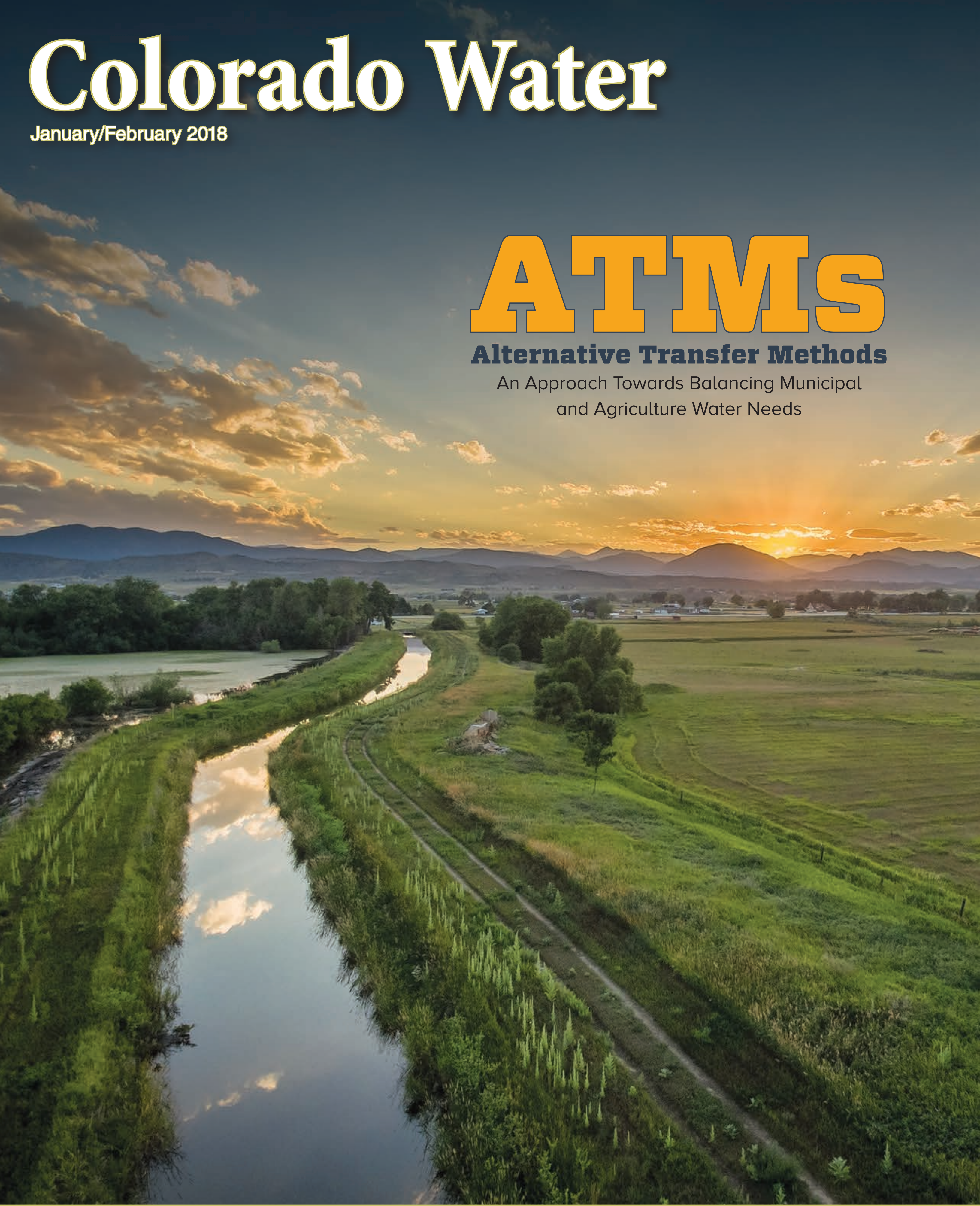
Colorado Water

January/February 2018



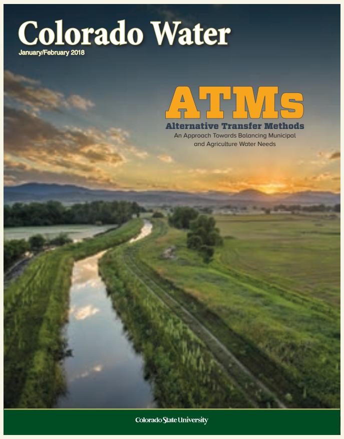
ATMs

Alternative Transfer Methods

An Approach Towards Balancing Municipal and Agriculture Water Needs

Colorado State University

Features — ATMs



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References can be found in the online version of this newsletter at http://cwi.colostate.edu/newsletters.asp

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COLORADO **WATER**

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Director's LETTER

As I write this letter, Cape Town, South Africa, a municipal area with almost 4 million people, is apparently running out of water after three years of drought. Can you imagine such a scenario here in Colorado? Municipal water managers in Colorado have worked diligently over decades to acquire enough water to provision the growing cities in our state through the inevitable dry periods, often buying and transferring senior agriculture water rights. Although termed "buy and dry", these transactions are willing buyer/ seller arrangements. Cites have often used agricultural purchases over developing new water projects because these rights are senior, transfers do not require federal permits, are often cheaper and quicker, and because agricultural water right holders were willing to sell. These transactions made sense for water suppliers and individual farm families.

Concern about the slow but steady loss of productive irrigated farm land as Colorado's population grows has led to the proposition of alternative transfer methods (ATMs) as a mechanism to keep water rights in agricultural ownership but allow transfer of water on a temporary or intermittent basis. This issue of *Colorado Water* summarizes the significant amount of investigation, pilot projects, and the implementation of alternative transfer methods to date.

In order to function, ATMs require a legal transfer mechanism, a water-saving method on the farm, and a way to physically move or exchange the water to an alternative point of use. CSU faculty have long explored agricultural water efficiency and conservation methods and it is important to understand the distinction. Efficiency improvements, such as moving from flood to sprinkler irrigation, reduce the total amount diverted to the field (and may alter historical return flow patterns), but will not necessarily reduce the amount of water consumed by the crop. Efficiency improvement benefits may accrue to the stream or aquifer and can help achieve more crop-per-drop of water diverted. Conservation practices, on the other hand, reduce crop consumptive use in order to yield transferable water under Colorado water law.

Fallowing, deficit irrigation, split season irrigation, and crop switching can all result in conserved crop consumptive use, but of these, fallowing is the most straightforward to implement, measure, and verify the transferable savings. Irrigation efficiency improvements and technology upgrades can help producers cope with less water, but at a cost that cannot be passed to the consumer. Importantly, changing irrigation technology will not change the water demand of the crop.

Recently, members of the Colorado Ag Water Alliance (CAWA) published their position on ATMs. Their deliberations revealed that producers are not of one mind on the benefits of ATMs to agriculture. After all, water taken out of agriculture, even on a temporary basis, affects the overall productivity and relative economic benefits of our food production system. Some in agriculture see ATMs as a business opportunity, some as inevitability, and some as undesirable erosion of our food production system and rural communities.

Bottom line, both cities and agriculture will have to be more efficient in the future, meeting their respective water needs though upgraded infrastructure, technology, conservation and storage. Not coincidentally, these are also the components needed to facilitate efficient water trading transactions. None of this will be cheap and it appears unlikely that ATMs offer a cheaper long-term option for growing cities. So, if we want ATMs as a public benefit, we will have to decide who pays for these arrangements. As we look to structure business deals that induce water trading from agriculture to municipal users, we need to think about the transaction holistically, considering the sustainability of our food system, environmental flow needs, and rural communities. It is complicated. But as this issue of *Colorado Water* points out, Colorado continues to push the envelope as we have some great legal, institutional, and agricultural minds working on the topic.

Reagan Waskom
Director, Colorado Water Institute

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Where Now with Alternative Transfer Methods—ATMs—in Colorado?

Special Report Puts Forth Ideas from Three Influential Meetings

MaryLou Smith, Colorado Water Institute

Colorado's Water Plan states a measurable objective of providing at least 50,000 acre-feet of agricultural water to municipal water providers through voluntary, compensated alternative transfer methods (ATMs) by 2030. Three separate meetings in the fall of 2016 addressed this challenge by convening water leaders from across the state, representing the interests of diverse sectors of the water community: agricultural, urban, and environmental.

The Colorado Water Institute (CWI) took the lead on combining the recommendations that came out of these three influential meetings into a document—Special Report 31, published April 2017—that provides a foundation on which further progress toward meeting the Colorado Water Plan's ATM goal can be built. Authors include Anne Castle, Senior Fellow with the Getches-Wilkinson Center at the University of Colorado; John Stulp, Water Policy Advisor to Governor Hickenlooper and chair of the Interbasin Compact Committee (IBCC); and Reagan Waskom, Brad Udall, and MaryLou Smith, all from the CWI.

Three Meetings

Three meetings were held in October and November 2016 (located in Broomfield, Grand Junction, and Golden, Colorado) to discuss the ATM goal in Colorado's Water Plan, ATM projects, as well as best management practices such as rotational fallowing, deficit or limited irrigation, as well as irrigation efficiency.

Primary Conclusions

Since all three meetings had different formats, all conclusions were not necessarily reached, discussed, or universally supported at each meeting. Common conclusions, however, include these:

- Irrigated agriculture is an essential component of Colorado's economy, culture, and ecology.
- While some progress has been made in facilitating ATMs, permanent fallowing of Ag land through land and water rights sales is currently the easiest way for users, such as municipalities, to obtain new water supplies.
- Permanent fallowing of Ag land weakens Colorado's agricultural and rural economies, as recognized in Colorado's Water Plan.
- Municipalities and Ag producers have expressed interest in exploring ATMs that make financial sense to both parties.
- From the Ag producer perspective, interest in ATMs is heavily influenced by current commodity prices. ATMs are recognized as a potential stabilizing source of farm revenue, but many are concerned about missing out on years of high commodity value. ATMs may also provide desirable security for bank loan purposes.
- Some ATMs will be used to provide supplemental urban water supplies, especially for the Front Range. Other

Colorado Cattlemen's Develops Decision Support Tool—a Tangible Response to Recommendations

Colorado Cattlemen's Ag Water Network has developed a web-based screening tool that Ag water right holders can use to assess the lease potential of their water rights. The Decision Support Tool allows an irrigator to input basic information about his or her water right—including the decree date, volume, and other details—to receive a numeric score and a rating indicating the potential for leasing the water right for other uses, such as municipal, industrial, and environmental.

The Colorado Water Plan estimates our state could lose up to one-fourth of its remaining irrigated agricultural land by 2050 due to "buying and drying" of farms for development. The Water Plan encourages ag water leasing—which is also called an alternative transfer mechanism (ATMs)—as a means of providing water to municipalities and other non-ag interests while providing farmers with a way to monetize part of their water rights without selling them.

The mission of CCA's Ag Water NetWORK is to help "keep ag water connected with ag land" in Colorado. The lease screening tool represents a first step in helping to expand opportunities for ag water right holders to participate in compensated, temporary, voluntary ag water leasing.

The lease decision support tool is available at www.agwaternetwork.org. The website also provides access to Ag Water NetWORK webinars and publications on leasing and other water-related information, as well as an interactive map showing the locations of ag water leases that are occurring around Colorado.

ATMs will be used to facilitate Colorado River Compact compliance or reduce the risk of a Compact call. These different types of ATMs often have different goals and requirements, and may be better addressed separately.

- For the Front Range/municipal supply-type ATM:
    - From the municipal supplier perspective, the ATM needs to be more cost effective than permanent acquisition—and some form of permanence is desirable. This could take various forms, such as a permanent conservation easement on the land, or a water bank or market that provides a reliable source of water for combined agricultural and municipal/industrial needs. Such approaches could provide opportunities for young farmers to get into agriculture without large capital outlay for land.
    - Infrastructure—in the form of storage or distribution facilities—will likely be needed to make this type of ATM work. Unfortunately, the permitting of such facilities is considered too burdensome and time-consuming. Better and more timely methods could be adopted to allow construction of needed facilities, while continuing the protections provided by existing laws.
    - The Super Ditch and Catlin lease-fallowing arrangements are developing in the Arkansas Basin, and are evolving into a good model for ATMs. In the South Platte Basin, an ATM agreement between the North Sterling Irrigation District, Fort Morgan Reservoir & Irrigation Company, and Xcel Energy provides another model of a successful ATM.
- For the Colorado River Compact compliance/risk reduction-type ATM:
    - The definition of "beneficial use" may need to be modified to include Compact compliance and risk reduction.
    - The ability to shepherd conserved water to Lake Powell needs further dialogue.
    - This type of ATM can be structured to also benefit the environment and/or endangered fish species.
    - The needs of this type of ATM are similar to the periodic need of East Slope municipal suppliers for the refill of reservoirs depleted by drought or other short-term drought-related needs.
    - An Upper Basin Drought Management Cooperative could expand this discussion to the other Colorado River Upper Basin states (Wyoming, Utah, and New Mexico) through the Upper Colorado River Commission.
- Deficit irrigation of forage crops, and rotational fallowing have been used in Colorado as underlying agricultural techniques to support ATMs.
- Crop switching to lower water-use crops is feasible in theory, but would be complex to utilize. Its use in the context of ATMs has been limited.
- Irrigation efficiency has been used to increase instream flows and improve water management. Efficiency measures, for the most part, do not create consumptive use savings, and therefore, do not make more water available for use in an ATM other than for instream flow in a limited stream reach.

- Opinions differ as to whether the existing water court and ATM processes are sufficient, with some believing that the water court change-of-use protections are essential to ensure against injury. Meanwhile, others are concerned that the process is too burdensome and costly, and could be streamlined in ways that continue appropriate protections.
- Common methodologies or presumptive factors for consumptive use and return flow measurement, timing, and accounting could be adopted to reduce the cost of temporary transfers while protecting water rights.
- Transparency in terms of ATM transactions, particularly price terms, benefits all. A database of ATM transactions could be developed and kept up to date.
- In many cases water providers have already purchased agricultural land and water for future use and are leasing that water back to agricultural producers until they need it for future growth or drought. This is typically called "purchase-leaseback." Some of these water providers have shown interest in working with agricultural and environmental stakeholders to create win-win benefits for all three sectors as they transition that portfolio of water over time.
- Every basin is different. There is no "one size fits all" solution. Regional entities, such as water conservancy or conservation districts, are the logical organizations to administer ATMs.
- Concerns about "use it or lose it" have kept some from considering ATMs or otherwise temporarily altering their historic diversions for conservation purposes. Further education or statutory clarification may be needed.
- Colorado has taken a leadership role to facilitate and spur progress on ATMs.
- Funding needs can be further explored and quantified.

Recommendations

Each meeting resulted in different recommendations, with a considerable amount of overlap. Some of the recommendations include:

- Establish and support two working groups, one to focus on the Front Range/municipal type of ATM and one to focus on the Colorado River Compact compliance/risk reduction type of ATM.
- Colorado could work with regional entities to facilitate and administer ATMs.
- Adopt a common technical platform for measurement, accounting, and verification.
- Identify storage and other infrastructure needs, and find ways to meet those needs.
- Provide professional support and network building for agriculture to cooperatively take advantage of ATMs.
- Provide professional support to encourage network-building among smaller domestic water providers, to cooperatively take advantage of ATMs.
- Identify the administrative or legislative changes that may be needed to allow the Compact compliance type of ATM.
- Identify secure funding to facilitate the ATM volume needed to meet Colorado's Water Plan goal.

Special Report 31—including a link to seventeen pages of summary from the three meetings and a link to the reports that make up the synopsis of alternatives to permanent fallowing—can be found at http://www.cwi.colostate.edu/publications/SR/31.pdf

Colorado Ag Water Alliance (CAWA) Adopts Position Statement on ATMs in Response to Recommendations

CAWA acknowledges that Alternative Transfer Methods (ATMs) and water leasing are a focus of Colorado's Water Plan. Members see a potential positive benefit, but believe a cautious approach is necessary for these agreements. With assistance from the Colorado Water Institute, over a series of meetings, the organization crafted a 15-point paper outlining their position. The document "offers areas of alignment and agreement among Colorado's agriculture organizations in order for interested audiences to clearly understand the set of baseline considerations that agriculture will review in context of ATMs." Read the full statement: https://docs.wixstatic.com/ugd/302b62_5fa2519338b24613aa282eefa8383453.pdf

On Farm Water Savings Techniques to Facilitate ATMs

Brad Udall and Greg Peterson, Colorado Water Institute

Western Colorado alfalfa field comes back to life with only two irrigations after 1.5 years without water.

Introduction

Coloradans want to keep agriculture in production while also providing water for growing municipalities and environmental needs. Alternative transfer mechanisms (ATMs) have been promoted as one way of accomplishing this goal. ATMs have also been proposed as a way to send water to Lake Powell for Colorado River compact compliance.

ATMs require two parts to effect a water transfer: a legal technique and a water-saving method. Deficit irrigation, rotational fallowing, crop switching, and the related topics of irrigation efficiency and water conservation are five physical ways to save water for ATMs. This article summarizes a recently study completed by the Colorado Water Institute (CWI), which covered these methods in detail[1].

Deficit Irrigation of Alfalfa and Other Hay

Irrigation is generally designed to meet the full water requirements of crops. ***Deficit irrigation*** is the generic term for applying less water than the full needs of a crop and can take many forms. It can be a planned, sophisticated strategy or an unplanned, natural consequence when water scarcity arises. Planned deficit irrigation is widely used with grapes, to improve quality. Unplanned deficit irrigation occurs commonly on forage crops that depend on diversions from mountain streams as the runoff pulse declines in late summer.

Alfalfa, because of its large consumptive use relative to other crops, its extensive acreage in Colorado, and its ability to go dormant when water is removed, is an obvious candidate for saving water through deficit irrigation. Although it is also possible to partially irrigate alfalfa throughout the growing season, split season irrigation results in higher relative yields, better quality, and lower labor than other forms of deficit irrigation, and thus has been the focus of almost all deficit irrigation studies. Split season irrigation entails watering the crop early in the year, and then completely ceasing irrigation later in the year.

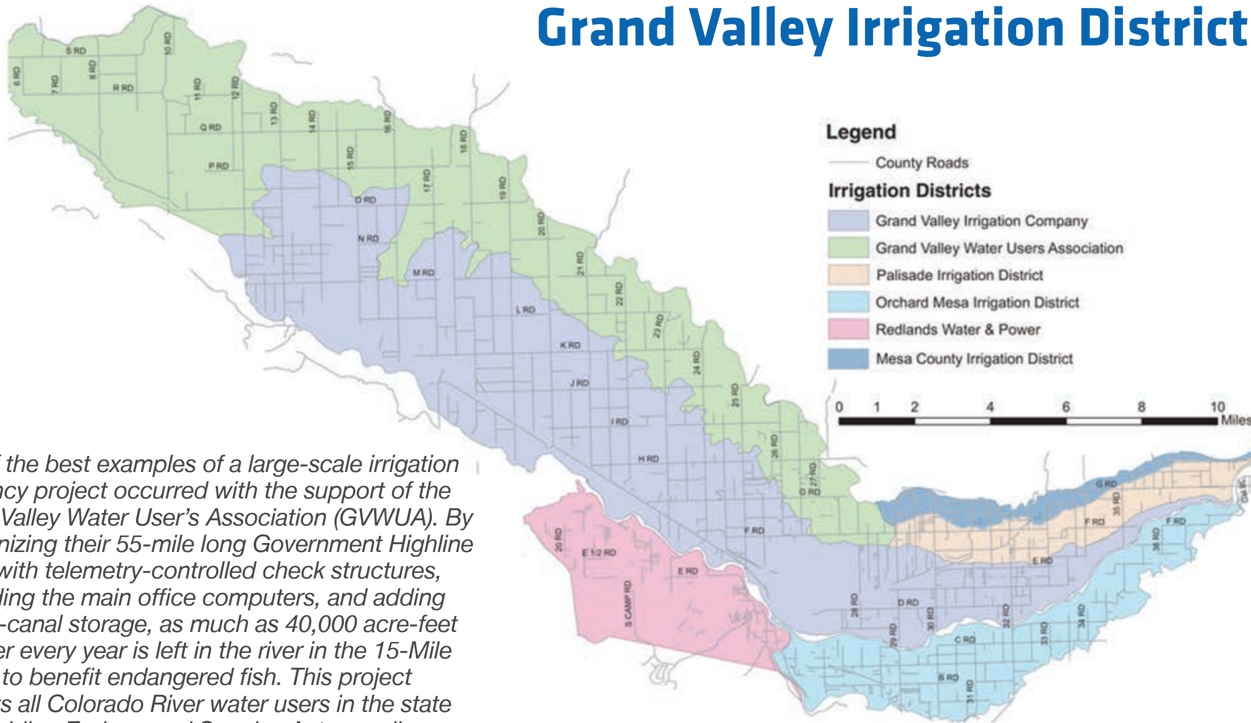
There have been numerous studies on deficit irrigation of alfalfa dating to the 1960s. Stand loss, i.e., the loss of some of the plants, has occurred in a few studies. Stand loss is especially related to sandy soils with little water-holding capacity, and lengthy deficit irrigation periods during very high temperatures. In general, yield returns quickly once irrigation resumes, and the hay quality does not appear to be affected. Deeper soils are generally better when water is cut off as they hold more water. Alfalfa's deep taproot can often obtain at least some water to keep the plant alive with deep soils.

Deficit irrigation of pasture grass has, unfortunately, had very little research. Like alfalfa, grasses can also go dormant. Unlike alfalfa, however, grass has fewer root reserves and shallower root systems, which are less able to tap deep moisture.

Rotational Fallowing

Rotational fallowing, also known as lease-fallowing, is the act of temporarily fallowing farm land to save water. Rotational fallowing has been used for more than 25 years in the Colorado River Basin. Unlike some of the other methods of saving water, such as crop switching and deficit irrigation, temporary land fallowing is a proven, successful strategy for conserving significant amounts of water. Although there can be substantial issues

Grand Valley Irrigation Districts



One of the best examples of a large-scale irrigation efficiency project occurred with the support of the Grand Valley Water User's Association (GVWUA). By modernizing their 55-mile long Government Highline Canal with telemetry-controlled check structures, upgrading the main office computers, and adding end-of-canal storage, as much as 40,000 acre-feet of water every year is left in the river in the 15-Mile Reach to benefit endangered fish. This project benefits all Colorado River water users in the state by providing Endangered Species Act compliance.

with quantifying the actual water savings from fallowing, there is little doubt that fallowing does save water.

Rotational fallowing negotiations can be complex with agreement needed on price, land, water savings, and fallowing period. These agreements may take a year or more to finalize. Fallowing agreements can impact nearby communities with job loss in agricultural support industries, decreased retail sales, and loss of sales and property taxes. In some agreements, these third-party impacts have been partially mitigated through dedicated funding provided by the purchaser. The irrigation district or ditch may have to be compensated for managing the program.

Rotational fallowing can improve soil health by resting the soil. In places with saline groundwater, capillary action can leave salts on the soil surface after fallowing, requiring a pre-planting leaching water application. Fallowed fields need to be managed to prevent weeds, dust, and soil erosion. Most agreements require landowners to manage the fallowed fields. Monitoring efforts are needed to ensure such activities occur.

In the Colorado River Basin, rotational fallowing agreements have been implemented in the Palo Verde Irrigation District, in the Imperial Irrigation District, and more recently in the Arkansas Valley's Super Ditch.

Crop Switching

Crop switching has been proposed as a way to save large amounts of water in the West. Unfortunately, Colorado's high mountain valleys, with their short growing season provide little opportunity to switch crops. Colorado's warmer West Slope valleys, however, may support crop switching. A number of practical considerations, both on- and off-farm, may constrain crop switching. For instance:

- On the farm, climate and soils limit crop selection. Some crops, such as vegetables, require higher water quality than do forage crops.
- The water delivery method may need to change from flood irrigation to drip or sprinklers, at considerable cost.
- Farmers need the knowledge, skills, equipment, and labor to plant and harvest the new crop. New types of insurance may be required.
- Off-farm issues include unfamiliar markets that may impact the price of the new crop.
- Often, supporting infrastructure—including processing facilities and marketing and distribution networks—needs a minimum amount of production to be profitable.
- Transportation costs and storage needs may also affect what crops can be grown.

There have been very few documented cases of crop switching in the Colorado River Basin for the purpose of saving water. Over time, however, there have been significant shifts in crops as markets have changed. The Yuma, Arizona area, provides a textbook example how such shifts have improved farmer revenues while saving water at the same time[2]. These crop shifts have been accompanied by a number of irrigation efficiency improvements.

Colorado's famous Grand Valley Project Diversion Dam just east of Grand Junction along I-70. Known as the "Roller Dam" for its multiple cylindrical moving crests, it diverts water into the Government Highline Canal for use by irrigators in Grand Junction. The canal was the site of a large-scale efficiency improvement project completed in 2002.

Irrigation Efficiency and Water Conservation

Two related ideas, water conservation and irrigation efficiency, can also be used to obtain water from agriculture. Although there are many definitions of these terms, for our purposes, the activities associated with water conservation and irrigation efficiency represent actions directed at the two different outcomes for water after it is diverted. The first outcome is that the water is consumed by plants (crops and other vegetation) or evaporated from soils. In this case, water is converted to vapor and is no longer available for use. The second outcome is that the non-consumed liquid water returns to the stream either immediately as surface water or over time as groundwater.

Water conservation thus deals with reducing the vaporized ("consumed") portion of the diverted water, while irrigation efficiency generally reduces the amount of liquid water diverted from and later returned to the stream. Note than under Colorado water law, irrigation efficiency improvements do not lead to legally transferable water because only historical consumptive use can be transferred. In other states, irrigation efficiency can sometimes lead to water transfers. Savings accomplished by water conservation in Colorado can create water for transfer. Irrigation efficiency improvements, even if not transferable, can leave more water in streams for environmental purposes.

By definition, improved irrigation efficiency involves increasing crop consumptive use per amount of water diverted from the stream, even if total consumptive use does not change. Historically, this has been viewed as a benefit by many but not all observers, much as we view increasing gas mileage per gallon of fuel as a worthy goal. Importantly, however, water not consumptively used is still available for reuse as a return flow. Return flows are often the source of water for many downstream diverters, and are discussed below.

Irrigation efficiency improvements involve canal linings, operational reservoirs, sprinklers, drip irrigation, computerized canal automation, high flow flood irrigation turnouts, pressed furrows, tailwater capture and reuse, laser leveling, and irrigation scheduling. Efficiency improvements get more of the diverted water to the field, apply water more evenly with less deep percolation, require less carriage water, and reduce spills in difficult-to-manage lengthy irrigation systems with long transit times.

Return flows are a critical feature of many water basins in the West. There is a vigorous debate over whether these return flows are good or bad—and implicitly, whether efficiency improvements (which almost always change return flows) are good or bad. The answer depends on the soil, runoff contaminants (if any), water temperatures, changes to the natural hydrograph, local geography, the location, and priorities of other diverters, and even the values of the observer. When return flows change, there are often winners and losers, including nature, which influences the answers to this question.

Other Results of Irrigation Efficiency

Improving irrigation efficiency can paradoxically lead to increased consumptive use. This is because more efficient water delivery methods can deliver water exactly when it is needed to the precise places where it is needed, thus improving yields. Efficient methods allow for water to be applied at the flip of a switch—rather than only when labor is available—and to avoid both over- and under-watering.

There are a number of co-benefits from improving irriga-

Government Highline Canal Modernization Project Results

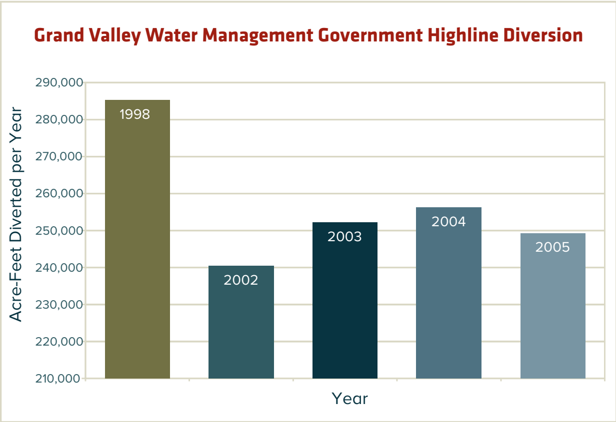


Figure 1. Yearly diversions, compared before and after implementation.

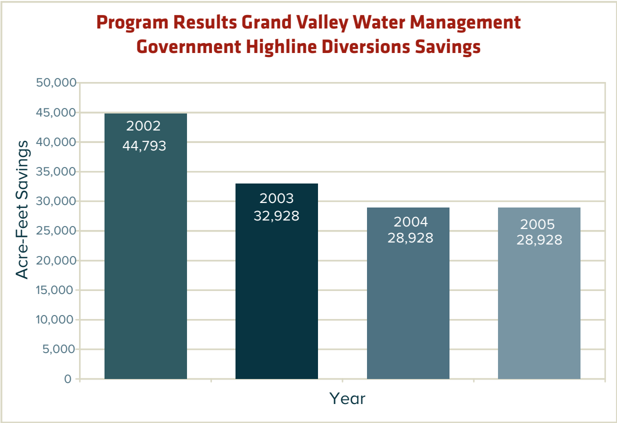


Figure 2. Yearly savings since implementation.

tion efficiency. Increased water quality from reduced contaminants (salt, chemicals), higher reliability due to less carriage water, and increased yields (economic gains) can occur when efficiency improves. Irrigation efficiency improvements also reduce labor and increase flexibility, which in turn can make management easier.

In theory, water conservation could be used to save water from non-crop plants that consume water. However, under Colorado Law such reductions (known as "salvage water") are not counted as historical consumptive use. Other forms of water conservation that save consumptive use generally lead to declines in yields, thus reducing farmer economic gains. Deficit irrigation and rotational fallowing are two forms of water conservation.

There are many cases of irrigation efficiency improvement projects in the West. In California's Imperial Irrigation District, the Metropolitan Water District of Southern California (MWD) has an ongoing program to save approximately 100,000 acre-feet of water every year. Most of this is accomplished by various projects paid for by the MWD.

In Colorado, one of the best examples occurred in Grand Valley Project in the late 1990s. These improvements keep environmental water in the 15-mile reach near Grand Junction for fish. A similar effort was recently undertaken by the nearby Orchard Mesa Irrigation District.

Conclusions

There are numerous ways to save water for agriculture, but all involve trade-offs. Water conservation techniques such as deficit irrigation and rotational fallowing involve some reduction in crop yield, and thus result in economic loss by farmers.

Crop switching may allow farmers to maintain or increase revenues while using less water, but this method involves many unknown—and possibly expensive and risky—changes to production. Irrigation efficiency improvements can reduce headgate diversions, and thus keep more water in a given stream reach, but these generally do not provide water for new consumptive uses.

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[1] http://cwi.colostate.edu/

[2] See Noble, 2015. A Case Study in Efficiency—Agriculture and Water Use in the Yuma, Arizona Area.

Colorado Water Conservation Board and Alternative Transfer Methods

Craig Godbout and Gregory Johnson, Colorado Water Conservation Board

While the Colorado Water Conservation Board (CWCB) is involved in many aspects of Alternative Transfer Methods (ATMs), it is just one of many organizations supporting this approach to maximizing the beneficial use and productivity of every drop of water.

Through Colorado's Water Plan (https://www.colorado.gov/pacific/cowaterplan/plan), the Alternative Agricultural Water Transfer Methods Grant Program, and other efforts, the State is working closely with the agricultural community in the same collaborative manner that has produced many agricultural transfer pilot projects. The goal is to share at least 50,000 acre-feet of agricultural water using voluntary ATMs by 2030.

A healthy economy and growing population in Colorado are increasing municipal and industrial water demands, subsequently intensifying pressure to transfer agricultural water rights, a process known as "buy-and-dry". The Statewide Water Supply Initiative (SWSI) estimates that by 2050, Colorado may lose 500,000 to 700,000 acres of currently irrigated farmland in order to meet new municipal and industrial demands. If Colorado continues down its current path, the South Platte River Basin could lose up to one-third of today's irrigated land by 2050. The Arkansas River Basin could lose another 17 percent of its total and the main-stem of the Colorado River Basin could also lose another 29 percent.

If Colorado continues down its current path, the South Platte River Basin could lose up to one-third of today's irrigated land by 2050. The Arkansas River Basin could lose another 17 percent of its total and the main-stem of the Colorado River Basin could also lose another 29 percent.

The Interbasin Compact Committee and basin roundtables throughout the state have concluded that the current status-quo path of buy-and-dry is not the best option for Colorado. Across the state, water stakeholders want to minimize buy-and-dry in a way that respects property rights, recognizes the importance of agriculture in Colorado, and supports a sustainable agricultural industry—while identifying diverse and flexible options to provide water for municipal needs.

U.S. Army Corps of Engineers

John Martin Dam and Reservoir on the Arkansas River in Bent County, Colorado, circa 1979.

Jeffrey Beall

The South Platte River pictured near Hartsel, Colorado.

These options, referred to as Alternative Transfer Methods (ATMs), do not limit the choice of private water rights owners to permanently sell their water rights. Instead, ATMs offer voluntary tools that enable both farmers and other water users to share water in a sustainable and economically beneficial manor. In addition, ATMs can support the environment, as well as recreation, industry, and groundwater sustainability. ATM approaches generally fall into the following categories:

- rational fallowing,
- interruptible supply agreements,
- municipal-agricultural water-use sharing,
- water cooperatives,
- water banks, and
- flex markets.

Temporary water-transfers provide diverse options, including both short-and-long-term arrangements. Program goals related to ATMs are aimed at specific objectives for various regions across Colorado. As such, it is unlikely that any one concept will be universally accepted and employed in every basin. Rather than a one-size-fits-all approach, a variety of alternatives will be needed to meet specific needs.

The execution of ATMs must overcome numerous, well-documented constraints, such as institutional, legal, financial, and court-related issues, along with technical site-specific complications. Examples include:

- a lack of necessary infrastructure for water transfers,
- supply reliability issues,
- impacts to long term agricultural productivity, and
- relatively high transaction costs.

Nonetheless, much progress has been made toward the implementation of effective ATMs in Colorado.

Colorado's Water Plan encourages alternatives to permanent dry-up through the CWCB's long-standing Alternative Agricultural Water Transfer Methods Grant Program. Colorado Senate Bill 07-122 authorized the ATM grant program with initial funding of $4 million to help implement lease fallowing, pilot projects, flex market studies, demonstration efforts, and other projects.

Subsequent legislation has provided an additional $1,750,000 for the program. With these funds the CWCB has awarded over two dozen grants, ranging from about $8,000 to almost $500,000. While grants awarded in early funding cycles focused on identifying potential impediments and researching promising solutions, the current focus is on implementing water sharing agreements that culminate in actual wet-water transfers.

Examples of active ATM projects along with their sponsors and potential yield in acre feet (af) include:

- Lower Arkansas Valley Water Conservancy District Catlin Canal Pilot Project (Fowler, Security & Fountain): 500 af (CWCB ATM Grant),
- Widefield Water and Sanitation District, Security Water and Sanitation District, City of Fountain Water Utility: 1,350 af,
- Fort Morgan Irrigation Company/Xcel Industrial Lease/Pawnee Power Plant: 2,500 af,
- North Sterling Irrigation District/Xcel Energy Industrial Lease: 3,000 af,

If Colorado follows current trends, the Colorado River Basin could lose up to 29 percent of today's irrigated land by 2050.

- North Sterling Irrigation District/BNN Energy Lease (Point of Rocks 2): 6,800 af,
- Larimer County/City of Broomfield Open Space Pilot Project: 80 af (CWCB ATM Grant),
- Colorado River Water Conservation District/System Conservation Pilot Program: 3,200 af,
- New Cache La Poudre Water Marketing Strategy: 1,000 to 2,000 af (CWCB ATM Grant), and
- South Platte ATM and Conservation Easement Project: 505 af (CWCB ATM Grant).

Colorado's Water Plan recognizes the need to increase agility within Colorado's water law, while respecting property rights. State legislation has provided several tools to help facilitate ATMs, some of which directed the CWCB to promulgate rules and/or criteria and guidelines. Examples of recent ATM legislation include:

- House Bill 13-1130 enacted Interruptible Water Supply Agreements, and supplemented or amended previous related authorizations. The legislation allows for a temporary change of an absolute water right to a new use, based on approval by the Division of Water Resources in lieu of the typical water court process.
- House Bill 13-1248 authorized the Fallowing-Leasing Pilot Program that allows for a pilot program to test the usefulness of fallowing-leasing as an alternative to permanent agricultural buy-and-dry. The pilot program may include up to 10 separate pilot projects statewide; however, no more than three are allowed in any single river basin. Each pilot can operate for up to 10 years in duration.
- House Bill 16-1228 allows the owner of a decreed irrigation water right to file a water court application to change the right to an "agricultural water protection water right" (AWPWR). The AWPWR is created to simultaneously preserve ongoing irrigation and provide the flexibility to lease a portion of the water right to accommodate potentially unknown future uses (up to 50% of historical consumptive use).
- The delivery of the AWPWR to the new point of diversion, for the new use, must be done in accordance with a substitute water supply plan approved pursuant to the new Department of Water Resource' rules. The law requires that the portion of the water right that is not leased remains in agricultural use. The owner must participate in a conservation program or an Agricultural Water Protection Program developed for the purpose of ensuring compliance (per Criteria and Guidelines established by the CWCB). This statutory allowance is applicable to Water Divisions 1 and 2 only.

The CWCB will continue to support the implementation of ATMs to help minimize buy-and-dry, while providing important flexibility to help address a portion of Colorado's future water needs. These voluntary measures are a key tool in meeting the objectives set forth in Colorado's Water Plan with balanced solutions.

Evaluating ATMs for Front Range Municipalities

Brett Bovee, WestWater Research LLC

An aerial view looking west across Windsor Lake, Windsor, Colorado.

What are ATMs?

Alternative water transfers methods (ATMs) refer to various methods, activities, and frameworks that have been established to transfer water on a temporary or intermittent basis, primarily from agriculture to other uses. They are labeled as "alternative" because they represent a type of water transfer that does not result in the permanent dry-up of agricultural land, which has been the primary form of water transfers in much of Colorado for decades. ATMs are a body of activities that represent general frameworks or concepts to be molded to the specific conditions of a place and need.

Table 1 provides a list of common ATM frameworks that have been applied in the Western U.S. An ATM is basically comprised of two parts: (1) an agricultural water supply method to generate the water from the farm, and (2) a water transfer method to provide for a new use of the agricultural water.

ATMs in Colorado

Flexible and temporary water transfers, inherent in ATMs, are often viewed as difficult to accomplish within the confines of Colorado's water rights system. A variety of recent laws have been aimed at making temporary and flexible water transfers more attainable, with less oversight in water court. These laws have allowed for water transfers to take place under a Substitute Water Supply Plan (SWSP), an Interruptible Water Supply Agreement (IWSA), pilot rotational fallowing programs, multiple use decrees, water banks, and other methods. Collectively, these recent laws have made it potentially easier and less-costly to transfer an agricultural water right to new uses, at least on a temporary and intermittent basis. These laws are largely the legal foundation on which ATMs are intended to be built in Colorado, providing flexibility for water transfers in an otherwise rigid water rights system. Such policy and legal changes have opened the door for water users to utilize ATM frameworks for water transfers.

Purpose of the EDF Project

The Environmental Defense Fund (EDF) obtained a grant opportunity to fund research, analysis, and outreach toward the development of ATMs on the Front Range of Colorado. The specific purpose of the EDF project was to fill an important information gap in the ATM discussion, by developing a financial comparison between status-quo water supply development options and applicable ATMs.

Two municipal water systems were evaluated as case studies, to explore the costs of ATMs. The project was completed in 2016, and the report is available online at https://www.edf.org/atmreport. This article summarizes important aspects of the research project, including recommendations for advancing ATMs in Colorado.

Table 1. Summary of Alternative Water Transfer Methods (ATMs).

Category	Name	Description
Agricultural water supply methods	Full-season fallow	An agreement to temporarily idle irrigated land for a full growing season in exchange for payment for the water that can be transferred to a new use.
	Split-season fallow	A lease agreement based on splitting the water use in a single growing season between agriculture and other uses, typically with irrigation occurring in the first part of the season, and water leased in the latter part of the season used for other uses.
	Rotational fallow	A temporary fallow in which the idled land is rotated periodically for agronomic and regulatory reasons, and no one field is idled for multiple consecutive years.
	Regulated deficit irrigation	Application of less irrigation water than is needed to satisfy maximum crop ET and achieve maximum crop yields.
	Crop switching	Compensate agricultural producers for adopting a crop rotation with a lower diversion requirement and consumptive use than traditional practices.
	Infrastructure	Direct funding of water storage and/or conveyance infrastructure that benefits agricultural producers in exchange for a share of the generated water supply.
Water transfer methods	Regional water bank	An administrative structure that connects buyers and sellers, allowing interested parties to conduct temporary water trades with a reduced regulatory burden and transaction cost.
	Public water bank	An entity with taxing authority that can purchase agricultural properties and water rights and make a portion of that supply available for other uses.
	Buy and supply	Purchase irrigated land and lease it back for farming with a permanent IWSA in place.
	IWSA/option contract	A long-term lease agreement that maintains water in its original use in most years, but provides an intermittent water supply to other uses under preset conditions.
	Purchase/lease	A standard permanent purchase or temporary lease contract.
	Lease to fix	Provide initial payments to agriculture in exchange for reduced water use. These payments are then applied toward water supply development or efficiency improvements with the intent of providing a long-term supply for other uses in partnership.

Case Study Selection

Municipal interest in ATMs is largely a function of cost and risk tolerance. Both in Colorado and other Western states, municipalities have been more interested in discussing ATM water supplies when: (1) more traditional water development project supplies are not available, and (2) the municipality is forced to pursue leased water supplies. Therefore, a municipality's level of interest in ATMs is directly related to the cost and reliability of other water supply options available to it.

A screening analysis was undertaken to evaluate the conditions that would likely influence municipal interest in an ATM, in order to identify potential case studies for a more detailed analysis. A total of 66 municipal water providers were initially identified on the Colorado Front Range. This total was reduced to 35 municipal water providers based on water-source and demand-size criteria.

This prioritized listing of 35 municipalities indicates that there might be a limited number of municipal entities on the Front Range who represent candidates to help meet state policy goals of expanded use of ATMs. Two case study participants were identified: City of Fountain and Town of Windsor. Both participants provide good representation of municipalities along the Front Range, based on the following characteristics:

- rapid population growth and development,
- proximate location to several irrigation ditches, and
- historical reliance upon large-scale regional water projects for much of their water supply.

Case Study Results

The two case studies represent independent evaluations of future water shortages, and the potential water supplies (both traditional and ATM types) that could be acquired to address such shortages. A financial analysis of water supply alternatives was completed based on a 30-year model of all major costs associated with each water

Figure 1. Cost comparison of water acquisition options for two case studies.

source, including things like:

- acquisition,
- transfer,
- annual ownership and operations,
- leasing, and
- infrastructure tied to reliability and flexibility of use.

A terminal cost value was incorporated to account for indefinite annual costs, in order to make leased water supplies comparable to permanent acquisitions beyond the 30-year model period. Figure 1 provides a summary of the results.

For Windsor, one ATM approach—in which water rights are both purchased and leased to address projected shortages —was found to a provide small cost savings, relative to more traditional water right acquisition approaches. Other ATM approaches, however—such as rotational fallowing and buy-and-supply approaches—were found to have greater long-term (indefinite) costs, compared with permanent acquisitions and traditional sources of supply.

For Fountain, many of the ATM water supply alternatives had similar estimated costs when compared with permanent water right acquisitions.

In both case studies, groundwater development was found to have the highest cost, because of the costs associated with augmentation and advanced treatment. The assumed rates of price appreciation and discounting utilized in the analysis influence the comparisons between water supply alternatives, and the results were found to be quite sensitive to assumed economic inputs. A sensitivity analysis adjusting input costs and rate assumptions was included in the analysis to illustrate this variability.

Fountain Creek Nature Center, Colorado.

Recommendations

The State of Colorado has made significant investments in both understanding and promoting the use of ATMs, and has set a policy goal of 50,000 acre-feet of ATM projects in place by 2030. Based on the information compiled and developed through the EDF project, we suggest that the following points should be considered to expand the use of ATMs in Colorado:

- ***Are new water laws needed?*** There have been a series of laws passed in recent years that make it possible to structure an ATM type of water agreement within the bounds of Colorado water law. In many cases, an ATM agreement can legally be implemented, and the higher hurdle to overcome is identifying parties to voluntarily agree to enter into an ATM agreement.
- ***Does anybody want to buy ATM water?*** Most ATMs inventoried in Colorado and the other Western states were initiated from the demand side, with an entity actually seeking out temporary and/or intermittent water sources that could be provided through an ATM type of water transaction or agreement. This should encourage efforts to implement ATMs toward the demand side as a starting point, with outreach to municipalities, industrial water users, and environmental organizations. Two important exceptions, where the supply-side offered water for lease, are the Catlin Canal project and the recent Larimer County agreement with Broomfield.
- ***Who are the potential buyers?*** The pool of potential municipal participants on the Front Range is somewhat limited. The study identified 35 municipal water providers across the Front Range who are potential candidates for participating in an ATM agreement. This number is not exhaustive, but it illustrates that the pool of potential users of ATM water supplies is small enough that each one could be contacted and analyzed for ATM opportunities.
- ***Are ATMs cost effective?*** Results of the financial analysis show that ATM water supplies can represent similar costs when compared against more traditional permanent water acquisition supplies. However, ATMs which are structured entirely as lease agreements, such as under a rotational fallowing program, were found to have higher costs over the long-term. Therefore, financial incentives may be required for municipalities to see the long-term financial benefit of ATM water supplies, as compared with permanent water acquisition options. Also, secondary factors beyond just the direct financial cost of a water supply, such as land use policies and rural economic concerns, might need to be considered to motivate the use of ATMs for municipalities.
- ***How can ATM costs be reduced?*** The higher long-term (or indefinite) costs associated with leased ATM water supplies might be one area for water leaders in Colorado to address in order to incentivize participation by municipalities in ATM projects. Reducing the cost of leased water supplies might be explored through a number of ideas, including:
  - direct subsidies,
  - creation of an institution (such as a water bank), to both reduce transaction costs and motivate participation by agricultural users by reducing lease terms, and/or,
  - development of shared infrastructure projects that could benefit water supply options or water exchanges.

  None of these ideas are considered silver bullets, but they might help lower the costs associated with ATM water supplies.
- ***Will reducing ATM costs be enough?*** Water supply risk is considered a significant roadblock to municipal acceptance of ATM supply sources. Potential cost savings—particularly in the short term—could encourage municipalities to explore the limited use of ATMs to fill some portion of their water supply portfolios. Over time, this may lead to a greater level of comfort with leased water supplies in the municipal sector. If ATMs are to be implemented, then the municipal water community will need to learn more about water leasing opportunities and alternative water supply options, in order to build a greater comfort level.

Financial Support: Project was completed in partnership with the Environmental Defense Fund.

One Opinion About ATMs

Alexandra Davis, Aurora Water

"Alternative Transfer Methods" (ATMs)[1], are aimed at enabling farmers to keep land available for agricultural production while temporarily moving their water to other users and uses. State and academic agencies, agricultural associations, utilities, NGOs, and individuals have poured resources, expertise, and time into defining the problem, understanding the obstacles and seeking technical, legal, and policy solutions. This work has been impressive, innovative, and successful in understanding and devising solutions to the myriad obstacles to leasing water quickly and affordably.

Despite the fact that cities and farmers regularly use temporary transfers to shore up supplies for augmentation and other water obligations, it has proven difficult to create a scalable leasing program to supplant "buy-and-dry". This is because we are trying to inject values into an allocation system that is not based on values.

The Prior Appropriation Doctrine is based on "1st in time, 1st in right". Generally there is no judgment regarding the value of the type of use to which senior rights are placed. In other words, the only determination of the seniority of the right are the adjudication and priority dates, not whether the use of the senior rights provides an appropriate value to society. When people want social values to drive financial or market decisions, either the allocation process needs to change or incentives/disincentives need to change.

The Values

Keeping water connected to farming is seen as a means to keep land in farming. Keeping land in farming protects concomitant rural communities, locally sourced food, food exports, reduced carbon footprints, food security, wildlife habitat and biodiversity, and agricultural and open landscape vistas.

Similarly, municipal water use supports our economy and livelihoods, sustains a high quality of life, and is critical to human health. Without water, there is no industry, including the industry that keeps most of us employed in professions

> Currently Aurora Water is pioneering a new program, The Cooperative Farm Purchase, wherein Aurora would financially assist new farmers acquiring farmland in exchange for conservation easements and the right to lease the water three out of 10 years.

outside of farming. Safe and readily available water for drinking, domestic use, food production, or recreation is critical to public health.[2] With a few notable exceptions, municipal water utilities provide clean, safe drinking water 24 hours a day, every day. The cost of not doing so can be enormous.[3] Thus, there are numerous benefits created by both keeping water in agriculture and in ensuring robust municipal water supplies.

Aurora Water has been at the forefront of seeking ways to access water and simultaneously support continued agriculture. In the Arkansas Basin, Aurora Water successfully leased water from farmers to recover from the 2002 drought. It also leases water to farmers to enable continued farming of land that would otherwise have been taken out of agriculture.

Currently, Aurora Water is pioneering a new program, The Cooperative Farm Purchase, wherein Aurora would finan-

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cially assist new farmers acquiring farmland in exchange for conservation easements and the right to lease the water three out of 10 years. Aurora is also very proud of its revegetation program in Rocky Ford, Colorado, whereby Aurora successfully revegetated about 6,000 previously irrigated acres with native grasses. This has returned the land to a healthy natural state and prevented an influx of invasive weeds (actions which meet some of the goals sought by ATMs). These actions and Aurora's continued commitment to the agricultural community grew out of a changing sense of values.

Similarly, motivating the changing values and the ATM work is the specter of losing that which we as a society care about (and need). Strong motivation can move many obstacles, yet there are two significant reasons why we may not get where the water community has said it would like to get:

- There are physical limitations.
- Our economic and water allocation systems are generally designed to allow the individual to make decisions about resource allocation; not the group. Thus, the decision-making is still made as a result of the needs of the individual entity (city, ditch company, or individual person).

The Physical Limitations

In the South Platte, there are a limited number of farmers who can benefit from ATMs. Theoretically, through an ATM, a farmer has water as his "crop" to sell in certain years, and can use the generated revenue to continue farming. However, in the South Platte area where significant farmland is at risk, many farmers actually lease the land they farm and the water they irrigate with. If the water they use is leased to a municipality, the farmer does not benefit from any lease revenue. Further, they may have to pay more for leasing the water as ATMs could increase competition for the water.

On the other side of the transaction, the pool of potential lessees is also limited. For example, the Environmental Defense Fund's (EDF) report titled *Alternative Water Transfers in Colorado Report* found that the pool of potential ATM [municipal] participants on the Front Range is likely limited to approximately 35 entities.[4] Finally, the Municipal uses for temporary water are limited to drought supply, drought

> Municipalities must have a permanent water supply for their base supply. A city utility cannot risk being unable to meet their citizens' basic needs, not in the least because that base supply is critical to health, welfare and the life of the city.

recovery, firming existing portfolios in average years, or filling short-term gaps. Municipalities must have a permanent water supply for their base supply. A city utility cannot risk being unable to meet their citizens' basic needs, not in the least because that base supply is critical to health, welfare, and the life of the city.

Economics and Decision-Making Structure

A number of entities have come to the conclusion that temporary supply mechanisms are more expensive than acquiring permanent supply. Most recently, EDF's report confirmed that while ATM water supplies can have similar costs to permanent water acquisition supplies, ATMs structured as lease agreements, such as rotational fallowing programs, had significantly higher costs over the long term.[5]

The financial equation for cities is that which makes prudent fiscal sense for their constituents. Cities are nonprofit entities spending taxpayer money. Therefore while some money, when properly supported by the City Council and city residents, may be spent on more abstract "public goods", expenditures generally must be focused on direct benefit to the city. So while some have suggested that municipalities should be willing to pay more for water because it means contributing to the identified public good, the idea of subsidizing public benefits often far from the city's boundaries can be a difficult proposition to sell to one's ratepayers.

On the other side of the transaction, individual farmers are guided in their decision making by what is best for them and their family. They may deeply support ATMs, but when their

Where the values of the community are at odd with the needs of the individual entities, our market system dictates that the needs of the individual generally prevails unless the "community" is willing to either pay for it or legislate a different outcome.

circumstances dictate a need to sell, they will sell.

Additionally, leases are inherently less certain than fee simple. While certainty can be addressed to some degree through long term leases providing more reliability to the lessee, some farmers are unwilling to enter into long-term leases because they want to keep their future options open. In fact, the inability to reach agreement on price has prevented a number of deals from coming to fruition, even after diligent work by Aurora and local farmers.

Where the values of the community are at odds with the needs of the individual entities, our market system dictates that the needs of the individual generally prevail unless the "community" is willing to either pay for it or legislate a different outcome.[6]

The economics inherent in implementing ATMs poses similar problems. The physical limitations in the ability to move ATM water and potential solutions have been explored in detail.[7] Solutions exist, but they are expensive. Farmers generally do not have the resources to pay for the necessary system improvements, and municipalities will have a hard time justifying the cost to their ratepayers if the end product results in only a temporary supply of water.

Further, solving the infrastructure challenge may inadvertently create a disincentive for temporary transfers, in that absent some artificial limitation on the use of the infrastructure, the ability to move more water upstream to cities will also facilitate "buy-and-dry" transfers. Not every water provider shares the values promoted by keeping water in agriculture. If temporary transfers remain the more expensive option, the unintended consequence may be to accelerate the sale of agricultural water by creating access to the water.

The good news is that ATMs create needed flexibility and options. They have demonstrated capability to meet some municipal, environmental, or industrial needs. The work done has also been successful in allowing new ways of water sharing to emerge.

The more difficult news is that agricultural land is being lost for a variety of economic and demographic reasons including:

- dramatic population growth,
- urbanization,
- technological efficiencies for farming, and
- increased opportunities in metropolitan areas.

Unless we change who pays the cost of keeping water connected to agriculture, or legislate a different result, the water needed to support the doubling of our population will likely come through permanent acquisition of agricultural water rights. However, this too, is a valuable use of water.

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[1] There are many variations on the 'ATM', but at the core, ATMs are leases, typically leases from farmers to cities, energy companies or environmental entities. Work on ATMs has looked at how to (1) create transferable supply without permanently drying up the land (e.g., fallowing, split season irrigation, deficit irrigation, and crop switching), (2) change the law to facilitate the temporary transfer (e.g., SWSP and IWSAs) and (3) create supportive legal entities (e.g., water banks).

[2] Contaminated drinking water transmits diseases such as cholera, salmonella, diarrhea, dysentery, hepatitis A and causes hundreds of thousands of deaths globally each year. http://www.who.int/mediacentre/factsheets/fs391/en/

[3] According to one estimate, the Flint MI water crisis exposed an estimated 8,000 children to lead and other toxins. The exposure could amount to almost $400 million in future costs to the city and thousands of cumulative years of poor health for those affected. time.com/4441471/flint-water-lead-poisoning-costs/

[4] Alternative Water Transfers in Colorado, Environmental Defense Fund November 2016 p.65

[5] Alternative Water Transfers in Colorado, Environmental Defense Fund November 2016 p.65

[6] There is significant merit to the idea that an "institutional" water bank operated by an independent party is key to advancing meaningful ATMs. A bank with the capability to ensure reliable water supplies for the lessees would thus reduce the risk of using temporary water sources for base uses. 6 Such a 'bank' could certainly answer many of the outstanding issues and seems likely to be the only way to really expand the limits discussed above. Aurora would be very supportive of the State providing significant leadership in creating a serious water bank.

[7] Completion Report: Development of Practical Alternative Agricultural Water Transfer Measures for Preservation of Colorado irrigated Agriculture, May 2011, Pages 2-13 to 2-15; C.R.S. 37-92-308

Benefits and Impacts of Partial Season Irrigation on Alfalfa Production

Perry Cabot, Colorado Water Institute, Joe Brummer and Sumit Gautam, Colorado State University

Water banking is a strategy to facilitate water sharing arrangements, whereupon water is "banked" in storage for later use. There is not currently a water bank in Colorado. That said, CRS Title 37 under "Water and Irrigation" (§37-80.5-104.5) contains provisions regarding the promulgation of "program rules necessary or convenient for the operation of a water bank within the division in which such district is located." The statute clearly limited a water bank to the use of the following: (1) stored water, (2) operation within Colorado water law, and (3) the transferred water be put to beneficial use.

The Colorado River Water Bank Work Group (CRWB-WG) supports a water bank approach for targeted locations on the Western Slope as part of demand management contingency planning to prevent Lake Powell from declining below minimum power levels. Guided water banking could prevent shortages under the Colorado River Compact or allow Colorado water users to weather regional shortages. A water banking approach would cooperate with agricultural and other water users to implement voluntary, interruptible supply agreements, making water available on a temporary basis.

The total amount of irrigated land and water supply on the West Slope that could occasionally sustain limited irrigation (and therefore potentially participate in water banking) has been assessed previously as part of the Colorado River Water Bank Phase I Feasibility Study (Natural Resources Consulting Engineers, 2012).

One aspect of this assessment suggested a focus on irrigated alfalfa (*Medicago sativa*) fields. Currently, more than 90,000 acres of such land exists in Colorado's portion of the Upper Colorado River basin. The focus on alfalfa is justified by the fact that this crop constitutes a large fraction of the

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Figure 1. Alfalfa evaluation field showing fully irrigated reference (REF) field (far left), stop irrigation after second cutting (SA2) field (center) and stop irrigation after first cutting (SA1) field (right) at the Western Colorado Research Center in Fruita, Colorado.

Table 1. Characteristics of CRWBWG Phase II-B and II-C Western Slope alfalfa study sites.

Location	County	Elev. (m)	Annual Precip. (mm)	Growing Season* (days)	Cuttings	Area (ha)	Dominant Soil	Irrigation
Fruita	Mesa	1,380	223	173	4	0.81	silty clay loam	furrow
Loma	Mesa	1,434	234	184	4	8.27	silt loam	furrow
Eckert (II-B)	Delta	1,697	318	166	3	3.48	loam	furrow
Eckert (II-C)	Delta	1,678	318	166	3	6.51	loam	furrow
Y. Jacket (II-B)	Montezuma	2,103	407	136	3	6.07	loam	sprinkler
Y. Jacket (II-C)	Montezuma	2,120	407	136	3	11.22	loam	sprinkler

* Growing season length estimated using the Western Regional Climate Center freeze-free (-2.2˚C) season probabilities.

agricultural water use on the West Slope. It is grown in concentrated regions of irrigated agriculture, and can withstand occasional limited irrigation in some areas without significant long-term effects.

Other studies have similarly evaluated alfalfa under irrigation curtailment regimes, whereby water applications were to be suspended by the first day of certain calendar months (Ottman et al., 1996; Hanson et al., 2007). Consistent with other studies (Orloff et al., 2005), a study conducted under Colorado River Water Bank Phase II-B and II-C imposed irrigation curtailment regimes congruent with the cutting dates chosen by the farmer. This study was supported by the CWCB-ATM Grant Program.

On-Farm Field Studies

This study was conducted at established alfalfa hayfields on the Western Slope of Colorado. Site selection criteria was heavily geared toward farmer willingness to engage in side-by-side plots irrigated for a full season as a reference (REF), along with two partial-season irrigation treatments.

The study was undertaken in two separate phases: the first in 2013-2015, and the second in 2015-2017. These timeframes corresponded to Phase II-B and Phase II-C of the CRWBWG project. Phase II-B and Phase II-C were located in regions of varying climate (Table 1).

The Fruita and Yellow Jacket sites were located at Colorado State University research centers. Each site produced three to four cuttings of hay each year. Gated pipe furrow irrigation systems were used at Fruita, Loma, and Eckert (II-B). Center pivot and sideroll sprinker systems were used at Yellow Jacket (II-B) and Yellow Jacket (II-C), respectively. Concrete lateral furrow irrigation with some gated pipe was used at Eckert (II-C).

In general, the irrigation regimes were defined by producer tendency towards risk, so not all regimes were identical across sites, although all study fields were divided into equal aliquots.

Phase II-B sites (Figure 1) received irrigation corresponding to a fully-irrigated reference (REF); irrigation stopped after the 1st cutting (SA1); and irrigation stopped after the 2nd cutting (SA2). The SA2 and SA1 regimes were considered "low-risk" and "high-risk." Treatments SA1 and SA2 continued for two years (2013-2014). Phase II-C sites were more contrasted, after conversations with farmers as to what approaches they would favor under a water leasing arrangement.

In Eckert (II-C), irrigation corresponded to REF control; irrigation stopped after the 2nd cutting (SA2); and waiting until after 1st cutting (WA1) to irrigate. Yellow Jacket (II-C) followed the SA1 and SA2 regime.

Fields in Loma had irrigation corresponded to REF control; irrigation stopped after the 2nd cutting (SA2); and irrigation stopped after the 3rd cutting (SA3). Treatments continued for two years (2015-2016). Plots were fully irrigated in 2015 and 2017.

Ten samples for yield and quality samples were collected prior to hay harvest at each site. Samples were hand-clipped at 7.5 cm to simulate approximate cutter-bar height. Plant material was dried in a forced-air oven at 55°C for 72 hours to evaluate yield in tons per acre. Samples from Phase II-B were homogenized further to determine neutral detergent fiber (aNDF), in vitro true digestibility (IVTD), and crude protein (CP) concentration for each treatment.

Forage Yields

Partial season irrigation treatments reduced plant growth and yields relative to the irrigated control. In the 1st cutting of year two, REF plot yields averaged 3,243 kg ha-1, while the "low-risk" and "high-risk" plots averaged 2,839 and 2,262 kg ha-1 after a single year of stress. These results are supported by previous reports (Carter and Sheaffer, 1983; Halim et al., 1990; Hattendorf et al., 1988; Lindenmayer, 2008; Peterson et al., 1992).

Alfalfa yields were largely positive once fields were returned to full irrigation after two seasons of partial-season irrigation. In the final year of recovery, average 1st cutting yield on REF, low-risk and high-risk plots was 1.0, 1.1, and 1.3 T/ac. Similarly, during the fully irrigated recovery year, average 2nd cutting yields on control, low-risk and high-risk plots was 1.2, 1.1, and 1.2 T/ac. Average third cutting yields on control, low-risk and high-risk plots was 1.0, 1.1, and 1.1

T/ac. The general trend was for alfalfa yields to improve in a fully-irrigated year of recovery after stress (Figure 1).

A minor exception of the low-risk 2nd cutting yield can be explained by a relatively low yield at the Yellow Jacket site in the recovery year on the low-risk plot. In a number of the evaluations, it was observed that some of the fields on which irrigation was curtailed showed improved yields once these fields were returned to full irrigation. This work supports the findings of others who reported yield recovery of alfalfa subjected to partial season water stress (Lindenmayer, 2008).

Extensive alfalfa tap roots are notable in their ability to tap deep soil moisture to maintain production under high levels of water stress (Hattendorf et al., 1988). Alfalfa has also been observed to react to water stress by accumulating total non-structural carbohydrates in plant roots (Ottman et al., 1996).

Average plot-relative yield changes from year 2 to year 3 on REF, low-risk and high-risk fields was 26.6%, 13.6%, and 27.8%, respectively, for the 1st cutting. A student's T-test identified the yield increases from the "low-risk" and "high risk" irrigation regimes as having a probability of 7.5% and 4.2% due to chance. In other words, a relatively significant probability exists that stopping irrigating after the 1st cutting can lead to yield increases during the year after stress. Slightly lower, but still significant probability exists that stopping after 2nd cutting is positive.

Forage Quality

Forage quality results are based only on the Phase II-B sites sampled in 2013 and 2014. Forage quality generally increased with partial-season irrigation treatments as indicated by reduced total fiber content. This content was measured by neutral detergent fiber (aNDF) and increased digestibility as measured by in vitro true digestibility (IVTD) (Tables 2 and 4).

Table 2. Neutral detergent fiber (aNDF) and crude protein (CP) concentrations of alfalfa from hayfields in western Colorado, under full and partial season irrigation treatments of stopping irrigation after the 2nd cutting and stopping irrigation after the 1st cutting.

	aNDF (%)	CP (%)
Treatment*		
Irrigated Control (REF)	33.9 a**	27.4 a
Stop after 2nd (SA2)	31.0 ab	26.6 a
Stop after 1st (SA1)	27.9 b	27.2 a
Cutting*		
1	29.9 b	27.0 a
2	33.8 a	23.9 b
3	29.1 b	25.8 b

* Means averaged over years 1 and 2 due to no interaction with year (P=0.2240 for aNDF and 0.2639 for CP).

** Means followed by the same letter within a column and variable are not significantly different at the P=0.15 level.

Generally, water stress and other factors that stunt plant growth result in higher quality forage, while factors that hasten growth result in reduced quality (Mueller and Orloff, 1994). In this study, quality tended to be lowest in the 2nd cutting, with increased aNDF and decreased IVTD. This was likely due to higher temperatures resulting in an increased rate of lignification (Putnam and Ottman, 2013). Increased growth observed in this cutting may have also contributed to reduced quality.

Neutral detergent fiber (aNDF) concentrations were lowest in SA1 plots and greatest in the control, ranging from 27.9 to 33.9%. Enhanced quality is likely due to delayed maturity resulting in a greater leaf-to-stem ratio and finer stems (Lindenmayer, 2008; Peterson et al., 1992). Our results also indicated a relationship between fiber content and cutting. When averaged over all treatments, aNDF was greatest in the 2nd cutting, with equally reduced concentrations of 15% in the 1st and 3rd cuttings.

Crude Protein (CP) evaluations exhibited an inconsistent response, by the year, by cutting interaction (P= 0.0288). In year 1 of the Phase II-B study, when averaged across all treatments, CP content was greatest in the 1st cutting. The 2nd and 3rd cuttings were similar with 13% and 15% lower CP contents, respectively.

Table 3. Interaction effect of year by cutting on crude protein (CP) content of alfalfa from hayfields in western Colorado.

	CP (%)	
Cutting	Year 1	Year 2
1	28.6 Aa*	25.6 Ba
2	24.4 Ab	23.3 Ab
3	24.8 Ab	26.8 Ba

* Means with the same lowercase letter within a year, or uppercase letter within a cutting do not differ significantly at the P = 0.15 level.

In year 2, the 2nd cutting generally had the lowest CP content with a value similar to the previous year. In year 2, CP content was 10% lower in the 1st cutting and 7% higher in the 3rd cutting resulting in similar values. Averaged over both years, CP was greatest in the 1st cutting (Table 3). Differing protein concentrations were likely due to plant maturity at harvest and environmental factors. No relationship between CP content and irrigation treatment was observed, as also has been reported (Carter and Sheaffer, 1983; Halim et al., 1989; Hanson et al., 2007; Vough and Marten, 1971), though this finding differs from othes (Walgenbach et al., 1981; Gifford and Jensen, 1967). Inconsistent results may be caused by differences in nitrogen fixation capabilities in plants (Carter and Sheaffer, 1983; Antolin et al., 1995).

In vitro true digestibility (IVTD) demonstrated a slight interaction between treatment and cutting (P = 0.1214),

Alfalfa is very resilient and adapted to water stress, but yields are significantly reduced during water stress periods.

Table 4. Interaction effect of irrigation treatment and cutting on in-vitro true digestibility (IVTD) of alfalfa from hayfields in western Colorado under full and partial season irrigation treatments of stopping irrigation after the 2nd cutting (SA2) and stopping irrigation after the 1st cutting (SA1).

	Treatment		
	Fully Irrigated	Stop after 2nd	Stop after 1st
Cutting 1	79.0^{*Aa**}	82.0^{Aa}	79.8^{Aa}
Cutting 2	74.3^{Bb}	74.4^{Bb}	80.4^{Aa}
Cutting 3	76.7^{Bab}	80.4^{Aa}	80.4^{Aa}

*Means averaged over years 1 and 2 due to no interaction with year (P=0.3906).

*Means followed by the same lowercase letter(s) in a column or uppercase letter(s) within a row do not differ significantly at the P = 0.15 level.

but generally increased with increasing water stress (Table 4). In the 1st cutting, irrigation treatments did not differ. By the 2nd cutting, SA1 plots were highest in digestibility averaging 6% greater than the control. By the 3rd cutting, the lowest digestibility occurred in the control with SA2 and SA1 plots being equally greater (5%). The control demonstrated the highest digestibility in the 1st cutting at 79% and lowest in the 2nd cutting at 74.3%.

Likewise, SA2 plots had the lowest digestibility in the 2nd cutting at 74.4%, with cuttings 1 and 3 being similar at an average of 81.2%. SA1 plots maintained similar values throughout all cuttings, averaging 79.2%. While response of alfalfa digestibility to water stress is inconsistent in the literature, our results are consistent with many previous reports (Snaydon, 1972; Vough and Marten, 1971).

Conclusions

Partial season irrigation of alfalfa appears to be a viable option for freeing up water to meet compact obligations, or for other uses. This is because alfalfa is very resilient and adapted to water stress. Yields are significantly reduced during the water stress period and producers will need to be fairly compensated for the water conserved.

Compensation could be based on the opportunity cost of lost production or other methods defined by the farmer. Current programs geared toward "system conservation" consider the preservation of return flows very seriously.

Stopping irrigation after the 2nd harvest is lower risk, but recovery and stand health in this study were excellent when irrigation was stopped after the 1st harvest. When all treatments were fully irrigated in year 3, partial season treatments yielded the same or more than the fully-irrigated reference field. Potential reasons for these increases include: reduced pressure from alfalfa stem nematodes, reduced disease pressure, and less weed competition (i.e. a healthier, more vigorous stand), which translates to higher plant density.

Stand longevity is as long or longer due to implementation of partial season irrigation. Also, there is potential for deeper root penetration and higher levels of nitrogen mineralization. Forage quality increases when plants are water stressed, suggesting the potential for quality incentives on cuttings with reduced yields.

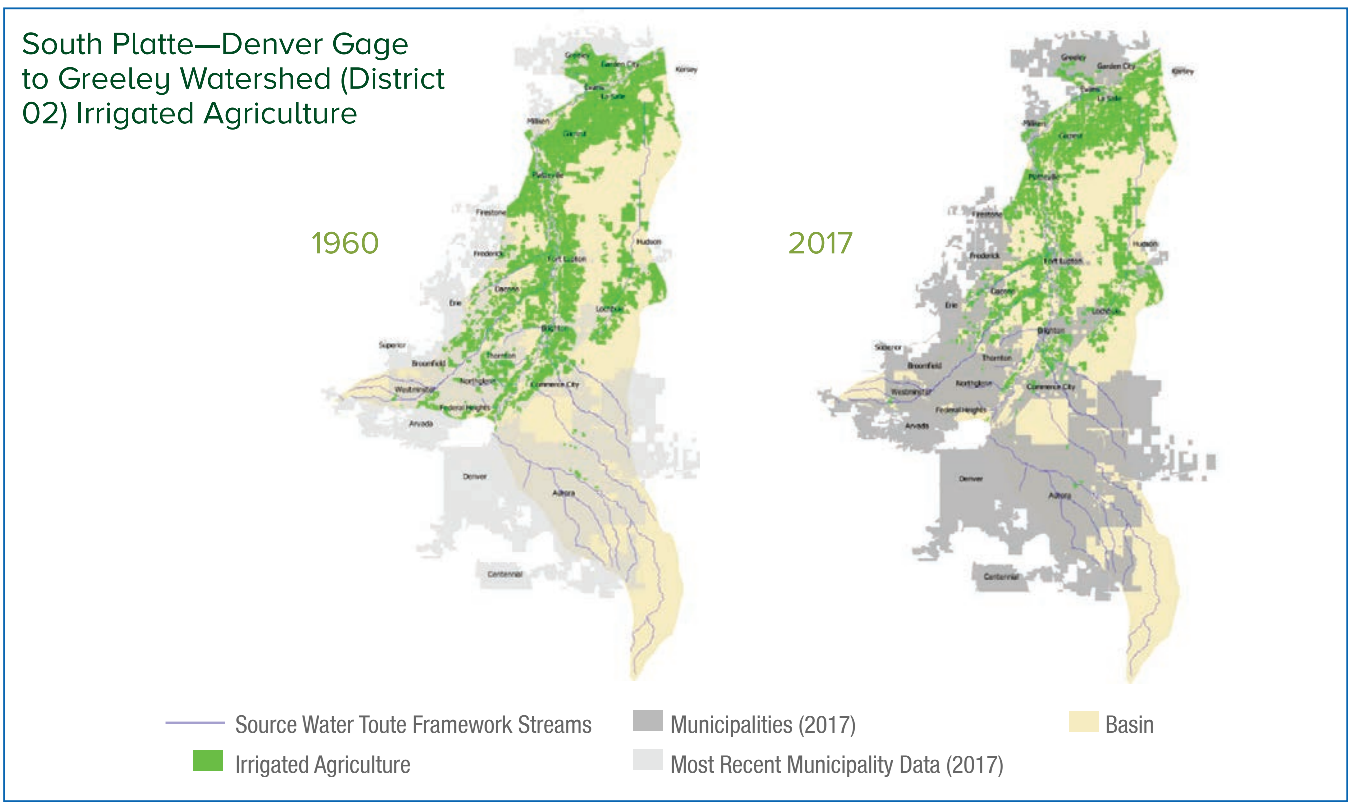
Agricultural-Municipal Water Agreements in Colorado

Moving from Concept to Implementation

Scott Lorenz, Colorado Springs Utilities
Todd Doherty, Western Water Partnerships, PBC

The Problem/Solution

With rapid population growth in the West, much of the future municipal and industrial water demands will be met through the reallocation of water from agricultural purposes. Traditionally, this has been accomplished through a practice called "buy-and-dry". This practice, while economically appealing to buyers and sellers, tends to have significant negative effects on the agricultural economy, rural communities, open space, and the water-dependent natural environment. No single strategy will solve the municipal and industrial water supply gaps in the western U.S. Therefore, market-based water sharing agreements between farmers and cities can and will be increasingly important into maximizing the efficient use of limited water resources, while protecting agricultural/municipal/environmental economies.



Open Water Foundation

Figure 1. Loss of irrigated farm land and urbanization in Water District 2, South Platte Basin (1960-2017).

Interruptible water supply agreements have significant potential to meet water supply needs of Colorado cities and towns while keeping water on farmland to sustain agriculture.

Interruptible Water Supply Agreements

While there are numerous variations of agricultural-municipal water sharing agreements, the focus of this paper is on interruptible water supply agreements (IWSAs). These have significant potential to meet water supply needs of Colorado cities and towns while keeping water on farmland to sustain agriculture.

IWSAs are arrangements between non-agricultural water users and farmers. Under these arrangements, water is transferred from agricultural use to another use, such as municipal or environmental. Irrigated lands are fully or partially fallowed during a specific period, and water is provided for a different use based on the historical consumptive use portion of the water right. IWSAs can be temporary or permanent in nature.

In Colorado, IWSAs may utilize state law, CRS 37-92-309, which provides for administrative approval by the State Engineer's Office for the fallowing of irrigated lands for three out of ten years, with the ability to renew for up to two additional ten-year periods and a total of 30 years. Since the IWSA statute limits the agreements to a maximum of 30 years, the value for municipal uses diminishes as cities cannot rely on this as a part of their permanent water supply portfolio. Since the IWSA was signed into law in 2003, no IWSAs have been approved by the State Engineer's Office[1].

Permanent IWSAs may utilize water court to add municipal uses to a water right so that it can alternate between the farm and the city's use. Impediments to this approach include the costs, time, and uncertainty associated with a water right change case. The benefit is that once decreed, the water right is legally available as a permanent component of a city's water supply and not subject to the uncertainty of annual administrative approval. While not perfect, water court is a tried-and-true system for the allocation of water in Colorado. It is a system, that when used correctly can, provide for both the permanency and flexibility needed to implement successful IWSAs.

Each Deal is Unique But Must Meet the Needs of All Parties Involved

An aspect of building a water sharing agreement that is both common sense, yet often overlooked, is that to be successful it must fundamentally meet the needs of all the parties involved. An agreement that favors one party over another may seem to be successful in the short run only to fall apart once the true costs and benefits are known.

Municipal Water Providers

IWSAs show significant promise in the medium to long term as a method to meet temporary demands that municipalities may experience, such as those required for drought response and risk reduction for possible system failures. Several questions need to be answered prior to acceptance of IWSAs as a viable water supply option for cities including the following:

- **Certainty of Supply.** Can lease IWSAs be structured in way that protects the time and money invested in setting them up with certainty that the water will be available for use by a municipality in the future?
- **Significance of Volume.** Can they be developed on a scale necessary to significantly affect the existing (or future) water supply gaps?
- **Economic Viability.** Can they be developed at a price point that works for all parties?
- **Roles.** What is the role for third parties?

Due to the scarcity of agricultural-municipal water agreements, the answers to these questions are not fully known. It is possible that there will be positive resolution of all four areas of concern, but failure to resolve any of them would make IWSAs an undesirable and unworkable water supply option.

The first two questions are largely technical and legal in nature. They will be answered (or not) based on the technical and legal acumen of proponents. The third, largely an economic question, will only be answered through the negotiating process. Unlike the markets for land and water purchases, the market for IWSAs is largely untested. Values will likely be derived from the alternative options that both farmers and municipalities have in relation to them.

This makes the ability to negotiate a fair price dependent on the presence of those alternatives. For cities, those alternatives may include traditional "buy and dry", other ATMs, or simply the ability to negotiate with several possible farmers.

Agricultural Producers

IWSAs also show significant promise for farmers to capitalize on their valuable assets while maintaining a productive agricultural operation. This aspect is often overlooked by those that seek to protect agricultural heritage and community without taking into consideration the wishes of farmers. Providing a market mechanism that offers farmers financial incentives to keep farming may offer a win-win situation for the farmer and the community that relies on the broader agricultural economy for survival. Several key considerations need to be addressed prior to acceptance of IWSAs as a viable tool for farm operations including:

- **Compensation.** What is the upfront payment versus dry-year payments? What if commodity prices go up?
- **Planning.** How soon will the city notify the farmer its intention of exercising its option?
- **Flexibility.** Does the farmer retain the ability to farm in years the city exercises dry-year option (dry-land crops)?
- **Certainty.** Are the agreement's terms sufficient to be used as collateral for equipment and/or farm operation loans?
- **Simplicity.** Is the agreement straightforward and easy to implement?
- **Transferability.** Can the farm and agreement be transferred if the farmer wants to sell to another farmer?

Providing a market mechanism that offers farmers financial incentives to keep farming may offer a win-win situation for the farmer and the community that relies on the broader agricultural economy for survival.

Conservation Easements or Other Land Preservation Mechanisms

The strategy of coupling conservation easements with IWSAs has been identified in the Colorado Water Plan and several Basin Implementation Plans as a promising means for assuring that the water stays on the farm while allowing for limited municipal use. The hurdles to implementation of this type of program include:

- Are there enough farmers willing to enter IWSAs to supply a significant volume of water
- Does the interplay between a conservation easement and an IWSA complicate an already difficult negotiation?
- Does the conservation easement offer benefits that could not be acquired through other, less complicated means (e.g. joint ownership, deed restrictions, long-term lease, 3rd-party ownership)?

These are questions that have not been answered fully; they need to be tested with real projects. Failure to answer them in a way that satisfies the farmer, the municipality, and the land trust will make them unworkable.

Third-Party Roles

IWSAs inherently involve multiple parties providing for opportunities for third-party roles. Entities including land trusts, local open space departments, social impact investors,

The strategy of coupling conservation easements with IWSAs has been identified in the Colorado Water Plan and several Basin Implementation Plans as a promising means for assuring that the water stays on the farm while allow for limited municipal use.

grantors and ATM facilitators can serve important functions to help facilitate IWSAs. These entities' roles could include:

- **Public Open Space Departments and Land Trusts**. Through conservation easements and other tools, these entities ensure that irrigated farm land will be preserved in perpetuity, therefore providing certainty of water supply for the cities.
- **Impact Investors.** These individuals can respond quickly, to provide the necessary capital to finance an IWSA. They can help promote socially and environmentally sound water solutions in the West, while achieving financial returns.
- **Grantors (Local, State, and Federal Agencies as well as Foundations).** Grantors can provide grants and low-interest loans to help lower the overall costs, making the IWSAs financially more attractive than buy-and-dry.
- **ATM Facilitator.** Entities that work with the cities, farmers, impact investors, and land trusts/open space departments to help develop the water sharing agreement and set up the administration of the IWSA.

Conclusion

While IWSAs will not completely prevent the loss of irrigated farmland due to agricultural to municipal water transfers, they are increasingly important tools for maximizing the efficient use of limited water resources, while protecting agricultural/municipal/environmental economies.

While the legal tools exist for both temporary and perpetual IWSAs, via administrative approval or water courts, the costs and complexities may deter parties from developing such agreements. By bringing in third-parties including grantors, impact investors, land trusts and others, the costs can be lowered to make IWSAs a financially attractive alternative to buy-and-dry. To be more widely adopted, a network of funding partners needs to be developed.

For IWSAs to be more broadly used, we need early adopters—innovators to prove the concept and the need to scale up (to include ditch companies versus single farmer participants). Once farmers and cities see that these agreements can help them meet their respective needs at a reduced cost, we believe they will be viewed as important tools for agricultural operations and water resources management.

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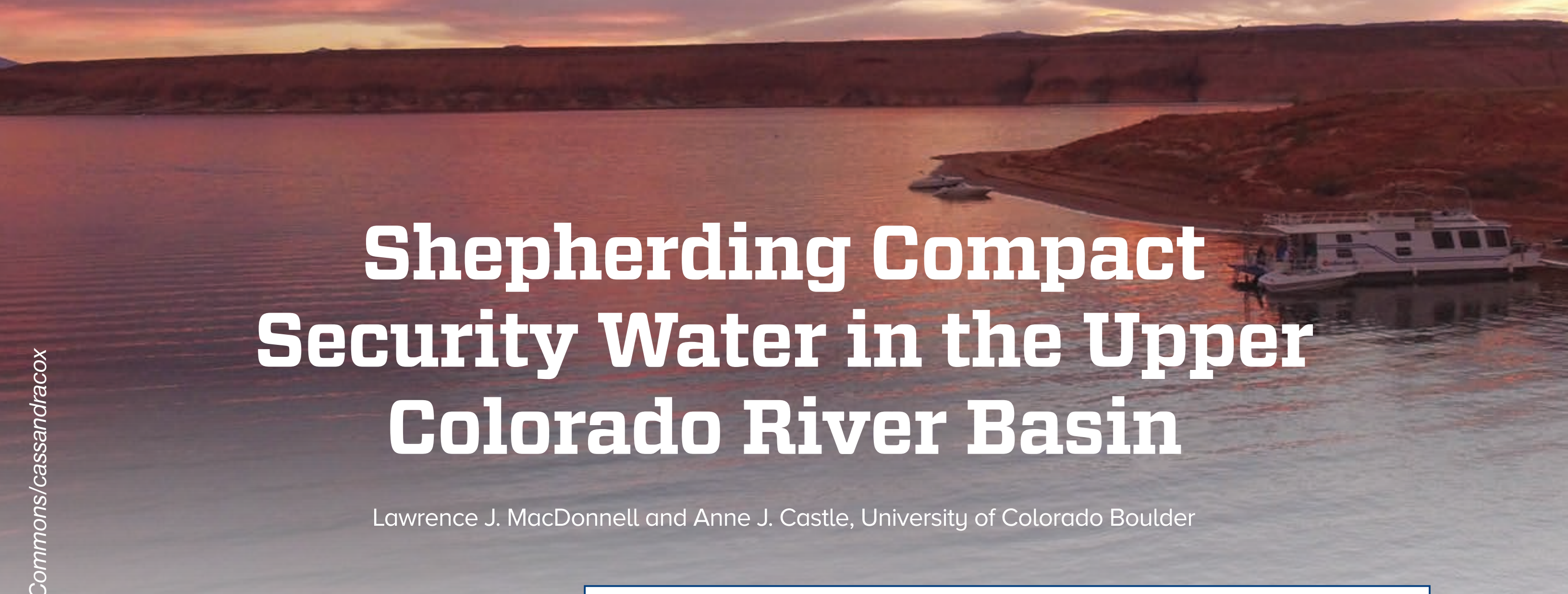
[1] In 2012, an IWSA application was submitted to the Colorado Division of Water Resources by the Lake Canal Company (Water Division One) but was withdrawn due to dry hydrologic conditions.



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Shepherding Compact Security Water in the Upper Colorado River Basin

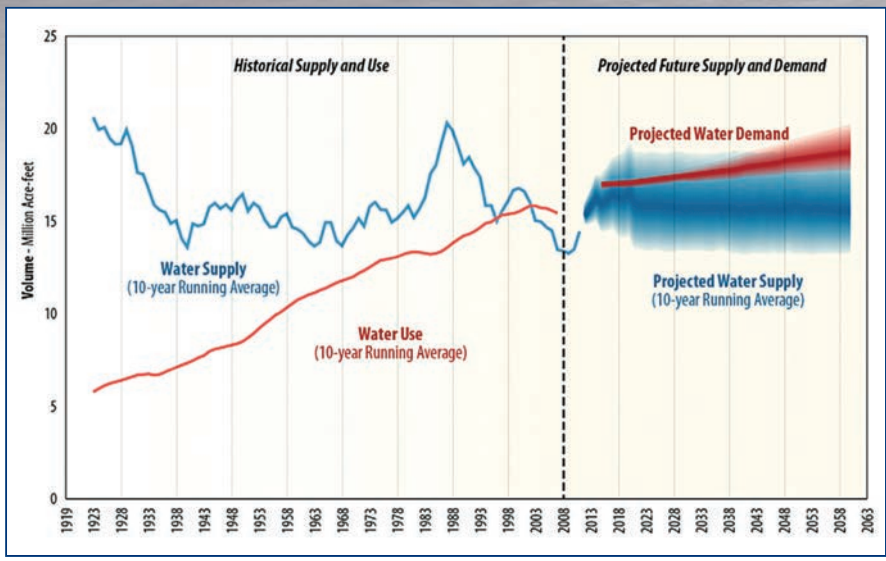
Lawrence J. MacDonnell and Anne J. Castle, University of Colorado Boulder

Moving water from its customary place of use to a new location, called shepherding, can raise difficult issues under Colorado law. It is particularly problematic when water is conserved under an existing right with the intent of providing the water at a downstream location. But the ability to shepherd conserved water could allow the State of Colorado to better prepare and protect itself against looming scarcity in the Colorado River Basin. It is a complex issue, tied up with deeply held beliefs about the nature of acceptable uses of water.

Background

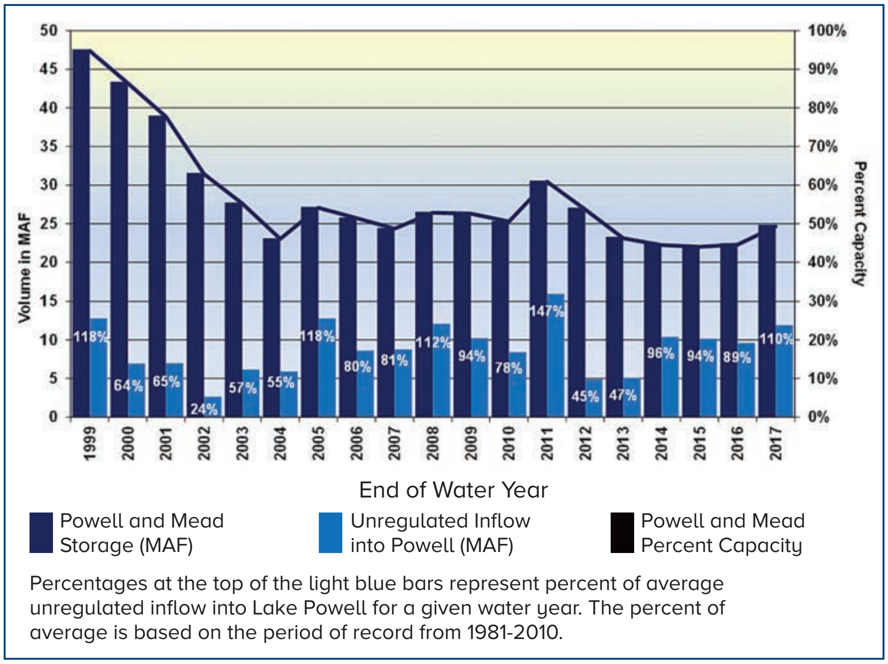
During most years, we now find ourselves using more water in the Colorado River Basin than nature provides (Figure 1). Long-term drought, beginning in 2000, has forced us to draw down storage water to make up the deficit, lowering storage levels in Lakes Mead and Powell. This increases the concerns about shortages in the Lower Basin states—and raises the risk that uses in the Upper Basin states may have to be curtailed. Figure 2 shows the effects of this hydrology on Mead and Powell storage between 1999-2017.

As illustrated in the graph in Figure 3, recent modeling indicates that a recurrence of the 2001-2006 hydrology could quickly drop storage levels in Lake Powell to dangerous levels.



Bureau of Reclamation

Figure 1. Historical supply and use and projected future Colorado River Basin water supply and demand.

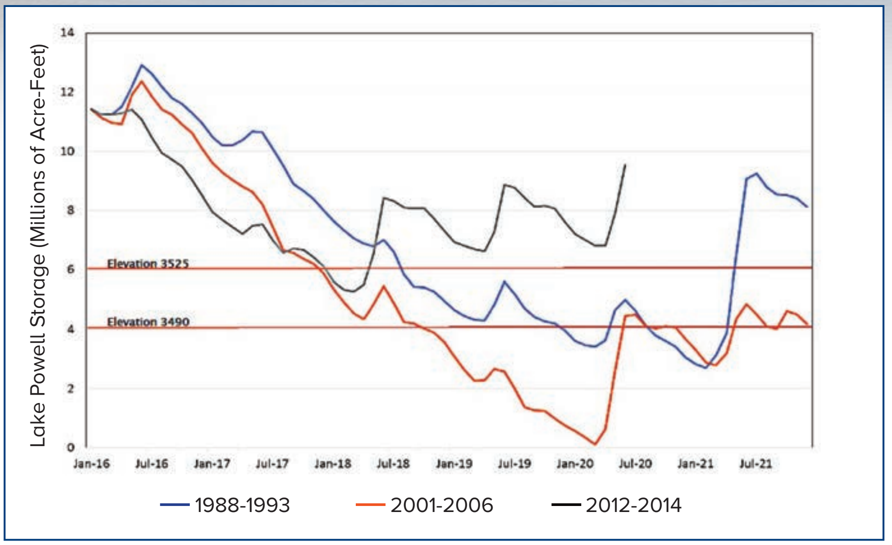


Bureau of Reclamation

Figure 2. Unregulated inflow into Lake Powell, Powell-Mead Storage, and percent capacity.

istock.com

Long-term drought has forced the draw down storage levels in Lake Mead.



Hydros Consulting

Figure 3. Recent droughts—Lake Powell drawdowns.

System Conservation Pilot Program

In response, the seven basin states worked with the Bureau of Reclamation to initiate Drought Contingency Planning. The goal was to provide protection against reaching critical water levels in both Lake Powell and Lake Mead.

As part of this planning, the System Conservation Pilot Program (SCPP) was instituted in 2014, with funding from Reclamation and four major municipal water suppliers, including Denver Water. The SCPP funds voluntary conservation in all seven states for the benefit of the overall Colorado River system.

All of the Upper Basin states—Colorado, New Mexico, Utah and Wyoming—have shown interest in supporting proactive, voluntary and compensated conservation that will shore up water levels in Lake Powell and reduce the risk that involuntary curtailment of water rights will be required to comply with the Colorado River Compact.

The pilot projects to date have proven that this type of program can work. The pilots in Colorado have focused on testing ways to conserve water historically used to irrigate crops, measuring the conserved water, and evaluating the effects on production.

What is Compact Security Water?

Under the 1922 Colorado River Compact, Colorado and the other Upper Basin states must not cause the depletion of Colorado River flows below that necessary to ensure that 75 million acre-feet of water passes Lee Ferry—the dividing line between the Upper and Lower Basins—during any consecutive ten-year period. Further, the 1948 Upper Colorado River Basin Compact provides for possible curtailment of existing water uses in the Upper Basin states if necessary to ensure this result.

Colorado, as the largest user of Upper Basin water, would have many of its Basin water uses subject to curtailment should Lee Ferry flows drop below the 75 million acre-foot mark. For this reason there is interest in creating a kind of savings account in Lake Powell using voluntarily conserved water to safeguard against the possibility of curtailment.

What's the Problem?

Water flowing in a stream generally is available for diversion and use by holders of water rights in the order of their priority. Under the SCPP, water historically diverted and consumed under an existing water right is being voluntarily left instream to be made available to the Colorado River "system." The SCPP envisions that this water will be stored in Lake Powell and other storage units of the Colorado River Storage Project Act (Aspinall, Flaming Gorge, and Navajo) and used as necessary to protect Upper Basin water uses. If instead the conserved water is diverted and used by others, it would amount to a windfall for those other users since this water otherwise would not have been available. It would also defeat the purpose of the SCPP for providing Compact security. This is why there is a need to "shepherd" this water without diminishment, into the Lake Powell savings account.

What Do We Need to Do?

How can we ensure that Compact Security Water can achieve its Compact security purposes? The following provides further insight:

- We need agreement as a state, that creating a Compact security savings account is a good idea.
- We need to identify water users who are willing to temporarily forego the use of a portion of the water available to them under their water rights, in exchange for compensation. The SCPP projects have demonstrated that interest exists, and that conserved consumptive use water can be made available from existing uses.
- We need to be able to move this water from its existing place of use to the state line and beyond, without diminishment by other water users. Either this conveyance must be possible under existing water rights, or some means must be found to legally protect Compact security water. One possible mechanism is the rule making authority of the State Engineer respecting Colorado's Compact commitments.

Legal Considerations

There are other legal challenges under Colorado water law to consider as well. Water users who agree to make water available will want assurance that there will be no adverse effects on their water rights if they allow temporary use for Compact security. Additionally, other water users in the area will demand that their uses are not harmed by this temporary change.

Historically, we have relied on change-of-use proceedings in water court to ensure that when a new use is made of an existing water right, there is no harm to other water users.

> While progress is being made in managing some existing water uses in the Lower Basin and Mexico, new uses are coming online in the Upper Basin.

Water court proceedings can, however, be lengthy and expensive—and can result in diminishment of the water right under consideration. This risk can discourage water right holders from allowing their water rights to go through water court proceedings. The alternative transfer methods currently available under Colorado law, or some new version of ATM, likely will provide a better means for handling temporary use of water for Compact security.

In addition, there are some uncertainties about how the use of water for Compact security fits under Colorado water law. Several aspects of this use are unusual:

- The use for Compact security is different than more traditional purposes such as irrigation.
- Unlike most Colorado water rights, there is no diversion until the water reaches its place of storage—likely in Utah.
- While the benefit is avoiding the need for curtailment of Colorado users, the water would actually be used to bolster storage in another state.
- The appropriator may not be the beneficiary of the water use.
- Finally, there are questions about how to ensure that water leaving Colorado for Compact security purposes can reach Lake Powell without being diverted and consumed by users in Utah or New Mexico. Other questions arise regarding how to manage the water once it reaches Lake Powell as well.

These are matters that will require agreement between the Upper Basin states and the Bureau of Reclamation, along with support from the Lower Basin states. There may well be a role for the Upper Colorado River Commission, established under the Upper Colorado River Basin Compact, as a coordinating entity.

Conclusion

Recent analyses have concluded that rising temperatures already are reducing the annual additions of water into the Upper Colorado River, further stressing the basin's out-of-balance water budget.

While progress is being made in managing some existing water uses in the Lower Basin and Mexico, new uses are coming online in the Upper Basin. In the face of these challenges, the Upper Basin—including Colorado—is pursuing proactive demand management strategies to ensure that existing uses are not curtailed. Alternative transfer methods can play an important role in providing the flexibility to be able to respond to short-term needs for additional water, without impairing existing uses.

Water made available through temporary arrangements must be transported (shepherded) to Lake Powell, without diminishment by other users—and then managed there for Compact security purposes.

As outlined in this article, the challenges are many, and will require coordination and agreement among multiple interests. The need for success is clear.

For more information on this subject, see Lawrence J. MacDonnell and Anne J. Castle, Shepherding Appropriated Water Within Colorado and to Lake Powell for Colorado River Compact Security, available online at https://www.colorado.edu/law/western-water-policy-program#overlay-context=research/gwc.

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Photo of Pearl Lake by Michael Kirsh.