TMP Scenario, groundwater use at sand and gravel facilities is projected to decrease by 1 percent to reflect increasing conservation requirements for this sector in the Third Management Plan. Effluent use by sand and gravel facilities is projected to increase from 0 to 1,200 acre-feet between 1995 and 2025 based on the assumption that some facilities located along the Santa Cruz River will convert from groundwater to effluent use over time.

11.3.4 Other Demands - Evapotranspiration

Evapotranspiration generally occurs along water courses where trees and other vegetation grow and where the water table is shallow enough to be tapped by this vegetation. Evapotranspiration losses are estimated at 3,700 acre-feet per year in the AMA, all of it occurring in the Upper Santa Cruz Valley Subbasin.

11.4 PROJECTED WATER SUPPLIES

Components of the available water supply in the AMA include the following:

- Renewable groundwater sources including net natural recharge and incidental recharge
- Allowable mined groundwater supplies including those allocated under the AWS Program
- Groundwater withdrawn during remediation projects
- Direct use of effluent
- Recharge and recovery of effluent
- Direct use of CAP water for Indian agriculture
- Recharge and recovery of CAP water
- Extinguishment of CAP recharge credits by the AWBA

Water supply estimates are compared to water demand projections to determine the adequacy of these supplies to meet demand. Water users in the AMA currently obtain the majority of their water supply from mined groundwater. Increased utilization of CAP water and effluent are essential to achieving AMA management goals. These renewable supplies can be used directly or can be used indirectly through storage and recovery projects.

Water providers will be making decisions about the volumes of each water supply to use on a year-to-year basis. These decisions are based on a large number of considerations that range from whether groundwater is physically available to pump to whether there are shortages of CAP water. Because of this dynamic decision-making process, it is difficult to project what supplies will be used when. For purposes of the water budget, a series of simplifying assumptions must be made. Water supply assumptions and projections used in the water budget are described in the following sections for groundwater, effluent and CAP water.

11.4.1 Groundwater

A small portion of the groundwater supply is renewable. Renewable groundwater is replaced yearly by precipitation, groundwater underflow, and flow back to the aquifer following human use (incidental recharge). The remainder of the groundwater supply is non-renewable and withdrawal of it, without associated recharge of the aquifer with a renewable water supply, constitutes groundwater mining. Some groundwater mining is allowed by the Department in the context of the AWS Program. Groundwater withdrawals are also allowed under new WQARF legislation as an incentive to pump and treat contaminated water. These categories of groundwater use are described below.

11.4.1.1 Renewable Groundwater

Groundwater supplies in the Tucson AMA are partially replenished by natural recharge to the aquifer originating from net groundwater underflow and infiltration of precipitation, and by incidental recharge originating from municipal, agricultural and industrial water uses that result in water percolating back to the aquifer.

11.4.1.1.1 Net Natural Recharge

Net natural recharge in a given year is the volume of water that naturally recharges the groundwater supply minus the natural depletions to the groundwater supply over the course of that year. The components of net natural recharge that increase the groundwater supply are stream channel infiltration, mountain front recharge, and groundwater inflow into the AMA. The groundwater supply is depleted by groundwater outflow out of the AMA. Net natural recharge in the AMA is estimated at 60,800 acre-feet per year. Components of AMA natural recharge are discussed in Chapter 2 and tabulated in Table 2-1.

11.4.1.1.2 Incidental Recharge

Incidental recharge originates as pumped, imported, or diverted water that percolates down to the water table after it is used for human activity. In the Tucson AMA, the volume of incidental recharge is largely dependent on the extent and efficiency of agriculture, the level of mining activity, and the quantity of effluent discharged into stream channels. Other factors affecting incidental recharge are the level of industrial activity other than mining and the level of water use by the municipal sector. The 4 percent incidental recharge factor for the municipal sector is the only incidental recharge factor that is specified by rules or regulations. It is referenced in the AWS Rules and in the Non-Per Capita Conservation Program as a volume of groundwater that municipal providers need not replenish or find renewable supplies to meet. While the volume of incidental recharge varies somewhat between water budget scenarios due to differences in sector water demand, the percentage rate of incidental recharge for these sectors is the same for both scenarios. Incidental recharge factors used in the water budget are shown in Table 11-4.

11.4.1.2 Mined Groundwater

Because of the detrimental effects that result from groundwater mining in the AMA, including decreasing groundwater levels, subsidence, reduced water quality and increased pumping costs, it is essential that groundwater mining be curtailed to the greatest extent possible. To reduce groundwater use in the long-term, the Department has provided transitional approaches that allow water providers certain limited amounts of groundwater use while they convert to renewable supplies. Groundwater may also be pumped on an ongoing basis by some existing water users pursuant to state regulations, and a specified volume of remediation water may be pumped. These categories of groundwater use are addressed below.

TABLE 11-4
INCIDENTAL RECHARGE ASSUMPTIONS
TUCSON ACTIVE MANAGEMENT AREA

Incidental Recharge Rate	Source of Incidental Recharge
4% 90%	Total municipal demand Effluent discharged in Santa Cruz River by regional wastewater treatment plants that is not part of managed in-channel effluent recharge projects
20% 16%	Total agricultural demand for agricultural efficiency of 75% Total agricultural demand for agricultural efficiency of 80%
12% 12%	Mining facility demand Other large industrial water users

11.4.1.2.1 Allowable Mined Groundwater

The Department has earmarked certain volumes of groundwater for use by water providers who are designated as having an assured water supply and for subdivisions that have a Certificate of Assured Water Supply (Certificate of AWS). These mined groundwater allowances have been provided to help municipal water providers transition from groundwater to renewable supplies, to provide time for the CAGRD to replenish groundwater, and, in conjunction with the use of CAP credits from water recharged by the Arizona Water Banking Authority, to assist in providing a secure water supply in years when there are shortages of CAP water. Such shortages are likely to occur during drought conditions on the Colorado River, which are projected to occur in about one-third of the next 100 years. Projections of the distribution of drought years is skewed toward the latter half of the 21st century. It would be beneficial if designated providers retained groundwater reserves for use in drought years since CAP supplies are currently relatively abundant and could be used instead of allowable mined groundwater.

Under the AWS Program, allowable mined groundwater supplies include the following categories for designated water providers:

- A "phase-in" groundwater allowance equal to 15 times the 1994 demand of the water provider's service area
- A groundwater credit based on the extinguishment of any Type 1 or Type 2 grandfathered rights

An early application incentive of "free groundwater for three years" was extended to providers who applied for an assured water supply by a specified date. The "free groundwater" period extends through 1998 for five out of six of the designated large water providers, and through 2000 for Tucson Water. Therefore, the need to meet demand with renewable supplies or allowable mined groundwater begins in 1999 for most large providers, and in 2001 for Tucson Water.

Groundwater served to subdivisions that are covered by Certificates of AWS that were applied for after February 1995 typically replenish this groundwater through contracts with the CAGRD. The CAGRD is required to replenish a minimum percentage of groundwater use in a given year through recharge of CAP water or effluent. This minimum percentage starts with 1/30 of the subdivision groundwater use in 1995, and increases 1/30 each year through 2014 when the replenishment obligation reaches 20/30 of groundwater use. For purposes of the water budget, it is assumed that the rate of replenishment continues to increase each year and is at 100 percent in 2025. The groundwater volume that is not replenished during this phase-in period is assumed for purposes of the water budget to be allowable mined groundwater.

Allowable mined groundwater is not subject to the replenishment requirements that other mined groundwater is, but its use is subject to conservation requirements. Mined groundwater allowances total approximately 1.9 million acre-feet for the six designated Tucson AMA water providers, including Tucson Water. It is assumed in the water budget that the mined groundwater allowance used in a given year is the volume of groundwater demand in that year for designated water providers and the portion of new growth in certificated subdivisions that has a replenishment obligation. The date at which these requirements commence varies between water providers depending upon when they received their designations or certificates. Allowable groundwater use at five-year intervals through 2025 is projected for each of the water budget scenarios as shown in Table 11-5. Cumulative use over this time period is projected to total around 829,500 acre-feet under the TMP Scenario, leaving a balance of around 1,070,500 acre-feet of the 1.9 million acre-foot allowable groundwater accounts of municipal providers. Projected allowable mined groundwater use increases sharply in the first 10 years of the next century, then levels off. This is because the CAGRD replenishment requirement increases by 1/30 each year, generally offsetting increasing municipal demand for allowable groundwater. The City of Tucson has an additional groundwater allowance as discussed in the next section.

TABLE 11-5
ASSUMED USE OF ALLOWABLE MINED GROUNDWATER BY MUNICIPAL PROVIDERS
TUCSON ACTIVE MANAGEMENT AREA

Water Budget Factor	Projected Use (acre-feet)							
	1990	1995	2000	2005	2010	2015	2020	2025
Allowable Mined Groundwater - BASE Scenario	0	0	10,000	33,400	37,000	39,200	40,300	41,100
Allowable Mined Groundwater - TMP Scenario	0	0	10,000	32,400	34,500	36,500	37,000	37,000

TMP=Third Management Plan

11.4.1.2.2 City of Tucson Avra Valley Groundwater Allowance

The City of Tucson is statutorily allowed to receive up to 2 million acre-feet of additional groundwater allowance because they purchased and retired over 16,000 acres of active farmland in the Avra Valley in the late 1970s and early 1980s. For purposes of the water budget, it is assumed this water will not be used before 2025 because the statutory formula for the allowance results in an incentive to delay its use; however, there is no prohibition that prevents this water from being used before 2025.

11.4.1.2.3 Pumpage by Existing Users

A certain number of municipal water users in the AMA, those who are not served by designated water providers and who live in subdivisions platted prior to February 1995, are not required under the AWS Program to replace existing groundwater use with renewable supplies. The volume of groundwater pumped by these existing users totals around 22,000 acre-feet per year. This groundwater demand is anticipated to continue through time in the Tucson AMA and is not subject to the existing AWS Program. This water does not have a replenishment obligation associated with it but is subject to conservation requirements.

11.4.1.2.4 Grandfathered Groundwater Rights and Permits

Groundwater is pumped by the industrial and agricultural sectors pursuant to grandfathered groundwater rights and permits. This industrial and agricultural pumpage constitutes a significant portion of the groundwater use in the AMA and is not required to be replenished under current provisions of the Code.

11.4.1.2.5 Remediated Groundwater

In 1997, the Legislature enacted legislation significantly revising the WQARF Program to provide incentives for the use of poor quality groundwater to facilitate the remediation of contaminated groundwater. The WQARF legislation provides that, when determining compliance with management plan conservation requirements, the Department shall account for groundwater withdrawn pursuant to approved remedial action projects under the Comprehensive Environmental Response, Compensation and Liability Act or Title 49 of the Arizona Revised Statutes, in a manner consistent with the accounting for surface water. Laws 1997, Ch. 287, § 51(B). It is assumed in the water budget that between 6,500 acre-feet and 8,400 acre-feet of remediation water will be pumped from the AMA each year from 2000 to 2025 based on the assumption that the Tucson Airport Remediation Project will continue to pump groundwater throughout this time period. This number could increase if additional remediation projects are developed that meet the statutory criteria for the WQARF incentive.

11.4.2 Effluent Supplies

A portion of the effluent produced in the AMA is used for agriculture facilities and for municipal and industrial turf-related facilities. Another portion becomes a source of incidental recharge to the aquifer as a result of being discharged into the Santa Cruz River and infiltrating back to the aquifer. Effluent may also be recharged for annual storage and recovery or for the accumulation and use of long-term storage credits. Recharge may occur through managed effluent recharge projects in the river channel, or through constructed effluent recharge projects. Effluent use approaches are discussed below along with information about their impacts on the water budget. Additional perspectives about the impacts of effluent use approaches on the water budget are shown in the sensitivity analyses in section 11.6.2.

11.4.2.1 Direct Secondary and Reclaimed Effluent Use

Effluent is directly used in two forms in the AMA. Secondary effluent is delivered directly from wastewater treatment plants to agricultural, municipal, and industrial users. Effluent is also diverted from Pima County's Roger Road wastewater treatment plant to the City of Tucson's reclaimed water treatment plant and recharge basins for treatment, storage and eventual delivery through the City's reclaimed water system primarily to serve turf-related uses. Approximately 10,300 acre-feet of effluent were directly used in the AMA in 1995 (Table 11-6). Projections indicate the direct use of around 31,300 acre-feet of effluent in 2025.

In many cases, direct use of effluent requires construction of delivery systems, so its use in the future depends to some extent on the investments made in delivery infrastructure. Around 7,700 acre-feet of effluent were used in 1995 by the municipal sector, which is projected to use 23,600 acre-feet of effluent in 2025. Municipal effluent use consists primarily of reclaimed water use for turf-related facilities but secondary effluent is also used at some facilities. Directly delivered effluent is not subject to municipal GPCD requirements.

Agricultural use of secondary effluent is projected to stay constant at around 3,000 acre-feet per year based on the average annual use by the CMID. There is potential for substantially more agricultural use of effluent if appropriate effluent supplies can be obtained and necessary infrastructure constructed.

Industrial use of effluent was 800 acre-feet in 1995 and is projected to reach 4,700 acre-feet in 2025. Projected industrial use consists primarily of use by turf-related facilities and some projected use by sand and gravel facilities located along the Santa Cruz River. It is assumed the sand and gravel facilities will use the river bed as a conveyance for this secondary effluent.

TABLE 11-6
SECONDARY AND RECLAIMED EFFLUENT SUPPLY ASSUMPTIONS
TUCSON ACTIVE MANAGEMENT AREA

Factors	Projections (acre-feet)							
	1990	1995	2000	2005	2010	2015	2020	2025
Total Effluent Deliveries	11,100	10,300	15,900	21,000	24,700	28,500	30,200	31,300
Secondary Effluent[1]	6,100	3,400	5,000	5,300	6,200	6,700	7,300	7,600
Reclaimed System Effluent	5,000	6,900	10,900	15,700	18,500	21,800	22,900	23,700
Total Effluent Demand	11,100	10,300	15,900	21,000	24,700	28,500	30,200	31,300
Total Municipal Effluent Demand[2]	6,300	7,700	11,600	16,300	18,800	21,900	23,000	23,600
Turf-related Facilities	5,300	5,900	9,300	13,800	16,100	19,000	19,900	20,300
Other	1,000	1,900	2,300	2,500	2,700	2,900	3,100	3,300
Total Agricultural Effluent Demand	4,000	1,800	3,000	3,000	3,000	3,000	3,000	3,000
Total Industrial Effluent Demand	800	800	1,300	1,700	2,900	3,600	4,200	4,700
Turf-related Facilities	800	800	1,100	1,300	2,300	2,800	3,200	3,500
Other	0	0	200	400	600	800	1,000	1,200

[1]Includes secondary effluent from Roger and Ina Road plants and from other outlier plants
[2] Includes secondary and reclaimed water demand only. Does not include effluent credits purchased from Secretary of Interior

Direct delivery of effluent to meet nonpotable water demands in the AMA is of particular benefit when it replaces existing groundwater demand. This reduces groundwater overdraft and leaves more groundwater to meet potable demand. In cases where direct use of effluent is intended to meet future demands that would otherwise be served with groundwater, existing groundwater overdraft is not reduced but increasing future overdraft could be reduced. In cases where the availability of effluent results in new demands being created that would not otherwise have occurred in the AMA, this effluent use is detrimental to the water balance because the effluent will not be available to offset existing or future groundwater pumpage.

11.4.2.2 Incidental Recharge of Effluent

It is estimated that 90 percent of the effluent discharged into the Santa Cruz River from the Ina Road and Roger Road treatment plants reaches the aquifer. This incidental recharge estimate is based on a recent study by the United States Geological Survey of effluent infiltration along the Santa Cruz River. Incidental recharge of effluent discharged to the river bed in 1995 was approximately 50,000 acre-feet (Table 11-7). Future incidental recharge of effluent will decrease as a result of the introduction of managed in-channel effluent recharge projects.

The benefits of direct use of secondary effluent or diversions of effluent to the reclaimed system are partially offset when the effluent is supplied from the County's regional wastewater treatment plants at Ina and Roger Roads because this reduces the volume of effluent discharged to the river and incidentally recharged. Currently, a portion of the effluent that is not directly delivered in the AMA is discharged to the Santa Cruz River bed where around 90 percent of the discharged volume infiltrates back to the aquifer as incidental recharge. This incidental recharge is beneficial to the AMA water budget because it offsets groundwater use in calculations of groundwater overdraft.

11.4.2.3 Managed Recharge of Effluent

Effluent discharged from the Pima County regional wastewater treatment plants at Roger and Ina Roads is controlled by Pima County, the City of Tucson, and the United States Secretary of the Interior. The Secretary controls 28,200 acre-feet, while 90 percent of the remaining effluent is controlled by the City of Tucson and the other 10 percent is controlled by the County. By the year 2000, the City of Tucson and the United States Secretary of the Interior anticipate undertaking managed effluent recharge in the Santa Cruz River with their portions of the effluent that is being discharged from the Ina and Roger Road treatment

TABLE 11-7
MANAGED EFFLUENT RECHARGE PROJECTS
ASSUMPTIONS FOR WATER BUDGET SCENARIOS
TUCSON ACTIVE MANAGEMENT AREA

Factors	Projections (acre-feet)							
	1990	1995	2000	2005	2010	2015	2020	2025
Total Effluent Production at all Plants[1]	59,100	68,600	77,100	85,200	93,400	101,500	109,600	117,400
Effluent Production at Roger and Ina[2]	55,800	65,400	73,500	81,200	88,800	96,300	103,700	111,000
Secondary Effluent Diversions	5,100	3,000	4,500	4,700	4,900	5,100	5,300	5,500
Reclaimed System Diversions	5,000	6,900	9,000	9,600	10,000	10,400	10,100	9,800
Discharge to the Santa Cruz River	45,700	55,500	60,000	66,900	73,900	80,800	88,300	95,700
Total Managed Recharge Volume[3]	0	0	9,300	59,100	64,900	70,600	76,900	83,000
Cut to the Aquifer (50%)[4]	0	0	4,700	29,600	32,400	35,300	38,400	41,500
COT Credits used for Reclaimed[5]	0	0	1,900	6,100	8,500	11,400	12,800	13,900
SOI credits used by Municipal[6]	0	0	0	7,100	14,100	14,100	14,100	14,100
Annual Accrual of Unused Credits	0	0	2,700	16,300	9,900	9,800	11,600	13,500
Cumulative Accrual of Unused Credits	0	0	2,700	50,200	115,700	165,000	218,500	281,200
Incidental Recharge of Effluent[7]	41,200	50,000	45,700	1,200	1,700	2,200	2,700	3,100

[1] Includes production from all wastewater treatment plants in the AMA
[2] Includes production from Roger Road and Ina Road plants only
[3] Assumes the managed in-channel recharge volume for 2005 to 2025 is 90 percent of the City of Tucson's and the Secretary of the Interior's portions of the volume discharged to the Santa Cruz River
[4] Cut to the aquifer is equal to 50 percent of the in-channel recharge volume
[5] Effluent credits recovered by City of Tucson (COT) for delivery through the reclaimed system to meet balance of reclaimed demand
[6] Secretary of the Interior's (SOI) effluent credits recovered for use by municipal water providers (in place of recovery of CAP credits)
[7] Assumes 90 percent of effluent discharged to the river without a subsequent use reaches the aquifer as incidental recharge

plants. This will change the status of effluent discharged to the river to a managed water resource that is the source of accrued effluent recharge credits.

Managed effluent recharge is intended to be an interim measure until a regional effluent utilization approach is determined for this water. Other uses of this effluent could include increased direct use to meet agricultural, municipal, or industrial needs, or recharge in a constructed storage facility. Because the ultimate form effluent use will take is not known at this time, for purposes of the water budget managed effluent recharge is shown continuing through 2025 with the understanding that this could change in the future.

The volume of effluent available for managed effluent recharge depends on the volume discharged to the river. This volume in a given year is the volume produced at the Ina and Roger Road plants that remains after portions are diverted for use by turf-related facilities, agriculture, and the reclaimed system. Increased diversions from the regional plants for direct delivery would reduce discharges to the river and thus the effluent volume that could be used for managed and constructed recharge of effluent. Of the effluent discharged to the river, approximately 90 percent is assumed to be available for managed effluent recharge projects proposed by the City of Tucson and the Secretary of the Interior.

In a managed effluent recharge project, the effluent is still released to the river where it infiltrates to the aquifer, but it is accounted for differently by the Department once it is part of a managed recharge project. Credits are accrued for 50 percent of the volume that recharges the aquifer and the remaining 50 percent is deemed a "cut to the aquifer."

The 50 percent cut to the aquifer for managed effluent recharge represents a substantial reduction from the 90 percent of effluent that previously benefited the aquifer through incidental recharge. Effluent that would otherwise have been tallied as incidental recharge will become available for recovery by pumping groundwater. This could be detrimental to the AMA from a water management standpoint.

The City's current plans are to recover a portion of its effluent credits each year using wells placed adjacent to the river, and to use this recovered effluent to meet a portion of reclaimed water demand. The City's surplus recharged effluent will be accrued as long-term storage credits. The Secretary's effluent credits are intended to be sold and the proceeds of the sale used to purchase water supplies for the Tohono O'odham Nation. It is anticipated that the Secretary's credits will be purchased by municipal water providers to meet renewable use requirements of the AWS Program. Since the water would be put to potable use, it is anticipated that it will be recovered by pumping groundwater from other parts of the basin. The ability to recover credits purchased from the Secretary by pumping groundwater might be limited at the request of the Tohono O'odham to areas of the AMA that are not near the Reservation.

Projections related to managed effluent recharge and recovery are shown in Table 11-7. Total effluent production from all wastewater treatment plants in the AMA was 68,600 acre-feet in 1995 and is projected to reach 117,400 acre-feet by 2025. Of the total effluent produced at the Ina and Roger Road plants, 55,500 acre-feet were discharged to the river in 1995 and 95,700 acre-feet are projected to be discharged in 2025. It is anticipated that managed effluent recharge will commence by 2000.

The volume of managed effluent recharge is projected to be 9,300 acre-feet in 2000 based on an existing permit application submitted to the Department by the City of Tucson and the Secretary of the Interior for effluent in the Santa Cruz River between Roger and Ina Roads. The City and the Secretary have indicated that they will expand their managed recharge permit application to include the rest of the Santa Cruz River inside the AMA, so in the water budget the managed effluent recharge volume is projected to increase to around 59,100 acre-feet per year by 2005.

A portion of projected reclaimed system demand will be met using effluent diverted from the Roger Road treatment plant (some of which will then be stored in the Sweetwater recharge basins) and the remainder will be met using annual storage and recovery of managed effluent recharge credits accrued from effluent recharge (Table 11-7). For purposes of the water budget, it is assumed that the balance of the City's yearly unused managed effluent recharge credits will be accrued, resulting in a cumulative credit balance of 281,200 acre-feet in 2025 (Table 11-7). However, these credits could be recovered at any time by pumping groundwater from other locations in the AMA to serve municipal demand and help meet the City's assured water supply requirements. Managed in-channel effluent recharge credits cannot be considered when the Department evaluates whether a water provider has met the requirements necessary to obtain an assured water supply designation.

Because effluent infiltration has occurred historically and will predictably occur in the future, the cut to the aquifer for managed effluent recharge is added into the water budget in each year that managed recharge occurs, regardless of whether effluent credits are recovered in that year.

11.4.2.4 Constructed Recharge of Effluent

Constructed recharge of effluent takes place in basins or constructed in-channel features rather than in existing river channels that normally receive the water. A portion of the effluent diverted for use in the

reclaimed system is currently recharged at basins constructed at the Sweetwater facility as part of City of Tucson's reclaimed system storage facilities. Effluent is recharged in the winter when demand for reclaimed water decreases and is recovered from this same area in the summer when water demand is high at turf-related facilities. This annual storage and recovery of effluent is accounted for in the reclaimed system diversions in Table 11-7. Annual storage and recovery of effluent stored in a constructed recharge project is considered direct use for purposes of the water budget. Effluent credits accrued through annual storage and recovery in basin recharge projects such as the Sweetwater facility can be used in the assured water supply determination.

Unlike managed in-channel recharge of effluent that has a 50 percent cut to the aquifer, long-term storage and recovery of effluent through constructed recharge projects does not have an associated cut to the aquifer. The volume of effluent recharge credits available for recovery is twice as large for effluent recharged through constructed projects as effluent recharged through managed in-channel projects. Recovery of stored effluent recharge credits can occur outside of the area where the effluent is recharged by pumping an equivalent volume of groundwater. Because effluent can be recovered from wells, the pumped water can be used to meet potable water needs at the same time it is accounted for as effluent. The implementation of this type of project could have the result of reducing the volume of water released to the river channel with corresponding implications for the health of riparian vegetation currently supported by effluent.

11.4.3 Central Arizona Project Water

CAP water can be used directly (except as limited by local ordinances) or through recharge and recovery projects. All CAP water used by the municipal sector, whether supplied though direct delivery or recovered storage, counts against municipal GPCD requirements. In addition, all CAP water use can be considered in obtaining an assured water supply. Because CAP is a renewable supply, CAP water use is considered consistent with achieving the safe-yield goal.

11.4.3.1 Direct Use of Central Arizona Project Water

CAP water is projected to be used directly for irrigation on the San Xavier District and Schuk Toak District by 2005 as discussed in section 11.3.1. CAP water can be delivered directly for potable use, but this has not occurred in the Tucson AMA since 1994. Direct delivery commenced in 1992 but was halted by the Mayor and Council of the City of Tucson in 1994 due to problems with the effects of direct delivery on piping and water quality in the Tucson Water distribution system. The Water Consumer Protection Act (WCPA) of 1995, a citizens' ballot initiative, prohibits direct delivery of CAP by the City of Tucson, as discussed in Chapter 8. The effect of the WCPA is to preclude direct delivery of CAP water unless CAP water can be treated to a quality that meets the initiative requirements or until other actions are taken that result in improvements in treatment plant technology and delivery infrastructure that are sufficient to secure public acceptance of CAP water as a potable supply. Due to these uncertainties regarding direct delivery of CAP water, direct delivery for use by the municipal sector is not projected to occur in the water budget scenarios. All future municipal use of CAP water is projected to occur through the recovery of recharge credits. Direct use of CAP water by the municipal sector in the amount of 100 acre-feet did occur in 1995 to maintain the Hayden-Udall water treatment plant.

11.4.3.2 CAP Recharge and Recovery

CAP recharge can occur in basins and channels, or through injection wells. Use of injection wells for CAP water recharge in the City of Tucson service area is effectively precluded by the WCPA, so basin and in-channel recharge are the current strategies being planned and implemented in the AMA. Recharge and recovery can occur on an annual storage and recovery basis or can be through long-term storage efforts. Credits are accrued by both of these methods; however, for annual storage and recovery projects, these

credits must be recovered the same year the water is recharged. Once CAP water is recharged, the location from which it is "recovered" also affects its management characteristics. Water can be recovered within the Area of Impact (AOI) of water storage or outside the AOI. Criteria listed in Chapter 8 affect the ability of entities to recover water outside the AOI.

Estimates of CAP recharge capacity that could possibly be developed in the Tucson AMA are listed in Table 11-8. These estimates are based on the Regional Recharge Plan prepared by the Department in 1998 to summarize the results of the Institutional and Policy Advisory Group (IPAG) process and represent relatively optimistic estimates. The projected demand for recovery of CAP recharge credits by water providers is less than the possible developable recharge capacity, and is listed in Table 11-9.

While Table 11-8 shows possible developable CAP recharge capacity in the Tucson AMA, the actual volume of CAP recharge is likely to be less. The projected recovery of CAP recharge credits in the water budget shown in Table 11-9 is based on the more probable assumptions about potential demand for CAP recharge capacity that are specified for various water providers in the Regional Recharge Plan. The assumption used in the water budget for Tucson Water is that the volume of CAP recharge in a given year is equal to 80 percent of potable water demand in 2005 and continues at this rate through 2025. For other water providers designated under the AWS Program, it is assumed that CAP recharge is 50 percent of potable demand in 2000, increases to 75 percent of potable demand in 2005, and continues at 75 percent through 2025. This allows some time for recharge facilities to be constructed and begin operation. For subdivisions with Certificates of AWS (applied for after February 1995), it is assumed that the minimum CAP recharge level required by the CAGRD will occur each year. These estimates have been further reduced by the assumption that water providers will replace a portion of CAP credit recovery with recovery of an equal volume of effluent credits available from the Secretary of the Interior. Recovery of these effluent credits by the municipal sector is assumed to start at 7,050 acre-feet in 2005 and reach the full 14,100 acre-feet in 2010 (Table 11-9).

While, for purposes of the water budget, simplifying assumptions have been made about the volume of CAP that will be recharged and recovered, the actual volume water providers choose to recharge and recover could vary substantially from water budget projections and will depend on a number of factors including the recharge capacity of permitted facilities, water demand, physical availability of groundwater, the use of allowable mined groundwater, recovery of effluent recharge credits, and other factors. With the exception of AWBA CAP recharge (see section 11.4.3.3), no estimates have been made of the additional CAP water that might be recharged before 2025 without recovery of the associated credits by 2025. This is due to the high level of uncertainty about the number, size, location, and type of recharge facilities that could be built, and the optimistic assumptions already made that sufficient physical recharge capacity will exist to recharge the CAP necessary to meet projected CAP credit recovery demands. Additionally, if CAP water was eventually treated and served to meet potable demand, this would greatly affect future recharge and recovery decisions.

The total volume of CAP recharge entered in the budget for a given year is based on the total demand for CAP credit recovery assumed for that year in the water budget. There is no cut to the aquifer associated with annual storage and recovery projects so the entire volume of CAP water recharged on this basis can be recovered as credits. Long-term storage projects for CAP water, by statute, have a 5 percent cut to the aquifer associated with the recharge. The cut to the aquifer for long-term storage projects is added into the budget in the year the corresponding CAP credits are recovered.

Subdivisions that are members of the CAGRD can pump groundwater but must have a specified portion of this groundwater pumpage replenished by recharge of a comparable volume of renewable water. There is an associated cut to the aquifer for this replenishment. For purposes of the water budget, it is assumed that the renewable water source used is CAP water. The CAGRD has up to three years after the replenishment

obligation is incurred to recharge the water, but, for purposes of the water budget, it is assumed this recharge occurs in the same year the replenishment obligation is incurred.

CAP water that is recharged but not recovered before 2025 does not appear in the water budget since it would result in an underestimate of groundwater mining. These credits will be recovered in the future and will appear in the water budget at the time they are recovered. The cut to the aquifer associated with these unrecovered credits will appear in the water budget in the year the credits are projected to be recovered.

TABLE 11-8
POSSIBLE DEVELOPABLE RECHARGE CAPACITY FOR CENTRAL ARIZONA PROJECT WATER TUCSON ACTIVE MANAGEMENT AREA

Projected Facilities	Year						
	1995	2000	2005	2010	2015	2020	2025
Groundwater Savings Facilities and Projected Capacity in Acre-feet							
BKW Farms	4,200	16,000	16,000	13,000	9,000	6,000	3,000
Cortaro Marana Irrigation District	5,900	20,000	20,000	16,000	12,000	10,000	5,000
Kai at Picacho	0	11,000	11,000	8,000	6,000	6,000	4,000
BKW Farms at Mile Wide Road	0	600	600	600	600	600	600
Avra Valley Irrigation District	0	12,500	12,500	9,000	6,000	4,000	2,000
Farmers Investment Company	0	20,000	20,000	20,000	15,000	12,000	10,000
ASARCO Mission Complex	0	0	10,000	10,000	10,000	10,000	10,000
Basin and In-Channel Recharge Projects and Projected Capacity in Acre-feet							
Avra Valley	0	11,000	11,000	11,000	11,000	11,000	11,000
Lower Santa Cruz	0	13,000	30,000	30,000	30,000	15,000	10,000
Pima Mine Road	0	10,000	30,000	30,000	30,000	30,000	30,000
CAVSRP	0	15,000	30,000	30,000	60,000	60,000	60,000
Cañada Del Oro - Big Wash	0	0	30,000	30,000	30,000	30,000	30,000
Pantano, Rillito, and Tanque Verde	0	0	10,000	10,000	10,000	0	0
San Xavier District Spreading Basins	0	0	15,000	15,000	15,000	15,000	15,000
San Xavier District Arroyos	0	9,000	9,000	9,000	9,000	9,000	9,000
San Xavier District Santa Cruz River	0	7,000	7,000	7,000	7,000	7,000	7,000
Pascua Yaqui Basins	0	10,000	10,000	10,000	10,000	10,000	10,000
Total	**10,100**	**155,100**	**272,100**	**258,600**	**270,600**	**235,600**	**216,600**

CAVSRP = Central Avra Valley Storage and Recovery Project

11.4.3.3 Extinguishment of CAP Credits

The AWBA recharges CAP water for several purposes, two of which affect water budget assumptions. These purposes are to support achievement of AMA management goals and to provide recoverable water in times of shortage on the Colorado River (see Chapter 8). The AWBA will participate in some CAP recharge projects in the AMA. While it has not occurred yet, a portion of the CAP recharge credits accumulated by the AWBA through these recharge activities could be extinguished to support water management objectives in the AMA. Extinguishment of these credits would prevent them from being recovered in the future, so the CAP water recharged for eventual extinguishment would become a

TABLE 11-9
PROJECTED ANNUAL RECOVERY OF CENTRAL ARIZONA PROJECT AND EFFLUENT RECHARGE CREDITS TUCSON ACTIVE MANAGEMENT AREA

Factors	Year					
	2000	2005	2010	2015	2020	2025
BASE SCENARIO PROJECTIONS IN ACRE-FEET						
Total Renewable Credit Recovery Needed for AWS	**8,550**	**118,940**	**131,230**	**145,360**	**160,650**	**176,190**
Total Demand for Effluent Credits	0	7,050	14,100	14,100	14,100	14,100
Total Demand for CAP Credits	8,550	111,890	117,130	131,260	146,550	162,090
Total CAP Recharge Needed for AWS	**9,000**	**115,500**	**120,960**	**134,200**	**150,230**	**166,520**
Total Demand for CAP Credits	8,550	111,890	117,130	131,260	146,550	162,090
Designations[1]: CAP Credits Projected for ASR[2]	0	43,280	44,330	75,470	76,700	77,960
Designations[1]: CAP Credits Projected for LTS[3]	8,070	66,850	67,990	46,880	56,560	66,410
Certificates[4]: CAGRD Replenishment with CAP[5]	480	1,760	4,810	8,910	13,290	17,720
Total Cut to the Aquifer	450	3,610	3,830	2,940	3,680	4,430
Designations[1]: Cut to the Aquifer[3]	420	3,520	3,580	2,470	2,980	3,500
Certificates: Cut to the Aquifer[5]	30	90	250	470	700	930
TMP SCENARIO PROJECTIONS IN ACRE-FEET						
Total Renewable Credit Recovery Needed for AWS	**8,550**	**114,860**	**121,420**	**134,700**	**148,100**	**160,470**
Total Demand for Effluent Credits	0	7,050	14,100	14,100	14,100	14,100
Total Demand for CAP Credits	8,550	107,810	107,320	120,600	134,000	146,370
Total CAP Recharge Needed for AWS	**9,000**	**111,230**	**110,690**	**123,040**	**137,090**	**150,060**
Total Demand for CAP Credits	8,550	107,810	107,320	120,600	134,000	146,370
Designations[1]: Credits Projected for ASR[2]	0	42,820	43,220	74,260	75,280	76,180
Designations[1]: Credits Projected for LTS[3]	8,070	63,230	59,290	37,430	45,430	52,470
Certificates[4]: CAGRD Replenishment[5]	480	1,760	4,810	8,910	13,290	17,720
Total Cut to the Aquifer	450	3,420	3,370	2,440	3,090	3,690
Designations[1]: Cut to the Aquifer[3]	420	3,330	3,120	1,970	2,390	2,760
Certificates[4]: Cut to the Aquifer[5]	30	90	250	470	700	930

CAP = Central Arizona Project; AWS = Assured Water Supply; CAGRD = Central Arizona Groundwater Replenishment District

[1] Service areas with Assured Water Supply Designations: Tucson Water, Oro Valley, Vail, Marana, Metropolitan Domestic Water Improvement District, Spanish Trail

[2] Annual storage and recovery (ASR) does not have an associated cut to the aquifer

[3] Long-term storage and recovery (LTS) has an associated 5 percent cut to the aquifer

[4] Includes existing and projected subdivisions with Certificates of Assured Water Supply

[5] The CAGRD can recharge CAP up to three years after a CAGRD member pumps groundwater that has an associated replenishment obligation. There is a 5 percent associated cut to the aquifer. For purposes of the water budget, CAP is assumed to be recharged the same year the replenishment obligation is incurred.

permanent addition to the groundwater supply in the aquifer. The volume of CAP recharge credits that could be extinguished by the AWBA has been projected based on estimated annual groundwater withdrawal fees that will be collected and used to purchase and recharge excess CAP water before 2017, the current legislative date for cessation of AWBA activities. Extinguishment of credits is projected to occur as shown in Table 11-10. On a cumulative basis, it would be possible for the AWBA to extinguish 156,650 acre-feet of CAP recharge credits in this AMA by 2017.

TABLE 11-10
PROJECTED EXTINGUISHMENT OF CENTRAL ARIZONA PROJECT RECHARGE CREDITS BY ARIZONA WATER BANKING AUTHORITY TUCSON ACTIVE MANAGEMENT AREA

Scenario	Extinguished CAP Credits (acre-feet)						
	1995	2000	2005	2010	2015	2020	2025
Base Scenario	0	0	0	0	0	0	0
TMP Scenario	0	11,700	8,400	7,900	7,600	0	0

CAP = Central Arizona Project
TMP = Third Management Plan

11.5 RESULTS OF WATER BUDGET ANALYSES

Projected water budget results through 2025 have been calculated for the Base and TMP Scenarios. These scenarios indicate the amount of water conservation and/or supply augmentation needed to offset future groundwater overdraft. The water budget scenarios do not reflect water savings that may result from conservation requirements in the Fourth and Fifth Management Plans. Results of the water budget calculations are tabulated and described in the following sections (Tables 11-11 and 11-12). Analysis and discussion of these results are presented in section 11.6.

11.5.1 Base Scenario

In the Base Scenario, it is assumed that the rate at which water is used by the municipal, industrial, and agricultural sectors in 1995 continues through 2025 (Table 11-11). Cumulative groundwater use by these sectors is shown in Table 11-13. The size of the municipal sector is projected to grow substantially during this period, the size of the industrial sector is expected to grow slightly, and the agricultural sector is projected to decrease in size by 2025.

Total water demand in the Base Scenario in 2025 is projected to be 416,700 acre-feet. Total municipal demand increases from 155,500 acre-feet in 1995 to 267,100 acre-feet in 2025 with a total population of around 1,266,500 in 2025. Recovery of CAP recharge credits by the municipal sector did not occur in 1995 but is projected to reach 8,500 acre-feet in 2000 and 162,100 acre-feet in 2025. This large increase is due to the phasing in of the AWS Program requirements for use of renewable supplies, which begin in 1999 for most large providers and begin in 2001 for Tucson Water. Groundwater use by the municipal sector is projected to be 67,300 acre-feet in 2025, a decrease from 147,700 acre-feet of groundwater use in 1995.

CAP water use for Indian agriculture, overall reduction in agricultural demand, and some effluent use by this sector results in a decrease in groundwater use for agriculture from 96,200 acre-feet in 1995 to 51,200 acre-feet in 2025. Total demand in the agricultural sector was 98,000 acre-feet in 1995 and is projected to decrease to 70,000 acre-feet in 2025. An increase in Indian irrigation is included in this total. Indian demand will be met with 15,800 acre-feet of CAP water by 2025.

TABLE 11-11
BASE SCENARIO: PROJECTED FUTURE CONDITIONS ASSUMING 1995 CONDITIONS CONTINUE THROUGH 2025, TUCSON ACTIVE MANAGEMENT AREA

Sector	1990	1995	2000	2005	2010	2015	2020	2025
Projected AMA Population	655,000	768,000	838,300	920,900	1,005,300	1,092,200	1,179,200	1,266,500
Projected Irrigation Acres	40,000	36,100	35,320	35,750	33,900	30,400	26,400	21,400
IGFRs	40,000	36,100	35,100	33,600	30,600	27,100	23,100	18,100
Indian Irrigation	0	0	220	2,150	3,300	3,300	3,300	3,300
Municipal Sector								
Total Demand	130,100	155,500	172,900	193,500	212,100	231,900	249,800	267,100
Non-Indian[1]	130,000	155,400	172,800	193,400	212,000	231,800	249,600	266,900
Indian[2]	100	100	100	100	100	100	200	200
Total Supply	130,100	155,500	172,900	193,500	212,100	231,900	249,800	267,100
CAP	0	100[3]	8,500[4]	111,900[4]	117,100	131,300	146,600	162,100
Effluent[5]	6,300	7,700	11,600	23,400	32,900	36,000	37,100	37,700
Groundwater	123,800	147,700	152,800	58,200	62,100	64,600	66,100	67,300
Agricultural Sector								
Total Demand	93,800	98,000	104,700	117,700	107,500	97,000	85,000	70,000
Non-Indian[1]	93,800	98,000	103,600	107,400	91,700	81,200	69,200	54,200
Indian[2]	0	0	1,100	10,300	15,800	15,800	15,800	15,800
Total Supply	93,800	98,000	104,700	117,700	107,500	97,000	85,000	70,000
CAP	0	0	0	10,400	15,800	15,800	15,800	15,800
Effluent	4,000	1,800	3,000	3,000	3,000	3,000	3,000	3,000
Groundwater	89,800	96,200	101,700	104,300	88,700	78,200	66,200	51,200
Industrial Sector								
Total Demand	48,800	60,200	71,000	72,100	73,800	73,500	74,700	75,900
Total Supply	48,800	60,200	71,000	72,100	73,800	73,500	74,700	75,900
CAP	0	0	0	0	0	0	0	0
Effluent	800	800	1,300	1,700	2,900	3,600	4,200	4,700
Groundwater	48,000	59,400	69,700	70,400	70,900	69,900	70,500	71,200
Other Demands								
Demand: Evapotranspiration	3,700	3,700	3,700	3,700	3,700	3,700	3,700	3,700
Supply: Groundwater	3,700	3,700	3,700	3,700	3,700	3,700	3,700	3,700
Total Demand	276,400	317,400	352,300	387,000	397,100	406,100	413,200	416,700
Total Groundwater Use	265,300	307,000	327,900	236,600	225,400	216,400	206,500	193,400
(Less) Net natural recharge[6]	60,800	60,800	60,800	60,800	60,800	60,800	60,800	60,800
(Less) Incidental recharge[7]	70,300	82,300	80,800	39,900	35,600	35,200	34,400	33,300
(Less) Cuts to aquifer	0	0	5,100	33,200	36,300	38,200	42,100	46,000
(Less) Extinguished credits[8]	0	0	0	0	0	0	0	0
Actual Overdraft	134,200	163,900	181,200	102,700	92,700	82,200	69,200	53,300
(Less) Remediation water	0	0	8,400	7,000	6,500	6,500	6,500	6,500
(Less) Allowable groundwater	0	0	10,000	33,400	37,000	39,200	40,300	41,100
Accounting Overdraft	134,200	163,900	162,800	62,300	49,200	36,500	22,400	5,700

NOTE: all units are acre-feet unless otherwise noted.
AMA = Active Management Area; IGFRs = Irrigation Grandfathered Rights; CAP = Central Arizona Project

[1] Non-Indian demand indicates demand for uses off Indian Reservation lands. For the municipal sector, this demand includes exempt well use. For the agricultural sector, this demand includes canal losses and irrigation use by exempt small rights.
[2] Indian demand includes San Xavier and Schuk Toak Districts of the Tohono O'odham Reservation within AMA boundaries
[3] 100 acre-feet of CAP water used for treatment plant maintenance
[4] Renewable supply use by Tucson Water commences in 2001
[5] Includes secondary effluent, reclaimed system effluent, and effluent credits purchased from the Secretary of the Interior
[6] Net Natural Recharge is composed of mountain front recharge, stream channel recharge, and groundwater inflow less outflow.
[7] Incidental recharge decreases between 2000 and 2005 when managed in-channel effluent recharge increases substantially
[8] Extinguishment of Arizona Water Banking Authority CAP recharge credits is not assumed to take place in the Base Scenario

TABLE 11-12
THIRD MANAGEMENT PLAN SCENARIO: PROJECTED FUTURE CONDITIONS ASSUMING THIRD MANAGEMENT PLAN CONSERVATION GOALS ARE ACHIEVED BY 2010 AND CONTINUE THROUGH 2025, TUCSON ACTIVE MANAGEMENT AREA

Sector	1990	1995	2000	2005	2010	2015	2020	2025
Projected AMA Population	655,000	768,000	838,300	920,900	1,005,300	1,092,200	1,179,200	1,266,500
Projected Irrigation Acres	40,000	36,100	35,320	35,750	33,900	30,400	26,400	21,400
IGFRs	40,000	36,100	35,100	33,600	30,600	27,100	23,100	18,100
Indian Irrigation	0	0	220	2,150	3,300	3,300	3,300	3,300
Municipal Sector								
Total Demand	130,100	155,500	172,900	188,300	199,800	218,500	234,000	247,300
Non-Indian[1]	130,000	155,400	172,800	188,200	199,700	218,400	233,800	247,100
Indian[2]	100	100	100	100	100	100	200	200
Total Supply	130,100	155,500	172,900	188,300	199,800	218,500	234,000	247,300
CAP	0	100[3]	8,500[4]	107,800[4]	107,300	120,600	134,000	146,400
Effluent[5]	6,300	7,700	11,600	23,400	32,900	36,000	37,100	37,700
Groundwater	123,800	147,700	152,800	57,100	59,600	61,900	62,900	63,200
Agricultural Sector								
Total Demand	93,800	98,000	104,700	117,700	107,500	97,000	85,000	70,000
Non-Indian[1]	93,800	98,000	103,600	107,400	91,700	81,200	69,200	54,200
Indian[2]	0	0	1,100	10,300	15,800	15,800	15,800	15,800
Total Supply	93,800	98,000	104,700	117,700	107,500	97,000	85,000	70,000
CAP	0	0	0	10,400	15,800	15,800	15,800	15,800
Effluent	4,000	1,800	3,000	3,000	3,000	3,000	3,000	3,000
Groundwater	89,800	96,200	101,700	104,300	88,700	78,200	66,200	51,200
Industrial Sector								
Total Demand	48,800	60,200	71,000	72,100	73,300	73,000	74,200	75,400
Total Supply	48,800	60,200	71,000	72,100	73,300	73,000	74,200	75,400
CAP	0	0	0	0	0	0	0	0
Effluent	800	800	1,300	1,700	2,900	3,600	4,200	4,700
Groundwater	48,000	59,400	69,700	70,400	70,400	69,400	70,000	70,700
Other Demands								
Demand: Evapotranspiration	3,700	3,700	3,700	3,700	3,700	3,700	3,700	3,700
Supply: Groundwater	3,700	3,700	3,700	3,700	3,700	3,700	3,700	3,700
Total Demand	276,400	317,400	352,300	381,800	384,300	392,200	396,900	396,400
Total Groundwater Use	265,300	307,000	327,900	235,500	222,400	213,200	202,800	188,800
(Less) Net natural recharge[6]	60,800	60,800	60,800	60,800	60,800	60,800	60,800	60,800
(Less) Incidental recharge[7]	70,300	82,300	80,800	39,700	35,000	34,500	33,700	32,400
(Less) Cuts to aquifer	0	0	5,100	33,000	35,800	37,700	41,500	45,200
(Less) Extinguished credits[8]	0	0	11,700	8,400	7,900	7,600	0	0
Actual Overdraft	134,200	163,900	169,500	93,600	82,900	72,600	66,800	50,400
(Less) Remediation water	0	0	8,400	7,000	6,500	6,500	6,500	6,500
(Less) Allowable groundwater	0	0	10,000	32,400	34,500	36,500	37,000	37,000
Accounting Overdraft	134,200	163,900	151,100	54,200	41,900	29,600	23,300	6,900

NOTE: all units are acre-feet unless otherwise noted.
AMA = Active Management Area; IGFRs = Irrigation Grandfathered Rights;

[1] Non-Indian demand indicates demand for uses off Indian Reservation lands. For the municipal sector, this demand includes exempt well use. For the agricultural sector, this demand includes canal losses and irrigation use by exempt small rights.
[2] Indian demand includes San Xavier and Schuk Toak Districts of the Tohono O'odham Reservation within AMA boundaries
[3] 100 acre-feet of CAP water used for treatment plant maintenance
[4] Renewable supply use by Tucson Water commences in 2001
[5] Includes secondary effluent, reclaimed system effluent, and effluent credits purchased from the Secretary of the Interior
[6] Net Natural Recharge is composed of mountain front recharge, stream channel recharge, and groundwater inflow less outflow.
[7] Incidental recharge decreases between 2000 and 2005 when managed in-channel effluent recharge increases substantially
[8] Extinguishment of Arizona Water Banking Authority CAP recharge credits is assumed to take place only in the TMP Scenario

Industrial demand is projected to continue to grow slightly during this period with effluent use replacing some groundwater use. Groundwater use is projected to be 71,200 acre-feet in 2025 for the industrial sector, an increase from 59,400 acre-feet in 1995. Total demand by 2025 is projected to be 75,900 acre-feet for the industrial sector, an increase from 60,200 acre-feet in 1995.

In the Base Scenario, groundwater accounts for 193,400 acre-feet of water use in 2025 for all sectors combined. This total volume is offset by a combined total of 140,100 acre-feet of net natural recharge, incidental recharge, and cuts to the aquifer from recharge projects to yield an actual overdraft of 53,300 acre-feet. The subtraction of allowable mined remediation water and allowable mined groundwater through the AWS Program reduces the actual groundwater overdraft to 5,700 acre-feet. For accounting purposes, the use of allowable mined groundwater is considered acceptable in the context of meeting the AMA's goal. However, in actuality groundwater overdraft continues and this issue may need to be revisited. Cumulative actual and accounting groundwater overdraft between 1995 and 2025 is shown in Table 11-13.

TABLE 11-13
BASE AND TMP SCENARIOS CUMULATIVE WATER BUDGET FACTORS
TUCSON ACTIVE MANAGEMENT AREA

BASE SCENARIO	
Cumulative Municipal Groundwater use 1995 to 2025 Cumulative Agricultural Groundwater use 1995 to 2025 Cumulative Industrial Groundwater use 1995 to 2025	2,704,200 acre-feet 2,660,200 acre-feet 2,142,900 acre-feet
Cumulative Municipal Remedial Groundwater Use 2000 to 2025 Cumulative Municipal Allowable Groundwater Use 2000 to 2025	178,150 acre-feet 887,250 acre-feet
Cumulative Arizona Water Banking Authority Extinguished Credits 2000 to 2017	0 acre-feet
Cumulative Actual Overdraft 1995 to 2025 Cumulative Accounting Overdraft 1995 to 2025	3,346,900 acre-feet 2,253,900 acre-feet
TMP SCENARIO	
Cumulative Municipal Groundwater use 1995 to 2025 Cumulative Agricultural Groundwater use 1995 to 2025 Cumulative Industrial Groundwater use 1995 to 2025	2,646,450 acre-feet 2,660,200 acre-feet 2,134,150 acre-feet
Cumulative Municipal Remedial Groundwater Use 2000 to 2025 Cumulative Municipal Allowable Groundwater Use 2000 to 2025	178,150 acre-feet 829,500 acre-feet
Cumulative Arizona Water Banking Authority Extinguished Credits 2000 to 2017	156,650 acre-feet
Cumulative Actual Overdraft 1995 to 2025 Cumulative Accounting Overdraft 1995 to 2025	3,126,650 acre-feet 2,091,400 acre-feet

11.5.2 Third Management Plan Scenario

The TMP Scenario assumes that Third Management Plan conservation goals are met by 2010 and this level of conservation continues through 2025 (Table 11-12). Cumulative groundwater use by these sectors is shown in Table 11-13. Water supplies projected to meet municipal, agricultural and industrial water demands are shown in Figure 11-2. Specific changes made between the Base Scenario and the TMP

Scenario to address conservation savings include a decrease in average municipal GPCD from 172 in 1995 to 158 in 2025 and a 1 percent savings in industrial water use for mines and sand and gravel facilities. Total demand for all sectors in the TMP Scenario is projected to be 396,400 acre-feet in 2025.

Total demand for the municipal sector is projected at 247,300 acre-feet in 2025, with estimated conservation savings of 19,800 acre-feet in the TMP Scenario compared to the Base Scenario. Groundwater demand by the municipal sector is projected to be 63,200 acre-feet in 2025. Agricultural demand is 70,000 acre-feet in both the Base and TMP Scenarios with groundwater demand in 2025 and cumulative groundwater demand remaining the same in both water budget scenarios. Industrial demand is projected at 75,400 acre-feet in 2025 in the TMP Scenario indicating conservation savings of around 500 acre-feet over the Base Scenario. Groundwater demand is projected to total 70,700 acre-feet for industrial users in 2025. Differences in sector demand between the Base and TMP Scenarios are shown in Figure 11-3 (Note: Base and TMP Scenario industrial demand differences do not show on this graph because of their relatively small magnitude).

Third Management Plan conservation requirements are projected to decrease municipal and industrial groundwater demand by a cumulative total of 57,750 acre-feet and 8,750 acre-feet, respectively, between 1995 and 2025 (Table 11-13).

In the TMP Scenario, groundwater accounts for 188,800 acre-feet of the water use in 2025 with around 138,400 acre-feet of this groundwater use offset by net natural recharge, incidental recharge, and cuts to the aquifer from recharge projects to yield an actual overdraft of 50,400 acre-feet. The subtraction of remediation groundwater and allowable mined groundwater through the AWS Program reduces the actual groundwater overdraft to an accounting-based overdraft of 6,900 acre-feet in 2025. While actual overdraft in the TMP Scenario is 2,900 acre-feet less than that in the Base Scenario, the accounting overdraft is 1,200 acre-feet higher in the TMP, reflecting the effects of reduced use of allowable mined groundwater due to lower overall municipal demand. Again, for accounting purposes, the use of allowable mined groundwater is considered acceptable in the context of meeting the AMA's goal. However, in actuality groundwater overdraft continues and this issue may need to be revisited. Extinguishment of CAP credits by the AWBA affects overdraft only in the water budget years of 2000 to 2015, therefore overdraft in 2025 is not reduced by this factor.

Cumulative actual and accounting groundwater overdraft between 1995 and 2025 is shown in Table 11-13. A comparison of the actual cumulative groundwater overdraft of 3,346,900 in the Base Scenario, and 3,126,650 acre-feet in the TMP Scenarios indicates a cumulative groundwater savings of around 220,250 acre-feet during the time period of 1995 to 2025. Groundwater reserves in the Tucson AMA in 1995 were estimated at 63 million acre-feet to a depth of 1,200 feet below land surface. Groundwater overdraft of around 3.1 million acre-feet by 2025 would reduce the volume of groundwater in storage by approximately 5 percent. It is important to note that although groundwater storage is estimated to a depth of 1,200 feet below land surface, it is not feasible to pump groundwater from this depth due to land subsidence, water quality deterioration, loss of well productivity, and increased pumping costs. With the large CAP allocations available for use in the Tucson AMA, the vast majority of this change in groundwater storage could be prevented by full utilization of this renewable water supply.

11.6 ANALYSIS AND DISCUSSION

The water budget can be evaluated relative to past projections, its sensitivity to changes in budget variables, and its context in the span of the next century. These topics are discussed in the following sections.

FIGURE 11-2
THIRD MANAGEMENT PLAN SCENARIO
TUCSON ACTIVE MANAGEMENT AREA

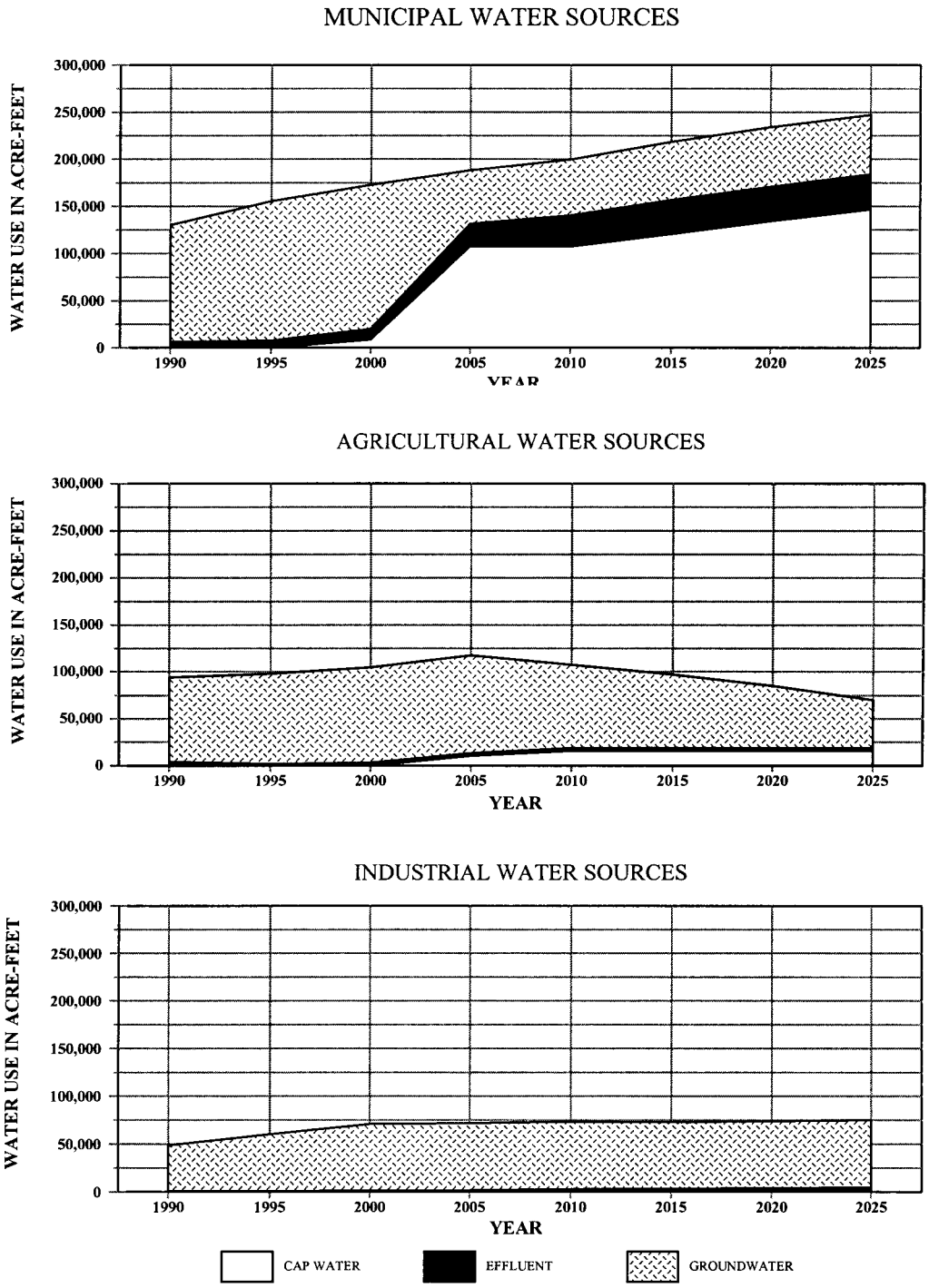
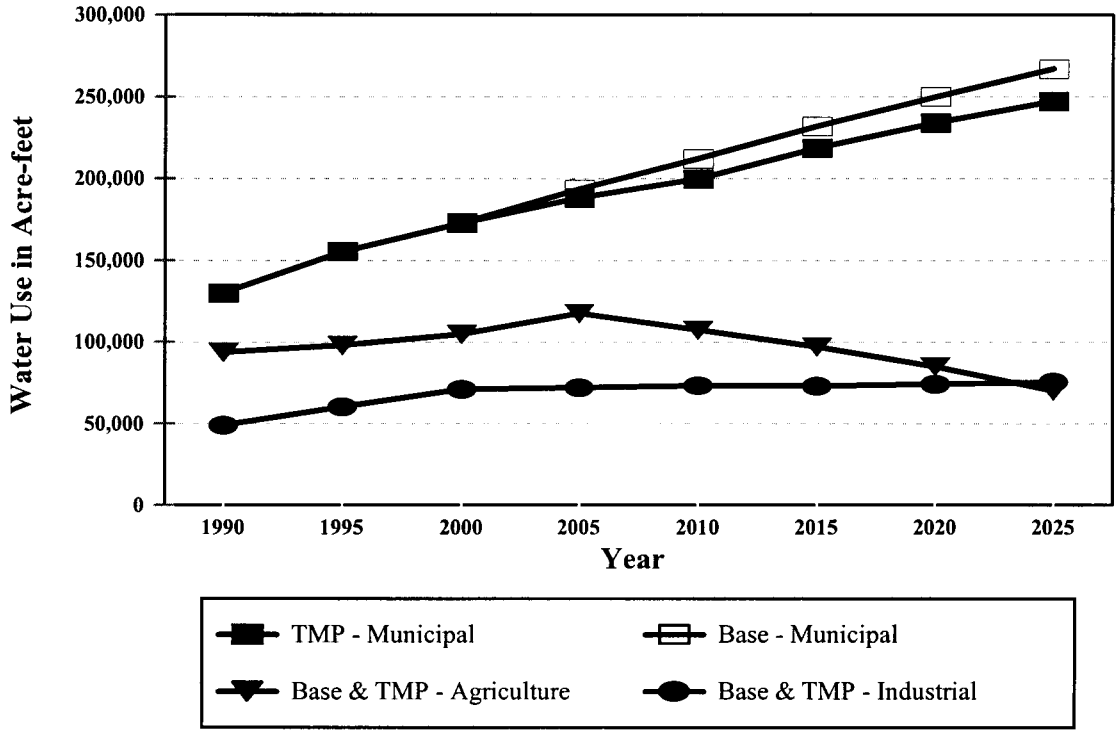


FIGURE 11-3
COMPARISON OF BASE SCENARIO AND
THIRD MANAGEMENT PLAN SCENARIO DEMAND
TUCSON ACTIVE MANAGEMENT AREA



11.6.1 Comparison to Previous Water Budget Analyses

Water use scenarios prepared for the Second Management Plan included the portion of the Upper Santa Cruz Valley Subbasin located between the United States/Mexico border and approximately the Pima/Santa Cruz County line. This area has since become the Santa Cruz AMA and is no longer included in water budget estimates for the Tucson AMA. Overdraft, water demand, and water supply numbers from the Second Management Plan are not strictly comparable to Third Management Plan numbers because of this change in geographic extent. Nevertheless, it is useful to compare selected assumptions to show their evolution from the Second Management Plan to the Third Management Plan.

Municipal, industrial, and agricultural sector water use projections have been updated to reflect current conditions and Third Management Plan conservation requirements. Population projections have been revised to an estimated 1,266,500 inhabitants in 2025 based on updated population data and growth projections. The Second Management Plan projected a population of 1,693,000 in 2025.

It was anticipated in the Second Management Plan water budget that 166,000 acre-feet of CAP water would be delivered for direct use by the municipal sector in 1995. Due to problems with direct delivery and the resultant shut down of the CAP water treatment plant, CAP water use in 1995 was only around

10,000 acre-feet and was almost all in the form of recharge through groundwater savings facilities; the associated recharge credits were not recovered in 1995. Only the 100 acre-feet of CAP water directly used to maintain the Hayden-Udall treatment plant is shown in the water budget for 1995. In the Third Management Plan, it is assumed that municipal sector use of CAP water takes the form of recovery of CAP recharge credits rather than direct delivery. Less acreage is projected to be used for Indian agriculture than the 11,300 acres projected in the Second Management Plan. The Third Management Plan projection is for 3,300 acres of irrigated agriculture to be developed based on current estimates of potential CAP utilization on Indian lands.

In the Second Management Plan document, it was expected that 50 percent of effluent would be used directly or artificially recharged by 2000, in part based on plans for effluent utilization by the City of Nogales, which was then part of the Tucson AMA. In the Third Management Plan, effluent use in the form of secondary effluent use and reclaimed system use is projected to reach around 31,300 acre-feet by 2025. An additional 14,100 acre-feet of long-term storage credits from managed effluent recharge projects are also projected to be used in 2025. This total use of 45,400 acre-feet represents around 40 percent of the 117,400 acre-feet of total effluent production.

Second Management Plan assumptions that storm water recharge, watershed management, and weather modification would supply 10,000 acre-feet per year beginning in 2000 have not been carried over into the Third Management Plan water budgets. This change reflects the increasing focus on using currently available renewable supplies rather than creating new water sources through technological efforts.

The Third Management Plan estimate of net natural recharge is 60,800 acre-feet per year, compared to 62,000 acre-feet per year in the Second Management Plan. This change reflects revisions based on recent computer modeling results and removal of net natural recharge volumes for what is now the Santa Cruz AMA.

Several incidental recharge factors have been revised since the Second Management Plan. Effluent discharged into the Santa Cruz River bed is now estimated to have an incidental recharge factor of 90 percent rather than the 40 percent factor used in the Second Management Plan. A 4 percent incidental recharge factor has been added for municipal sector use based on assumptions about the level of municipal incidental recharge used in the AWS Program and the municipal Non-Per Capita Conservation Program. Incidental recharge from the metal mines has been revised from 25 percent of demand in the Second Management Plan to 12 percent in the Third Management Plan based on a recent analysis of water use at AMA metal mines. A 12 percent incidental recharge factor has been added to address other large industrial water users as well.

CAP recharge projects in which long-term storage credits are accrued or CAGRD replenishment occurs include a 5 percent cut to the aquifer. Managed effluent recharge using the Santa Cruz River channel results in a 50 percent cut to the aquifer. These cuts to the aquifer offset total groundwater use in the calculation of groundwater overdraft. Additional factors added to the Third Management Plan water budgets affect overdraft calculations. These include extinguishment of AWBA CAP recharge credits, use of remediation water, and use of allowable mined groundwater under the AWS Rules.

11.6.2 Sensitivity Analyses

Sensitivity analyses were performed on selected water budget factors to determine the hypothetical impacts of these factors on sector demand, cumulative groundwater use, actual overdraft, and accounting overdraft. As discussed in the following sections, the Department's control over these factors varies from having a major impact to having no impact at all.

Two types of variations were evaluated. In the first approach, sector demand and supply factors were increased or decreased by a consistent 10 percent, one factor at a time. In the second approach, selected factors were changed one at a time by a variety of amounts based on hypothetical future changes in demand and supply. Each variation can affect other calculations in the budget such as incidental recharge. Both sensitivity analysis approaches illustrate hypothetical ranges that could occur in the future and do not constitute projections. The TMP Scenario was used as the starting point for all sensitivity analysis calculations.

11.6.2.1 Variations of 10 Percent in Sector Variables

Municipal, industrial, and agricultural factors were adjusted one at a time to 110 percent of their current projections and to 90 percent of their current projections in order to determine the relative impact of these factors on 2025 sector demand, cumulative groundwater use for that sector between 1995 and 2025, actual groundwater overdraft in 2025 and accounting overdraft in 2025. These are listed below and include both demand and supply factors. Results of these analyses are shown in Table 11-14.

- Municipal GPCD water use rates
- Municipal demand for CAP recharge credits
- Irrigation efficiency
- Agricultural effluent use
- Metal mining water demand
- Industrial effluent use

The sensitivity analysis results illustrate the complex interaction between water budget variables. For example, changes in municipal GPCD have a large potential impact on municipal sector demand in 2025 and cumulative municipal groundwater demand from 1995 to 2025 (Table 11-14). In terms of the demand factors, this is consistent with the growing dominance of municipal use in the water budget. In 1995, the municipal sector constituted about 50 percent of water use in the AMA. In 2025, it is projected to increase to around 60 percent of AMA water use. Variations in GPCD had a relatively small impact on actual and accounting overdraft in 2025. The overdraft volumes illustrate the effect of the AWS Rules, which require the municipal sector to meet its growing demand with renewable supplies. This buffers the effects of changes in municipal demand on overdraft. However, neither projections nor sensitivity analyses cover all possible future scenarios, nor do they extend past 2025. If, due to large increases in population, large increases in per capita use, reduced availability of renewable supplies, and/or depletion of allowable mined groundwater reserves, municipal demand becomes greater than the available CAP, effluent, and allowable mined groundwater supplies, municipal demand will have a substantial effect on overdraft. Reductions in municipal demand now reduce the rate at which allowable groundwater reserves are used, retaining them for future use.

If use of CAP recharge credits increased by 10 percent, municipal demand would not change but actual groundwater overdraft and cumulative municipal groundwater use could be reduced substantially. Accounting overdraft would change only slightly, since increased CAP use would basically replace allowable groundwater use, with an associated small change in the CAP cut to the aquifer. The need for municipal recovery of CAP recharge credits is a function of requirements of the AWS Rules, but the time table for recovery of these credits is flexible for water providers. Complete conversion to renewable supplies by 2025 is not within regulatory control.

TABLE 11-14
RESULTS OF SENSITIVITY ANALYSIS OF 10 PERCENT VARIATIONS ON OVERDRAFT IN 2025
TUCSON ACTIVE MANAGEMENT AREA

Variable Values in 2025	2025 Sector Demand (AF)	Change in Sector Demand (AF)	1995 - 2025 Cum Grw use by Sector (AF)	Change in Cum Grw Use (AF)	2025 Actual Overdraft (AF)	Change in Actual Overdraft (AF)	2025 Accounting Overdraft (AF)	Change in Accounting Overdraft (AF)
GPCD Variations								
142 GPCD (-10%)	225,000	-22,300	2,479,700	-166,750	47,600	-2,800	8,700	1,800
158 GPCD (TMP)	247,300	0	2,646,450	0	50,400	0	6,900	0
174 GPCD (+10%)	269,700	22,400	2,811,200	164,750	53,400	3,000	5,300	-1,600
CAP Credit Recovery								
161,040 AF (+10%)	247,300	0	2,360,950	-285,500	35,500	-14,900	6,200	-700
146,400 AF (TMP)	247,300	0	2,646,450	0	50,400	0	6,900	0
131,760 AF (-10%)	247,300	0	2,931,200	284,750	65,300	14,900	7,500	600
Irrigation Efficiency								
88% (+10%)	65,100	-4,900	2,442,450	-217,750	46,200	-4,200	2,700	-4,200
80% (TMP)	70,000	0	2,660,200	0	50,400	0	6,900	0
72% (-10%)	76,000	6,000	2,927,200	267,000	55,400	5,000	11,900	5,000
Agricultural Effluent								
3,300 AF (+10%)	70,000	0	2,651,950	-8,250	50,300	-100	6,800	-100
3,000 AF (TMP)	70,000	0	2,660,200	0	50,400	0	6,900	0
2,700 AF (-10%)	70,000	0	2,668,450	8,250	50,400	0	6,900	0
Mining Demand								
42,300 AF (-10%)	70,700	-4,700	2,004,400	-129,750	46,300	-4,100	2,800	-4,100
47,000 AF (TMP)	75,400	0	2,134,150	0	50,400	0	6,900	0
51,700 AF (+10%)	80,100	4,700	2,263,900	129,750	54,500	4,100	11,000	4,100
Industrial Effluent								
5,200 AF (+10%)	75,400	0	2,125,900	-8,250	50,100	-300	6,600	-300
4,700 AF (TMP)	75,400	0	2,134,150	0	50,400	0	6,900	0
4,300 AF (-10%)	75,400	0	2,141,900	7,750	50,800	400	7,300	400

Cum Grw = Cumulative Groundwater
AF = acre-feet
GPCD = gallons per capita per day
TMP = Third Management Plan
CAP= Central Arizona Project

In 2025, agricultural and industrial uses are each projected to constitute around 20 percent of AMA demand. Increases or decreases in variables affecting demand in these sectors result in a smaller change in water volume than those experienced in the municipal sector. However, in contrast to the municipal sector, changes in agricultural and industrial demand have a relatively direct effect on actual overdraft, accounting overdraft, and cumulative groundwater use since groundwater is the predominant supply for these sectors.

Changes of 10 percent in agricultural and industrial effluent use have no impact on overall sector demand, and only small impacts on cumulative groundwater use by these sectors, since a 10 percent change equates to less than 500 acre-feet difference in effluent use each year. Actual and accounting overdraft change very little in the case of shifts in agricultural effluent use because this effluent is supplied by Pima County and would be discharged to the Santa Cruz River if it were not diverted for agricultural use, where the majority would infiltrate as incidental recharge. Actual and accounting overdraft change slightly with changes in industrial effluent demand because it is assumed that most of this effluent would otherwise become part of the managed effluent recharge project, so only 50 percent of it would infiltrate as incidental recharge if it were not diverted for industrial use.

11.6.2.2 Hypothetical Variations in Selected Factors Affecting Groundwater Overdraft

Several additional factors were evaluated to determine the effect on water use of hypothetical major shifts in variables (Table 11-15). The following supply and demand factors were evaluated:

- Comparison of TMP Scenario population estimates to a hypothetical population of 1,000,000 by 2025.
- Comparison of TMP Scenario CAP demand estimates to CAP demand if 100 percent of potable demand was met by recovery of CAP recharge credits.
- Comparison of TMP Scenario for managed effluent recharge to hypothetical effects of using this same volume of water in constructed effluent recharge projects or of not conducting either managed or constructed effluent recharge.
- Comparison of TMP Scenario reductions in IGFRs of 50 percent to a hypothetical 75 percent reduction in IGFRs.
- Comparison of TMP Scenario agricultural effluent use projections to the hypothetical effects of agricultural use of 28,200 acre-feet of effluent available from the United States Secretary of the Interior in place of groundwater.
- Comparison of TMP Scenario metal mining demand estimates to the lower mining demand level experienced in the 1980s.
- Comparison of TMP Scenario metal mining demand met entirely by groundwater to hypothetical direct use of 10,000 acre-feet of CAP water to meet mining demand.

Since these changes are hypothetical and not related to one another, they are not strictly comparable, but they do illustrate the impact of several key factors on water use. Population projections change when new data indicate shifts in growth rates. If population reached only 1,000,000 people in 2025, municipal demand would be reduced substantially (Table 11-15). Because municipal demand must be met primarily with renewable supplies, this population change has a relatively small impact on cumulative groundwater use and actual and accounting overdraft.

Municipal demand for recovery of CAP credits will be determined on a year-to-year basis by water providers. If CAP credits were used to meet 100 percent of potable demand by large water providers in 2025, municipal demand in that year would not change, but actual groundwater overdraft would be reduced while accounting overdraft would not change substantially. Cumulative groundwater savings from 1995 to 2025 would be substantial if CAP credits were used to meet 100 percent of potable demand as soon as the assured water supply requirements took effect.

TABLE 11-15
RESULTS OF HYPOTHETICAL CHANGES OF SELECTED VARIABLES ON OVERDRAFT IN 2025
TUCSON ACTIVE MANAGEMENT AREA

Variable Values in 2025	2025 Sector Demand (AF)	Change in Sector Demand (AF)	1995 - 2025 Cum Grw use by Sector (AF)	Change in Cum Grw Use (AF)	2025 Actual Overdraft (AF)	Change in Actual Overdraft (AF)	2025 Accounting Overdraft (AF)	Change in Accounting Overdraft (AF)
Municipal Population								
1,000,000	200,400	-46,900	2,540,950	-105,500	44,400	-6,000	10,500	3,600
1,266,500, TMP	247,300	0	2,646,450	0	50,400	0	6,900	0
Municipal CAP Credit Recovery								
183,400 AF, 100 % of potable	247,300	0	1,917,950	-728,500	11,700	-38,700	5,200	-1,700
146,370 AF, TMP	247,300	0	2,646,450	0	50,400	0	6,900	0
Municipal Effluent Recharge								
0 AF of effluent recharge	247,300	0	2,646,450	0	8,100	-42,300	-35,400	-42,300
83,000 AF constructed effluent recharge	247,300	0	2,646,450	0	92,600	42,200	49,100	42,200
83,000 AF managed effluent recharge	247,300	0	2,646,450	0	50,400	0	6,900	0
IGFR Acreage								
9,000 acres, reduce 75%	42,900	-27,100	1,459,950	-1,200,250	27,600	-22,800	-15,900	-22,800
18,100 acre, TMP	70,000	0	2,660,200	0	50,400	0	6,900	0
Direct Effluent Use by Agriculture								
28,200 AF, SOI effluent	70,000	0	2,093,200	-567,000	35,800	-14,600	-7,700	-14,600
3,000 AF, TMP	70,000	0	2,660,200	0	50,400	0	6,900	0
Mining Demand								
24,000 AF, 1987 demand	52,400	-23,000	1,497,150	-637,000	30,200	-20,200	-13,300	-20,200
47,000 AF, TMP	75,400	0	2,134,150	0	50,400	0	6,900	0
Mine CAP Use								
10,000 AF direct CAP; rest groundwater	75,400	0	1,859,150	-275,000	40,400	-10,000	-3,100	-10,000
47,000 AF groundwater, TMP	75,400	0	2,134,150	0	50,400	0	6,900	0

AF = acre-feet
TMP = Third Management Plan
IGFR = Irrigation Grandfathered Right
Cum Grw = cumulative groundwater
CAP = Central Arizona Project
SOI = Secretary of the Interior

The impact on overdraft of changes in municipal effluent use approaches reflect the complexity of relationships between direct use of effluent, incidental recharge of effluent, and recharge of effluent through managed in-channel or constructed basin recharge with later recovery of effluent credits. If effluent was not subject to recharge and recovery, actual and accounting overdraft would be substantially lower in 2025. Conversely, recharge of effluent through the use of constructed basins results in a substantial increase in actual and accounting overdraft in 2025. These changes are the result of variations in incidental recharge volumes and cuts to the aquifer that result from these different effluent use approaches. Recovery of effluent credits was not projected to increase for the municipal sector under this sensitivity analysis.

Future reductions in IGFR acreage will be a function of urban development patterns in agricultural areas of the AMA. If, by 2025, acreage decreased by 75 percent from its level in 1995, this would result in significant reductions in sector demand, actual overdraft, accounting overdraft, and cumulative groundwater use by this sector compared to the 50 percent acreage reduction assumed in the Third Management Plan. The direct use of 28,200 acre-feet of effluent by the agricultural sector with no corresponding accrual of credits through, for example, a groundwater savings project, also results in substantial reductions in actual and accounting overdraft and cumulative groundwater use.

Mining demand fluctuates with worldwide market conditions, local ore quality, and the state of mining technology, among other factors. If mining demand were to return to the low water use levels experienced in 1987, sector demand, cumulative groundwater use, actual overdraft and accounting overdraft would all decrease significantly. The direct use of 10,000 acre-feet of CAP water by metal mines would not change sector demand but would result in decreases in the other factors.

11.6.3 Factors Affecting the Ability to Reach and Maintain Safe-yield

Some of the factors that influence the AMA's ability to achieve safe-yield are affected by mandates of the Code. These include conservation requirements, the AWS Program, AWBA efforts to store excess CAP water, and incentives for use of renewable supplies. There are a number of factors that affect safe-yield that are not under the control of the Department. Many of these factors relate to CAP water utilization while others relate to pricing, municipal growth, changes in land utilization, and industrial demand. The impacts of factors that are not under departmental influence vary depending on the time frame in which they are viewed.

Conservation requirements specified in this and subsequent management plans will need to become increasingly stringent to reduce water demand particularly in the agricultural and industrial sectors since these conservation requirements have a direct effect on both actual and accounting overdraft calculations. The Department will prepare additional conservation requirements in the fourth and fifth management periods.

Regardless of these conservation requirements, some volume of groundwater will need to be pumped on an ongoing basis to meet the demand for the 1995 population of municipal users who do not obtain water from designated water providers. Additionally, groundwater will continue to be pumped to meet established grandfathered rights under the Code and allowable groundwater use under the AWS Rules. These continued uses could result in further depletion of groundwater supplies and resultant aquifer compaction and land subsidence. This problem could be mitigated to a certain extent by the purchase and retirement of grandfathered water rights and by managing critical areas of the AMA to prevent damage from further water level declines. In addition, it may be prudent to examine the potential need for replenishment requirements for some of the existing groundwater uses that currently do not have these requirements.

There is currently a surplus of available CAP water due to excess supply on the Colorado River. Storage of excess water in the near term will make it available during future shortages. This is one of the goals of the AWBA. In addition, the AWBA can recharge CAP and extinguish the associated credits to provide water to the aquifer itself. The AWBA is mandated to continue only through 2017. Possible future strategies could be to extend the mandate of the AWBA for more years or increase the groundwater withdrawal fees, which could be used to purchase and recharge CAP water and extinguish the credits.

The ultimate capacity for CAP recharge in the AMA depends on multiple physical, economic, and political variables. Pricing of CAP water is controlled by the CAWCD and is slated to increase with time. CAP terminal storage is necessary if direct use by the City of Tucson or other water provider is to occur at some point in the future, but funding for this project has an uncertain future. Potential treatment processes are being investigated that might be capable of providing CAP water at an acceptable quality for direct use, but the costs could be very large. Besides the CAP allocations held by water users in the AMA, some additional CAP water could become available as a result of resolution of the Southern Arizona Water Rights Settlement Act (SAWRSA). This water could be used by non-Indian users through arrangements made with the Indians to lease supplies or purchase recharge credits. Any assumptions made about CAP water either for direct use or for recharge and recovery must take into account predicted shortages on the Colorado River.

Other diverse factors will affect AMA water use in the next 25 years. The price of potable water is controlled by water providers and the Arizona Corporation Commission and is affected by the cost of energy, infrastructure needs, and other factors. Population growth can lead to retirement of agricultural land and replacement by housing, but can also result in higher water demand to support industries and increased municipal demand. The ongoing demand of the metal mining industry and continued growth of the turf industry are likely to result in increasing water demand by the industrial sector.

Beyond the year 2025 and into the latter part of the next century, it is anticipated that some general trends in water supply and demand could appear. Agricultural production is likely to continue to decrease but may not disappear since some farmlands are in the floodplain and may never be developed. Metal mining could decrease substantially and eventually disappear as the ore bodies at AMA mines are gradually exhausted. Conversely, water use by other industries served by grandfathered groundwater rights and permits could increase in the long run. Municipal water use is likely to continue to increase throughout the next century, further increasing the need for renewable water supplies in the AMA. Effluent is a key water supply that is constantly regenerated within the AMA. In the long-term, increased direct use of effluent could occur if it were treated to potable standards and delivered for direct potable use. The obstacles in terms of public acceptance of this strategy would be substantial.

The decisions made by municipal water providers in the next 25 years will be affected by the long-term water use strategies needed to address the requirements of the AWS Program. These strategies will include their decisions about the use of allowable mined groundwater, recharge and recovery of CAP water, recharge and recovery of effluent, and possible acquisition of additional CAP credits that may become available through agreements with the Tohono O'odham following resolution of SAWRSA. The physical availability of groundwater may increasingly affect water management decisions in the future. Tucson Water is already experiencing problems with decreasing productivity of wells due to water level declines. The declining groundwater levels could make recovery of CAP or effluent credits through groundwater pumping difficult or impossible in some areas of the basin. The Department's computer model will be a valuable tool for evaluating the possible effects of various recharge and pumping scenarios inside the AMA.

11.7 CONCLUSIONS

The last decade has seen rapid changes in water resources management strategies in the Tucson AMA. Assumptions about direct delivery of CAP water made in the Second Management Plan have been reevaluated due to the emergence of difficulties resulting from direct delivery of CAP water and subsequent adoption of the 1995 WCPA. The water budgets presented here indicate that given current projections, **actual groundwater overdraft will continue and the AMA may not reach safe-yield by 2025.** Additional conservation measures and water supply augmentation will be needed in the fourth and fifth management periods to address the shortfall but will only be part of the effort needed to achieve and maintain safe-yield. A variety of additional factors will affect whether safe-yield can be reached, including CAP and effluent recharge and recovery strategies selected by municipal water providers, strategies for the use of allowable mined groundwater, changes in population, agricultural acreage retirement, changes in mine production, changes in demand for other industries, possible increases in CAP supply as a result of Indian water supply settlements, and many others.

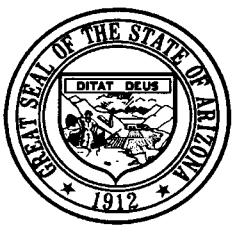
The AWS Program addresses the availability of water supplies for 100 years into the future. This 100-year period moves forward as time passes, so in 2050 the 100-year period will extend to 2150. The goal of the AMA is to reach a balance between the use of renewable supplies and diminishing groundwater supplies in order to prevent ongoing mining of the aquifer, and to maintain this balance through time. This balance will be reached only after a transitional period. The volatility of current water use plans reflects this transition and makes the projection of water use difficult.

The water budget is a useful planning tool that needs to be viewed in the long-term planning context. Water management decisions made in the next 25 years will increasingly reflect the need to balance current demands with the anticipated needs of future water users. The water budget will continue to be updated throughout the third management period as new data and water use plans become available. Water budget updates will be coordinated with the computer modeling efforts of the Department so that changes in supply and demand can be understood in terms of their impacts on water levels and subsidence in the AMA. In this way the water budget will continue to be a key tool in understanding the progress the AMA is making toward reaching and maintaining a balance in its groundwater supplies.

CHAPTER

12

Future Directions



12.1 INTRODUCTION

The Tucson Active Management Area (AMA) faces a number of major challenges in meeting the safe-yield goal and addressing key water supply issues. The Tucson AMA has a diverse economy and is growing rapidly. Residential, commercial, and industrial growth is occurring at a record pace with similar projections for future years. Water use patterns in most sectors are showing corresponding increases. The Tucson area's water management issues are in part political, but the effects of rapid growth and groundwater overdraft are real and must be addressed. Safe-yield is achievable in the Tucson AMA, but only if regional efforts to maximize use and storage of CAP and effluent are successful.

This Future Directions Chapter is intended to provide perspective on resolving the long-term water management issues in the Tucson AMA. It also presents for consideration potential future activities and alternatives that address key issues, assist in the achievement of safe-yield, and establish the framework for long-term water sustainability. Many of the concepts discussed in this chapter fall outside the Arizona Department of Water Resources' (Department) responsibility or authority. Responding to the challenges in meeting safe-yield may require institutional and legislative changes or revised management approaches.

Significant progress has been made in management of water supplies. Over the course of the second management period, many new programs, rules and laws were adopted to aid in the distribution, conservation, augmentation and management of the state's water supplies within AMAs. During the third management period, the Department will continue to develop new approaches to move the AMAs closer to their management goals and to protect water supplies for future use.

The Third Management Plan was developed by building on programs that were incorporated in the First and Second Management Plans. The Third Management Plan also incorporates new programs that will result in incremental progress towards achievement of the safe-yield goal. Most importantly, it identifies alternative strategies for consideration in moving towards attainment of safe-yield. Development of the Third Management Plan involved the following steps: (1) issue identification and data base development, (2) development of alternative programs to address the issues, (3) analysis of alternatives, (4) program development, and (5) publication of the draft plan. Although these activities form a solid basis for future planning, additional efforts may be required to achieve statewide and local management goals.

12.2 THE DEPARTMENT'S PERSPECTIVE ON WATER MANAGEMENT IN THE TUCSON ACTIVE MANAGEMENT AREA

Groundwater use in the Tucson AMA currently exceeds the rate of natural and incidental recharge by a factor of two. The water budgets in Chapter 11 illustrate that based on current projections of water use, the Tucson AMA may not achieve safe-yield by 2025 unless additional management efforts are undertaken. Attainment of safe-yield will require optimal use of Central Arizona Project (CAP) water and effluent currently available to all municipal users in the AMA in place of groundwater. However, there are many physical, institutional, and financial impediments to full utilization of these supplies. In addition, agricultural and industrial water users are not required to use renewable water supplies. These entities hold substantial groundwater rights that are projected to remain in use beyond the year 2025.

Even if additional progress is made towards the basin-wide goal of safe-yield, there is an increasing concern that, if groundwater withdrawals continue at existing levels, there may be localized impacts and threats to long-term supply reliability in certain areas. Groundwater resource management conducted on a smaller scale than AMA-wide may be considered as a means to address concerns of a more local nature, such as subsidence and depletion of water supplies. Although safe-yield is an attainable goal, it is apparent that sufficient progress has not been made toward this goal, nor have the statutory and institutional structures necessary to succeed been fully established. For these reasons, the water interests in the state and the AMA may need to redefine their goals and the tools available to attain them.

12.2.1 The Safe-Yield Goal

In theory, safe-yield is a balance between groundwater withdrawals and recharge, resulting in stabilizing water levels on an AMA-wide basis over time. In practice, safe-yield is a much more complicated concept. Aquifer water levels are affected by underground storage and recovery activities, aquifer compaction due to subsidence, and use of groundwater allocations made through the Assured Water Supply Program (AWS Program). Under these conditions, water levels may never completely stabilize. (The complexities are more fully described in the preface to section II.) Although the specifics of calculating safe-yield are daunting, the theory of safe-yield is simple. It is closely related to the concept of sustainability, which means that resource availability does not diminish over time. Safe-yield is entirely consistent with the goal of ensuring long-term, reliable water supplies.

Support for the safe-yield goal remains strong in the Tucson AMA, but concerns exist regarding inequities in the allocation of costs and benefits within and between the water-using sectors that may require a re-evaluation of current water management approaches. In particular, there are concerns that the municipal sector is the only sector that is required to bear the cost of utilizing renewable supplies. The municipal sector is required, through the Assured Water Supply Rules (AWS Rules), to develop and use renewable water supplies. Neither the agricultural nor the industrial sectors have similar requirements. In addition, there are structural weaknesses in certain portions of the Groundwater Code (Code) because few of the Code provisions are tied directly to achieving the goal.

There are now multiple tools and agencies (the AWS Rules, the Central Arizona Water Conservation District (CAWCD), the Central Arizona Groundwater Replenishment District (CAGRD), and the Arizona Water Banking Authority (AWBA)) that are designed to address specific portions of the water management agenda. Additional tools are likely to be developed in the future. The Department intends to assist in coordinating these agencies and their activities with a focus on achieving safe-yield and other AMA management objectives.

12.2.2 Critical Area Management

In addition to achieving the AMA-wide safe-yield goal, there may be a need to focus on particular water management needs in specific geographic areas of the AMA if significant declines in groundwater levels continue into the future. Hydrologic conditions vary widely within the Tucson AMA, ranging from areas with rising groundwater levels to areas of serious overdraft. Access to renewable water supplies is not uniform throughout the basin. If groundwater withdrawals continue at existing levels, land subsidence due to water level declines and resulting aquifer compaction is now considered to be likely in some areas, while other parts of the AMA are not expected to be affected. Water supply reliability is a concern for most municipal providers, but some have more options than others.

In order to address the variety of localized water-related concerns, water management tools and processes may need to be developed that are designed to address long-term water issues on a subregional or "critical area" basis. The Department, in cooperation with the water users in the AMAs, intends to investigate the concept of a critical area management program as a high priority during the third management period. However, if currently planned reductions in groundwater withdrawals occur in the near future or if replenishment occurs within the area of hydrologic impact of groundwater withdrawals, there may be no need to consider additional regulatory authority.

12.2.3 Under-Utilization of Available CAP Supplies

CAP water is the primary augmentation supply for the Tucson AMA. Although a total of 215,333 acre-feet of CAP allocations are available to the region, and additional use of excess CAP water is possible, a number of circumstances have limited use to a level far below Second Management Plan projections. The

largest single difference in the projected versus actual demand is in the City of Tucson's CAP water utilization level.

The City planned to be using its entire allocation (138,920 acre-feet after transfer of 9,500 acre-feet to two northwest AMA providers) through direct potable delivery and recharge by 1995. Actual City use (through agricultural exchanges) in 1995 was 10,000 acre-feet and was accomplished through groundwater savings projects after direct delivery was halted. The City has made substantial progress since 1995 in developing large recharge facilities at Pima Mine Road and in the Avra Valley, and these projects should significantly increase the City's use of CAP water within the next few years.

Other water users in the basin have also not fully utilized available CAP water. Agricultural use of CAP water in the basin has occurred through a number of groundwater savings projects sponsored by municipal users. Like the City of Tucson, some other municipal users are directly recharging a portion of the CAP water available and have plans to develop additional recharge capacity. In spite of these efforts, CAP water use remains at a much lower level than anticipated.

Public perceptions of CAP water quality have been strongly affected by the brown color, taste, and odor problems associated with some of the initial deliveries by Tucson Water. Although the treatment and delivery difficulties encountered by the City have reportedly been corrected, the public's perceptions will be much more difficult to overcome. Water quality issues associated with CAP water itself and with treatment strategies for this supply are expected to continue to be of major concern to the public within this AMA and ultimately will affect all municipal water providers in the basin.

Although this short-term under-utilization of CAP water may not directly endanger the long-term goal of safe-yield, CAP water use and storage during the third management period is a key component of the region's management strategy. Stored CAP water will be needed to provide a buffer for droughts in future years. The region ideally should be making greater use of CAP water during the period of time when CAP water availability is at its peak and when the cost of CAP is relatively low. It is possible that the large groundwater allocations allowed under the AWS Rules and the slow contractual phase-in of replenishment requirements for CAGRD members provide more flexibility than is needed in the short term.

The Department will continue to evaluate mechanisms to increase CAP water utilization in the short term. Most solutions will require substantial commitment by water users and water providers.

12.2.4 Conjunctive Use and Management of Supplies

The Code provides a strong regulatory approach to groundwater management within AMAs, but a more comprehensive yet flexible approach may be required to meet water management objectives. Water management is currently fragmented because effluent, CAP water, surface water and groundwater are all regulated differently and owned or controlled by different jurisdictions. This fragmentation exacerbates political issues in the Tucson AMA, particularly those associated with ownership of water supplies. The ability to conjunctively manage all water supplies while working towards a safe and reliable water supply for the future is a logical long-term goal. In addition, a more comprehensive approach to water management could consider objectives such as protection of riparian habitat, sustainability and other quality of life issues.

Although the Department does not currently contemplate a major legislative agenda to address conjunctive management, it is appropriate to evaluate opportunities to move in this direction.

12.2.5 Implications of Indian Water Rights Claims

Water management in the Tucson AMA is complicated by unresolved Indian water rights claims. The major non-Indian water users in the basin have been working with the Tohono O'odham Nation and the federal government since the late 1970s to resolve claims for damages to water rights of the San Xavier and Schuk Toak Districts resulting from off-reservation groundwater pumping. Failure to implement the Southern Arizona Water Rights Settlement Act (SAWRSA) leaves major questions about water supply and demand unanswered. Since the activities of off-reservation water users affect on-reservation conditions and vice-versa, it is necessary to improve the coordination of water management across reservation boundaries.

The Department will continue to assist the negotiating parties in seeking a final resolution of Indian water rights issues and in establishing cooperative programs with the Tohono O'odham and the Pascua Yaqui. In the course of these efforts, there may be opportunities to pursue water management projects that benefit water users both on and off the reservations.

12.2.6 Integration of Water Quality Management

Water quality problems must be addressed with both public health and water supply management needs in mind. Opportunities to match end uses with supplies of different qualities and efforts to maximize the beneficial use of treated water associated with remediation are integral to efficient management of our water resources. The following areas specifically need close coordination between the Arizona Department of Environmental Quality (ADEQ) and the Department:

- Development and implementation of ADEQ effluent reuse regulations
- Participation in the design of remedial action projects, including the type and amount of beneficial end uses
- Evaluation of the impacts of incentives for remediation, including the conservation requirement exemption and the assured water supply groundwater account exemption of 65,000 acre-feet statewide in light of AMA-wide and local area water management goals

The Department's goal is to ensure that end uses of treated water do not conflict with achievement of the AMA water management goals. The Department's increased role in ADEQ's remediation programs and better integration of the databases of the two agencies are steps forward in this coordination effort. The Department intends to continue working towards increased coordination between the two agencies.

12.2.7 Economic Considerations

Water management strategies must be analyzed from the perspective of equitable apportionment of total costs and benefits to the community, not just the costs and benefits to an individual or utility. Water management decisions must be economically justified, taking into consideration the long-term needs and concerns of the community. As has become apparent in recent debates regarding the use and treatment of CAP water in the Tucson area, adequate information about total costs to consumers and the community is vital to long-term decision-making.

In addition, although groundwater is of higher quality and is more reliable than renewable supplies, it costs less. The price that is paid for groundwater is based only on the production costs and does not reflect its full value. The economic incentives to use groundwater are in conflict with the long-term goals of maintaining a reliable water supply for the community. However, there are limited opportunities for the Department to affect the price structure for water users. One option that could be considered, but is

unlikely to be supported in the context of the state's legal and political institutions, is to increase groundwater withdrawal fees to reflect the full value of groundwater.

12.2.8 Integration of Land Use Planning with Water Policy

A closer association between land use planning and water policy needs to be established. County and local land use and economic development planning programs must continue to plan for and incorporate water supply and infrastructure requirements as well as conservation objectives. Principal areas of concern include the following:

- The need to secure and utilize renewable water resources that meet AWS Program criteria for developing areas
- Strategic location of wastewater treatment facilities and underground storage facilities to maximize the use of renewable water sources and to stabilize the local area aquifers
- Identifying groundwater characteristics in local areas that may impact the community; including changes in depth to groundwater, water quality changes, and land subsidence
- Evaluating the water resource implications of development occurring on desert land rather than on retired farmland
- Evaluating water use as a factor in economic development decisions by considering such factors as jobs created per gallon of water used, ability to utilize effluent or remediated water, quality of effluent generated, ability to develop aggressive reuse programs, etc.

The Department may be able to assist in this process by providing relevant water demand and supply information, scenario analysis using hydrologic models, and planning assistance. Each of the areas above need to be more closely linked to local general plans, zoning, infrastructure development, and other development decisions.

12.2.9 The Need for Community Support

Community support is a key component in the development of any program, but it is particularly important in water policy. The quality, quantity, and cost of the water supply is an issue that concerns virtually every citizen, and its importance in the Tucson area cannot be overstated. Although most citizens are concerned about water issues, many are not aware of the critical nature of current groundwater overdraft conditions in the AMA. The public is likely to focus on growth and visible water uses such as golf courses as the cause of the problem, without recognizing that current groundwater users in every sector already exceed the natural groundwater replenishment rate. Equity considerations must move beyond the needs of current water users, and the community must begin to consider ecological values and the needs of future generations.

The Department will continue to work with advisory groups, public citizens, and elected officials to initiate and develop programs that are supported by the community.

12.3 CHALLENGES TO ACHIEVING SAFE-YIELD AND DEPARTMENTAL STRATEGIES IN RESPONSE

This section identifies some of the factors limiting achievement of safe-yield, and the Department's proposed role in addressing these problems.

12.3.1 Residual Overdraft by Existing Users

Municipal, industrial, and agricultural users are all expected to continue to pump groundwater through 2025. Most municipal water supplies will be delivered by designated water providers who are required to utilize renewable supplies but are authorized to pump some "allowable" groundwater. However, the ongoing pumpage associated with undesignated providers (water companies without an assured water supply) is about 21,000 acre-feet per year. In the agricultural sector, most of the demand is expected to continue to be supplied by groundwater, with total demand projected to be 68,500 acre-feet per year in 2025.

The industrial sector is likely to be responsible for a significant component of the groundwater overdraft. If current projections of copper mining activity are correct, copper mines alone could be responsible for 47,000 acre-feet of groundwater use in 2025. Any evaluation of the tools available to reach safe-yield must address the problem of continued groundwater pumpage by grandfathered right holders and by undesignated water companies past the year 2025. An additional consideration is the need to sustain safe-yield once it has been achieved.

The Department will initiate a discussion of these issues and potential mechanisms to address residual overdraft by existing users.

12.3.2 Community Conflict

An obstacle to utilizing renewable supplies is conflict within the Tucson community. Although specific problems such as the City-County 1979 Intergovernmental Agreement concerning effluent are frequently cited, there is a general lack of trust between certain water interests. Conflicts over ownership of effluent, CAP utilization, assignment of costs and benefits associated with the reclaimed water system, and other issues have resulted in numerous legal actions, political battles, and lost opportunities. Opportunities for utilization of renewable supplies are available now, but are likely to become more limited in the future. The public is confused by conflicting information they receive. Lack of a common vision affects the community's ability to utilize these supplies and to present a united front at the local, state, and federal levels.

12.3.3 Inadequate Information

A major shortcoming of water management efforts to date is providing accurate information to the public; it is difficult to ensure that the media and other sources report information accurately. There is a lack of knowledge of the basic facts of water supply and water quality that severely constrains the ability to achieve consensus on water management issues.

In addition to the problems of adequately communicating broad concepts to the public, experts disagree on some specifics. The Regional Recharge Planning effort has addressed some of these issues. The development of the Tucson AMA's hydrologic model will provide a tool for scenario analysis and graphic displays of current and future conditions. The recent initiation of regional subsidence and aquifer storage monitoring should substantially increase our understanding of subsurface hydrology. The Department intends to expand its outreach efforts and will continue to share its extensive data on water levels, water use, water rights, and other water management information with water experts and the public.

12.3.4 Need for Continuing Conservation Efforts

Safe-yield and sustainable water use can only be achieved through some combination of efficient use of renewable supplies and reduced demand. The Tucson area has historically been supportive of conservation programs, but this commitment to demand reduction must be continued and expanded in the future.

General confusion about the water picture in Tucson may have lessened the opportunities for individuals to understand the role their own personal decisions play in the broader resource picture. It is the collective decisions of individuals regarding landscape type, the need for water-requiring amenities such as pools and misting systems, and other water-using appliances that affect the gallons-per-capita use of each municipal provider. Strategies such as water harvesting, proper management of irrigation systems, and changes in personal water use habits require ongoing commitment at the individual level.

Although there have been expectations that construction of new housing units using low water use fixtures and landscaping would reduce the average water use in most water provider service areas, in some areas new units are using more water than anticipated. It is likely that the conservation message is not reaching homeowners when they are making key long-term decisions about water-using fixtures and landscaping in new homes. It is possible that media reports regarding availability of excess CAP water and general frustration with water management efforts are affecting water use patterns.

Although the availability of excess Colorado River supplies is expected to continue in the short-term, shortages on the Colorado River are expected to affect deliveries in Arizona thirty years out of the next 100. Perhaps more important is the fact that Colorado River supplies are projected to be cut back 50 percent of the time after 2050. It is much easier to achieve conservation objectives if people perceive there is an imminent water supply problem, or if they are aware of the long-term supply issues. Conservation goals need to be reinforced through pricing structures, ordinances, and public information about the serious long-term nature of water supply limitations in the area.

The Department continues to believe that conservation efforts are an appropriate water management technique. The Department's programs are focused in the areas with the greatest conservation potential and in sectors that are expected to continue using mined groundwater. This focus on the future will provide substantial dividends over time.

12.3.5 Regulation of Private Water Companies

Private water companies have repeatedly pointed out that they have difficulty meeting AMA requirements and contributing to achieving the safe-yield goal. This situation occurs because of a lack of regulatory authority over their customers' water usage and because of perceived conflicts between the Department's objectives and decisions of the Arizona Corporation Commission (ACC), which controls the water rates in these service areas. There have been ongoing discussions between the Department and the ACC concerning pass-through of investments in renewable supply use and conservation program costs. The policies and procedures of the two agencies regarding these matters are not effectively integrated. Some issues may be resolvable in the context of a strong, ongoing commitment from both agencies. Other issues may require resolution through statutory changes.

12.3.6 Important Factors not Affected by Regulatory Programs

Many of the decisions that affect the ability to achieve safe-yield are outside of the influence of current regulatory programs. Economic factors have a strong influence on water use. For example, as world copper prices rise and fall, there is a direct effect on copper production in the mines in the Tucson AMA. Likewise, irrigated acreage has responded dramatically to changes in crop prices and federal subsidies. As was illustrated in the sensitivity analysis in Chapter 11, a change in population growth rates could have a dramatic effect on total water use. However, under the AWS Rules all new subdivisions must utilize renewable water supplies, so the impact of population growth on groundwater demand and hence safe-yield is negligible so long as sufficient renewable supplies are available.

Water costs strongly influence the rates of water use in all sectors, but there are few opportunities for the Department to significantly affect pricing structures to reduce demand. The cost of using groundwater

should reflect the cost of overdrafting the aquifer. These costs include the loss of a supply, land subsidence and aquifer compaction, water quality degradation, and future alternative water supply sources.

Water supply utilization associated with Indian settlements such as SAWRSA also may affect the regional ability to reach safe-yield. However, the use of these supplies is outside of the jurisdiction of the Department and the Code.

12.4 EVALUATION OF ALTERNATIVE APPROACHES

Overcoming some of the challenges to achieving safe-yield may require legislative or rule changes. The Department will work with regional entities to identify optimal responses to the problems that have been identified and the timeframe within which these responses are necessary. In order to develop a consensus response, a number of committees or task forces will be established to work on solutions. In the Phoenix and Tucson AMAs, a broad range of issues has been identified relative to achievement of safe-yield. These issues are both local and statewide in scope. Depending on the subject matter involved, issues identified at the AMA level could be considered at the state level if more than one AMA is affected by the problem or could benefit from the proposed solutions. The "big picture" issues relating to the basic structure and effectiveness of Groundwater Code provisions will be addressed at the state level with representation of each major water-using sector and each AMA. The director has committed to working with the Governor to develop a multi-AMA task force proposal that is representative, equitable, and efficient.

One area that clearly merits further discussion in the Tucson AMA is development of the "critical area" concept. In this context, specific problem areas within the AMA could be targeted with incentives for recharge, restrictions on new pumpage, enhanced monitoring, or regional planning and technical assistance. Specific tools and authorities could potentially be developed, such as limiting new uses in the area. The impact of new exempt wells in critical areas may need to be evaluated. Activities of the CAGRD and AWBA might be expanded to allow for replenishment on behalf of certain users who are not currently able to participate. Such activities could be focused in critical areas as well.

12.5 IDEAS FOR CONSIDERATION IN FUTURE DISCUSSIONS REGARDING SAFE-YIELD AND CRITICAL AREA MANAGEMENT

There are a number of issues that will need to be addressed to achieve safe-yield and the other water management objectives discussed in this chapter. This section lists ideas and potential activities to address inadequacies in existing programs and suggests new authorities that could be used to address critical areas within the AMA.

12.5.1 Resolving Issues in Attaining Safe-Yield

The options that are listed below, in some combination, can address problems associated with achieving safe-yield on an AMA-wide basis:

To address ongoing (residual) pumpage by existing users:

1. Re-evaluate the effectiveness of various Code provisions in making progress toward achieving safe-yield, addressing sectors that are expected to cause ongoing groundwater depletions. Develop programs and authorities to ensure that all groundwater pumpers contribute to achieving safe-yield.

2. Re-examine the ability of irrigation grandfathered rights to be converted in the future to Type 1 non-irrigation rights with no replenishment obligation.

3. Reduce groundwater mining by General Industrial Use (GIU) permits either through pumpage limitations or a replenishment obligation.

To address under-utilization of renewable supplies:

1. Address the disparity between the cost of groundwater and the cost of renewable supplies.

2. Develop incentives for utilization of renewable supplies that are consistent with overall management objectives.

3. Encourage the CAGRD to expand its authority and to develop appropriate and equitable financing mechanisms to replenish supplies for members and non-members

4. Increase public education efforts targeted towards local officials, the general public, community groups, and the development community.

5. Evaluate conjunctive management approaches, including revised authorities, incentives and other mechanisms.

6. Encourage cooperative projects that will result in use or storage of renewable supplies.

To prevent new uses of groundwater from exacerbating existing overdraft:

1. Limit or require replenishment by new residential growth that is not subject to the AWS Rules including small dry-lot subdivisions, existing undeveloped lots, and new subdivisions of less than six lots. These categories of development are currently not required to use renewable sources of water, demonstrate physical water availability, or undergo well impact analysis when drilling exempt wells.

2. Evaluate replenishment requirements for undesignated municipal providers and re-evaluate allowable groundwater pumping by designated providers.

3. Ensure that all water users associated with a development plan, including associated golf courses, are required to meet the assured water supply restrictions.

4. Limit new GIU permits.

5. Re-examine the assured water supply depth-to-water rule that currently allows groundwater levels to decline to 1,000 feet below the land surface over 100 years. This depth to water may result in water quality problems, subsidence, and earth fissure development. This rule limit may need to be raised to avoid substantial damage to the aquifer.

6. Restrict ability of new industrial users such as golf courses to use groundwater supplies.

To improve databases and understanding of hydrologic conditions:

1. Continue to monitor land subsidence in the AMA.

2. Identify and quantify existing problems created by excessive pumping, which include land subsidence and earth fissures, aquifer compaction, water quality degradation, declining groundwater levels, and physical availability problems under the AWS Program.

3. Develop groundwater modeling capabilities to allow testing of alternative planning scenarios, including prediction of the extent and rate of subsidence. The ability to correlate pumping and soil conditions to land subsidence rates would be an invaluable tool in a rapidly urbanizing area.

12.5.2 Resolving Issues Regarding Critical Area Management

All of the ideas and potential activities described above to address AMA-wide water management issues pertain to critical area management as well. The options listed below could address water management problems in specific "critical areas" within AMAs.

1. Obtain the authority to protect water recharged in critical areas but recovered outside the area of impact, and to protect non-recoverable storage from pumpage by new users and existing residual users who do not shift onto renewable supplies. A.R.S. § 45-856.01.

2. Provide the ability to manage water levels in critical areas by restricting pumpage using the following mechanisms:

   - Limiting new GIU permits and industrial users in critical areas
   - Restricting the ways in which new service areas can be established
   - Limiting Type 1 non-irrigation grandfathered right conversions
   - Increasing the level of conservation requirements
   - Buying out or providing incentives for extinguishing existing grandfathered rights in specified areas
   - Limiting new exempt wells

3. Encourage the CAGRD to develop equitable financing mechanisms that enable replenishment in critical areas or near the location where the groundwater pumping obligation was incurred.

4 Require groundwater pumpage that is to be replenished by a conservation district that provides replenishment services to be consistent with the management plan drawdown criteria in Chapter 8. These criteria currently apply only to storage credits that are recovered outside of the area of hydrologic impact, but could be expanded to address all pumpage that is recharged or replenished in another location.

5. Develop well-spacing rules that have specific provisions to protect critical areas.

6. Provide economic or regulatory incentives to utilize renewable supplies in lieu of pumping groundwater in critical areas.

12.6 CONCLUSIONS

The key to effective water management is to anticipate change and to develop systems that are flexible enough to respond to conditions that are unlike those we experience today. As has been noted many times, the one aspect of the future that is certain is that it will be unlike the past. The ability to identify and understand trends in water use and supply is central to the functions of the Department. It will be necessary to expand basic monitoring programs, improve the management of the data that are collected, and improve hydrologic modeling capabilities in order to effectively manage the state's water supplies in the context of change. The Department intends to expand its technical and advanced planning capabilities to better serve the State of Arizona and the AMAs in the next management period.

This chapter has set the stage for activities within the Tucson AMA that could contribute to the AMA's goals and objectives. To ensure safe, dependable water supplies for the existing and future residents of the

Tucson AMA we must efficiently use the renewable water supplies available. Achieving safe-yield and resolving water issues within critical areas of the AMA are major challenges. The ability to meet these challenges is dependent to a substantial degree on community support. New strategies and tools for water management may be required in the Tucson area in order to rebuild public trust. A combination of education, cooperative efforts, and changes in legislation may be required to address water issues in the future. The Department will continue to work with community interests to develop innovative, cooperative solutions and to respond to the area's changing needs.