

ADVANCING AGRICULTURAL WATER CONSERVATION IN COLORADO

Reagan Waskom¹
Troy Bauder²
Faith Sternlieb³
Julie Kallenberger⁴

ABSTRACT

Population growth and climate variability are increasing pressures on limited water resources, and extensive collaboration is needed to develop long-term working solutions to this complex issue. Agriculture consumes an estimated 90 percent of available water resources in the western U.S., and future water needs for an expanding urban population will likely come from agriculture. Therefore, it is increasingly urgent for farmers, water managers, extension agents, and policy-makers to understand agricultural water conservation methodology, technology, and policy to make informed management decisions. Reliable information on the subject is often not readily available to water users, especially outside of the academic and government communities. The USDA-NIFA Northern Plains and Mountains Regional Water Team (NPM) has addressed the need for increased knowledge, understanding and adoption of agricultural water conservation through an innovative web-based project. The Agricultural Water Conservation Clearinghouse (AWCC) (www.agwaterconservation.colostate.edu) seeks to join communities of practice to collaboratively address the complex issues of agricultural water use. The AWCC is designed as a comprehensive resource for the latest news, research, literature and tools related to agricultural water conservation. The focal point of the AWCC is a library that contains references to published materials populated by Extension specialists, research scientists, and educators, providing a refined bibliographic review of agriculture water conservation grey literature. The Library encompass over 3,600 entries of refereed journal articles, books, reports, theses and dissertations, and conference proceedings. The AWCC has been searched by over 21,000 users since it was unveiled in 2008 and participation continues to grow.

INTRODUCTION

Agricultural water conservation is complicated by a number of physical, legal, institutional and economic factors, while the forces applying pressure on agricultural water use are acute. Notable among these pressures are increasing competition for water resources due to population growth and resulting impetus to transfer agricultural water to other uses, while at the same time sustaining or increasing agricultural output.

¹ Director, Colorado Water Institute, 1033 Campus Delivery, Ft. Collins, CO 80523-1033; reagan.waskom@colostate.edu

² Extension Specialist, Colorado State University, 1170 Campus Delivery, Ft. Collins, CO 80523-1033; troy.bauder@colostate.edu

³ Research Associate, Colorado Water Institute, 1033 Campus Delivery, Ft. Collins, CO 80523-1033; faith.sternlieb@colostate.edu

⁴ Research Associate, Colorado Water Institute, 1033 Campus Delivery, Ft. Collins, CO 80523-1033; julie.kallenberger@colostate.edu

Additionally, the need for water for wildlife habitat, recreation, energy production and other uses continue to increase. Today, competition for limited water supplies is a continual theme in the semi-arid and arid West, and it recurs whenever drought persists in the wetter regions of the United States (U.S.).

A number of factors constrain how agricultural producers manage their water supplies including availability, timing, quantity and quality of water, water rights administration, crop needs, precipitation patterns, irrigation equipment performance, labor, production costs and anticipated returns. Agricultural water conservation is a highly complex issue that is often mistakenly simplified in the public discussion and at the policy level. The complexity of agricultural water conservation is further influenced by:

- state laws which limit incentives for agricultural water conservation;
- variability and inconsistency of policies from state to state, despite water resources transcending political boundaries;
- research that has far surpassed application by many irrigators;
- financial barriers and lack of recognizable incentive to irrigators for conservation;
- cumulative basin-scale impacts and the downstream dependency on return flows;
- individual producer debt/equity ratio and risk management strategies;
- limitations imposed by inefficient irrigation equipment and water delivery infrastructure; and
- current approaches to ditch and reservoir system management and administration.

The World Economic Forum predicts that percentage change in demand for water between 2000 and 2030 for industrial and domestic use will crowd out any growth in agricultural water use (WEF 2009). Water demands from urban growth, increases in reservoir evaporation, and increases in crop consumptive use must be accommodated by timely improvements in agricultural water delivery, management practices, and technology (Strzepeck et al. 1999).

Because agriculture accounts for over 70 percent of the water used consumptively in the U.S., the public, some natural resource regulatory agencies, and policy makers have started to place an increasing focus on the notion of agricultural water conservation as a partial solution to existing water shortages or those being forecast as a consequence of climate change predictions, over-appropriate and use of existing water resources, and growing and shifting populations throughout the U.S. Yet, in light of growing emphasis on water conservation, it is estimated that present agricultural water shortages have cost the U.S. agricultural sector \$4 billion a year for the past two years (WEF 2009).

Agriculture Water Conservation in Colorado

According to the 2007 USDA Ag Census, slightly less than half (48 percent) of Colorado's three million irrigated acres have been converted to sprinkler or drip systems. In particular, irrigators who rely on deep or declining groundwater already have significant incentive for water conservation. Many Colorado farmers have switched to irrigation systems with enhancements such as drop nozzles, low-pressure delivery

systems, irrigation scheduling, soil moisture monitoring, minimum tillage, and other techniques to improve on-farm efficiency and reduce pumping requirements (Barta et al., 2004).

However, in Colorado a relatively complex set of laws, regulations, and customs pertaining to the use and transfer of water rights has evolved over the past 150 years. In particular, this body of law leads to the orderly allocation and administration of water rights when surface flows are inadequate to satisfy demand.

Under Colorado water law, water rights can be changed in the type, place, or timing of use as long as the change does not adversely affect other vested water rights, whether absolute or conditional. Put another way, appropriators are entitled to the continuation of stream conditions at the time of their appropriation—including return flows from upstream water users. The doctrine of prior appropriation recognizes a right of junior appropriators "in the continuation of stream conditions as they existed at the time of their respective appropriations" (*Farmers High Line Canal & Reservoir Co. v. City of Golden*). The "No Harm Rule" provides protection to water right holders from injury when a water right is changed in Water Court (DiNatale et al., 2008).

Increasing the efficiency of irrigation water use under a valid water right does not require a formal change of use proceeding. For example, an agricultural user may increase efficiencies by improving water delivery (e.g., lining ditches, pipelines, or polyacrylamides) or by on-farm applications (e.g., sprinklers, drip systems), yet still maintain the overall decreed use of irrigation on the same lands. Water conserved within a given ditch system may in some cases be used within that ditch system. There are potential legal issues with the irrigation company conserving water and then giving or selling that water permanently outside of the system. Although such activities do not require a change of use proceeding in water court, these types of improvements could have detrimental impacts on other water users to the extent that the change alters return flows and/or increases the consumptive use. With no formal change case involved, legal mechanisms to protect downstream water rights and interstate compacts are limited. If irrigation conservation and efficiency measures are to be promoted on a broad scale, then consideration should be given to the substantial effects this might cause, including reduced water available to water right holders and interstate compacts.

Ensuring the continuation of historical return flow patterns to protect downstream juniors is possibly the largest hurdle to overcome when dealing with agricultural water conservation. To illustrate the complexities involved, the Colorado Water Division II Engineer's Office has recently promulgated rules and regulations for agricultural water users in the Arkansas River Basin to ensure that irrigators converting to higher efficiency systems do not adversely affect return flow patterns and increase consumptive use, thereby affecting the state's ability to meet its compact obligations with Kansas (Colorado Division of Water Resources, 2011). While Colorado water law allows the conversion of irrigation systems to more efficient ones (i.e., flood to sprinkler systems) without a formal change proceeding in the water courts, the promulgation of these rules is a recognition that these actions can have negative effects on return flows and those relying

upon them.

In addition to impacting downstream water right holders, implementing agricultural water conservation measures may have other significant effects. For instance, flood irrigation and seepage through earthen ditches and canals provide for significant aquifer recharge. In certain cases, domestic and irrigation wells have been impacted when groundwater recharge from historical irrigation practices was not maintained.

Increased agricultural water conservation could potentially result in a voluntary reduction in the diversion of water to the farm, creating benefits such as improved water quality, allowing water to remain in the streams, and reducing energy costs for pumping, but may not result in water that can be legally transferred to other uses. If water conservation measures can improve water supply availability without causing injury to downstream users or the environment, then the result may be increased water supplies for agriculture and other uses.

When evaluating agricultural water conservation improvements, it is important to distinguish between practices that lead to improved application efficiency and those that lead to reduced consumptive use. Water use efficiency is defined as the ratio of water applied compared to water consumed by crop (i.e., ET). Increasing efficiency is likely to reduce losses from deep percolation and runoff (thereby altering historical return flow patterns), but it may or may not materially affect the amount of water consumed by the plant. Much of the water lost to these inefficiencies will return to the river or groundwater system for use by downstream diverters. For this reason, the administrative practice in Colorado is that water saved due to improved efficiency is not available for additional irrigated lands or other expanded uses.

Salvaged and Saved Water in Colorado

Two concepts related to water conservation have emerged from Colorado case law: salvaged water and saved water.

- Salvaged Water is generally viewed as water that results from reducing nonproductive consumptive use of water, such as by the cutting or removal of phreatophytes.
- Saved Water is generally viewed as water that results from more efficient diversion and application methods.

In 1974, the Colorado Supreme Court in *Southeastern Colo. Water Conservancy Dist. v. Shelton Farms* (1974) ruled that water salvaged by the removal of phreatophytes ("water-loving" plants such as tamarisk and cottonwoods) belongs to the river system and is subject to administration in order of priority. Water salvaged by reducing evaporation or cutting vegetation does not belong to the person responsible for the salvage and cannot result in a new water right, free of the river's call. The Court in *Shelton Farms* stated that while landowners are prohibited from claiming water rights by cutting down phreatophytes, there is a need for the Legislature to address and clarify the issues of saved and salvaged water.

Over the last two decades, there have been attempts in Colorado to create legislation that would provide the right to sell, transfer, and/or reuse water resulting from salvaged, saved, or conserved concepts. An attempt was made to address the issue of "saved" water in 1991 when HB 91-1110 was introduced as a bill allowing the sale, transfer, or reuse of "saved water" as long as it caused no injury to any downstream water right holders. This bill was not successful. Discussions regarding new state legislation on this topic since that time have gained insufficient traction to even result in proposed legislation.

Nonetheless, agricultural water conservation measures have been implemented in a number of specific situations in Colorado. A few examples include:

- The federally funded salinity management program on the West Slope where water conservation measures, improved irrigation, and canal lining were implemented to reduce salinity mobilization due to deep percolation.
- In 2005 and 2006 some San Luis Valley irrigators voluntarily shut off end guns on their center pivots to reduce ground water withdrawals by an estimated 8 percent.
- Some Colorado growers on the High Plains Aquifer where groundwater levels are declining have adopted cropping patterns that include splitting pivot circles acreage of cool season crops such as wheat or lower water use crops such as sunflowers.
- Also on the Eastern Plains, the combined use of deficit irrigation practices and conservation tillage practices have been employed where well capacity cannot meet ET.
- In the Arkansas Valley, to address impacts of a large Ag to urban water transfer, drip irrigation and new crops were cost-shared by a large municipality to take advantage of reduced ET and specifically, reduced evaporative losses.
- In the South Platte Basin, center pivot irrigation has been widely adopted in recent years to achieve labor savings, but has also resulted in increased irrigation application uniformity and efficiency and changed return flow patterns.
- During the 2002 drought in the South Platte Basin, agricultural users implemented higher levels of irrigation management including reduced set times to minimize runoff and deep percolation in order to meet crop needs under significantly reduced surface water supplies.
- The Grand Valley Water Management Plan was implemented to improve canal hydraulics, which will reduce the need to maintain full canal head to make deliveries to canal users.
- Polyacrylamide (PAM) applications to irrigation canals and ditches on the West Slope and in the Arkansas Valley have shown a 25 percent decrease in seepage losses, while providing sufficient water for the maintenance of riparian plants, e.g., cottonwoods.

Agricultural Water Technology

Sustainable agricultural water conservation technologies and practices are not always the cheapest or the least technically complex. In addition, the impact of agricultural water conservation at the river basin scale can be either beneficial or detrimental to the

environment, particularly if irrigated acreage is expanded or consumptive use of water by agriculture is increased. Despite these complexities, the future of U.S. food security and agricultural water security are tightly linked to and dependent to some degree on our ability to use water more efficiently to produce food, fiber, and bioenergy. However, as noted by other authors, the push for more crop per drop may indeed result in more crops, but no additional drops (Burt, 2011).

There is no shortage of information about agricultural water management and technologies available to irrigators and the public. However, published information and research results are scattered throughout an array of sources that are often hard to locate or reconcile. Moreover, the technical language in which most of the research articles and bulletins are published may be a limitation for some audiences seeking information about agricultural water conservation. Hence, there is a great need to compile and make accessible the array of technical information, tools, and water expertise for these audiences.

The Agricultural Water Conservation Clearinghouse Project

To help address the need for better information and understanding of agricultural water conservation, the Northern Plains and Mountains Regional Water Program funded by the USDA National Institute for Food and Agriculture (USDA-NIFA) National Water Program developed the Agricultural Water Conservation Clearinghouse (AWCC) (www.agwaterconservation.colostate.edu). The AWCC (Figure 1) has been instrumental in building partnerships within the academic community. Colorado State University (CSU) Libraries has provided support for the library feature, while the Agricultural Network Information Center (AgNIC) has increased the visibility necessary to build a resource information network for irrigators, agricultural producers, and water resource managers.



Figure 1. The Agricultural Water Conservation Clearinghouse (www.agwaterconservation.colostate.edu)

The AWCC is a comprehensive repository of information and resources with a central focus on agricultural water management and conservation. Our vision is to develop a globally recognized information source and community of practice consisting of technical experts and researchers who will collaboratively address the complex issues of agricultural water conservation and water security. The mission of the AWCC is to create a comprehensive, one-stop-shop information resource system on agricultural water conservation by accomplishing two goals: 1) building linkages between water agency partners and experts to share information, research, and outreach activities; and 2) providing the agricultural water community tools and resources to assist them in coping with water management in a changing climate.

Currently, policies applied to saved, conserved, produced, or developed water vary greatly from state to state. Collective and coordinated watershed-scale approaches to managing any conserved water can only enhance national water security. The AWCC has created an online meeting place, where individuals can express ideas, facts, and opinions and where discourse about solutions to agricultural water conservation challenges will open a dialogue between experts, decision makers, and stakeholders. The AWCC supports the development of teams of experts who will be instrumental in discovering information gaps in both technical literature and educational curriculum.

Building partnerships between researchers, educators, practitioners, and industry experts can be instrumental in helping agricultural water users learn about new technologies and how to implement them. These partnerships foster a community of practice that enables communication between different interest groups to share common concerns about

agricultural water management and conservation. Connecting water users to the manufacturers of water technologies enhances the possibility of adopting and implementing agricultural water conservation practices in the field, thereby improving farmers' abilities to remain financially solvent and profitable, while at the same time dealing with short and long-term water scarce circumstances. Such exchange and dialogue furthers the formulation of well-thought-out standards for best management practices in agricultural water conservation. This leads to improved data sharing and a better understanding of agricultural water policy implications on basin scale hydrology.

The AWCC is in the form of an interactive website, featuring a searchable library database, an agricultural water expert directory, Frequently Asked Questions (FAQs), and fact sheets. The AWCC Library (Figure 2) is a comprehensive database which identifies current research and educational outreach publications regarding agricultural water policy, agricultural water recovery and recycling, resource economics, crop water use, cropping systems, drought tolerance, irrigation management and systems, irrigation water conveyance and delivery, phreatophyte management, utilization of marginal water, and water supply, sources and storage. The searchable library database hosts bibliographic records of refereed journal articles, books, reports, theses/dissertations, conference proceedings, and fact sheets and bulletins.

AGRICULTURAL WATER CONSERVATION CLEARINGHOUSE

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Figure 2. The Agricultural Conservation Clearinghouse Library

The Library is populated by contributions from Extension specialists, research scientists, and educators and provides a refined bibliographic review of agriculture water conservation grey literature. Grey literature refers to materials that cannot be found easily through conventional channels such as publishers, however is frequently original and usually recent. Examples of grey literature include technical reports from government agencies or scientific research groups, working papers from research groups or committees, white papers, or preprints. The term grey literature is often, but not exclusively, used for scientific reports.

The AWCC Library contains over 3,000 entries and the website has been searched by over 21,000 users since it was unveiled in 2008. Request for feedback from users helps strengthen the resource system and expand the network of water resource practitioners from local, state, regional, and national organizations instrumental in providing solutions for water management challenges now and in the future.

In addition, the AWCC website provides current links and contact information to federal and state Agricultural Experiment Stations and Land-Grant Universities, as well as up-to-date information on agricultural water related research centers, irrigation management curricula, workshops, conferences, irrigation tools, software, manuals, guides, calculators, and irrigation schedulers. It also features upcoming events and news related to agricultural water conservation at a regional and national scale.

The AWCC project expands outreach and education efforts by initiating virtual online communities of interest for 1) policy-makers and administrators, 2) agricultural producers, 3) water educators and practitioners, and 4) research scientists. Online forums enable ongoing dialogue about alternatives and the effects of agricultural water policy, and the impacts of basin scale agricultural water conservation. Additionally, online forums foster and promote interaction between the community of practice and communities of interest.

Partnerships are crucial to the success of the AWCC. Besides the collaborating entities, the NPM Regional Water Team has built relationships with the Central Plains Irrigation Association and the U.S. Committee on Irrigation and Drainage Association. A primary outcome of these partnerships is greatly increased access to grey literature published through these organizations. These include proceedings of regional and national conferences and special reports on topics concerning irrigation water management. Until recently, much of this literature has only been available in hard copy and would not be available from traditional library or web searches.

The NPM Regional Water Team has also focused on increasing the knowledge level of private consultants and agency personnel that influence decision making by growers in the NPM Region and around the U.S. To accomplish this, we have published a series of on-line, self-study modules for the professional Certified Crop Adviser (CCA) recertification and proficiency program. Using a pilot survey of CCA Boards in the NPM Region, the NPM Regional Water Team focused the modules on water conservation under limited irrigation and irrigation water quality. The modules were developed

through collaboration with research scientists, university faculty from throughout the region, and from neighboring regions. Since the fall of 2009, over 50 Certified Crop Advisers have demonstrated knowledge of limited irrigation and irrigation water quality by correctly answering 70 percent of the questions built into the modules. Over seventy five percent of CCA's completing post module surveys indicated that they would utilize knowledge gained from the series while advising their farmer clients.

CONCLUSION

The outcomes of this project have provided benefits to agricultural water users, natural resource management agencies, policy-makers, the general public, and the industries supporting agricultural water users attempting to address the increasing complexity of agricultural water conservation. While better and more accessible information alone cannot bring the institutional and policy gaps we face in Colorado and other parts of the West, it can help inform the policy discussion as it occurs. The AWCC currently serves the following functions:

- Creates a venue for sharing of information regarding agricultural water conservation; advances awareness about and increasing access to new technologies and best management practices; offers a platform which unites researchers, administrators and policy-makers, practitioners, and educator communities with a commonality of focus of addressing the complexities of agricultural water conservation in the future.
- Provides targeted audiences current information about pressing and complex agricultural water conservation and security challenges, helping them to make more informed decisions and to accurately communicate information about agricultural water use and conservation.
- Identifies gaps in current research, education, and outreach related to agricultural water conservation, thereby helping U.S. federal, state, and local natural resource management and policy-making agencies to better target programs to improve water and food security.
- Informs technical experts, support industries, and educators of the latest agricultural water research and technology, allowing them to better inform their clientele.
- Links industry with the research and education communities.
- Links educators to scientists and technical experts to resource materials.
- Helps agricultural water users make better-informed decisions about their cropping systems.
- Enhances resources and information available through eXtension by expanding virtual and live networks to provide extended outreach.
- Provides support and assistance to policy makers by linking them to experts and current research, as well as to the USDA-NIFA National and Regional Water Programs.

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