June 29, 2020

Safe-Yield in the Phoenix AMA

An AMWUA Staff Analysis

Executive Summary

Among its many successes, Arizona's innovative Groundwater Management Act of 1980 established the Phoenix Active Management Area (AMA) and its management goal of safe-yield. Today, AMWUA is an ongoing participant in two State-led processes that seek to evaluate the AMA's progress toward achieving its goal and develop near- and long-term management solutions that reduce our reliance on groundwater. It is within the context of providing support to these processes that AMWUA produced this analysis of the progress and impediments toward achieving safe-yield in the Phoenix AMA.

The effectiveness of safe-yield as a management goal has long been a debated topic in Arizona. The aim of this analysis is fourfold: 1) to provide context on the issues surrounding safe-yield; 2) to more clearly explain and evaluate the approach employed by the Arizona Department of Water Resources (ADWR) to track the AMA's safe-yield status; 3) to evaluate our progress in the Phoenix AMA; and 4) to shed light on the obstacles and impediments to achieving safe-yield by 2025 and thereafter. In meeting these objectives, this paper reaches several main conclusions.

First, safe-yield has been valuable in encouraging water users to focus on groundwater sustainability, and the Phoenix AMA has, in fact, made some progress to that end. In combination with the Assured Water Supply Rules that limit groundwater use for new growth, the AMA has been successful in gradually reducing groundwater use over time as well as limiting additional groundwater reliance. Although groundwater remains the largest supply used to meet agricultural demands in the Phoenix AMA, a reduction in irrigated acreage since the 1980s has helped drive an overall reduction in agricultural demand. The municipal sector's use of groundwater has also declined by about 30% on average since that time. Further, groundwater accounted for approximately 35% of municipal water supplies in the late 1980s but today represents approximately 15% of supplies, despite a large increase in total demands due to rapid population growth.

However, the AMA has not achieved a safe-yield balance and is unlikely to meet the goal by 2025. In evaluating this further, this paper demonstrates ADWR's approach to calculating safe-yield is, in some ways, unnecessarily complex, making it difficult to discern which uses of groundwater most often prevent the AMA from reaching a safe-yield balance. AMWUA makes further suggestions on ADWR's need to develop an established methodology for assessing safe-yield on a long-term basis, per its statutory definition.

The main obstacles to achieving safe-yield are the many exemptions that grant continued groundwater use within all sectors and are out of the State's regulatory control. Ongoing unreplenished withdrawals pursuant to these exemptions are a large issue that must be addressed if safe-yield is ever to be achieved. This has been long recognized by ADWR, yet conservation requirements alone do not reach far enough to

address the sheer volume of pumping pursuant to those exemptions in the AMA. Requirements to offset or replenish groundwater pumping only apply to a portion of the municipal sector. Therefore, inequities have been created within and between sectors in relation to which is responsible for keeping their groundwater use consistent with the management goal. In addition, other successful ADWR water management strategies, such as the State's underground water storage program, do little to help achieve safe-yield today, despite what many would think.

Finally, in seeking a safe-yield balance at the broad AMA scale, AMWUA finds the management goal alone falls short of addressing other pertinent groundwater management issues, such as more localized groundwater supply and demand imbalances. Future water management goals should be more considerate of the unique aquifer conditions and uses of groundwater in different parts of the AMA.

Based upon the common understanding of safe-yield in the Phoenix AMA and the findings of this analysis, AMWUA intends to work with ADWR to develop policy proposals that address the current barriers to safe-yield and to develop future management goals. ADWR will need to be given expanded authority to create the programs and regulations needed to achieve both the current and future management goals if we are to make continued progress in groundwater management in the AMA.

Introduction

Preparing for its next management period, the Arizona Department of Water Resources (ADWR) has been engaging stakeholders in a number of state-level processes to develop the Fifth Management Plans (5MP). A 5MP Safe-Yield Technical Subgroup was formed to examine the management goal of safe-yield, as it applies in four of the five active management areas (AMAs). As designated water providers, AMWUA municipalities are committed to reducing groundwater dependency in their service areas and have made significant investments in renewable water resources to provide secure, sustainable supplies to their customers while contributing to the management goal. Yet, the Subgroup discussions have illuminated larger uncertainties associated with the implementation and calculation of the safe-yield goal. Those uncertainties are apparent in the Phoenix AMA, where annual groundwater use has only gradually declined through time, and the calculated level of annual overdraft fluctuates inconsistently, year-over-year.[1]

To support the discussions of the 5MP Safe-Yield Technical Subgroup as well as others being held in committees of Governor Ducey's Water Augmentation, Innovation, and Conservation Council, this analysis seeks to accomplish four major objectives:

1. To contextualize the issues surrounding the AMA management goal of safe-yield by reviewing the evolution and implementation of the goal;
2. To describe ADWR's water budget accounting approach to quantifying and tracking the safe-yield goal;

[1] ADWR 5th Management Plans Work Group - Safe-Yield Technical Subgroup, Meeting Materials. (September 23, 2019). https://new.azwater.gov/sites/default/files/media/2019.09.23_SY_Subgroup_Kickoff_0.pdf.

3. To evaluate progress toward the goal using that methodology, in the Phoenix AMA specifically, and;
4. To identify and define the issues with attaining safe-yield during the Fifth Management Period and subsequent management periods, in order to serve as a resource for developing AMWUA's policy position on safe-yield issues.

While it is difficult to contest the reasonableness of a safe-yield goal from a sustainable groundwater management standpoint, issues with calculating safe-yield by AMA and questions on the working definition of the goal present serious challenges for its use going forward. Forty years after the passage of Groundwater Management Act, stakeholders and ADWR must reflect on whether and how the AMA management goal might be reconsidered to better manage and reduce the withdrawal of groundwater for the benefit of all areas of the AMA.

The Evolution of Safe-Yield as a Management Goal

Arizona's Groundwater Management Act (GMA or Code) was passed in 1980 to address longstanding groundwater issues across the State, including those related to severe groundwater overdraft. The GMA established the Arizona Department of Water Resources to oversee State water planning and regulations and created Active Management Areas where groundwater would be managed to mitigate the effects of groundwater withdrawals. Within each AMA, groundwater use is managed and directed by an AMA management goal. In addition, AMA water users in all sectors are subject to mandatory conservation requirements designed to reduce groundwater reliance through time.

For the Phoenix AMA, the Code set forth the management goal of 'Safe-Yield'. Safe-yield is statutorily defined as:

> 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.[2]

While the Phoenix AMA goal was established by the Legislature to be achieved by 2025 and maintained thereafter, there are no regulatory penalties if the goal is not met in that timeframe.[3] Under its current definition, the goal does not require the maintenance of specific groundwater levels, nor does it curtail future groundwater pumping. However, the goal does influence a variety of water management regulations, from implementation of the Code to the Assured Water Supply (AWS) Rules. The AMA Management Plans detail the mandatory water conservation programs for the agricultural, municipal, and industrial sectors. These programs are designed to reduce withdrawals of groundwater and their requirements become increasingly stringent over time, for the purpose of achieving safe-yield. However,

[2] A.R.S. § 45-561(12)
[3] A.R.S. § 45-562(A)

changes to the statutory requirements starting in the Third Management Plans resulted in some programs focusing on simply increasing efficiency rather than leading to reductions in total water use.

The AWS Rules require that new subdivisions demonstrate consistency with the AMA management goal. For new developments in the Phoenix AMA, groundwater use may be deemed consistent with the goal of safe-yield if groundwater is replenished through membership in the Central Arizona Groundwater Replenishment District (CAGRD), or accounted from extinguishment credits, a groundwater allowance, or another ADWR-approved source.

The Phoenix AMA Since 1980

Much has changed in the Phoenix AMA since the management goal was established. Rapid population growth has more than doubled the number of people living in the AMA since the mid-1980s.[4] The municipal sector's use of groundwater has indeed declined by about 30% on average since that time despite simultaneously increasing municipal water demands.[5] But overall AMA groundwater use has only gradually declined.[6] All water using sectors continue to pump mined groundwater. On the other hand, the availability of renewable supplies has increased with the growing use of treated effluent and the arrival of Central Arizona Project (CAP) water. But at the same time, an extended period of severe drought has resulted in numerous regional impacts including decreasing streamflow and lowering the availability of surface water supplies.

Some assumptions that predicated the development of the goal and the application of the AWS Rules have not come to fruition. While it is true that considerable urban growth has occurred on retired agricultural lands with existing water rights (mostly within Salt River Project, Roosevelt Water Conservation District, and Maricopa Water District lands), leading to a 55% reduction in non-tribal irrigation acres since the First Management Plan, the lack of existing water rights on native desert land hasn't been the impediment to growth once envisioned by the Code.[7] New urban growth occurring on native desert land has added to existing water demands, rather than replacing one demand type (agricultural) with the other (municipal) as had been anticipated in early agricultural-to-urban transfer assumptions.[8] Of the irrigation grandfathered rights (IGFRs) partially or fully extinguished since 1995, under 50% have been pledged to a certificate or designation of assured water supply.[9] And a large proportion of IGFRs that could have been extinguished as they urbanized were either not, or converted to a Type 1 non-irrigation grandfathered right.

Groundwater remains the largest supply used to meet agricultural demands in the Phoenix AMA.[10] One reason may be that the cost of groundwater pumping is generally less expensive than the costs associated

[4] US Census Bureau, 2010, and ADWR.
[5] ADWR Phoenix Active Management Area Fourth Management Plan. 5-6 (2020).
[6] *Id*. at 3-19.
[7] *Id*. at 3-15.
[8] *Id*. at 11-7.
[9] *Id.* at 3-12.
[10] *Id.* at 3-14.

with delivering and using renewable supplies, when they are available.[11] Another may be that there is no incentive or obligation for agriculture to eliminate groundwater mining through the management periods. The agricultural sector accounted for nearly 60% of AMA water demand in 1985 but due to a reduction in irrigated acreage, the sector now accounts for a third of all water demands in the AMA.[12]

Other uses of groundwater that were authorized by the Code or exempted from the AWS Rules have persisted or grown. For example, they include groundwater delivered to pre-1995 demands by non-designated water providers, the groundwater allowances associated with certificates and designations of AWS, Type 1 and Type 2 non-irrigation grandfathered rights, industrial sector general use permits, remediated or poor-quality groundwater, and exempt wells. Groundwater use pursuant to these rights and permits, while highly variable in volume, represent sources of unreplenished withdrawal that hinder the achievement of safe-yield.

Since the adoption of the Code and promulgation of the Rules, various committees and studies have examined issues related to local and regional water management and the efficacy of the AMA management goals. In 1999, after conducting a performance audit of ADWR as part of its Sunset review, the State Auditor General documented "a number of statutory restrictions and exemptions that limit Arizona's ability to achieve the statutory goal of safe yield by 2025."[13] For example, "statutes and rules do not require non-designated providers to convert from groundwater to renewable water sources to meet customers' needs."[14] In 2001, Governor Hull's Water Management Commission noted in its findings and recommendations, "although groundwater mining has not been eliminated, water users, in response to the goals and requirements set forth in the Groundwater Code, have significantly reduced groundwater mining in three of the five AMAs since the 1980s. However, current data indicate the Phoenix, Prescott and Tucson AMAs may not reach their goal of safe-yield by 2025."[15]

The Third Management Plans produced by ADWR during the same timeframe further emphasized the limited ability to achieve safe-yield by 2025. The Phoenix AMA Third Management Plan states, "the amount of groundwater pumping allowed under the Code, the Second Management Plan, and the AWS Rules through grandfathered rights, groundwater withdrawal permits, designated and undesignated providers, and untreated providers creates a significant obstacle toward our efforts to achieve safe-yield. The burden of reducing mined groundwater does not apply proportionately or equitably to all water-using sectors."[16]

Most recently, the Fourth Management Plans have provided an updated look at the status of achieving the management goals of each AMA. The Phoenix AMA Fourth Management Plan echoes that while significant actions were taken toward reaching safe-yield in prior management periods, the AMA has not

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[11] *Id*. at 11-3.
[12] *Id*. at 4-2.
[13] State of Arizona Office of the Attorney General, Performance Audit of Arizona Department of Water Resources, Report No. 99-8. 1 (April 1999).
[14] *Id.* at 14.
[15] Governor's Water Management Commission, Final Report. vi, (December 2001).
[16] ADWR Phoenix Active Management Area Third Management Plan. 1-12, (1999).

achieved safe-yield and has likely been in a state of overdraft since 2010.[17] Many of the Management Plan's conclusions have also reflected the challenges and the points of confusion in defining and measuring safe-yield. ADWR noted the "disagreement on the appropriate time-scales for analyzing long-term overdraft" and reiterated that "the current cumulative volume of grandfathered groundwater right allotments far exceeds the amount of groundwater available for pumping under safe-yield conditions."[18]

Evaluation of the Safe-Yield Methodology

To understand ADWR's conclusions from the Fourth Management Plan, it is critical to develop an understanding of the calculation of safe-yield in the Phoenix AMA. At the Fall 2019 meetings of the 5MP Safe-Yield Technical Subgroup, ADWR staff provided detailed information on their methodology for calculating annual safe-yield. Staff describe the measurement of safe-yield as an annual water budget approach.

ADWR's Water Budget Components

Table 1 lists the inflow and outflow components of safe-yield, as provided by ADWR.[19]

Table 1: ADWR Safe-Yield Components

Inflows	**Outflows**
Groundwater Inflow	Groundwater Outflow
Streambed Recharge	Riparian Demand
Mountain-front Recharge	Groundwater Pumping by Sector:
Incidental Recharge*	Agricultural
Canal Seepage	Municipal
Cut to the Aquifer	Industrial
CAGRD Replenishment	Indian
	Remediated Groundwater
	Poor Quality Groundwater

* Includes incidental recharge from Agricultural, Municipal, and Industrial sectors

The water budget consists of inflow and outflow components of safe-yield, some of which are *natural* while others are *artificial*, and some of which are *reported* while others are *modeled*. For example, several component values are obtained from ADWR's hydrologic model of the Phoenix AMA including annual volumes of natural groundwater outflow and riparian demands, as well as natural groundwater inflows, streambed and mountain-front recharge, canal seepage, and incidental recharge associated with agricultural water use. All incidental recharge components reduce the overdraft volume attributed by sector, by recognizing that a portion of water use applied to the land will *incidentally* recharge the aquifer in time. The agricultural incidental recharge volume is an output of ADWR's regional groundwater models and is a function of irrigable acres, unlike the incidental recharge associated with municipal and industrial

[17] ADWR Phoenix Active Management Area Fourth Management Plan. 1-4, (2020).
[18] *Ibid.*
[19] ADWR 5th Management Plans Work Group - Safe-Yield Technical Subgroup, Meeting Materials. (February 24, 2020). https://new.azwater.gov/sites/default/files/media/2020-02-24_Agenda.pdf

sectors, which are calculated as a percentage of total sector demands. The timeframe for obtaining modeled component values is often delayed by at least a year to provide time to collect all the relevant inputs required to run the model. Some of the modeled component values may be modified during the process of calibrating the AMA hydrologic model, which can be problematic if they change through time considering the ultimate calculation of safe-yield relies on those very water budget components.

Artificial components are mainly derived from annual water user reports. In most cases, the reported outflow components can be accounted at face value because they reflect metered groundwater pumping. The first exception is domestic exempt well pumping, which is estimated by ADWR each year based on the number of people in an AMA that are not served by municipal water providers and is included as an outflow in the safe-yield calculation. Another exception is tribal sector demands, which are an estimated outflow since tribal water users are not required to report their groundwater withdrawals to ADWR. Agricultural IGFRs associated with farming operations of 10 acres or less were deregulated in 1994, so groundwater withdrawals associated with those rights are estimated as well.[20] Incidental recharge values associated with the industrial and municipal sectors are calculated by ADWR based on total annual reported water use, because the proportion of water use deemed incidental recharge is pre-determined by ADWR, not measured or modeled annually.

Understanding these water budget components, including both the modeling results and the reported values, is an ongoing issue for water users trying to track and evaluate the state of safe-yield in the Phoenix AMA. What makes the budget calculation most difficult to follow are the inconsistencies within and among the components. For example, there are those components which represent legal rather than physical groundwater flows, those whose accounting is time-lagged, those whose value is essentially estimated, and those held constant when they could be modeled or calculated annually. **Table 2** below provides a summary of the variations, denoting the data source and the method of accounting for each component of ADWR's safe-yield water budget. Overall, the amalgamation of these components makes it difficult to discern whether ADWR's water budget methodology provides the most accurate picture of safe-yield.

[20] ADWR Phoenix Active Management Area Third Management Plan. 3-4, (1999).

Table 2: Safe-Yield Components by Source and Accounting Method

	Source			Accounting		
	ADWR Groundwater Models (M)	Estimated (E) or Calculated (C) by ADWR	Annual Reports (R)	Annual/In-Year Accrual (A)	Time-Lagged (L)	Constant Value (k)
OUTFLOWS						
Natural						
Groundwater Outflow	M			A		k
Riparian Demand	M			A		
Artificial						
Indian Sector Demands		E		A		
Industrial Sector Demands						
Groundwater			R	A		
Poor Quality Groundwater			R	A		
Agricultural Sector Demands						
Groundwater		E (<10 acres)	R	A		
GSF Water (CAP)			R	A		
GSF Water (effluent)			R	A		
Municipal Sector Demands						
Remediated Groundwater			R	A		
Groundwater		E	R	A		
Excess Pumping (CAGRD lands)			R	A		
Exempt Well Pumping		E		A		
Groundwater Allowance Pumping			R	A		
GSF Water (CAP)			R	A		
INFLOWS						
Natural						
Groundwater Inflow (AKA underflow)	M			A		k
Streambed Recharge	M				L	
Mountain-front Recharge	M			A		k
Artificial						
Incidental Recharge: Ag	M				L	
Incidental Recharge: Industrial		C		A		
Incidental Recharge: Municipal		C		A		
Canal Seepage	M			A		k
Cut to the Aquifer			R	A		
CAGRD Replenishment			R	A		

Seeking a Long-Term Balance

In support of achieving the 'long-term balance' noted within the definition of safe-yield, ADWR states that "the hydrologic conditions in the Phoenix AMA cannot simply be viewed in the short-term, but rather must be viewed over a longer period. Further, establishing a *balance* is more complicated than comparing the total amount of groundwater withdrawals in the Phoenix AMA to the amount of recharge occurring in the area in a given year."[21] This being the case, ADWR has not formally offered any other evaluation or interpretation of safe-yield aside from the annualized water budget and overdraft calculation. Recent 5MP Safe-Yield Technical Subgroup conversations have centered around this topic. For instance, it was proposed that safe-yield could incorporate the measurement of natural components as one long-term average value in each AMA, compared to a shorter-term measurement (perhaps a 5-year median) of artificial components. This method could better pinpoint the impediments to achieving safe-yield in the long-term, make the intra-year calculation less volatile, and thusly set the stage for more meaningful policy discussions among the State and water users.

It is broadly acknowledged that ADWR's groundwater models are intended to provide a numeric representation of the potential impacts of various assumptions on our hydrologic systems at the regional scale. Using numerous data inputs, the models can simulate future impacts of groundwater management activities at different scales. Being a simplified representation of more complex natural systems, the model outputs lack a level of specificity or precision and are assumed to level out and show directionality in physical processes over time. Considering that 7 of the 23 water budget components are derived from the models (as shown in **Table 2**), it would befit ADWR to establish a long-term analysis methodology so that inherent variations in the budget components are less consequential and long-term trends are more apparent. Components that are better evaluated in the long-term, like those that are modeled, would be set as such. Until ADWR's long-term balance methodology is established, concern remains about how the current annual calculation addresses the long-term balance called for in the statutory definition of safe-yield.

Progress in the Phoenix AMA

Despite not yet reaching safe-yield, Phoenix AMA total groundwater use has gradually decreased since 1985. The Fourth Management Plan states that the total amount of groundwater used in the AMA decreased from 977,000 acre-feet (AF) in 1985 to just over 716,000 AF in 2017. The decline also represents a proportionate decrease in groundwater used to meet demands, from 45% of the AMA's water supply in 1985 to 32% of the supply in 2017.[22] ADWR's tracking of annual groundwater overdraft in the AMA shows a less consistent trend, detailed below.

Figure 1 displays the annual calculation of safe-yield in the Phoenix AMA from 1985 through 2016. These data were made available by ADWR to assist with the Fifth Management Plan Work Group discussions.[23] Each inflow and outflow component of safe-yield is differentiated by color. The groundwater *outflows* are positive values, shown above the horizontal axis, while groundwater *inflows* are negative values, shown below the x-axis to visually demonstrate that they counteract the outflows in the annual water budget. In a single year, the difference between the inflows and the outflows is shown on the black line labeled *overdraft*. In most years, the line is positive, meaning there were more outflows than inflows and the AMA

[21] ADWR Phoenix Active Management Area Fourth Management Plan. 10-9, (2020).
[22] *Id.* at 1-3.
[23] ADWR AMA Annual Supply and Demand Dashboard. Online Dataset. Accessed April 1, 2020. https://new.azwater.gov/ama/ama-data

is in a state of overdraft. From 2006 through 2010, the line is negative, meaning there were more calculated inflows than outflows in the AMA and safe-yield had been temporarily achieved. In more recent years as well as during the early 1990s, it is evident that safe-yield is very susceptible to changes in agricultural groundwater use as well as the amount of incidental recharge afforded to agricultural water use as derived from ADWR's regional groundwater model. Each of the agricultural components is shown in a shade of green. Also evident from **Figure 1**, natural inflows displayed in shades of blue, like streambed recharge, have leveled out in recent years but went a long way toward reducing AMA overdraft in some early years, like 1990. Not as apparent in these values is the variability of surface water flows which may impact water users' reliance on groundwater in any given year.

<u>Figure 1: Annual Calculation of Overdraft in the Phoenix AMA</u>

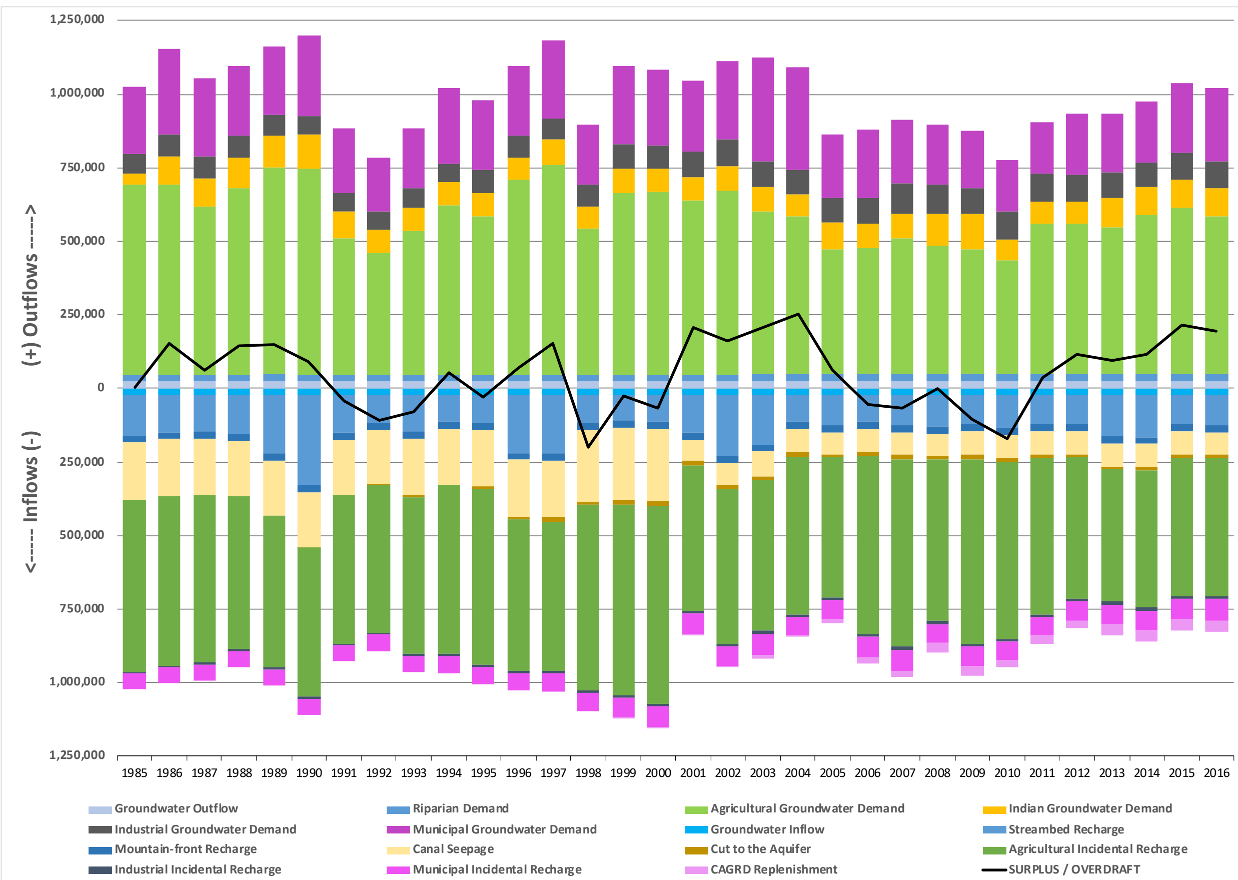


Figure 1 also shows how ADWR's water budget, in its focus on annual overdraft, masks some of the impacts of unreplenished, allowable groundwater withdrawals on safe-yield. Agricultural groundwater withdrawals pursuant to IGFRs are not *required* to be replenished or offset. Taken at face value, they represent a large portion of the annual groundwater outflows – 53 percent of all the Phoenix AMA outflows in the year 2016, for example. However, ADWR models the incidental recharge of agriculture, an artificial inflow component, as a proportion of *total* water use. In 2016, the agricultural incidental recharge component totaled nearly 468,000 acre-feet. Because incidental recharge is time-lagged and based on the

total use of all water supplies, not just groundwater, the incidental recharge for agriculture appears to have offset 87 percent of that years' groundwater withdrawals. Still, the estimated incidental recharge afforded to the sector is different from the intentional replenishment required for a portion of municipal sector groundwater demands. In this way, the final overdraft value makes it hard to distinguish the extent of allowable groundwater withdrawals by sector so that policy discussions may begin to address them.

Municipal Sector Role in Safe-Yield

The inflow and outflow components associated with the municipal sector are limited in number. The only *inflow* components are incidental recharge and annual replenishment performed by the CAGRD. A single *outflow* component consists of all municipal groundwater uses, which evidently include:

- designated and certificated groundwater allowances,
- excess groundwater (pumping that is subject to replenishment, likely by the CAGRD),
- exempt well use,
- groundwater savings facility (GSF) water used for urban irrigation,
- extinguishment credits,
- Type 1 and Type 2 GFRs, and
- remediated groundwater.

Although reported in the water budget as one component, groundwater outflows of these types are mostly reported and easily validated. **Table 3** provides a finer level of detail than shown in ADWR's overdraft calculation on the annual use of designation of AWS-related groundwater allowance pumping, domestic exempt well pumping, excess groundwater, remediated groundwater, and GSF water delivered to municipal uses. **Figure 2** displays the same data back to 1985 along with an 'other municipal groundwater demand' component which is a catch-all for undesignated water provider groundwater pumping (including CAWS-related groundwater allowance utilization), Type 1 and Type 2 GFRs, and lost and unaccounted for water.

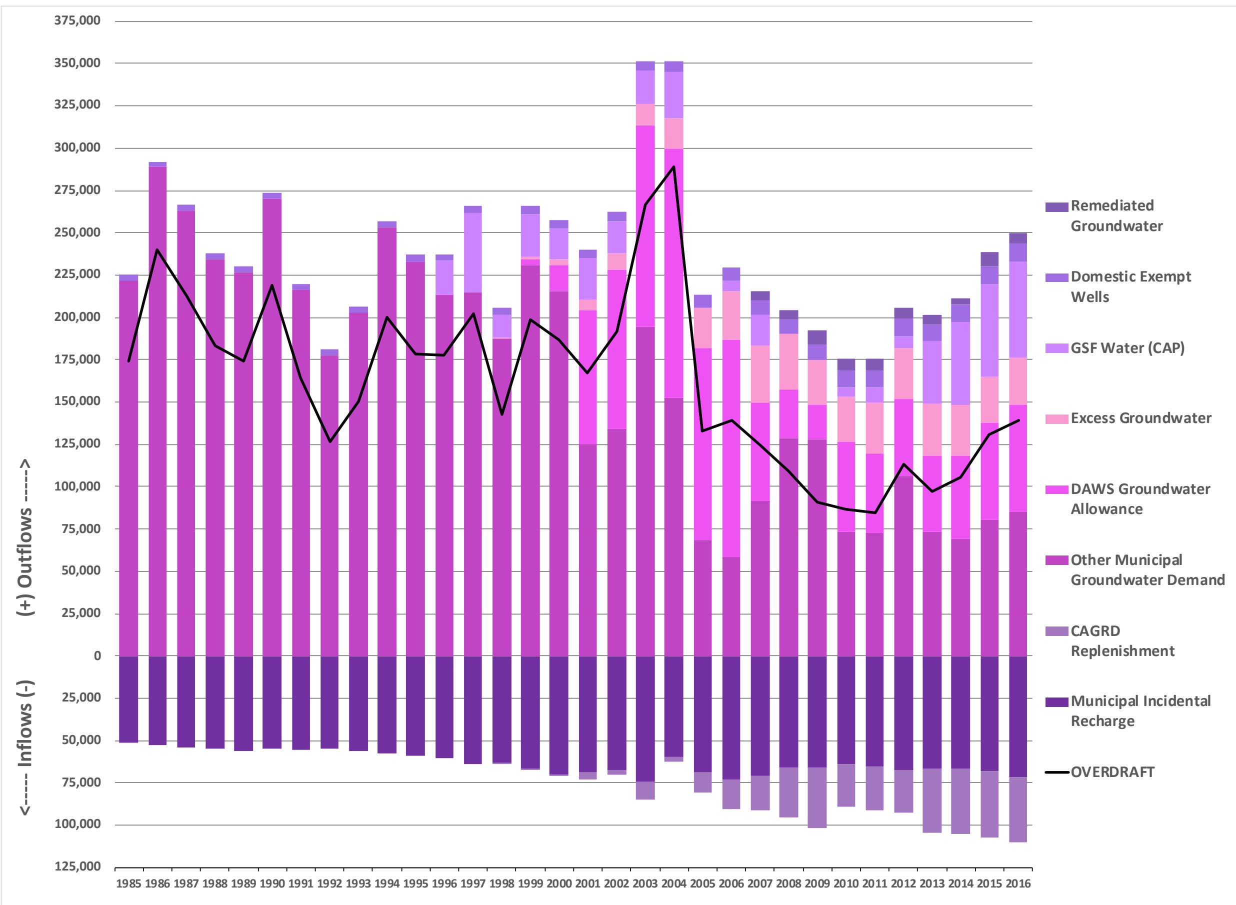
Table 3: Phoenix AMA Municipal Sector Groundwater Outflows

	2012	2013	2014	2015	2016
DAWS Groundwater Allowance	45,658	45,048	48,609	57,577	62,957
GSF Water (CAP)	7,281	36,677	49,078	54,787	57,107
Domestic Exempt Wells	10,061	10,118	10,174	10,231	10,288
Excess Groundwater	30,049	30,967	30,357	27,436	27,894
Remediated Groundwater	6,721	5,057	3,375	8,115	6,005
Source: ADWR. (2020). Phoenix AMA Annual Supply and Demand Data, Historic Template and Summary Dataset.					

Figure 2 shows Groundwater use attributed to the municipal sector has varied between approximately 175,000 acre-feet in 2010 and 2011 to over 350,000 acre-feet at its peak in 2003 and 2004. These variations were less obvious in **Figure 1** when all AMA groundwater outflows were considered as a whole. One takeaway from the Municipal Sector chart is that when singled out, the sector's contribution to

ADWR's calculation of overdraft is seemingly substantial. Groundwater outflows have been highly sensitive to the use of groundwater allowances, as well as the use of GSF water (deemed groundwater) by irrigation districts providing untreated water for urban irrigation including Salt River Project, Maricopa Water District, and Roosevelt Water Conservation District. Excess groundwater pumping and its replenishment by CAGRD represent municipal outflow and inflow components, respectively, that balance each other in approximately three years' time, not annually. Although storing entities contribute inflows through a statutorily required 'cut to the aquifer' when renewable supplies are stored to earn long-term storage credits, ADWR does not attribute those inflows by sector due to the complexity of doing so. Even so, the municipal inflow components - CAGRD annual replenishment and incidental recharge - do not serve as enough of a counter to the volume of outflows, demonstrated by the persistent overdraft shown in **Figure 2**.

Figure 2: Phoenix AMA Municipal Components of Safe-Yield



Alternative Approaches

Water users have neither achieved nor maintained the long-term balance called for in the safe-yield goal, in any single sector, nor AMA-wide. The level of Phoenix AMA overdraft has not consistently improved year-over-year, either. On the other hand, many water users would note that the utilization of water management tools, such as ADWR's Underground Water Storage and Recovery Program or storage by the Arizona Water Banking Authority, have noticeably benefited the aquifer by improving groundwater levels, for example. ADWR substantiates its water budget and component-based approach to calculate safe-yield by noting the importance of maintaining consistency with *legal* water accounting.[24] From a legal standpoint, renewable water stored at an underground storage facility (USF) today is not counted as an inflow to the aquifer, but rather it is deemed stored water.[25] An exception is the small 'cut to the aquifer' credited as an inflow during the year of storage.[26] Nevertheless, some of the safe-yield components are the result of *physical* water accounting, such as the hydrologic components derived from the Phoenix AMA groundwater model. The meshing of the two realms – legal and physical – in the calculation of safe-yield is one of the reasons why water users are generally limited in their ability to assess the current state of overdraft and, specifically, their role in it.

One change that could make the calculation of safe-yield more straightforward is to implement an accrual accounting approach across all components in the water budget. This means all components would be accounted in the year the inflows/outflows occurred, no longer lagging the temporal components. For example, the estimated incidental recharge for agriculture would be accounted during the same year the water use occurred, rather than lagging the inflow by a year or more. It would be a function of total water use and annual irrigated acreage, not modeled. ADWR would establish unique incidental recharge estimates for different agricultural areas of the AMA. In effect, all incidental recharge would be made consistent, similar to the 'cut to the aquifer' accounting concept. This is not to say that ADWR's calculation of this component could be completed sooner, but once known, the incidental recharge volume would be accounted in the same year as the water use upon which it was earned. Accrual accounting is one way to make the components more transparent and uniform as well as easier to update and maintain. It could also allow sector contributions to be more easily identified so all water users can track the progress toward achieving the management goal.

Alternatively, ADWR could consider evaluating safe-yield in more purely physical terms, while still adhering to the statutory definition of safe-yield. If water budget accounting more strictly reflected *physical* hydrologic conditions rather than a hybrid of physical and legal, only a handful of the inflow and outflow components would need be reconsidered but it could result in a much different outcome. From the definition of safe-yield, "the annual amount of groundwater withdrawn"[27] would include all the outflow components currently included by ADWR except water stored at a groundwater savings facility, since no groundwater was physically pumped in that year in that arrangement. It would mean that long term storage credits (LTSCs) earned at a GSF would instead be counted as a groundwater withdrawal in the year they are recovered. Correspondingly, one additional outflow component would be required

[24] ADWR Phoenix Active Management Area Fourth Management Plan. 11-9, (2020).
[25] A.R.S. § 45-802.01
[26] A.R.S. § 45-852.01
[27] A.R.S. § 45-561(12)

under this proposed calculation – the volume of recovered LTSCs, including annual storage and recovery (AS&R) volumes.

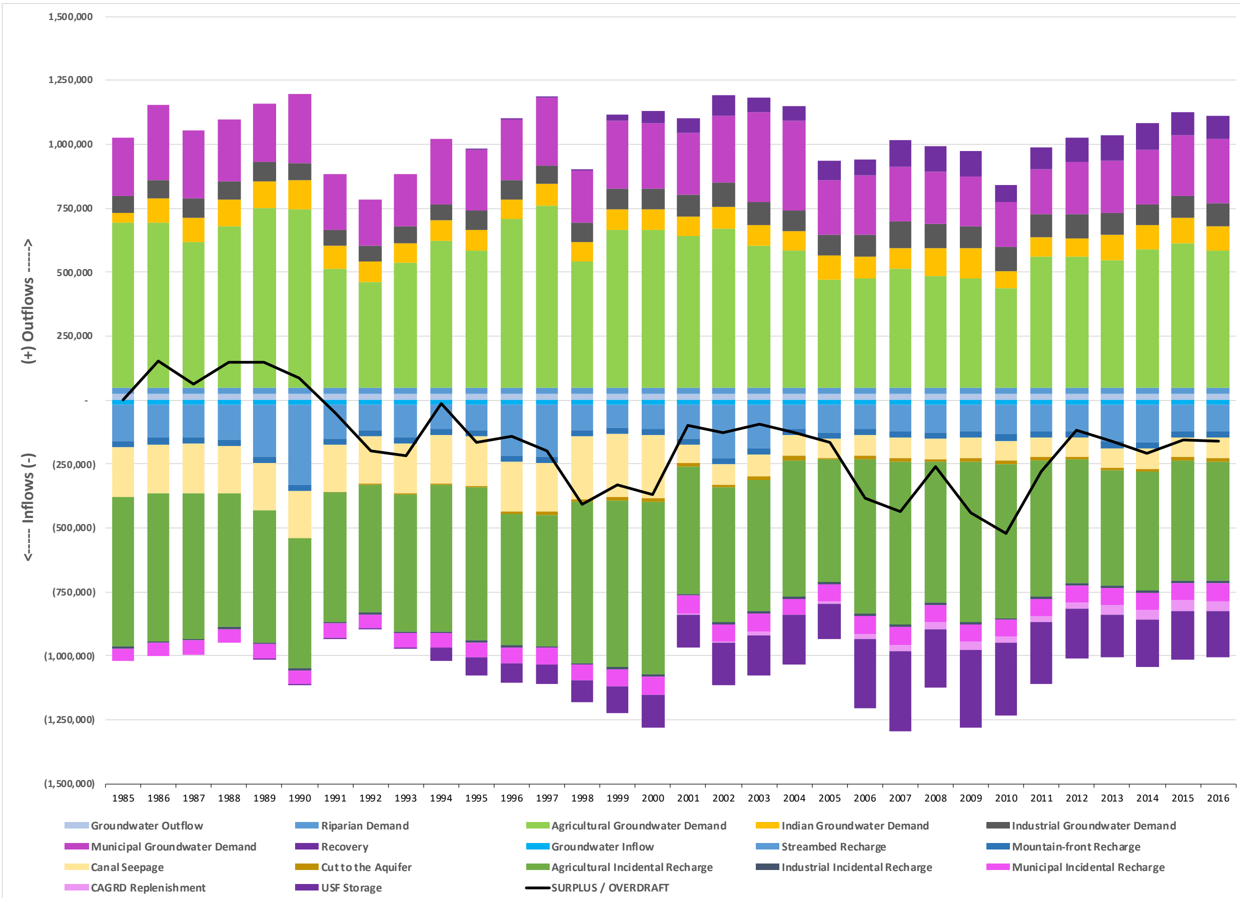
Inflows related to safe-yield include "the annual amount of natural and artificial recharge"[28] which, in this accounting, would include all ADWR's current inflow components, with the addition of USF storage. Although it's seen as temporary storage, the volume of surface water artificially recharged in the aquifer has been significant. Nearly 3 million AF of LTSCs have been earned at USFs in the Phoenix AMA, through 2016.[29] The Recharge Program has allowed water users to engage in more strategic, long-term water resources management, and has provided near-immediate benefits to the aquifer. Rather than create a run on LTSCs, recovery is anticipated to take place over a long period of time as surface water supplies are curtailed due to shortages and water users supplement their demands with recovered credits. As it currently stands, recovery of LTSCs has no impact on the achievement or maintenance of safe-yield. If long-term health and management of the aquifer is an objective of safe-yield, physical inflows and outflows seem more reflective of broader water management practices than legal water movements.

An analysis of physical inflows and outflows in the Phoenix AMA as proposed here shows the AMA to have been in a position of safe-yield since 1991. This means that, in reality, more water has been recharged into the aquifers of the Phoenix AMA than has been extracted over that time period. On average, there was a 223,000 AF per year surplus of recharge from 1991 through 2016. The chart below shows the inflows and outflows on either side of the horizontal axis, along with the corresponding annual overdraft/surplus volume shown on the solid line.

[28] *Ibid*.

[29] ADWR Long-Term Storage Credit Accumulation by Year. Online Dataset. Accessed April 9, 2020. https://new.azwater.gov/recharge/accounting.

Figure 3: Results of Proposed Physical Flow Calculation of Safe-Yield in the Phoenix AMA



Ultimately, the safe-yield calculation ought to follow a consistent methodology and help clarify the need for policy or regulatory changes that could reduce our reliance on groundwater. These alternative approaches are intended to demonstrate that there may be other ways to simplify the calculation to that end. However, there are obstacles to these proposals, including, for one, that LTSCs have been deemed a renewable supply and are thus treated differently than groundwater by law and the AWS Rules. Moreover, including the storage and recovery of renewable supplies might mask the impacts of allowable groundwater pumping that must be addressed in the long-term. But these proposals also serve to demonstrate how the safe-yield goal, as statutorily defined, offers a limited framework within which to truly assess aquifer health. For instance, if LTSCs earned at a USF are kept out of the calculation, the management goal, much like Arizona's bifurcated legal system, remains out of touch with actual groundwater/surface water interactions. If they are included, when it comes time to recover those LTSCs, the AMA could easily and quickly revert to a state of overdraft. Neither approach seems to accurately reflect the condition of the aquifer nor the larger sustainability issues that underly our current regulatory structure.

Impediments to Safe-Yield

Setting aside the complexities of tracking safe-yield progress under ADWR's current methodology, part of the issue with achieving the goal is the lack of clarity on which water management strategies are aiding or hindering its achievement, while another part is the limited regulatory and legal framework in which to limit groundwater withdrawal, a problem ADWR has recognized for decades. Despite well-meaning intentions, the State's strategies to provide incentives to store surface water supplies at USFs for later recovery do surprisingly little to help the AMA reach safe-yield - only a small 'cut to the aquifer' inflow. One could argue that recovery of LTSCs earned with surface water supplies limits the need for the storing entity to instead rely on groundwater during shortages or other disruptions to their renewable supplies. While that is true, physical groundwater will be pumped during the recovery process, regardless of its legal classification, to unknown impact on the aquifer. And in the meantime, the practice of earning LTSCs, one of the most heavily utilized water management strategies, does not help to achieve safe-yield by the imminent 2025 milestone.

The limitations of ADWR's ability to influence pre-authorized uses of groundwater through its regulatory programs are also significant. This is because the GMA authorized the continued use of groundwater in all sectors, by establishing service area rights, grandfathered rights (irrigation and Type 1 and 2 non-irrigation), the AWS Program groundwater allowances, and other withdrawal permits. Tribal agricultural demand may increase, though tribal water use is exempt from the requirements of the Code but may be subject to limitations under the terms of a tribal water settlement.[30] Allowances and exemptions were granted for all other water use sectors, representing a large current and potential volume of unreplenished groundwater withdrawals that obstruct the State's ability to meet its long-term groundwater management goals. While requirements to offset or replenish groundwater pumping only apply to a portion of the municipal sector, inequities have been created within and between sectors in relation to which is responsible for keeping their water use consistent with the management goal. The current effect is that water users must voluntarily attempt to reach safe yield or suffer the eventual physical and economic consequences of a depleting aquifer.

The management plans establish mandatory conservation requirements for agricultural, municipal, and industrial water users. However, ADWR has stated that "conservation alone is not sufficient to achieve safe-yield in the Phoenix AMA or in any AMA, because replenishment is not required for most water demand sectors. Certain types of groundwater rights are perpetual and certain segments of demand can continue to develop using groundwater."[31] So long as unreplenished groundwater demands exceed the amount of natural, artificial, and incidental recharge, they will remain a substantial, persistent impediment to safe-yield. If the burden of replenishment is only placed on *some* new uses and high-demand exemptions continue, it is difficult to see how safe-yield would ever be achieved in the Phoenix AMA.

[30] ADWR Phoenix Active Management Area Fourth Management Plan. 3-15, (2020).
[31] ADWR Phoenix Active Management Area Fourth Management Plan. 11-7, (2020).

Safe-Yield By 2025 and Beyond

Safe-yield as a management goal has served well to organize water users around a common ethic of groundwater sustainability, but it has unfortunately not led the Phoenix AMA to drastic reductions in unreplenished groundwater demand. Safe-yield continues to be meaningful conceptually, but the impediments to reaching the goal are too significant in practice. ADWR's tracking of safe-yield is somewhat complex, not readily transparent, and still lacking a clear determination of what a long-term balance means. This makes it difficult to discern what might prevent the AMA from achieving safe-yield or lower annual overdraft. The relatively low decline in Phoenix AMA-wide groundwater use since 1985 has been perplexing to those who thought the GMA would have alleviated this issue. Add to that the jarring recognition that the number of groundwater use exemptions may completely prohibit safe-yield, and it becomes clear that the State has failed to create a regulatory structure under which to achieve the Phoenix AMA management goal. Unless additional statutory authority is granted to ADWR to address some of these concerns, the burden of achieving safe-yield falls inequitably on designated water providers and CAGRD members alone under the current regulatory structure.

There is also a dearth of widely-distributed information on the location of specific, smaller-scale groundwater management problems of concern to many. 'Critical area management' and 'sub-regional water management' are terms employed by ADWR to describe specific target areas within AMAs that would benefit from the development of new tools or policies to address localized groundwater issues.[32] The Phoenix AMA Fourth Management Plan noted, "because the water table is greatly affected by localized recharge and withdrawal, achieving safe-yield Phoenix AMA-wide does not ensure that all local areas of the Phoenix AMA will attain a balance of supply and demand."[33] As defined, safe-yield ignores the locational distribution of pumping and recharge which varies widely within and among the AMAs. A workgroup formed in the Tucson AMA in 2000, known as the Safe-Yield Task Force, to address this very issue and develop local solutions. One of the group's proposals was to divide the AMA into 'water accounting areas' to improve water planning and address areas experiencing declining water levels.

Sub-regional management issues point to the crux of the issue with safe-yield as an AMA-wide management goal: even if the Phoenix AMA had achieved and maintained safe-yield, numerous ongoing groundwater management issues still persist. The Code does not recognize the achievement of safe-yield on a localized basis, only AMA-wide. It therefore overlooks the size and complexities of sub-basins within the AMAs yet understanding small scale variabilities is key to their management. Experts at ADWR have recognized for over 20 years that a more local resource management approach is needed to avoid the impacts of localized safe-yield imbalances. Addressing sub-basins in severe overdraft, land subsidence, aquifer compaction, and waterlogged areas may be more pertinent than achieving AMA-wide safe-yield, with its limited focus on inflows and outflows. ADWR's efforts, guided by a new management goal, might be better focused on addressing the sub-basin issues that require its expertise and leadership.

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[32] *See* ADWR Phoenix Active Management Area Fourth Management Plan. (2020); ADWR Phoenix Active Management Area Third Management Plan. (1999).

[33] ADWR Phoenix Active Management Area Fourth Management Plan. 11-5, (2020).

It is unrealistic to expect a single management goal will ever be comprehensive enough to lead to the resolution of all known groundwater issues. But when it comes to safe-yield, there are a high number of exemptions that will prevent us from ever achieving the goal, many of which could be seen as inconsistent with the GMA's original intent. There are overallocated sub-basins which will be disadvantaged in the future from the lack of sub-basin management strategies. That being said, post-2025 groundwater management conversations are working to set the stage for a new era of groundwater management in Arizona – one that should be based on the lessons learned from the GMA and AWS Rules in practice. Both the Fifth Management Plan and ADWR's post-2025 management strategy will require water users and regulators to envision the desired long-term state of the Phoenix AMA and develop the tools and additional statutory authorities necessary to achieve that objective, including the establishment of a clearly defined, effective and achievable management goal.