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Highlights

In Every Issue

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Editorial

by Reagan Waskom, Director, Colorado Water Institute

Colorado's newly drafted Water Plan outlines a path forward to accommodate coming growth. The State Demographer tells us to plan on another five million Colorado residents within the next 40 years, with the Front Range sustaining most of the growth. The water needs of the next five million people cannot be accommodated with the practices that supplied the first five million, and of course this is also true for energy, food, transportation, and other growth-related resource demands.

For most of Colorado's history as a state, we have met our water needs by expanding supply. Though ditches, reservoirs, tunnels, pipes, and treatment plants, water was moved to where humans wanted it. In recent decades, we have reached and realized the limits of Colorado's water supply and now, we are living in an era of limits and redistribution. Since most of the water diverted in Colorado is currently used to grow food, without planned interventions, the path we are on will dry up vast areas of irrigated agriculture on both sides of the continental divide. Water-based environmental and recreational amenities at the heart of the Colorado lifestyle will also be jeopardized unless a changed growth ethic emerges. Future solutions lie in managing water demand through changing the way we grow our urban and suburban areas, increasing efficiency in water use and infrastructure, and devising new water trading solutions and markets. In some cases, additional water storage and distribution infrastructure will be a needed part of the solution.

Rather than view this future with pessimism, we should envision the opportunity to build more livable and sustainable urban spaces in Colorado, with less sprawl, traffic, and pollution and smaller energy, land, and water footprints. Better connecting land use and development to water planning is one obvious aspect of this future, but we still have a way to go in this regard. Currently, nearly half of our municipal water goes to outdoor landscapes, including parks, medians, and other public spaces. These landscapes are important to our quality of life and provide value and cooling to our homes. Research has shown we can derive much of this value with a significantly smaller water footprint using water conservation and improved landscaping techniques. Additionally, emerging Millennials and aging Baby Boomers seem more interested in smaller lots with less lawn care, likely steering future development in new directions.

The Colorado Water Plan uses the Statewide Water Supply Initiative (SWSI) calculation for future municipal water demand, which is determined by multiplying current per person water use by the number of new people minus a conservation factor plus a climate change increment. Yet cities like Albuquerque, Seattle, Phoenix, and San Diego have experienced significant population growth in the past two decades with relatively little increase in treated water supply. Across the U.S., there are many examples of successful water use efficiency programs. The recent 2014 USGS Circular 1405 shows that public water supply in the U.S. actually decreased by five percent from 2005 to 2010.

We can and eventually will grow water smart in Colorado. The question is how to make this happen sooner as we plan for our water future. Looking beyond the borders of Colorado for inspiration and solutions can help. State mandated per capita limits on water consumption are not considered a desirable control mechanism as per capita demands vary considerably across space and time. However, there are numerous examples of municipal planning ordinances for model water conservation programs and growth planning that we can look to. It is also critical that we plan for episodic multi-year drought as a separate phenomenon from growth and water conservation goals. More transparent and active water markets and institutional mechanisms that create flexibility in moving water among uses will also be important to meeting the water supply gap. This issue of the *Colorado Water* newsletter offers analysis of some of the methods and approaches for better connecting urban growth and water supply planning.

Addressing the Water and Growth Dilemma in Colorado

Todd Bryan, Senior Program Manager, CDR Associates

The Colorado Water and Growth Dialogue aims to redirect the issue of water and growth from the question of where to find water for future growth to the question of how we can make better decisions by understanding the consequences of land use decisions. A dialogue framework was developed, with the goal to identify strategies and actions for water and growth on the Front Range with the help of several collaborators.

Colorado Water and Growth Summit at REI store in Denver (July 2012). Courtesy of Todd Bryan

Like many curious and insecure researchers, I Googled the title of an article I had published to see if it was being referenced by others. The article, *Tragedy Averted: The Promise of Collaboration* (Bryan 2004), makes a case for the unique role that collaboration can play in fostering shared ownership of the paradoxical challenges we face in complex societies.

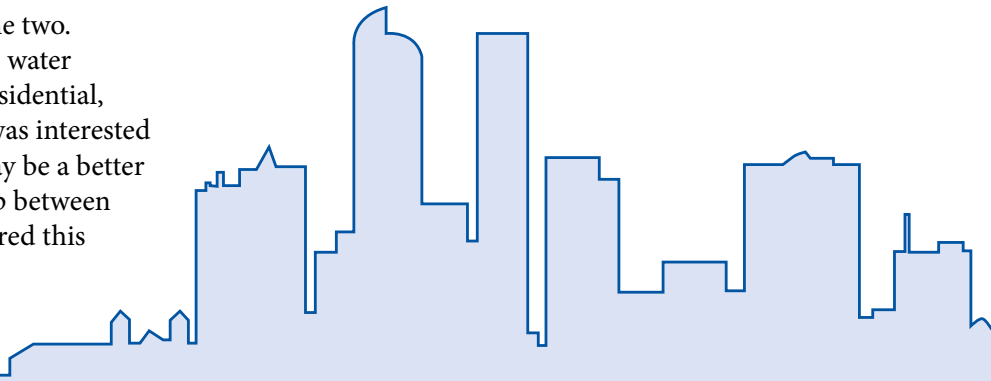
This was not the first time I searched for an article online, but it was the first time I followed up with the person who referenced it. She was a fellow Coloradan and worked in the water sector—MaryLou Smith, CWI's Policy and Collaboration specialist, used the article in workshops and writings with CWI and was quite good at articulating the paradoxical challenges surrounding water in Colorado and the West, and the role that collaboration can play in managing the paradoxes. One of those paradoxes involves the dilemma between water and growth.

I have a keen interest in the interface between seemingly related but often disconnected things and the bridging elements that can provide linkages. At the University of Wisconsin, I pursued graduate degrees in landscape architecture and water resource management, and I was drawn to the nexus and the tension between the two. In the West, this nexus often plays out through water conservation best practices and strategies in residential, commercial, and public landscaping. While I was interested in those practices and strategies, I felt there may be a better and more comprehensive way to bridge the gap between water and growth. MaryLou, it turned out, shared this interest and worked extensively with the water community in Colorado.

The dilemma MaryLou and I identified, which has been articulated by others, occurs as local land use decisions are made with little regard for the water use consequences of those decisions or for the cumulative land use decisions of myriad other decision makers. According to a 2011 University of Montana study of western water and land use titled *Bridging the Governance Gap: Strategies to Integrate Water and Land Use Planning*:

> *With few exceptions, land use planners have addressed water in a fairly cursory fashion, if at all. Planners safely assumed that water would be available for all projected growth and would not be a limiting factor. Increasingly, however, many local land use decisions run headlong into concerns about the sustainability of water resources and the impacts of withdrawals on aquatic ecosystems, recreational resources, and other public values.*

Addressing this dilemma presents challenges of scale, politics, and complexity. In Colorado, like most states, land use planning is the responsibility of local governments that often compete with each other for tax revenues and



amenities. By contrast, water planning and allocation occurs on multiple levels, from water utilities that are expected to deliver water to accommodate growth; to state agencies that administer water rights, plan to meet projected water needs, and facilitate interstate agreements; to federal agencies that manage water facilities and approve new supplies in an increasingly over-allocated river system.

Despite these challenges, MaryLou and I began exploring the idea of a Colorado water and growth "dialogue" that would bring together the water, land use, and economic development communities to find ways to address the water and growth dilemma in Colorado and the West. A partnership was born.

We decided early on that we would not tackle the "limits to growth" challenge since it had a history of intractability in settings where it had been broached. We also decided to avoid the "show me the water" challenge since legislation was already in place or pending in other venues. We chose instead to frame a new question that we hoped the water, land use, and economic development communities would find compelling. Instead of asking, "Where will the water come from to support new development?" we are asking, "If we knew the water use consequences of land use decisions, might we make different decisions?" This reframing, we felt, better connected land use decisions to the water use consequences of those decisions.

The question we were pursuing reminds me of the consumer movement to list calories next to food items on restaurant menus. In fact, as I write this I am surveying the menu board at the local Starbucks where I note the caloric content of their Pumpkin Spice Frappuccino—550 calories. The idea of making this information available at the point of purchase is to produce better informed and therefore healthier decision makers. Similarly, we wondered, would knowing the water use consequences of land use choices make for better informed and discerning decision makers in the land use arena? That is the hope as well as the recognized need. In addition, by better integrating water and land use planning at the local level, information about the water use consequences of various land use approaches will be better understood and more likely to be used.

Stapleton Community. Courtesy of Stapleton Community (stapletondenver.com)

UrbanSim computer planning tool used to simulate land use scenarios. Courtesy of Paul Waddell

How will we get there? A dialogue framework was developed and refined with the assistance of a small and dedicated committee of land use and water professionals from Denver Water, the Denver Regional Council of Governments (DRCOG), Colorado Parks and Wildlife, the Lincoln Institute of Land Policy, and the Sonoran Institute. The framework is a five-stage, two-year process that is guided by a larger Working Group of seasoned land and water professionals.

The heart of the dialogue is a two-part effort to 1) identify land uses and land use types that show promise for reducing the water footprint from new development and redevelopment, as well as their water use profiles, so that quantifiable comparisons can be made, and 2) model different land use scenarios over a given landscape using computer scenario planning tools in a multi-stakeholder planning process. To do this, the Working Group is working with DRCOG's UrbanSim scenario planning tool and Denver Water and Aurora Water data to develop water use profiles for the modeling process. A pilot landscape that overlays DRCOG, Denver Water, and Aurora Water service areas will be selected for the demonstration.

The goal of the dialogue is to identify strategies and actions that can be taken to overcome barriers and to better

integrate water and land use planning in ways that will measurably reduce the water footprint of new development and redevelopment. The project is focused on the Front Range of Colorado, since that is where land use decisions can have the greatest impact on water use. The project will also connect with the State water planning process as it progresses and will build on previous and ongoing research by Western Resource Advocates, the Lincoln Institute of Land Policy, and the Sonoran Institute. It is funded by the Gates Family Foundation, the Walton Family Foundation, Colorado Water Conservation Board, and Denver Water, with in-kind contributions from steering committee organizations.

In 1878, John Wesley Powell published his *Report on the Lands of the Arid West*, which advocated for settlement patterns that were strongly tied to the location and availability of water resources. Powell saw that homesteaders coming from water-abundant eastern states were ill-prepared for the arid conditions they would find in the West and sought to plan their settlements in ways that improved their chances for success. He recognized the fragile relationship between water and human settlement on an arid landscape and could foresee pitfalls when the two were disconnected. Powell's plan to settle the West was not followed, and the consequences are becoming apparent. We cannot return to the days when Powell made this observation. However, we have opportunities today to replace our aging water infrastructure and the land use patterns that are tied to it. If we do that with Powell's wisdom, and through collaboration, we can move closer to this connection.

For additional information about the Colorado Water and Growth Dialogue, please visit www.keystone.org or contact Matt Mulica at mmulica@keystone.org.

Todd Bryan is a mediator, facilitator, and trainer in negotiation and collaboration decision making, formerly a senior associate with the Keystone Center. He can be reached at tbryan@mediate.org.

USGS science for a changing world

Recent Publications

Analysis of water quality in the Blue River watershed, Colorado, 1984 through 2007 USGS Scientific Investigations Report: 2013-5129; Bauch, Nancy J.; Miller, Lisa D.; Yacob, Sharon

Simulating water-quality trends in public-supply wells in transient flow systems Journal Article; Starn, J. Jeffrey; Green, Christopher T.; Hinkle, Stephen R.; Bagtzoglou, Amvrossios C.; Stolp, Bernard J.

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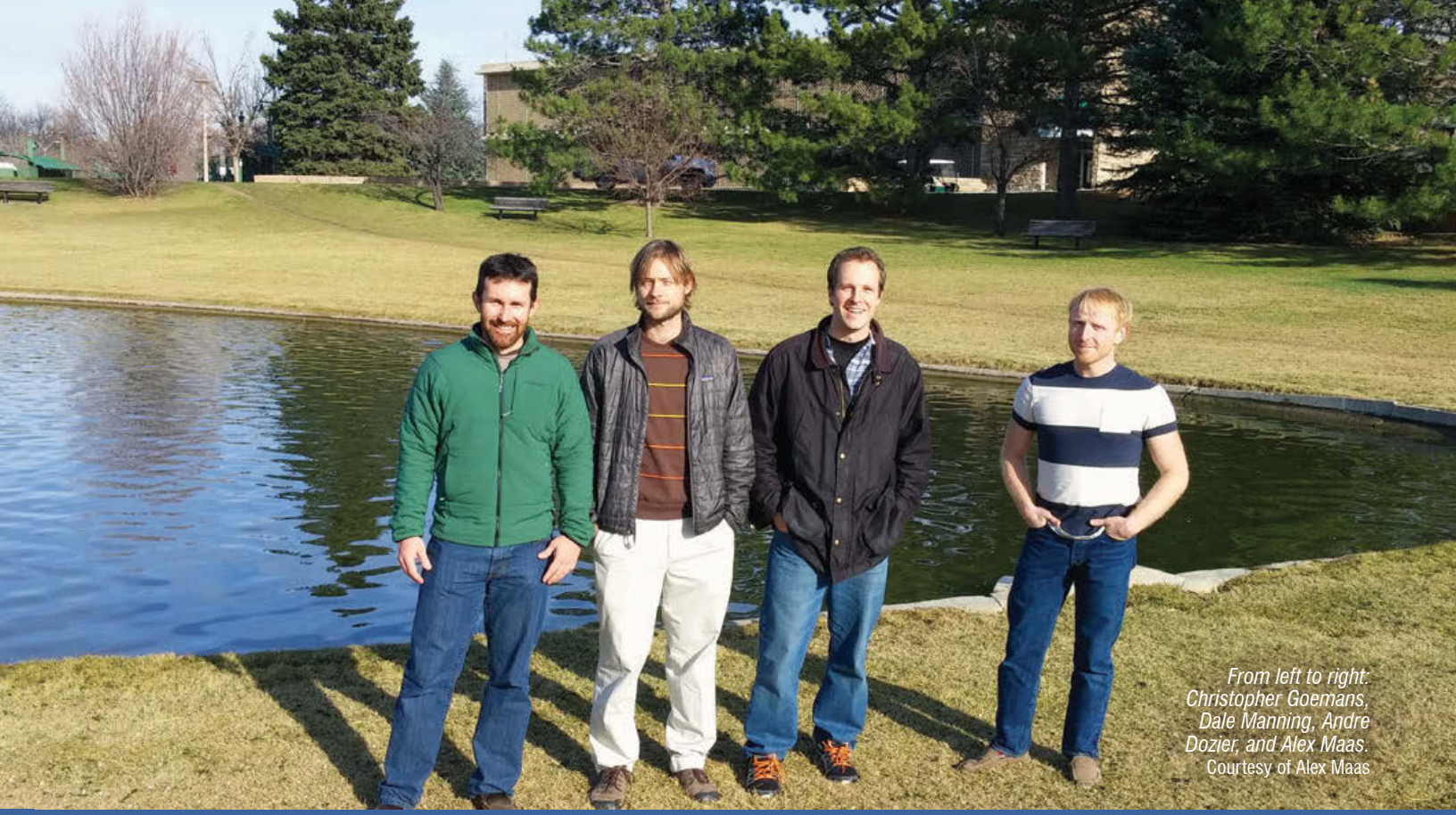
Groundwater and surface-water interaction and potential for underground water storage in the Buena Vista-Salida Basin, Chaffee County, Colorado, 2011 USGS Scientific Investigations Report: 2014-5095



From left to right: Christopher Goemans, Dale Manning, Andre Dozier, and Alex Maas. Courtesy of Alex Maas

The Value of Stored Water and Trading in the West

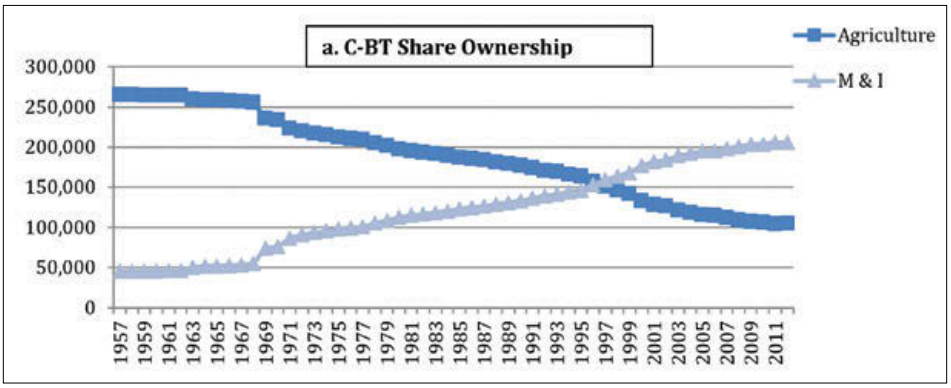
Lessons from the Colorado-Big Thompson Project

Alex Maas, PhD Student, Agricultural and Resource Economics, Colorado State University
Andre Dozier, PhD Student, Civil and Environmental Engineering, Colorado State University
Dale Manning, Agricultural and Resource Economics, Colorado State University
Christopher Goemans, Agricultural and Resource Economics, Colorado State University

Water and growth has had an impact on Colorado-Big Thompson water shares—in the past, agriculture owned a majority of shares, and currently, municipal and industrial users own the majority. Models were run to determine the difference in water markets under each ownership scenario (with and without trading) and for different climate scenarios over 50 years, finding that with trading, the value of stored water increased by 37 percent in all years and 43 percent in the driest years.

Water represents an important scarce natural resource in many arid parts of the world. Rapid population growth in water-scarce regions can exacerbate the problems associated with water scarcity. Currently, five of the eight fastest growing U.S. states are located in the water-scarce Southwestern United States. In Colorado, only 80 percent of projected demand will be met by the year 2050 even if planned supply and conservation projects are successful. Annual expected shortfalls for the state may exceed 500,000 acre-feet. The solution to water scarcity has traditionally been supply-side based, but over the last 20 years, conservation and institutional reform (e.g., improving the functionality of water markets) have played increasingly larger roles. While much of the research has pitted one approach against another (e.g., new reservoirs versus water transfers versus conservation), our research aims to better understand the complementarities between the different ways to meet future water challenges.

Reservoirs play a critical role in reallocating water within and across years to match supplies with urban and agricultural demands. Significant investments in infrastructure have already been made, and more capacity is likely on the horizon. The question is: How



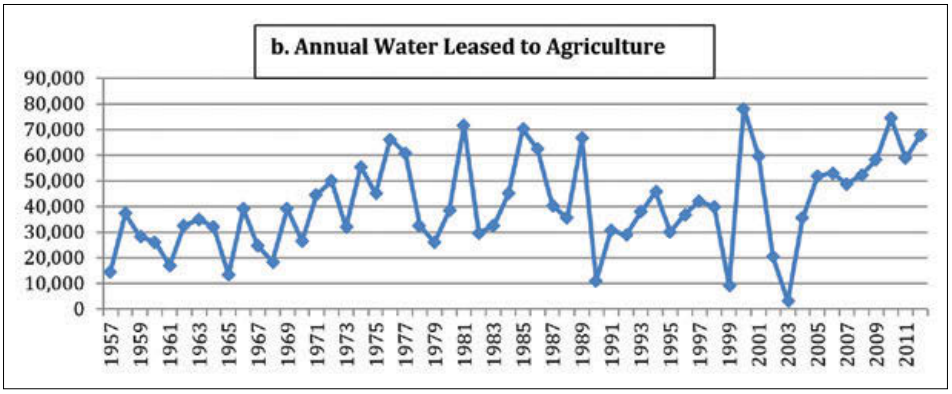


Figure 1. *C-BT water saw an increase in the share of M&I ownership in the latter part of the 20th century; as of 1997, the majority of C-BT water is owned by M&I users.*

can we maximize the returns on our past and future investments in reservoir storage? To help answer this question, we developed a dynamic-economic-optimization model of the Colorado-Big Thompson (C-BT) project and compared the value derived from the water in the system with and without markets for water. The results suggest that the flexible trading institutions adopted by the Northern Colorado Water Conservation District (NCWCD) have had a substantial positive impact on the value generated from the system.

Why focus on the C-BT system? Currently, most of Colorado water use is governed by the Prior Appropriation Doctrine (PAD), which has its roots in the mining laws of the late 1800s and has been part of Colorado Law for 150 years. While there are numerous reasons PAD exists, the particular implementation of it in Colorado has restricted water transfers due to the high transaction costs associated with trading.

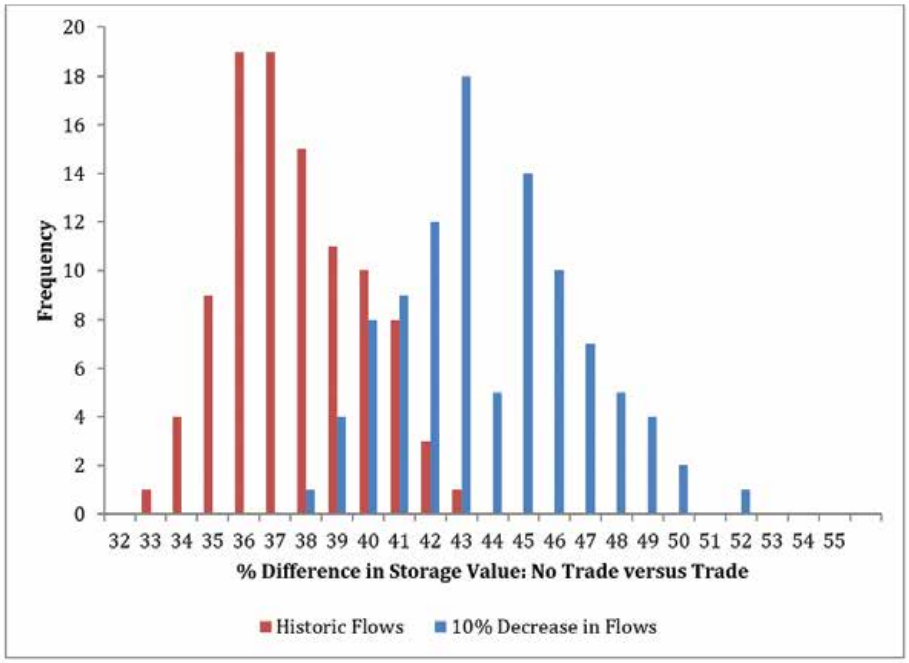
The C-BT project collects water from the Upper Colorado River Basin and delivers this water to a service area in northeastern Colorado, which is the northern section of a populated area more commonly referred to as the Front Range. Uniquely, water provided by the C-BT (roughly 210,000 acre-feet each year on average) is a supplemental water source to the existing native supplies and can be transferred or traded to multiple uses without the restrictions normally associated with native water. Because of this, the C-BT represents one of the few working water markets in the U.S. (and one of the most studied). Therefore, the C-BT system provides an ideal case study to compare the economic gains from trading water stored across time. Historical delivery data provide information to calibrate a model of stored water value under a free trade scenario. Introducing trade restrictions allows for a comparison with a scenario in which water use remains at initial (1957) ownership levels across uses. This comparison offers insights into the potential benefits of relaxing trade in other areas.

Our model consists of two aggregate water users. The first user represents municipal and industrial (M&I) use, and the second user represents agricultural use. While the vast majority of Colorado's water remains in agriculture, M&I users became the majority C-BT shareholders in 1997 (Figure 1a). Specifically, share ownership shifted from the original allotment (85 percent agriculture, 15 percent M&I) to one in which M&I currently owns 64 percent of all C-BT shares. However, because there are few trade restrictions associated with C-BT water, considerable water is leased to agriculture (Figure 1b) such that the majority of water is still used for agricultural purposes.

We use this information to create two water allocation scenarios: a functioning water market and a restricted one with 15 percent of water in M&I and 85 percent in agriculture. Water allocation scenario one (water market) is the baseline scenario used to model allocation under the existing institutional setting. Water allocation scenario two (fixed allocations) represents the original allocation of C-BT water shares. Restricting allocations to this level mimics an extreme setting where water markets of any type are not allowed. The model simulates the use of C-BT storage on an annual basis by performing dynamic optimization of storage levels over a 50-year time horizon with water availability from year to year randomly determined based on an

assumed inflow distribution, which served as a proxy for variations in climate. Model runs corresponding to two inflow distribution scenarios are presented below to illustrate how results might change under differing climatic conditions: one based on past climate conditions and another assuming a 10 percent decrease in average annual water availability. After performing dynamic optimization, the model runs in simulation mode and produces 100 traces of reservoir inflow realizations for each of the four combinations of water allocation and climate conditions.

Of interest is the difference between the value generated by the project over the 50-year time horizon with and without trading. Figure 2 illustrates the distribution of the percentage difference between the value of stored water with and without trading across the two different climate scenarios. Figure 2 also shows the average percent difference in the total value of stored water across all years and the average in the ten driest years. On average, allowing trade increases the value of stored water by approximately 37 percent in all years and 43 percent in the driest years. Having a flexible system (institutionally speaking) is even more important under reduced flows; trade increases the value of storage by 41 percent in all years and 50 percent in the driest years under an alternative (dry) climate scenario. A comparison of the value derived from the system with and without trading suggests that the institutional setting adopted by the NCWCD has had a significant impact on the value derived from their investments in infrastructure. Moreover, maximizing the return on our investments moving forward likely requires having more flexible institutions.



Average Percent Difference	Historic Flows	10% Decrease
All years	37%	41%
10 Driest Years	43%	49%

Figure 2. *Percent difference in the value of stored water with and without trade under both climate scenarios.*

Our model focuses on the overall value of stored water from the C-BT system. This is a partial equilibrium analysis, as water demands along the Front Range likely would have evolved differently had trading not been allowed. We do not account for value generated from the within-year timing of water delivery. Intra-annual flexibility and reliability of water allocations likely further enhances the benefits derived from infrastructure such as reservoirs. It is also important to recognize that this model assumes zero autocorrelation in annual water availability. If drought years occur in succession, the impact of markets on the value of stored water is also likely to increase.

The analysis presented here highlights the potentially significant impact institutional settings can have on the value of water infrastructure in which we invest. Future policy discussions should involve choosing a combination of infrastructure, conservation, institutional change, etc. that takes advantage of the complementarities between the different policies, not one that pits one policy versus another. While the initial results are consistent with expectations, further work is necessary to test the robustness of results. Specifically, future work will investigate the sensitivity of results to functional forms, inflow distributions, evaporation, and the time step of the model.

Acknowledgments

We would like to acknowledge the Colorado Water Institute and the I-Water program at CSU for their support.



Other States' Policies to Reduce Outdoor Water Use

Drew Beckwith, Water Policy Manager, Western Resource Advocates

In arid and semi-arid Southwestern U.S. states, regulatory and incentive-based approaches are being used to minimize the amount of water used in urban settings. These include modified landscapes and reductions in potable water use. Such strategies are useful as examples of strategies that Colorado can implement to stem issues surrounding water and growth.

Colorado is not the only state facing a challenge in supplying reliable water to a rapidly growing population. The southwestern states of Arizona, California, New Mexico, and Nevada are also facing double-digit population growth and limited water supplies. The strategies these other states are using to deal with water and growth challenges, however, provide good models for Colorado to consider in developing its own plans.

In dry climates like the Southwest, outdoor water use typically accounts for 40 to 50 percent of the total water supplied in a community. And individual household outdoor water use can be as high as 60 percent. Importantly, water that is used outdoors does not "return to the system," unlike water that heads down the drain that can be captured, recycled, and used for other purposes. Water used for irrigation is mostly evaporated by the sun or transpired by plants—it's gone. Although it will eventually turn back into water that we humans can drink courtesy of the hydrologic cycle, that process tends to take a while.

Therefore, it should come as no surprise that other dry and fast-growing Southwestern states have placed significant attention on how to reduce, or replace, the use of drinking water for outdoor irrigation. Several strategies are discussed below that provide useful examples for implementation in Colorado.

Regulatory-Based Approaches

Statewide

Several states have adopted policies to reduce outdoor water use at a statewide level. California's model landscape ordinance (AB 06-1881) was the most recent step in a nearly twenty-year effort to reduce outdoor water use in the state. The ordinance applies to all new and modified landscapes over 2,500 square feet in size, and requires the use of a water budget to design and maintain the landscape. Notably, the water budget for landscapes is set to 60 percent of the local evapotranspiration rate, which functionally means that landscapes cannot use exclusively turf grass. The state allowed five years for local communities to adopt equally or more restrictive (with respect to water savings) ordinances before the state's model became the default.

Also at work in California is the state's urban conservation goal (SB09-X7-7) that calls for all cities and towns to reduce potable per capita use 20 percent by 2020, from approximately 2010 levels. Entities that do not meet intermediate goals set up in statute are ineligible for state funding, which carries a healthy pot of money for water projects. Arizona's Groundwater Management Act presents another statewide approach, initially developed in 1980 to respond to declining groundwater levels in the Phoenix metropolitan area and to attain federal funding for the Central

Above Photos: *Civano, Arizona - A community built to be water efficient, using native landscaping as required by local landscaping codes.* Courtesy of Civano Neighbors



Arizona Project. The act has always contained important direction on reducing outdoor water use, even though several changes have been made in its implementation over the past three decades. As two examples, the act places significant restrictions and limits on "turf facilities" greater than 10 acres (like golf courses and cemeteries), and forbids the planting of high water use vegetation in public rights of way.

Local

Several other sets of strategies to reduce outdoor use have been implemented at the local level. Most blunt and effective are prohibitions on the amount or placement of turf grass in landscaping. Every city and town in the Las Vegas Valley prohibits turf grass in the front yard of new homes, and sets a limit of no more than 50 percent turf cover on side and rear yards. Turf is also prohibited in all in commercial and industrial complexes. Sierra Vista, Arizona has very similar restrictions.

Rainwater harvesting programs, meant to replace the use of drinking water for landscape irrigation, are also popular in other states. Santa Fe, New Mexico requires a rainwater cistern to serve all landscaped areas of residential homes greater than 2,500 square feet, while Flagstaff, Arizona requires rainwater to meet the total landscape demands of all non-residential and multi-family residential properties—that is to say, no drinking water may be used for outdoor irrigation.

Table 1. *Turf rebate programs in the Southwest*

Community	Rebate Amount ($)
Los Angeles, CA	3.50
San Diego, CA	3.00
Las Vegas, NV	2.00
Albuquerque, NM	1.00
Scottsdale, AZ	0.50

Demand offset programs are another strategy that often focuses on outdoor use. In San Luis Obispo and Santa Cruz, California, developers must conduct retrofits on existing water users in order to reduce water use by twice the amount of water needed for a new development.

Incentive-Based Approaches

In contrast to using a "stick," states and local governments also provide "carrots" to reduce outdoor water use. Though incentive programs are more popular at the local level, the state of Arizona offers an individual income tax credit up to $1,000 for implementing water conservation systems at a home.

Perhaps the best known outdoor incentives are the "cash for grass" programs widely implemented throughout the Southwest. As an example, Southern Nevada Water Authority's program has cumulatively saved nearly forty billion gallons of water over the past fifteen years. Across the West, rebate amounts range from as little as 50¢ per square foot of turf removed, all the way up to $3.50 per square foot (Table 1), with the upper end of these programs creating a financial driver to spur private industry into removing lawns at no cost to the homeowner.

Rainwater harvesting rebates are also popular, most prominently in Arizona, with the communities of Tucson, Sierra Vista, and Prescott offering up to $2,000 for rainwater systems. There are other types of programs to reduce outdoor use, as well, including expedited permitting through local land use requirements for developments with water-efficient landscapes, or reducing tap fees for low-water-use landscaped homes.

Colorado has made significant strides toward reducing water use in the past decade, but much of our collective efforts have focused on reducing indoor use. As we embark on addressing outdoor use in the context of continued population growth, there is much to learn from our neighboring states.

Above Photos (left to right): *Boulder, Colorado - A raingarden at Western Resource Advocates' building uses roof runoff to irrigate flowers.* Courtesy of Drew Beckwith
Stapleton, Colorado - Non-landscaped open spaces save water and provide areas for activity. Courtesy of Forest City Enterprises
Stapleton, Colorado - Front yards use flowering perennials instead of turf. Courtesy of Forest City Enterprises

How Green Industry Best Management Practices Support Senate Bill 14-017

Brenda O'Brien, Consultant, GreenCO and Colorado WaterWise

Senate Bill 14-017 was revised with the help of GreenCO to stipulate that study is needed on the issue of quantifying where outdoor water savings can be achieved. GreenCO and WaterWise have provided conservation best management practices, and have expressed eagerness to provide tools based upon this senate bill stipulation.

The Green Industries of Colorado (GreenCO) and Colorado WaterWise teamed-up to present "*How Green Industry Best Management Practices Support Senate Bill 14-017*" to the Colorado Legislature's Water Resources Review Committee. The overarching message presented to the Water Resources Review Committee in August of 2014 was in response to their amendments to SB14-017. GreenCO opposed the original version of the bill—specifically, its 15 percent turf restriction. Instead, GreenCO worked with its sponsors to significantly amend the bill because it focused overly on turf in the absence of science and data. SB14-017 now stipulates that a "study is needed" to quantify where outdoor water savings can be achieved. The issue we have today is the absence of definitive, scientific, technological, and quantifiable horticultural data that pinpoints when and where water can be saved. GreenCO applauds the Water Resources Review Committee for amending this Bill from a specific crop restriction, to a viable study to identify and quantify landscape conservation Best Management Practices (BMPs).

GreenCO, the voice of Colorado's green industry, and Colorado WaterWise, the voice of Colorado's water conservation community, have been organizational partners for over two decades. GreenCO represents seven trade associations from all facets of the horticulture and landscape industries, with more than 2,500 member companies employing 40,000+ Coloradans and contributing nearly $2.4 billion per year to the state's economy. GreenCO members are committed to water conservation and industry-wide best management practices (BMPs) as a way of doing business. GreenCO's partnership with Colorado WaterWise flourishes because of the dedication and interconnectedness of the water user and the water supplier as it relates to outdoor water use efficiency. GreenCO and Colorado WaterWise have already embarked on several projects with representation from both groups at the onset. This mindset and project strategy has paid off for all involved; the scientific and technical tools and resources produced are still in use today. But there is more work to be done to bring the intent of SB 14-017 to fruition. GreenCO, with Colorado WaterWise as a key stakeholder, has a plan and is up to the task. After all, water conservation is important everywhere—indoors and out.

In the late 2000s, GreenCO laid out a sequence of staggered projects with the Colorado Water Conservation Board (CWCB) to deliver BMPs for water conservation and water quality protection, and recommended steps to merge the best practices with a measurement system to quantify the water savings if implemented by local governments. Many of these projects came to fruition; others did not due to grant funding cuts at CWCB.

One of the first projects realized was in 2008 when GreenCO completed an update of the *Green Industry Best Management Practices for the Conservation and Protection of Water Resources in Colorado: Moving Toward Sustainability*. This manual identifies 39 BMPs, the majority of which support landscape water conservation objectives; however, water conservation benefits of these practices were not quantified in the manual.

In 2009, GreenCO completed a review of landscape water conservation literature and provided a series of recommended steps needed to maximize use of this information in water conservation planning. The key findings within the Literature Review determined that landscape water conservation can and should play a role in demand management to help stretch limited water supplies. A few of the initial BMPs identified are: *All 7- Principles of Xeriscape, Irrigation Audits, Irrigation Technology and Retrofits, Soils, Plant Selection, and Turf Management and Water Budget Based Landscape Design*. A plethora of data

was collected, but additional work is needed to "normalize" the data that would result in meaningful and comparable figures for use in statewide landscape water savings projections.

In 2010, Colorado WaterWise integrated a select group of GreenCO's BMPs into the *Guidebook of Best Practices for Municipal Water Conservation* in Colorado. The guidebook houses both indoor and outdoor best practices and is the standard for municipal water conservation in Colorado. CWCB uses the guidebook in developing Water Conservation Plans, and in it's used in SWSI II's Conservation Section as a means to help meet the water supply gap by 2050.

Since then, various Basin Roundtable efforts and the State Water Plan have continued moving forward, generally referencing potential water conservation opportunities associated with landscaping but not quantifying the benefits of specific practices, since this information does not exist today.

SB14-017 has put the last intended, and most important step in the sequence of projects back on the table. SB14-017 specifically calls for "identifying and quantifying the benefits of landscape water conservation." GreenCO, in partnership with Colorado WaterWise, has a plan to address the *key* deliverable outlined in this legislation, and is currently drafting a Water Efficiency Grant Application to CWCB to fund its development.

SB14-017 Legislative Declaration Section 1(c) declares that it is critical to identify and quantify the best practices that limit municipal outdoor water consumption, as this holds the great potential for reducing Colorado's projected water supply gap.

The need for quantitative landscape water conservation BMPs is imminent. GreenCO's BMPs are the standard for outdoor water use in Colorado. The BMPs are a comprehensive set of practices that can and should be used as the foundation for SB 14-017's call for a study to quantify them. The BMPs were developed in cooperation with over 100 green industry professionals, utility conservation personnel, environmental groups, engineering partners, academia, and other stakeholders. GreenCO's BMPs have been cited in many House and Senate Bills from prohibiting Xeriscape in HOAs (SB 13-183), to water efficient fixtures in new homes (HB 10-1358), to identifying and quantifying landscape water conservation BMPs (SB 14-017). They've been integrated and/or adopted by utilities, industry, cities and municipalities. The GreenCO BMPs are packaged and ready to evolve into a quantifiable and implementable tool that is voluntary based upon the needs of the local communities.

GreenCO and Colorado WaterWise have shared their eagerness to provide expert support in developing two tools for Landscape Water Conservation: *Quantification of Landscape Water Conservation Practices and Model Landscape Water Conservation Framework*. GreenCO will spearhead the project and work with utility experts and other stakeholders to build them.

The study has six key tasks:

1. **Supplemental Literature and Model Ordinance Review**: Building on the 2009 CWCB-funded GreenCO literature review, conduct a supplemental literature review to a) identify additional studies/resources that may have become available in the past five years that are useful in quantifying the benefits of landscape water conservation and b) collect example landscape ordinances, particularly those in semi-arid/arid communities. As part of this review, key findings will be tabulated and summarized in a manner to support the remaining project tasks. Collection of landscape water conservation ordinances will be supplemented by interviews with local water providers to assess strengths and weaknesses of such ordinances. Expected savings identified with outdoor water conservation activities in Water Conservation Plans may also be inventoried for comparative purposes.

2. **Develop Semi-Quantitative Approach to Normalize Landscape Water Conservation Practice (BMP) Benefits**: Quantitative landscape water conservation studies are specific

Photo by Dave Townsend

to geographic locations, land use patterns, population densities, soil types, plant types, irrigation practices, socioeconomic characteristics, behavior, and other factors. To transfer findings from published literature, such factors need to be documented and studies "normalized" to either account for these factors or to develop ranges of expected water conservation benefits for a given set of typical landscape characteristics. Engineering principles used in water supply planning and water rights evaluations can be used to help normalize these estimates to some extent, combined with professional experience. Under Task 2, an approach will be developed to increase the transferability of landscape water conservation literature, including input from landscape professionals, local governments, and other experts.

3. **Develop Summary of Estimated Quantitative Water Conservation Benefits of Landscape BMPs:** This task will involve applying the approach developed in Task 2 to the landscape water conservation practice literature findings from Task 1. The product will be a summary of ranges of expected water conservation benefits of key landscape practices, where sufficient data exist. This work product may be in the form of a short written summary, a summary matrix, or a combination of flow charts (decision diagrams), depending on input from stakeholders and CWCB. Findings from Task 3 will provide the technical underpinnings of Task 4. Examples of landscape water conservation practices expected to have available data include: Xeriscape, irrigation audits, irrigation practices/ technology, soil amendment, turf management, and water budget-based landscape design.

4. **Develop Model Landscape Water Conservation Framework**: In 2004, the Department of Local Affairs (DOLA) sponsored a Model Landscape Water Conservation Ordinance effort; however, the ordinance has not been widely adopted in Colorado. GreenCO believes that a simpler and more adaptable approach is more likely to be adopted by Colorado communities and that an alternative Model Landscape Water Conservation Framework is needed, building upon the GreenCO BMPs and successful landscape water conservation ordinances in other communities and states. Based on findings in Tasks 1-3 and stakeholder input, an alternative Model Landscape Water Conservation Framework will be developed. This will be written to allow a local community to either use this framework in a voluntary manner or tailor the information for use in an ordinance developed to local conditions. The target audience is smaller water providers and communities in Colorado. Task 4a will focus on development of the Model Landscape Water Conservation Framework; Task 4b will distribute the Model Landscape Water Conservation Framework to local water providers and provide implementation recommendations on integrating the guidance into their local demand management and water conservation plans.

5. **Stakeholder/Industry Input and Review (Stakeholder Meetings)**: Stakeholder input from Green Industry professionals and local water providers is critical to the success of a Model Landscape Water Conservation Framework, as well as in developing quantitative estimates of various landscape practices. A series of five stakeholder meetings is proposed to support the project. As a statewide project, it is important that both Front Range and West Slope viewpoints are considered. GreenCO has a strong history of effectively involving and integrating viewpoints of diverse stakeholders through such meetings.

6. **Project Administration and Reporting**: GreenCO will be responsible for administrative coordination with CWCB and project stakeholders, preparation of meeting notes, and grant-related progress reports.

GreenCO is eager to be part of the solution, not the originator of the problem. GreenCO is enthusiastic about working with its partners to build *Landscape Water Conservation Tools: Quantification of Landscape Water Conservation Practices and Model Landscape Water Conservation Framework* to aid in statewide landscape conservation projections. Identifying and quantifying the GreenCO BMPs is what the water user and water supplier want, what SB 14-017 needs, and what CWCB and others will use for years to come.

If you are interested in supporting this project, please email a letter of support to Brenda O'Brien at brenda.obrien@comcast.net.

Spring Water Seminar 2015

Mondays from 4:00 to 5:00 PM

January 26
LSC Room 322

Brad Udall, Senior Water and Climate Scientist, Colorado Water Institute
The Colorado River Structural Deficit: Why it Matters to Colorado

February 2
LSC Room 322

Ashley Anderson, Assistant Professor, Department of Journalism and Technical Communication
Floods, Communication, and Climate Change: Exploring the Role of Media Use and Interpersonal Discussion in Connecting Water-Related Extreme Weather Events to Perceptions about Climate Change

February 9
NR Room 109

Sybil Sharvelle, Associate Professor, Department of Civil & Environmental Engineering
Evaluation of Urban Nutrient Loading and Recommendations for Cost Effective Treatment Technologies

February 16
NR Room 109

Reagan Waskom, Director, Colorado Water Institute
State of the CSU Water Center & Faculty Listening Session

February 23
NR Room 109

Tim Covino, Assistant Professor of Watershed Science Department of Ecosystem Science & Sustainability
Loss of Catchment Retention: Interactions between Catchment Morphology, Residence Time, and Geochemical Processing Amidst a Changing Hydrologic Regime

March 2
NR Room 109

Ed Hall, USGS Research Biologist, Natural Resource Ecology Laboratory
Across the Aquatic-Terrestrial Interface: Understanding the Hydro-Bio-Geo-Chemistry of Extreme Events

March 9
NR Room 109

Jessica Davis, Professor, Department of Soil and Crop Sciences
Joshua Wenz, Graduate Student
The Water-Nitrogen Tradeoff: Optimizing the Use of Water to Fix N and Reduce Agriculture's C Footprint

March 30
NR Room 109

Ryan Bailey, Assistant Professor, Department of Civil & Environmental Engineering
Developing a Framework for Simulating the Fate and Transport of Salinity Species in the Lower Arkansas River Valley, Colorado

April 6
NR Room 109

Jay Ham, Professor of Environmental Physics, Department of Soil and Crop Sciences
New Technology for Measuring Sap Flow and Transpiration in Agricultural and Native Ecosystems

April 13
NR Room 109

Stephanie Malin, Assistant Professor, Department of Sociology
When Water Rights Ebb into Energy Development: Unconventional Oil & Gas Development and Changes to Water Allocation in Northern Colorado

April 20
NR Room 109

Dana Winkelman, Unit Leader, U.S. Geological Survey Colorado Cooperative Fish and Wildlife Research Unit
Rocky Mountain Streams Past and Present: The Influence of Forest Stand Age and Wood Deposition on Trout and Insect Biomas

April 27
NR Room 109

Yan Vivian Li, Assistant Professor in Textile Science, Department of Design and Merchandising
William Sanford, Associate Professor, Department of Geosciences
How Carbongenic Nanoparticles (Cnps) Move Through Various Types of Porous Media Under Conditions that Replicate the Natural Environment

May 4
NR Room 109

Stacy Lynn, Research Scientist, Natural Resource Ecology Laboratory
From Water Scarce to Water Source: The Governance of New Water in the Kenyan Drylands

Sponsored by: CSU Water Center, USDA-ARS, Civil and Environmental Engineering, and Forest and Rangeland Stewardship.
All interested faculty, students, and guests are encouraged to attend.
For more information, contact Reagan Waskom at reagan.waskom@colostate.edu or visit watercenter.colostate.edu

Outdoor Water Use in Colorado

A Growing Concern, a Growing Opportunity

Paul W. Lander, Consultant, Dakota Ridge Partners

An August, 2014 legislative meeting held by the Water Resources Review Committee led to a recognition of the need to further study the issue of addressing water use in cities. Recommendations later provided to the committee include ideas on improving infrastructure inspection, facilitating rainwater harvesting and greywater reuse, and establishing a Water Efficiency Fund, among other recommendations.

There is a growing consensus across the state that more efficient water use in cities is both necessary and achievable. What is still open to debate is what exactly can be done, and whether activities should be mandated by the state, or promoted simply as voluntary guidelines. Using terms like "measurable outcomes," "meaningful and aggressive measures," and "multi-pronged approach," water experts filled a legislative committee meeting in early August with ideas on how to address water use in cities, with the particular focus of outdoor water use.

A bill in the Colorado legislature last session (SB14-017) sought to require efficient use by cities who diverted water from agriculture, but led instead to a directive to further study the issue. The meting in August was one of many held by the Water Resources Review Committee, with the goal of better understanding both the current state of outdoor use, and possible measures for increasing efficiency and the effective use of this valuable resource.

Many of the urban water providers presenting that day outlined their many efforts at promoting wise water use, including the idea of "water budgets." This concept, giving each customer an "allocation" of water based on their landscape size, is fast becoming a staple of cities across the state. It has met with considerable success, as it creates more certainty in usage patterns (and thus costs) for both customers and providers, and results in more of the water going onto plants and not onto pavement. Cities also offered detailed information on the numerous ways that maintained landscapes were important assets to their communities, from providing shade in a

McIntosh Lake, Longmont, CO.
Photo by Bryce Bradford

semi-arid climate, to cleaning the air, to serving as so-called "green infrastructure" to help manage stormwater.

As a follow-up to the August meeting, many sent the committee further suggestions as to how to move forward in creating more water-wise cities in Colorado, in an effort to both increase efficiency and reduce the impacts growing cities might have on the agricultural community. Among the ideas for state leadership:

- Require that all water providers of a certain size utilize water budgets for all outdoor uses in their communities. These can be designed to reflect local conditions, but should be applied to all landscape areas over 1,000 square feet and be monitored on a regular basis.
- Require that all automatic irrigation systems be inspected at the time of installation, and on a regular basis, to ensure proper functioning and efficient delivery of water for landscape plantings and greatly reduce irrigation runoff—a water quality concern for many cities.
- Promote the use of harvested rainwater in a manner that creates better infiltration for the benefit of landscape plants, reducing water runoff and stormwater surges and recharging local groundwater.
- Promote the re-use of indoor water by clarifying the language on greywater use by a single account holder. This would create certainty for providers seeking to encourage non-consumptive re-use within one building site or account.
- Require that all those working on outdoor irrigation systems meet minimum standards of professional training.
- Establish a Water Efficiency Fund to significantly increase the resources available to bring all urban water providers up to the level of efficiency suggested at the meeting. This fund would be sourced through a monthly fee collected by each water provider from each account (with low-income exemptions) and distributed by the Colorado Water Conservation Board through their established grant processes.

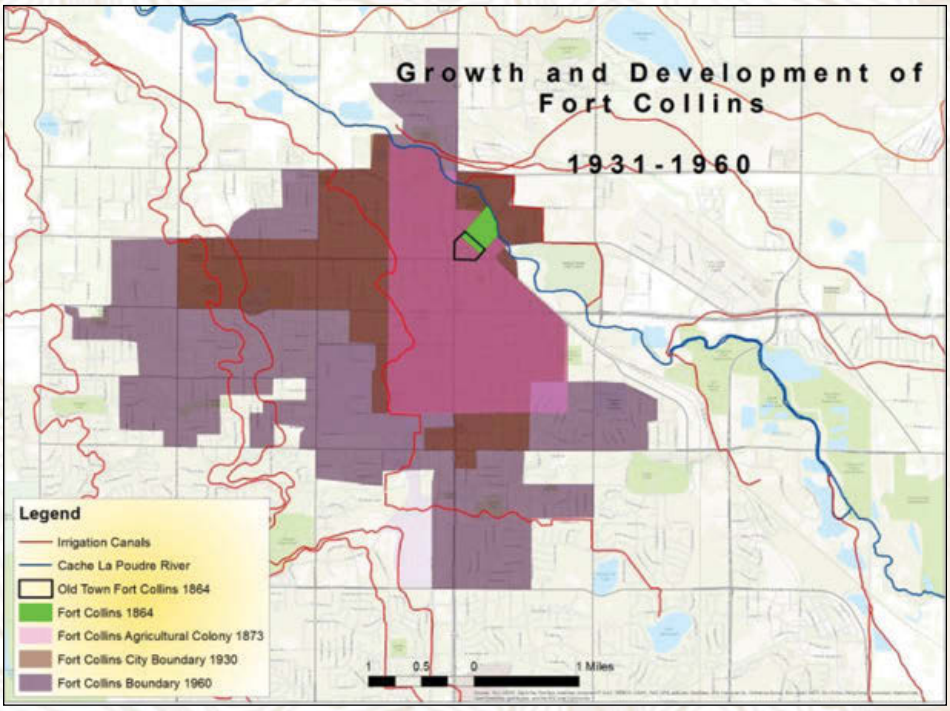
Outdoor water use is significant for the cities of Colorado (and the West) as a driver of system costs, overall system demands, and the need for peak water supply during our hot summers—outdoor use is commonly 50 percent or more of total annual use of treated drinking water. At the same time, it is the maintained landscape assets of our communities that add tremendous value to the quality of life here. These challenges can be addressed with serious attention and management, and, as the primary manager of water, the state can offer valuable guidance on this important concern that no other party can.

How Did Fort Collins Address Water for Growth in the 20th Century?

Maren Bzdek, Administrative Director, Public Lands History Center

Like all communities in the semi-arid High Plains, Fort Collins confronted the limits of readily available water while it was still a very young community. In its first decade, raw river water conveyed in a few open irrigation ditches or obtained by the bucket or barrel from water wagons met the immediate domestic and agricultural needs of the citizenry, but loss of property from several devastating fires in commercial blocks created urgent demand for the first water works, which was constructed in 1883.

Modernization and regional growth in the next century quickly tested the limits of Fort Collins's first basic water supply system. As agriculture expanded, construction of the sugar beet processing factories and an influx of laborers and related development hurtled the small communities of Northern Colorado into a boom period at the turn of the century. Between 1900 and 1910, the population of Fort Collins more than doubled from 3,053 to 8,210. Demand for water for residential and industrial use led officials to push for transmountain water diversions from the western slope to the more populated eastern slope communities that were already well-connected to the national markets. The most comprehensive and far-reaching diversion project launched on July 5, 1938 with the signing of a contract between the Bureau of Reclamation and the newly created Northern Colorado Water Conservation



Growth of Fort Collins from 1931-1960, showing irrigation canals used to provide water for the growing population. Courtesy of the Public Lands History Center

District, which would manage the Colorado-Big Thompson (C-BT) project. The C-BT project provided a new water supply from the Colorado River and its reservoirs contributed to hydroelectric production, recreation, and flood control.

As the region's urban water use demands increased in the twentieth century, so did the percentage of C-BT water delivered for those needs. In 1974, only 12 percent of C-BT water served municipal and domestic uses. By 2009, municipalities owned two-thirds of C-BT water units and leased some units back to farmers while using 40 percent for municipal purposes. Growth in Fort Collins benefitted directly from the diverted western slope water. The population of Fort Collins doubled again in the postwar period from 12,251 residents in 1940 to 25,027 in 1960. In 1958, the City of Fort Collins purchased 6,052 units in the CB-T system for delivery from Horsetooth Reservoir, which was created in 1949. Acquired water rights from ditch companies along the Cache la Poudre River and the Horsetooth Reservoir supply from the CB-T system became the two main sources of water for Fort Collins.

The City of Fort Collins had begun buying water rights from ditch companies as early as 1889, but in the 1960s, officials recognized the need

Public Lands History Center digital history projects include a History of Agricultural and Urban Water Use in Fort Collins, located at http://publiclands.colostate.edu/digital_projects/dp/poudre-river/.

for a stronger planning process to meet the community's future water demands. Mayor Harvey Johnson, who was also president of the Water Supply and Storage Company, used his expertise and influence to create a Water Board that would provide guidance to City Council. In 1971, the Water Board, led by president Ward Fischer, recommended acquisition of the Michigan Ditch and Joe Wright Reservoir, which required enlargement and raised the storage capacity from 800 acre-feet to 7,200 acre-feet. The project increased Fort Collins's raw water holdings by 182 percent between 1972 and 1982—another major turning point for the stability of the city's water supply.

In addition to the water secured for demands inside city limits, growth in Fort Collins benefited from the water and sanitation districts that developed on its borders in the early 1960s. Today those districts serve 50 percent of the urban growth area. Known as the "Tri-Districts," the East Larimer County Water District, the North Weld County Water District, and the Fort Collins-Loveland Water District exchange water with the City of Fort Collins but remain separate, quasi-municipal entities even though many of the customers they serve now live within the Fort Collins city limits due to annexation.

Drought years in the late twentieth century triggered policy and planning changes in Fort Collins as the community confronted the limits of its supply for existing and future needs and recognized the role of conservation measures in managing water. The late 1970s saw the introduction of water meters for new homes, and in 1988, the City Council adopted its first official *Water Supply Policy*, which grew again in 1992 to include conservation measures and water use goals. Those policies and goals continue to evolve in the twenty-first century as the uncertainties of drought conditions loomed.

The introduction of universal metering that started on a volunteer basis in 1997 transitioned to mandatory metering by 2005. A drought year in 2002 led to stricter water use goals in 2003 in the form of the new *Water Supply and Demand Management Policy*, which included the goal to reduce water use to 185 gallons per capita per day and 475 gallons per capita for peak daily demand by 2010. The policy also recommended pursuit of additional storage capacity and opportunities for regional cooperation and protection of stream flow for ecological and recreational benefits.

The State of Colorado's *Water Conservation Act of 2004* led to the Fort Collins *Water Conservation Plan* in 2010. As of November 2012, the revised Water Supply and Demand Management Policy contains reduction goals of 140 gallons per capita per day and 350 gallons per capita for peak daily demand by 2020. As the region continues to balance ongoing municipal, industrial, and agricultural uses for water, conservation will become increasingly important as a tool for addressing the inevitable growth in demand.

Note: The sources for this article are Christy Dickinson and Maren Bzdek, "Growing Water: A History of the Fort Collins Water Utilities, 1882-2013,"a draft manuscript in development with the City of Fort Collins, and "The History of Agricultural and Urban Water Use in Fort Collins," a digital project of Colorado State University's Public Lands History Center, funded by the Colorado Agricultural Experiment Station. For more information, please visit http://publiclands.colostate.edu/digital_projects/dp/poudre-river/.

A Short Review of Colorado's Water Year 2014 Climate

Nolan Doesken and Wendy Ryan,
Colorado Climate Center, Department of Atmospheric Science, Colorado State University

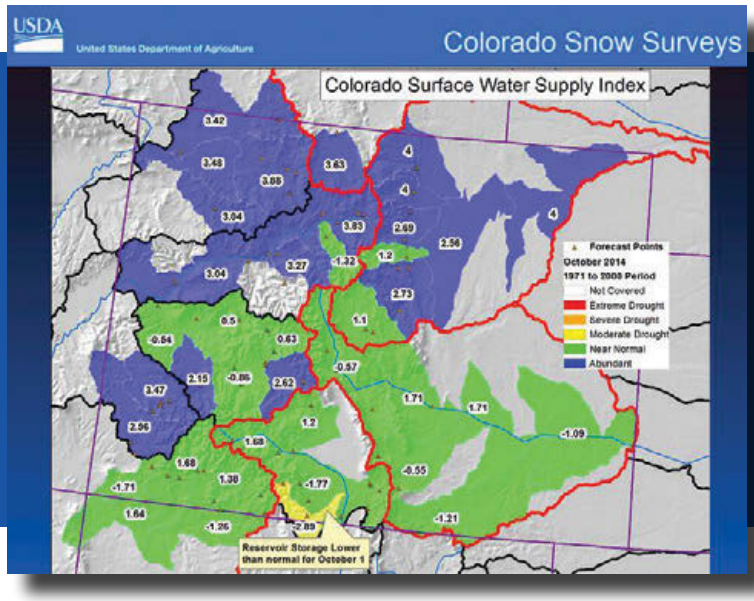


Figure 1. *Monthly temperature departures from average in degrees Fahrenheit for four regions of Colorado: Eastern Plains, Foothills, Mountains, and Western Valleys. Temperatures for the 2014 water year were generally close to average over most of the state except for the cold weather in December 2013 in western Colorado and the very cold conditions on the eastern plains in February 2014. The water year ended with a warm September across the state.* Courtesy of Colorado Climate Center

Water year 2014 (October 1, 2013 - September 30, 2014) proved to be a relatively docile and near-normal year following recent prolonged drought from 2011-2013 and the catastrophic flood of September 2013. There were the typical ups and downs of temperature and a few large rainfall events here and there, but overall it was a solid "good year" for many parts of the state with periodic storms, adequate surface water supplies, and sufficient precipitation. Southern Colorado remained in the grips of long-term drought, but even there, noticeable improvements were observed. By fall, the last area of "Extreme Drought" was erased from the U. S. Drought Monitor (www.drought.gov/drought/).

Winter snow accumulation tracked near the long-term average for most of the winter across many parts of the state, providing great snow for Colorado's winter recreation industry. Some early winter snows in western Colorado provided valley snow cover that resulted in impressive December temperature inversions and much below average temperatures. Grand Junction's December temperatures ended up almost 13 degrees Fahrenheit below average, making this their second coldest December on record (1919 was the coldest). Meanwhile, at higher elevations, December temperatures were closer to normal but still cooler than normal.

Beginning in early February, snows fell frequently in the northern mountains, building a much above average snowpack by March and April. Meanwhile in southern Colorado, late winter snows were infrequent. Several major storms across the southwestern U.S. picked up clouds of dust, which covered Colorado's late season snowpack and likely contributed to rapid and early melt in southwestern Colorado. There was concern of potential snowmelt flooding, especially for areas of the Colorado Front Range hard hit by last year's floods. Rivers did run high, but flooding was generally not a problem. Very dry weather in June over the mountains and western slope helped avoid problems, as well as near normal seasonal temperatures from March through June.

Near average summer temperatures (Figure 1), moderate cloud cover, and higher humidity than in recent years contributed to relatively low evapotranspiration rates. In combination with generous summer rains in parts of the state, irrigation water demand was less than average. This put less stress on water supplies and resulted in reservoir levels improving in drought stricken areas of southern Colorado (Figure 2). Across northern and central Colorado, summer reservoir depletions were less than average, helping to keep reservoir levels quite high even through the end of September.

It was generally a very good year for Colorado agriculture. The fall moisture in 2013 helped Colorado's winter wheat crop get off to a good start. Then well-timed spring rains gave it a strong finish. Summer rains were also generous and fairly widespread, especially over northeastern Colorado. Some dryland corn growers reported yields exceeding 150 bushels per acre, which is exceptional for dryland corn. Late season rains also contributed to good soil moisture over northeast and east central Colorado, and improved conditions over the drought-stricken southeast. As a result, the 2015 winter wheat crop appeared to be getting off to a very good start.

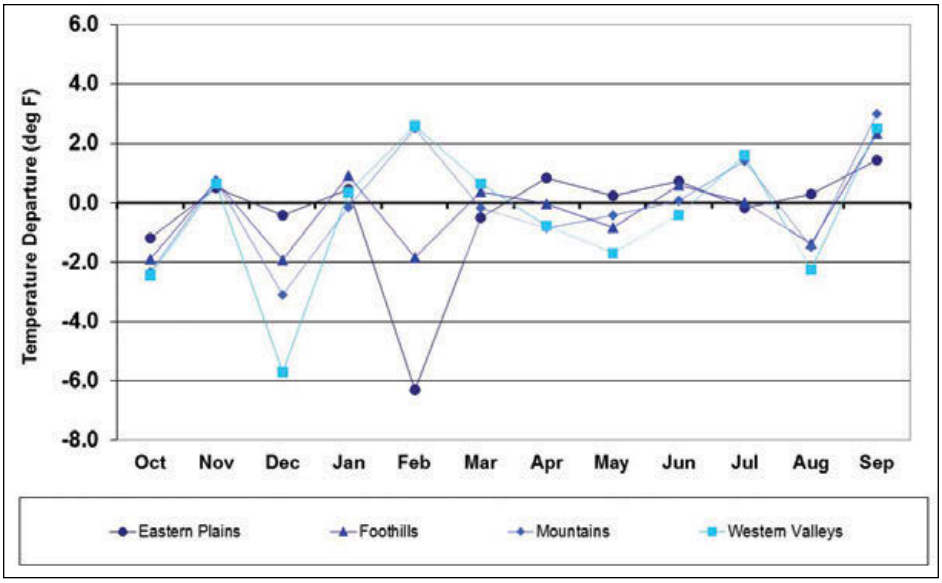


Figure 2. *Surface water supply index (SWSI) for Colorado as of October 2014. This index, based on reservoir storage in combination with streamflow (observed and predicted), showed that by the end of the 2014 water year, most of northern Colorado was experiencing abundant water supplies. Southern Colorado was generally near normal but with very small pockets of moderate drought still persisting due to lower streamflow and reservoir storage.* Courtesy of USDA Natural Resources Conservation Service

On the tough side, a late freeze in mid-May along the Front Range and some of northeastern Colorado slowed some crops, and then a very early hard freeze September 13 brought a quick end to tender garden plants in some areas (Figure 1). For Fort Collins, this was the shortest growing season since 1983. Also, on the Western Slope, the extreme subzero cold of early December appeared to damage grape vines and some fruit trees, resulting in reduced production later on. There was also February cold snap of subzero temperatures over the northeastern plains, which brought temperature anomalies of 6-12 degrees below average for the month in that region. As usual, there were local dry spots for the year, especially over southern Colorado. But since Colorado's last very wet year back in 1999 (23 inches average statewide precipitation), this was only the second year with annual precipitation at least one inch above the statewide average (19 inches). The other year was 2007, when annual precipitation averaged nearly 20 inches. The statewide average is currently between 17 and 18 inches. By comparison, 2002 received less than 11 inches (the driest water year on record), and 2012 totaled about 13 inches.

CSU Offers Free Online Course on Water Challenges

Glenn Patterson,
PhD Candidate, Watershed Science
Julie Kallenberger,
Water Education and Outreach Specialist, CSU Water Center

Courtesy of Nove da Firenze

In the spring semester of 2014, CSU offered a massive open online course called, "Water, Civilization, and Nature: Addressing 21st Century Water Challenges." The course will be repeated in the spring semester of 2015 and is scheduled to begin in February.

Ensuring sufficient clean freshwater for humans and ecosystems is one of the major challenges of the 21st century. Accordingly, in 2014, Colorado State University (CSU) combined its strength in water-related teaching and research with its growing interest in online learning to create one of the nation's first massive open online courses (MOOCs) pertaining to water. A joint project of the CSU Water Center, OnlinePlus, and The Institute for Learning and Teaching (TILT), the MOOC, entitled "Water, Civilization, and Nature: Addressing 21st Century Water Challenges," went live on January 27, 2014 and concluded on March 23. Six hundred twelve students from at least 32 countries registered for the eight-week course, which has no tuition and carries no credit. As is typical for MOOCs, participation tapered off with time, though 44 students earned a Statement of Accomplishment for completing the course. Enthusiasm among the students ran high, producing comments such as:

"I signed up for this course in the hopes that I might pick up a few tidbits of knowledge to help build my frame of reference on the subject and was delighted to find that the information you folks presented far and away exceeded my expectations."

Building on this positive reception, the Water Center, OnlinePlus, and TILT have decided to offer a revised and updated version of the course starting in February 2015.

Why a MOOC?

While the MOOC model of free tuition, no credit, eight weeks duration, and content designed to appeal to a broad audience may represent a step outside the tradition of rigorous academic courses, the concept fits well with CSU's outreach efforts. And while the course generates no tuition revenue, it does provide benefits to the University:

- Helps to establish CSU as a recognized leader in these fields of knowledge

- Demonstrates that CSU is up to date with learning technology
- Complements other outreach activities
- Helps introduce the interested public to various CSU information resources
- Helps in recruiting students
- Helps to introduce CSU faculty and their research products to a broader audience; may help in recruiting graduate students or research projects for participating faculty
- Helps advance one of the goals of CSU as a public university, which is to help educate the public

What's in the Course?

The objective of the course is to introduce a broad audience to water-related issues that are likely to influence world affairs during the 21st century, to present implications of these issues for the world as a whole and for individuals, and to describe innovative ways in which these issues are being addressed. The course is built around a series of 20-minute lectures by faculty members from several departments of the university. For the first offering of the course, these included:

- Brian Bledsoe, Civil and Environmental Engineering
- Steven Fassnacht, Ecosystem Science and Sustainability
- Mike Gooseff, Civil and Environmental Engineering
- Neil Grigg, Civil and Environmental Engineering
- Melinda Laituri, Ecosystem Sciences and Sustainability
- Chris Myrick, Fish, Wildlife and Conservation Biology
- Glenn Patterson, Geosciences
- LeRoy Poff, Biology
- James Pritchett, Agricultural and Resource Economics
- Sara Rathburn, Geosciences
- John Stednick, Forest and Rangeland Stewardship
- Reagan Waskom, Colorado Water Institute
- Ellen Wohl, Geosciences

A course developer and facilitator, watershed science Ph.D. candidate Glenn Patterson, worked with the faculty members, the Water Center, and TILT to incorporate additional content such as short video introductions, readings, web links, interactive exercises, discussions, and quizzes to round out the learning experience. Ancillary material such as water in art and music were added to pique additional interest. A few recurring geographic themes, the Colorado River, the Ogallala Aquifer, the Brahmaputra-Mekong River, and the Murray-Darling River, helped to lend some coherence, but otherwise the geographic scope of the course was intentionally very broad. The lectures were organized into eight weekly modules:

Week 1: Overview and Water Conflicts

Week 2: Agriculture, Geography, and Snow

Week 3: Leaky Rivers (The importance of physical complexity in headwater streams)

Workers along the Connecticut River as it passes through Fairlee, Vermont, United States. During the summer of 2002 a restoration project aimed at restoring a severely eroded riverbank utilized overgrown Christmas trees to create a revetment at the work site. The trees were eventually planted with various aquatic plant life to help further trap sediment and prevent erosion. Courtesy of US Environmental Protection Agency

Discharge pipe. Courtesy of US Department of Agriculture

Globally, two thirds of the burden of carrying water is borne by women. In the absence of water being accessible to households, girls and women are often forced to carry water for long distances. Loads of 20 kilograms, as shown in this image, are common. Photo by Leonard Tedd/DFID

Week 4: Groundwater, and Water Quality

Week 5: Climate Change

Week 6: Water for Aquatic Life, Restoring Streams and Wetlands, and Invasive Species

Week 7: Water-Related Disasters, and Rivers after Fire

Week 8: Gender Issues, and Integrated Water Resources Management

An outline of the course organization is evident on the menu from the home page. The recommended textbook is The World's Water, Volume 7, 2012, by Peter Gleick et al., sponsored by the Pacific Institute, and published by Island Press. For the 2015 offering, the recommended textbook will be Volume 8 (2014).

Course Delivery

The course was designed for a large enrollment, yet opportunities for student-instructor interaction were still provided. The facilitator sent out weekly announcements and joined and mediated discussion forums, frequently responding to student posts. Weekly live online office hours were offered, but few students opted for this interaction. Private email messages, however, were a more popular means of communication. The platform for course delivery was the popular "CourseSites" MOOC platform, associated with Blackboard, CSU's regular online learning system.

The Next Offering

In preparation for the second offering of the course in February 2015, the course menu was revised, with a few lectures dropped and some new ones added. Ancillary material was reviewed and updated. As with the first offering, The Water Center and Online Plus are promoting the course to a wide potential audience. For information about registration, please visit: www.online.colostate.edu/free-online-courses/water-civilization-and-nature/. Questions about the course may be directed to Glenn Patterson at glenn.patterson@lamar.colostate.edu.

To view the spring semester, 2014 MOOC YouTube videos, please visit the CSU Water Center website at www.watercenter.colostate.edu. Follow us on Facebook to learn about registration (www.facebook.com/CSUWaterCenter).

"Colorado Water: Live Like You Love It"

A New Statewide Water Message

Lindsey Bashline, Colorado WaterWise and Loveland Water and Power

There's a special ingredient in Colorado water –snow! In fact, up to 90 percent of the West's water starts as snowfall. It fluffs our skis, rocks our rafts, and fuels our lives. Though seemingly abundant, we only have a finite amount of fresh water in Colorado. But the real question is, do you Live Like You Love It?

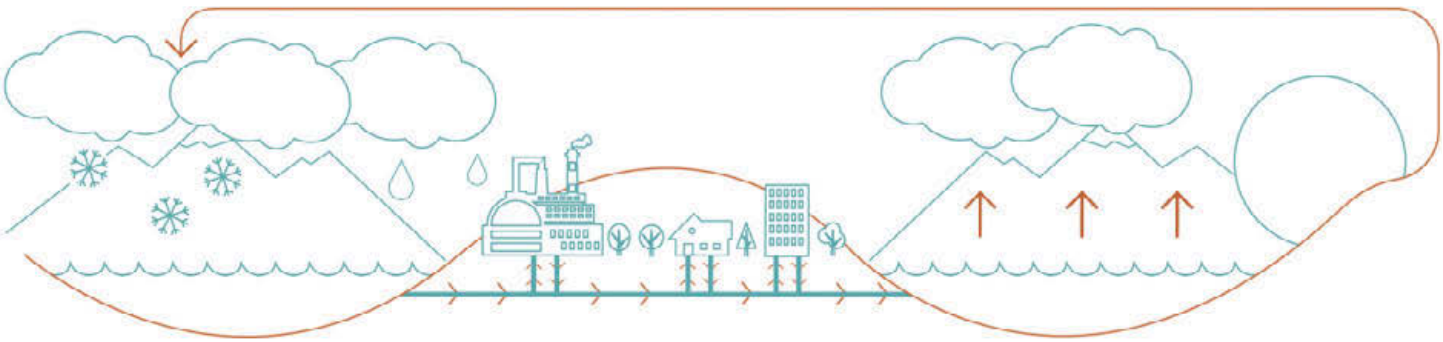
Colorado Water: Live Like You Love It is a new statewide water message that was released at the 2014 Annual Water Conservation Summit hosted by Colorado WaterWise in October. The messaging and educational toolkit provides communication tools for water stakeholders who communicate the importance of water, water conservation, and water quality. The toolkit collateral includes social media graphics and copy, tip sheets, web and print advertisements, a video, presentation templates, and a communications guide.

Through a series of stakeholder meetings, Colorado WaterWise recognized the critical importance of educating the public about the value of water they use. Sponsors for the development of the toolkit included Loveland Water and Power, the City of Greeley water conservation program, Colorado Springs Utilities, Northern Water, One World One Water, City of Fountain, and Western Resource Advocates. Colorado WaterWise retained Sigler Communications, Inc., a Denver-based strategic communications firm with water expertise, to develop components of the toolkit and a communications plan. Additionally, Colorado WaterWise tasked the firm with developing a "brand" for the toolkit including a name, slogan, and logo. After four long years, the toolkit became a reality.

"With the state of Colorado embarking upon creating its first water plan, we believe that the findings will undoubtedly be that there is a need for more education in our state about the value of our water," said Alyssa Quinn, the Colorado WaterWise committee chair.

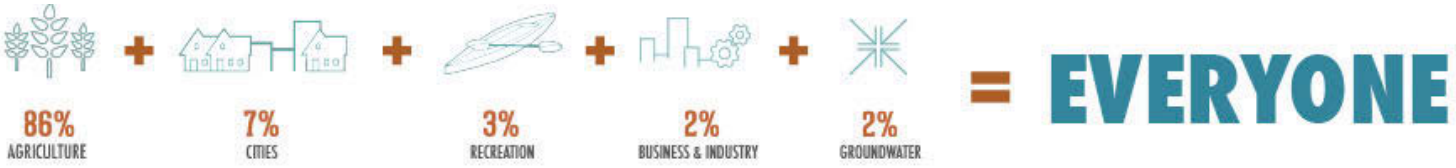
One of the major catalysts of the project was the realization that large portions of the general public, specifically young adults in the millennial generation, lack vital information about how we get our water and the scarcity of the resource. As a headwaters state, Colorado water is a topic of great discussion among the 18 states who receive water from the state. Colorado is the only state other than Hawaii where water flows out of its borders but doesn't flow in. With the Colorado population expected to double by 2050, the need to Live Like You Love It is more important than ever. The toolkit uses the positive emotional connection people have to their water to send the message. Here are ways that people can show love to Colorado water:

- **Conserve** - Conserving water and using water efficiently must be our way of life, not just a response to drought. Everyone who uses water—including farmers, consumers, businesses and recreators—has a responsibility to use water efficiently. Small changes in our daily lives can lead to significant savings.
- **Care** - Because we live in the state where water originates, Coloradans enjoy some of the best water in the country. Let's keep it that way. Whatever you put on your lawn, driveway, or park can end up in your water supply. Simple measures like picking up after pets and using pesticides and fertilizers sparingly help our water quality.



Colorado-specific water cycle graphic

Infographic created to show how water is used in Colorado



- **Commit** - Compared to other expenses—mobile phones, internet, cable television, food—water is a pretty good deal. Most consumers only pay around a half of a penny per gallon for the water coming out of their tap. However, aging infrastructure, rising energy costs, climate change, and the need for new water projects to meet a growing population will all contribute to the increasing cost of water. As demand for water increases, solutions to complex water issues will need to be crafted.

By utilizing the professionally created tools available in the toolkit, water organizations and other interested stakeholders can easily spread the word about protecting this finite resource, doing our part to conserve and committing to learning about water issues. Collateral available in the toolkit can be co-branded and is designed to be Colorado specific from the tips to the rainbow trout in the graphics.

Organizations must agree to a financial sponsorship and become a project partner of Colorado WaterWise to gain access to the toolkit, logo, and other components. Members and project partners will have access to a password-protected area of the Colorado WaterWise website to download materials.

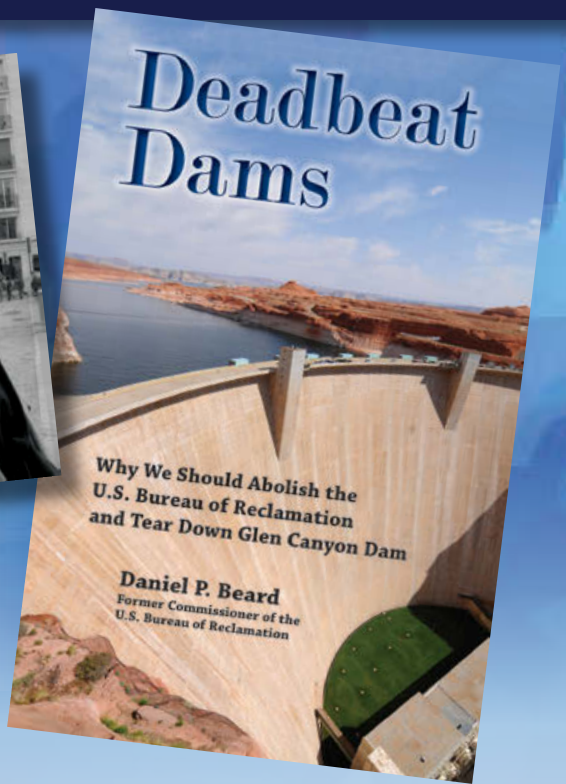
To join the movement and Live Like You Love It, like "Love Colorado Water" on Facebook or follow it on Twitter at @LoveCOWater. To find out more about the toolkit and sponsorship, visit Colorado WaterWise at coloradowaterwise.org.

In conjunction with CSU Hydrology Days 2015 and World Water Day, The CSU Water Center Presents:

DANIEL BEARD

TIME & LOCATION:

Tuesday, March 24, 2015
6:00 pm: Book Signing
6:30 pm: Presentation
Lory Student Center Theater
FREE *and open to the public*



HYDROLOGY DAYS

March 23 - March 25, 2015
Colorado State University, Fort Collins, Colorado

Hydrology Days Award Lecturer:
Scott W. Tyler, University of Nevada, Reno

Borland Lecturers:
Amilcare Porporato, Duke University; Gordon Grant, Oregon State University

CSU WATER CENTER

Colorado State University

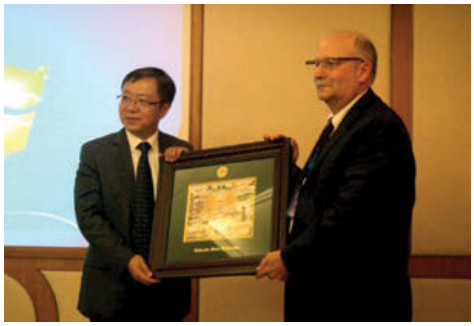
Water Center and Confucius Institute Join CSU Delegation to China

Glenn Patterson, PhD Candidate, Watershed Science, Colorado State University

In September 2014, representatives from CSU met with partner universities in China to discuss the countries' shared challenges and opportunities related to water. The CSU delegation traveled to China to open two new joint research centers, participate in two joint symposia, visit field sites pertaining to water issues, and discuss opportunities for collaboration and exchanges. CSU Water Center Director Reagan Waskom and Vice Provost for Engagement and Partnerships Lou Swanson were part of the group, which was led by Jim Cooney, Vice Provost for International Affairs, and Wei Gao, Assistant Provost for China Initiatives and Director of the Confucius Institute at CSU (CICSU). Unique among Confucius Institutes, CICSU has a research focus on water and environmental sustainability. Other delegation members represented the Natural Resources Ecology Lab, the Watershed Science Program, and the Colorado Stormwater Center.

The visit began in Shanghai, home of East China Normal University (ECNU), with the announcement by ECNU Vice President Sun Zhenrong, and CSU Assistant Provost Wei Gao, of a new ECNU-CSU Research Center on Urban Water Issues. The center will be co-directed by Kai Yang Professor of Environmental Science at ECNU, and Reagan Waskom, with Chris Olson of CSU's Colorado Stormwater Center serving as Associate Director. Speakers from both universities also participated in a Sino-U.S. Symposium on Urban Water Issues, exchanging information about stormwater management, flood control, and water quality in Shanghai, one of the 10 largest cities in the world.

Members of the CSU team visited Suzhou Creek, which has been the focus for extensive restoration work.



Clockwise from top left: *Fishermen at work in eutrophic Lake Erhai. NREL Director John Moore presents a gift to ECNU Vice President Youqun Ren in Shanghai. Jim Cooney and CCNU Vice President Wang Enke sign the agreement for the new joint research center in Wuhan. Lake Erhai, city of Dali, and Cangshan Mountain.* All photos courtesy of Glenn Patterson

They also gave a talk on climate change to a local high school, fielded questions from students, and paid a visit to the CSU Office in China. At one point two representatives from the Shanghai Science and Technology Commission, Vice Director General Xinfa Ma and Associate Director for Water Yu Qing, joined the delegation. Their Commission is a funding partner for the new research center on urban water issues. The leaders of the new research center are working on plans for joint research projects and faculty and student exchanges with the goal of advancing the science and management of urban stormwater.

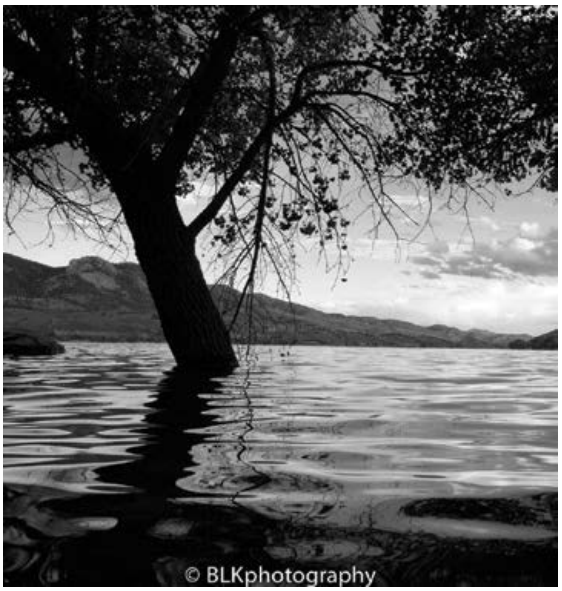
The group then traveled to Wuhan, home of Central China Normal University (CCNU), where Jim Cooney and CCNU Vice President Wang Enke signed an agreement establishing a CCNU-CSU Research Center on Aquatic Environmental Protection. Baoshang Qiu and Reagan Waskom will co-direct the center, with Professor Shao Yang of the CCNU Department of Biotechnology and Ed Hall of CSU's Natural Resource Ecology Lab serving as co-executive directors. CCNU also hosted a second symposium, a Sino-U.S. Symposium on Aquatic Environmental Protection. Major topics included eutrophic lakes, remediation of toxic contaminants, effects of land use on water quality, and sustainability of ecosystem services.

The delegation then split up, and half of the members accompanied Shao Yang of CCNU to Dali in Yunnan Province, where they visited field sites related to the algal blooms that regularly occur in Lake Erhai. As in Shanghai, the visits in Wuhan and Dali included discussions aimed toward additional research collaborations, student and faculty exchanges, and other joint activities with our Chinese colleagues.

CSU Water Center Photo Contest

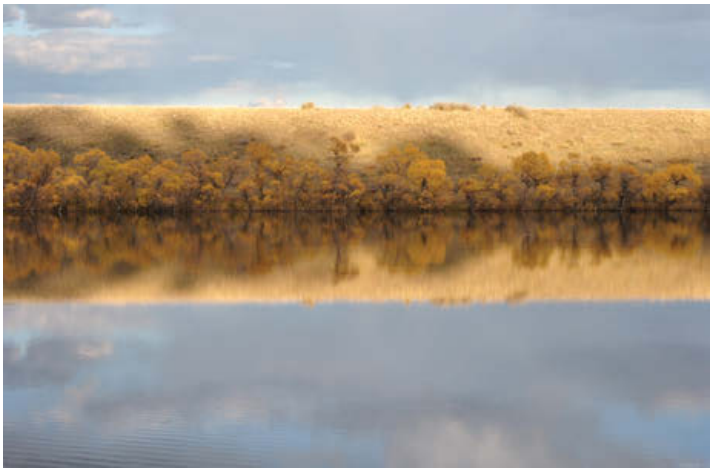
The CSU Water Center held its first student photography contest in Fall 2014. We received many creative and artistic photographs depicting the beauty and importance of water around Colorado. We would like to congratulate this year's winners and encourage all students to participate in our next contest.

1st Place: *Sprague Lake in Rocky Mountain National Park.*
Photo by Rihab Khattar (Natural Sciences)



2nd Place: *Horsetooth Lake near Fort Collins, Colorado.*
Photo by Budd Kerr (Sociology)

3rd Place: *Trout Creek, Fairplay, Colorado.*
Photo by Carter Stoudt (Agricultural and Resource Economics)



Most likes on Facebook: *Dixon Reservoir, Fort Collins, Colorado.*
Photo by Meryem Bingul (Human Dimensions of Natural Resources)

International Colloquium on Future Earth Features Water Issues in Panel, Lunch Sessions

Emilie Abbott, Student Intern, CSU Water Center

Colorado State University hosted its fifth International Colloquium on October 6-8, 2014. The theme was *Visions of Future Earth: Linking Society, Economics, and the Environment*. The university was recently selected to be a hub for Future Earth in the U.S., along with the University of Colorado at Boulder. Future Earth is a worldwide initiative to research environmental change and sustainability. This colloquium "provided students, faculty, staff, and the public with opportunities to learn about the concept of Future Earth and our shared role in global environmental sustainability," according to Jim Cooney, Vice Provost for International Affairs.

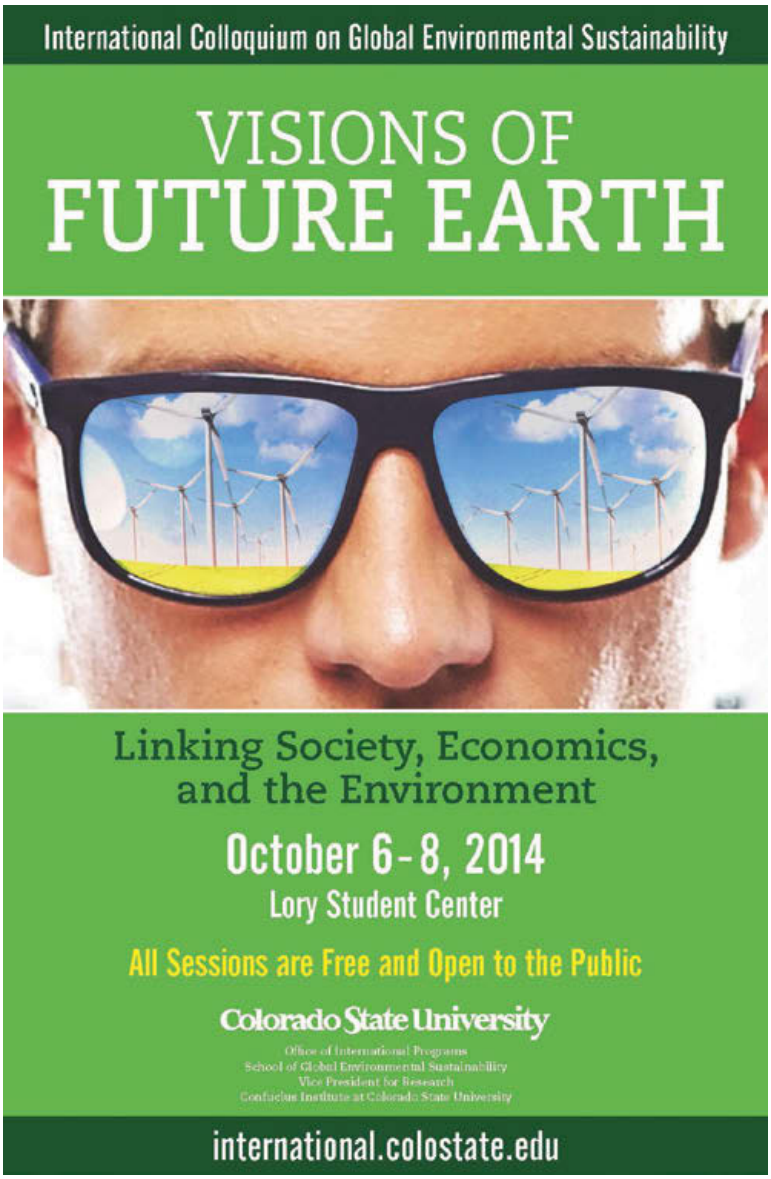
When thinking of major themes that will play a role in sustainability in the future, water undoubtedly comes to mind. To kick off the colloquium, the first panel session examined the topic of "Forging a Vision for a Sustainable Water Future." This panel featured Ben Grumbles, President of U.S. Water Alliance and former Assistant Administrator for Water, U.S. EPA; Jianjun Zhou, Professor at State Key Laboratory of Hydroscience and Engineering, Tsinghua University, Beijing, China; and Stephanie Kampf, Associate Professor, CSU Department of Ecosystem Science and Sustainability. This session was moderated by Reagan Waskom, Director of the Colorado Water Institute. Session organizers were Glenn Patterson, Ph.D. candidate in the department of Ecosystem Science and Sustainability; John Moore, Professor and Department Head of Ecosystem Science and Sustainability; and Wei Gao,

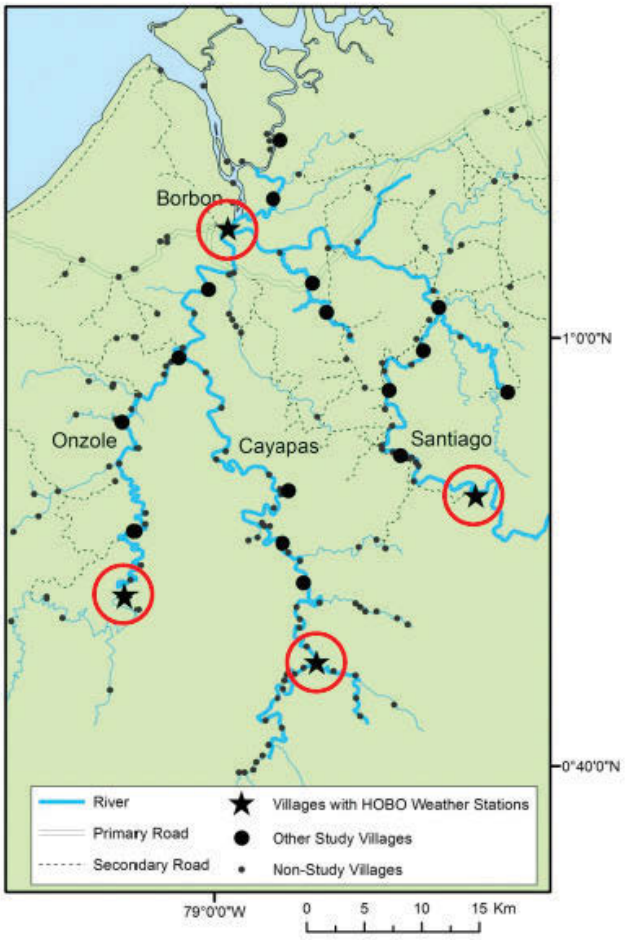
Forging a Vision for a Sustainable Water Future panel speakers. From left to right, Stephanie Kampf, Jianjun Zhou, and Ben Grumbles. Photo by Emilie Abbott

Professor of Ecosystem Science and Sustainability.

The session began with a presentation from Ben Grumbles, who addressed a need for innovation and collaboration to tackle current and future water challenges. Grumbles outlined three main threats to water sustainability. The first was the fact that water is forgotten and taken for granted. Water infrastructure is hidden and is in disrepair in many places. Also, water's low cost does not reflect its full value. The second threat is fractured and fragmented policies. He argued that sustainability comes from thinking about energy, water, and land together, which necessitates collaboration between agricultural and municipal entities, among others. The third threat is fearful and frozen innovators—Grumbles advocated for a system that would encourage innovation in the water industry. Grumbles went on to outline some possible scenarios for the future that would improve the current system in innovative ways. One example of this is the idea of a Watershed Protection Utility. Another idea which is already being implemented at a relatively small scale in many places around the globe is green infrastructure. Grumbles suggested that this needs to extend far beyond simple rain gardens and green roofs into cities where natural features are fully integrated into the urban environment.

Jianjun Zhou focused on changes in the Yangtze River in recent decades, specifically changes due to the construction of many dams, including the famous Three Gorges





Left Photo: *Visions of Future Earth: Linking Society, Economics, and the Environment Colloquium poster*
Above Photo: *Map of data collection sites in Ecuador.*
Courtesy of Elizabeth Carlton

Dam. One of the changes caused by these dams is the endangerment or extinction of species. In addition, the amount of discharge in the river is decreasing, causing once-rare droughts to become common. This is especially true in the fall season, which then results in the reservoirs not having sufficient water in the spring. Sediment loads are also affected, especially during the dry season at sites such as the Yichang station (immediately downstream from the Three Gorges Dam) where instead of a pattern of sedimentation and erosion, there is only erosion. This pattern continues down the Yangtze. Lake Dongting, to which water from the Yangtze is diverted, has seen a steady decrease in volume and sediment load due to decreased flows overall and retention of water in the Three Gorges Reservoir. Zhou also addressed nutrient loads, temperature fluctuations, and chlorophyll a concentration. In summary, Zhou stated that although the full effects of these megadams are not yet known, adding more dams will only intensify these negative effects. Zhou stressed that water sustainability can only be achieved when humans prioritize rivers over the GDP—when we care for, preserve, and restore the rivers instead of dumping and exploiting as we have done and continue to do.

While Ben Grumbles discussed water on a national scale and Jianjun Zhou brought an international perspective, Stephanie Kampf focused her presentation on the Poudre River, specifically related to distributed impacts of snow, fire, and floods. Snowpack is extremely important in the Poudre River watershed as over half the water supply comes from snowy areas covering less than 20 percent of the basin. To monitor this snowpack, there are currently snow telemetry (SNOTEL) water supply forecasting stations around the watershed. A problem highlighted

by Kampf is that in Colorado, there are no SNOTEL stations in areas of intermittent snow, which are most sensitive to losses in the persistent winter snow. These gaps in crucial data must be filled in order to be able to understand and protect these vulnerable areas.

Aside from snow, Kampf addressed the recent High Park fire and some concerns it raised about water, such as water quality degradation, flood hazard, debris flow hazard, and road washout. High-intensity localized rains following the fire caused channel scouring and erosion and washed sediment into the Poudre River. There is now a need for mulching and other restoration projects to mitigate these water quality impacts in the future, focusing on the areas with the greatest downstream impacts. Kampf then spoke about the September 2013 flood. Again, this flood was an example of distributed impacts of extreme events. While roads were destroyed and previous peak flow records were shattered in some areas, this event was not out of the normal rainfall range in other areas. For future flood events, there is a need for rapid warnings, responses targeted to the most affected areas, and long-term land use planning to reduce vulnerability. As far as water sustainability, Kampf identified different needs for dry times and wet times. In dry times, we must diversify our water supply by employing techniques such as rain collection and reduce demand by xeriscaping and installing efficient irrigation systems. In wet times, we must take into account that developed areas have higher peak flows and create solutions to lessen these flows, such as allowing for stormwater infiltration along roads and planning recreation areas that double as stormwater management. Lastly, Kampf noted the importance of community education to encourage awareness of and participation in the local watershed.

On October 7, Elizabeth Carlton of the Department of Environmental and Occupational Health at the University of Colorado at Denver presented a lunchtime talk on "Estimating the effects of climate change on waterborne diseases: Challenges and opportunities." Carlton is an environmental epidemiologist who works with neglected tropical diseases. Her goals are to study climate-disease relationships and to account for demographics and social and environmental stressors occurring along with climate change. In this lecture, Carlton detailed three projects she has worked on which dealt with disease and climate change. The first project examined the correlation between heavy rainfall events and diarrhea incidence in villages of northern coastal Ecuador. The study also looked at whether the incidence of diarrhea was related to the vulnerability of the community: level of sanitation, drinking water treatment, hygiene, and social cohesion. Carlton also described a graduate student's project on the impact of climate change on the water-borne disease burden in China. This study looked at potential future changes in access to safe water and sanitation via an exponential increase in access, a linear increase, or maintenance of the current trend. The study then modeled each of these scenarios paired with different projected levels of greenhouse gas emissions to examine effects of climate change on reducing the disease burden. Carlton's third project studied the potential impact of climate change on O*pisthorchis viverrini*, a parasite that is usually transmitted to humans through raw fish and which causes bile duct cancer. This parasite is common among the poor in Thailand and other areas of Southeast Asia. The research looked at a combination of three lakes that flood in the wet season, increasing the amount of feces in the water. In the dry season, the lakes are isolated, providing an opportunity to examine the role fish dispersion may play in the spread of disease. This study also has a cultural element—raw fish is especially common among the Laotian population in Thailand, so any efforts to change the local diet for safety reasons have cultural implications. Carlton also participated in a panel session later the same evening which addressed how changing environmental conditions impact emerging disease.

A problem highlighted by [presenter Stephanie] Kampf is that in Colorado, there are no SNOTEL stations in areas of intermittent snow, which are most sensitive to losses in the persistent winter snow. These gaps in crucial data must be filled in order to be able to understand and protect these vulnerable areas.

The colloquium was hosted by the Office of International Programs with support from the School of Global Environmental Sustainability, the Confucius Institute, and the Vice President for Research. Other sessions addressed topics such as the Arctic, biodiversity, education abroad, and climate-smart agriculture.

A New Window to the Irrigated Past

Patricia J. Rettig, Head Archivist, Water Resources Archive, Colorado State University Libraries

It's the collection we'd been waiting for. Seventeen boxes of original reports, data, letters, articles, and charts. Five boxes of photographs and negatives. All related to irrigation research. Created from sixty to one hundred years ago!

Known as the Irrigation Research Papers, this collection has a long history, significant content, and a happy home at last. The materials have been saved and stored for nearly forty years, but only now does the Water Resources Archive have the opportunity to preserve them and make them accessible to the public.

A Long History

The collection's story begins in 1975, when Gordon Kruse, now retired from the USDA Agricultural Research Service, donated the Irrigation Research Papers to the Colorado State University Libraries. The materials originated from predecessors in Kruse's office, and he knew the importance of those people and their work. In a letter a decade later, Kruse affirmed that "the archived materials are of enduring value and should be retained." Due to storage space limitations at the Libraries, the archivist at the time made arrangements for the collection (and several others) to be stored at the Colorado State Archives. Staff there would be able to retrieve it upon request.

After the Water Resources Archive was formed in 2001, we determined that the Irrigation Research Papers should be part of the new archive. Having expanded storage space, we contacted the State Archives to request its return in full, but the collection could not be readily located amongst their many thousands of boxes. Not until this year, that is. A renewed request uncovered the collection, and we picked it up from Denver in early September.

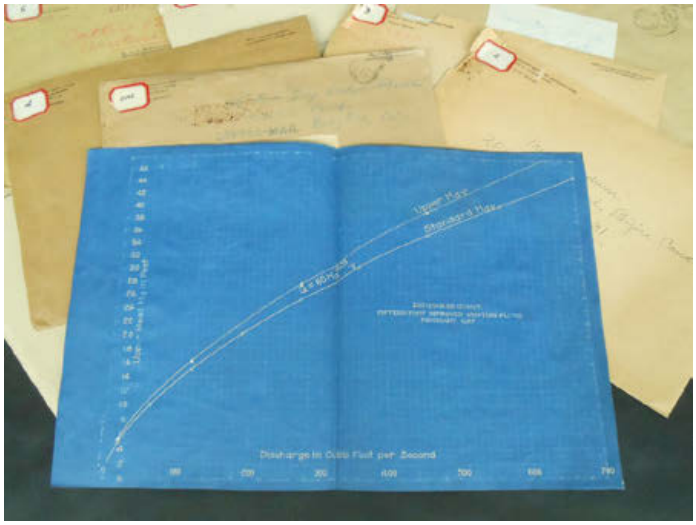
Photograph from the late 1890s or early 1900s of the Home Supply Dam on the Big Thompson River.
Courtesy of the Water Resources Archive, CSU Libraries

Significant Content

For years, we had been eagerly hoping for and anticipating the return of this collection, knowing it had some wonderful materials in it. Upon initial inspection, it has proven to be even better than expected! We knew that the materials documented the research and activities of USDA irrigation researchers and their CSU collaborators, such as Ralph Parshall, Carl Rohwer, V. M. Cone, and Bill Code. These are the men whose research furthered the understanding of irrigation methods, equipment, and techniques in the early twentieth century. Parshall developed what he called the Improved Venturi Flume, a device eventually renamed for him and still used around the world.

Nearly 500 numbered manila envelopes containing Parshall's and his group's original data, report drafts, letters, charts, and more fill seventeen boxes. Subjects cover flumes, weirs, meters, sprinklers, wells, pumps, and other equipment, as well as seepage, snow surveys, and other subjects related to irrigation and water supply. Various locations are documented, primarily being in or near Fort Collins and Bellvue—where the group had a laboratory—with Colorado's San Luis and Arkansas valleys also included. Additionally, the team collected data and information from other

The Irrigation Research Papers collection contains hundreds of glass plate negatives, capturing intriguing—but often unidentified—images. Courtesy of the Water Resources Archive, CSU Libraries



Ralph Parshall and his colleagues gathered nearly 500 envelopes of charts, letters, data, drafts, and reports related to irrigation research in the early 20th century. Courtesy of the Water Resources Archive, CSU Libraries

states, including Wyoming, Idaho, California, North Dakota, and Texas.

The photographic materials were a wonderful surprise! The five boxes of photos contain at least 3,000 images in a variety of formats. There are both negatives and prints, with many of the negatives being on glass plates or nitrate film, both early and fragile media. The images were all arranged into topical categories such as Structures, Canals, Pumping, Snow Surveys, and so on, with further breakdowns as needed such as Dams, Headgates, Siphons, and Flumes under Structures. Beyond the categorization, often there is no further information on locations, dates, or people's names, unless written on the backs of prints. It is entirely possible that half or more of the images will be unidentified. Nevertheless, just by browsing, we have found previously unseen photos of Parshall, stunning pictures of dams at the turn of the century, and snapshots of men immersed in streams measuring flow.

This set of papers and photographs provides insight into not only early research on irrigation in Colorado, but also the activities of the researchers, their working methods, and their unpublished knowledge. Correspondence exchanged with ditch companies about the latest research and experiments reveals the interests of practicing irrigators. Additionally, the visual materials allow us to examine exact conditions, environments, and practices. Altogether, the collection provides both the "big picture" of federal and university irrigation research at the time, as well as the finer details of the impact of that research on practitioners. The collection certainly holds numerous stories, and we look forward to researchers digging into it to write articles, enhance presentations, and distribute that information to the wider world, helping us all to understand better the effort it took to reach today's common practices and standard equipment.

A Happy Home

To facilitate research over the long term and make these materials last along as possible, the Water Resources Archive is doing significant preservation work. Acidic envelopes cause discoloration and brittleness, and fragile formats become more delicate over time. Two students have been assigned to the work of rehousing and inventorying the materials. For both preservation and access purposes, digitization of the images will begin as soon as possible.

Now back in our possession, the Irrigation Research Papers will finally get the care and attention it deserves. We hope to post the collection inventory online early in 2015, with digitized materials soon to follow. In the meantime, feel free to request access in the Archives reading room in Morgan Library—or volunteer to help identify a few thousand images!

For more information about this or other Water Resources Archive collections, see our website (http://lib.colostate.edu/water/) or contact me (970-491-1939; Patricia.Rettig@ColoState.edu) at any time.

Water Research Awards

Colorado State University (September 16, 2014 to November 15, 2014)

Abt, Steven R, Civil & Environmental Engineering, Georgia Institute of Technology, Combining Individual Scour Components to Determine Total Scour, $11,573

Arabi, Mazdak, Civil & Environmental Engineering, Humboldt State University Foundation, Assessing the Benefits of Wetlands in the Upper Klamath River Basin on Water Quality, $30,573

Arabi, Mazdak, Civil & Environmental Engineering, USDA-Agricultural Research Service, Improve and Enhance the Object Modeling System for Building New Models and Conservation Tools and Transferring, $112,000

Bestgen, Kevin R, Fish, Wildlife & Conservation Biology, DOI-Bureau of Reclamation, Abundance Estimates for Colorado Pikeminnow in the Green River Basin, Utah and Colorado, $212,082

Bestgen, Kevin R, Fish, Wildlife & Conservation Biology, DOI-Bureau of Reclamation, CSU Assistance in Recovery of Endangered Fish, $20,063

Bestgen, Kevin R, Fish, Wildlife & Conservation Biology, DOI-Bureau of Reclamation, Identification and Curation of Larval and Juvenile Fish by Colorado State University Larval Fish Laboratory, $139,100

Bestgen, Kevin R, Fish, Wildlife & Conservation Biology , DOI-Bureau of Reclamation, Monitoring Effects of Flaming Gorge Dam Releases on the Lodore/Whirlpool Fish Community, $19,646

Bledsoe, Brian, Civil & Environmental Engineering, Colorado Division of Parks and Wildlife, Upper Arkansas River Stream Rehabilitation Habitat Comparison and Vegetation Monitoring, $121,170

Chavez, Jose L, Civil & Environmental Engineering , Various "Non-Profit" Sponsors, Implementation of Deficit Irrigation Regimes: Demonstration and Outreach, $17,500

Fontane, Darrell G, Civil & Environmental Engineering, Water Resources University (Vietnam), Capacity Building of Vietnam Water Resources University, $20,963

Gates, Timothy K, Civil & Environmental Engineering, USDA-NIFA-National Institute of Food and, Water Quality and Productivity Enhancement in an Irrigated River Basin through Participatory Conservation Planning and Analysis, $329,977

Hawkins, John A, Fish, Wildlife & Conservation Biology, DOI-Bureau of Reclamation, Evaluation of Smallmouth Bass and Northern Pike Management in the Middle Yampa River, $102,987

Johnson, James Bradley, Biology, Colorado Water Conservation Board, Empowering Future Management and Conservation of Water in Colorado by Building Mitigation Capacity, $65,000

Kampf, Stephanie K, Ecosystem Science & Sustainability, City of Greeley, Effects of Mulch Treatments on Peak Flows, Sediment Delivery, and Water Quality in the High Park Fire, $87,098

Schranz, Sherri M, CIRA, DOC-NOAA-Natl Oceanic & Atmospheric Administration, Hydrologic and Water Resources Research and Applications Outreach, $91,041

S**ueltenfuss, Jeremy**, Colorado Natural Heritage Program, Environmental Protection Agency, Colorado Wetland Tools 4: Watershed Planning Toolbox, $89,187

Venkatachalam, Chandrasekaran, Electrical & Computer Engineering, University of Massachusetts, Hazard SEES Type 2: Next Generation Resilient Warning Systems for Tornados and Flash Floods, $90,000

Waskom, Reagan M, Colorado Water Institute, University of Colorado, SRN: Routes to Sustainability for Natural Gas Development and Water and Air Resources in the Rocky Mountain Region, $32,723

Golden, CO.
Photo by Ryan O'Shea

Calendar

March

30-1 **2015 AWRA Spring Specialty Conference; Los Angeles, CA**
The conference, *Water for Urban Areas: Managing Risks and Building Resiliency,* will have over 60 presenters working and researching topics related to water and wastewater services nationwide and internationally.
www.awra.org/meetings/LosAngeles2015

April

13-15 **2015 Federal Water Issues Conference; Washington, D.C.**
National Water Resources Association presents Federal Water Issues
www.nwra.org/upcoming-conferences-workshops.html

13-16 **Colorado Rural Water Association's 34th Annual Conference & Exhibition; Denver, CO**
The conference covers a wide range of programs with multi-simultaneous sessions including water, wastewater, source water, groundwater, and management and operator certification topic.
https://coloradoruralwater.sharepoint.com/Pages/2014AnnualConference.aspx

May

1 **AWRA Colorado 2015 Symposium; Golden, CO**
This one-day symposium will bring together experts from governmental agencies, academia, the private sector, and non-profits to present and discuss challenges and opportunities that we will face in the next 5 to 6 years.
www.awracolorado.org/call-for-abstracts-awra-colorado-2015-symposium-colorado-2020clearly-seeing-our-future/

20-22 **2015 Open Science Conference; Fort Collins, CO**
This conference will bring together the regional climate research community and local stakeholders to foster productive engagement with the North Central Climate Science Center.
http://revampclimate.colostate.edu/conference

June

18-20 **39th Annual Colorado Water Workshop: *The People's Water;* Gunnison, CO**
Join us in Gunnison for three days of presentations, conversation, and debate on water issues in Colorado and the West.
www.western.edu/academics/undergraduate/environment-sustainability/conferences/colorado-water-workshop

August

16-18 **2015 UCOWR/NIWR/CUASHI Conference; Las Vegas, NV**
Water is Not for Gambling: Utilizing Science to Reduce Uncertainty
http://ucowr.org/conferences

19-21 **Colorado Water Congress Summer Conference; Vail, CO**
The high-energy Summer Conference is packed with great topical content. It's a don't-miss event for those who wish to stay informed about water issues in Colorado while engaging in numerous professional development activities.
www.cowatercongress.org/cwc_events/Summer_Conference.aspx

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Lafayette Lake, Lafayette, CO.
Photo by Lloyd Rochester