Colorado Water Institute

2014 - 2015 Annual Report

Colorado State University

Contents

Message from the Director

This has been another outstanding year at the Colorado Water Institute. CWI continued to serve its research, outreach, and training mission through funding research projects and student internships in cooperation with the Colorado Water Conservation Board and the U.S. Geological Survey. Several of our projects are highlighted in this annual report, including our work on the Cache la Poudre and Colorado rivers.

CWI staff had the opportunity this year to collaborate with U.S. Department of State and U.S. Army Corps of Engineers on providing U.S. inputs to the international dialog on the water-energy-food nexus. Additional work on hydraulic fracturing and agricultural conservation put CWI in the middle of currently controversial water topics in Colorado. Regional Water Specialist Blake Osborn was hired to work in the Arkansas River Basin and across southern Colorado.

This year marks the 50th anniversary of CWI. Through the work of outstanding past leaders such as Robert Ward, Neil Grigg, and Norm Evans, the institute has worked with faculty and students from all of Colorado's institutions of higher education to produce many important projects that provide water managers with new information to improve decision-making. While the societal context of water management continues to evolve, we confront the same water management, quality, and quantity problems as Colorado seeks to cope with limited water supplies punctuated with periodic drought and flood. CWI will continue to support the training of the next generation of water managers through research project funding and internships.

As CWI director, I am pleased to report this year that the institute continues to benefit from a committed staff, excellent support from Colorado State University upper administration, strong research faculty at Colorado universities, and the guidance of an outstanding advisory committee. This annual report contains only the highlights of our activities in service to Colorado this past year. More information on our activities can be found at www.cwi.colostate.edu.

Cover Photo: Chatfield Reservoir, Colorado. Photo courtesy of Kent Kanouse

COLORADO WATER RESEARCH

CWI, an affiliate of Colorado State University (CSU), exists for the express purpose of focusing the water expertise of higher education on the evolving water concerns and problems being faced by Colorado citizens. CWI coordinates research efforts with local, state, and national agencies and organizations. CWI works closely with researchers, scientists, and private industry to develop sound science that assists and informs Colorado water managers and users. CWI accomplishes this by facilitating the transfer of new water knowledge and assisting in educating the next generation of Colorado water professionals by working with all Colorado institutions of higher education.

OUTREACH/INFORMATION TRANSFER

CWI collaborates with CSU Extension to house three water outreach specialists around the state. CWI operates several websites with up-to-date water information that have become a consistent source of knowledge for water professionals and community members alike. Publications available on these sites include research reports and Colorado Water, a bimonthly newsletter containing information on current research, water faculty, outreach program updates, climate, water history, Colorado State Forest Service updates, and water-related events and conferences, featuring a different research theme each issue.

CWI outreach activities are conducted in conjunction with the CSU Water Center, CSU Extension, the Colorado Agricultural Experiment Station, the Colorado State Forest Service, and the Colorado Climate Center. Our primary partners include water managers, water providers, and water agencies.

TRAINING

One of CWI's primary missions is to facilitate the training and education of university students. To this end, the institute works with the U.S. Geological Survey and the Colorado Water Conservation Board to place student interns in positions and also funds student research grants and manages scholarships on behalf of students. Student researchers funded by CWI work with faculty members and gain valuable water expertise as well as knowledge of the research process.

Ph.D. student Rosemary Records (left) and Steven Fassnacht, Professor of Snow Hydrology, construct a meteorological tower to estimate snow surface roughness (see page 8).

CWI Websites

cwi.colostate.edu/southplatte/

cwi.colostate.edu/ThePoudreRunsThroughIt/

crbagwater.colostate.edu/index.shtml

cwi.colostate.edu/workshops/nexus2014/Default.aspx

agwaterconservation.colostate.edu/

2 Selected Current Projects

FACULTY RESEARCH PROJECTS

Using Remote Sensing Assessments to Document Historical and Current Saved Consumptive Use (CU) on Alfalfa and Grass Hayfields Managed Under Reduced and Full Irrigation Regimes: A New CU Documentation System
Perry Cabot and Jose Chavez, Colorado State University; CWCB

Data Collection and Analysis in Support of Improved Water Management in the Arkansas River Basin, Phase 2
T.K. Gates and Jeffrey Niemann, Colorado State University; CWCB

Modeling the Influence of Conjunctive Water Use on Flow Regimes in the South Platte River Basin Using the South Platte Decision Support System Groundwater Flow Model
Ryan Bailey, Domenico Bau, and Ayman Alzraiee, Colorado State University; CWCB

Evaluating the Time Series Discontinuity of the NRCS Snow Telemetry (SNOTEL) Temperature Data across Colorado
Steven Fassnacht and Amanda Weber, Colorado State University; CWCB

River Change and Flood Hazards on the Colorado Front Range
Brian Bledsoe and Joel Sholtes, Colorado State University, CWCB

The Ecological Benefits of Irrigated Agriculture and Potential Risks Under Changing Water Allocation/Supply
David Cooper and Erick Carlsen, Colorado State University; CWCB

Determination of Consumptive Water Use of Winter Wheat in the Arkansas Valley (Year 2)
Allan Andales, Michael E. Bartolo, and Lane Simmons, Colorado State University; CWCB

Spatio-temporal Snow Surface Roughness Changes Due to the Impurities and Their Implication for Hydro-climatic Modeling
Steven Fassnacht, Colorado State University; CWI

WOOD: Windows of Opportunity for Debris Retention in Response to 2013 Front Range Flooding
Ellen Wohl, Colorado State University; CWI

Uniting Water Related Research Expertise in Latin America at CSU
Edward Hall, Colorado State University; CWI

Alternatives to Permanent Fallowing Research Synthesis and Workshops
Brad Udall, Colorado State University; Walton Family Members

Economic Impact Analysis of Decreased Crop Production Due to Reduced Groundwater Irrigation in the San Luis Valley
James Pritchett, Colorado State University; San Luis Valley

SRN: Routes to Sustainability for Natural Gas Development and Water and Air Resources in the Rocky Mountain Region
Reagan Waskom, Colorado State University; CU-Boulder

Enhancing Decision-Making by Agricultural Producers in Colorado with Weather Variability: Reducing Enterprise
Lou Swanson, Reagan Waskom, and Brad Udall, Colorado State University; USDA-ARS

Moving Forward on Agricultural Water Conservation in the Colorado River Basin
Reagan Waskom, Colorado State University; USDA-NIFA

Trace Organic Contaminants (TOrCs) in Urban Stormwater and Performance of Urban Bioretention Systems: A Field and Model
Christopher Higgins, Colorado State University; NIWR 104 G/DOI-USGS

Application of Remotely Sensed Data for Improved Regional and National Hydrologic Simulations - Year 2
Terri Hogue, Colorado School of Mines; DOI-USGS-Geological Survey

ICIWaRM Research Workshops and Advisory Committee
Reagan Waskom, Colorado State University; DOI-USGS-Geological Survey

MOWS - Modeling of Watershed Systems NIWR-USGS Student Internship II
Steve Reagan, USGS; DOI-USGS-Geological Survey

USGS Sedimentary Transport Internship
Allen Gellis, USGS; DOI-USGS-Geological Survey

WEBB - Water, Energy, and Biogeochemical Budgets NIWR-USGS Student Internship Program
Reagan Waskom, Colorado State University; DOI-USGS-Geological Survey

STUDENT RESEARCH PROJECTS

Combined Influences of Hydrologic Connectivity and Nutrient Uptake on System-scale Retention
Tim Covino, Colorado State University; NIWR 104B/DOI USGS

Temporal Consistency of Spatial Snowpack Properties
Steven Fassnacht, Colorado State University; NIWR 104B/DOI USGS

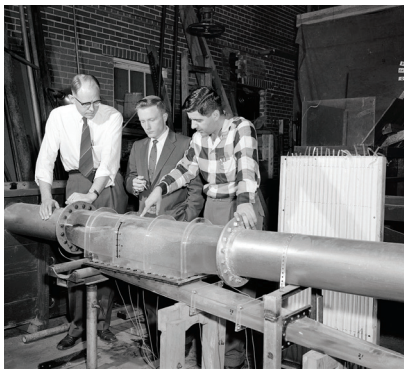
Impact of Limited Irrigation on Health and Growth of Three Ornamental Grass Species
James Klett, Colorado State University; NIWR 104B/DOI USGS

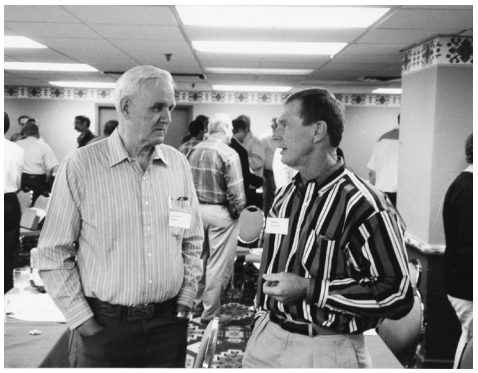
Identifying Differential Access in Water Allocation Mechanisms: Water Rights for Oil and Gas Development in Colorado
Melinda Laituri, Colorado State University; NIWR 104B/DOI USGS

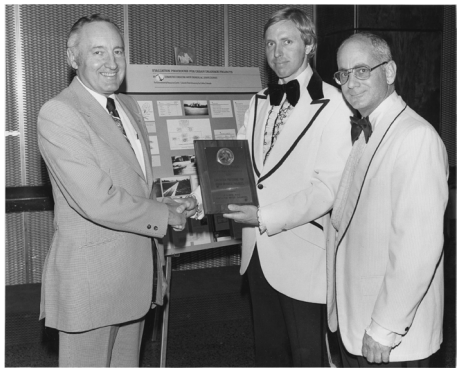
Groundwater Recharge Within the South Platte Basin
John McCray, Colorado State University; NIWR 104B/DOI USGS

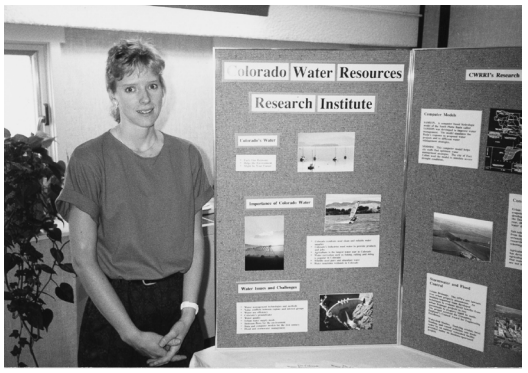
Floating Wetlands Systems: Managing Aquatic Plants as a Salt and Se Sequestration Strategy
Gigi Richard, Colorado State University; NIWR 104B/DOI USGS

Nutrient Retention and Productivity in Rocky Mountain Streams Under Alternative Stable States
Dana Winkelman, Colorado State University; NIWR 104B/DOI USGS









Above Photos (left to right): 1.) Maury Albertson (left) and Ray Chamberlain (center), pictured in the CSU Hydraulics Lab in 1958, were among CSU's many faculty members who have pushed the growth of water programs and research. 2.) One of the institute's leading goals is to connect academia with the greater water community. Here, local water manager Ralph Curtis talks to CSU professor Dan Smith. 3.) Former CWI director Norm Evans (director from 1967-1988) congratulates Leonard Rice Consulting Water Engineers on a project award, 1975. 4.) Martina Gessler (now Martina Wilkinson), who edited CWI publications in the early 1990s, represents the institute at a State Fair Exhibit.

Over its 50 year history, the Colorado Water Institute has been led by five directors, run by several dedicated staff members, and influenced by the work of many students, faculty, and water professionals throughout the state. The institute has overseen the publication of more than 225 completion reports, 116 information series reports, and over 100 other publications that signify both the institute's dedication to supporting water research and its adherence to outreach, which includes making the research detailed in these reports widely accessible. Serving as a gateway between the state's water academia and the greater community of water professionals in the state, CWI has filled the role of water research, education, training, and outreach since it was first established under the auspices of the state's land grant university, Colorado State University (CSU), in 1965.

CWI owes a great deal to those who have come before in the water community. Colorado's semi-arid climate, its water law system, and its status as a headwaters state make Colorado home to a wide variety of complex water issues. CWI has funded and participated in a wide variety of research topics over the years, with an evolving focus from water management and storage to water quality to drought and climate issues. Recurring topics have included groundwater research and development, consumptive use, water transfers, modeling projects, and water supply, and water use efficiency. Water leaders like Elwood Mead, Louis Carpenter, and Ralph Parshall in the early 1900s and many current and retired water faculty have helped build the strong interdisciplinary network that has approached such topics over the years. When the Water Resources Research Act that founded the institutes, including CWI, passed in 1964, CSU's own president Bill Morgan played a central role by acting as a spokesperson to Congress for institutes of higher education. With this foundation, CWI has been involved with efforts that include helping assemble the Water Resources Archive, which assembles and preserves historic water documents that would otherwise be lost; projects that connect water managers and agricultural producers with research that meets their needs; and support of the training and education of future water leaders, among other efforts.

The institute looks forward to continuing the partnerships formed over its first 50 years as Colorado faces its own unique water challenges in the years to come.

4 Investigation of the Effects of White Water Kayak Parks on Aquatic Resources in Colorado

Tim Stephens, Graduate Student, Civil and Environmental Engineering, Colorado State University
Brian Bledsoe, Civil and Environmental Engineering, Colorado State University
Matt Kondratieff, Colorado Parks and Wildlife, Aquatic Wildlife Research Section, Fort Collins Research Center
Eleanor Kolden, Civil and Environmental Engineering, Colorado State University
Brian Fox, Civil and Environmental Engineering, Colorado State University

The reproductive success of migratory fishes and other organisms depends on the quantity, quality, and connectivity of available habitats that vary spatially and temporally across dimensions and scales. Human extraction of water resources has resulted in fragmentation of many rivers by dams, diversions, and other instream structures. When impassable, these structures cut off necessary habitat linkages and migration routes of aquatic organisms, particularly fishes. Successful passage for fishes of all life stages across barriers to migration is imperative to restore and maintain ecosystem function, and structures are often designed and constructed without direct knowledge of fish passage success in response to altered hydraulic conditions. Velocity, depth, turbulence, and vorticity can impact the ability of fish to swim upstream.

A whitewater park (WWP) consists of one or more instream structures primarily constructed to create a hydraulic jump that is desirable to recreational kayakers and other boaters. The hydraulic jump is typically formed by grouting a laterally constricted chute over a steep drop into a downstream pool. WWPs provide a valuable recreational and economic resource that is rapidly growing in popularity. WWPs were originally thought to enhance aquatic habitat; however, recent studies have shown that WWPs can act as a partial barrier to upstream migrating trout, and WWP pools may contain lower densities of fish compared to natural pools.

Whitewater parks may pose a barrier for upstream fish movement.

Kimon Berlin

Concerns have arisen that the hydraulic conditions required to meet recreational needs are contributing to the suppression of movement of upstream migrating fishes and disruption of longitudinal connectivity. Without a direct understanding of the factors contributing to the suppression of movement in WWPs, making informed management and policy decisions regarding WWPs will continue to be difficult and could have unintended consequences.

This study used the results from a three-dimensional computational fluid dynamics model to provide a continuous and spatially explicit description of the hydraulic conditions along potential fish movement paths and examine their influence on fish passage at a WWP on the St. Vrain River in Lyons, Colorado. Quantifying the hydraulic conditions in this manner captured important and unique hydraulic characteristics at each WWP, and described velocity and depth throughout the flow field at a scale meaningful to a fish. Logistic regression indicated a significant influence of velocity and depth on passage success, and accurately predicted 87 percent of individual fish movement observations. However, cost, vorticity, and turbulent kinetic energy did not have a significant effect on passage success. When designing hydraulic structures for fish passage, it is imperative that continuous movement paths exist, providing adequate depth and velocities that do not exceed fish swimming capabilities. Similar hydraulic analyses coupled with fish movement data can be utilized to evaluate the effects of hydraulic conditions on passage success at other types and sizes of hydraulic structures. This study lays the groundwork for a novel and powerful approach to mechanistically evaluate the effects of hydraulic structures on fish passage. Further, the results of this study can serve as a reference for managers and policy makers, provide design guidance for future hydraulic structures, and be used to evaluate existing structures of similar size, design type, and hydrologic regime.

Brian Bledsoe teaches an environmental river mechanics lab on the Cache la Poudre River in Fort Collins.

Tim Stephens and a fellow student on the Cache la Poudre River northwest of Fort Collins test a method for surveying whitewater parks that are too difficult to wade.

6 Impact of Limited Irrigation on Health of Three Ornamental Grass Species

Sam Hagopian, MS Candidate, Horticulture and Landscape Architecture, Colorado State University
James Klett, Horticulture and Landscape Architecture, Colorado State University

This work is part of a two-year study, and only preliminary data and analyses have been reported thus far. The purpose of this study is to quantify a feasible irrigation standard at which ornamental grasses should be watered. More generally, it is important to know if deficit irrigation is feasible with ornamental grasses. In Colorado's climate, is this deficit irrigation feasible once periods of drought are introduced? While studies have touched on growing these grasses, this study serves as a pioneer in linking ornamental quality with physiological stress and growth. Discovering critical water potentials and other aspects of plant stress will help give a baseline for the levels of stress these plants can endure while maintaining aesthetic quality. A final goal lies in quantifying the actual evapotranspiration (ET) that these plants undergo. Industry personnel and researchers tend to base a majority of irrigation practices on ET, and this is why effective quantification of ET is a key aspect of precise irrigation management.

Work thus far has included a water stress study in which stress and ornamental quality were measured for four species of grass maintained at zero, 25, 50, and 100 percent of bluegrass evapotranspiration. Irrigation treatments were calculated with an atmometer and applied weekly. Findings included that generally, 25 percent plants are under the same low stress as 100 percent plants and have similar aesthetics, indicating that these grasses may be watered less while still achieving the same quality. A separate lysimeter study included one species treated with four dry down periods in which plants reached critical stress levels. Plants watered less (25 percent) and subjected to dry down periods were more at risk for stress symptoms than plants watered more.

This study will continue in the summer of 2015. Data will be combined with one year of previous work to formulate conclusions regarding a feasible level of irrigation under which ornamental grasses maintain long-term health and aesthetics.

Sam Hagopian and advisor James Klett use frequency domain reflectometry (FDR) to determine where the plant accesses water (vertically), as well as where the plant ceases to access water, as part of a plant stress and aesthetics watering study.

Erick Carlson, PhD Student, Ecology, Colorado State University
David Cooper, Forest and Rangeland Stewardship, Colorado State University

Nitrate has been reported in Weld County, Colorado irrigation water, drinking water, and monitoring wells in agricultural areas at levels exceeding the EPA drinking water standard. Improvements to irrigation and fertilizer application efficiency have not yet significantly reduced groundwater nitrate levels in the region. We propose investigating the functioning of wetlands created by irrigation runoff to trap and process nitrate.

The goal of this pilot project was to locate and instrument sites to explore the hydrology of these irrigation dependent wetlands and test methods of investigating the potential fate of nitrate exiting the field as runoff and shallow groundwater. The primary objective was to test the acetylene block technique for inhibiting microbial denitrification. In anaerobic (waterlogged) conditions, some microorganisms use nitrate in the absence of oxygen for respiration. The presence of acetylene gas blocks the chemical process that moves the intermediate nitrous oxide to elemental nitrogen gas. In a controlled experiment, nitrous oxide can be measured accurately and used to determine the denitrification activity in the soil, a potentially significant component to nitrogen cycling in wetlands. This method, however, is not commonly performed in the field, and experimental equipment and procedures needed to be tested for efficacy.

Four sites were studied in Weld County, Colorado to explore hydrology as well as wetland nitrate dynamics near agricultural fields. Trends were seen in water table rise following rain events and assumed irrigation events, and water tables rose gradually over the growing season, indicating a correlation with irrigation. However, water table levels and precipitation were weakly correlated over the growing season. Denitrification was tested in soil incubation chambers using the acetylene block technique, and results showed that the incubation time used (five hours) was not enough to block most of the denitrification, which will inform future work in the field.

Future work will continue to look into the fate of nitrate and will also include analyzing soil temperature, soil pH, soil bulk density, soil type, soil carbon, and microbial biomass. Plant uptake is another pathway that will be investigated with measurements of total plant nitrogen at the end of the growing season. The goal is an estimate of the amount of nitrogen endogenous to the wetland (cycling locally with plant tissues and soil reserves) and the amount entering the wetland through surface flow and shallow groundwater.

Soil incubation chamber in the field near Gilcrest. Notice the gas exchange port and stockcock for taking samples.

A groundwater well and piezometer set in a wetland near Ault, Colorado.

8 Exploration of Morphometric Approaches for Estimating Snow Surface Roughness

David Kamin, MS Student, Watershed Science, Colorado State University
Steven Fassnacht, Ecosystem Science and Sustainability, Colorado State University

In cold climates, the snow surface is often the interface between the atmosphere and the earth. Changes in this surface can have important effects on the hydrologic process, but it is difficult to characterize and model these changes. One measure used to understand the flow of air, temperature, and moisture over a surface is called surface roughness length (Z0). This is a measure of the vertical turbulence that occurs when a horizontal wind flows over a rough surface. The greater Z0, the greater the magnitude of turbulence that arises when wind passes over a roughness element. Due mainly to the difficulty and cost of obtaining estimates of Z0, most land surface models and climate models do not address the variability of this value due to changing snow surfaces. This research, funded by a grant from the Colorado Water Institute, compared methods for estimating Z0 and tested the viability of an approach that does not rely on expensive wind tower instrumentation.

The anemometric approach is more commonly used. This method relies on field observations of wind turbulence movement to generate a logarithmic wind profile and solve for aerodynamic parameters such as Z0. The anemometric method can be used for any surface or roughness elements, but its disadvantage is the expense and difficulty involved in installing and operating a wind tower to obtain measurements. The geometric approach, which uses algorithms, is compared as an alternative that does not require tower instrumentation. Work is still ongoing, and preliminary trends indicate that the geometric results do not match precisely with the anemometric Z0 values, but they do follow the correct trends with changing surfaces. These results are encouraging, because they show the responsiveness of the geometric methods to changing surface conditions. Further analysis is expected to strengthen the correlation between the two approaches.

Student researcher David Kamin adjusts instruments on the meteorological tower, which records temperature, humidity, and wind speed.

Natalie Anderson, PhD Candidate, Geosciences, Colorado State University
Ellen Wohl, Geosciences, Colorado State University

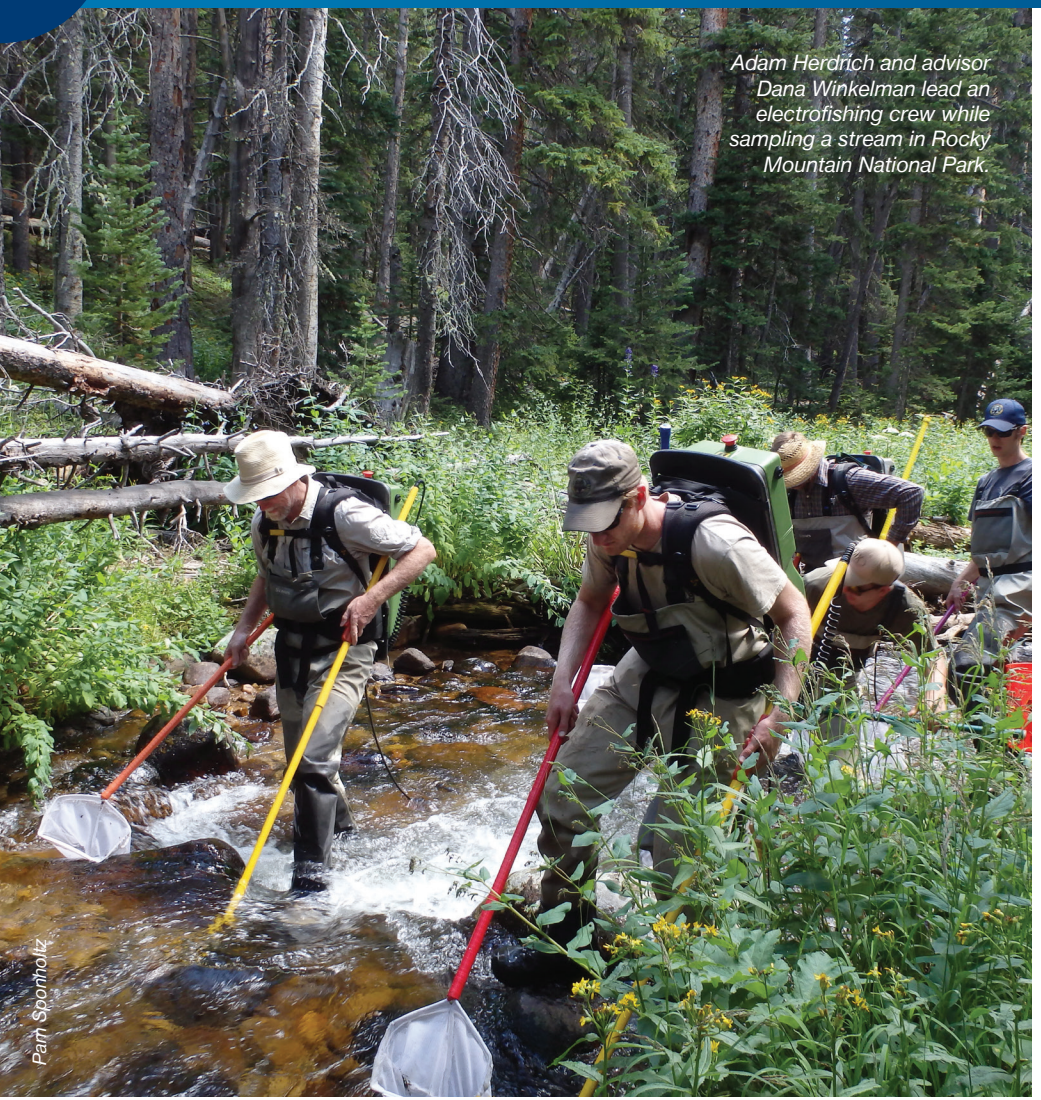
Large wood in rivers provides numerous physical and biological benefits to river corridors, but may also pose risks to inhabitants, infrastructure, property, and public safety. This project provided managers with a framework and tools to be able to assess the benefits and risks of leaving wood in river corridors via a technical report titled: "Management of Large Wood in Streams of Colorado's Front Range: A Risk Analysis Based on Physical, Biological, and Social Factors." The project team, comprised of several CSU faculty and Natalie Kramer, met with and advised water resources professionals at the city and county levels in Boulder and Larimer Counties during the fall of 2013 and the spring of 2014. These meetings provided valuable feedback to the academic team on how to design guidelines for assessment and monitoring that would be practical and regularly implemented by staff in stormwater utilities, floodplain management, and natural resources programs. Based on this feedback, the team wrote and distributed the technical guide in the fall of 2014. Informal feedback in the form of emails and verbal communications has indicated that the report has been widely circulated among interested parties and is now being used by private consulting firms and non-profit watershed groups, as well as by local governmental agencies.

Within the report, a decision process for managing large wood is outlined, particularly for assessing the relative benefits and risks associated with individual pieces and with accumulation of wood. The process is designed so that varying levels of effort can be applied, from a cursory visual assessment to detailed numerical modeling, and is usable by individuals with diverse technical backgrounds working in a range of rivers, from urban to natural.

The risk assessment designed in the report has been enthusiastically taken up by the management community, especially by Boulder County Parks and Open Space. Local government agencies and consulting firms across the Front Range are currently using the document to help design and implement new waterways master plans. The success of this project is partially due to swift response of the team from concept to publication following the 2013 Front Range flooding. To reach a broader national and global audience, a version of this report has been submitted to the peer-reviewed Journal of American Water Resources Association.

Student awardee, Natalie Anderson (center left with co-authors Brian Bledsoe (left, Civil and Environmental Engineering), Ellen Wohl (center right, Geosciences) and Mike Gooseff (right, Civil and Environmental Engineering). Not pictured are co-authors Kurt Fausch and Kevin Bestgen (Fish, Wildlife, and Conservation Biology).

10 Nutrient Retention and Productivity in Rocky Mountain Streams Under Alternative Stable States



Adam Herdrich and advisor Dana Winkelman lead an electrofishing crew while sampling a stream in Rocky Mountain National Park.

Pam Sponholtz

Adam Herdrich, Graduate Student Research Assistant, Department of Fish, Wildlife, and Conservation Biology, Colorado State University

Dana Winkelman, Unit Leader, Colorado Cooperative Fish and Wildlife Research Unit, Colorado State University

Streams of the southern Rocky Mountains suffer legacy effects of beaver trapping, wood removal, timber harvest, log floating, and other activities that have greatly reduced the size and frequency of large wood (LW) and resulting log jams. Historical studies of LW and effects on fish and habitat have focused on streams in the wet coastal forests of the Pacific Northwest. However, differences in precipitation rates, geology, flow regimes, forest composition, tree sizes, LW sizes, and LW decay rates exist between coastal forest ecosystems and the Southern Rocky Mountains of the Front Range in Colorado. For example, while abundance of LW pieces have been found to be similar in undisturbed sites in Colorado, Alaska, and British Columbia, overall volume of LW in the Rocky Mountains can be two to 10 times less than the Pacific Northwest. Further, large-scale studies of jam effects on watersheds are lacking, with most previous studies limited to the 10-100 m scale, or occurring in the Pacific Northwest. Few other studies have attempted to link land management/disturbance to wood load and animal production in headwater streams.

Construction of instream structures to increase habitat heterogeneity has become one of the most common techniques in stream restoration. However, previous studies of stream restoration via LW replacement have shown variable results in increasing fish communities, and LW additions are not beneficial for all species or all developmental stages. Previous studies in Rocky Mountain streams have shown that the addition of LW increases fish populations through immigration of individuals from relatively long distances and not by increasing forage, habitat, or survival. Also, studies propose that a lack of a priori endpoints and post-project monitoring make it difficult to classify most restoration projects a success or failure.

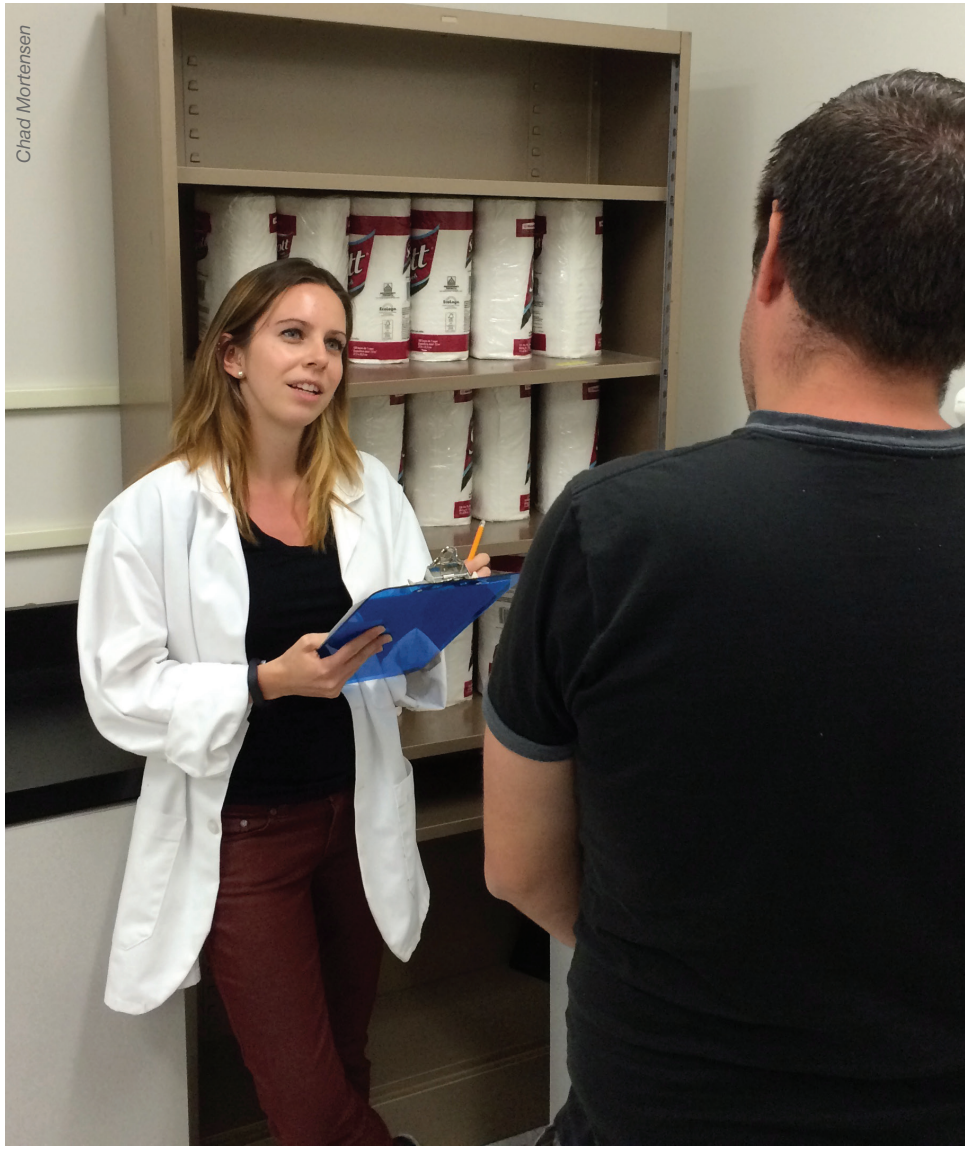
This work is part of an ongoing project to analyze stream habitat in the Rocky Mountains, including an analysis of the health of brook trout populations. Field studies have been completed, and several fish were collected for analysis—this lab work is currently taking place, and will include growth rate analyses, diet content, and lipid analyses. Preliminary results include that lipid content varies seasonally, that growth rates are similar among the sites, and that whether brook trout live in environments with large wood deposits significantly affects both the amount and type of macroinvertebrate prey consumed.

Anastasia Bacca, Undergraduate Student, Psychology, Metropolitan State University of Denver
Chad Mortensen, Assistant Professor, Psychology, Metropolitan State University of Denver

Colorado's proclivity for drought and the fact that it is the only state other than Hawaii in which water flows out, but not in, makes conservation of water resources in the state vitally important. Encouraging socially responsible behaviors—like conservation of water resources—among the population can be successfully carried out in many ways, such as fines for improper water use or financial incentives for conservation. However, communication campaigns are a relatively inexpensive way to further reduce water use through more psychological means. Recent campaigns have already sought to do so, but perhaps harnessing the powerful influence of group behavior can further increase the effectiveness of these types of communication campaigns.

Past research has looked into the effectiveness of conveying social norms, but there may be a limitation to this approach when only a small percentage of people take part. To overcome this limitation, this study conducted experiments and found that both conveying that a small but increasing percentage of people already take part in the conservation activity (e.g., currently 48 percent, up from 37 percent) and asking participants to think about how popular water conservation would be in the future encouraged water conservation behaviors.

Though social norms are already known to be effective in communication campaigns, our research shows there may be ways to further increase the their effectiveness. Notably, these strategies for improving communication campaigns are not only effective, but also low cost or free, allowing for greater conservation of valuable water resources without having to increase funding for campaigns. Specifically, this research demonstrates strategies that can be used to encourage water conservation, but more generally, it can also be seen as helping to demonstrate the value of taking a psychological approach to promoting water conservation.



Anastasia Bacca gave instructions for the "Toothpaste Taste Test Study," which was used to discretely measure water conservation study participants' water use while brushing.

John Fetcher Scholarship Award

The Upper Yampa Water Conservancy District John Fetcher Scholarship provides financial assistance to a committed and talented student who is pursuing a water-related career in any major at a public university within the state of Colorado. Congratulations to this year's scholarship recipient, Josie Rossi.

- **Name:** Josie Rossi
- **University:** University of Colorado - Boulder
- **Anticipated Graduation:** Spring of 2017
- **Major:** Mechanical Engineering
- **Minor:** Watershed Science
- **Area of Interest:** Agricultural Water

Josie was born and raised on a fourth generation family ranch outside of Yampa, Colorado and grew up learning about water from a headwater perspective. She would like to return to the Yampa valley working as a water resource engineer on dams or on irrigation systems. She has interned for the Division of Water Resources office in Steamboat Springs and with Applegate Group, a water resource firm that focuses on water planning, water rights engineering, water policy, and development of water infrastructure. Josie hopes that in combining mechanical engineering with a minor in watershed science, her skill set will benefit the agricultural community.

Blake Osborn

Blake Osborn joined the Colorado Water Institute in June of 2015 as an Extension Regional Water Specialist for the Arkansas and Rio Grande river basins. Prior to joining Extension, Blake was a Graduate Research Fellow in Water Resources for the Wyoming Center For Environmental Hydrology and Geophysics. He has a Master of Science in Hydrology and Water Resources Science from the University of Wyoming and Bachelor of Science in Natural Resources Management and Policy from Colorado State University. Blake's work focuses on subsurface hydrologic processes including hydrochemical transport, unsaturated water movement, agricultural return flows, geospatial data applications, irrigation scheduling, and how land use changes may affect subsurface processes. He is interested in subsurface hydrologic processes at many spatial scales, and his work will include a mix of wildland hydrology in both natural and developed systems.

Blake's Extension responsibilities will include collaborating with researchers and producers to solve water quality and quantity issues in the Arkansas and Rio Grande River Basins, providing leadership in the area of water resources throughout southern Colorado, and partnering with municipal, non-profit, state, and federal agencies to provide research and education about water topics most concerning in southern Colorado. His work with the Wyoming Center For Environmental Hydrology and Geophysics included collecting and analyzing surface and groundwater data, soil moisture data collection, and laboratory analysis.

MaryLou Smith, Policy and Collaboration Specialist, Colorado Water Institute

While much of CWI's work revolves around the technological issues of water, another category of work captures a great deal of our attention: people and policy. Without relating technology to what is happening with people and policy, technological achievements don't get employed as productively as they could be.

Moving Forward on Agricultural Water Conservation in the Colorado River Basin—Use it or Lose It, Myth or Reality?

While the general public assumes that agriculture, which diverts most of the water in Colorado and the West, can conserve and free water up for other uses, Ag producers and those who manage their water know that it isn't so simple. Through our grant with the U.S. Department of Agriculture, we are digging into the fine nuances of what stands in the way of Ag water conservation, including economic and legal arrangements that have historically governed water to optimize it for beneficial use. What we have discovered will form the basis of an educational campaign throughout the state, with the assistance of the Colorado Ag Water Alliance.

NISP—and its SDEIS—in a Nutshell

Throughout Colorado and in the West, engineers have built dams and reservoirs that capture and save water during times of plenty for times of drought. What seems straight-forward and practical to many is an anathema to others. CWI dug into this arena through public education on a contentious topic—whether the Northern Integrated Supply Project (NISP) in Northern Colorado should be permitted to divert water from the Poudre River to reservoirs to meet the needs of 13 entities. Working with CSU's Office of Engagement, we produced an animated video objectively conveying what the project is all about and how the National Environmental Policy Act process was playing out via the SDEIS—supplemental draft environmental impact statement. Community feedback included appreciation that the video did not take sides but helped the public better understand a very complex subject.

Best Practices for Collaborative Water Decision: Moving from Concept to Action

For the past two years, the state of Colorado has been working on a Colorado Water Plan to present to Governor Hickenlooper for how the state's water basins will work together to bridge the gap between anticipated demand and supply by the year 2030. Input has come from the Interbasin Compact Committee and its nine basin roundtables, the legislature's Water Resources committee, and the public. It includes a list of issues and some recommendations, but forging agreements between different constituencies with different values and interests is still ahead of us. CWI joined with internationally recognized mediation/facilitation training organization CDR Associates to put on the first of three workshops to teach Colorado water stakeholders how to collaborate. Meeting in Palisade, Colorado in October, 24 participants from conservancy and conservation districts, state and federal agencies, ditch companies, and conservation groups spent two days learning about and practicing best practices for making collaborative water decisions.

Ryan Golten

Ken Curtis, Dolores Water Conservancy, and other workshop participants role play collaborative water decision making in Palisade, October 2015.

Outreach and Research in Southern Colorado

Lane Simmons (2)

Photos on Left: Blake Osborn takes gridded soil samples for electrical conductivity at the Arkansas Valley Research Station in Rocky Ford, Colorado.

Blake Osborn, Regional Water Specialist, CWI and CSU Extension

The process of drafting Colorado's first Water Plan is a signal of things to come. Although the Water Plan has been criticized by those within and outside of the water community, it has already served as a catalyst within Colorado's expanding water agenda. Principally, the dialogue around water issues has increased substantially; Coloradans are readily talking about the state's water issues. Much like the Water Plan, I too am entering the Colorado water landscape for the first time—well, more or less. As a native of southern Colorado, I have lived and worked in a drought hardened water community. I couldn't be more excited to be joining the Colorado Water Institute at a time when the water conversation in Colorado is more dynamic than I can remember.

As the new southern Colorado Extension Regional Water Specialist, I have taken the opportunity to engage with stakeholder groups and join committees working together to find solutions to the region's water issues. I take seriously the mission of bridging the gap between higher education and water managers/users. I am currently in the process of building my research program—a few of my interest include groundwater surface water interactions, the impact of management decisions on water quality and quantity, crop water use, and basin scale watershed health. Since starting in my position, I have become involved in a variety of projects, including the following.

- **Lawn Irrigation Self Audit (LISA) Project**
  This goal of this project is to develop a Web-based irrigation scheduler that gives homeowners access to a no-cost, self-auditing tool that will improve landscape irrigation watering efficiency. The LISA program works collaboratively with the Colorado Agricultural Meteorological Network (CoAgMet) weather data network to provide highly localized turf grass ET; this collaboration gives us the best chance to accurately predict local ET conditions and therefore maximize the precision of the LISA tool.

- **Arkansas River Management Action Committee (ARMAC)**
  This project seeks to demonstrate that, through participatory basin-wide planning and analysis, conservation practices can be identified and evaluated to economically improve water quality, boost agricultural productivity, and save water in an irrigated river basin, while assuring compliance with legal-institutional constraints. This overall goal will be achieved through integrated research, extension, and education activities.

One of the most common phrases I receive from constituents welcoming me to the new job is, "It is an exciting time to be getting into Colorado water." I couldn't agree more. I am motivated to build upon my experience in the region and help facilitate action-based solutions. Both the Arkansas and Rio Grande river basins, like much of Colorado, are having to reckon with the balancing of issues associated with a strong agronomic heritage and an exploding urban population. It is my goal to work with colleagues in the Colorado Water Institute to help guide this process with research based information.

Alternatives to Permanent Fallowing Synthesis Study

Brad Udall, Senior Water and Climate Research Scientist/Scholar, Colorado Water Institute

Since its very beginnings, CWI has been interested in ways to conserve agricultural water. In recent years, high municipal growth rates in Colorado and the resulting projected future water gaps have made understanding potential agricultural water conservation savings and efficiency improvements even more timely. Many efforts, including the 2003, 2007, and 2010 Statewide Water Supply Initiatives and the new 2015 Colorado Water Plan, have investigated these types of water savings, although much more remains to understand the issue.

In mid-2015, CWI received a Walton Family Foundation grant to do an academic synthesis of alternatives to permanent fallowing to conserve water while keeping agriculture viable. The project was started this year and will continue into 2016.

The study's geographic focus is the Colorado River Basin, including both the upper and lower basins, with particular focus on the states of Colorado, Arizona, and California. The findings will be applicable to broad parts of the West, however, including Colorado's Front Range.

We expect to study rotational fallowing, efficiency improvements, deficit irrigation, crop switching, and technology improvements among other water savings techniques. Our goals are to be able to say how much water was saved, where was it saved, for how long, and how the savings were measured. We also plan to analyze limitations and objections in both the technical and legal realms. We will subject our findings to outside review prior to publication. Brad Udall, MaryLou Smith, and Greg Peterson will perform much of the work, with support from other CWI staff.

This effort will build upon much existing work including Reclamation's 2012 Colorado River Basin Water Supply and Demand Study, Reclamation's 2015 follow-on "Moving Forward" report, the Colorado Water Conservation Board's Alternative Agricultural Water Transfer Methods efforts, and a broad amount of peer-reviewed and gray literature. Selected interviews with producers and water providers will also be done.

The project will culminate in a document and workshops held along Colorado's Front Range, in the Lower Colorado River Basin—likely Tucson or Phoenix—and in Washington, D.C. in the spring of 2016.

2013, Boquillas Canyon Mouth, Rio Grande, Big Bend National Park

Water Management Issues and Outreach in Northeastern Colorado

Joel Schneekloth, Regional Water Resources Specialist, CWI and CSU Extension, Water Resource Specialist

Covering the South Platte and Republican River basins in Northeast Colorado provides different water management issues within irrigated agriculture. The South Platte River Basin is a surface water system which is influenced by annual snowpack availability and future issues of growth. The Republican River Basin is a groundwater fed system with a declining water resource, which will result in the loss of irrigated agriculture.

AGRICULTURAL WATER MANAGEMENT

Irrigation and water management have been the crux of decision making by producers. Without good research available to producers, management changes/decisions are much more difficult. Research on issues that producers will face into the future is important to help with decision making 10 to 15 years into the future.

- **Drought genetics:** Improvements in technology are continuing in agriculture. The advent of drought genetics has a possible impact on the efficiency of irrigated production with limited resources. Research has been conducted on the impact of drought genetics in irrigated production and how they respond to water stress as well as the yield impact of these genetics when water stress occurs.
- **Residue and water management**: With the future of energy production looking at crop residue as an ethanol source, what are the implications of residue removal on water issues. Current research is looking at implications of water management in these systems as well as nutrient management.
- **Extension/Education:** Education of water issues is important to irrigators. As a board member of the Central Plains Irrigation Association, we strive to give producers up to date research within the High Plains Region of Colorado, Kansas, and Nebraska. The Central Plains Irrigation Association is a consortium of industry and Universities in Colorado, Kansas, and Nebraska.

SOUTH PLATTE ROUNDTABLE

The roundtable structure was developed for individual basins to solve water issues. Membership of these roundtables are made up of agricultural, municipal, environmental, and recreational interests within the basin. Over the past 11 years, the South Platte Roundtable has had discussions on the future issues within the basin and the potential to resolve the water gap created by growth within the Front Range of Colorado. The past three years have involved development of the Basin Implementation Plan.

- As part of the Educational Outreach committee of the South Platte Roundtable, we have been developing approaches to educate residents within the South Platte River Basin on water issues today and into the future. As the Colorado Water Plan has been developed, education and outreach will become the forefront of the roundtable.

Stacey Poland

Joel harvests research plots, in Akron, Colorado.

Collaboration on Agricultural and Water Use Issues in Western Colorado

Perry Cabot, Regional Water Resources Specialist, CWI and CSU Extension

Since its beginning, CWI has been involved in water research and education related technology, economics, and sociological aspects of water. Increasingly, CWI has been seeking out and taking advantage of opportunities for direct engagement with stakeholders who are struggling with water policy conflicts. Helping stakeholders open their eyes to beliefs and values different than their own is at the root of all of this work.

The realities of drought and compact obligations bring the CWI to the table as a partner on several major projects, dealing primarily with agricultural water use.

Perry Cabot often gives presentations as part of his outreach and education efforts within CSU Extension.

- **Water Bank Workgroup (WBWG) Partnership:** This representative group of stakeholders consists of the Colorado River District, Southwestern Water Conservation District, The Nature Conservancy, and the Front Range Council. The group was formed to explore the use of a voluntary and compensated market approach to temporarily reduce consumptive uses in Colorado in the event of extreme shortages that affect Lake Powell's operations or our ability to meet the Colorado River Compact obligations. A large part of this work is focused on how foregone diversions can work for the agricultural sector. The WBWG is partnering with the CWI on a multi-year field study to assess the water conservation, crop impacts, and soil quality due to partial-season irrigation of alfalfa and grass hay fields.
- **Resource Conservation Partnership Program (RCPP) Support:** The RCPP is a locally coordinated, comprehensive approach supported by the U.S. Department of Agriculture to maximize agricultural water use efficiency through modernization of irrigation water. CWI is engaged in soil-water budgeting through on-farm monitoring at four sites in the Gunnison Basin, which led to a fruitful partnership with Irrometer® Company to deploy and test their new platform for monitoring soil moisture.
- **Evaluation of Remote Sensing as a Tool for Evaluating ET:** CWI has embarked on a project to apply Remote Sensing of Evapotranspiration (ReSET) in order to understand consumptive use of alfalfa and grass fields experiencing partial season irrigation.
- **Alternative Crops and Alternative Fuels:** Working with CSU Extension and the Agricultural Experiment Station, we secured a grant from the Unconventional Energy Program at Colorado Mesa University to design and construct a mobile oilseed press, expected to roll out in 2016
- **Extension and Engagement:** Workshops and presentations are provided in coordination with the various Extension offices on the Western Slope, including Master Gardner Programs, Water Users Association board meetings, and County-based trainings for well-water maintenance and irrigation scheduling practices.

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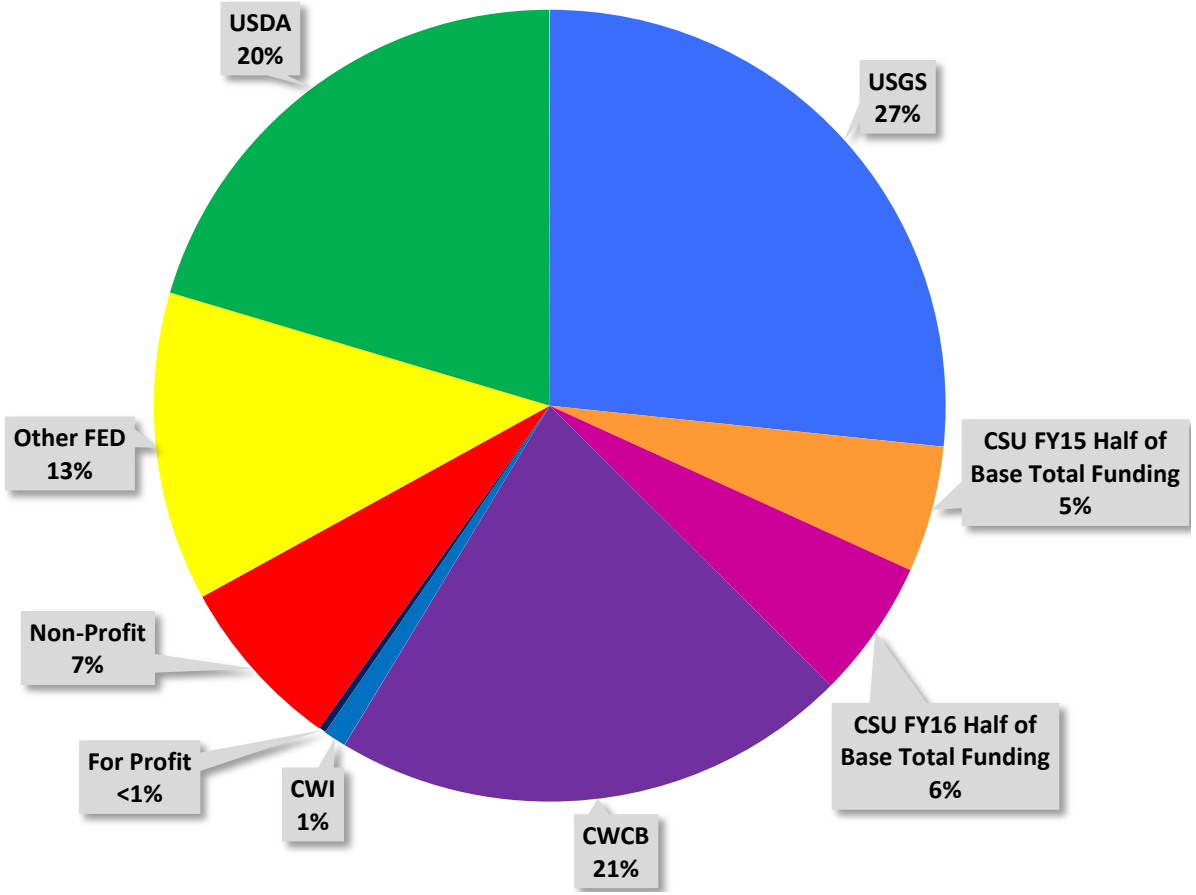
CWI Funding Sources
(November 1, 2014 - October 31, 2015)

CSU Base Funding	$ 383,663
CWCB	$ 753,028
CWI	$ 33,000
For Profit	$ 10,000
Non-Profit	$ 253,141
Other Federal	$ 448,326
USDA	$ 724,000
USGS	$ 946,930
Total	$ 3,552,088

Active Project Type

Research	37
Education	7
Outreach	3
Internships	5
Training	2
Total	54

CWI Funding Sources



Student Degree Level on Projects

Undergraduates	20
Master's Students	12
Ph.D. Students	5
Total	37

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Colorado Water Institute

A Division of the Office of Engagement

Highline Canal – Platte Canyon Reservoir.

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