

Colorado Water

Newsletter of the Water Center of Colorado State University

March/April 2008 Volume 25, Issue 2

Colorado
State
University



Theme:

Water Conservation

Feature
Article:

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at Colorado State
University (page 8)*

Co-Sponsored by Colorado Water Resources Research Institute, Colorado State University Agricultural Experiment Station,
Colorado State University Extension, and Colorado State Forest Service

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Editorial

by Reagan Waskom, Director, Colorado Water Resources Research Institute

Rethinking Water Conservation

Looking back, the first era of massive dam construction in the West seems to have ended in 1966 with the completion of Glen Canyon Dam. But booming population and concern about climate variability have us seriously considering how to meet future water needs. New water projects are now being contemplated in Colorado and across the West to quench the thirst of our growing cities.

There are many schools of thought on how to meet the needs for increasing water supplies in the West. They include storage of water in natural underground aquifers, pipelines to carry water from the distant reservoirs and rivers, desalination plants to make drinking water from the ocean, transfer arrangements with agriculture, enlarging existing dams to serve local areas, to name a few. However, many believe our water future does not lie with new dams, but in water conservation. A reasonable argument is made that we are running out of good options on the supply side and we must begin seriously managing the demand side of the water resource equation.

Most cities and even small towns in Colorado now have a water conservation program; in some cases, remarkable results have been achieved since the 2002 drought. Conservation gains of up to 30% were recorded in Denver and other metro cities following the drought. Reduced urban water consumption has been sustained since the drought, although on a smaller scale. The question is not whether water conservation is achievable or desirable, but whether it can be a viable, long-term substitute for new water storage projects or agricultural transfer. Some argue the reservoir of urban conservation must be saved for times of drought and not used to provide the next increment of water for more growth.

While it is true there are unsettling disconnects between water supply and growth in the West, the new growth paradigm seeks to create compact urban centers that preserve open space and working landscapes, while reducing transportation needs and energy demand. These more

compact urban centers have a smaller water footprint as well, especially when native and xeric plants are used in the landscape.

Currently, municipal and industrial water use accounts for approximately 10% or less of Colorado's total consumptive water use, providing for the 85% of Coloradoans reliant on public water systems. Agriculture, on the other hand, accounts for some 86% of the consumptive use in Colorado and over 90% of all diversions. A simple reckoning of this calculus leads some to the conclusion that small increments of water conservation from agriculture can meet the M&I needs of Colorado.

The common fallacy surrounding agricultural conservation is that increasing irrigation efficiency by upgrading to sprinkler or drip systems will create conserved water which can be put to other uses. While increased irrigation efficiency has many benefits, such as improved water quality and reduced water logging, in Colorado

this saved water is presumed to belong to the river system and downstream diverters. Several articles in this issue of *Colorado Water* point out that reducing crop consumptive use is the only reliable way to gain water from irrigated agriculture. The Colorado Ag Water Alliance has addressed this issue head on with their recently released discussion paper on irrigation water conservation, excerpted on page 34 of this newsletter. This group wants to foster a discussion on the issue of irrigation water conservation in Colorado to move the dialog past platitudes and on to economically viable solutions for the state.

In a land of plenty, populated by folks accustomed to being able to consume whatever they can afford, what can be done about something as inconvenient as aridity? When our population was low, we were able to engineer our way around it, but at some point we must return to the stark reality that we live in a dry place. And while we don't consciously think of it this way, aridity is part of what we love about Colorado and the West. Accepting aridity means we must plan, we must develop our capacity to store water in wet times, and eventually we must learn to live within the limits of our environment by reducing our water footprint through conservation.



Reagan Waskom

Colorado Water Congress 50th Annual Convention

January 23-25, 2008

The 50th Annual Convention of the Colorado Water Congress kicked off with a Legislative Breakfast. Senator Jim Isgar and Representative Kathleen Curry reviewed the pending water legislation for 2008 and answered questions from a record crowd of 540 attendees.

Governor Bill Ritter opened the general session by stating that, "Water is one of the most significant issues facing Colorado. Water is a scarce resource due to growth, drought, and climate change. Colorado has much to lose if we do not address climate change and make the most of conservation, reuse, and efficiency. Water conservation is one of the cornerstones of Colorado's water future. We are over appropriated in the South Platte, Rio Grande, and Arkansas basin and finding it difficult to integrate groundwater and surface water administration. Furthermore, we cannot move forward on oil shale without understanding the water requirements and where it will come from."



Governor Bill Ritter addresses the Water Congress



From left: Michelle Pierce, Gunnison; Mike Gibson, Rio Grande; Dave Merrit, Colorado; Gary Barber, Arkansas; Harris Sherman; Steve Harris, S. West; Bill Jerke, S. Platte; Tom Sharp, Yampa/White; John Hendrix, Metro

Department of Natural Resources - Executive Director Harris Sherman followed up and thanked the water community for all their help during his first year. He acknowledged the new water leadership in the state - Jennifer Gimbel, CWCB Director; Alex Davis, Assistant Director for water at DNR; Dick Wolfe, State Engineer.

Sherman noted the seriousness of the challenges we face in securing an adequate water supply for Colorado. "Collaborative processes such as Roundtables are the best opportunity to find lasting solution to our water problems." However, the future of IBCC and Roundtable process is still in question. It is a unique process that is risky, but benefits are becoming evident, specifically 1) new players in discussion, 2) basins have been able to study needs, 3) funding has helped greatly, 4) setting up framework for cross-basin



Dan Merriman and Lewis Entz



Don Ament receiving the Aspinall Award



Robert Ward and Kevin McBride confer

dialog. Sherman stated that “Water is not the factor that determines growth, but it should be part of the mix.”

The nine Chairs of the Basin Roundtable formed a panel to informally discuss their successes and failures. Common themes from the Roundtable chairs included concurrence that the process serves as a forum for constructive conversations and that the new funding has been very helpful. The process of trust building and education has also been beneficial, but is time consuming.

Higher Education was exceptionally well represented on the program with three CU, eleven CSU and one CSM faculty to present their new research findings. The conference wrapped up with an update by former Department of Interior Assistant Secretary, Mark Limbaugh, providing an update on federal affairs. The 2008 CWC Aspinall Award Recipient, Don Ament was honored for his many years of effort on behalf of Colorado water.

Colorado
State
University

Watershed Science

50th Anniversary Celebration

27-29 March 2008

Come celebrate the accomplishments and history of the Watershed Science program at CSU. The exciting three day program includes technical sessions, panel discussions, keynote addresses, luncheons, dinner and reception, and even a water play day! You'll have a chance to reunite with friends and colleagues, meet watershed folks spanning multiple generations, and participate in the discussion about the future of watershed science and management. All are welcome to attend all or any part of the Anniversary events.

To learn more about the events, register, or submit an abstract, biographic sketch or share photos, go to:

<http://watershed50th.colostate.edu>

OR contact Cara DiEnno at cara.mail.colostate.edu; #970-491-4081

50 years flowing strong

Third Annual Water Tables Benefit: A Night of History and Heritage

by CSU Libraries Staff

Water Tables made another big splash this year. The annual benefit, hosted by Colorado State University Libraries, attracted nearly two hundred respected guests from across the state and raised more than \$30,000 for the CSU Water Resources Archive, which preserves materials critical for documenting the state's water history.

"Water Tables allows the Archive to make connections with friends in Colorado's water community," said Patty Rettig, the institution's head archivist. "The collections here are important, and this event helps people learn more about them."

During the cocktail hour, hosted in the Morgan Library, guests were able to tour the archive and invited to inspect materials documenting the state's water heritage, including items related to interstate water compacts, reclamation projects, groundwater, and the environment. On display was an array of historic items, including an exhibit featuring Colorado water leaders and innovators Ival V. Goslin and Ralph L. Parshall.

Now in its third year, Water Tables surpassed previous records for attendance and donations. Guests were treated to good food, lively conversation and networking opportunities in what has become a showcase for distinguished personalities in the Colorado water community.

Among those in attendance was Dick MacRavey, a fixture at the Colorado Water Congress for nearly fifty years. MacRavey recently donated to the archive several personal items documenting his long and celebrated career in water policy and administration. Other guests included water engineers, lawyers, administrators, farmers and ranchers, and interested citizens.

A highlight of the evening came when Dick Farr remembered his late father WD, a respected figure in Colorado's



CSU Vice President Joyce Berry views historic documents in the Archive with table host John Hill during the opening of Water Tables 2008.

water history who is best remembered for his leadership and his ability to unite the state's fractious water interests behind common causes. The Farr family recently announced its decision to donate the papers of WD to the Water Resources Archive.

"Dad would be thrilled to know the work you all are doing," said Farr.

In addition, more than a dozen CSU graduate students were able to attend the event thanks to the benefit's silver sponsors. Students Carol Hutton and Nick Kryloff offered remarks highlighting the importance of archival collections for historical research.



Dick MacRavey and Dick Farr converse after addressing the crowd during Water Tables 2008. Dick Farr represented the Farr family in announcing the donation of his father's papers to the Archive.



CSU graduate student Nick Kryloff emphasizes the importance of the Archive to primary research.



The 2008 Water Tables hosts--experts in all fields related to water who moderated discussions for guests.

“At the archive I found a wealth of untapped information here that made my graduate research possible,” Kryloff said. Hutton, a first-year graduate student still deciding on a research topic, received encouragement and advice from some of the state’s top water professionals.

Dave Stewart, head of the event’s planning committee, similarly emphasized the importance of the Water Resources Archive for CSU students. “Tonight is really all about the students,” Stewart said. “And tonight we are helping to develop a key resource for them to use.”

Guests enjoyed a three-course dinner, as well as discussions at each table about important water issues—from reclamation and environmentalism to imminent personalities in western water history. Each table was hosted by water experts from a wide range of disciplines, including water history, policy, and administration.

Many attendees commented on the organization and classiness of the event, as well as the extensive knowledge of their table hosts.

“The evening was enjoyable, and it was a credit to CSU and its library system,” noted Ken Wright of Wright Water Engineers, event sponsor and Archive donor whose materials are housed in the Archive. “The 19 or so tables all had good discussion moderators who had been thoughtfully selected. We are already looking forward to the 2009 Water Tables.”

The benefit has grown significantly since its inception in 2006, thanks to the guidance of the Water Tables Planning Committee and the support of the event’s sponsors. With its success this year, Water Tables promises to continue to raise awareness of the materials at the Water Resources Archive and to attract outstanding members of the state’s water community.

Table Hosts

Dick Bratton, John Hill, Karl Dreher, Sara Duncan, Jo Evans, Alan Hamel, Mark Harvey, Diane Hoppe, Dave Little, Don Lopez, Dan Luecke, Dan Merriman, Del Nimmo, Don Pisani, Leroy Poff, Jack Ross, Steven Schulte, Dan Tyler, Brian Werner, Ellen Wohl

Water Tables Planning Committee

Mike Applegate, Mark Fiege, Webb Jones, Mary Lou Smith, Dave Stewart, Robert Ward

Sponsors

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Mr. and Mrs. Robert Ward

Wright Water Engineers, Inc.

Papers Of Water Legend And Rancher, W.D. Farr, Donated To Colorado State University Water Archive

by Judea Franck, CSU Libraries

At Water Tables, the Annual benefit for the Colorado State University Water Resources Archive, Colorado State University Libraries announced that the papers of a water legend, the late WD Farr, will find a permanent home in the CSU Water Resources Archive.

Home to nearly 50 collections of individuals and organizations, the Archive preserves, organizes and makes available primary resource materials that document the history of water resource development throughout Colorado and the West. As a collection of the Water Resource Archive, the Farr materials, which document Farr's remarkable contributions to water and agriculture, will be available to researchers, industry professionals, historians, students and citizens.

"WD Farr is one of the true giants in Colorado history—and in the history of the modern American West," said Colorado State University President Larry Edward Penley. "Given CSU's role as the center for research on water issues



William Daven Farr

and resources in our state, it seems fitting that we would provide a home for this remarkable collection. We are deeply honored that the Farr papers will now be a permanent part of our Library's Water Resources Archive, and we are proud that the legacy of WD Farr as a visionary and leader will be preserved for study by future generations."

Known to many as Mr. Water, Farr, a Greeley native, was a key figure in the development of water resources and agriculture in Northern Colorado. In the 1930s, Farr worked with his father lobbying for support of the Colorado-Big Thompson Project, which would bring water from the head of the Colorado River across the Continental Divide and to the Front Range. The project, completed in 1947, provided an important economic stimulus as a vibrant Front Range sprung up throughout Northeastern Colorado and helped Weld County to become one of the highest-yield agricultural areas in the U.S. Today, the Big Thompson Project brings water to 30 municipalities and eastern Colorado farms.

Farr served on the Board of Directors for the Northern Colorado Water Conservancy District and the Greeley Water Board for 40 years. In the 1970s, he served on President Nixon's Environmental Protection Agency, then a 12-member commission charged with protecting and cleaning the nation's water. During his three-year appointment, he helped clean up the Great Lakes and fill them with fish after massive dumping of chemicals by Midwest manufacturers.



Representing of the Farr family, Dick Farr, son of WD Farr, announces the donation of his father's papers to the Water Resources Archive. The crowd of 200, gathered for the annual Water Tables fundraiser, was awed by the historic announcement.

"To study the life of WD Farr is to understand leadership in the 20th century... Extraordinary leadership is what made Farr so successful in his endeavors."

Farr also contributed greatly to agriculture throughout the West. As president of the National Cattlemen's Association in the 1970s, Farr regularly testified before Congress to give voice to many Western cattlemen's concerns about increased government regulation. He also was instrumental in developing modern cattle feeding techniques with fellow ranchers in Greeley during their "regular T-bone steak dinners," as the group called their meetings.

Farr died in August last year. He is survived by his four sons and their families. Historian and CSU emeritus faculty member Dan Tyler, who is working on a book about WD Farr's life, his contributions to Western water and agriculture, and his significance as a community and national leader, recognized immediately that Farr's materials would make an essential addition to CSU's Water Archive and its ability to tell the story of Western water through primary source materials.

"To study the life of WD Farr is to understand leadership in the 20th century," Tyler notes. "Extraordinary leadership is what made Farr so successful in his endeavors."

With Tyler's encouragement, the Farr family has decided to donate the Farr papers to the Water Resources Archive at CSU so that researchers, historians, students and citizens will have access to the work of this remarkable man long into the future. The collection includes papers and photographs related to all aspects of Farr's life and work in water, agriculture and banking. (He served as chairman of the Greeley

National Bank after following his father and grandfather into the banking business.)

"Colorado is where water law originated, and the Big Thompson (Project) was a huge part of that," says Dick Farr, WD Farr's son. "Dad would be thrilled to have his papers at CSU. This (CSU) is the heart of everything. It's where Northern (Colorado Water Conservancy District) is located and where engineers are trained. I can see that his papers will be well taken care of and well used at the Water Archive."

Housed in CSU's Morgan Library, Farr's papers will join the archival collections of fellow water greats such as Delph Carpenter, father of the Colorado Compact, and Ralph Parshall, inventor of the Parshall Flume, a key water measurement device.

After receiving the Farr materials, the Archive will begin processing the collection, organizing its contents and creating an online search program of the items, known as a finding aid. The Archive hopes to make the Farr materials available for public use in 2009.

Albert Yates, former CSU President, considered Farr a friend and mentor and described him as a "quintessential scholar."

"I've combed a great number of documents over the years," Yates said in a 2007 Denver Post interview. "None were more impressive than those that were written by WD Farr."

AGU Hydrology Days 2008 March 26-28, 2008 Cherokee Park Room Colorado State University

Sponsored by
Hydrology Section of the American Geophysical Union
For registration information, visit: www.hydrologydays.colostate.edu

Hydrology Days has been held on the campus of Colorado State University each year since 1981. Hydrology Days is a unique celebration of multi-disciplinary hydrologic science and its closely related disciplines. The Hydrology Days vision is to provide an annual forum for outstanding scientists, professionals and students involved in basic and applied research on all aspects of water to share ideas, problems, analyses and solutions.

Borland Lecturer in Hydraulics

William E. Dietrich

University of California, Berkeley

Hydrology Days Award Lecturer

Wilfried H. Brutsaert

William L. Lewis Professor of Engineering
Cornell University

Borland Lecturer in Hydrology

Dennis P. Lettenmaier

University of Washington

Water Conservation at Colorado State University

by Patrice Stafford and Carol Dollard, CSU Facilities Management

Water is a valuable resource, especially here in the semi-arid west. As growth, and past drought, has put additional pressures on water resources, the cost of potable water continues to rise – currently making water a utility expense in excess of \$1.5 million for the entire Colorado State University system. In effect, minimizing water usage reduces operational costs and reduces the environmental burden on local water resources. With that in mind, Colorado State Facilities Management and other University departments have worked to decrease campus water use for decades.



The lagoon at CSU, photo by Patrice Stafford

Even with substantial University growth, both in population and building square footage, the total University potable water consumption has decreased since the late 1980s. To be specific, since 1990, potable water use has decreased over twenty-two percent (108 million gallons), despite a student population increase of twenty-five percent and building square footage increase of nineteen percent (Fig. 1).

In order to conserve water, several retrofits have been completed throughout campus. The Department of Housing and Dining Services, with Facilities Management, converted walk-in refrigeration systems from once-through cooling to air-cooled compressors, saving roughly 17.5 million gallons of water a year. In addition, retrofits have been made to the residence halls toilets, faucets and showers, as well as the residence hall laundry facilities. The Energy Star clothes

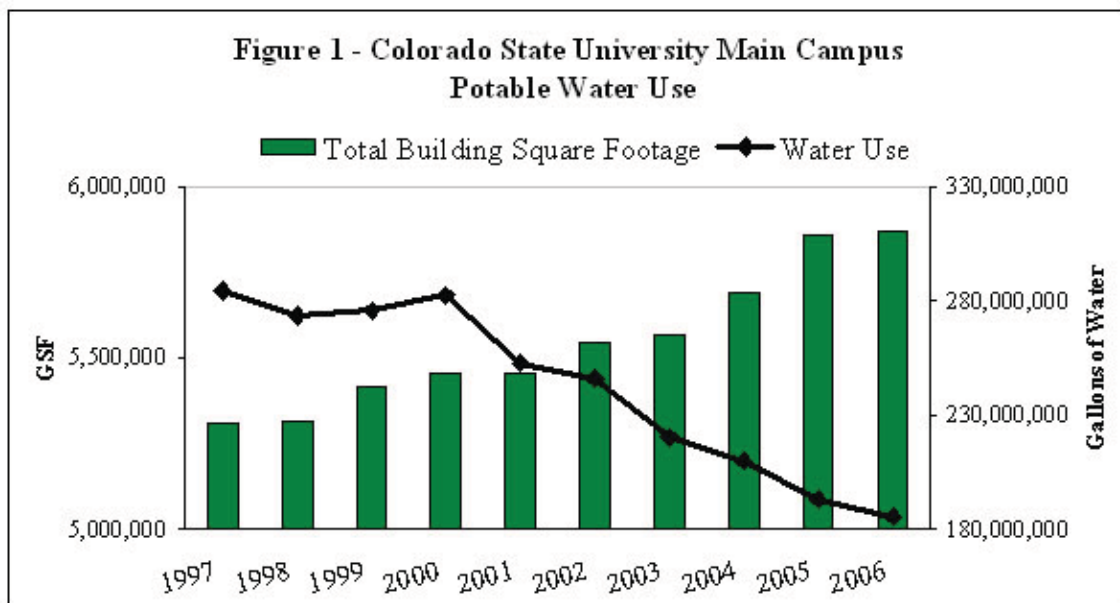
washers in the residence halls are estimated to save twenty-two gallons of water per load.

With the large amount of research on campus, there comes a great demand for water. The top water-consuming buildings on campus have been noted and deemed crucial components in water conservation on campus. Water conservation projects have been implemented in several of these buildings, which include Chemistry, Microbiology and Painter, among others.

Autoclaves, devices using steam to sterilize laboratory equipment for reuse, are some

of the largest water users in these buildings. In order to reduce the amount of water used in this process, Colorado State installed forty-two water-saver kits, which monitor the temperature of the drain line and only inject cold water when needed. These devices are estimated to save the University over \$60,000 and fifteen million gallons of water annually.

A recent water conservation project, with huge savings, is the addition of closed loop process cooling for research equipment, such as lasers and spectrometers, in the Chemistry building. Typically, this equipment is cooled with once-through cooling where the water is used once and then lost. The installation of a loop means that water will no longer be sent down the drain. The water in the process cooling loop absorbs the heat from the equipment and then is returned to a chiller to be cooled again. This system is under construction, but expected to be running later this



year and initially anticipated to save five to ten million gallons of water annually. As more labs are added to the system, those savings will continue to increase.

Figure 2: Colorado Canyon, photo by Patrice Stafford



Landscaping is an important component for conserving water resources. Trees, shrubs and other plants on campus are selected for their compatibility with the climate of Northern Colorado. One of the factors for selecting turfgrass at Colorado State is water consumption. For that reason, Facilities Management prefers to use Kentucky bluegrass, buffalograss or tall fescue – all of which are winter hardy, relatively heat tolerant and possess excellent drought resistance. The Colorado Canyon, located in between the Engineering Building and the north end of the Lory Student Center, is an example of landscaping with water conservation in mind (Fig. 2). While rocks are the dominant motif for the “canyon,” plants whose natural requirements are appropriate to the local environment were emphasized.

Figure 3: Heron at University Greenhouse wetland, photo by Fred Haberecht



The irrigation system to water the campus vegetation uses ninety-five percent raw water, mostly from College Lake. That means that the water has not undergone chemical treatment, in order to be consumable, but is perfect for watering the campus landscape. The irrigation system is carefully run on an automated system that prevents over watering, in addition to not watering if there is already sufficient moisture. The annual cost avoidance by not using treated tap water for irrigation is approximately \$250,000 and the environmental impact is the prevented emission of 281 tons of carbon-dioxide equivalent, each year.

The bioremediation wetlands have also been a great visual example of Colorado State’s commitment to water issues. The first completed wetland, known as the “Water Conservation Demonstration Garden,” is located on the east side of the University Greenhouses (Fig. 3). The wetland is a working demonstration of both the remediation of waste water from a commercial use and the use of the reclaimed water in a water conserving landscape. The reclaimed water also serves as a source for sub-surface irrigation. The second wetlands, expected to be functional this spring, is located at the Equine Center on the Foothills Campus and a third wetlands is planned at the Spring Creek ropes course.

Water conservation can even be found in the campus District Heating and Cooling systems. Most of the condensate for the District Heating plant is returned for reuse, saving millions of gallons annually. By centralizing the District Cooling plant, the diversity in the cooling loads improves the overall efficiency and reduces water consumption by the cooling towers, in addition to eliminating many once-through process-cooling loads that used City of Fort Collins water for cooling. A project soon to be completed will convert the Main Campus cooling tower from treated water to raw water in the summertime. While this will not save water directly, it will reduce costs and the environmental impact.

Additional steps taken to address water consumption on a growing campus included installation of dozens of water meters and a complete building-by-building water audit, compiling an inventory of hundreds of water consuming devices. Approximately ninety percent of the Main Campus and Foothills Campus are metered in order to monitor water use.

Currently, the University is exploring high-efficiency water fixture options, such as better toilets, urinals and faucets, for current and future buildings. In the future, additional water conservation strategies will be implemented on the Foothills Campus in the form of process cooling improvements, including an autoclave cooling water process loop. The proposed use of graywater is still in preliminary research stages to determine if using graywater could be a safe alternative for some water uses.

Colorado State University will continue to implement water conservation strategies wherever possible as many of these measures involve relatively small cost and have significant financial and environmental payback.

CSU Research Colloquium

Global Water: From Conflict to Sustainability

Tuesday, March 25th, 2008

Hilton Hotel, Fort Collins, Colorado

2005-2015 is the decade designated by United Nations as the International Decade for Action: "Water for Life." 2008 or the "International Year for Sanitation" coincides with many of the issues we are facing today in Colorado including: poor water quality and salinization, wastewater treatment, aging sewer systems, and antiquated policy & institutional frameworks. Historically, international work in water resources has long been a focus at Colorado State University. Today, international water research and development continues and is spread across campus ranging from Engineering, Natural Resources and Agriculture to Sociology, Environmental Health, Business and Biological Sciences.

Environmental and human induced climate changes are effecting natural water regimes world-wide. The Global Water Colloquium aims to present the impact these changes have on decreasing water quality and increasing water scarcity visible across spatial and temporal scales in the hope that the university community will engage in open discussions and collaborative solutions. Many such solutions in the form of technological advances in hydrology and hydraulics will be presented during the 28th Annual Geophysical Union - Hydrology Days being held directly after the Global Water Research Colloquium on March 26-28. Warner College of Natural Resources will be hosting a three day event to celebrate 50 years of the Watershed Science Program beginning March 27th.



The colloquium is designed to benefit investigators with research activities that could be applied to water resources at a local, regional, national and international level as well as researchers with established water resources research programs. Individuals, private consultants, public administrators, managers, policy makers, and those interested in learning more about international research activities in water resources would also benefit from the research colloquium.

The Global Water: From Conflict to Sustainability Colloquium is hosted by the Office of the Vice President for Research. For updates on all these events please visit the Vice President for Research Web site: vpr.colostate.edu

Contact

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Limited Irrigation Research And Demonstration In Colorado

by Joel Schneekloth, Regional Water Resource Specialist
Colorado State University Extension

The combination of climate variability, drought, groundwater depletion, and increasing urban competition for water has created water shortages for irrigated agriculture in Colorado and is driving the need to increase water use efficiency. A statewide water supply survey predicts that 428,000 irrigated farm acres will be converted to dryland cropping or pasture within the next 15 years, mostly due to transfer of water from agricultural uses to meet the water needs associated with population growth (Colorado Water Conservation Board, 2004). A shift from irrigated to dryland cropping would significantly impact the economic viability of agricultural producers and have far reaching indirect effects on businesses and communities that support irrigated agriculture.

Water conservation options other than complete land fallowing are desirable because of the potential economic and environmental concerns associated with conversion to dryland. One approach to reducing consumptive use of irrigation water is adoption of limited irrigation cropping systems. With limited irrigation, less water is applied than is required to meet the full evapotranspiration demand of the crop. Crops managed with limited irrigation experience water stress and have reduced yields compared to full irrigation, but management is employed to maximize the efficient use of the limited irrigation water applied. These systems are a hybrid of full irrigation and dryland cropping systems and are currently of great interest to Colorado farmers. Successful limited irrigation systems are based on the concepts of:

1. Managing crop water stress
2. Timing irrigation to correspond to critical growth stages for specific crops
3. Maximizing water use efficiency by improving precipitation capture and irrigation efficiency
4. Matching crop rotations with local patterns of precipitation and evaporative demand

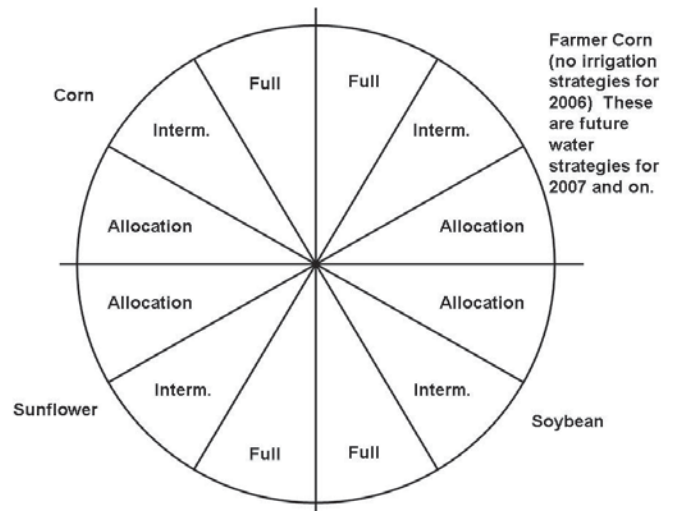
Research in the Great Plains illustrates that limited irrigation cropping systems are significantly more profitable alternatives than dryland (Schneekloth, 1991 and 1995).

Methods

A large scale demonstration site was located near Burlington, Colorado on a silt loam soil. This field is center pivot irrigated. Alternative water management strategies were studied at this site within a 4-year crop rotation of corn-sunflower-soybean and winter wheat. This study looked at full irrigation management, an average allocation of 10 inches per year and an intermediate irrigation management strategy that limits water applied between that of full irrigation and allocation management. Each crop is grown

in a quarter of the center pivot (Figure 1). Within each crop, three water management strategies are being demonstrated. The crops will rotate in clockwise around the pivot each year while the water management strategies will not move. This will show the management issues when water is limited continuously.

Figure 1: Crop and water management layout in 2006



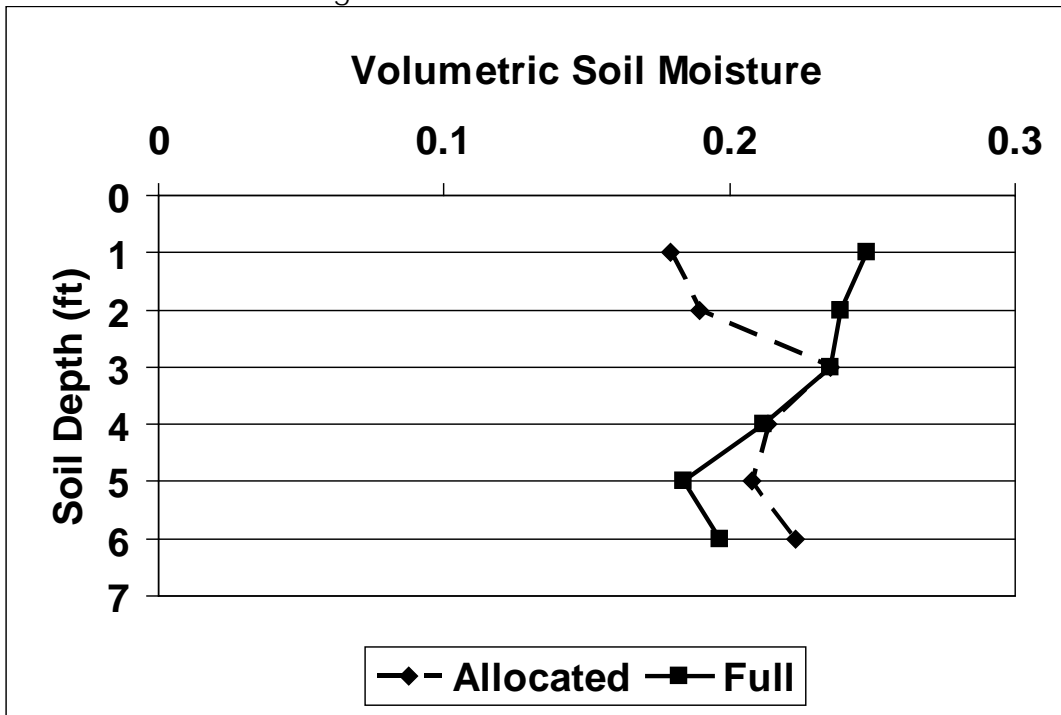
Corn is the predominant irrigated annual crop in Colorado. Alternative crops that use less water were included in the rotation. Soybeans are a new crop in Colorado that responds well to irrigation. Acreage of soybean has been expanding westward from the traditional soybean region.

Results

Burlington

Average grain yields for corn and soybeans were reduced when irrigation was limited as compared to full irrigation. However, in 2006, corn grain yields for all irrigation strategies were similar. Precipitation during 2006 was above average for the growing season by 1.0 inches. Timing of irrigation for the reproductive growth stage did increase early season utilization of stored soil moisture (Figure 2). Approximately 1.4 inches of stored soil moisture was utilized for allocation irrigation as compared to full irrigation. Irrigation requirements for allocation management were 8 inches while full irrigation required 12 inches. This is less than what is estimated for full irrigation management in a normal year. However, there is a potential savings of 4 inches of applied irrigation when limiting water during the vegetative growth stage.

Figure 2: Volumetric Soil Moisture



Grain yields in 2007 were less than in 2006. Approximately two weeks prior to tassel, a severe infestation of corn rootworm was noted in the entire field with 6 larvae per plant being observed. The allocated and intermediate corn was more severely impacted as compared to full irrigation. An insecticide was applied at planting but apparently failed due to insect pressure. After visual observations of damage were taken, it was noted by entomologist that the reduction in grain yield by damage to the roots was approximately 20% for full irrigation (Picture 1). This would have increased yields too approximately 200 bu/acre which was observed in adjacent fields with this variety. The yield reduction for the allocation irrigation was adjusted at approximately 40% (Picture 2).

Soybean grain yields were greater for full irrigation than either intermediate or allocation irrigation by 7 to 10 bu/acre. Grain yields in 2006 were substantially less than would be expected due to herbicide damage. Residual dicamba was in the farmers' sprayer and damage was done when the soybeans were sprayed with glyphosate. Evidence of herbicide damage was evident by leaf cupping on the top of the soybean plants. Soybean yields of a test plot near this region had soybean yields for this variety average near 70 bu/acre.

In 2007, soybeans were drilled. Grain yields for full irrigation were 56 bu/acre with intermediate and allocation management yields of 50 and 45 bu/acre. Although yields were greater than 2006, harvest loss was significant. A fixed 30 foot wheat header was used for harvest. The ability to adjust the location of the head in the field was difficult and losses

Picture 1: Rootworm damage for full irrigation management corn (2007)



Picture 2: Rootworm damage for allocation management corn (2007)



Picture 3: Allocation management soybean on August 1, 2007. The soybeans are in the early reproductive growth stage



Picture 4: Soybeans close to harvest



for the entire field averaged 28 plus bu/acre. The potential yield of the soybean was 70 to 80 plus bu/acre. These yields were also verified by crop adjuster estimates. After further discussion with the producer, harvesting of the soybeans will be changed to include a flex-header. This harvesting equipment floats along the soil surface and automatically adjusts to terrain differences. Irrigation requirements for full irrigation soybeans in 2007 were 13 inches with 9 inches applied to allocation management. (Picture 3 and 4)

Sunflowers respond well to limited amounts of irrigation. Sunflower grain yields in 2006 averaged 2500 to 2600 lbs per acre for allocation and intermediate irrigation management (Table 1). Full irrigation yields were 2400 lbs per acre. These yields were 400 to 500 lbs per acre less than hand harvested yield. Harvest losses were greater than expected due to increased lodging from insect pressure. Oil content for the allocation and intermediate management averaged 47% while full irrigation management oil content was 42%. This yield response is similar to previous research which has shown in average precipitation years, sunflowers do not respond to irrigation during the vegetative growth stage. Irrigation requirements for full irrigation management were 8 inches while the allocation management had 4 inches of applied irrigation.

In 2007, grain yields for sunflower were less than 2006. Full irrigation management averaged 2050 lbs per acre while allocation and intermediate irrigation management

averaged 1700 and 1550 lbs per acre respectively. Harvest losses were again a significant impact on grain yields. Hand harvested yields were approximately 2500 lbs per acre for each of the three management strategies. The full irrigation management sunflowers were planted approximately 1 week later than the intermediate and allocation management sunflowers due to rainfall. The full irrigation management sunflowers did stand better than the earlier planted sunflowers which may have increased harvested yield of the full irrigation compared to allocation management.

Conclusion

Limited irrigation management of crops is management intensive and is potentially more risky than full irrigation management. However, research and demonstration projects in Colorado have successfully shown that irrigation water can be reduced and economical yields obtained. Alternative crops such as sunflower and soybeans can reduce the amount of irrigation needed as compared to corn. Education and marketing will play an important factor in the acceptance of these crops for irrigation conservation.

However, under current water law and regulations, water management such as limited water is not practical in years other than water short years in ditch and reservoir systems. In groundwater management areas, declining water resources and compact litigation may force limited irrigation changes with less water in the future.

Table 1. Grain yields for corn, soybean and sunflower at Burlington, Colorado.

Irrigation Strategy	Corn (Bu/acre)			Soybean (Bu/acre)			Sunflower (lbs/acre)		
	2006	2007	Avg	2006	2007	Avg	2006	2007	Avg
Allocation	193	127	160	40	45	42.5	2490	1710	2100
Interm.	203	145	174	37	50	43.5	2580	1560	2070
Full 198	198	160	179	47	56	51.5	2390	2050	2220

The Agricultural Water Conservation Clearinghouse A New Resource For Agricultural Producers And Water Managers

by Matt Neibauer and Faith Sternlieb, Colorado Water Resources Research Institute

As we move along in the 21st Century, Colorado and the Western United States (U.S.) are experiencing water shortages as rapid urbanization and limited water resources shape how we farm, manage our water supplies, and create natural resource policies and laws. With production agriculture accounting for about 90 percent of the consumptive use of water in Colorado, it is important to address the needs of producers and water managers living in these areas where critical water resources are limited. Based on the issues and problems agriculture faces with regards to limited water supplies, the Colorado Water Resources Research Institute (<http://cwrr.colostate.edu/>) and the Northern Plains and Mountains Regional Water Program (<http://region8water.org>) are currently developing an online regional and national clearinghouse of information, concerning agricultural water conservation, which highlights state of the art research and technology by international experts facing similar water constraints. The Colorado Water Conservation Board has allocated funding beginning July 2008 to build and maintain the website as a resource for Colorado.

The Ag Water Conservation Clearinghouse (<http://agwaterconservation.colostate.edu>) will ultimately provide current, science-based information on a wide variety of agricultural water conservation issues. The centerpiece of this online clearinghouse is a comprehensive database and library, which identifies current research and educational outreach publications regarding irrigation management, irrigation technology, efficient water delivery systems, agricultural water reuse and recycling, soil moisture and evapotranspiration measurement, cropping systems, as well as agricultural economics and water law/policy. This database will eventually house all of these agricultural water conservation topics in a variety of formats, including refereed journal articles, books, fact sheets, bulletins, reports, theses/dissertations, and conference proceedings

National Water Program
A Program of the Colorado Water Resources Research Institute

Colorado State University

AGRICULTURAL WATER CONSERVATION CLEARINGHOUSE

home | library | research | news | tools | resources | FAQs | glossary | contact us | feedback

PROJECT DESCRIPTION

This website is a clearinghouse of information about agricultural water conservation. The project's goals are to increase access to information which will help build collaborative relationships between and among agencies region and nation-wide, provide technical expertise regarding agricultural water conservation, and offer detailed information on the management, policies, and laws surrounding agricultural water conservation.

PRACTICES & TECHNOLOGY

So that the user may maneuver easily throughout the website, the information contained within the library is largely organized by agricultural water conservation practices and technology which have been divided into eight categories: Cropping Systems, Delivery Systems, Irrigation Management, Irrigation Technology, Ag Econ & Policy, Ag Water Recovery, Reuse & Recycling, Phreatophyte Control, and Soil Moisture/ET Measurement.

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Highlights/Events

EVENT: CSREES-USDA National Water Conference
Feb 3-7, 2008
Reno, Nevada

EVENT: AWWA 2008 Sustainable Water Sources: Conservation and Resources Planning
Feb 10-13, 2008
Reno, Nevada

EVENT: 13th Water Conservation & Xeriscape Conference
Feb 21-22, 2008
Albuquerque, New Mexico

What's New . . .
Colorado State University has been granted newly funded National Facilitation Project
Read more . . .

The Agricultural Water Conservation Clearinghouse website will also provide current links to Agricultural Experiment Stations and Land Grant Universities, as well as up-to-date information on agricultural water related research centers, irrigation management curriculum / workshops, and irrigation tools. As development of the website expands, we will also be featuring upcoming events and news related to agricultural water conservation to regional and national audiences. This newly developing resource also contains a comprehensive glossary, frequently asked questions (FAQs), and current news on agricultural water conservation and irrigation efficiency.

With a built-in feedback option, this clearinghouse is designed to help build knowledge and connect water resource managers from various local, state, regional, and national organizations providing agricultural water conservation expertise.

We would like to invite you to take a look at this new and developing online resource. We also encourage you to provide us with feedback and contact us with questions, comments, and suggestions as to how this dynamic resource might be improved to optimize its utilization. Please contact the following people for more information about this new online agricultural water conservation clearinghouse:

- Faith Sternlieb, Research Associate, CWRRRI
(970) 491-6328
faith.sternlieb@research.colostate.edu
- Matt Neibauer, Assistant Regional Water Coordinator, CWRRRI
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matt.neibauer@research.colostate.edu



Colorado Water Workshop

Pete Lavigne, Director 970-943-3162 fax 970-943-3380 plavigne@western.edu

Call for Papers, Posters and Presentations! Water Workshop May 14-16, 2008

Our theme for 2008 is **Mining, Energy and Water in the West**. We'll be looking at the water quality and supply issues around the revival of mining and energy production in the region including coal bed methane production in Colorado, Utah, Wyoming and elsewhere; coal mining in Colorado, Arizona and other areas; reopening and/or new uranium and molybdenum mining; water related effects of the ethanol boom; and other topics you suggest related to mining, energy development and water.

We'll also have updates on other Colorado issues including the 1177 process and possibly the Black Canyon litigation.

*Send your proposals now! **Abstract deadline January 10, 2008.***

Send to water@western.edu



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www.western.edu/water

Colorado Water Workshop 2007 Photographs



(top) A CWW Presentation

(left) Pat Mulroy, Pamela Hyde and Jack Schmidt at the 2007 Water Workshop

(right) Ferrell Secakuku former Chairman, Hopi Tribe.



Development of Oilseed Crops for Biodiesel Production Under Colorado Limited Irrigation Conditions

by Dr. Jerry Johnson, Research Scientist, and Mr. Nicolas Enjalbert, Graduate Research Assistant, Department of Soil and Crops Sciences, Colorado State University

Since 2001, Colorado State University's Crops Testing Program, in collaboration with many other university and USDA ARS researchers, extension agents, farmers, private companies, and a non-profit organization, has undertaken oilseed-for-biofuel crop research and extension. Collaboratively, this work has been undertaken with the objective of testing and adopting oilseed crop species (and varieties) to dryland, limited irrigation, and fully irrigated cropping systems prevalent in eastern Colorado, eastern Wyoming, western Kansas, and the Nebraska Panhandle. Regional applied research has focused on crop variety and agronomy trials, interaction with first-adopter farmers, weed control experiments, insect pest observations, crop water use experiments, crop response to variable climatic conditions, and has resulted in a strong collegial relationship among researchers, farmers, private company representatives, and extension agents within the Great Plains area.

This multifaceted limited irrigation oilseed research project is an integral contributor and benefactor of our overall efforts to provide cropping alternatives that are agronomically sound, economically feasible, and environmentally sustainable to eastern Colorado producers, specifically those needing to adapt to limited irrigation due to water depletion or by regulation.

Target Species Variety Performance Trials Results and Analyses

In 2007, five target oilseed crops were studied: soybeans, safflower, sunflower, canola and camelina. Performance trials were conducted at nine locations within Colorado: Fort Collins, Akron, Walsh, Dailey, Idalia, Yuma, Brandon, Julesburg and Rocky Ford. Oilseeds crops were tested under three environmental conditions: dryland, limited irrigation and full irrigation. Crop data collected yields, percent grain moisture, plant height and pod shattering. Safflower, canola and camelina were studied with greater detail. The oil profile was evaluated for canola, camelina, and safflower.

The five target oilseed crops are being studied in three Colorado cropping systems (Table 1). Sunflower, soybean and safflower are summer annual broadleaf crops. Late fall harvest of these crops make it difficult to get back to winter wheat in Colorado cropping systems the same year. Soybean is primarily an irrigated crop. Sunflower is both a dryland and an irrigated crop. Safflower is primarily a dryland crop. Winter canola and winter camelina can be either integrated into the dryland wheat cropping system or into an irrigated cropping system. However, canola should be considered as an irrigated crop whereas camelina is competitive in dryland conditions.

Spring canola and camelina provide opportunity crops that can be integrated into the dryland wheat rotation predominant in eastern Colorado, planted in early spring, harvested in July and followed by wheat planting in September. Spring canola may be limited by high summer temperatures which reduce pollination and pod filling. Camelina is more drought tolerant and less sensitive to high temperature during pollination and pod filling



Camelina experiment in the greenhouse

Table 1. Cropping Systems Adaptable Oilseed Crop for Colorado

Crops	Months											
	August	September	October to February	March	April	May	June	July	August	September	October	
Soybean						Planting Date				Harvesting		
Sunflower							Planting Date				Harvesting	
Safflower							Planting Date				Harvesting	
Winter Canola & Winter Camelina		Planting Date						Harvesting	Planted back to wheat			
Spring Canola & Spring Camelina				Planting Date				Harvesting	Planted back to wheat			

Results of 2007 Crop Variety Performance Trials

In 2007, six variety performance trials of soybean, nine of sunflower, three of safflower, six of canola and three of camelina were conducted. A total of 27 oilseed crop variety trials were conducted in nine eastern Colorado locations.

Soybean

Soybean is presently the primary source of virgin oil for biodiesel in the US. More than 1.5 billions pounds of soybean oil are currently used in the biodiesel industry. The soybean oil profile is in accordance of the US biodiesel standard (ASTM PS 121-99). It has a high level of oleic fatty acid, low level of saturated fatty acid, and medium polyunsaturated fatty acid content (24%), which makes soybean oil a good source for SVO. Soybeans are grown successfully on 62.8 millions acres in the US mainly in the Mid West. Soybean production is well understood, but it is a relatively new crop for Colorado. In the High Plains, soybeans need to be grown under irrigation, and need relatively large amounts of water at the same time as other summer crops. Soybean trials at Yuma in 2006 and 2007 demonstrated soybean yield potential up to 100 bu/ac (Table 2).

Sunflower

Sunflower is native to the High Plains and is well adapted. It is a drought tolerant crop and suitable for dryland production. Average yields for dryland sunflower is 1,100 lbs/ac. Best management practices for Colorado have been established. New cultivars with high oleic content make sunflower oil healthier for human as well as very suitable for SVO. A dryland trial conducted in 2007 demonstrated yields up to 2,445 lbs/ac, and up to 3,474 lbs/ac under limited irrigation (Table 3).

Safflower

Safflowers are grown on a limited number of acres in the High Plains. Its center of origin is in Asia where it is used for vegetable oil and dye pigment. In Colorado, safflower production is for bird seed. Safflower is drought tolerant and has high oil content. Safflower has an acceptable oil profile for SVO. 2007 trial results show yields up to 467 lbs/ac (Table 4). But much higher yields have been achieved in different years and with better crop management practices. Safflower oil content can approach 50% in some cultivars.

Winter and Spring Canola

Canola is grown on a limited acreage in the High Plains. However, it has the potential to become an important crop. It contains about 40% oil.

Canola yields are limited by temperatures greater than 90°F during the flowering period, as heat reduces pollen fertility. Low moisture profile will reduce yields more than camelina. Canola has a taproot system giving the crop access to deep water and nutrients (Downey et al., 1974). However, when grown in semiarid regions such as the High Plains, the canola roots require adequate subsoil moisture to sustain the crop during flowering and seed filling. Under managed irrigation winter canola is capable of yielding more than 3,000 lbs/ac. Winter and spring canola varieties are being screened to identify promising cultivars for Colorado's limited irrigation and dryland conditions. Trials conducted in 2007 demonstrate yields of 800 lbs/ac under dryland and of 2,400 lbs/ac under limited irrigation (Table 5).



Winter oilseed trials at Akron

Camelina

Camelina is an oilseed crop native to Southeast Europe and Southwest Asia. The plant has been known for about 4000 years as a cultivated crop but there has been relatively little research conducted on it worldwide. Camelina is adapted to more marginal environments and could be a new introduced crop for dryland systems in Colorado. Presently, it is grown on a limited number of acres in the High Plains. Montana is a leading producer of camelina with approximately 40,000 acres in 2007.

Table 2. Soybean Trial Performance Summary

Location	Maturity	Water Regime	Average (bu/ac)	Max (bu/ac)	Min (bu/ac)
Akron	Early	Dryland	11.4	18.2	5.9
Fort Collins	Early	Limited Irrigation	20.7	30.3	10.9
Fort Collins	Medium	Limited Irrigation	25.4	33.3	15.4
Rocky Ford	Early	Limited Irrigation	34.5	48.9	20.6
Rocky Ford	Medium	Limited Irrigation	40.4	44.9	36.5
Yuma	Late	Irrigated	78	99.4	66.9

*Soybean oil content can be assumed to be 18%

Table 3. Sunflower Trial Performance Summary

Location	Type	Water Regime	Average (bu/ac)	Max (bu/ac)	Min (bu/ac)	Oil (%)
Brandon	Oil	Dryland	11.4	18.2	5.9	38.70
Julesburg	Oil	Irrigated	20.7	30.3	10.9	41.15

Table 4. Safflower Trial Variety Performance Summary

Location	Water Regime	Average (bu/ac)	Max (bu/ac)	Min (bu/ac)
Akron	Dryland	430	467	395
Fort Collins*	Limited Irrigation	221	301	182
Walsh	Dryland	208	250	148

Camelina is a drought and cold tolerant crop, resistant to flea beetles and other insect pests. In the past two years, camelina has had higher yield than spring canola under dryland condition at Akron. However, camelina does not have entirely determinant plant growth habit which can lead to significant harvest losses. Moisture received by either rainfall or irrigation at maturity can cause camelina to initiate new growth resulting some green and some shattering pods.



Charlie Rife (Breeder from Blue Sun) observing the Camelina

Camelina is a drought and cold tolerant crop, resistant to flea beetles and other insect pests. In the past two years, camelina has had higher yield than spring canola under dryland condition at Akron. However, camelina does not have an entirely determinant plant growth habit which can lead to harvest losses if it rains in July and new flowers and pods are produced. Camelina uses less water and less nitrogen to obtain good yields than canola. Camelina is suited for the High Plains (Pavlista & Baltensperger, 2006). However, best management practices for sustained camelina crop production are not well understood.

Screening New Alternative Crops

One aspect of the study is to identify new germplasm of targeted crops that will have a better response to limited irrigation. Currently, 140 accessions, 101 *Camelina sativa* and 39 of *Brassica carinata* are being evaluated in the CSU greenhouse.

Economic Feasibility

The economic feasibility of these new oil crops must be addressed, specifically two practical economic questions frequently asked about oilseed production for use as Straight Vegetable Oil (SVO) on the farm.

1. What is the break-even price per pound and yield that would make it economically feasible to produce oilseed under limited irrigation conditions?
2. What price per gallon of petroleum diesel, and crop yield, does it become feasible to grow your own fuel under limited irrigation conditions?

There are cropping systems options that can be considered that includes oilseed production for biofuel, but in the interest of answering these two questions as succinctly

and clearly as possible, our economic example is based on a hypothetical crop rotation producing three crops in three years and including winter wheat: Corn / Spring Canola / Winter Wheat (as opposed to an alternative four year rotation with three crops that might be Corn / Corn / Winter Wheat). The rotation with spring canola allows the producer to harvest canola in late July and plant back to winter wheat the same year. Our limited irrigation cropping system production costs differ from the costs of full irrigation by lower costs of nitrogen fertilizer and slightly lower irrigation costs. Moreover, the fixed cost per crop is lower in the spring canola/winter wheat rotation because there are three crops in three years as opposed to three crops in four years. Oilseed crops in the Brassicaceae family, like canola and Camelina, are good rotation crops because high levels of glucosinolates can effectively break some harmful pest cycles.



Student working on the greenhouse experiment

Benefits of Straight Vegetable Oil (SVO) for Colorado

SVO has many benefits when compared to petro-diesel. Because it requires no refining, it also has advantages over biodiesel and other biofuels. Most importantly, as a renewable resource, it provides an opportunity for farming communities for generations to come.

SVO is not harmful to humans, animals, soils or water. The German Federal Water Act on the Classification of Substances Hazardous to Waters denotes SVO as NWG (non hazardous to water). Biodiesel on the other is slightly hazardous to water while diesel and gasoline are rated as highest toxicity. A North American study on the toxicity of vegetable oil in freshwater also found no harmful effects.

As a fuel, it emits 40 to 60% less soot compared to petro-diesel. It does not contain sulfur and therefore does not cause acid rain. In addition, carbon monoxide and particulate emissions are slightly lower. CO2 emissions are also reduced by 80 to 96% compared to petro-diesel when locally produced and used fuel. Finally, Polycyclic Aromatic Hydrocarbons (PAH) emissions are distinctly lower for all vegetable fuels, reducing risks of cancer.

Table 5. Canola Trial Performance Summary

Location	Source	Water Regime	Average (bu/ac)	Max (bu/ac)	Min (bu/ac)
Akron	Commercial	Limited Irrigation	1891	2397	1458
	Commercial	Full Irrigation	1837	2424	1205
	Cargill	Limited Irrigation	1645	2900	1205
	Cargill	Dryland	401	807	343
	Blue sun	Limited Irrigation	1259	1777	1406
Fort Collins	Commercial	Limited Irrigation	259	761	79

Canola Oil Emissions Testing Results

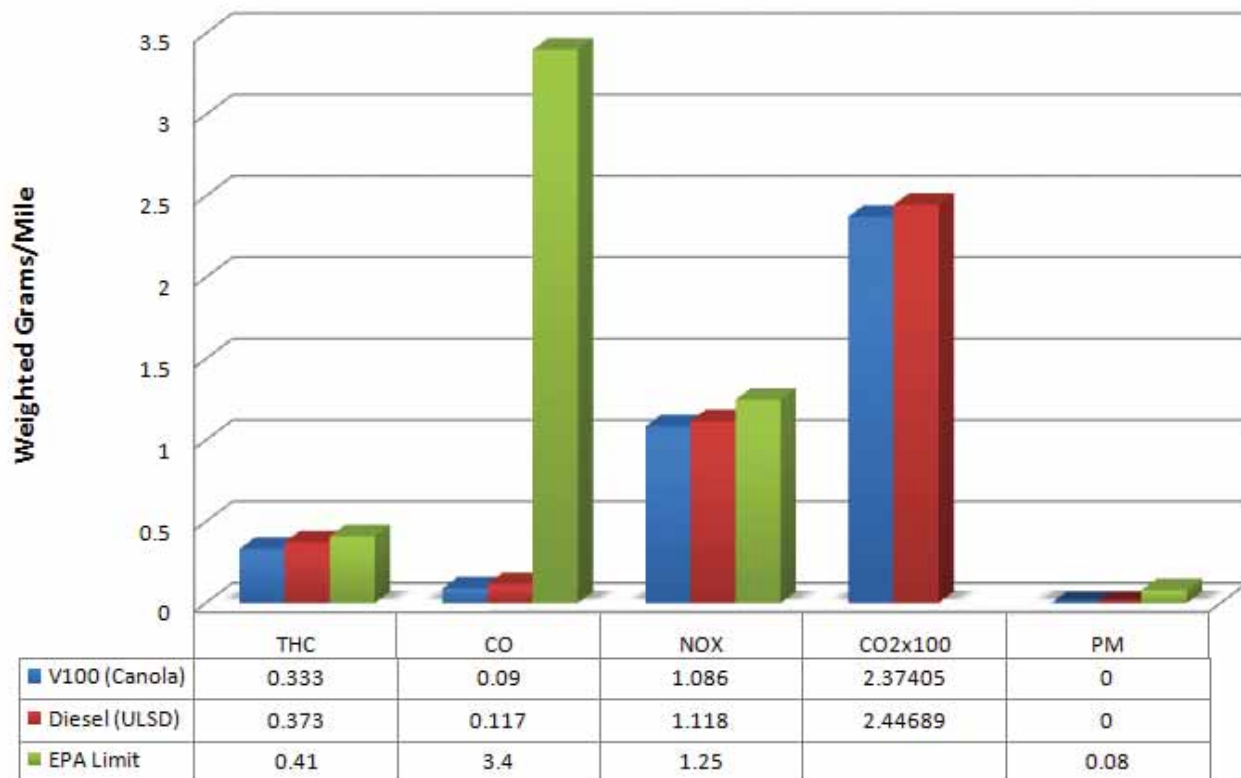
SVO can contribute to an energy-independent Colorado agricultural system as well as increase food and feed sector security. Gasoline has a 0.873 energy ratio (energy yield/energy input). If we include distribution and the value of canola meal, the energy ratio number for canola based SVO is 5.45 while for sunflower based SVO, it is 6.33. At average yields of 2200 lb/ac and petroleum diesel at \$2.50/gallon, net returns would be expected to be \$148/ac. Perhaps equally important is that on-farm production of biofuel (independence from foreign energy) would make Colorado's food and feed supply more secure and less likely to be affected by world affairs beyond local control. In addition, the carbon footprint of Colorado agriculture would be smaller and new crops that require less water could be a new source of farm income.



iCAST Engineering Project Manager Micah Allen presenting to farmer group on how to make fuel

Canola Oil Emissions Testing Results

Testing by Albuquerque Alternative Energies, PlantDrive and VO Control Systems on a 2002 VW Golf TDi at the National Center for Vehicle Emissions Control and Safety (EPA certified) on January 19th, 2007



PUBLIC EARTH DAY EVENTS

April 22, 2008

GARY A. PETERSON AND DWAYNE G. WESTFALL ANNUAL LECTURE



William Bryant Logan is an award-winning nature writer. He regularly makes presentations and teaches classes and workshops regarding the care of trees and regarding the natural history of soils, including a lecture to the Soil Science Society of America. He also taught nonfiction writing at the Columbia University Graduate School of Journalism.

DEPARTMENT OF
SOIL & CROP SCIENCES

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Please join us to celebrate Earth Day and to recognize the importance of our soil and water resources. All events are free and open to the public.

Lectures Presented by award winning nature writer

William Bryant Logan

discussing his literary works about natural resources.

Lecture Details

Dirt: The Ecstatic Skin of the Earth

2:00 p.m. – 3:30 p.m.

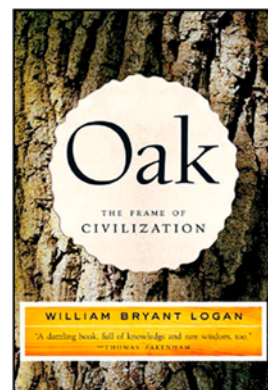
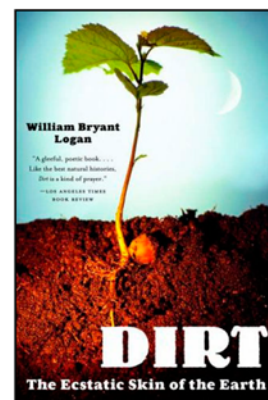
West Ballroom, Lory Student Center
Colorado State University

Please stay for a reception and book signing from 3:30 - 4:00 p.m.

Oak: Frame of Civilization

7:00 – 8:00 p.m.

West Ballroom, Lory Student Center
Colorado State University



Books will be available for sale before and after the lectures and the author will be available to sign your copy.

Potential Reforms Concerning Expert Testimony in Water Cases

by Mariam J. Masid, J.D., Ph.D.

On December 4, 2007, Colorado Supreme Court Chief Justice Mary Mullarkey signed an order authorizing the establishment of the Water Court Committee of the Colorado Supreme Court. The Committee is currently chaired by Justice Gregory J. Hobbs, Jr. and is comprised of 21 members who will serve through August 1, 2008. The Water Court Committee is charged with the task of reviewing the water court process; identifying possible ways to achieve efficiencies in water court cases through rule and/or statutory changes; and ensuring the highest level of competence in water court participants. The committee must make its recommendations to the Chief Justice by August 1, 2008, and the report will then be thereafter made available to the Colorado General Assembly and Governor Bill Ritter. A public input meeting is scheduled for March 10, 2008, relating to the work of the Water Court Committee as a whole.

In the order authorizing the committee, the Chief Justice set forth ten issues for the Committee to consider. Included in the matters under consideration are the rules pertaining to experts and expert testimony before the referee and water judge. In the organizational meeting of the Committee held on December 20, 2007, six subcommittees were formed. Included is a "Role of Experts Subcommittee" made up of David Robbins and Hal Simpson as Co-Chairs, and Andy Jones and Judge John Kuenhold as subcommittee members. This subcommittee had two meetings scheduled in February 2008.

The resource materials that are being reviewed by the subcommittee include this author's doctoral dissertation, which researched the history, problems and international reforms related to expert witness testimony. The research also included a survey conducted with participants of Dividing the Waters (DTW) a water education project for judges and quasi-judicial officers. This article provides a brief summary of the dissertation, which is posted in its entirety on the Colorado Supreme Court's website: <http://www.courts.state.co.us/supct/committees/waterctcomm.htm>

Admissibility of Experts in the Courts

The increasing competition for water resources has given rise to greater pressure on water courts and administrative bodies to resolve disputes. Adding to the court's burden, have been the changing standards for admissibility of expert witness testimony under the state and federal rules of evidence, and the need to assimilate the standards by which those rules have been interpreted by the courts. This gatekeeping role requires the judge to assess the qualifications of the expert, analyze the expert's proposed theories and processes, and to determine whether or not to admit the expert's testimony. Because most judges are generalists in the law and are usually not trained in the sciences or

engineering, there have been recommendations that judges, in order to be effective gatekeepers, should become more learned in the scientific method. This is so that they can assess whether the expert's methodology is scientifically valid, and whether that methodology can be properly applied to the facts at issue in the case. The challenges faced by water judges and administrative hearing officers are compounded by the sheer complexity of hydrological science and engineering in water matters.

In the U.S. common law tradition, the parties select the witnesses and present them to the court for consideration. The process is by its nature adversarial and the culture is combative. The parties and their lawyers select expert witnesses to help them win. The opposing parties will marshal their own experts, transforming the courtroom into a battle of experts. The judge or hearing officer is left to discern which party's expert to believe, often with experts reaching diametrically different opinions.

In water allocation cases, a water right must be defined and quantified, and in prior appropriation states like Colorado there must be a showing that there is no injury to other water users. The judge or hearing officer must be informed as to the effect of altering diversions and return flows. Enforcement of prior appropriation requires sophisticated knowledge of complex systems involving surface and ground water sources that are hydrologically connected. As a result of technological advances of computers, hydrologic models have become an essential tool by the parties and their experts in water cases. The first step in constructing a model is defining the purpose of the model. In the context of courtroom science, case studies show that some experts are constructing models with the primary purpose of providing results that will support the case or position of the party or attorney that hired them.

Because hydrologic modeling can be misused, the judge's gatekeeping role becomes that much more critical. The quality and reliability of a hydrologic model may be suspect because of its complexity, the paucity of data used in calibration and validation, and the lack of transparency. The existing rules of evidence and standards of admissibility dictate that a judge must become sufficiently knowledgeable in hydrologic science and engineering in order to assess the reliability, not only of the model, but also of the method by which the model is operated. The judge must determine whether the model has been operated in such a fashion that the results are reliable and useful to the court.



Mariam Masid

Expert witnesses were initially allowed into the courts only for the purpose of assisting the trier of fact to understand matters beyond their common knowledge. This is an exception to the general rule that only fact witnesses may testify, and opinions are not allowed. An exception was also made to the rule that persons with a financial interest may not testify. In eighteenth century England, scientific men were on their honor to be honest and impartial, and the judges were not concerned that a scientist would jeopardize his reputation by expressing an opinion that was biased or partial to one side or the other.

As changes occurred in the common law system and the rules of evidence were developing, attorneys took on the role of calling the witnesses and the judge had a less active role in the dispute. To better assist their client's cause, attorneys selected and called experts who would testify in support of their client's position. Experts took on more of a partisan role, and became advocates themselves, often expressing the scientific theory or opinion that would support their side of the case.

Attempts to control the use of expert witnesses in the courts of England and the United States in the 19th century met with little success. Beginning in the early 20th century, the nearly uniform admissibility standard in the United States was that the testimony of the scientific expert had to be generally accepted in the scientific community. It was not until the 1990's that the U.S. Supreme Court ruled that 'general acceptance' was only one factor to be considered, along with falsifiability, error rate and peer review. *Daubert v. Merrell Dow Pharmaceuticals, Inc.*, 509 U.S. 570 (1993). Judges must now determine whether the proffered expert witness will testify to scientific knowledge that will assist the trier of fact to understand or determine a fact in issue. This entails a preliminary assessment of whether the reasoning or methodology underlying the testimony is scientifically valid, and whether that reasoning or methodology properly can be applied to the facts in issue.

In the legal literature, the discourse reveals a debate as to what is expected of judges; how to assist them in learning enough about scientific and technical matters so that they can be effective gatekeepers; and what effect the *Daubert* factors has had on the courts and the admission of expert testimony. Arguments supported by researchers conducting empirical studies have, for the most part, concluded that:

1. *Daubert* has made very little difference with regard to keeping junk science out of the courtroom
2. Judges do not generally understand the scientific methodology and so are gatekeeping in their own way
3. *Daubert* has had unintended consequences, and judges are making decisions in pretrial hearings that are preventing many experts from testifying
4. Good science is not always allowed in and bad science may be coming in, because judges may not be learned enough in the sciences to make the necessary distinctions

The literature also reveals judges' complaints that cross-examination is not being used effectively in making the expert accountable, or to help the judge decide between two or more opposing expert opinions. Cross-examination has also been criticized because it is used to attack the expert witness or find flaws, rather than clarify the issues or solve the discrepancies. There are also complaints of partisanship and bias by experts, the excessive number of experts being used, and the ensuing cost to the courts and the parties. These problems have been identified not just in the United States, but also in most international jurisdictions that follow the common law adversarial tradition.

International Reforms

Since the mid-1990's civil justice reforms regarding the use of expert witnesses has begun and is gaining momentum. The reforms in England and Wales, and the expert witness 'code' set out in *National Justice Compania Naviera SA v. Prudential Assurance Co. Ltd.*, 2 Lloyd's Rep 68 (Comm. Ct. Q.B. Division 1993), commonly referred to as *The Ikarian Reefer* case, have been catalysts and models for reforms in Australia, New South Wales, Canada and Hong Kong. Early reports reveal that those reforms are meeting with general acceptance and apparent success.

Literature concerning potential reforms in the United States suggests that reform is needed; however the adversarial system is very much entrenched, and if reform is to occur, it will need to be done with localized, context-specific solutions which respect the need for diversity in problem solving approaches. Water disputes are not tried to juries and therefore are not subject to the often cited concern that reforms will affect the right to a trial by a jury of one's peers.

The DTW Survey

In order to assess the need and receptiveness for reform concerning expert witness testimony in water cases, a survey was created for the members of *Dividing the Waters*. The DTW survey instrument served two purposes, first to compare the issues and problems experienced by DTW with experiences of Australian judges and magistrates responding to surveys conducted by the Australian Institute of Judicial Administration (AIJA) in the last decade; and second to determine the receptiveness of Western water judges and administrative officers to the various reforms that have been adopted in various international jurisdictions.

The DTW survey results reveal that the problems with expert witnesses in the Western water courts and tribunals are very similar to the problems encountered in Australia. Similar to the Australian experience, 'adversarial bias' was identified as the most serious problem with expert witness testimony encountered. The next most serious problem is use by the expert of oral or written language that is difficult to understand. The DTW survey also revealed that judges who have difficulty evaluating the opinions of one expert against another, blame first the fundamental irreconcilability of the views expressed by the experts, and second the inadequate cross-examination of expert testimony. The

responses by the Colorado water judges and administrative officers followed the overall majority of DTW participants who answered the survey.

The survey revealed that the majority of DTW judges and administrative officers are in favor of reforms that will:

- Create a paramount duty to the court or tribunal
- Require experts to discuss issues prior to trial or hearing without attorneys or parties
- Require a joint report of experts that narrows the issues – indicating areas of agreement and areas of disagreement
- Require the parties to consider whether a single joint expert should be appointed
- Require all written instructions and notes of oral instructions to the expert be annexed to their report
- Require the expert to specify the bases of their opinion in writing
- Require the expert to specify all assumptions that they made in forming their opinions
- Require the expert to disclose whether, and to what extent, their written reports were edited by the parties or the attorneys

- Require experts to sign a declaration acknowledging their role as advisors to the court rather than advocates of the parties
- Require the expert to disclose whether their reports are inconsistent with any other report they have proffered in any other adjudicative or administrative hearing
- Promote more frequent use of court appointed expert witnesses
- Require parties to disclose whether a shadow expert has been used

The dissertation includes a discussion of the reforms that have been adopted in other jurisdictions and makes proposals for phasing in new rules for similar reforms in the United States water courts and administrative bodies. These proposed reforms are currently under consideration by the Colorado Water Court Committee, along with the consideration of other potential reforms in the areas of interest identified by Chief Justice Mullarkey's order.

[Portions of this article are from a dissertation submitted to the Academic Faculty of Colorado State University in partial fulfillment of the requirements for the degree of Doctor of Philosophy, by Mariam J. Masid entitled "Reforming the Culture of Partiality: Diffusing the Battle of the Experts in Western Water Wars," October 30, 2007]



Recent Publications

A Post-Wildfire Hydrologic Hazards in the Wildland Urban Interface of Colorado and the Western United States, by M.R. Stevens, C.R. Bossong, M.G. Rupert, A.J. Ranalli, E.W. Cassidy, and A.D. Druliner <http://pubs.usgs.gov/fs/2007/3036/>

Presentation Showing Results of a Hydrogeochemical Investigation of the Standard Mine Vicinity, Upper Elk Creek Basin, Colorado, by A.H. Manning, P.L. Verplanck, M.A. Mast, and R.B. Wanty <http://pubs.usgs.gov/of/2008/1012/>

Rocky Mountain Snowpack Chemistry at Selected Sites, 2004, by G.P. Ingersoll, M.A. Mast, L. Nanus, H.H. Handran, D.J. Manthorne, and D.M. Hultstrand <http://pubs.usgs.gov/of/2007/1045/>

Urban-Related Environmental Variables and Their Relation with Patterns in Biological Community Structure in the Fountain Creek Basin, Colorado, 2003-2005, by R.E. Zuellig, J.F. Bruce, E.E. Evans, and R.W. Stogner <http://pubs.usgs.gov/sir/2007/5225/>

Water-Quality Data Collected from Vallecito Reservoir, Its Inflows and Outflows, Southwestern Colorado, 1999-2002, by A.J. Ranalli <http://water.usgs.gov/ds/305/>

Assessment of Historical Water-Quality Data for National Park Units in the Rocky Mountain Network, Colorado and Montana, through 2004, by M.A. Mast <http://pubs.usgs.gov/sir/2007/5147/>

Climate Variability and Change, by U.S. Geological Survey <http://pubs.usgs.gov/fs/2007/3108/>

Ground-Water Quality and Potential Effects of Individual Sewage Disposal System Effluent on Ground-Water Quality in Park County, Colorado, 2001-2004, by L.D. Miller, and R.F. Ortiz <http://pubs.usgs.gov/sir/2007/5220/>

Trace-Element Concentrations in Tissues of Aquatic Organisms from Rivers and Streams of the United States, 1991-1999, by L.R. DeWeese, V.C. Stephens, T.M. Short, and N.M. Dubrovsky <http://pubs.usgs.gov/ds/309/>

Water-Quality Assessment of the High Plains Aquifer, 1999-2004, by P.B. McMahon, K.F. Dennehy, B.W. Bruce, J.J. Gurdak, and S.L. Qi <http://pubs.usgs.gov/pp/1749/>

U.S. Geological Survey Colorado Water Science Center: <http://co.water.usgs.gov>

Production Management with Reduced Irrigation Water Supplies

by Robert Pearson, Assistant Water Quality Specialist Dept. of Soil and Crop Sciences
Troy Bauder, Water Quality Specialist Dept. of Soil and Crop Sciences
Neil Hansen, Associate Professor, Dept. of Soil and Crop Sciences
James Pritchett, Assistant Professor, Agricultural and Resource Economics

Reduced irrigation water supplies influence farm production economics and sustainability. With limited or no irrigation water supplies, area producers are faced with lower margins of profit and decreased farm productivity. Area producers are questioning what crops they should produce with less irrigation input or how best can they manage formerly irrigated land. Low water use crops such as small grains, oil seeds and sunflower offer cropping system options, which may provide interim production possibilities when producers are faced with a limited irrigation water supply. Although fully irrigated corn has higher evapotranspiration (ET) requirements, its water use efficiency is higher than these low water use crops. Therefore, corn has the potential of yielding more pounds of grain when it uses the same amount of water as these crops. However, with less water supplied to corn than it needs to meet full ET requirements, yields will be impacted negatively. Timing irrigation events by development stage can also influence crop performance and yield. With limited irrigation provided and potential precipitation events occurring at key developmental stages, yield impact can be mitigated or sustained near fully irrigated corn. Cover crops are a potential option where

producers are faced with extremely limited irrigation or no irrigation water supply. If managed properly, cover crops increase soil productivity by improving soil physical and soil chemical properties. Cover crops can be managed to reduce soil erosion, evaporation and weed infestations, transition an irrigated cropping system to dryland agriculture, aid in the establishment of a grassland or native plant ecosystem, provide an interim solution to weed and soil management while waiting for irrigation water restoration and offer cash benefits from forage or grain harvests.

As part of the Irrigation Water Optimization Project, (limitedirrigation.agsci.colostate.edu) researchers from the Departments of Soil and Crop Science and Agriculture and Resource Economics at Colorado State University investigated corn and cover crop production under limited irrigation and dry-land scenarios¹. This on-farm demonstrative research was conducted to help stake-holders better understand impacts of reduced irrigation water availability on corn grain yield (Limited Irrigation trial) and how to effectively manage land with no irrigation water supply (Cover Crop trial).

2007 Limited Irrigation Research, Weld County, Colorado



¹ Funding for research and demonstration was provided by the CSU Agriculture Experiment Station, the Natural Resources Conservation Service Conservation Innovation Grants, the West Greeley Conservation District, and the National Research Initiative of the Cooperative State Research, Education and Extension Service, USDA, Grant # 2006-55618-17012

Limited Irrigation

On-farm demonstrative research was conducted in 2006 and 2007 near LaSalle, Colorado to study limited irrigation effects on corn yields. We applied full irrigation inputs matching evapotranspiration (ET) requirements of corn to maximize yield potential. Irrigation inputs not matching the full ET requirement of corn are considered as “limited irrigation”. Proper irrigation timing is important to maximize use of limited irrigation water in most crops. Previous corn production research has demonstrated that corn plants should not be water stressed during early vegetative growth stage V4, during VT (flowering) and through R2 (blister corn). Periods when corn grain production is less influenced by water stress include post V4 to up to V16 and post R3 development stages.

The trials were conducted at the same site for both years, under corn on corn rotation management with furrow irrigation. Two treatments of full irrigation and limited irrigation imposed on corn produced on Julesberg sandy loam soil. Strip plot experimental design of three replications per treatment included flex hybrid corn populations of approximately 20,000, 26,000 and 34,000 plants per acre. Irrigation scheduling was accomplished utilizing Water Mark Sensors equipped with an AM400 Hansen Data Logger. Neutron density gauge readings were taken the next day following irrigation events to assist with water balance accounting.

Table 1: Irrigation and Precipitation for the Limited Irrigation Site near LaSalle

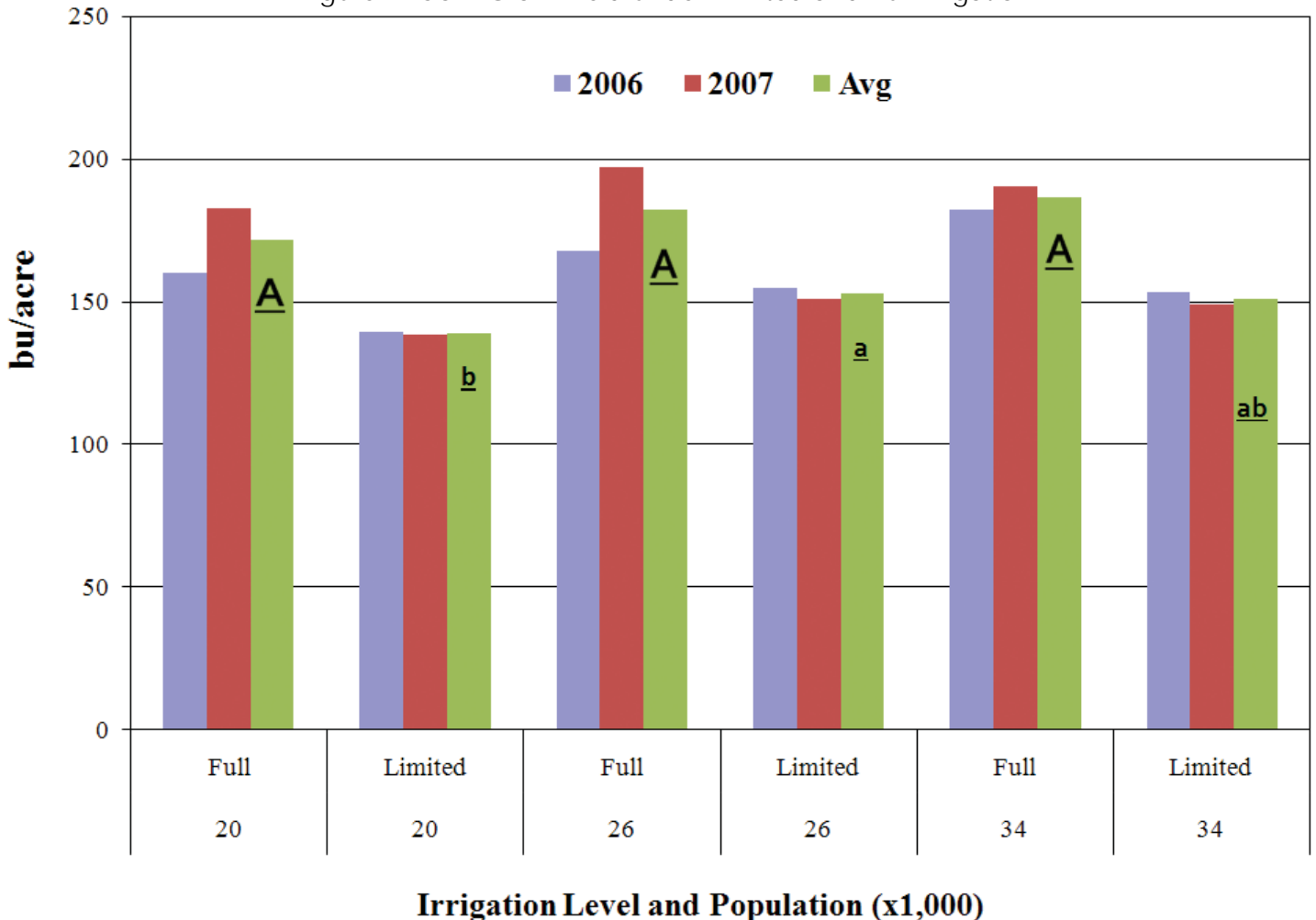
Year	Full	Limited	Precip.
----- inches -----			
2006	34.5	18.1	2.9
2007	27.8	13.1	4.0

Furrow flumes equipped with pressure transducers monitored irrigation level input. ET was monitored onsite with an ETgauge and locally via estimated ET from the Pekham CoAgMet weather station. Precipitation was measured with tipping bucket and manual rain gauges.

Results

As expected, corn yields were lower with reduced irrigation inputs relative to full irrigation meeting ET requirements (Fig. 1). Average yields for 2006 and 2007 were 182 and 190 bu/acre for full irrigation. Limited irrigation yields were 155 and 151 bu/acre for 2006 and 2007, which was an average yield reduction of 18% for limited irrigation relative to full irrigation treatments. We reduced irrigation in the limited treatment during vegetative and late grain fill development. Precipitation for both years was well below average (table 1), however almost three inches of precipitation in 2007 occurred between R1 and R2 developmental stages. This precipitation was timely and provided sufficient soil

Figure 1: Corn Grain Yield under Limited and Full Irrigation



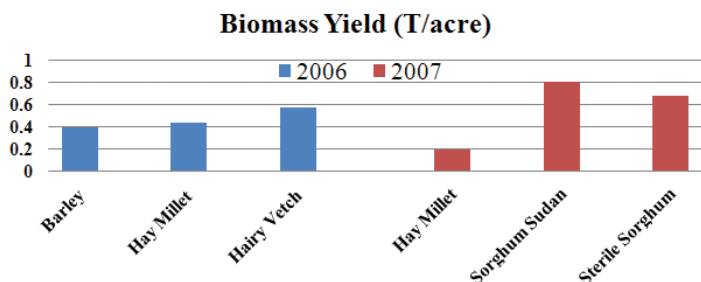
water to allow reductions in both full and limited irrigation amounts.

Yield results suggest that 26,000 corn plants per acre support near optimal yields under our limited irrigation treatments (Fig. 1). Fully irrigating 34,000 plants per acre produced the highest average yields. However, average yields under limited irrigation were significantly greater for 26,000 plants per acre relative to 20,000 plants per acre. Average limited irrigation yields for 26,000 and 34,000 plants per acre were not significantly different. This suggests that under limited irrigation, 26,000 plants per acre may be a strategic population worth examining.

Cover Crops

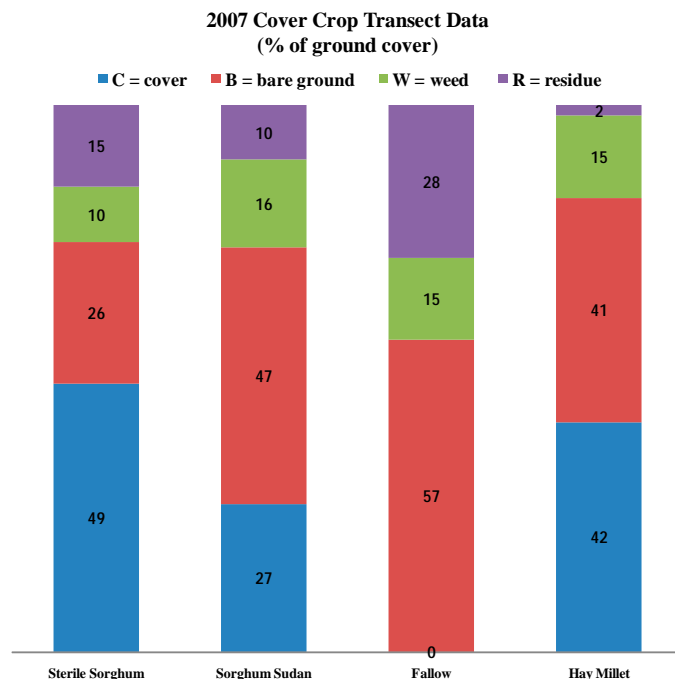
Converting formerly irrigated land to dryland or grassland production requires a cropping system designed to utilize stored soil nutrients and to compete with weed species. Field research was conducted in 2006 on a Julesburg sandy loam and 2007 on a Vona sandy loam soil in Weld County near LaSalle, Colorado. The purposes of these demonstrative cover crop trials were to help develop best management practices to establish soil cover and manage soil N to transition from irrigated ground to dryland or grassland management. The following figure (Fig. 2) shows the amount of biomass cover in terms of dry matter production possible with only precipitation providing available soil water – no irrigation was provided.

Table 2: Dry matter forage yields for the cover crop sites near LaSalle



Hairy vetch, barley, and hay millet were no-till seeded into Julesburg sandy loam soil May 5, 2006. On June 27, 2007 barley, hay millet, sterile sorghum and sorghum-sudan were no-till seeded in formerly irrigated fields (Vona sandy loam soil). Glyphosate was broadcast applied as pre-emerge treatments. Two replications per crop were seeded into plots 20 ft wide by 100 ft long. In 2007, Weedmaster herbicide was broadcast applied on sorghum, sorghum-sudan and fallow treatment areas. Transect data was collected just prior to hand harvest (Fig. 3). Biomass harvest samples were weighed wet and dry. Biomass was removed by sickle mowing to simulate forage harvest with subsequent biomass-N removal. Following 2007 harvest, plots were fall seeded on September 19th into winter wheat, triticale and fallow (Fig. 4). Various scenarios for returning these plots to permanent grass or dryland cropping systems will be investigated.

Table 3: Percent ground cover collected with line-transect method (August 17, 2007)



Conclusions

Limited irrigation water supplies reduce the profitability of farms and may increase the risk the farm faces from too little precipitation. However, with careful intensive irrigation management and timely precipitation events, the potential exists for achieving corn yields of seventy-percent or more of fully irrigated corn. Cover crops may offer both economic and farm sustainability benefits where extreme reductions in irrigation water supplies have occurred. Further investigations are underway, including economic analyses, to more completely understand implications of reduced water supplies.

Acknowledgements: The authors greatly appreciate Dave and Frank Eckhardt and Roger Alexander for their contributions to the research projects.

[Full color version available on the web, cwrri.colostate.edu]

Figure 4: Fall seeded triticale 58 d after no-till seeding into sorghum sudan residue



Heritage Area Designated along the Poudre River

by Robert Ward, CWRRRI Emeritus Director



Signs were installed along Interstate 25 on January 28, 2008, identifying the Cache la Poudre River National Heritage Area, according to the Poudre Heritage Alliance.

The Poudre Heritage Alliance is a local nonprofit organization established to guide programs and activities related to the Heritage Area, focusing on the role the Poudre River and its early settlers played in establishing the appropriation doctrine for allocating limited water. The Poudre Heritage Alliance is made up of representatives from local governments, area universities, water managers and private citizens.

The Cache la Poudre River National Heritage Area is one of 37 National Heritage Areas (as of 2006) and was the first to be established west of the Mississippi River. The Heritage Area extends for 45 miles and includes the lands within the 100-year flood plain of the Cache la Poudre River. It begins in Larimer County at the eastern edge of the Roosevelt National Forest and ends east of Greeley, one-quarter mile west of the confluence with the South Platte River. Along its course, the Heritage Area links cities, towns and unincorporated areas rich with water history.



The Poudre Heritage Alliance approached the Colorado Department of Transportation in early 2005 about the possibility of erecting signs identifying the Heritage Area. Under its authority for providing signs for national parks and monuments, CDOT agreed to design, erect and maintain the signs in perpetuity if the Poudre Heritage Alliance paid for them.



Dr. Robert Ward

Through a matching funds challenge from Friends of the Poudre, the Poudre Heritage Alliance and board members were

able to meet the challenge and provided the funds to erect the signs on I-25 where it crosses the Cache la Poudre River. The signs will notify northbound and southbound travelers on I-25 that they are entering the Cache la Poudre River National Heritage Area. As more funds become available, additional signs will be installed where major highways cross the Cache la Poudre River in the designated corridor.

Working on the project were: Larry Haas, P.E., Region 4 Operations Engineer (CDOT), Greeley; the Poudre Heritage Alliance (Rick Brady, City of Greeley and board President, Richard Maxfield, Weld County member-at-large and Bill Bertschy, Friends of the Poudre).

It should also be pointed out that two additional Colorado national heritage areas are currently being considered for creation by Congress. The Sangre de Cristo National Heritage Area will highlight the exceptional culture and history of the San Luis Valley, including Mexican land grants, the Cumbres and Toltec Scenic Railroad, and Fort Garland. The South Park National Heritage Area will assist visitors in experiencing how native peoples, early explorers, trappers, miners, ranchers, and settlers lived on the frontier of the United States.

Cache La Poudre National Heritage Area website:
<http://www.fortnet.org/PRHerCor/index.htm>

Perry E. Cabot

Extension Specialist, Colorado State University

When people ask me why I moved to Colorado, I tell them about a weekend almost 20 years ago when I attended an informational session put on by Colorado State University for high-school seniors. At the time, my family lived in Hawaii where my father was an Army lieutenant-colonel stationed at Camp H.M. Smith, the headquarters for Marine Force Pacific. The session featured a presentation on admissions requirements, possible majors and typical questions. My attention was drawn, however, to a promotional poster showing a group of what I assumed to be CSU students crammed into a whitewater raft careening down one of Colorado's major rivers. I liked the poster so much that I took it home and hung it on one of the walls in my bedroom, resolving that I had picked my future university. So, in a sincere way, I can say that water attracted me here in the first place, and I am grateful that it has brought me back again.

Shortly after that visit in 1989, I enrolled as an undergraduate in civil engineering at CSU. The campus seemed enormous to me and I resentfully faced winter trudges to class, an arduous plight for a kid who had spent the past 5 years surfing in the Hawaiian sun. The rigorous pace of the engineering program didn't leave much time for self-pity however, and I worked hard in my classes while trying to learn where my career would take me. I still fondly recall my former instructors during that time; for example, the deep humility of the late Arne Magnus, who taught all my math courses, and the avuncular charm of Thomas Siller. They were later followed by Paul Heyliger's and Marvyn Criswell's fittingly nicknamed "solids" and "concrete" courses, the unremitting pace of Tom Sanders in environmental engineering, and the enthusiasm of Prof. Tim Gates in fluid mechanics.

One of my favorite courses was in hydrology with Jorge Ramirez, who introduced me to the mathematical and statistical explanations for watershed dynamics that intrigue me to this day. Consequently, my interest in water resources began in earnest during my junior year, when I was hired by Steve Abt to work at the CSU Hydraulic Research Laboratory on various open-channel hydraulics projects. Another aspect of this job took me to Mississippi with Chester Watson, who hired students to conduct field surveys for the Demonstration Erosion Control projects in the Yazoo River basin (and fend off water moccasins, I hasten to add). It was during these Mississippi trips that I developed a love of field-based research that has been important to me ever since. Upon



graduating with my Bachelor's Degree in 1994, I happily took a job with a local engineering firm in Ft. Collins, where I primarily designed construction and drainage plans, but also worked with HEC software for floodplain modeling. Some of my fondest recollections from this time are those of long summer days ensconced in the Poudre Canyon, fly-fishing the caddis hatch along the river's abundant and cozy reaches.

Three years into my new career, my burgeoning interests in environmental and water resources engineering compelled me to consider graduate school. I ultimately made the difficult decision to leave Colorado in 1997 to attend the University of Illinois at Urbana-Champaign, from which I obtained my Master's Degree in Environmental Engineering in 1999. Although the program at UIUC was primarily

devoted to point-source pollution prevention, I chose to work as a research assistant on projects involving watershed hydrology, stream channel restoration and aquatic ecology. At Illinois, I acquired what I would call a "callow but honest" enthusiasm for Aldo Leopold's A Sand County Almanac as a result of extracurricular study and volunteer work. This enthusiasm motivated me to apply for graduate school at the University of Wisconsin-Madison where the Institute for Environmental Studies carries on Leopold's legacy through a unique land resources program rooted in Leopold's idea of the "Land Ethic."

Also significant to me was that UW-Madison embraced a philosophy called the "Wisconsin Idea" which holds that the boundaries of the university should extend to the boundaries of the state, and that research conducted in the UW system should be applied to solve problems and improve health, quality of life, the environment and agriculture for all citizens of the state. Needless to say, between the "Land Ethic" and the "Wisconsin Idea," I developed an abiding sense that science and service were natural partners. As a student in land resources, I entered a rewarding period of collaboration with local farming communities. This collaboration introduced me to the practical aspects and interdisciplinary perspectives pertaining to a range of farming topics, including nutrient management, soil conservation, and cropping systems. Local farmers even generously allowed me to conduct research directly on their farms and operations. By virtue of these experiences, coupled with advice from my faculty mentors, I came to appreciate what Hugh Hammond Bennett¹ meant when he stated that conservation treatments

¹ Founder and first director of the USDA Soil Conservation Service. His influence on soil conservation issues, especially through the Dust Bowl years, eventually led to the passage of the Soil Conservation Act of 1935. This Act created the Soil Conservation Service, which he headed until he retired in 1951.



“must fit not only the needs and adaptabilities of the land but the needs and adaptabilities of the farmer as well.”

Just over a year into my Ph.D. program at UW-Madison, I attended a workshop for using a numerical watershed model, where I noted an almost exclusive attendance by agricultural engineers. It was evident to me that these engineers were grounded in core disciplines like hydrology and soil science, but valued their close work with farmers, growers and producers. Agricultural engineering seemed a perfect fit for me, but I was determined to maintain my connection to the land resources program, which at this point had also convinced me of the value of Cooperative Extension. Therefore, shortly after returning from the workshop, I started a joint graduate degree in Land Resources & Agricultural Engineering. Matriculation as an agricultural engineer allowed me to focus on scientific areas, such as watershed dynamics and erosion mechanics, but by maintaining my connection to the land resources program, I was also afforded opportunities to work directly with farmers in an extension capacity. The research program I was linked to at UW-Madison focused on lake eutrophication, an inherently interdisciplinary problem involving researchers across the university. I specifically examined the watershed dynamics of phosphorus delivery in runoff from agricultural watersheds. I hypothesized that phosphorus, which tends to be the limiting nutrient affecting algae blooms and freshwater eutrophication, was stored across watersheds in coluvial sinks that naturally buffered phosphorus movement at catchment scales. I applied a method of examining soil aggradation behavior with fallout and natural radionuclides to the question of whether phosphorus was being stored for long periods in upland agricultural soils. I later used similar techniques to research on: (1) budgeting sediment movement; (2) understanding proportionate contributions from rill and interrill erosion processes, and; (3) collecting quantifiable data on sediment and contaminant delivery as a function of sediment size.

One of my greatest experiences at UW-Madison was working with undergraduate engineering students through

the UW chapter of Engineers Without Borders. Our signature project was devoted to the development of sustainable water supply and purification systems for several thousand villagers in a war-ravaged region of Rwanda. As a reward for our efforts, our chapter was honored with the EWB Humanitarian Award and the Daimler-Chrysler/UNESCO Mondialogo Award.

As an agricultural engineering researcher focused on land and water resource management, one of my priorities is to develop strategies for conserving these resources, thus supporting broader goals of ensuring adequate supplies of food, plant material and bio-energy products. At CSU, I plan to maintain the tradition of my profession for applying scientific principles to the purpose of helping agricultural communities utilize, conserve and restore healthy productive farmland. Because of agricultural-municipal water sharing, Colorado's urban front is also linked to this goal, while facing its own water quantity and quality predicaments. I am currently developing my Extension program, which I plan to structure around conservation approaches for agriculture and urban living in the arid West. Farmers in Colorado face specific constraints such as excessive soil and water salinity, interstate river compacts, and prior appropriation doctrines that will require cooperation among numerous partners in the water resources arena. I am specifically interested in the possibility for new irrigation, farming and river management approaches to be linked for the purpose of conserving water on the farm, while meeting Colorado's compact obligations to its neighbors. I am also interested in developing an outreach program focused on low impact development practices, specifically pertaining to stormwater, for new construction and subdivisions in my southern regional area. I'm not naive about these challenges, but I do get the sense at least from my experience in the Arkansas River Valley thus far, that the “native home of hope” that Wallace Stegner extolled in *The Sound of Mountain Water* is still very much alive in Colorado, where the famous pioneering spirit is finding a new value in the realm of conservation.

2008 IGWMC Short Course Schedule

Short Course/Dates/Instructors	Description
<p>MODEL CALIBRATION with UCODE May 16-18 by Eileen Poeter Fee: \$1045 before May 2 and thereafter \$1245 with MODFLOW and MORE 2008 Conference registration</p>	<p>If you have a working knowledge of ground-water flow modelling and some knowledge of basic statistics, you will benefit the most from this short course. This course introduces ground-water professionals to inverse modeling concepts and their use via UCODE, relying heavily on hands-on exercises for automatic calibration of ground-water models to promote understanding of UCODE and avoid "black-boxing". If you would like to spend more time being a hydrologist and less time as a "number twaker", please join us in the UCODE course.</p>
<p>Coupled Geochemical and Transport Modelling May 16-18 by Henning Prommer and Chunmiao Zheng Fee: \$1045 before May 2 and thereafter \$1245 with MODFLOW and MORE 2008 Conference registration</p>	<p>The course is designed to introduce the participants to the model-based quantification of a wide range of water quality problems from various industries and disciplines, e.g., contaminant hydrology, mining and water supply. Taking this short course will help groundwater practitioners: (1) Understand the basics of coupled geochemical transport modeling, (2) Learn how to apply state-of-the-art models to real-world water quality problems, (3) Apply the theoretical framework with hands-on experience in the computer lab, (4) Use the modeling tools MODFLOW, MT3DMS, PHREEQC-2 and PHT3D (which couples MT3DMS and PHREEQC-2), and (5) Approximately half the time of the course is devoted to computer labs. Simplified exercises that are based on real-world problems will help participants to translate theory into practice.</p>
<p>Polishing Your Ground-Water Modeling Skills May 16-18 by Peter Andersen and Robert Greenwald Fee: \$1045 before May 2 and thereafter \$1245 with MODFLOW and MORE 2008 Conference registration</p>	<p>This course is designed to provide significant detail on practical ground-water flow modeling concepts and techniques. It explores development of conceptual models for complex sites or regions, how to convert these conceptual models to appropriate ground-water flow models, and how to apply supplemental MODFLOW modules to effectively solve such problems. This course takes the user beyond topics covered in introductory modelling courses and beyond courses that teach the mechanics of applying various pre- and post-processing software. It revolves around a series of realistic problem sets that highlight practical aspects of ground-water flow modeling. These exercises serve as a basis for comparing alternative approaches to solving various types of problems.</p>
<p>Modeling Water Flow & Contaminant Transport in Soils and Groundwater Using the HYDRUS Packages May 21-23 by Jirka Simunek Fee: \$595 before May 6 and thereafter \$695 with MODFLOW and MORE 2008 Conference registration</p>	<p>This course begins with a detailed conceptual and mathematical description of water flow and solute transport processes in the vadose zone, followed by a brief overview of the use of finite element techniques for solving the governing flow and transport equations. The course introduces a new generation of Windows-based numerical models for simulating water, heat and/or contaminant transport in variably-saturated porous media. These include the HYDRUS-1D and HYDRUS (2D/3D) codes for one- and two-dimensional simulations, respectively, the STANMOD code for evaluating solute transport in the subsurface using one- and multi-dimensional solutions of the advection-dispersion equation, the RETC code for evaluating the hydraulic properties of unsaturated media, and the Rosetta code for estimating the soil hydraulic properties from soil texture and related data.</p>
<p>Beyond MODFLOW May 21-23 by Peter Schätzl, Volker Clausnitzer, and Douglas Graham Fee: \$495 before May 6 and thereafter \$595 with MODFLOW and MORE 2008 Conference registration</p>	<p>MODFLOW is the trusted workhorse for thousands of groundwater modelers around the world. For a range of applications MODFLOW continues to be a sufficient and well proven technology. However, groundwater issues are becoming more complex and many real world problems require more sophisticated solutions. DHI delivers the two most widely-used tools for advanced groundwater and watershed related modeling that go beyond the traditional limitations of MODFLOW. FEFLOW and MIKE SHE together cover all aspects of advanced groundwater and watershed related processes. This two day training course is designed to give you an overview of the features, benefits, and typical applications of these two modeling packages and provide you with the opportunity to get some hands-on experience using the software to develop and run a model</p>
<p>Groundwater Modeling For Non-Modelers May 22 by Peter Andersen Fee: \$295 before May 6 and thereafter \$345 with MODFLOW and MORE 2008 Conference registration</p>	<p>This course is designed to introduce groundwater modeling concepts to professionals who use results of models for decision making but are not familiar with the genesis of these results. These professionals may include managers, attorneys, or field personnel who are in charge of obtaining data for the models. The course provides a broad perspective on the entire modeling process, from developing the objectives for the study to making predictions with the model. The course attendee will leave the course with an improved appreciation of what goes into a model and hence the assumptions and limitations that underlie the model results that the attendee may rely upon in making decisions. Parts of this course have been taught previously on three occasions to water managers, attorneys, and water purveyors. Reviews for these lectures have been excellent. Course attendees have ample time to ask questions and interact with the instructor.</p>
<p>JUPITER API for Calibration, Sensitivity Analysis, and Uncertainty Evaluation, And OpenMI for Linking Process Models at the Grid and Time-Step Scale May 22 by Ned Banta, Matt Tonkin, Peter Gijbers, Mary Hill, and Douglas Graham Fee: \$195 before May 6 and thereafter \$245 with MODFLOW and MORE 2008 Conference registration</p>	<p>The JUPITER API is the Joint Universal Parameter Identification and Estimation of Reliability Application Programming Interface. The purpose of the JUPITER API is to provide programmers with a paradigm and a set of utilities for developing computer applications for model analysis. Examples of model analyses which the JUPITER API is designed to support include sensitivity analysis, data needs assessment, calibration, uncertainty analysis, model discrimination, and optimization. The JUPITER API part of the course covers the philosophy behind the development of the API, the structure of applications in which the API is used, and an introduction to many of the capabilities supported.</p> <p>OpenMI (the Open Modelling Interface) is an interface specification in .NET and Java, with the aim to become a global standard for model linkage in the water domain. An open source Software Development Kit is available in .NET. Its functionality is primarily focused on easing the migration of typical Fortran based simulation engines. The OpenMI part of the course covers the architectural structure based on a request-reply (i.e. GetValues) based data exchange concept. The data structure concepts of OpenMI will be discussed with examples of data representation in the water domain. Conceptual design patterns for linking/coupling components in the water domain will be discussed, as well as time stepping patterns. Software technical design patterns, based on the SDK, to transfer typical simulation engines into a pull-based component will be presented.</p>
<p>GMS and More May 22 by Norm Jones and Jeffery Davis Fee: \$295 before May 6 and thereafter \$345 with MODFLOW and MORE 2008 Conference registration</p>	<p>This is a hands-on, application oriented training course. The course provides the attendees with the knowledge and tools necessary to solve groundwater modeling problems quickly and efficiently. The course will begin with a discussion of some of the new tools recently added to GMS to make building conceptual models easier. One of these tools is the "Import from Web" application. Building a single conceptual model or several conceptual models is simple and straightforward. The workshop will also cover the linkage between ArcGIS and GMS and how GIS data is seamlessly passed between the two applications. Some sample MODFLOW models will be built during the workshop using these tools. Finally, the development of the MODFLOW Analyst and other ESRI ArcGIS tools will be discussed and some hands-on application will provide participants an introduction to these new and exciting tools.</p>

Lower South Platte Irrigation Research and Demonstration Project

by Neil Hansen, Soil and Crop Science, Colorado State University



In 2005, a research team at Colorado State University initiated a pilot research project at the Agricultural Research, Education, and Demonstration Center (ARDEC) near Fort Collins with the objective of developing profitable irrigated cropping systems that reduce historic consumptive water use. The study takes a systems approach to evaluate how water saving irrigation practices interact with all aspects of crop production including crop rotation, pest management, tillage, and soil fertility. In 2007, the pilot project was expanded to include a comprehensive new study location near Iliff, CO in the Lower South Platte basin. The new study, made possible with funding support from Parker Water and Sanitation District, greatly expands the scope of the initial pilot project. In addition, the new project adds a detailed study on the economic implications of adopting limited irrigation practices at the farm scale and the regional economic impacts of agricultural to urban water transfers.

The field study evaluates crop water use and saving in both limited irrigation and rotational fallow systems. The study was initiated in 2007 on a 35 acre field near Iliff, CO with a state of the art linear move sprinkler system capable of automated irrigation control at the individual plot level on nearly 150 individual research plots. The site is designed for a detailed water accounting including a fully automated weather station that has been integrated into the Colorado Agricultural Meteorological Network (CoAgMet, Iliff station), monitoring of soil moisture, depth to ground water, and control of all applied irrigation.



The linear move sprinkler irrigation system customized for irrigation control on individual research plots



Sunflower and soybeans are being evaluated as an alternative to rotationally fallowed corn.



Limited Irrigation in Dynamic Crop Rotations. A major emphasis in the study is integrating limited irrigation practices with 7 alternative crop rotations (Table 1). Changing the cropping mix to decrease the magnitude of consumptive use within a growing season is one alternative to drying up land. Corn, alfalfa, and grassy hay crops dominate the existing irrigated acreage in the South Platte. These crops have high water demand because they are produced during the warmest period of the year, they have long growing seasons, and they are produced under conditions of complete canopy cover for most of their growing season. Adjusting the crop mix to decrease the length or alter the timing of the growing season can reduce consumptive water

use while minimizing loss of farm income and the exposure of soil to erosion. Changing fully irrigated corn, alfalfa, or vegetable cropping systems to include winter annual crops has the greatest potential to decrease consumptive water use. Winter annual crops that have a high potential for reducing consumptive use include winter wheat, forages and oil seed crops. Limited irrigation is based on timing irrigations to crop growth stages and managing crop water stress to improve water use efficiency.

Rotational Fallow. Rotational fallow cropping systems consist of a fully irrigated crop in rotation with one or more years without irrigation. These systems are of interest

Table 1. Experimental cropping systems, irrigation approach, and anticipated average annual consumptive water use (ET) at the Lower South Platte Irrigation Research Site near Iliff, CO.

Cropping System	Crop Rotation	Irrigation Approach	Average Annual ET (in)
Full irrigation	Continuous Corn	Full ET	24
Full and Limited Irrigation	Corn-soybean-winter wheat-winter canola	All crops irrigated Growth stage timed irrigation	17 Full 13 Limited
Full and Limited Irrigation	Corn-sunflower-winter wheat-winter triticale	All crops irrigated Growth stage timed irrigation	18 Full 14 Limited
Rotational Fallow - 2 yr	Corn - Fallow	Full ET (corn)	12*
Rotational Fallow - 3 yr	Corn - Fallow - Winter Wheat	Full ET (corn) No irrigation (wheat)	11*

*Excludes evaporation during fallow period

because they are a simpler way of administering water leasing arrangements than limited irrigation approaches. The drawback to these approaches is that land is taken out of production. The study is evaluating a variety of land management approaches during the years without irrigation including chemical fallow, cover crops, and dryland crop production. Of special interest is the effect of the “fallow” period management on issues such as weed management, soil erosion, productivity of the subsequent crop. The fully irrigated crops being evaluated in the fallow rotations are grain corn and sugar beets.

Perennial Hay Crops. Another portion of the study is evaluating water use of perennial grass hay crops. Fourteen different species of perennial grasses including various wheatgrasses, fescues, bromes, and orchard grass will be evaluated for biomass production potential under a variety of irrigation regimes. While the immediate interest in these

crops is for hay and pasture production, there is also interest in the potential use of these grasses as bioenergy crops.

Better understanding of these concepts of agricultural water conservation can be the foundation of a new approach to meeting changing water supply and demand issues in Colorado while maintaining a viable agricultural and rural economy in Colorado. Beyond the farm level issues are questions about how different models of water leasing would affect local and regional economies. The economic portion of this study is evaluating this question using a variety of techniques including enterprise analysis, state of the art economic forecasting models, and models that project farm level changes to community and regional scales. We welcome public input on this project. For more information, please contact Neil Hansen by email, neil.hansen@colostate.edu, or by phone at 970-491-6804.

12th Annual Water Reuse & Desalination Research Conference May 5-6, 2008 The Westin Tabor Center, Denver Colorado

The 12th Annual Water Reuse & Desalination Research Conference provides an opportunity for the water reuse and desalination community to hear and see presentations by researchers on the latest results of ongoing research. The conference provides a forum for water reuse and desalination research professionals to interact, network, and discuss current and future research needs and trends.

The focus of the conference is on research that is likely to generate future scientific breakthroughs in water reuse and desalination. More than 30 presentations in the “single track” program provide a focused and unique opportunity for water reuse and desalination professionals to learn about new developments and trends emerging from current and ongoing research on innovative technologies, applications, and projects.

Additional Information

For more information on the 12th Annual Water Reuse Research Conference, contact:
Courtney Tharpe, Director of Conferences and Events, at ctharpe@watereuse.org.

Conference Website with Schedule of Events, Hotel Information, Sponsorships, and Registration:

<http://www.watereuse.org/Foundation/2008conf/>

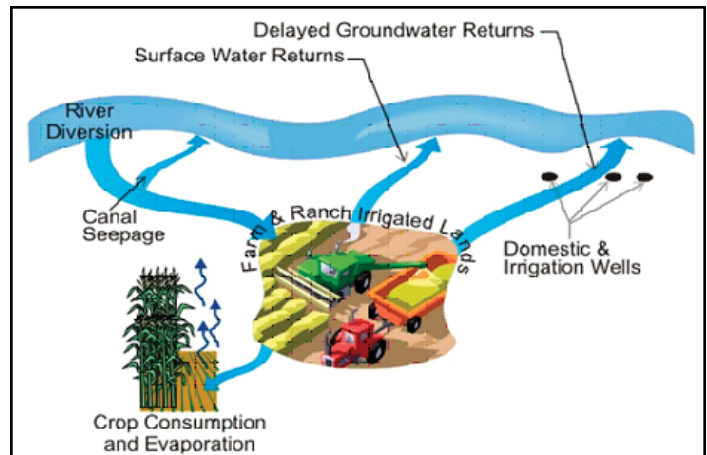
Colorado Ag Water Alliance Produces White Paper on Agricultural Water Conservation

The Colorado Ag Water Alliance is an association of agricultural organizations committed to the preservation of irrigated agriculture through the wise use of Colorado's water resources. Agriculture in Colorado currently owns and manages the majority of the state's water rights, placing this water to beneficial use for the production of our food, feed, fiber, and bioenergy crops. There is a public perception that implementation of agricultural water conservation measures such as canal lining and conversion to sprinklers can easily provide additional water supplies to meet growing demands for urban, industrial, recreation, and environmental water needs in Colorado. To address these perceptions, an analysis of the current scientific literature and the administrative precedents in Colorado was undertaken to identify the opportunities and challenges associated with irrigation water conservation. This document is not a legal brief; it is intended to help foster dialog and a greater understanding of the challenges facing irrigated agriculture in Colorado.

Under current laws and customs, opportunities for producing significant amounts of transferable water for municipal and industrial (M&I) uses through agricultural conservation measures are constrained by certain physical, legal and economic factors. When considering the potential for agricultural water conservation, it is important to understand the distinctions between saved and salvaged water, as opposed to water that is made available by reducing the consumptive use from irrigated crops. Much of the debate over water conservation indicates that imprecise use of terminology creates confusion and often obscures the real policy considerations. Saved and salvaged water, as currently construed in Colorado, do not include the concept of water potentially conserved through the reduction of crop consumptive use. A new term, **Conserved Consumptive Use Water**, is proposed to describe water that is part of the consumptive use of a water right that is removed from an irrigated cropping system. The transfer of this water, while possible under Colorado water law, has not yet been tested in water court or codified by the legislature.

Approximately one-third of Colorado's irrigated acres have already been converted to more efficient sprinkler or drip systems. In particular, irrigators who rely on deep or nonrenewable groundwater already have significant incentive for water conservation. Reducing the amount of groundwater pumped decreases energy costs as it prolongs the economic life of aquifers. Many Colorado farmers have switched to irrigation systems with enhancements such as drop nozzles, low-pressure delivery systems, irrigation scheduling, minimum tillage, and other techniques to improve on-farm efficiency and reduce pumping requirements.

Water conservation measures, such as converting to more efficient irrigation systems, also have significant limitations. A primary factor is that the amount of water legally transferable is an irrigator's historic consumptive use, not



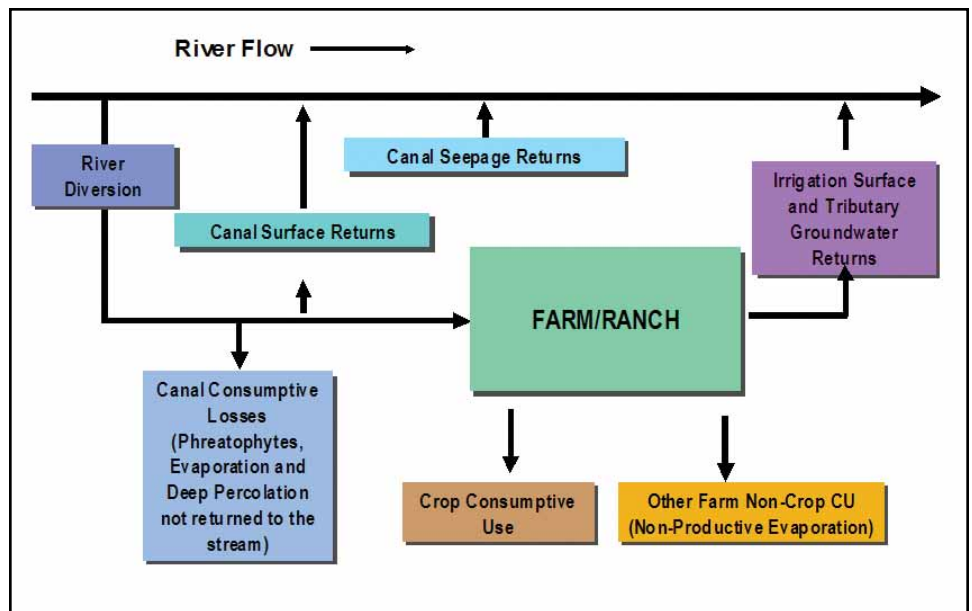
the amount of water diverted. Increasing irrigation efficiency is likely to reduce losses from deep percolation and runoff, but it may or may not materially affect the amount of water consumed by the plant. Much of the water lost to these inefficiencies will return to the river or groundwater system for use by downstream water diverters. The reliance upon irrigation return flows is a common occurrence in Colorado and downstream water rights holders that relied upon historical return flows are entitled to protection from injury that could occur when a water right is changed. For this reason, the law and customs in Colorado are clear that water made available from improved irrigation efficiency is not available to the original appropriator for irrigation of expanded acreage or transfer to other uses. For agricultural water conservation measures to be successful, these aspects of water in Colorado must be considered.

Reductions in crop consumptive use (conserved consumptive use water) only occur when:

1. Irrigated acres are decreased
2. Crop selection is changed from a summer crop to a cool season crop
3. Crop selection is changed to one with a shorter growing season
4. Deficit irrigation is practiced, applying some amount less than full or historical evapotranspiration over the growing season
5. Evaporative losses from the field surface are reduced as a result of conservation tillage, mulching, and or drip irrigation

It is important to recognize that reducing agricultural water consumptive use will limit crop yields and may increase producer exposure to risks such as irrigation system failure, pests or drought. Implementing water conservation measures usually results in increased equipment, labor, and management costs that must be borne either by the irrigator or by those who benefit from the conserved water.

Increased and enhanced use of irrigation water conservation measures may be beneficial in certain areas of Colorado if the basin scale impacts are evaluated as part of the adoption process. Increased agricultural water conservation could potentially result in a voluntary reduction in the diversion of water to the farm, creating benefits such as improved water quality, allowing more water to remain in the streams, reduced waterlogging of soils, and reducing energy costs for pumping, but may not result in water that can be legally transferred to other uses. If the use of water conservation measures can improve water supply availability without causing injury to downstream users or the environment, then the result may be improved water supplies for agriculture and other uses.



The Colorado Ag Water Alliance believes that water conservation is only one component in meeting Colorado’s future water needs. Better use of existing surface and groundwater storage resources and the development of new storage to meet future demands and for drought years will be required to meet both existing agricultural shortages and future M&I demands. In order for agricultural water conservation to play a meaningful role in meeting the State’s future water needs, a number of legal and administrative issues must be resolved and sufficient financial incentives offered to mitigate the increased risk and loss of productive capacity that occur under reduced water supplies. Furthermore, an in-depth basin-by-basin analysis of agricultural water conservation will need to be conducted to gauge the opportunities to obtain transferable water within the constraints of our interstate compacts and priority system.

Future Considerations

The following points are considerations are presented by the Colorado Ag Water Alliance as a starting point for further dialog. It is important to note that any successful implementation of these measures is only one component in meeting Colorado’s future water needs. The better use of existing surface and groundwater storage resources and the development of new storage to meet future demands and for drought years will also be required to meet both existing agricultural shortages and future M&I demands.

1. Each agricultural operation and basin is unique and has unique water management considerations. As such, thoughtful consideration should be made of the effects of implementing agricultural water conservation measures, either at the farm scale or basin-wide scale.
2. Incentives for on-farm implementation of conservation measures should be considered and evaluated in the context of compacts and basin hydrology.
3. Incentives for landowner control of phreatophytes, given salvaged water limitations, should be developed.

4. To help create incentives for implementing water conservation measures, the cost of water conservation measures should be borne by the beneficiaries of the conserved water. The agricultural user is unlikely and/or unable to bear the costs if the benefits only accrue to improved stream flow, water quality, or the basin as a whole.
5. It must be recognized that if irrigation water conservation measures are implemented, in some areas there will be a periodic need for salinity leaching to maintain productivity.
6. There is a need for clearer statutory definitions of saved, salvaged, and conserved water.
7. There is an opportunity for statutory clarification of the legality to transfer conserved CU water.
8. If legislation is enacted, the state will need to develop administrative means to track and allocate conserved water and ensure compliance.
9. There is a need for irrigation water conservation demonstration and pilot projects in each basin.
10. There is a need for a more thorough analysis of the impact of widespread adoption of sprinkler and drip irrigation systems in Colorado.
11. The state should conduct an in depth basin-by-basin analysis of the opportunities for agricultural water conservation.
12. The role of agricultural water conservation in meeting future water demands requires additional discussion as to whether it offers opportunities for meeting existing agricultural demands, a drought supply for M&I users, or a base supply for new M&I growth.

[The full version of the Ag Water Conservation White Paper is available on the CWRRI website. For more information on the Ag Water Alliance, contact Don Shawcroft at dshawcroft@colofb.com]

Research Awards

*Colorado State University, Fort Collins, Colorado
Awards for January 2008 to February 2008*

- Abt, Steven R**, USDA-USFS-Rocky Mountain Research Station-Colorado--Bedload Transport in Gravel-bed Rivers & Channel Change, **\$79,968**
- Barbarick, Kenneth A**, City of Littleton--Land Application of Sewage Biosolids, **\$102,077**
- Berg, Wesley K**, NASA - National Aeronautics & Space Admin.--Assessing the Impact of Regime-Dependent Biases on Climate Variability/Trends from a Radiometer Constellation, **\$100,000**
- Black IV, William C**, The University of Liverpool--Innovative Vector Control Consortium: Improved Control of Mosquito-Borne Diseases, **\$39,560**
- Brozka, Robert J**, USDA-USFS-Rocky Mountain Research Station-Colorado--Fisheries and Wildlife Management Support at Fort A.P. Hill, Virginia, **\$62,032**
- Clements, William H**, DOI-USGS-Geological Survey--Effects of heavy metals in Rocky Mountain streams, **\$20,925**
- Culver, Denise R**, Boulder County Parks & Open Spaces--Survey & Assessment of Critical Wetlands in Boulder County, **\$10,154**
- Gates, Timothy K**, Desert Research Institute--Evaluation of the Use of Polyacrylamide to Reduce Seepage Losses from Earthen Irrigation Canals, Part I, **\$16,580**
- Gates, Timothy K**, Southeastern Colorado Water Conservancy District--Part 2, Monitoring and Modeling Toward Optimal Management of the Lower Arkansas River, **\$100,000**
- Jayasumana, Anura P**, Colorado School of Mines--Wireless Sensor Network Based Subsurface Contaminant Plume Monitoring, **\$45,859**
- Kummerow, Christian D**, NASA - National Aeronautics & Space Admin.--The Next Generation Rainfall Retrieval Algorithm for Use by TRMM and GPM, **\$191,280**
- Liston, Glen E**, NSF - National Science Foundation--IPY: Collaborative Research: A Prototype Network for Measuring Arctic Winter Precipitation and Snow Cover (Snow-Net), **\$85,000**
- Matsumoto, Clifford R**, UCAR-NCAR-COMET Atmospheric Tech. Division--Inspiring the Next Generation of Explorers: The GLOBE Program, **\$353,308**
- Miller, Steven D**, Mississippi State University--A Rapid Prototyping Capability Experiment to Evaluate Potential Soil Moisture Retrievals of Aquarius Radiometer..., **\$84,000**
- Myrick, Christopher A**, University of Washington--Native Trout, **\$28,383**
- Poff, LeRoy N**, Camp Dresser McKee--Developing Flow-Ecology Relationships for Regional Application in Rivers of Colorado, **\$21,407**

Calendar

2008

- March 17-19** **2008 AWRA Spring Specialty Conference GIS and Water Resources V.** San Mateo, CA. For up-to-date information, visit www.awra.org
- March 20** **GIS I for Ditch Companies Workshop.** Fort Collins, CO. For more information visit <http://www.darca.org>
- March 21** **GIS II for Ditch Companies Workshop.** Fort Collins, CO. For more information visit <http://www.darca.org>
- March 25** **2008 Research Colloquium-Global Water: From Conflict to Sustainability Challenges and Opportunities in an Interdependent World.** Fort Collins, CO. For more information visit <http://vpr.colostate.edu>
- March 26-28** **Hydrology Days 2008.** Fort Collins, CO. More information available at <http://hydrologydays.colostate.edu/>
- March 27-29** **50th Annual Celebration of Watershed Science.** Fort Collins, CO. For more information visit <http://watershed50th.colostate.edu>
- April 14** **Ditch Hazards Awareness & Safety Workshop.** Grand Junction, CO. More information available at <http://www.darca.org>
- April 18** **AWRA-Colorado Section Symposium: Water, Energy & Climate Change.** Mount Vernon Country Club, CO. For more information visit <http://www.awra.org/state/colorado/programs.htm>
- April 22** **Emerging Issues in Soil and Water.** Fort Collins, CO. For more information contact Neil Hansen at 970 491-6804 or neil.hansen@colostate.edu
- April 30-May 1** **Arkansas River Basin Water Forum: Rolling Down the River.** Westcliffe, CO. For registration and more information visit www.arbwf.org or call (719)539-5106.
- May 1-2** **Climate Change and Water Utilities: Planning for the Future.** American Water Works Association. Denver, CO. www.awwa.org/awwa/education/seminars/index.cfm?SemID=65
- May 5-6** **12th Annual water Reuse and Desalination Research Conference.** WaterReuse Foundation. Denver, CO. www.watereuse.org/Foundation/2008conf/
- May 14-16** **33rd Colorado Water Workshop: Mining, Energy and Water in the West.** Gunnison, CO. For more information please visit <http://www.western.edu/water>
- May 28-31** **USCID Water Management Conference: Urbanization of Irrigated Land & Water Transfers.** Scottsdale, AZ. For more information visit <http://www.uscid.org>
- June 8-12** **AWWA Annual Conference & Exposition.** Atlanta, GA. For more information visit www.awwa.org
- June 30-July 2** **2008 AWRA Summer Specialty Conference Riparian Ecosystems and Buffers: Working at the Water's Edge.** Virginia Beach, VA. For more information visit www.awra.org
- July 22-24** **UCOWR/NIWR 2008 Conference.** Durham, NC. For more information visit <http://www.ucowr.siu.edu/>
- August 20-23** **CWC Summer Convention 2008.** Vail Marriott Mountain Resort. For more information visit <http://www.cowatercongress.org>
- Nov. 17-20** **2008 AWRA Annual Water Resources Conference.** New Orleans, LA. For more information, visit www.awra.org

2009

- March 4-7** **2009 AWRA Spring Specialty Conference: Managing Water Resources and Development in a Changing Climate.** Anchorage, AL. More information at www.awra.org
- June 29-July 1** **2009 AWRA Summer Specialty Conference: Adaptive Management of Water Resources II.** Snowbird, UT. More information at www.awra.org
- Aug. 3-7** **7th Annual StormCon, The North American Surface Water Quality Conference & Exposition.** Orlando, FL. More information at www.gradingandexcavating.com/sw.html
- Nov. 8-12** **2009 AWRA Annual Conference.** Seattle, WA. More information available at www.awra.org



COLORADO WATER

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