COLLEGE OF AGRICULTURE & LIFE SCIENCES
COOPERATIVE EXTENSION
WATER RESOURCES RESEARCH CENTER

GETTING DOWN TO FACTS

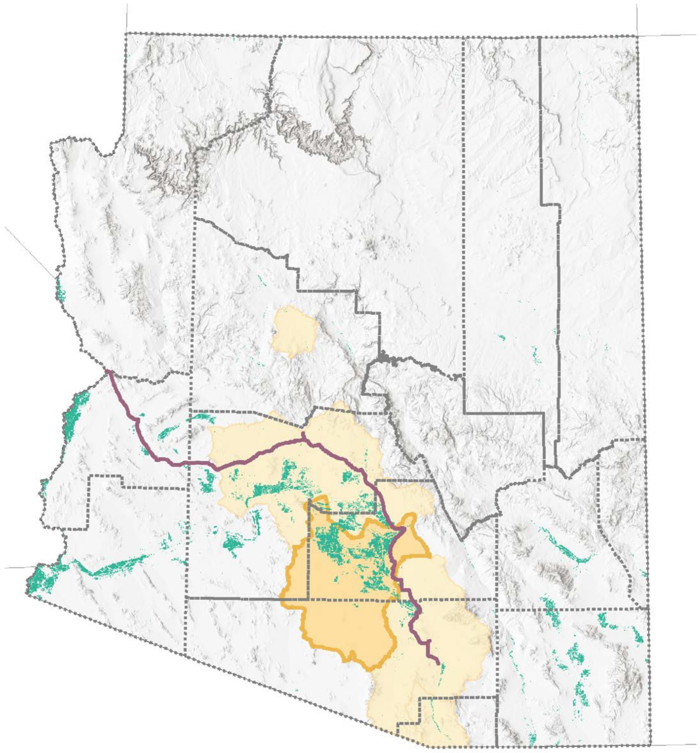
A VISUAL GUIDE TO WATER IN THE PINAL ACTIVE MANAGMENT AREA

June 12, 2020

GETTING DOWN TO FACTS

A VISUAL GUIDE TO WATER IN THE PINAL ACTIVE MANAGEMENT AREA

JUNE 12, 2020



Report prepared by the University of Arizona Water Resources Research Center

Ashley Hullinger, Research Analyst, with assistance from

Blase Evancho, Pinal County Cooperative Extension

COLLEGE OF AGRICULTURE & LIFE SCIENCES
COOPERATIVE EXTENSION
WATER RESOURCES RESEARCH CENTER

The Water Resources Research Center's mission is to tackle key policy and management issues, empower informed decision-making, and enrich understanding through engagement, education, and applied research. We work with a variety of stakeholders, including decision makers, professionals, students, and the public; conduct “real-world” research; and produce and disseminate independent and reliable water information.

Suggested Citation: Hullinger, A. (2020). Getting Down to Facts: A Visual Guide to Water in the Pinal Active Management Area. Water Resources Research Center, University of Arizona: Tucson, Arizona. June 12, 2020.

Cover photo credit: Blase Evancho

ACKNOWLEDGMENTS

Thank you to Susanna Eden, Sharon Megdal, and Jim Holway for their guidance and support in creation of this report, as well as the helpful feedback provided by Supervisor Stephen Miller, Bill Garfield, Jake Lenderking, Terri Sue Rossi, Brian Betcher, Bill Plummer, David Snider, and Bill Collings. A special thanks to Austin Carey and Kenneth Seasholes for their significant contributions. We also greatly appreciate the assistance and diligent review from Arizona Department of Water Resources to ensure the accuracy of the information provided here.

THE UNIVERSITY OF ARIZONA
Cooperative Extension
Pinal County

Thank you to the Pinal County Cooperative Extension for their partnership in producing this report.

BABBITT CENTER
FOR LAND AND WATER POLICY

A Center of the Lincoln Institute of Land Policy

Thank you to the Babbitt Center for Land and Water Policy for contributing knowledge, resources, expertise, and the funding for this work.

The Babbitt Center for Land and Water Policy, a center of the Lincoln Institute of Land Policy, seeks to advance the integration of land and water management to meet the current and future water needs of Colorado River Basin communities, economies, and the environment.

CONTENTS

COLLEGE OF AGRICULTURE & LIFE SCIENCES
COOPERATIVE EXTENSION
WATER RESOURCES
RESEARCH CENTER

INTRODUCTION

Two primary issues have increased focus on water in the Pinal Active Management Area (AMA): 1) the reduced availability of Central Arizona Project (CAP) water, particularly for agricultural users, and 2) difficulties faced by new proposed residential subdivisions in satisfying the physical availability criterion of Arizona's Assured Water Supply (AWS) Rules. This report provides background information and a snapshot of the water supply and demand situation in the Pinal AMA in order to build common understanding of current issues in the context of sometimes complicated water topics.

Water policy and management in the Pinal AMA are influenced by a complex mix of geographic, hydrologic, climatic, and regulatory factors. The maps and data visualizations in this report are intended to give context to understand the interconnections of water demands and supplies, jurisdictional boundaries, hydrologic setting, resource availability, current institutional framework, and the roles of various governmental and non-governmental entities.

This report serves as a visual overview and resource for interested residents, decision makers, and other stakeholders, summarizing existing data helpful to understanding the big picture of water issues in the Pinal AMA.

FIGURES

TABLES

ACRONYMS

AAWS	Analysis of Assured Water Supply
ADWR	Arizona Department of Water Resources
AMA	Active Management Area
AF	Acre-Feet
AWBA	Arizona Water Banking Authority
AWC	Arizona Water Company
CAGRD	Central Arizona Groundwater Replenishment District
CAIDD	Central Arizona Irrigation & Drainage District
CAP	Central Arizona Project
CAWS	Certificate of Assured Water Supply (subdivisions)
CAWCD	Central Arizona Water Conservation District (which operates the CAP)
DAWS	Designation of Assured Water Supply (water providers)
GRIC	Gila River Indian Community
GSF	Groundwater Savings Facility
HIDD	Hohokam Irrigation & Drainage District
IGFR	Irrigation Grandfathered Rights
MAF	Million Acre-Feet
MSIDD	Maricopa-Stanfield Irrigation & Drainage District
SCIDD	San Carlos Irrigation & Drainage District
USF	Underground Storage Facility

PINAL AMA WATER SUPPLY AND DEMAND BASICS

The Pinal Active Management Area (AMA) comprises areas of abundant groundwater, but much of this water was stored thousands of years ago. Especially before CAP water became available, more groundwater had been withdrawn than recharged, drawing down available supplies. This overpumping resulted in deeper pumping depths, land subsidence, and earth fissures. Artificial recharge with renewable water or non-groundwater sources has helped rebalance the AMA's groundwater budget. As illustrated in this section, however, the sheer scale of future groundwater demand will be challenging to offset.

Simply defined, the Pinal AMA's groundwater budget consists of 1) water that recharges the aquifer and 2) pumping demands that remove groundwater from the aquifer (Figure 1). While intentional and natural recharge can impact groundwater levels over time, groundwater is regarded primarily as a non-renewable supply.

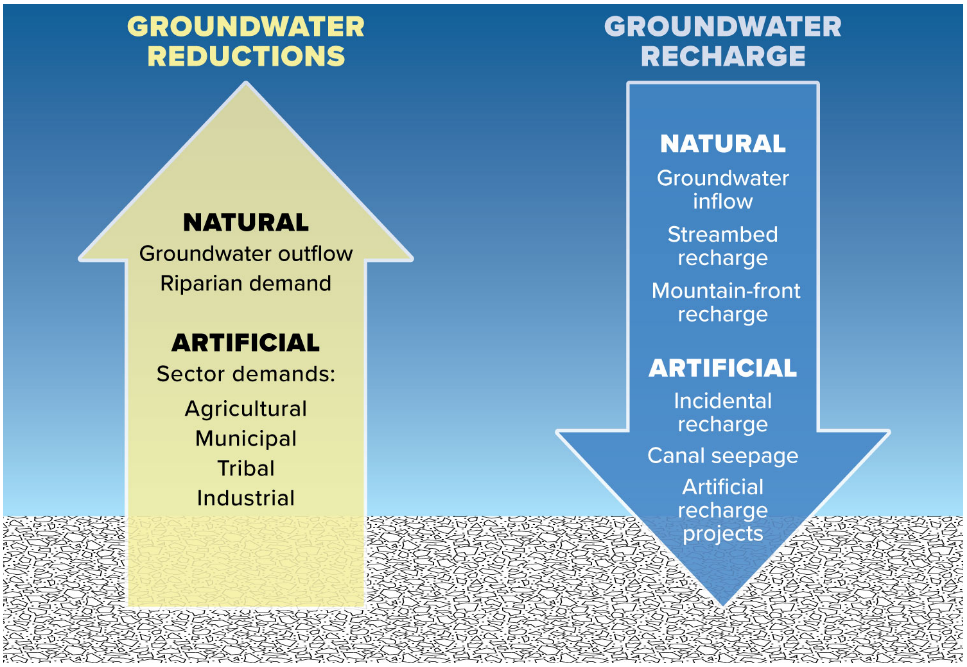
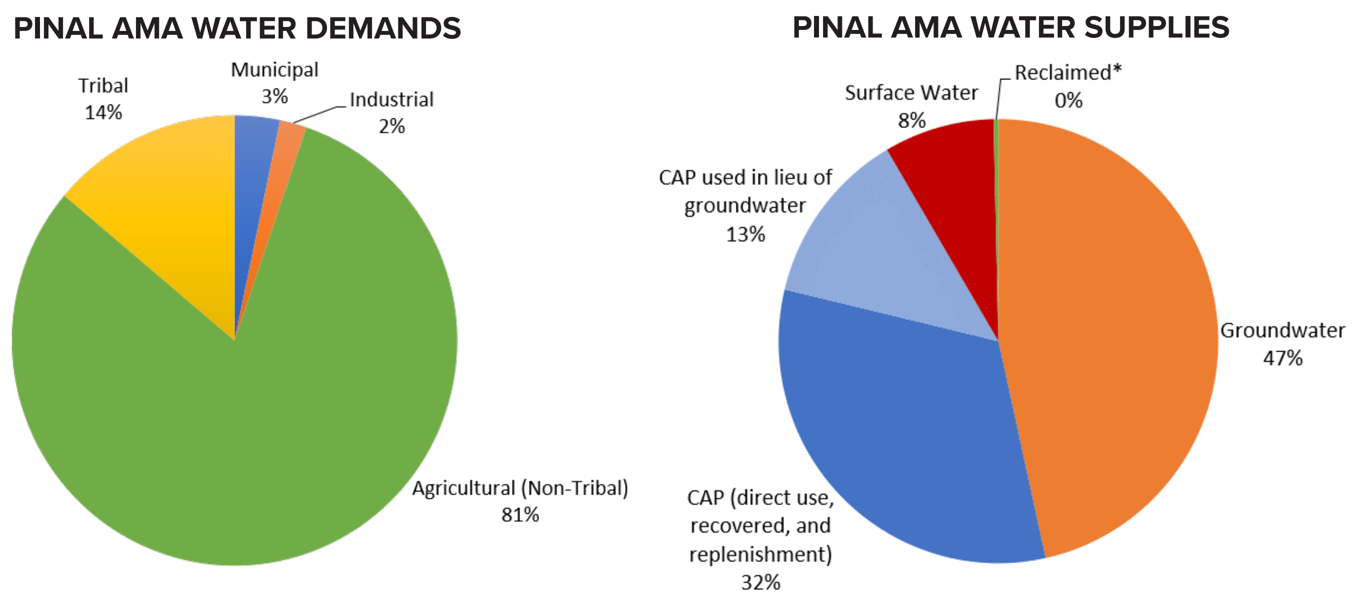


Figure 1. Elements of Groundwater Recharge and Reductions

The Pinal AMA's water use remains mostly agricultural, accounting for about 90 percent of the AMA's total annual demand of 1,113,538 acre-feet (AF) per year (both Tribal and non-Tribal agriculture based on 2008-2018 average) (Figure 2-3). If the total agricultural water demand included water used by dairies and feedlots, which are categorized as industrial uses by Arizona Department of Water Resources (ADWR), the percentage would be even higher. The growth of industry and urban areas has altered the supply and demand picture somewhat in the last 20 years, but municipal water demand has remained a small component even as the population more than doubled. See page 14 for more details about municipal water demand.



*Reclaimed water accounts for 0.35% of total supplies

Figure 2. Pinal AMA Average Water Demands and Supplies, 2008-2018 (ADWR 2020a)

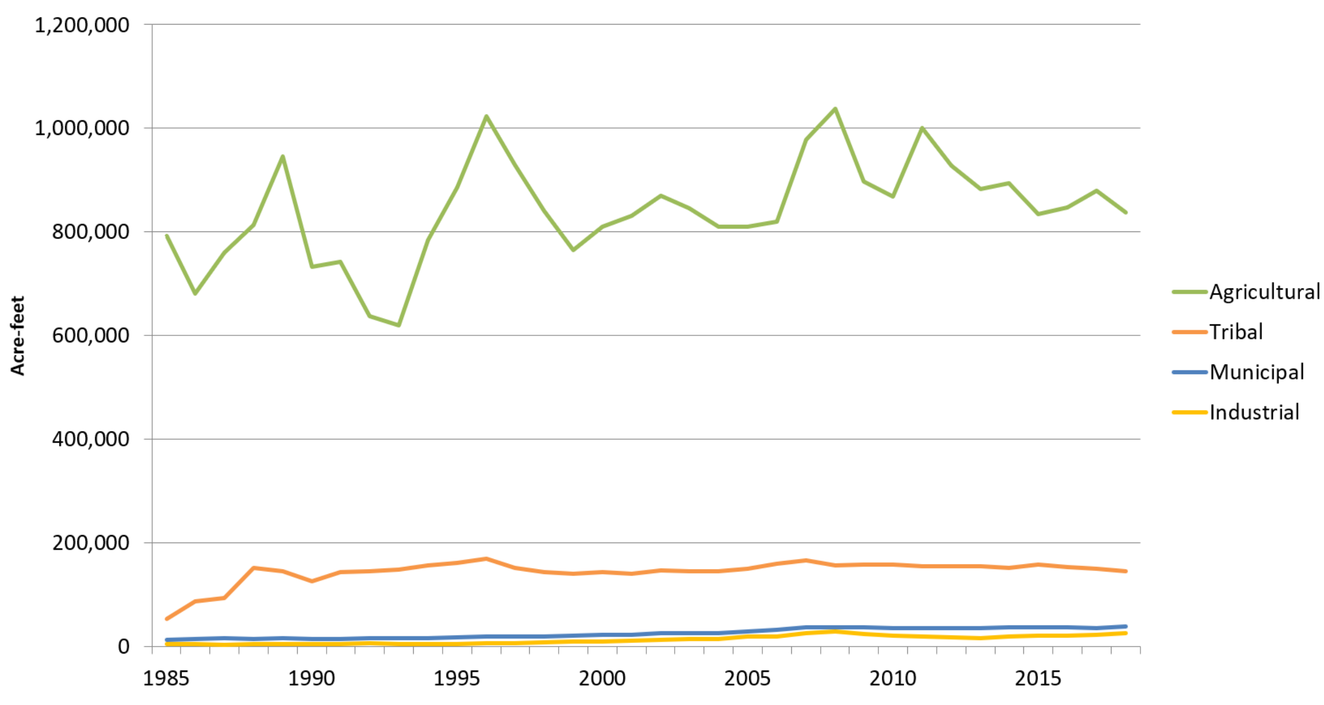


Figure 3. Pinal AMA Water Demand by Sector in Acre-Feet, 1985-2018 (ADWR 2020a)

WATER SUPPLIES BY SECTOR

In addition to its aquifers, the Pinal AMA receives water from the CAP and utilizes other surface water and reclaimed supplies (Figures 4-5). "In lieu" water refers to deliveries of CAP renewable supplies that replace groundwater pumping and reduce the volume of groundwater that would otherwise have been withdrawn historically. See page 26 for more details about water supplies by source used by the agricultural sector.

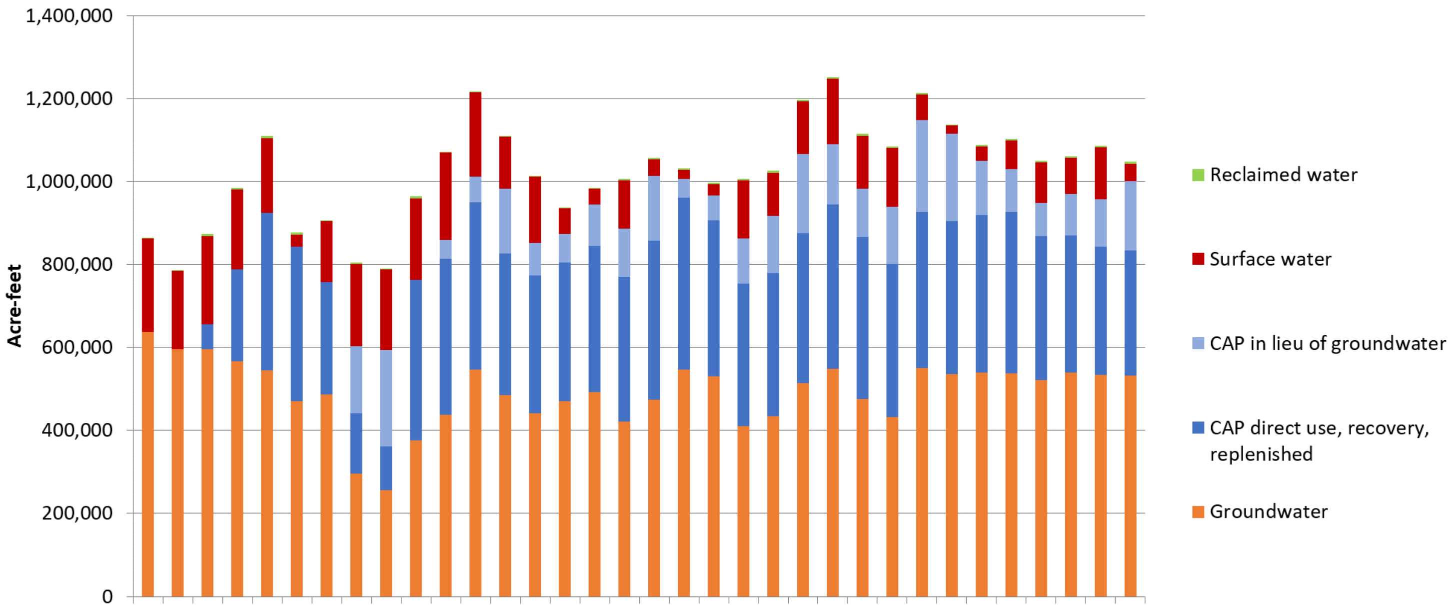


Figure 4. Pinal AMA Water Supply by Source in Acre-Feet, 1985-2018 (ADWR 2020a)

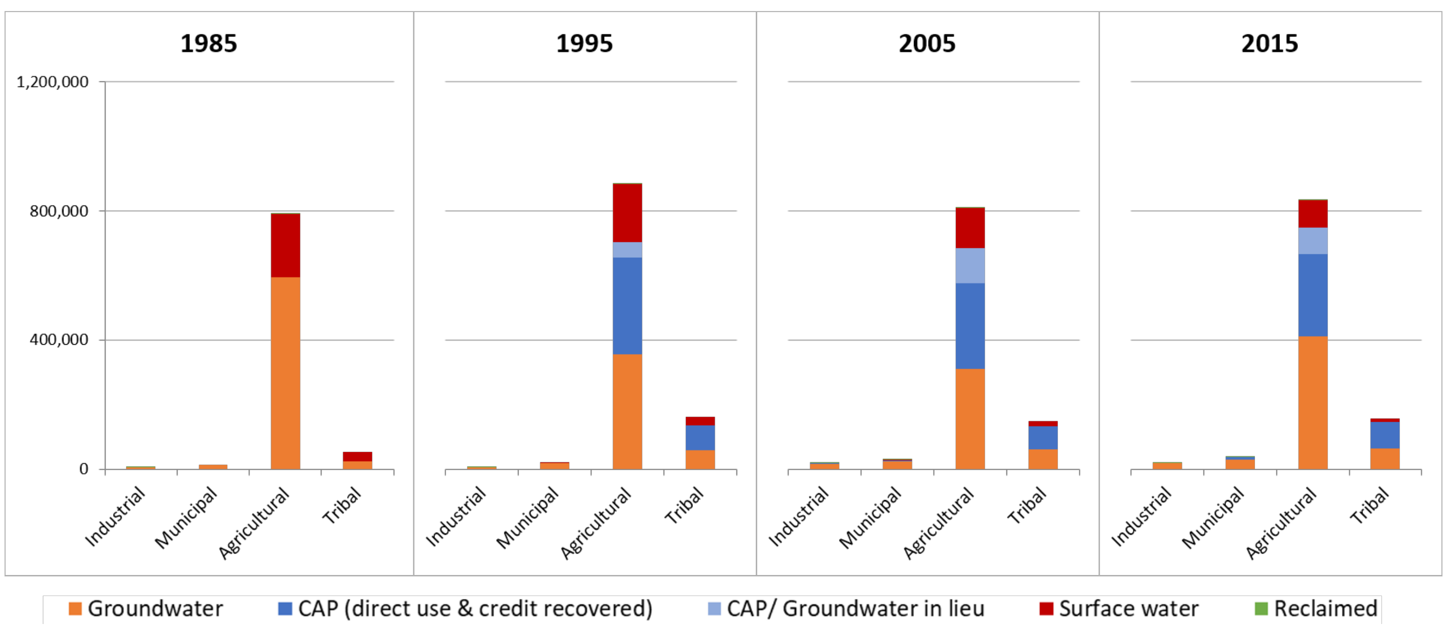


Figure 5. Water Demand Sectors by Water Source, Annual Snapshots, 10-year Intervals over 1985-2015 (ADWR 2020a)

Prior to 2000, industry accounted for less than one percent of water demand in the Pinal AMA. Industrial water use has more than tripled since 1985, increasing from an average of 4,500 AF between 1985-1990 to an average of 19,000 AF between 2010-2015 (Figure 6). This growth has been driven primarily by increases in dairy and cattle operations as well as turf irrigation (including golf courses). Other water using industries include: sand and gravel, electric power generation, and "other." "Other" refers to non-irrigation uses of water not supplied by a city, town, or private water company (ADWR 2020a). Groundwater is industry's primary water supply, but reclaimed water use has increased over time. Casa Grande based Frito Lay Inc. is one of the largest permitted users of reclaimed water in Arizona (Cusimano et al. 2015).

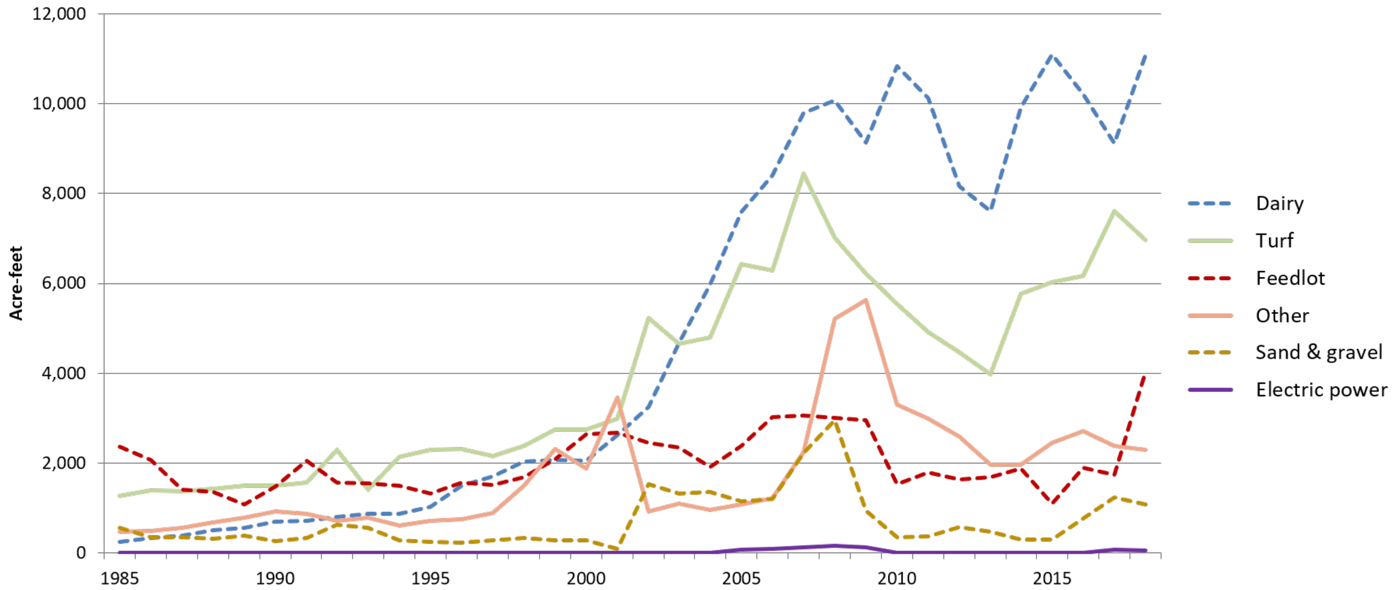


Figure 6. Water Use by Industry in the Pinal AMA, 1985-2018 (ADWR 2020a)

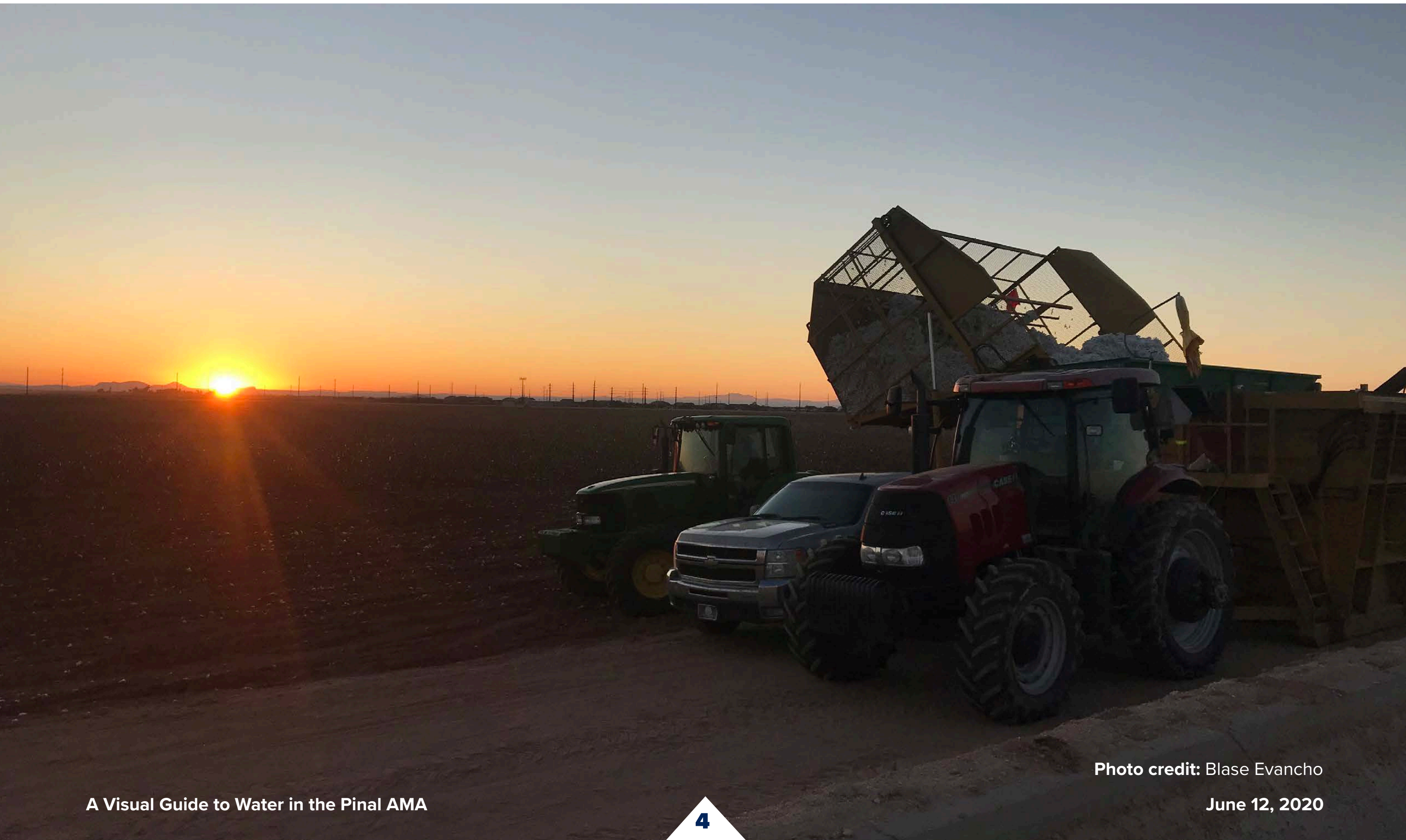


Photo credit: Blase Evancho

ACCOUNTING FOR INDUSTRIAL WATER - WHICH PIECE OF THE PIE?

Coolidge, Eloy, and Casa Grande have diversified their economic base to include manufacturing, trade, and services. This expansion and diversification has been facilitated by their location in the major growth corridor between Phoenix and Tucson near the junction of I-10 and I-8 highways. Electric car manufacturers, Lucid Motors and Nikola Corp., are expected to bring more than 4,000 jobs to the region, with Lucid Motors stating that it will have a $32 billion revenue impact over 20 years. Construction and other supply chain jobs are expected to bring thousands more jobs.

For accounting purposes, however, it is important to note that potential industrial growth can fall under either the municipal or industrial water demand categories depending on who provides the water and who has a right to the water. Water demand is only counted as "industrial" when the industrial user has their own right or water supply. This may result in underestimating the impact of industrial water demand. On the other hand, as noted previously, water use for livestock and dairy production is included in estimates of industrial demand.

DECREASING GROUNDWATER IN STORAGE

Figure 7 depicts annual changes in groundwater in storage based on ADWR's estimates of "paper" water, indicating a growing overdraft in the Pinal AMA through the early 2000s. The “paper” method of water budget calculations means that water below the land surface, not legally classified as groundwater, is not included (e.g. long-term storage credits are not counted and the cut to the aquifer is counted). This means that overdraft figures will not necessarily match measured changes in depth to water (see Appendix 1 and 2 for more information about "paper" water and the water budget calculation). Overdraft is calculated by subtracting aquifer recharge from total groundwater use by all the sectors. Recharge includes estimates for incidental recharge, net natural recharge, and canal seepage (ADWR 2020a). CAP water used in lieu of groundwater by the agricultural sector is counted as groundwater demand on an annual basis. ADWR estimated groundwater overdraft for 20 of the 31 years between 1985 and 2015, with the most significant overdraft occurring after 2010. This trend persists despite increased use of renewable supplies, primarily CAP water. The spike in estimated surplus in 1993 (over 700,000 AF) was due to an increase in net natural recharge from extreme precipitation events occurring in January of that year. Conversely, extended drought also plays a role in decreasing natural recharge and groundwater in storage over time.

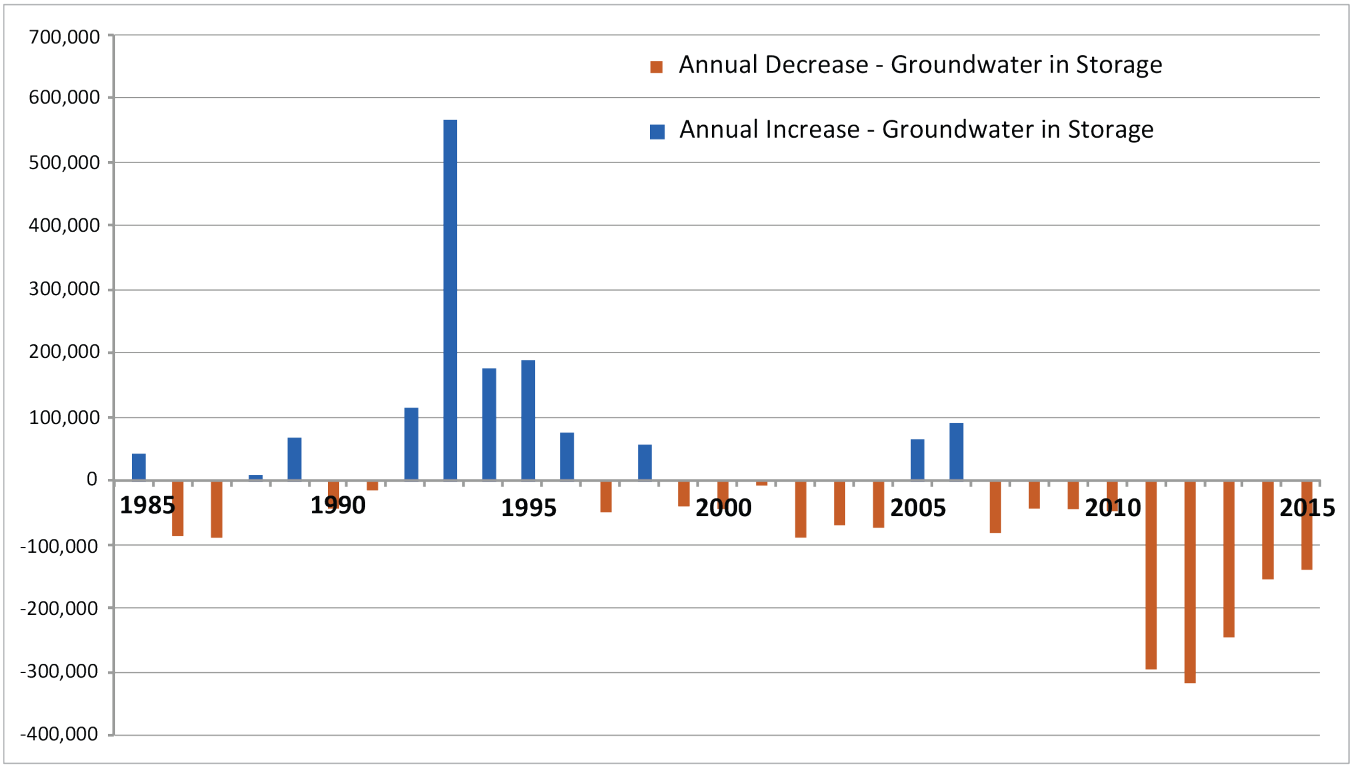
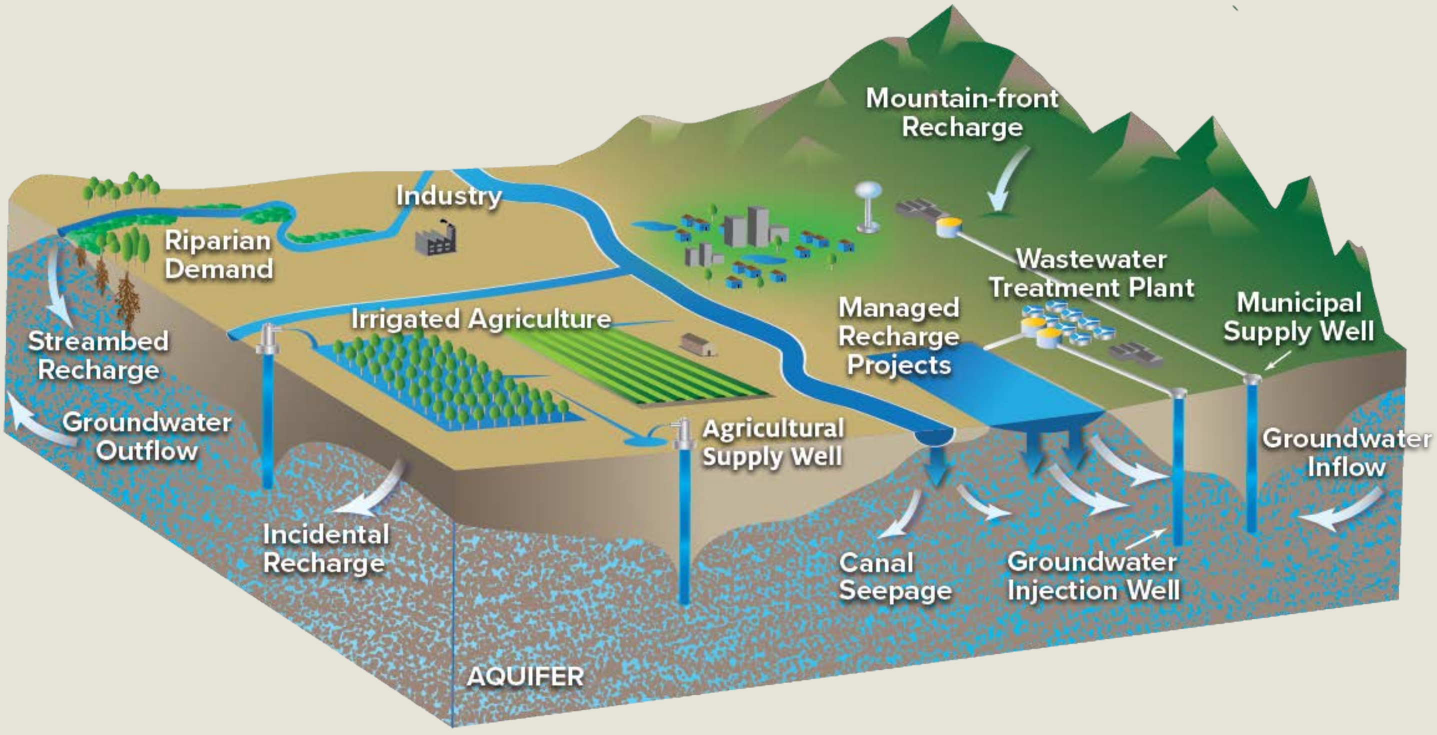


Figure 7. Estimated Annual Groundwater in Storage and Overdraft in Acre-Feet, 1985-2015 (ADWR 2020a)

PHYSICAL REALITIES

LOCAL WATER CYCLE AND GROUNDWATER BASICS



In order to put water supply and demand numbers into perspective, it helps to look above and below the aquifer. The local water system is controlled by a variety of factors, human and natural.

The majority of the groundwater in the Pinal AMA is stored within two distinct, historically productive groundwater subbasins. The area in between these subbasins, where the depth to bedrock is shallow, is known as the Casa Grande Ridge (Figures 8-9). Bedrock is the hard rock that lies below the porous, unconsolidated sediments of the aquifer (e.g. sand, gravel and soil). The saturated thickness of an aquifer sits above the bedrock and below the water table, representing potentially extractable water. Shallow bedrock indicates there is less groundwater available in those areas to pump. In the Casa Grande ridge area, the saturated thickness is only a few hundred feet compared to thousands of feet in the Central Arizona Irrigation & Drainage District (CAIDD) and Maricopa-Stanfield Irrigation & Drainage District (MSIDD) areas (see Figure 12 for mapped locations of CAIDD and MSIDD).

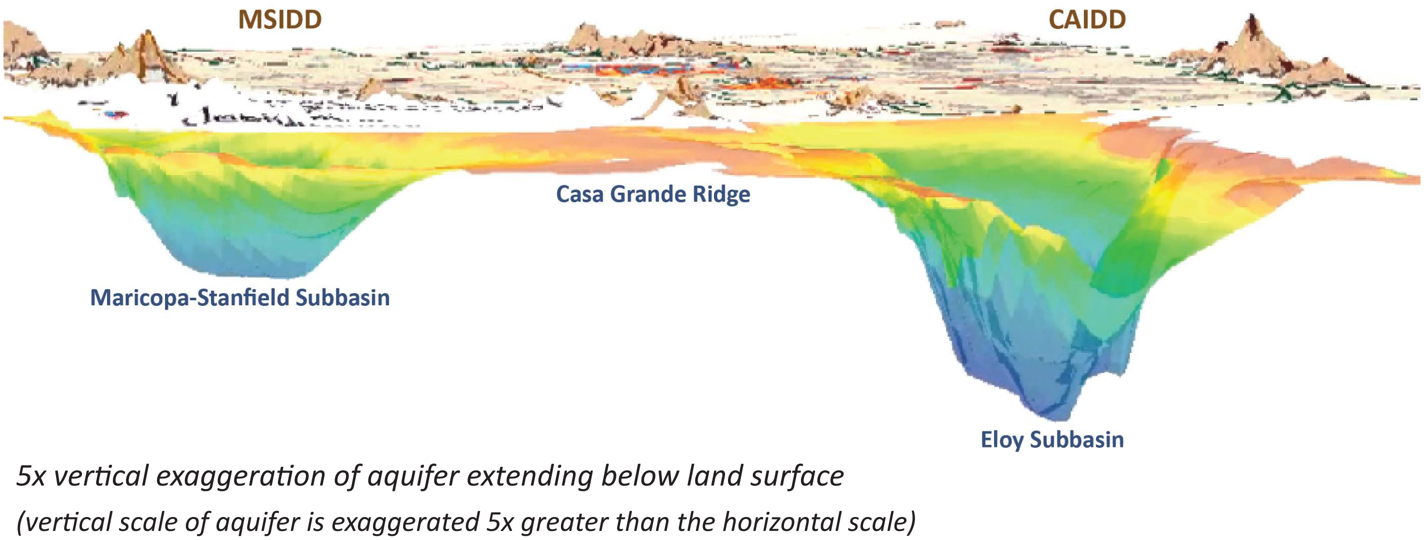


Figure 8. 3-D Representation of the Pinal AMA Aquifer from 2019 ADWR model, extended to 3000 feet below land surface, based on ADWR's 2014 geology update (Seasholes 2020) - Note: the aquifer bottom is modeled to 3000 feet and is deeper in certain areas

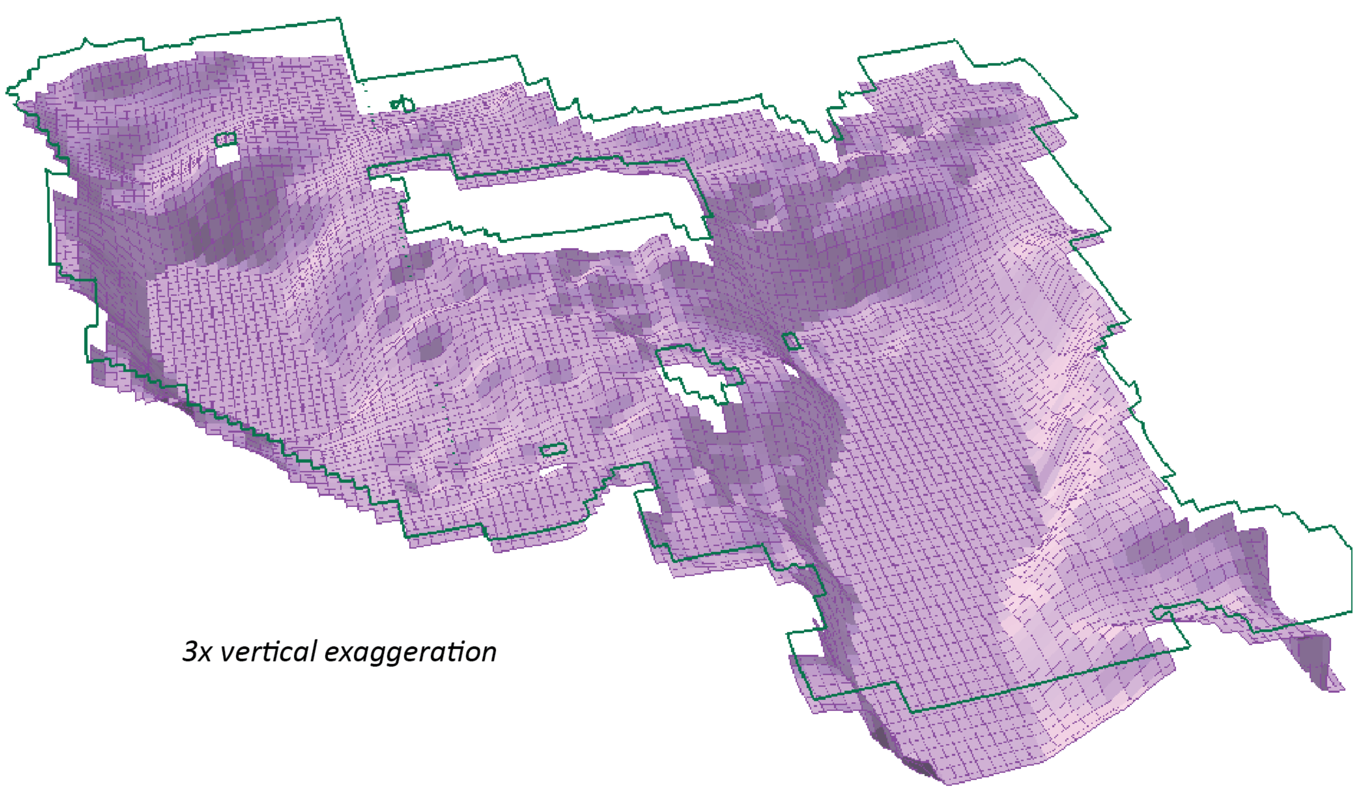


Figure 9. 3-D Representation of the Pinal AMA Aquifer Bottom (Nelson & Inwood 2020)
Note: the aquifer bottom is modeled to 3000 feet and is deeper in certain areas

ARIZONA WATER WORDS TO KNOW

As a visual guide, this report does not provide an in-depth analysis of Arizona water policy. **Appendix 1** contains important terms and context useful for understanding groundwater management in the Pinal AMA. As an introduction to the subject, however, readers should be familiar with the following:

Arizona Groundwater Management Code

To eliminate severe groundwater overdraft in the State's most populous regions, Arizona committed to long-term management and conservation of this resource through the Groundwater Management Code, first enacted in 1980 (Arizona Revised Statutes § 45-101 et seq). The Code set up a management framework and established the Arizona Department of Water Resources (ADWR) to administer the Code's provisions. The Code contains six key provisions:

1. Establishment of a program of groundwater rights and permits.
2. A provision prohibiting irrigation of new agricultural lands within AMAs.
3. Preparation every 10 years of a water management plan for each AMA, designed to create a comprehensive system of conservation targets and other water management criteria.
4. A framework for requiring developers and water providers to demonstrate a 100-year assured water supply for new growth.
5. A requirement to meter/measure water pumped from all non-exempt wells.
6. A program for reporting annual water withdrawal and use.

Pinal Active Management Area (AMA)

The Pinal AMA is a subdivision of the state with boundaries based primarily on groundwater basins, established as part of the Groundwater Code, to address the groundwater mining that was leading to groundwater depletion and other issues such as subsidence and infrastructure expenses prior to 1980. Arizona Revised Statutes § 45-411

Pinal AMA Management Goal

The management goal of the Pinal AMA is to allow development of non-irrigation uses and to preserve existing agricultural economies in the active management area for as long as feasible, consistent with the necessity to preserve future water supplies for non-irrigation uses (Arizona Revised Statutes § 45-562). The Code does not specify the quantity of water that must be preserved for non-irrigation uses or for how long it will be feasible to preserve the agricultural economy.

Drought Contingency Plan (DCP)

In response to ongoing drought conditions in the Colorado River Basin, and to reduce the likelihood of Colorado River reservoirs declining to critical elevations, Arizona and the other six Colorado River Basin states agreed to implement Drought Contingency Plans. The DCP agreements include an Upper Colorado River Basin DCP and a Lower Colorado River Basin DCP (see Appendix 1 for further details).

For the Arizona parties who signed on in 2019, DCP means accepting smaller water reductions sooner to reduce the likelihood of catastrophic shortages. As "low priority" users of CAP water, farmers in Pinal County agreed to reduce their use of Colorado River by 20 percent when a "tier zero" shortage occurs, as defined in the DCP. The agreement supersedes the schedule of gradual reductions farmers agreed to when they signed on to receive CAP water at a discounted rate in 2004.

JURISDICTIONAL AND REGULATORY BOUNDARIES

LAND OWNERSHIP AND AUTHORITY

Situated between two metropolitan areas and intersected by two major interstates, Pinal County sits in the middle of Arizona's Sun Corridor and contains portions of the Pinal AMA (42 percent), Phoenix AMA (15 percent), Tucson AMA (13 percent), and non-AMA land (30 percent) (Figure 10). These jurisdictional and regulatory subdivisions also overlap the boundaries of Tribal Nations, including Gila River Indian Community (GRIC), Ak-Chin Indian Community, and Tohono O'odham.

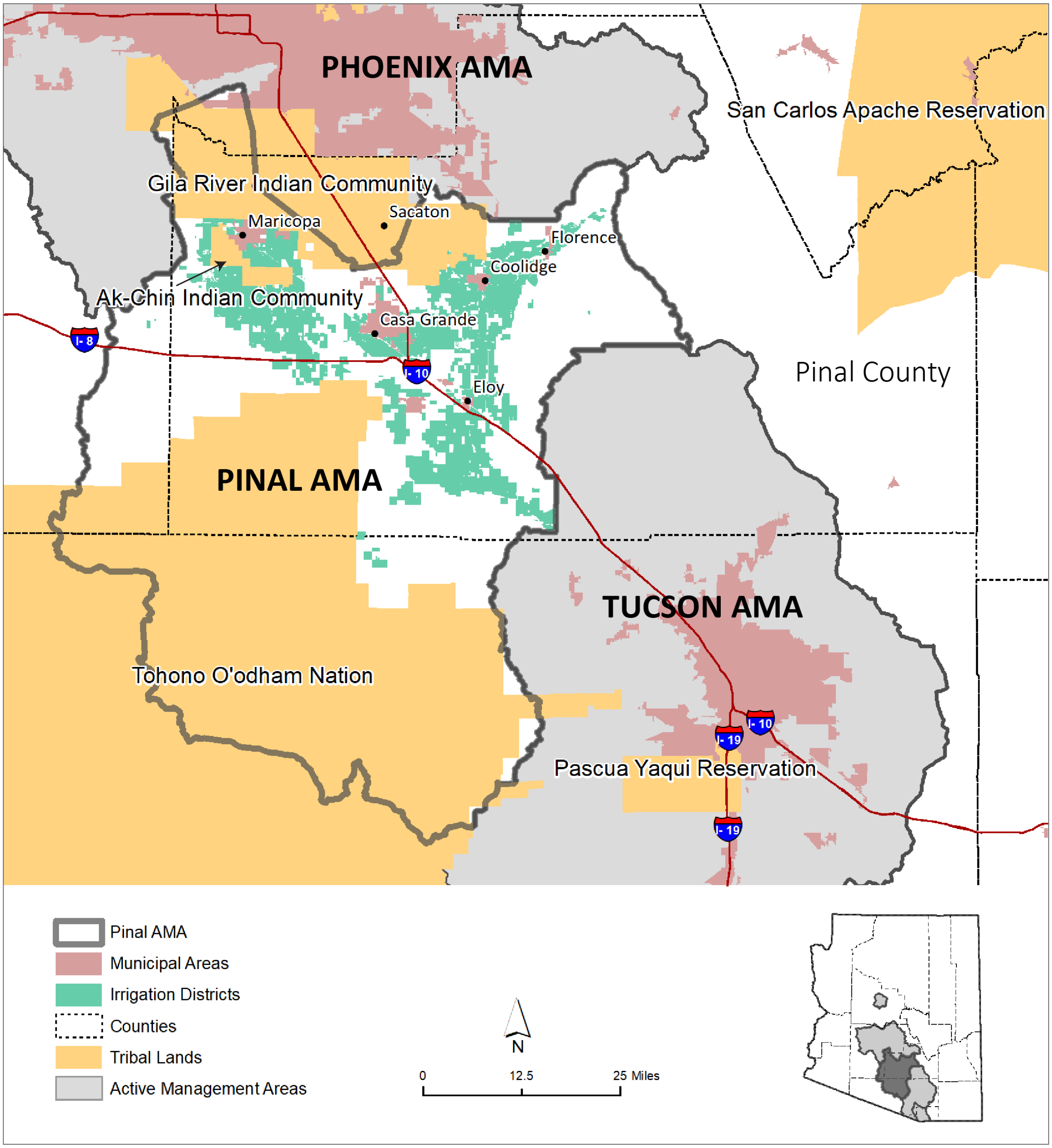


Figure 10. Municipal Areas, Tribal Lands, and Irrigation Districts in the PInal AMA (ALRIS 2018, ADWR 2020d)

Adding to the layers of complex geography, the boundaries of private and public water providers are different compared to the boundaries of cities and towns (Table 1, Figures 11-12). Water providers may serve customers located within a city or town with the same system that serves customers in another town or unincorporated area. Additionally, a single city or town may be served by more than one water provider. In some cases, city and provider boundaries overlap the AMA boundary meaning that an individual city or water provider may be both inside and outside the Pinal AMA.

Table 1. Private, Public, and Mixed Ownership of Large Community Water Systems in the Pinal AMA (ADWR 2020)

LARGE COMMUNITY WATER SYSTEMS*	POPULATION SERVED
Privately owned water companies	
Arizona Water Co - Pinal Valley	83,940
Johnson Utilities - Pinal County**	55,074
Global Water - Santa Cruz Water Co.	39,367
Publicly owned water utilities	
City of Eloy	9,800
Town of Florence	8,297
Mixed ownership	
Thunderbird Farms Improvement District	2,100

* Picacho Water Company, AZ Dept of Corrections - Eyman, and AZ Dept of Corrections - Florence are also classified as large community water systems.
**In August of 2018, EPCOR stepped in as interim manager of Johnson Utilities.

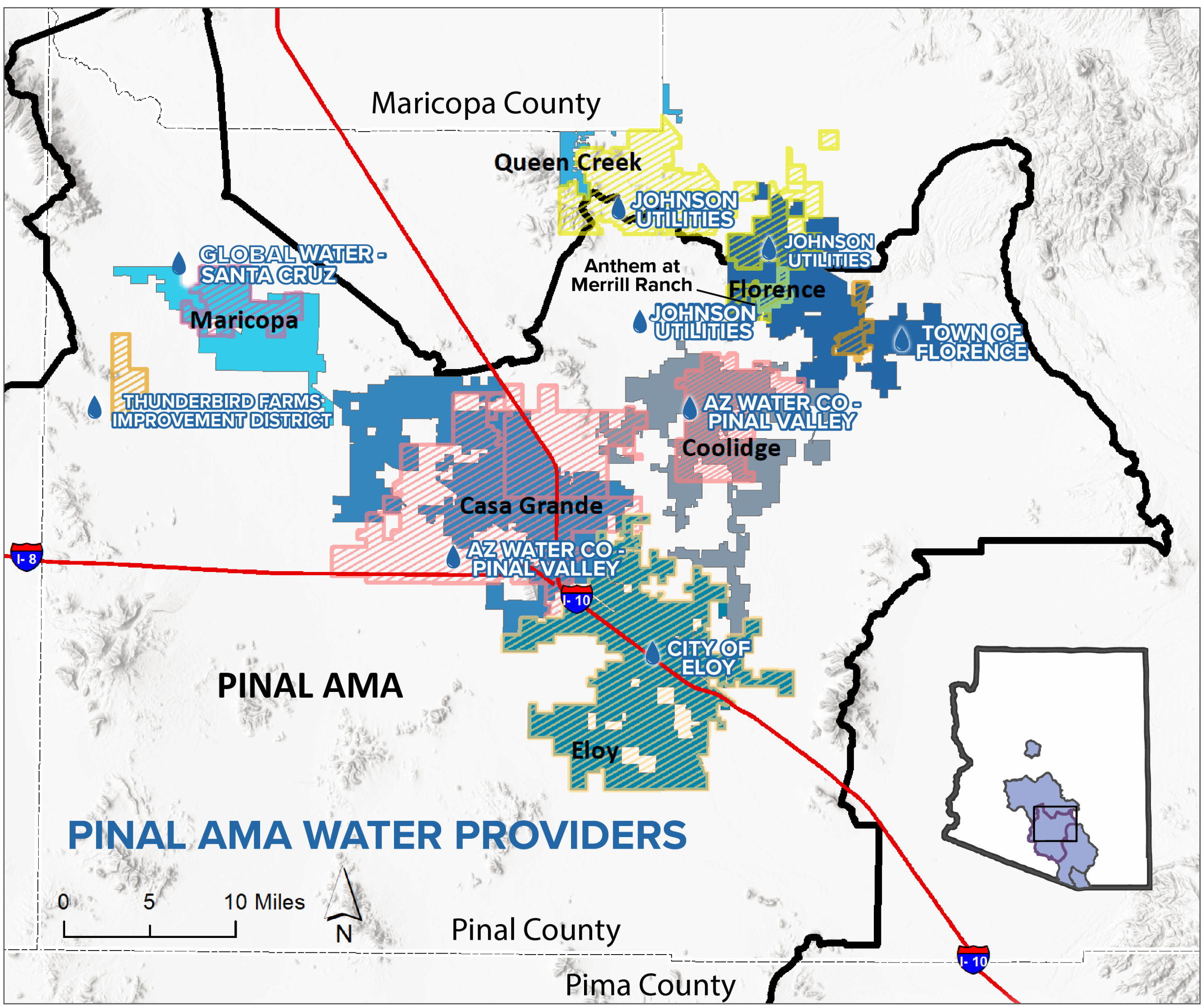


Figure 11. Boundaries of Large Water Providers Overlaying Incorporated Towns and Cities in the Pinal AMA (ADWR 2020d, US Census 2018)

Defining boundaries is also a matter of the terminology in use. For instance, Figure 11 depicts the boundaries of "Large Community Water Systems" (CWS) based on ADWR's definition of "large," which is any water system that serves more than 1,850 residents. These boundaries are different from "municipal service area" boundaries (Figure 12) relevant to water providers. Irrigation districts, on the other hand, are municipal corporations with broad powers and purposes, providing their district with water, electricity, and other public conveniences and necessities generally provided by municipalities (Figure 12).

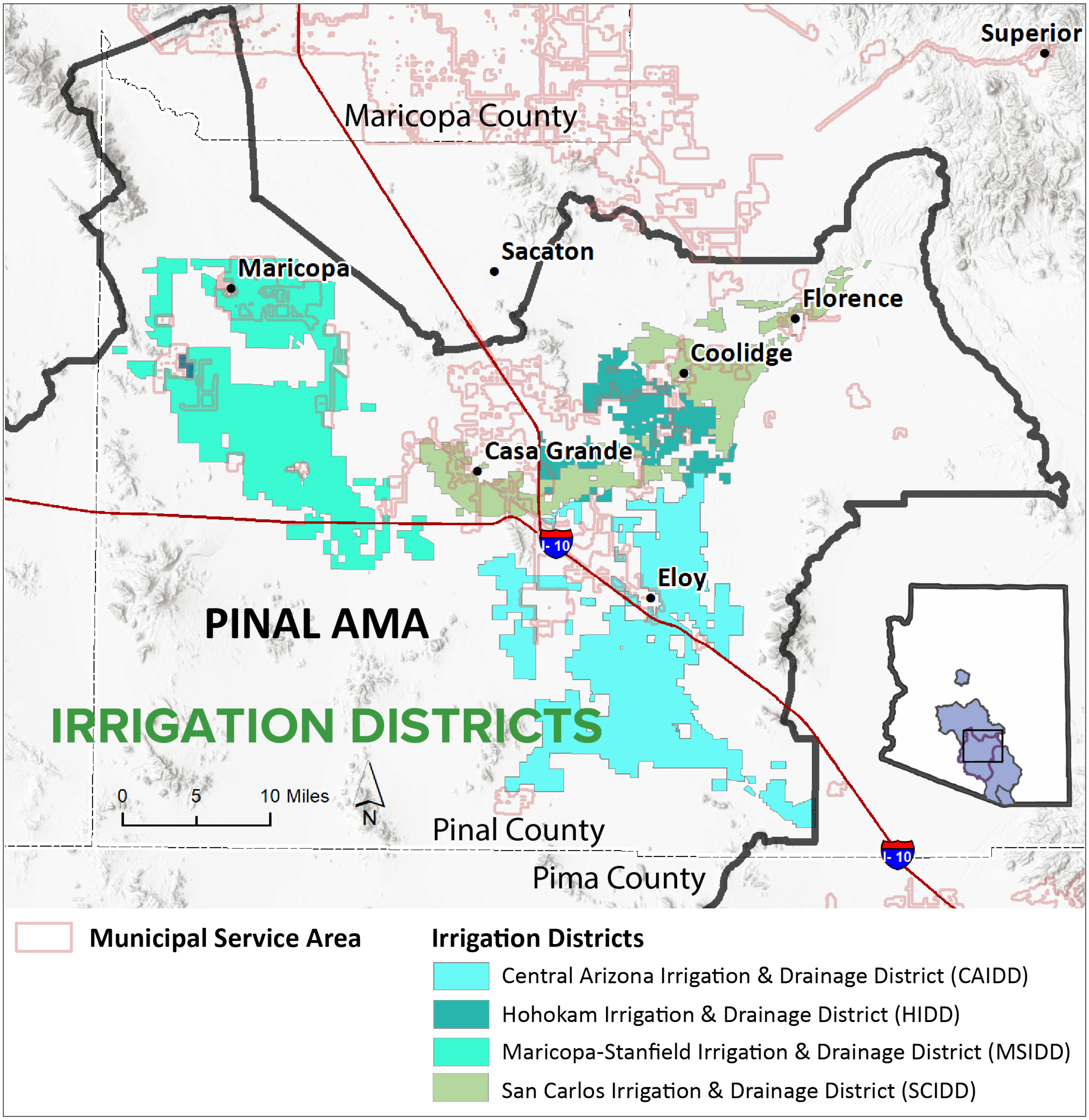


Figure 12. Municipal Service Areas Overlaying Irrigation Districts in the Pinal AMA (ADWR 2018, 2020d)

Land under different ownership is managed in different ways and shapes water use trends. Only 20% of the land in Pinal AMA is privately owned, used primarily for farming, ranching, and housing. Half of the land in the AMA is Tribal land (Table 2, Figure 13). The Gila River Indian Community, Ak-Chin Indian Community, and Tohono O'odham Nation are sovereign nations with independent systems of land and water management and water rights. The U.S. Bureau of Land Management and Arizona State Land Department also own large swaths of land and lease lands to private citizens for such uses as grazing, agriculture, recreation, and rights of way for transportation and utilities. State Trust Lands are often interspersed with federally managed land and privately owned land and may be sold under certain conditions. Several small areas in the AMA are managed for wildlife and recreation by the U.S. Bureau of Reclamation, the National Parks Service, and the State.

Table 2. Land ownership in Pinal County and the Pinal AMA (ALRIS 2018)

Owner	Acres	Sq. Miles	% County	% AMA
PRIVATE	4,587,830	7,168	29.09%	22.55%
TRIBAL	5,009,350	7,827	31.76%	51.42%
USFS	3,257,361	5,090	20.65%	0
STATE	1,766,256	2,760	11.20%	12.98%
BLM	1,116,970	1,745	7.08%	11.63%
MILITARY	6,746	10	0.04%	0.81%
LOCAL OR STATE PARKS	7,943	12	0.05%	0.23%
COUNTY	3,837	6	0.02%	0
RECLAMATION	15,046	23	0.10%	0.37%
NPS	473	0.7	1.92%	0.02%

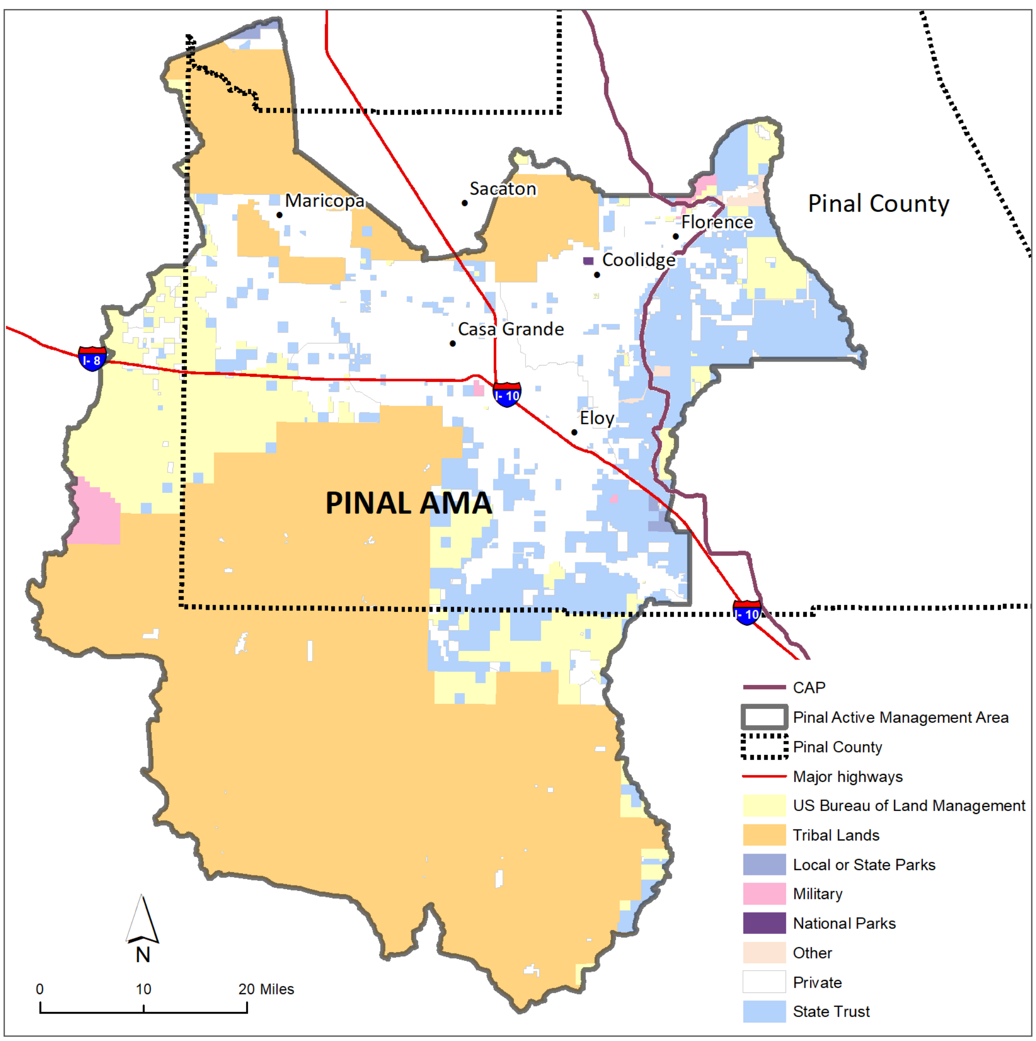


Figure 13. Land Ownership in the Pinal AMA (ALRIS 2018)

WATER POLICY AND REGULATIONS

Arizona's water policy management objectives center upon protecting the general economy and welfare of the state by promoting the use of renewable water supplies and innovative water management strategies, such as storing water underground and augmenting local water supplies. Different water supplies are managed under different statutes and regulations. The foundation of groundwater management in the Pinal AMA is the Groundwater Management Code (Code). It established ADWR to implement and enforce its provisions. The Code defines and distinguishes between categories of water users, the principal categories being agricultural, municipal, and industrial.

PINAL AMA AGRICULTURAL WATER

An Irrigation Grandfathered Right (IGFR) allows land to be legally irrigated within an AMA (see Appendix 1 for more information about IGFRs). IGFRs have a perpetual right to annually withdraw a specified amount of groundwater, which may be reduced by periodically reviewed conservation requirements (ADWR 2020c). The amount of annual groundwater withdrawal associated with IGFRs was calculated by ADWR based on the quantity of water needed to irrigate the acreage and type of crops grown in one year between 1975 and 1979. The establishment of new IGFRs is prohibited.

An existing IGFR may be conveyed to a new owner. Under limited conditions, an IGFR may be converted to a Type 1 Non-Irrigation Grandfathered Right (Type 1 GFR) or may be extinguished for credits to demonstrate that groundwater use is consistent with the management goal for Assured Water Supply (AWS) determinations (i.e. real estate development). A Type 1 GFR is associated with land permanently retired from farming and converted to non-irrigation use. Similar to IGFRs, these rights are appurtenant to the land. The trend through 2017 in the Pinal AMA has been a very slow reduction in IGFRs. Since 1985, less than 10 percent of irrigation acres have been retired due to IGFR conversions to Type 1 or extinguishment for AWS credits (Figure 14) (ADWR 2020c).

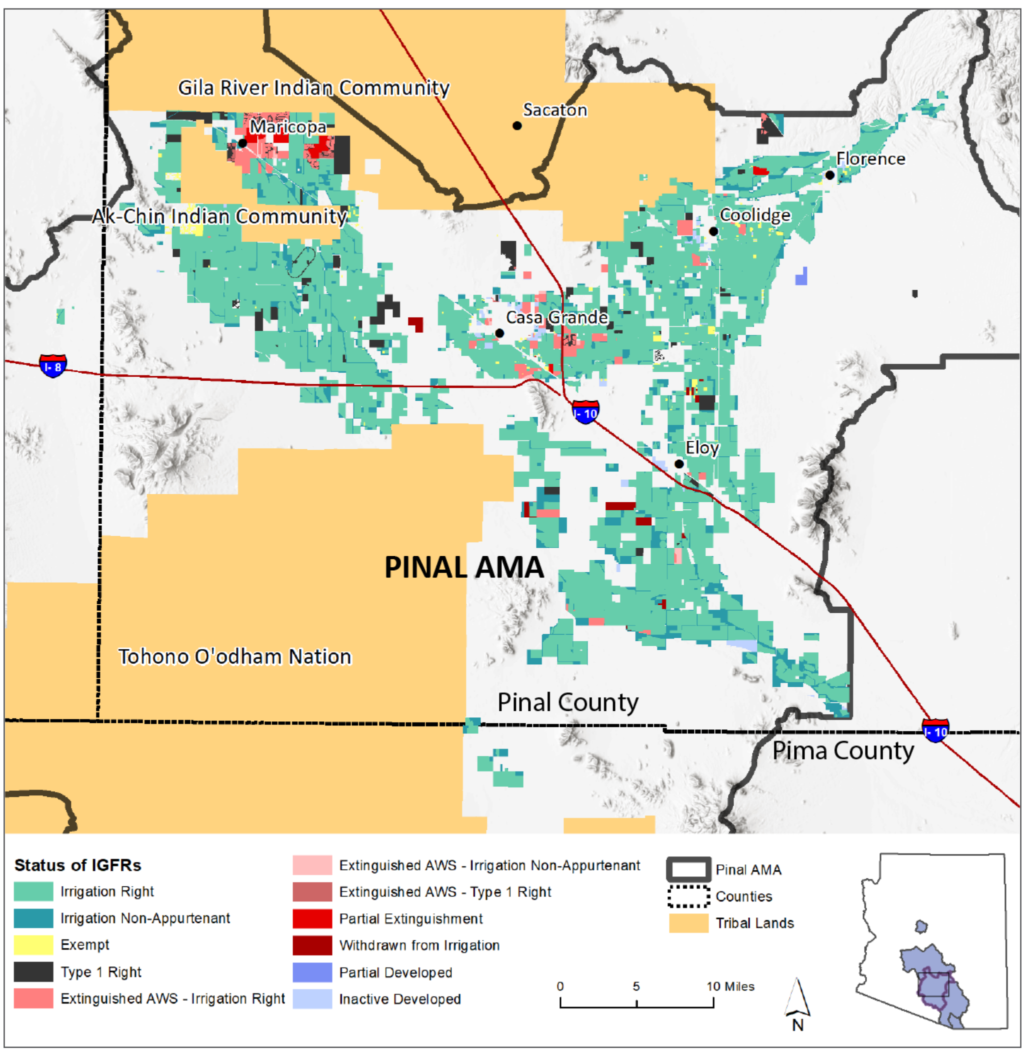


Figure 14. Irrigation Grandfathered Rights (IGFRs) in the Pinal AMA (ADWR 2020d)

PINAL AMA MUNICIPAL WATER SUPPLIES

In the Pinal AMA, municipal demand relies primarily on groundwater pumping, which increased by about 50 percent between 1985 and 2008, from approximately 13,000 AF to over 27,000 AF, and has remained fairly steady since then (Figures 15-16).

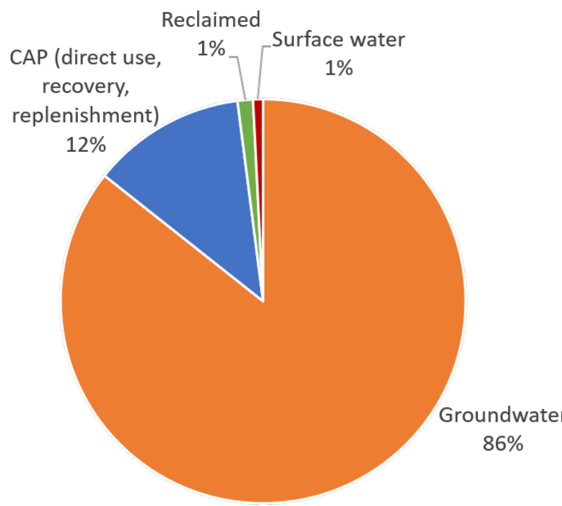


Figure 15. Average Annual Municipal Water Demand in the Pinal AMA by Source, 2008-2018

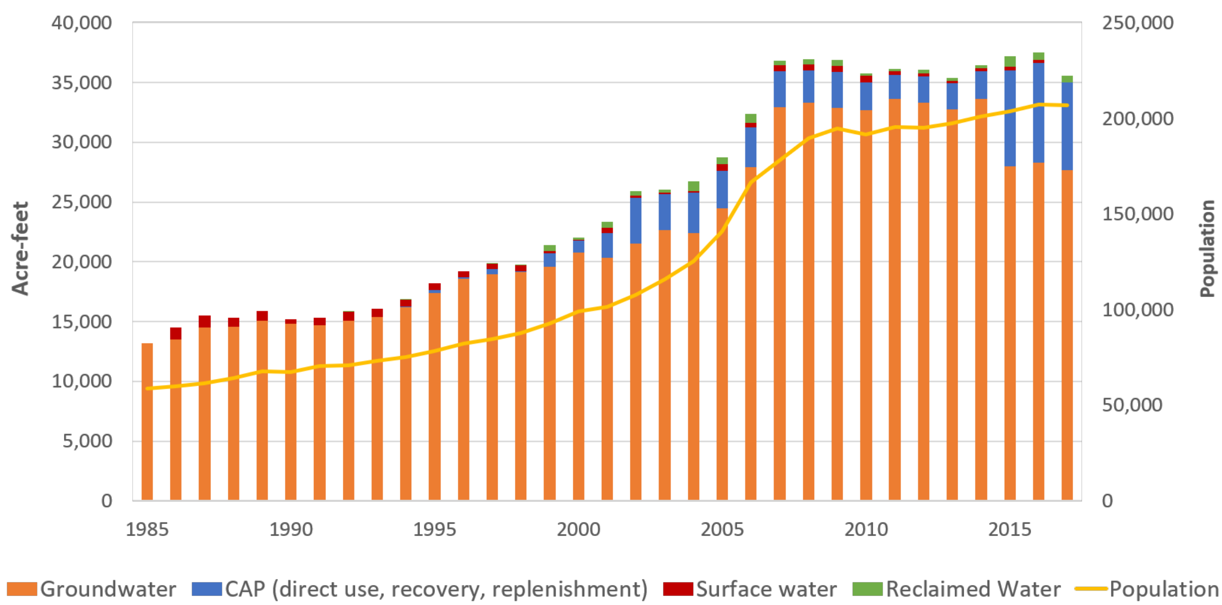


Figure 16. Municipal Water Use by Source and Population Growth, 1985-2017 (ADWR 2020a)

As Pinal AMA cities and towns continue to grow, the relationship between population growth and water demand is not linear, with increased conservation activities resulting in water use efficiency and reduced per capita use rates. Pinal County's population is projected to double over the next 20 years (ADOA 2018) and the number of housing units has more than doubled between 2000-2018, although most of the growth occurred before 2008 (Figures 17-18) (U.S. Census Bureau 2012, 2019). In addition, a significant portion of planned development is still unconstructed. This potential urban growth raises questions about where development will occur relative to where there are groundwater supplies. For example, Casa Grande is expected to experience urban growth; however, the city is located over a shallow part of the aquifer and susceptible to dewatering from groundwater pumping (see Figure 8). More than 10,000 acres of new residential housing has been constructed since 2002, of which less than 2,000 acres (20 percent) has occurred on retired agricultural land (ADWR 2020c).

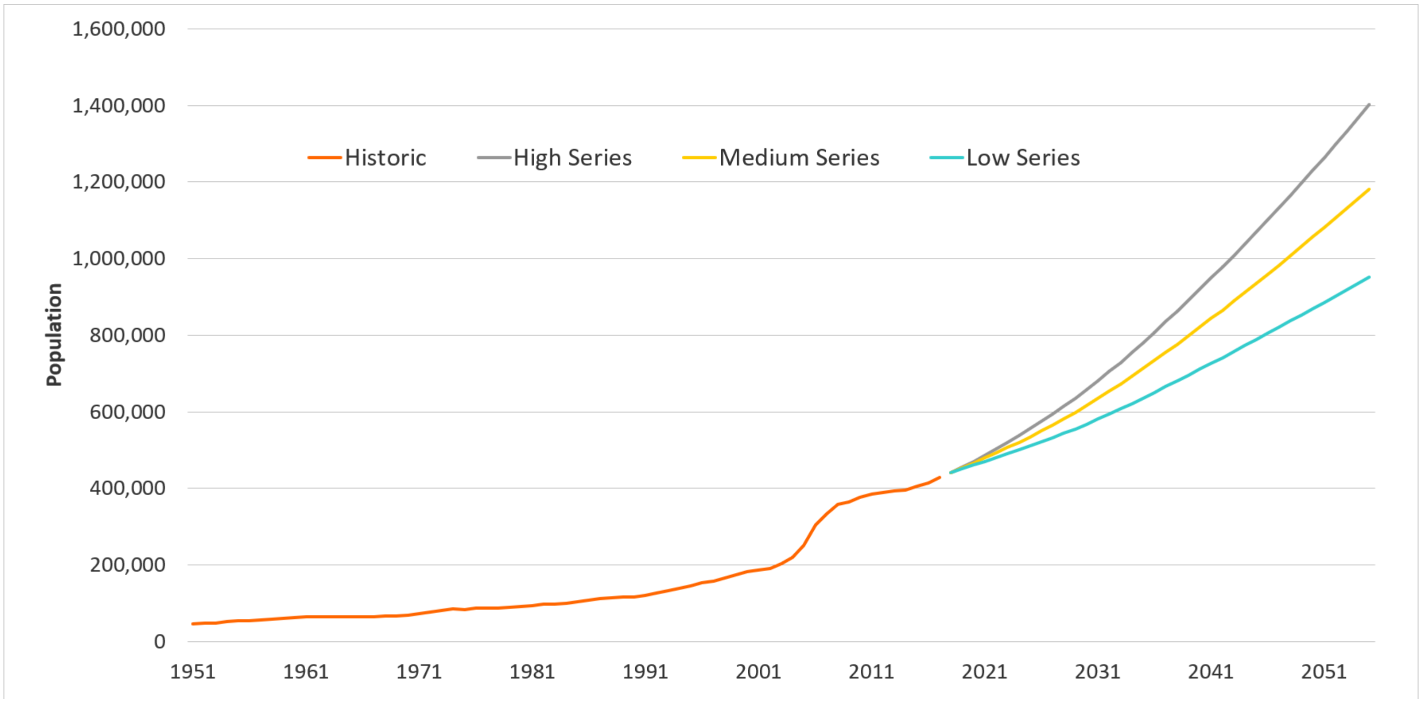


Figure 17. Pinal County Population Growth and Projections (U.S. Census Bureau 2012, ADOA 2018)

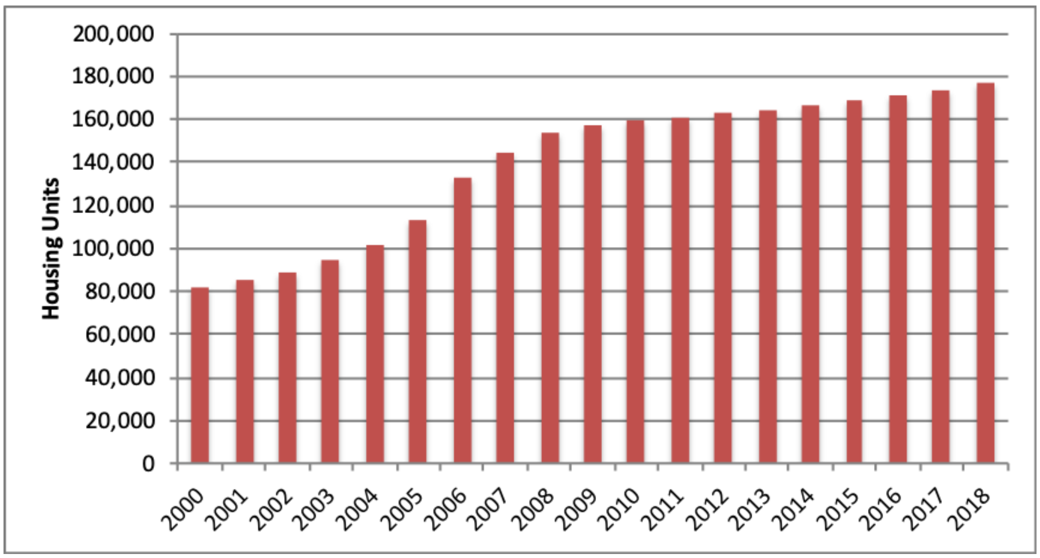
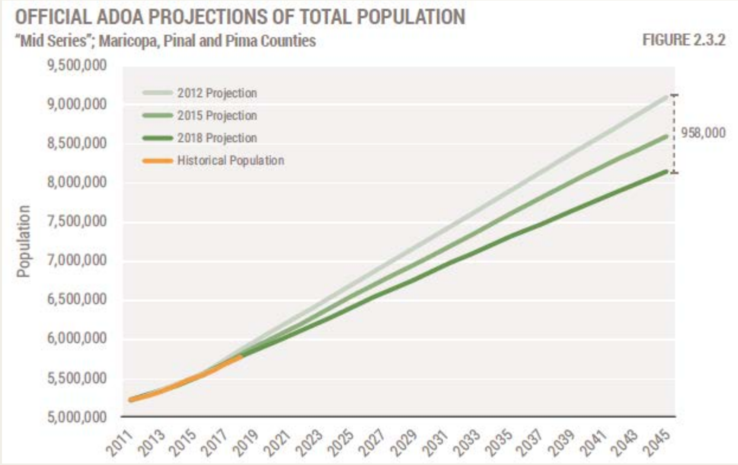


Figure 18. Number of Housing Units in Pinal County (U.S. Census Bureau 2012, 2019)



A NOTE ON POPULATION PROJECTIONS

The Arizona State and County Population Projections are produced by Arizona Department of Administration based on a detailed demographic methodology and population projection model. These projections are used for a wide range of planning purposed. As shown at left, official projections have been revised twice in the last ten years to show slower growth (CAGRD 2019).

ASSURED WATER SUPPLY PROGRAM

A cornerstone of the Groundwater Management Code is the consumer protection built into the Assured Water Supply (AWS) program (see Appendix 1 for more information about the AWS program). The AWS program protects homebuyers and sustainable growth by requiring that a 100-year water supply must be available to meet the demands of future growth and be consistent with the management goal of the AMA. The program evaluates current and committed demand, as well as growth projections, in assessing water availability. In general, the modifications to the AWS rules that were made in 2007 require new developments in Pinal AMA to be sustained predominantly by renewable water supplies, including effluent and CAP water. The AWS rules do allow satisfaction of the 100-year supply on the basis of groundwater, but most of the pumping must be offset through the recharge of renewable supplies. One of the primary mechanisms for offsetting groundwater pumping is to enroll in the Central Arizona Groundwater Replenishment District (CAGRD) (see Appendix 1 for more information about CAGRD).

An assured water supply can be demonstrated in two ways: 1) Certificate of Assured Water Supply (CAWS) issued to landowners for a subdivision and 2) Designation of Assured Water Supply (DAWS) issued to water providers. A landowner can also apply for an Analysis of Assured Water Supply (AAWS) to demonstrate that one or more of the AWS criteria are met, including that sufficient water supplies are physically available to meet the estimated water demand of a development for 100 years.

Certificates of Assured Water Supply: In an AMA, a landowner must demonstrate an assured supply of water to ADWR before the land may be marketed to the public. A new certificate can be issued if the applicant demonstrates the physical availability of water through a hydrologic study or by using a previously issued determination. To receive a CAWS from ADWR, a developer must demonstrate that:

1. Water of sufficient quantity and quality is legally available to serve the proposed development for 100 years,
2. The proposed use is consistent with the management plan (e.g., it adheres to conservation requirements) and achievement of the AMA management goal, and
3. The water provider has the financial capability to construct water delivery and treatment systems to serve the proposed development.

Designations of Assured Water Supply: Rather than a CAWS, if a subdivision will be served by a designated municipal or private water provider and the developer obtains written commitment of service from the provider, the water provider becomes responsible for compliance with the AWS program requirements. The water must be demonstrated physically available for current, committed, and projected demands of the water provider.

Analysis of Assured Water Supply: Typically, landowners apply for an AAWS to demonstrate physical availability of groundwater. An AAWS issued for physical availability of groundwater accounts for a subdivisions' water demands, but a CAWS is still necessary to sell lots to the public. The AAWS is issued to master planned communities and reserves groundwater for 10 years (and may be extended in additional five-year increments), allowing developers and water providers enough time to obtain a CAWS or DAWS.

Under the AWS Program, designated water providers are granted a groundwater allowance to provide credits for a finite amount of groundwater withdrawals without incurring a replenishment obligation (see replenishment obligation in Appendix 1). ADWR concluded in the development of the AWS Rules that a limited quantity of the groundwater in storage could be allocated as a portion of the allowable water supply for an applicant over a 100-year period. To support the growth of future non-irrigation uses of water, the original AWS Rules approved generous groundwater allowances in the Pinal AMA, renewed on an annual basis in perpetuity. As water committed to AAWS, CAWS, and DAWS was increasing, the AWS Rules were modified in 2007 to reduce (or in some cases eliminate) the groundwater allowance.

The AWS Rules allow credits accrued by extinguishing grandfathered rights (IGFRs, Type 1 GFRs, and Type 2 GFRs) in the Pinal AMA to be added to the groundwater allowance of a water provider or developer/landowner that has an AWS designation/certificate also within the Pinal AMA. In compliance with the AWS Rules, 160 IGFRs were partially or fully extinguished in the Pinal AMA since 1995, representing more than 13,000 acres that can no longer be used for agricultural production (ADWR 2020c). Most of these have not yet been developed. Since 1985, 27,000 acres have been retired and converted to Type 1 Non-Irrigation GFRs or have been extinguished (ADWR 2020c).

One of the key requirements for a CAWS, DAWS, or AAWS is proof that water is physically available for proposed development. Many stakeholders question the accuracy of the estimated water demand associated with existing Pinal AMA AWS determinations, because of inflated expectations during the housing boom, slow housing recovery after the 2008 bust, and the subsequent recession. Regardless of its accuracy, the current water demand associated with AAWS results in a volume of reserved groundwater, which ADWR must consider when new AWS applications are submitted. The inability to demonstrate sufficient water for new AWS applications has effectively created a moratorium on development in the Pinal AMA. In other words, the already existing allocations of groundwater exceed ADWR's calculations of physically available groundwater for 100 years in certain areas of the Pinal AMA, so no new CAWS can be issued.

ADWR uses a groundwater model to project all issued AWS demands for AAWS, CAWS, and DAWS over a 100-year time period, not including pending AWS applications (Table 3). The model quantifies existing and projected future groundwater use and recharge over the 100-year period, as well as unmet demands by sector. To calculate the most

Table 3. Assured Water Supply Issued Determinations in the Pinal AMA Model Area (ADWR 2019)

AWS Type	Analyses	Certificates	Designations	Totals
ISSUED DETERMINATIONS (COUNT)*	41	210	6	257
ORIGINALLY ISSUED DEMAND (AF/YEAR)	127,287	55,775	48,865	231,601
ISSUED OUTSIDE MODELED AREA (COUNT)	1	1	0	2
CURRENTLY DEVELOPED DEMAND (BUILT-OUT AND SERVED DEMAND) (AF/YEAR)	0	5,991	10,611	16,602
UNMET DEMAND (AF)	1,070,770	265,926	633,253	1,969,950

*Estimates of built out and served development exclude one AAWS and one CAWS outside of ADWR's groundwater modeled area, which represents the majority of Pinal AMA.

DEFINING UNMET DEMAND

Unmet Demand does not necessarily mean "running out of water." It refers to simulation results from ADWR's 100-year groundwater model that projects a decline in groundwater to below currently accessible levels in certain areas. In the model, unmet demand occurs when groundwater can no longer be pumped from a well at the modeled rate due to aquifer depletion. The model does not incorporate the feasibility of modifying wells and infrastructure to access deeper groundwater.

accurate groudwater pumping numbers for the 100-year model run in 2019, ADWR tracked current built-out demands, which are subdivisions already being served water. In all, only seven percent of demand in already existing CAWS or DAWS is currently being served water (Table 3, Figure 19). As of 2016, 84 percent of 78,454 lots with issued CAWS remained to be built out (66,163 lots remain to be built out and 12,291 lots are currently built and served) (ADWR 2019). Thus there is significant ability to build new housing within these already approved developments.

SNAPSHOT OF PINAL AMA ASSURED WATER SUPPLY

CERTIFICATES OF ASSURED WATER SUPPLY: BUILD OUT AND ISSUED DEMAND

There are 209 issued CAWS in the Pinal AMA modeled area with a total issued demand of 55,763 acre-feet per year. Of that total, 124 CAWS developments have been built or partially built out with an estimated total current demand of nearly 6,000 AF per year (Table 3). Unmet demand over 100 years is projected to be about 266,000 AF (five percent of total 100-year demand).

BUILT OUT:

49 CAWS developments have zero remaining lots to be built out. The total current demand is estimated to be 1,967 AF per year.

PARTIALLY BUILT OUT:

75 issued CAWS developments are partially built out, meaning about 23% of the lots (7,334 of 31,598 lots) have been built. The current demand of these developments is estimated to be 4,024 AF per year.

NOT YET BUILT:

85 issued CAWS developments have no developed lots and an issued demand of 32,097 AF per year.

DESIGNATIONS OF ASSURED WATER SUPPLY:

There are six designated water providers in the Pinal AMA: Town of Florence, City of Eloy, City of Casa Grande, Global Water Resources – Santa Cruz Water Company, Johnson Ranch Estates (SW Environmental Utilities), and Johnson Utilities, LLC. Issued demand associated with DAWS is approximately 49,000 AF per year. Over 100 years, unmet demand for DAWS is projected to be about 633,000 AF (13 percent percent of total 100-year demand).

ANALYSES OF ASSURED WATER SUPPLY:

There are 41 issued AAWS within Pinal AMA with a total issued demand of 116,872 AF per year. For groundwater modeling purposes, the AAWS demand is removed from the database and the certificated demand is added. Over 100 years, unmet demand for AAWS is projected to be about 1.1 MAF (nine percent of total 100-year demand).

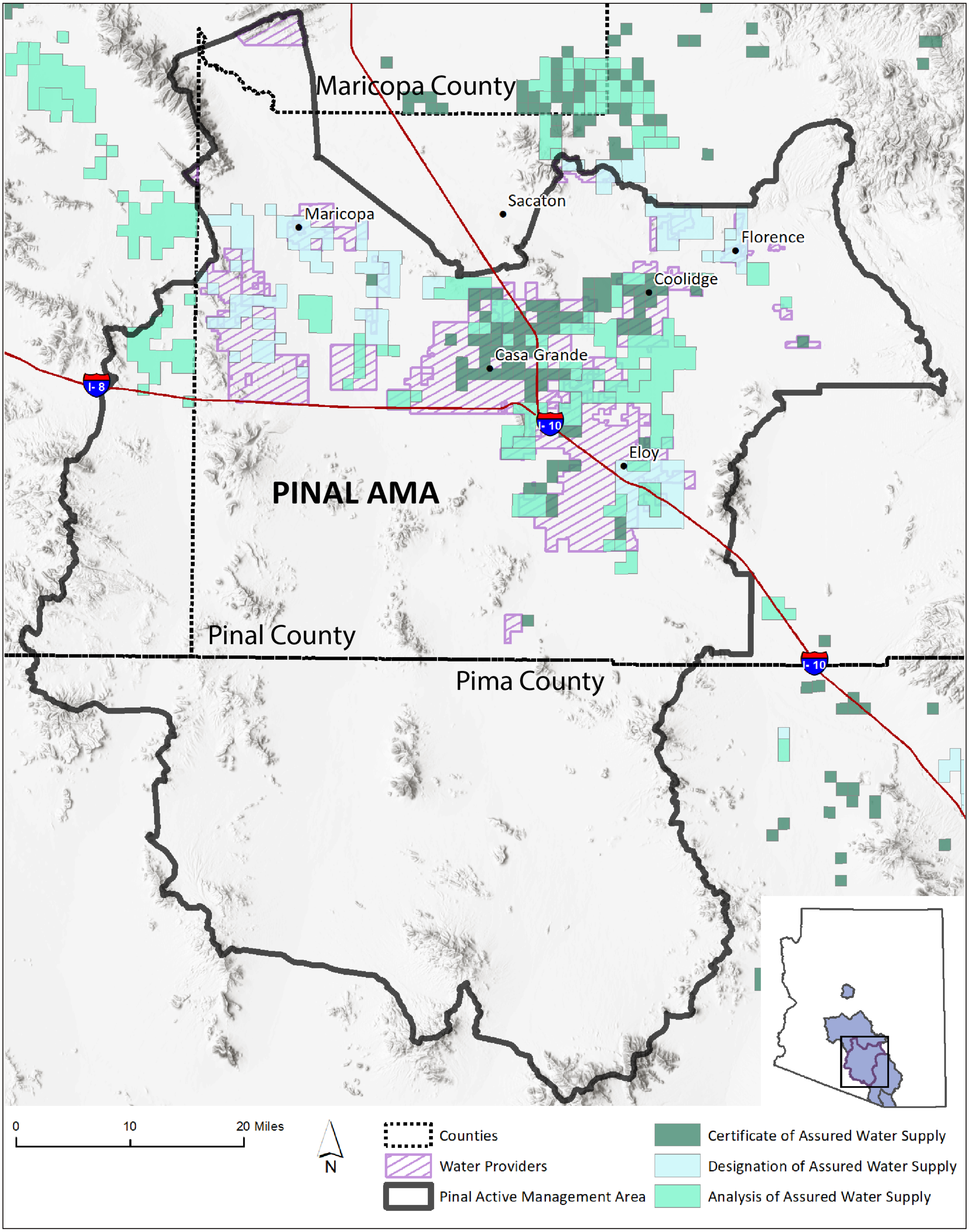


Figure 19. Issued Determinations of Assured Water Supply Overlaying Water Provider Boundaries (ADWR 2020d)

GROUNDWATER RECHARGE AND RECOVERY IN PINAL AMA

Recharge programs are a key augmentation strategy in the Pinal AMA, either through direct recharge to the aquifer in Underground Storage Facilities (USFs) or through an indirect process where use of renewable supplies replaces groundwater pumping in Groundwater Savings Facilities (GSFs) (Figure 20). There were 15 permitted recharge facilities in the Pinal AMA as of 2016: 12 USFs and three GSFs (ADWR 2020c) (Table 4). From the beginning of the program through 2017, over 3.1 million acre-feet (MAF) of water have been recharged in the Pinal AMA: 24,161 acre-feet by USFs (less than one percent) and 3,093,465 acre-feet by GSFs (99 percent) (ADWR 2020c).

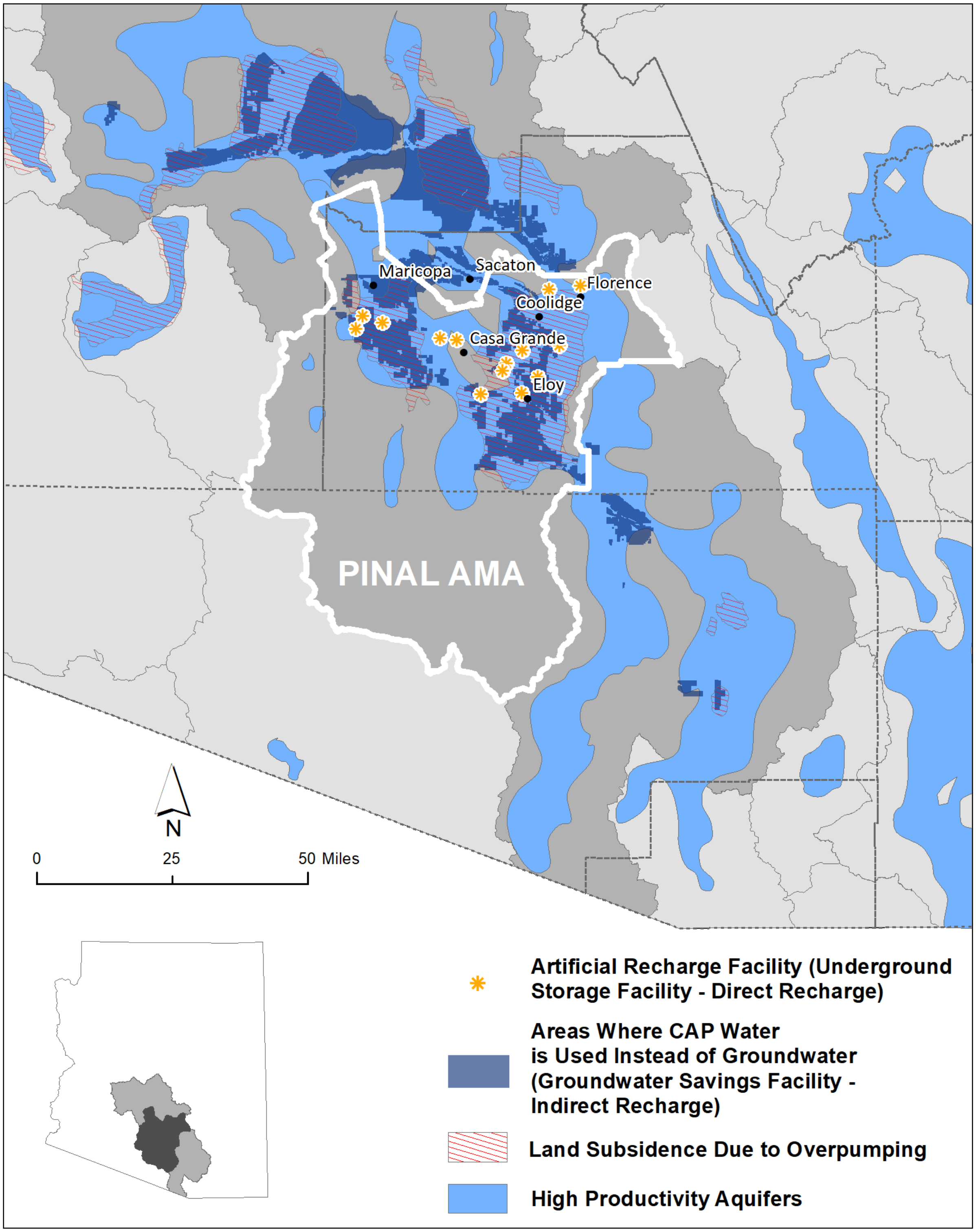


Figure 20. Recharge activities and subsidence (ADWR 2020d)

Groundwater Savings Facilities

Irrigation districts and farms can act as Groundwater Savings Facilities (GSFs). At a GSF, renewable water, such as CAP water or effluent, is used in lieu of groundwater. Colorado river water is delivered to GSFs through the CAP canal. In the Pinal AMA, Central Arizona Groundwater Replenishment District (CAGRD) is permitted to store up to 97,700 AF per year at two GSFs: Maricopa-Stanfield Irrigation & Drainage District (MSIDD) and Central Arizona Irrigation & Drainage District (CAIDD) (CAGRD 2019). The Arizona Water Banking Authority (AWBA) also has stored water in those two GSFs. Since the beginning of the recharge program, GSFs have stored the most renewable water in the Pinal AMA (3,093,465 AF), taking CAP water in lieu of pumped groundwater (ADWR 2020c).

Underground Storage Facilities

In an Underground Storage Facility (USF), renewable water recharges aquifers, commonly through one of three methods: shallow constructed infiltration basins, a river or stream bed used as infiltration medium, and injection wells. As of 2017, a total of 24,161 AF of renewable water supplies (2,766 AF of CAP water and 21,394 reclaimed water) were delivered to be stored at USFs in the Pinal AMA (ADWR 2020c). Only one USF is permitted to recharge CAP water, the Arizona Water Company's Pinal Valley Recharge Facility. Pinal AMA USFs have a total combined permitted recharge capacity of 38,221 AF per year. The GRIC Managed Aquifer Recharge 5 (MAR 5) project is also operating and recharging CAP water.

Table 4. Recharge Facilities and Storage in the Pinal AMA (ADWR 2020c)

FACILITY NAME	PERMIT VOLUME (AF/YEAR)	SOURCE WATER	WATER DELIVERED TO BE STORED THROUGH 2017
Underground Storage Facilities (USFs)			
ANTHEM AT MERRILL RANCH RECHARGE FACILITY	3,360	Reclaimed	4,543
ARIZONA CITY SANITARY DISTRICT USF	2,240	Reclaimed	1,223
AWC PINAL VALLEY RECHARGE USF	10,884	CAP	0
CASA GRANDE CONSTRUCTED RECHARGE FACILITY	2,100	Reclaimed	0
CASA GRANDE MANAGED RECHARGE FACILITY	3,500	Reclaimed	328
EJR RANCH USF	2,092	Reclaimed	0
ELOY DETENTION CENTER USF	2,726	Reclaimed	5,696
ELOY RECLAIMED WATER RECHARGE PROJECT USF	2,240	Reclaimed	8,065
SANTA ROSA UTILITY COMPANY USF	2,577	Reclaimed	0
SOUTHWEST WATER DISTRIBUTION CENTER USF	1,120	Reclaimed	0
SOUTHWEST WRF CAMPUS 2 (Global Water-Palo Verde Utilities Co. #2) USF	2,240	Reclaimed	0
SUN LAKES AT CASA GRANDE EFFLUENT RECHARGE FACILITY USF	340	Reclaimed	183
TOWN OF FLORENCE USF	2,802	Reclaimed	0
HOHOKAM RECHARGE FACILITY #1 USF (expired)		CAP	823
TOWN OF FLORENCE NORTH RECHARGE FACILITY (expired)		Reclaimed	1,356
GRIC OLBERG DAM PILOT USF1 (expired)		CAP	1,944
TOTAL			**24,161**
Groundwater Savings Facilities (GSFs)			
CENTRAL ARIZONA IRRIGATION & DRAINAGE DISTRICT GSF	110,000	CAP	852,197
HOHOKAM IRRIGATION AND DRAINAGE DISTRICT GSF	82,000	CAP	953,512
MARICOPA-STANFIELD IRRIGATION & DRAINAGE DISTRICT GSF	120,000	CAP	1,269,779
GILA RIVER INDIAN IRRIGATION AND DRAINAGE DISTRICT GSF (Pinal AMA portion) (expired)	18,480	CAP	17,976
TOTAL			**3,093,464**

Long-term Storage Credits (LTSCs)

With the passage of the 1994 Underground Storage, Saving and Replenishment Act, the state legislature streamlined the authorization and creation of long-term storage credits (LTSCs) through aquifer recharge via GSFs or USFs with CAP water or effluent (Figure 21).

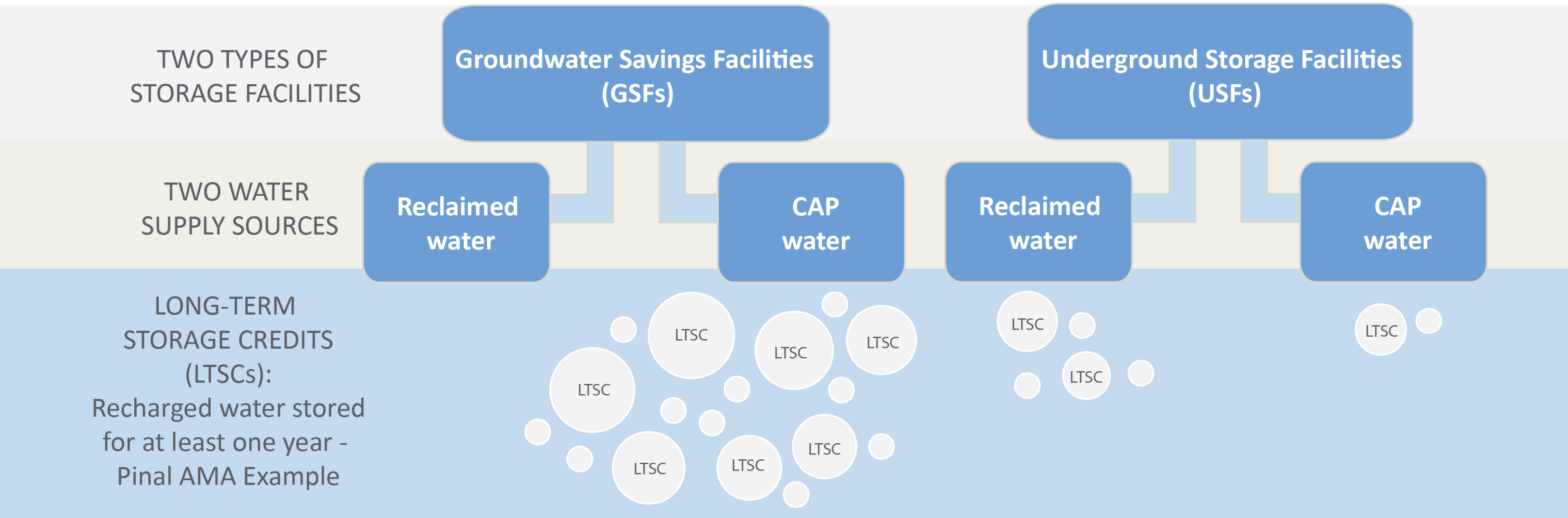


Figure 21. Conceptual Diagram Illustrating the Composition of Long-term Storage Credits in the Pinal AMA

Note: USFs can be further defined as managed and constructed facilities. At a constructed USF, water can be stored in an aquifer by using injection wells, percolation basins, or other constructed devices. At a managed USF, water can be discharged to a naturally water-transmissive area such as a streambed that allows the water to percolate into the aquifer.

When eligible water is stored underground for more than one year, LTSCs may be issued. Stored water is generally eligible for long-term storage credits when:

1. The water cannot reasonably used directly, per Arizona Revised Statutes § 45-802.01(23).
2. The water is stored for at least one year and not recovered on an annual basis.
3. The water would not have been naturally recharged within an AMA.

Anyone holding long-term storage credits may recover stored water through a permitted recovery well from anywhere within the same AMA in which it was stored, so long as:

1. Recovery is consistent with the management plan and the goals of the AMA. Arizona Revised Statutes § 45-834.01
2. When recovery will occur inside or within three miles of the service area of a city, town, private water company or irrigation district, that city, town, private water company or irrigation district is the person recovering the water or has given consent to the recovery. Arizona Revised Statutes § 45-834.01

These credits can be recovered in the future to be used for various reasons, including establishing an Assured Water Supply. The AWS rules allow LTSCs to help demonstrate 100-year water supply availability, but LTSCs have different physical availability requirements depending on whether they are recovered inside or outside the area of impact of storage. LTSCs can be used to demonstrate physical availability, whether those credits exist at the time of the application or the applicant expresses the intention and demonstrates the means to generate LTSCs and recover them within the area of impact. Existing and future LTSCs recovered outside the area of impact of storage have specific physical availability requirements that must be met to be included in an AWS determination. Refer to Arizona Administrative Code R12-15-716(F), (H), and (I).

Owners may also sell LTSCs, for example, when a municipal water provider has generated more LTSCs than needed for customer deliveries and wants funds for infrastructure projects. A market for LTSCs exists in Arizona. ADWR maintains a record of LTSCs and credits or debits accounts when credits are used or sold.

The CAGRD, as a special function of the Central Arizona Water Conservation District (CAWCD), is responsible for meeting the replenishment obligations of its members. A replenishment obligation is incurred when a water provider pumps groundwater in excess of its groundwater allowance. Generally, ADWR designations and certificates include a quantified groundwater allowance. Any groundwater withdrawn by CAGRD members in excess of the groundwater allowance, as reported to ADWR, is replenished by the CAGRD within the same AMA. Extinguishment credits are the third way groundwater can be made consistent with the management goal. Water providers can opt not to use any of their accumulated groundwater allowance as well.

The CAWCD has 316,216 AF LTSCs stored in Pinal AMA, currently dedicated to the replenishment reserve for the CAGRD (Seasholes 2020). CAGRD's Replenishment Reserve is mandated by statute and comprises LTSCs accrued in a Replenishment Reserve subaccount for the AMA. The purpose of the Replenishment Reserve is to help CAGRD meet its replenishment obligation in times of water supply shortage or infrastructure failure (CAGRD 2020). CAGRD can use LTSCs from the Replenishment Reserve to offset its annual replenishment obligation in these circumstances. This reserve can also be used to meet replenishment obligations anywhere in the Pinal, Phoenix, and Tucson AMAs but potentially not in the Pinal AMA at all.

Recovery

Of the approximately 3.1 MAF of renewable water delivered to recharge facilities in the Pinal AMA by the end of 2017, only about 19,000 AF was recovered through annual storage and recovery (ADWR 2020c). During the same time period, only 3,088 AF of long-term storage credits were recovered (Figure 22). The "net storage" (recharge minus recovery) of just under 3 MAF, does not account for evaporation, other losses, or the "cut to the aquifer" (the percentage of long-term recharged water that is dedicated to preserving water in the aquifer).

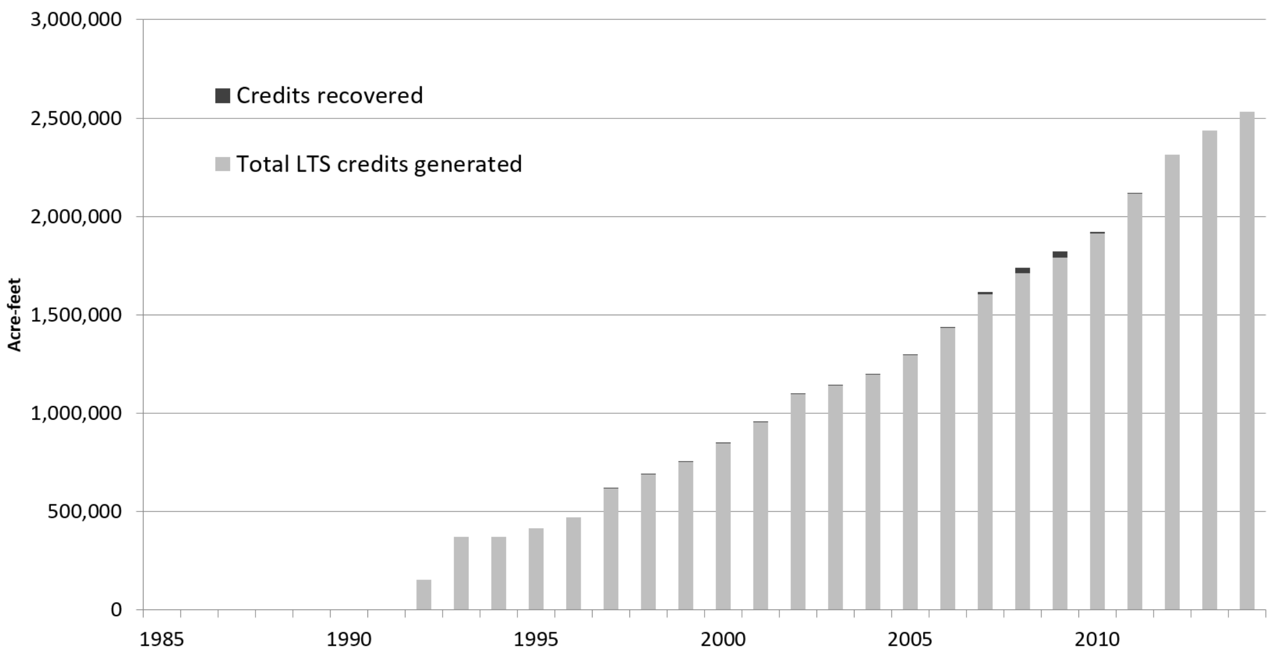


Figure 22. Long-term Storage Credits Generated and Recovered in the Pinal AMA, 1985-2014

The majority of LTSCs in the Pinal AMA are held by govnernmental entities (AWBA and CAWCD) and Gila River Indian Community (Table 5). It is not clear where all the credits will be used, but the demand for credits and the existing markets are largely outside of the Pinal AMA.

Table 5. Long-term Storage Credits Ownership by Category in the Pinal AMA, 2016 (Bernat et al. 2020)

Category	% Ownership
Governmental entities	66.4%
Municipal water providers	3.0%
Industries	3.3%
Tribes	7.9%
Gila river water storage	19.3%
Investment firms	0.2%

PINAL AMA AGRICULTURE

Irrigated agriculture is highlighted in this section because it is the sector most immediately impacted by current and potential CAP water shortages. In addition, agriculture retains an important role for the economy and cultural vibrancy of the region. Currently agriculture accounts for approximately 90 percent of water demand in the Pinal AMA (Non-Tribal and Tribal agricultural water use combined), and therefore the future of Pinal County agriculture will impact, and be impacted by, all other water users in the region.

There were 938 farms in Pinal County in 2012, covering nearly 1.2 million acres of land, with approximately 223,626 irrigated acres (Figure 23) (USDA 2014a). The average farm size in Pinal County was 1,252 acres, slightly smaller than the Arizona average of 1,312 acres, but much larger than the national average of 434 acres (USDA 2014a). These statistics include agriculture on Ak-Chin Indian Community land (four reported farms with undisclosed acreage) (USDA 2014b). The Gila River Indian Community, spanning both Pinal County and Maricopa County, had 41 farms in 2012 on more than 345,000 acres, with approximately 27,000 of those acres irrigated (USDA 2014b). Finally, the Tohono O'odham Nation, located in Pinal, Pima, and Maricopa counties, had 64 farms in 2012 with undisclosed total acreage, but approximately 8,400 irrigated acres (USDA 2014b).

Despite a loss of about 20,400 irrigation acres since the year 2002, water diverted to agriculture in the AMA has not decreased (ADWR 2020c). This may be due to more double cropping today than in the past (growing multiple crops throughout the year on IGFR acres) (ADWR 2020c). At the same time, irrigation efficiencies have been achieved in the Pinal AMA. Increased irrigation efficiencies can lead to greater productivity with less water (Lahmers & Eden 2018); however, these water savings may be negated by growing more crops throughout the year, which uses more water.

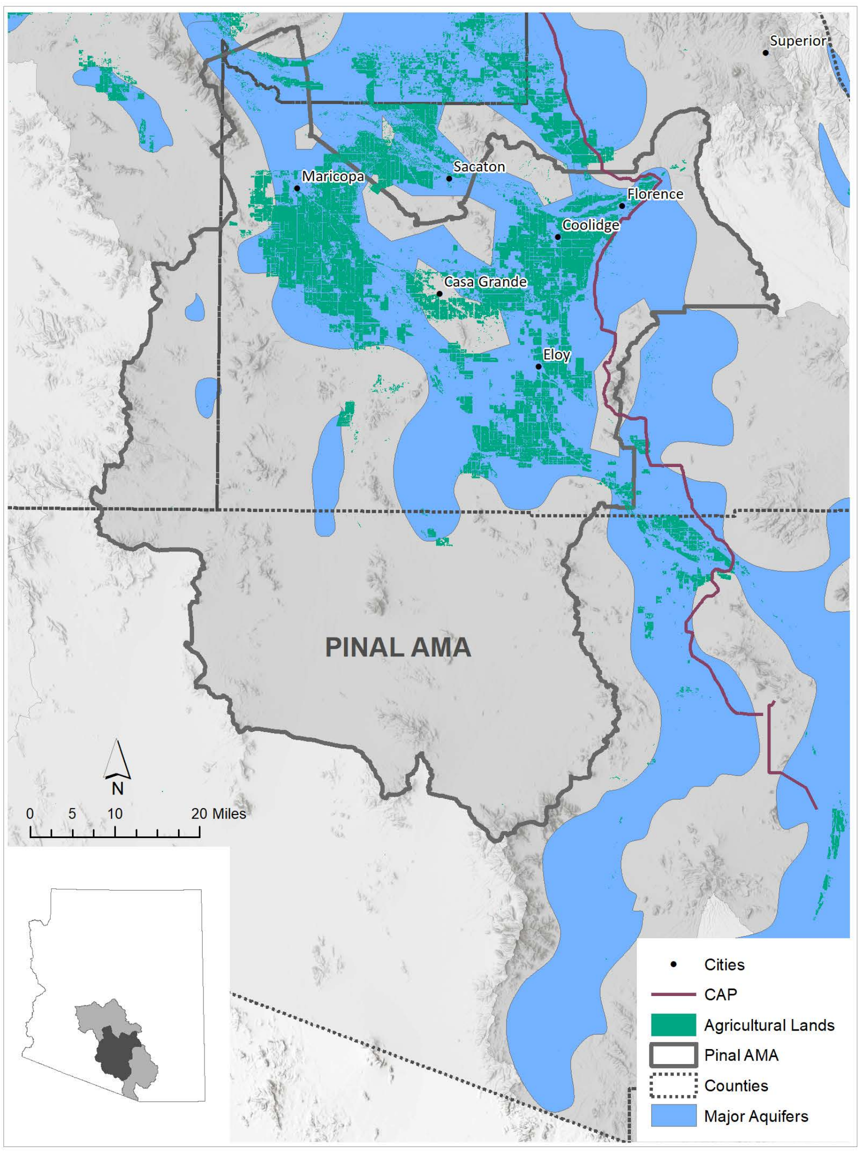


Figure 23. Irrigated Agriculture in the Pinal AMA (USDA 2014)

The Roots of Water Efficiency

Beyond climatic conditions and market forces, the water efficiency of a crop is important in understanding what and why certain crops are grown in the Pinal AMA (Table 6, Figures 24-25). The foundational concept of water efficiency relates to a plant's use of applied water through its root system (consumptive use) compared to losses due to runoff and evapotranspiration. Technological improvements and management practices increase irrigation efficiency and conservation to use even less water for greater crop yield.

Table 6. Water Usage and Productivity of Top Crops in Pinal County (Erie et al 1982, Jama & Ottman 1993)

Crop	Seasonality	Measured Consumptive Water Use	Estimated Applied Water Use	Acres in Production
COTTON	March-November	41.2”	36”- 72”	88,107
ALFALFA	Continuous	74.3”	72”- 84”	70,060
SILAGE CORN	February-June	31.3”	54”- 72”	17,312
CANTALOUPE	March-July or July-October	20.5” or 16.8”	30”- 42”	5,845
WHEAT	December-May	25.8”	36”- 42”	25,993

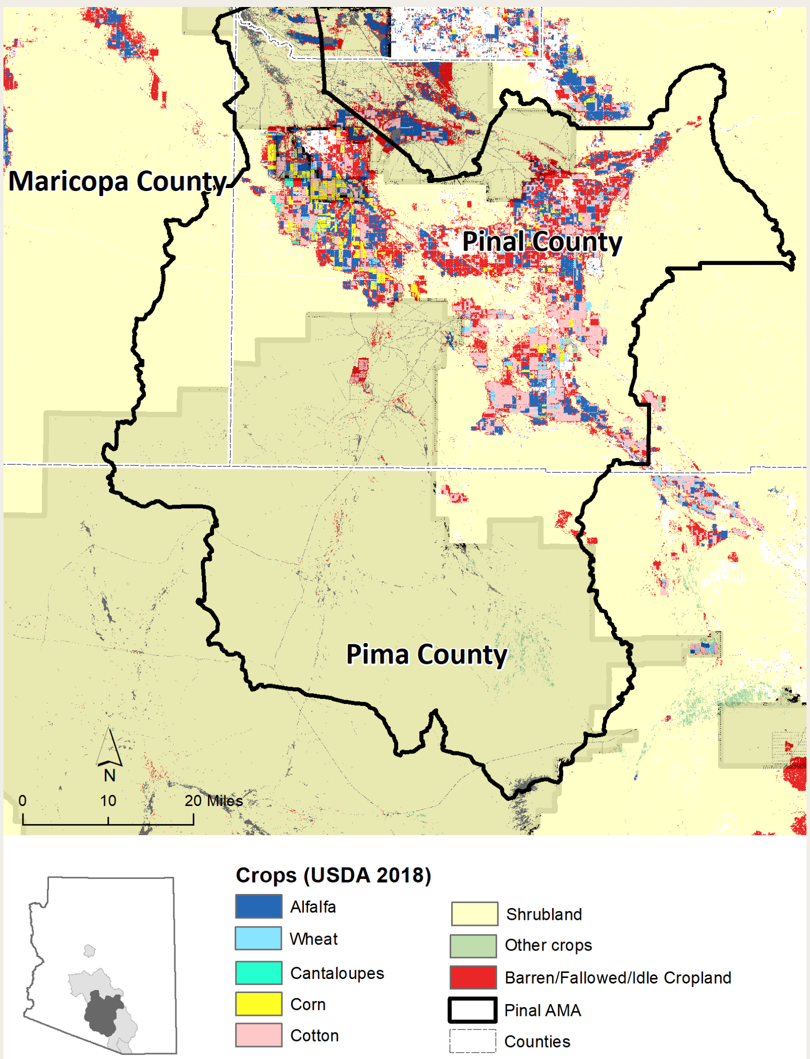


Figure 24. Major Crops Grown in Pinal County (USDA 2018)

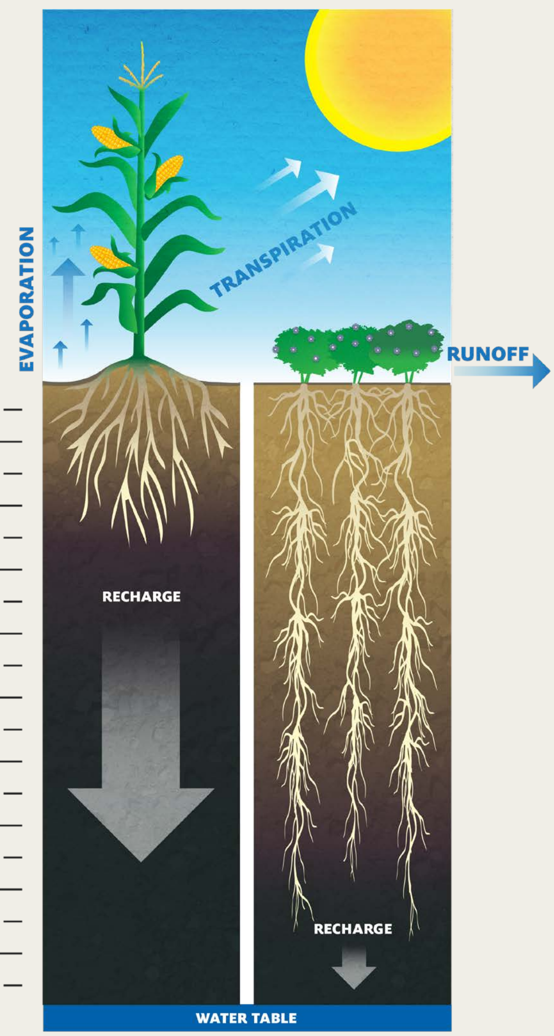


Figure 25. Conceptual Illustration Depicting Aspects of Irrigation Efficiency

As agricultural water demand has remained consistent, the supplies used to meet demands have shifted dramatically in the Pinal AMA (Figure 26). In 1985, there were only three sources of supply used by the agricultural sector: groundwater, surface water (non-CAP), and reclaimed water. The CAP provided new supplies of renewable water through the 1) direct use of CAP water and 2) CAP water used in lieu of groundwater pumping (i.e. the delivery of CAP renewable water supplies replaces groundwater pumping). Direct use of CAP water has decreased slightly since 1994 (Figure 27). Since 1992, fluctuations in the use of CAP water in lieu of groundwater follow the availability of excess CAP water. Use of CAP in lieu of groundwater pumping through Groundwater Saving Facilities (GSFs) has fluctuated on a yearly basis, averaging about 117,000 AF per year (1995-2017). GSF water represents a future physical draw on the aquifer when those credits are recovered, but those credits will be classified as the stored water type (CAP or effluent) when recovered (Figure 27). Non-CAP surface water use has fluctuated due to natural supply conditions.

Reclaimed water use by agriculture has been somewhat steady over time, averaging about 2,200 AF per year (1985-2017). That estimate does not include reclaimed water use on Tribal agricultural lands, which are exempt from Arizona's reclaimed water regulations. A large user of recycled water is the Gila River Indian Community (GRIC), receiving up to 40,000 AF of treated wastewater per year from cities of Mesa and Chandler, sources outside of the AMA, as part of a three-way exchange of water supplies (Cusimano et al. 2015). This exchange was part of the 2004 Arizona Water Settlements Act.

The introduction of CAP water had the overall effect of reducing groundwater pumping in the state's AMAs from 1985 levels, however groundwater pumping levels stabilized around 2011 for the past eight years (Figure 26, Table 7).

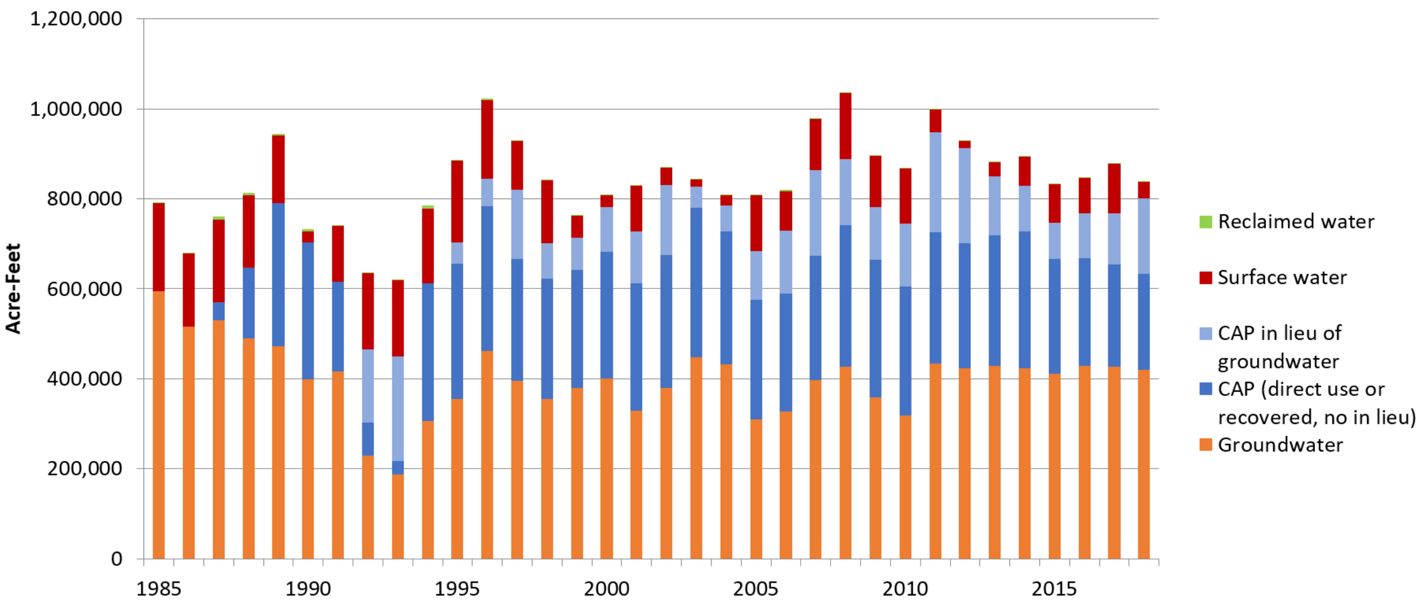


Figure 26. Pinal AMA Non-Tribal Agricultural Water Use by Supply Source in Acre-Feet, 1985-2018 (ADWR 2020a)

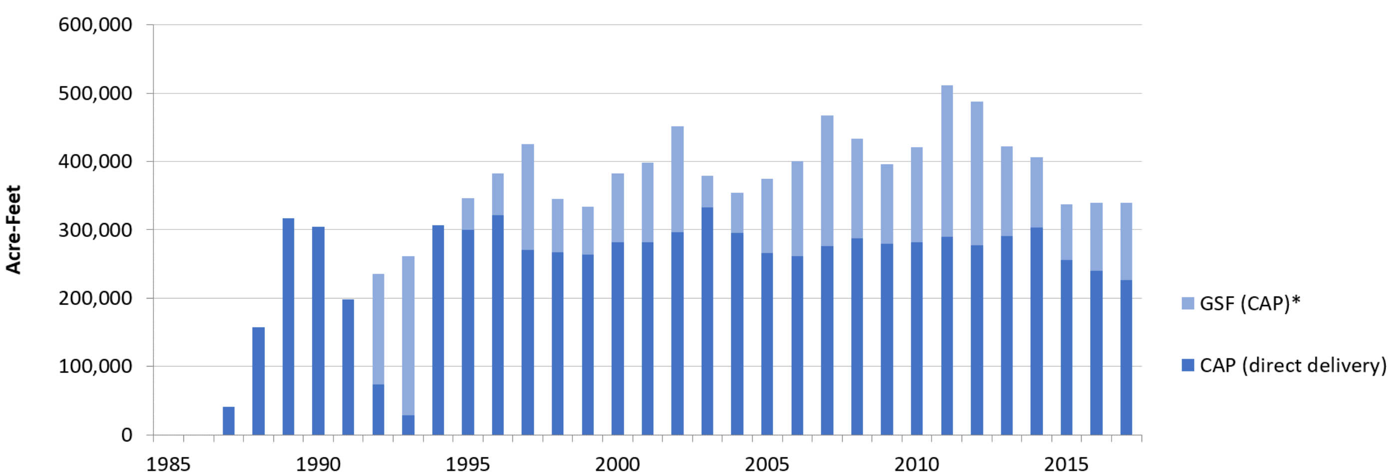


Figure 27. Agricultural Use of CAP Water Supplies in Acre-Feet, 1985-2018 (ADWR 2020a)

Note: GSF water is accounted as groundwater in the year of delivery to a farm, because the "saved" volume of gruondwater is legally classified as stored CAP or effluent. These supplies represent a future draw on the aquifer by the sector storing.

The original CAP settlement pool water - the source of direct use CAP water for many farmers - was scheduled to decrease from 400,000 AF to 300,000 AF in 2017, 225,000 AF in 2024, and zero after 2030 (ADWR 2020c). This CAP settlement pool water was agreed to as part of the Arizona Water Settlements Act in 2004. The recent Drought Contingency Plan agreements have greatly reduced the anticipated availability of CAP water for Pinal County agriculture. As a result, some agricultural water use is expected to shift back to reliance on groundwater, but the scale is yet unknown.

Over 85 percent of agricultural demand in 2017 occurred within the four major irrigation and drainage districts: Maricopa-Stanfield Irrigation & Drainage District (MSIDD), Central Arizona Irrigation & Drainage District (CAIDD), Hohokam Irrigation & Drainage District (HIDD), and San Carlos Irrigation & Drainage District (SCIDD) (Table 7) (ADWR 2020c). SCIDD's water portfolio differs somewhat from the other Pinal AMA irrigation districts as it relies primarily on surface water to meet demand. For instance, SCIDD provided 125,187 AF of surface water to meet annual demand of 150,330 AF in 2017 (including losses), with most of the remaining demand being met by groundwater and smaller quantities of CAP and reclaimed water (ADWR 2020c). In 2017, the four irrigation districts used 808,743 AF of water on more than 235,364 irrigation acres, while 39,381 AF of water were used on 21,291 irrigation acres outside of irrigation districts (ADWR 2020c).

Table 7. Irrigation and Drainage District Water and Land Utilization Rates in the Pinal AMA, 1990-2015 (ADWR 1999, ADWR 2020b)

			1990[1]	1995[1]	2000[2]	2005[2]	2010[2]	2015[2]
MSIDD	**Water utilization**	% Groundwater	36	39	34	37	30	47
		% CAP/ Groundwater In-lieu	0	8	12	21	23	13
		% CAP Water	64	53	53	42	47	40
	Total water use	Acre-Feet	257,043	281,047	230,300	248,400	263,000	263,000
CAIDD	**Water utilization**	% Groundwater	44	28	36	35	42	55
		% CAP/Groundwater In-lieu	0	1	7	14	11	9
		% CAP Water	56	71	57	52	47	36
	Total water use	Acre-Feet	183,688	188,598	233,200	220,900	256,300	277,500
HIDD	**Water utilization**	% Groundwater	74	62	0	0	0	0
		% CAP/Groundwater In-lieu	0	22	73	41	51	38
		% CAP Water	26	16	27	59	49	62
	Total water use	Acre-Feet	23,746	39,025	75,300	61,300	83,100	56,900
TOTAL WATER USE (ALL)		**Acre-Feet**	**464,477**	**508,670**	**538,800**	**530,600**	**602,400**	**597,400**
Irrigation Acres[3]		Acres	280,917	277,901	276,676	270,992	255,719	256,207

[1] Pinal AMA Third Management Plan, ADWR, 1999.

[2] Public Records Request, ADWR, 2020b.

[3] Includes all irrigation acres (> 10 acres) with irrigation grandfathered rights in the Pinal AMA, not only within irrigation districts (ADWR 2020a).

Pinal County ranks among top 2 percent of counties in the US in total value of agricultural sales and the top 1 percent in cotton sales, milk, and cattle and calves inventories (Table 8). Other commonly produced crops include wheat, barley, alfalfa, melons, and more (Figure 24, Table 5).

The 2018 study by Bickel et al. confirmed that agriculture's contributions to Pinal County's economy go beyond direct sales and jobs. A "ripple" of economic activity is stimulated in other industries to meet the demands of agricultural producers for inputs (indirect multiplier effects) and for consumer goods and services by households that derive their income from agriculture (induced multiplier effects). These multiplier effects mean the total economic contribution of on-farm agriculture is considerably greater than indicated by direct farm sales (Figure 28). The overall economic contribution of agricultural to Pinal County for 2016 was calculated as $2.3 billion (Bickel et al. 2018).

As irrigation water is necessary for crop production in the region, there are bound to be economic consequences of agricultural water reductions, both directly and in-directly. Direct on-farm effects include reduced acreage, crop sales, and hired farm labor. Reduced agricultural production would also impact the broader economy of Pinal County through indirect and induced effects (Bickel et al. 2018).

Indirect effects measure economic activity generated by agricultural demand for inputs or supplies. These effects are the business-to-business transactions that provide goods and services as inputs to Pinal County farmers and ranchers, such as the insurance, utility, or banking industries.

Induced effects measure the economic activity generated when households employed by Pinal County farms spend their earnings on local goods and services. These effects are the household-to-business transactions that occur in industries that provide consumer goods and services to households (Bickel et al. 2018).

Table 8. Pinal County's Rankings in Sales and Acreage Among other U.S. Producing Counties, 2012 (Bickel et al. 2018)

ITEM PRODUCED IN PINAL COUNTY	TOP % OF U.S. COUNTIES
Market value of agricultural products sold ($1000)	
Total value of agricultural products sold	2
Value of crops including nursery and greenhouse	3
Value of livestock, poultry, and their products	1
Value of sales by commodity group ($1000)	
Grains, oilseeds, dry beans, and dry peas	25
Cotton and cottonseed	1
Vegetables, melons, potatoes, and sweet potatoes	7
Fruits, tree nuts, and berries	6
Other crops and hay	1
Cattle and calves	2
Milk from cows	1
Top crop items (acres)	
Cotton, all	3
Forage-land used for all hay and haylage, grass silage, and greenchop	4
Barley for grain	4
Corn for silage	4
Top livestock inventory items (number)	
Cattle and calves	1

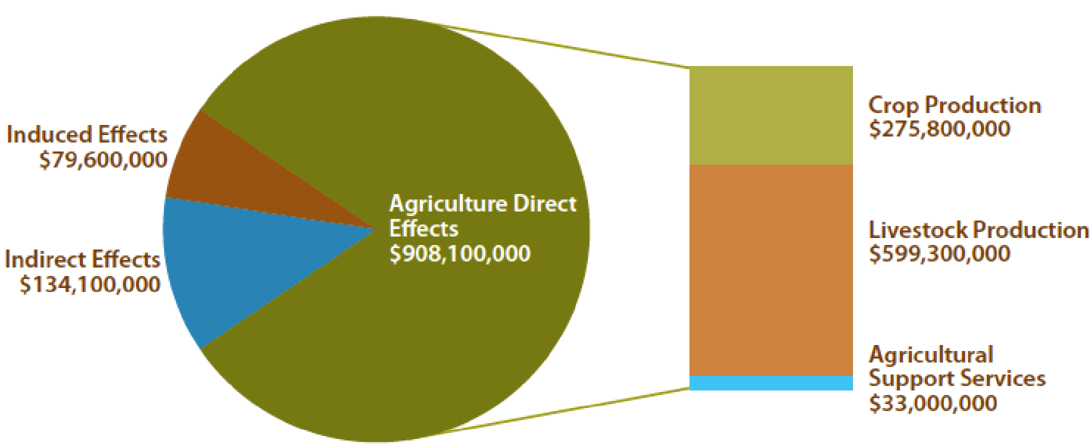


Figure 28. Economic Contribution of On-Farm Agriculture to Pinal County, 2016 (Bickel et al. 2018)

The 2018 Bickel et al. study explored the possible utilization of two sources of water - surface water and groundwater - in consideration of the future of agriculture in Pinal County. Groundwater was determined to be the most important resource for sustained irrigated agricultural development, and its availability largely determined the amount, location, and field design of future irrigated lands.

Testing a hypothetical cutback of 300,000 AF, economic losses would be expected in Pinal County based on the results of six scenarios involving fallowed crops. Fallowing between 54,500 to 71,100 acres (between a quarter and a third of irrigated cropland in Pinal County) could result in on-farm sale losses between $63.5 million to $66.7 million in a year (about seven percent) (Bickel et al. 2018). Under these simplified scenarios, Pinal County would see economic losses of $31.7 to $35 million in value-added economic activity. Reducing crop production could also cause the loss of potentially 270 to 480 jobs. Currently agriculture is estimated to provide 7,516 jobs directly or indirectly through agricultural services and related employment, which accounts for approximately five percent of the jobs in Pinal County.

Photo credit: Blase Evancho

“Looking out 100 years, there is insufficient groundwater in the Pinal Active Management Area to support all existing uses and issued assured water supply determinations.”

- ADWR, October 11, 2019 meeting of House Ad Hoc Committee on Groundwater Supply in Pinal County

PRESENT AND FUTURE GROUNDWATER CHALLENGES

ESTIMATES AND PROJECTIONS

In 2017, ADWR alerted developers with pending Assured Water Supply (AWS) applications that insufficient groundwater was physically available to serve anticipated water demands for new development in parts of the Pinal AMA. In 2019, ADWR updated its Pinal AMA groundwater flow model. ADWR’s updated model is a peer-reviewed decision support tool that simulates groundwater level changes due to pumping and recharge. In addition to updating the model, ADWR used the model to determine AWS Physical Availability over the 100-year projection period, accounting for current and committed demands (Table 9). For more detailed information, ADWR prepared the 2019 Pinal Model and 100-Year Assured Water Supply Projection Technical Memorandum.

The 100-year projection shows unmet demand of 8.1 MAF and a substantial decline in water levels throughout the modeled area (Table 10) (ADWR 2019). According to the model results, AWS unmet demand (2 MAF) and agricultural unmet demand (5.1 MAF) make up 87 percent of the total 8.1 MAF unmet demand. Identifying where groundwater supplies have already been allocated to approved developments through issued AWS determinations, a cluster of insufficient water supplies appear in shallow groundwater areas (Figure 29) (ADWR 2019). For modeling purposes, demand that exceeds the amount of water that can be pumped from a portion of the aquifer is classified as unmet demand. It is important to note that "unmet demand" refers to portions of the Pinal AMA that are over-allocated, but it does not mean an insufficient volume of groundwater in general.

In Pinal AMA, an area of the aquifer is considered “dewatered” when the depth to groundwater reaches or exceeds the regulatory limit of 1,100 feet below ground surface (bgs), although sections of the aquifer may be shallower or deeper than the regulatory limit. In a model simulation, Unmet Demands occurs when:

1. Model layers become dewatered.
2. The simulated water level falls below the bottom of an existing well’s perforated depth.
3. There is a decrease in the saturated thickness and corresponding aquifer transmissivity.

The groundwater flow model is a scientific tool comprised of two distinct components: 1) mathematical formulas and hydrologic estimates that represent the physical reality of the Pinal AMA’s groundwater basins, and 2) assumptions of future groundwater pumping that will determine demand and recharge. The assumptions being used for ADWR's analysis are based on programmatic requirements for satisfying the physical availability criterion of the Assured Water Supply rules (see Appendix 3; ADWR Tech Memo Appendix D, 2019). In general, this analysis requires assuming water demand at 100-percent build-out and service for all AAWS and CAWS that have been issued in the Pinal AMA. This allows ADWR to observe the effects of pumping on groundwater in order to determine if there is enough water to cover the existing CAWS as well as allow for any new CAWS to be issued.

Table 9. Pinal AMA Model Projected Existing and Permitted Demands, 2016-2115 (ADWR 2019)

SECTORS	TOTAL DEMAND (AF)	TOTAL DEMAND (%)
AGRICULTURE	48,573,365	60%
MUNICIPAL	2,005,524	2%
GRIC M&I	500,342	1%
INDUSTRIAL	2,329,255	3%
Existing Uses Subtotal	**53,408,486**	**66%**
EXISTING LTSC	1,169,993	1%
FUTURE LTSC	4,620,964	6%
LTSC Subtotal	**5,790,958**	**7%**
ANALYSIS (AAWS)	11,687,181	14%
CERTIFICATES (CAWS)	4,875,410	6%
DESIGNATIONS (DAWS)	4,886,490	6%
AWS Subtotal	**21,449,081**	**27%**

Projections of unmet demand could change if pumping assumptions are modified. The 2019 groundwater model did not use maximum agricultural groundwater allotments projected over time, but used historical agricultural water demand instead and projected assumptions about increased groundwater use as CAP supplies taper off to zero in 2030 (Figure 30). Additional unmet demand included pumping to recover long-term storage credits (LTSCs) (Table 10, Figure 30).

Table 10. 2019 Pinal AMA Model Results (ADWR 2019)

2019 Pinal model 100-year cumulative projections	100-year projection 2016-2115
TOTAL DEMAND – MODEL ASSIGNED (AF)	80,648,525
SIMULATED DEMAND (AF)	72,560,695
UNMET DEMAND (AF) – TOTAL SIMULATED (MODEL ASSIGNED MINUS SIMULATED)	**8,087,830**
AWS UNMET DEMAND (AF)	1,969,950
AGRICULTURAL UNMET DEMAND (AF)	5,059,056
EXISTING M&I USES UNMET DEMAND (AF)	782,112
LTSC REMOVAL UNMET DEMAND (AF)	276,712

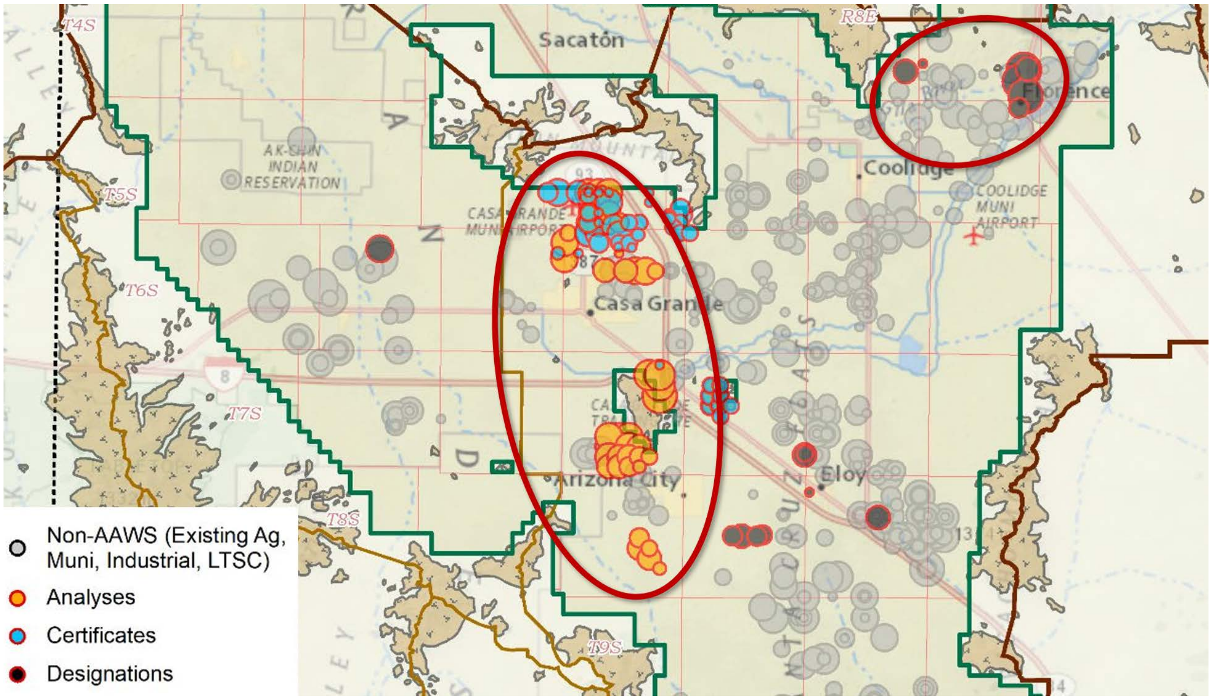


Figure 29. Pinal AMA Groundwater Flow Model Results: Locations of Unmet Demand Based on Fulfillment of Current Sector Demands and Fulfillment of Issued AAWS Demands (ADWR 2019)

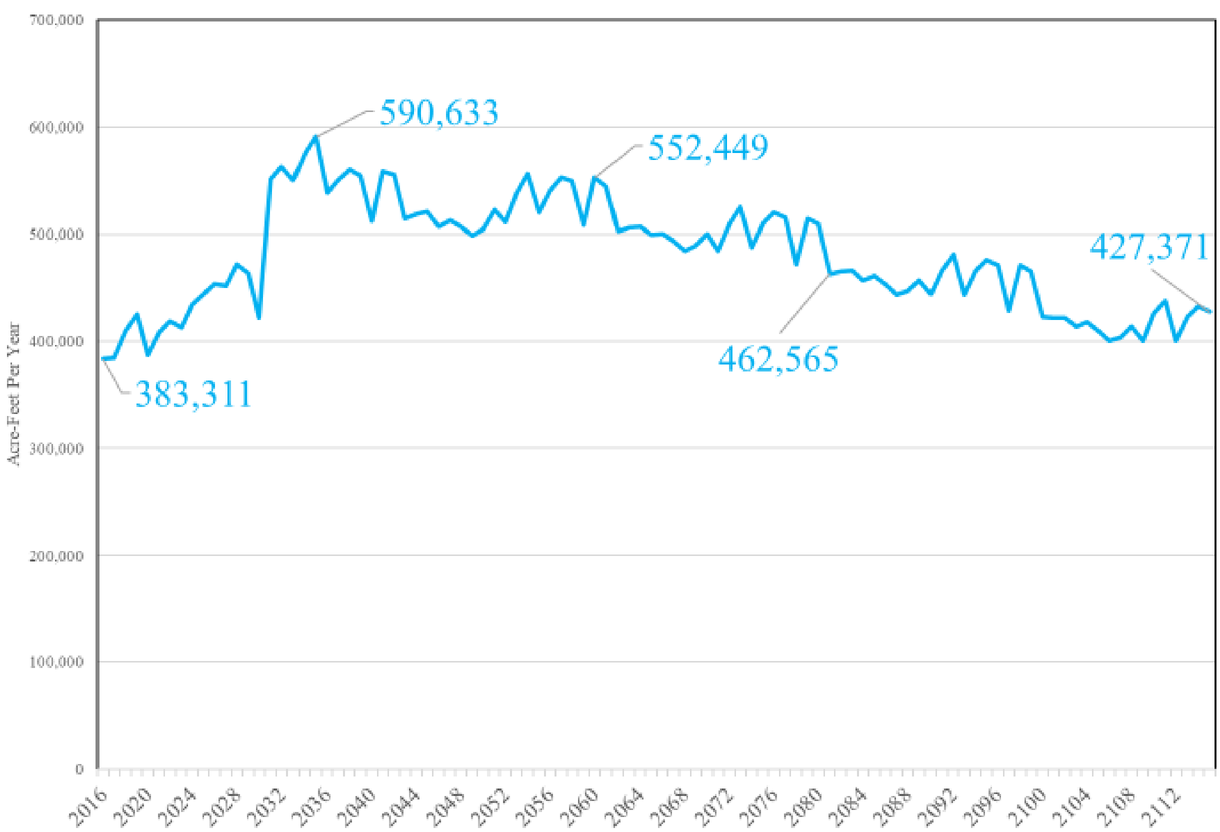


Figure 30. Projected Groundwater Use by Agriculture in the Pinal AMA, 2016-2115 (ADWR 2019)

Note: Periodic episodes of higher water use are contested, as they were not reflected in the projections that MSIDD and CAIDD presented to ADWR

LOOKING FORWARD

Pinal AMA communities face unprecedented challenges to their landscapes and economies. ADWR's 2019 Assured Water Supply modeling revealed unmet water demands of 8.1 million acre-feet over 100 years. While it is not the case that there is insufficient water in the Pinal AMA, the unmet demand poses a number of challenges and considerations (e.g. moving resources to areas of need, growth limitations in areas of shallow groundwater, etc.). Local leaders and stakeholders are working on strategies to meet the Pinal AMA's future water needs and their plans will impact generations to come (see Appendix 1 for information about the Pinal AMA Water Supply Stakeholder Group and Eloy and Maricopa-Stanfield Basin Study).

Balancing the groundwater budget of the Pinal AMA raises many questions, and numerous uncertainties have the power to impact the future of the area. Agricultural trends, industrial growth, and urban development are major and foreseeable "drivers of change" in the region. Other factors that may potentially affect water supply, demand, and reliability include climate variability, socio-economic changes, water storage decisions, policy, infrastructure, and public behavior and awareness.

Collaboration among all the varied interests in Pinal County is a valuable tool with which to address and understand this complex, multi-piece water puzzle. Innovation, clear and trusted data and process, and transparency will be crucial as Pinal AMA communities make difficult but necessary decisions essential for a resilient future.

Photo credit: Sharon Megdal

SOURCES CITED

ADOA (Arizona Department of Administration). (2018). Pinal County – Medium Series, 2018-2055. Retrieved from: https://population.az.gov/population-projections

ADWR (Arizona Department of Water Resources). (1999). Third Management Plan for Pinal Active Management Area: 2000-2010. Retrieved from: http://infoshare.azwater.gov/docushare/dsweb/Get/Document-10005/PinalAMA_3MP.pdf

ADWR (Arizona Department of Water Resources). (2019). 2019 Pinal Model and 100-Year Assured Water Supply Projection Technical Memorandum. Retrieved from: http://infoshare.azwater.gov/docushare/dsweb/View/Collection-19686

ADWR (Arizona Department of Water Resources). (2020a). Pinal AMA Historic Template and Summary for web. Accessed on 5/6/2020. Retrieved from: https://new.azwater.gov/ama/ama-data

ADWR (Arizona Department of Water Resources). (2020b). Updated Pinal 3MP Agricultural Water Use by Type. Retrieved via Public Records Request, March 2, 2020.

ADWR (Arizona Department of Water Resources). (2020c). Draft Pinal Active Management Area Fourth Management Plan. Accessed on March 6, 2020. Retrieved from https://new.azwater.gov/sites/default/files/media/20200305_PAMA4MP_Draft.pdf

ADWR (Arizona Department of Water Resources). (2020d). Open Data Portal. Retrieved from: https://gisdata2016-11-18t150447874z-azwater.opendata.arcgis.com/

ALRIS (Arizona Land Resource Information System). (2018). Public Land Ownership/Surface Management Areas. Retrieved from: https://azgeo.az.gov/AZGEO/

Bernat, R. F., Megdal, S. B., & Eden, S. (2020). Long-Term Storage Credits: Analyzing Market-Based Transactions to Achieve Arizona Water Policy Objectives. Water, 12(2), 568.

Bickel, A.K., D. Duval, and G. Frisvold. (2018). Contribution of On-Farm Agriculture and Agribusiness to the Pinal County Economy: Economic Contribution Analyses for 2016. Department of Agricultural and Resource Economics, University of Arizona. Retrieved from: https://cals.arizona.edu/arec/publication/contribution-farm-agriculture-and-agribusiness-pinal-county-economy

CAGRD (Central Arizona Groundwater Replenishment District). (2019). Draft 2019 Mid-Plan Review. Accessed on February 19, 2020. Retrieved from: https://www.cap-az.com/board/meetings/meeting/1797

Cusimano, J., Eden, S., Rock, C., and McLain, J. (2015). Agricultural Use of Recycled Water for Crop Production in Arizona. College of Agriculture & Life Sciences, University of Arizona. Retrieved from: https://extension.arizona.edu/pubs/agricultural-use-recycled-water-crop-production-arizona

Erie, L. J., French, O. F., Bucks, D. A., & Harris, K. (1982). Consumptive use of water by major crops in the southwestern United States. Conservation research report, (29).

Jama, A. O., & Ottman, M. J. (1993). Timing of the first irrigation in corn and water stress conditioning. Agronomy Journal, 85(6), 1159-1164.

Lahmers, T. and Eden, S. (2018). Water and Irrigated Agriculture in Arizona, 2nd Edition. Water Resources Research Center, University of Arizona. Retrieved from: https://wrrc.arizona.edu/sites/wrrc.arizona.edu/files/attachment/Arroyo-2018-revised.pdf

Nelson, K. and Inwood, J. (2020). Pinal Model 2019 Update. Arizona Department of Water Resources. Presentation to Pinal AMA Water Supply Stakeholder Group, January 6, 2020.

Seasholes, K. (2020). Report on Pinal AMA Activities. Presentation to CAP Board Meeting, January 9, 2020.

U.S. Census Bureau. (2012). Table 2. Intercensal Estimates of Housing Units for Counties of Arizona: April 1, 2000 to July 1, 2010 (HU-EST00INT-02-04). Accessed on 2/23/2020. Retrieved from: https://www.census.gov/data/tables/time-series/demo/popest/intercensal-2000-2010-housing-units.html

U.S. Census Bureau. (2019). Annual Estimates of Housing Units for the United States, Regions, Divisions, States, and Counties: April 1, 2010 to July 1, 2018. Accessed on 2/23/2020. Retrieved from: https://factfinder.census.gov/faces/tableservices/jsf/pages/productview.xhtml?src=bkmk

USDA (U.S. Department of Agriculture). (2014a). 2012 Census of Agriculture: American Indian Reservations, Volume 2, Subject Series, Part 5, AC 12-S-5. Issued August 2014. Retrieved from: https://www.nass.usda.gov/Publications/AgCensus/2012/

USDA (U.S. Department of Agriculture). (2014b). 2012 Census of Agriculture: Arizona State and County Data, Volume 1, Geographic Area Series, Part 3 AC 12-A-3. Issued May 2014. Retrieved from: https://www.agcensus.usda.gov/Publications/2012/

APPENDIX 1. KEY TERMS

Arizona Groundwater Management Code

To eliminate severe groundwater overdraft in the State's most populous regions, Arizona committed to long-term management and conservation of this resource through the Groundwater Management Code in 1980 (Arizona Revised Statutes § 45-101 et seq). The Code set up a management framework and established the Arizona Department of Water Resources (ADWR) to administer the Code's provisions. The Code contains six key provisions:

1. Establishment of a program of groundwater rights and permits.
2. A provision prohibiting irrigation of new agricultural lands within AMAs.
3. Preparation of five water management plans for each AMA designed to create a comprehensive system of conservation targets and other water management criteria.
4. Development of a program requiring developers and water providers to demonstrate a 100-year assured water supply for new growth.
5. A requirement to meter/measure water pumped from all non-exempt wells.
6. A program for annual water withdrawal and use reporting.

Assured Water Supply (AWS) Rules

AWS Rules require developers and water providers to prove that they have the water they need to meet the State's requirement that a subdivision show physical, legal, and continuous availability of water for 100 years of demand and to meet the management goal of the AMA (Arizona Revised Statutes § 45-576). There are seven basic criteria, found under the Arizona Administrative Code, that an applicant must prove before recording plats or selling parcels of six or more lots within an AMA:

1. The water supply must be physically available for 100 years.
2. The water supply must be legally available for 100 years.
3. The proposed supply must be continuously available for 100 years.
4. The water must be of sufficient quality for the proposed use.
5. The proposed water use must be consistent with the management goal of the AMA.
6. The proposed water use must be consistent with the current management plan of the AMA.
7. The applicant must demonstrate the financial capability to construct any necessary water storage, treatment, and delivery systems.

Augmentation

Augmentation refers to supplementing the water supply of an AMA and may include the importation of water into the AMA. Arizona Revised Statutes § 45-801.01 et seq.

Central Arizona Groundwater Replenishment District (CAGRD)

In 1993, Arizona legislature created a groundwater replenishment function to be operated by the Central Arizona Water Conservation District (CAWCD) throughout its three-county service area (Maricopa, Pinal, and Pima Counties). CAGRD stores water underground, replenishing groundwater pumped by property owners and water providers enrolled as CAGRD members. The purpose of CAGRD is to provide members with the ability to demonstrate consistency with the management goal of the AMA under the AWS Rules. Members include municipal provider service areas and subdivision lands that rely on CAGRD membership for part of their AWS 100-year water supply demonstration.

Drought Contingency Plan (DCP)

In response to ongoing drought conditions in the Colorado River Basin, and to reduce the likelihood of Colorado River reservoirs declining to critical elevations, Arizona and the other six Colorado River Basin states agreed to implement DCP agreements. The DCP agreements include an Upper Colorado River Basin DCP and a Lower Colorado River Basin DCP.

The Lower Basin DCP is designed for Arizona, California, and Nevada to contribute additional water to Lake Mead storage at predetermined elevations and create additional flexibility to incentivize additional voluntary conservation of water to be stored in Lake Mead. The Lower Basin DCP also requires additional contributions to Lake Mead from the U.S. The Upper Basin DCP strives to protect critical elevations at Lake Powell and help assure continued compliance with the 1922 Colorado River Compact.

For the Arizona parties who signed on in 2019, DCP means accepting smaller water reductions sooner to reduce the likelihood of catastrophic shortages. As "low priority" users of Central Arizona Project (CAP) water, farmers in Pinal County agreed to reduce their use of Colorado River by 20 percent when a "tier zero" shortage occurs, as defined in the DCP. The agreement supersedes the schedule of gradual reductions farmers agreed to when they signed on to receive CAP water at a discounted rate in 2004.

Read more about Upper and Lower Basin DCPs and their actions.

Eloy and Maricopa-Stanfield (EMS) Basin Study

The EMS Basin Study began in 2019 through a cost-share agreement with the U.S. Bureau of Reclamation with a goal to assess current and future water demands and supplies and develop strategies to help ensure future water supply sustainability in the Pinal AMA.

Exempt well

An exempt well has maximum pump capacity of not more than 35 gallons per minute and is used to withdraw groundwater for non-irrigation uses. Larger capacity wells are subject to well spacing rules and must report their water use and pay a withdrawal fee. Exempt wells are exempt from those requirements and do not require a separate groundwater right or permit.

Extinguishment credit

An extinguishment credit refers to a credit that is issued by ADWR in exchange for the extinguishment of a grandfathered right and that may be used to make groundwater use consistent with the management goal of an AMA. While extinguishment credits are used to make groundwater use consistent with the AMA management goal, they do not demonstrate physical availability of water.

Incidental recharge

The percolation of water to the water table after the water has been used by human water use, such as irrigated agriculture. Other human water uses include municipal and industrial incidental recharge from septic tanks, turf watering, effluent discharge, etc. Incidental recharge from agricultural activity can take up to two decades to reach the water table.

Irrigation Grandfathered Rights (IGFR)

An IGFR is a right to irrigate land in an AMA that was legally irrigated any time between 1975 and 1979, based on crops historically grown and applicable certificate, with few exceptions for substitution or transfer of acres under certain circumstances. The process for determining acres entitled to and for calculating a groundwater allocation is specified in Arizona Revised Statutes § 45-465.

Paper water

"Paper water" refers to the legal right to use a specified quantity of water. This right does not normally include any guarantee that "wet water" will be physically available or accessible.

Pinal Active Management Area (AMA)

The Pinal AMA is a subdivision of the state with boundaries based primarily on groundwater basins, established as part of the Groundwater Code, to address the groundwater mining that was leading to groundwater depletion and other issues such as subsidence and infrastructure expenses prior to 1980. Arizona Revised Statutes § 45-411

Pinal AMA Management Goal

The management goal of the Pinal AMA is to allow development of non-irrigation uses and to preserve existing agricultural economies in the active management area for as long as feasible, consistent with the necessity to preserve future water supplies for non-irrigation uses (Arizona Revised Statutes § 45-562). The Code does not specify the quantity of water that must be preserved for non-irrigation uses or how long agriculture should be preserved.

Pinal AMA Water Supply Stakeholder Group

This committee was established by the House Ad Hoc Committee on Groundwater in Pinal County on November 12, 2019, chaired by Pinal County Supervisor Steve Miller and co-chaired by William Garfield, Arizona Water, and Jake Lenderking, Global Water Resources. The members include cities, utilities, agricultural interest groups, development interest groups, local organizations, Tribal communities, and ADWR.

The overarching goal of the committee is to address the 8.1 million acre-feet unmet demand revealed by ADWR's 2019 model run through multiple creative solutions that involve both more efficient management of existing supplies and new renewable water supplies that can be imported to the Pinal AMA. Other solutions may involve further refinement of ADWR's updated groundwater model to incorporate more realistic assumptions.

Replenishment Obligation

The CAGRD must replenish (or recharge) in each AMA the amount of groundwater pumped by or delivered to its members which exceeds the pumping limitations imposed by the AWS Rules. This category of water is referred to as "excess groundwater."

Recharge may be accomplished through the operation of underground storage facilities or groundwater savings facilities. CAWCD may sell its indirect storage and recovery credits to the CAGRD at fair value.

Safe Yield

"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." Arizona Revised Statutes § 45-561(12)

Unlike Arizona's other AMAs, the Pinal AMA does not have a safe yield goal. Safe yield occurs when no more groundwater is being withdrawn than is being replaced annually, which in theory would result in stable groundwater levels.

Subsidence

Settling or lowering of the surface of land that results as aquifer materials consolidate from the withdrawal of groundwater.

Type 1 Non-Irrigation Grandfathered Rights

These rights are associated with retired irrigated land and generally allows a right-holder to either withdraw or receive no more than three AF of groundwater per acre per year for a non-irrigation purpose for use on the retired land. These rights may not be transferred to other locations.

Type 2 Non-Irrigation Grandfathered Rights

These rights account for the maximum amount of groundwater withdrawn and used for non-irrigation purposes in one of five years before June 12, 1980. Type 2 non-irrigation grandfathered rights can be transferred to other locations within the same AMA by sale or lease.

APPENDIX 2. PINAL AMA "PAPER" WATER BUDGET

	Annual Water Demands and Supplies (Example from 2015)(ADWR 2020a)	Acre-feet
MUNICIPAL		
TOTAL DEMAND		**37,183**
SUPPLIES	Groundwater	28,009
	Surface water	292
	CAP (direct use, recovery, replenishment)	8,016
	Reclaimed water	867
	Incidental recharge	1,487
INDUSTRIAL		
TOTAL DEMAND		**20,986**
SUPPLIES	Groundwater	18,698
	Surface water	29
	CAP (direct use & credit recovered)	-
	Reclaimed water	2,259
	Incidental recharge	858
AGRICULTURAL		
TOTAL DEMAND		**834,976**
SUPPLIES	Groundwater	410,895
	CAP water in lieu of groundwater	80,627
	Surface Water	85,477
	CAP (direct use or recovered)	256,136
	Reclaimed water	1,842
	Incidental recharge (lagged)	319,643
TRIBAL		
TOTAL DEMAND		**157,553**
SUPPLIES	Groundwater	63,248
	Surface water	11,606
	CAP	82,699
	Reclaimed water	0
	Incidental recharge (included in Agricultural IR above)	
OTHER		
Riparian		1,578
Cuts to the aquifer		3,726
Canal seepage		61,788
CAGRD replenishment		397
Net natural recharge		74,885
GROUNDWATER PUMPING TO MEET DEMANDS		
(-) Groundwater pumping by water using sectors, including CAP water in lieu of groundwater		**- 601,477**
OFFSETS TO GROUNDWATER PUMPING		
(+) Incidental recharge, net natural recharge, cuts to the aquifer, CAGRD replenishment, and canal seepage (-) riparian demand subtracted from subtotal		**+ 461,206**
ESTIMATED ANNUAL OVERDRAFT (2015)		
Groundwater pumping subtracted from offsets (or inputs) to groundwater in storage		**- 140,271**

For the purpose of calculating groundwater overdraft, this budget does not consider renewable supplies (CAP, surface water, and effluent) used to meet demand.

APPENDIX 3. ADWR PINAL AMA GROUNDWATER MODEL ASSUMPTIONS (2019)

1. Municipal and Industrial Groundwater Uses

a. Existing (current) municipal and industrial groundwater withdrawals are based on reported 2015 well-specific Registry of Grandfathered Rights pumping data.

b. Some of the existing municipal groundwater pumping is serving built-out lots within AWS developments.

c. Existing municipal and Designation of Assured Water Supply (DAWS) demands are simulated in the location of existing wells.

d. Agricultural lands with AWS development overlays/footprints are assumed to urbanize at the beginning of the projection period (2016).

e. For partially built-out certificates, any issued, but currently unserved AWS demands are calculated by subtracting the reported 2016 groundwater uses for existing AWS developments from their full issued AWS volumes and are simulated to begin pumping in 2016.

f. For fully built-out certificates, current demands are assumed to be represented in the existing municipal pumping and no new demands were created, although current demands were generally less than the original issued volume.

g. For designations, rates are increased to the full issued volumes beginning in 2016 and pumping assigned to existing wells.

h. Projected future pumping to serve unbuilt lots within AWS developments is simulated only within the footprints of AWS developments.

i. Pumping associated with exempt wells is not included.

2. Agricultural Groundwater Uses

a. Existing agricultural groundwater withdrawals are based on reported 2015 well-specific Registry of Grandfathered Rights pumping data.

b. Future agricultural water use is projected for the Central Arizona Irrigation and Drainage District, the Maricopa-Stanfield Irrigation & Drainage District, the Hohokam Irrigation & Drainage District (HIDD), the San Carlos Irrigation & Drainage District (SCIDD), non-ID IGFRs, the Gila River Indian Community, and the Ak-Chin Indian Community (Ak-Chin).

c. Future agricultural acreage and water demand (consisting of a combination of groundwater and Central Arizona Project (CAP) surface water) is projected for CAIDD and MSIDD based on information supplied by the two irrigation districts and estimates developed by ADWR.

d. Future agricultural water demand (consisting of a combination of groundwater and CAP) is projected for HIDD based on estimates developed by ADWR.

e. Future agricultural water demand (consisting of a combination of groundwater, CAP and Gila River surface water) is projected for SCIDD based on estimates developed by ADWR.

f. Future agricultural water demand (consisting of a combination of groundwater, CAP surface water, and Gila River surface water) for the GRIC is based on estimates developed by ADWR.

g. Future agricultural water demand (consisting of CAP surface water) for the Ak-Chin is based on estimates developed by ADWR.

h. Future agricultural water demand (consisting of groundwater) for non-Indian, non-irrigation district IGFRs is based on estimates developed by ADWR.

i. Within the Analysis of Assured Water Supply (AAWS) and Certificate of Assured Water Supply (CAWS) development footprints, agricultural wells that were active in 2015 are not assigned any further pumping during the 2016 – 2115 projection period.

3. Projected Recovery of Long-Term Storage Credits and Groundwater

a. All existing Central Arizona Groundwater Replenishment District (CAGRD) replenishment obligations accrued in the Pinal AMA will be met by using previously accrued (from the beginning of the program through 2015) Central Arizona Water Conservation District (CAWCD)/CAGRD long-term storage credits (LTSCs), excluding a small volume set aside as Replenishment Reserve Account credits.

b. Future CAGRD replenishment obligations after 2016 will be met through storage of CAP water in Groundwater Savings Facilities (GSFs) located near the AWS developments where the replenishment obligations were incurred.

c. Total Pinal AMA Replenishment obligations are limited to a maximum annual rate of 15,500 AFA based on the CAGRD 2015 Plan of Operation.

d. Non-CAGRD LTSCs accrued as of the end of 2015 at eight Underground Storage Facilities (USFs) and four GSFs were removed at a rate of 1/100th of the total for each location over the next 100 years.

4. Recharge

a. Non-CAGRD CAP GSF water making up a portion of three irrigation district supplies are treated as accruing future long-term storage credits. However, these credits will be removed in the same year, at a rate of 95 percent, thereby leaving 5 percent of the recharged volume in the aquifer ("cut to the aquifer").

b. Future agricultural incidental recharge will be applied evenly on remaining active irrigable acres without AWS development overlays at a rate of 34 percent rate based on current dominant use of flood irrigation in Pinal and will not be subjected to any lagging (the period of time it takes water to infiltrate the aquifer after application or use).

c. Within GRIC and Ak-Chin lands agricultural incidental recharge is based on estimates developed by ADWR and are estimated to be 26 percent and 33.4 percent, respectively.

d. Stream and canal recharge follow the previous pattern estimated from 1995 - 2010 that is repeated every 16 years through the projection period.

e. All other types of recharge (urban, mountain front, Picacho Reservoir) remain at 2014 rates.

f. No recharge is simulated at USFs for accrual of FLTSCs, because they cannot be relied upon by non-storing entities. In addition, the potential volume of future recharge at USFs is considered insignificant over the 100-year projection based on the minimal volume of storage historically at USFs.

5. Groundwater underflows at model boundaries are held constant at 2009 published model rates from 2010 - 2115.

wrrc.arizona.edu
350 N. Campbell Ave. • Tucson, AZ 85719 • (520) 621-9591