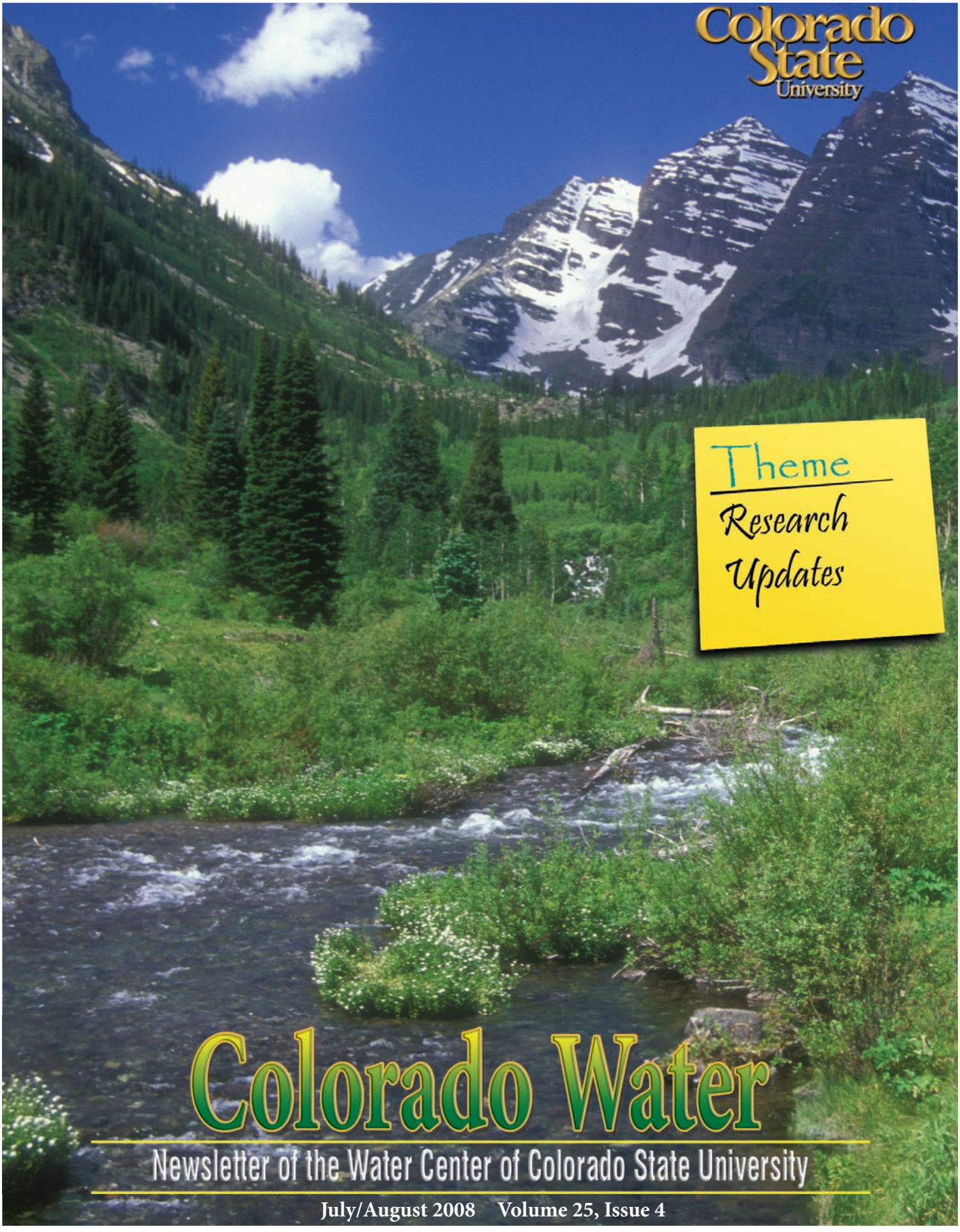


Colorado Water

Newsletter of the Water Center of Colorado State University

July/August 2008 Volume 25, Issue 4

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

Highlights:

In Every Issue:

COLORADO WATER is a publication of the Colorado Water Institute at Colorado State University. The scope of the newsletter is devoted to enhancing communication between Colorado water users and managers and faculty at the research universities in the state. This newsletter is financed in part by the U.S. Department of the Interior, Geological Survey, through the Colorado Water Institute. The contents of this publication do not necessarily reflect the views and policies of the U.S. Department of the Interior, nor does mention of trade names or commercial products constitute their endorsement by the U.S. Government.

Director: *Reagan Waskom*
Assistant to the Director: *Nancy Grice*
Research Associate: *Faith Sternlieb*

Editor: *Laurie Schmidt*
Graphic Design: *Zach Hittle*

Published by: Colorado Water Institute, Colorado State University, Fort Collins, CO 80523-1033
Phone: (970) 491-6308, FAX: (970) 491-1636, Email: cwi@colostate.edu

Cover Photo: Maroon Creek and Maroon Bells near Aspen, Colorado. Image courtesy of Laurie J. Schmidt.

Editorial

by Reagan Waskom, Director, Colorado Water Institute

Creating a Vision for Water in Colorado—Does Science have a Role?

If you haven't been following the Basin Roundtable process, it might interest you to know that Colorado's water leaders are presently working to create a unified vision for our state. Department of Natural Resources director Harris Sherman has engaged members of the Interbasin Compact Committee (IBCC) in dialog on what the different regions of Colorado will look like in 50 years if we let our current approach to water supply play out, and what alternative futures might be more desirable. In our pluralistic society, developing a shared vision based upon mutual values and needs offers possible paths through the conflicts that accompany the development and sharing of our water resources.

Our current water supply is, to a large degree, the result of huge investments of federal money that have occurred over the past 100 years. In the current season of political campaigns, it is interesting to note that Jimmy Carter was the last president to have water as part of his national platform. The so-called "Carter Hit-List" evolved from his platform, changing the way we calculated benefit-cost ratios of projects to include environmental criteria. Big projects in Arizona, Utah, Colorado, and North and South Dakota were subsequently shelved as a result of this sea-change, including the Two Forks project. The ensuing Reagan administration changed the national focus from the environment to an obsession with smaller federal government—but the effect on large water projects was essentially the same. Without the dominant Federal role, water projects today are driven largely by local needs and hence are more thoroughly vetted through local political processes, with federal oversight focused mainly on environmental impact rather than project cost and engineering feasibility.

As local citizens engage in dialog and debate surrounding new projects, water managers would obviously prefer that the public's perception was primarily driven by knowledge, experience, and science. However, any student of local politics can tell you it is emotion rich, not driven by science and hard data. Local citizens are also voters, and the political process eventually will respond to their values. Political leaders must effectively navigate the ambiguity of science and emotion or soon face discontented voters at the polls.

Will we arrive at a shared vision for water in Colorado? Can we reconcile new needs for environmental and recreational flows with growing traditional water uses and the uncertainty of future climate? In some sense, we must and we will, as whatever we do or do not do binds our future.

Reagan Waskom

What is the role of science, education, and outreach in creating a vision for Colorado's water future? It seems obvious that the process of discovery and learning should have some influence. However, the inclusion of science-based information in river basin planning and management is only achieved if the academic community can find mechanisms to effectively inform and engage citizens and decision makers—to help them understand new knowledge and deal with the inherent uncertainties of data.

As Colorado attempts to find a shared vision for its water future, higher education has a role and a responsibility in the visioning process—to provide information in a format that is useful and accessible. This issue of Colorado Water features recent work of a just a few of the many graduate students currently working on water research projects at universities in Colorado. To help higher education provide timely research-based information that can be most useful to the public and to water professionals, we need your input to set and steer the research agenda. University faculty must steer their research to where the money is, but if Colorado can effectively collaborate on setting and prioritizing the water research agenda, it is likely that funding will follow. I invite our readers to contact us anytime to suggest water research priorities.

Environmental Effects of Magnesium Chloride Dust Suppression Products on Roadside Trees, Soils, and Streams

by Betsy A. Goodrich, Graduate Student
Ronda D. Koski, Research Associate
Dr. William R. Jacobi, Professor
Dept. of Bioagricultural Sciences and Pest Management, CSU

Magnesium chloride ($MgCl_2$) solutions are applied to non-paved roads in spring and summer months to reduce fugitive dust, which can contribute to air pollution and be harmful to human health. $MgCl_2$ solutions also work to sustain the road base and minimize erosion of non-paved roads. Hygroscopic salts, such as $MgCl_2$, stabilize road material and control fugitive dust by drawing moisture from the air and keeping the road damp by resisting evaporation.

Previous research has implicated other chloride - based salts, such as sodium chloride (NaCl), as agents associated with roadside vegetation damage or decline, while research focusing on $MgCl_2$ solutions has been limited. A series of studies investigating the environmental impacts of magnesium chloride dust suppression products on roadside environments was initiated in spring 2004. The study was conducted by members of the Forest and Shade Tree Health Laboratory at Colorado State University under the supervision of Dr. William Jacobi. Cooperators included Larimer County Road and Bridge Department, Grand County Department of Road and Bridge, USDA Forest Service: Sulphur and Canyon Lakes Ranger Districts, Colorado Agricultural Experiment Station, and several other Colorado counties affiliated with the Colorado Association of Road Supervisors and Engineers (CARSE).

Roadside Surveys

To quantify the regional effects of $MgCl_2$ dust suppression products on roadside vegetation, 370 kilometers (km) of forested, shrubland, meadow, rangeland, riparian, and wetland roadside habitats were initially surveyed along 55 major non-paved roads in Grand and Larimer Counties, Colorado. Roadside vegetation was visually surveyed every 0.32 km in 30.5 x 6-meter plots. Dominant species composition and visible damages to roadside vegetation were quantified. The majority (72.3 to 79.3%) of roadside vegetation surveyed was considered healthy (<5% damage to crown or stem), depending on slope position from the road. Severely damaged (>50% damage) vegetation ranged from 6.4% to 11.4% of roadside cover, with the most severely damaged vegetation occurring downslope from the road. Percent of tree cover with severe or moderate damage increased with increasing $MgCl_2$ application rates for roadside Aspen, Engelmann Spruce, and Lodgepole and Ponderosa Pines. These patterns indicated that $MgCl_2$ application was positively correlated with visible damage to some species of woody roadside vegetation, and roadsides needed to be more extensively studied and sampled to determine causal agents of declining tree health.

Roadside and Drainage Vegetation Plots

In 2004–2006, 60 roadside and 79 drainage vegetation health plots were established along 15 and 18 non-paved roads, respectively, with a range of $MgCl_2$ application rates. Evaluations were made of the roadside environment, including assessments of foliar damage, tree health, biotic (insects, diseases, animal damage, etc.) and abiotic (herbicide, winter desiccation, etc.) damage incidence and severity, and other common site and stand characteristics of Lodgepole Pine, Aspen, Engelmann Spruce, Subalpine Fir, and lower elevation plots dominated by shrubs and grasses. Soils and foliage were sampled at several distances from the road and ion concentrations were determined.

Betsy Goodrich samples Lodgepole Pine foliage in Larimer County, Colorado.

Matt Carpenter (former CSU undergraduate) assesses Aspen health in a drainage vegetation health plot.

Angela Hill (former CSU undergraduate) collects water samples in Larimer County, Colorado.

High concentrations of soil magnesium and chloride (400–500 ppm), high foliar chloride (>500–5000 ppm depending on species), and high incidences of foliar damage were measured in roadside plots along straight road segments in the first 3 to 6.1 meters adjacent to treated roads. Precipitation appears to move some $MgCl_2$ ions from the road into roadside soils, and trees absorb the magnesium and chloride through the soil. In drainage plots, where water is channeled off roads via roadside ditches, high concentrations of both magnesium and chloride ions and associated foliar damage were measured between 3 and 98 meters from the road. High incidences of foliar damage and elevated ion concentrations were not apparent in control plots along non-treated roads. High concentrations of $MgCl_2$ in roadside soils and plants did not appear to cause appreciable changes in typical concentrations of other elements, including calcium, potassium, phosphorus, or total nitrogen. Sodium, sulfur, and boron, however, were slightly elevated in roadside soils and foliage, as all three elements are minor components of $MgCl_2$–based dust suppression products.

The amount of chloride and magnesium in roadside tree needles or leaves positively correlated with percent of foliar damage for all species, while the incidence and severity of biotic damages (insects, fungal pathogens, animal damage, etc.) did not. While chloride was considered the main ion associated with foliar damage in our study, trees may have been stressed by other abiotic issues such as drought years and subsequent water stress. Water stress and chloride toxicity are difficult to separate and may interact with one another to further stress the tree. Foliar samples should be collected and analyzed for ion content to separate chloride toxicity from water stress or other damages. Currently, a controlled shadehouse experiment is underway to study the effects of various $MgCl_2$ soil concentrations on well-watered, evenly aged potted trees.

Aspen along a $MgCl_2$-treated non-paved road In Larimer County, Colorado.

Dust suppression application rates were obtained from county road and bridge departments for all study roads. The amount of $MgCl_2$

Ronda Koski and Bill Jacobi measure stream depths in Grand County, Colorado.

that was applied to the road (kg $MgCl_2$ per km-1 per yr-1) was strongly correlated with the amount of chloride in the roadside tree's needles or leaves and percent foliar damage. Positive relationships between foliar chloride and $MgCl_2$ application rates can be used to predict foliar concentrations and subsequent damage to roadside trees and may be useful as management techniques for transportation officials.

Roadside Stream Chemistry

To determine if $MgCl_2$ applications affected water chemistry of nearby streams, 16 streams were monitored upstream and downstream of roads treated with $MgCl_2$-based dust suppression products. Water samples were collected every two weeks for one to two years in both counties in 2004–2005. Concentrations of chloride, magnesium, and a suite of other ions were measured in the stream water over this time. Stream site measurements, including stream velocity, area, and flow rates, were measured each time water was collected. The length and slope of drainage ditches and area of road surface draining into the stream (surface area index) were also measured when stream sampling sites were established.

Nine of sixteen Colorado streams monitored for $MgCl_2$ had low but significantly higher downstream than upstream concentrations of chloride and magnesium ($p < 0.10$). When all sampling dates were combined, mean upstream chloride concentrations ranged from 0.14 to 31.96 mg/L and 2.40 to 13.96 mg/L for magnesium. Mean downstream chloride concentrations ranged from 0.35 to 36.75 mg/L, while mean downstream magnesium concentrations ranged from 2.08 to 13.96 mg/L. Some of the upstream sites were affected by chloride input of other roads and streams, but the majority of the streams represented typical background concentrations for chloride (0.14–2.9 mg/L) and magnesium (2.2–5.7 mg/L) in these areas of Colorado.

The upstream equivalent concentration most strongly correlated with the downstream values of electrical conductivity, chloride and magnesium concentrations. Based on ANCOVA models, other site factors that generally increased downstream values were average yearly $MgCl_2$ application rate and the surface area index. Chloride concentrations were highest in early fall (September and October) and lowest in spring months (May and June). Chloride loads were higher in the spring and decreased towards the end of the sampling season. Based on a literature review of chloride concentrations in Colorado streams, these concentrations are fairly low and similar to other streams throughout Colorado. Our preliminary findings suggest that $MgCl_2$-based dust suppression products may move into roadside streams but the concentrations detected are below the concentrations reported to adversely affect fresh water aquatic organisms.

Continuing Research

The next steps for research include determining if there are safe levels of $MgCl_2$ to apply for dust suppression without damaging trees, determining the timeline of damage and mortality rates from various amounts of $MgCl_2$ on different species, and partnering with county agencies to determine best management practices for its application. Larimer County, Colorado, has responded to this research by lowering application rates or discontinuing the application of $MgCl_2$ on roads with steep grades or strong curvature and on roads that pass through forested habitats. The Forest and Shade Tree Laboratory at Colorado State University is continuing work with Larimer County Road and Bridge Department to explore the effects of alternative dust suppression products on tree health.

Stream crossing under a non-paved road treated with $MgCl_2$ for dust suppression.

NEWS, WEATHER AND WATER

19th Annual South Platte Forum

Oct. 22-23, 2008 — Radisson Conference Center, Longmont

breaking news

extended weather

perspectives

no-spin zone

U.S Bureau of Reclamation photo

sturgeon general report

registration fees

Registration fees include meals, breaks and reception.

Early Registration (by Oct. 1).....$100
Registration (after Oct. 1).....$115
Additional invoicing fee (if necessary) $20

payment information

Send this form with check or money order to:
South Platte Forum
c/o Northern Water
220 Water Avenue
Berthoud, CO 80513

forum location & hotel information

Radisson Conference Center - 1900 Ken Pratt Boulevard - Longmont, CO
303-776-2000 - www.radisson.com/longmontco

The Radisson offers a $99 nightly rate to Forum attendees. Call 800-333-3333 by **Oct. 1** to make your reservation. Be sure to mention you're with the South Platte Forum.

news line & information

For general questions, contact
Jennifer Brown, Coordinator
402-960-3670
Jennifer@jjbrown.com

For billing and payment questions, contact
Veronica Gomez, Northern Water
970-622-2322
vgomez@ncwcd.org

For additional information, visit
www.southplatteforum.org

presented by

TETRA TECH
www.tetratech.com

sponsors

Aurora Water
Northern Water
Parker Water and Sanitation District
Colorado Water Institute
Metro Wastewater Reclamation District

U.S. Department of the Interior, Bureau of Reclamation
Colorado Division of Wildlife
U.S. Fish & Wildlife Service
USGS science for a changing world
Colorado State University Extension
Denver Water

Characterizing Riparian Width in the Colorado Front Range

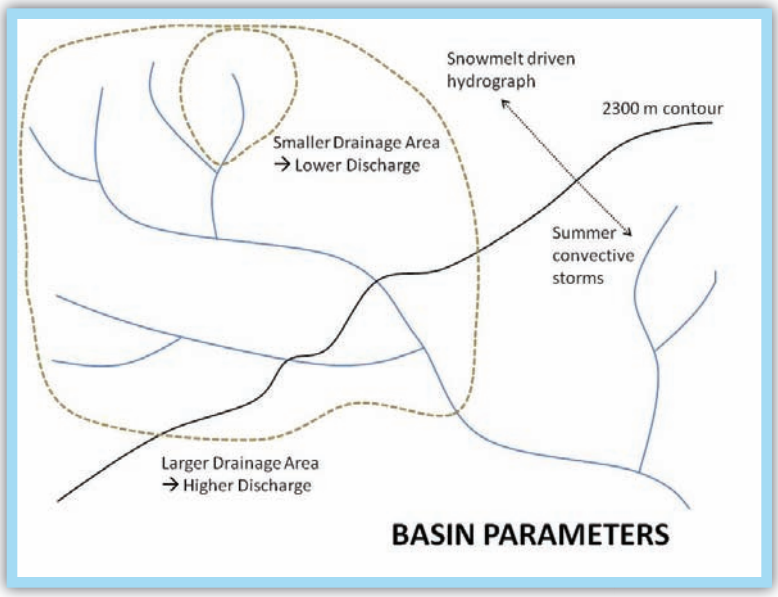
by Lina Polvi, Graduate Student, Geosciences

The importance of riparian zones, the vegetation that borders a stream and provides a transition between aquatic and terrestrial vegetation, is constantly stressed in stream restoration and conservation. We know that although only 2% of Colorado's area comprises riparian ecosystems, over 80% of the fauna rely on this patch of land that has a much higher biodiversity than any other ecosystem in the state.

We also know that the riparian buffer plays a key role in the health of a stream ecosystem by:

- Protecting the stream's physical processes through reduction of sediment inputs
- Protecting the stream's chemical processes through reduction of chemical and pollutant contaminants
- Protecting the stream's biological processes by providing shade, organic matter, and the interactions of a complex aquatic-terrestrial food web for aquatic organisms

Most land and water managers recognize the vital functions that a healthy and intact riparian zone provide to the stream; however, what is not as clear is how wide this riparian zone is for a healthy stream and how we should delineate the edge of the riparian zone. Through my research, I am asking these questions by looking at the geomorphic controls and the physical characteristics of the channel and valley on the width of the riparian zone. In addition, I am developing a consistent method for defining the edge of the riparian zone using a three-pronged approach.



Schematic showing possible basin scale controls on riparian width.

Author Lina Polvi

Mountain streams exhibit large amounts of variability in physical processes, shaping the template on which ecological processes occur. Two main concepts have been introduced to explain the variability we see as we move downstream through the watershed:

- The River Continuum Concept (RCC), which states that physical and biological characteristics will change in a predictable and gradual pattern in the downstream direction
- The Process Domain Concept (PDC), which asserts that the watershed can be subdivided based on the dominant disturbance-forming processes, such as floods or landslides

Imagine you are driving or hiking along your favorite drainage here in Colorado, maybe along the Poudre Canyon or from Tennessee Pass to where the Eagle River joins the Colorado River. You will notice some gradual downstream changes, such as increasing channel width. However, you will also find that the valley width oscillates from narrow canyons to wide, open valleys. The gradient of the channel will not be steady but will vary, which is reflected in the changing bedforms: from low gradient, meandering pool-riffles to steeper step-pool sections. Each reach is a continuous section of river with similar channel and valley geometry and gradient. In each of these reaches different processes will be at work governing the floodplain development through discrete disturbances. Because reach properties change within a few miles to less than a few hundred yards or feet in mountain rivers, we need to be able to define processes according to reaches rather than for an entire river or region as a whole.

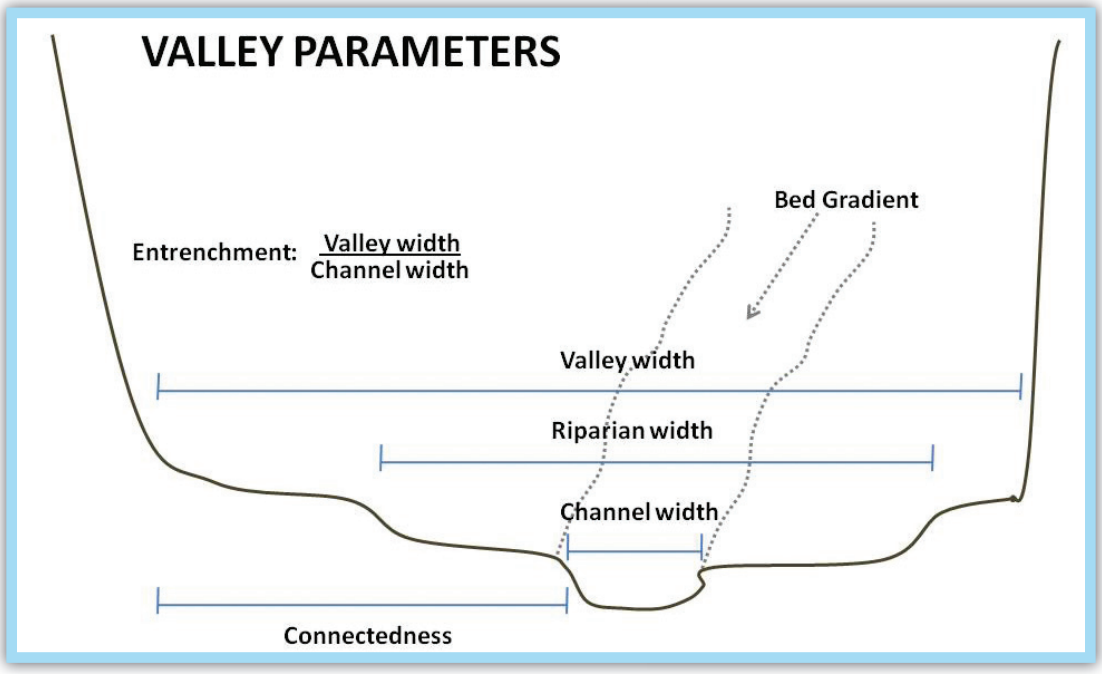
This research project focuses on a portion of the Colorado Front Range, which encompasses the South Platte River drainage and extends from the Wyoming border to the South Fork of the South Platte, from the mountain front to the Continental Divide. Because I am interested in studying natural river systems, I have had to weed out areas affected by people through mining, development, roads, and major diversions. Due to these restrictions, study reaches have mostly been located in the St. Vrain watershed, which drains from the southern end of Rocky Mountain National Park and flows through Lyons and then into the South Platte River, and in the Cache la Poudre watershed, which begins in the peaks along the Continental Divide in the northern edge of Rocky Mountain National Park, then flows through Fort Collins before joining the South Platte River in Greeley. The data and processes defined through this research may be specific to the Colorado Front Range, but the concepts and techniques should be applicable to the rest of the mountainous regions of the state.

The project was divided into two main objectives: determining geomorphic controls on riparian width and testing a three-pronged approach to delineating the edge of the riparian zone.

Geomorphic Controls

The landscape and the degree of influence of disturbances from the hillslope and the channel will serve as a filter for the range of ecological possibilities. First, I looked at potential controls from a watershed perspective: drainage area and elevation. It is well established that the drainage area can serve as a proxy for the discharge at bankfull conditions, the point at which the water fills a channel just before it overtops its banks and flows onto the floodplain. The elevation of the study reach is not so important in and of itself, but it serves as a proxy of another much harder to measure characteristic; the precipitation type and amount changes with elevation in the Colorado Front Range. Not only does average annual precipitation increase as you gain elevation, there is also a sharp demarcation at 2300 meters (7500 feet), where the main precipitation type changes. Above that elevation the precipitation is dominated by snow, while areas below that will experience very localized summer storms that produce high precipitation intensities. These storms often contribute to dangerous flash floods, such as the Big Thompson Flood in 1976. The differing precipitation regimes will contribute to different hydrographs, snowmelt vs. summer spikes from storms, which in turn shape the channel morphology and thus the disturbance types on the floodplain. If either the drainage area or elevation are found to be the main controls on the riparian width, then this would support the River Continuum Concept, since these controls will change more or less gradually as we go downstream through the watershed.

Possible local controls on floodplain processes are those that will change between reaches along a stream and may not follow a gradual pattern. These local controls will be the gradient and the valley geometry as well as other floodplain characteristics, such as the presence of colluvium, large boulders originating from the hillslope and the vegetation type, whether it is dominated by grasses, herbs, shrubs, or trees. Valley geometry can be qualitatively thought of as the broad shape of the valley, whether it is a broad U-shaped valley or a confined canyon, and how much the stream channel is confined within the valley walls. A more confined valley will not allow the channel to



Schematic showing possible valley scale controls on riparian width.

move from side to side or meander freely. Quantitatively, I measure valley geometry using two metrics: entrenchment, which is the ratio of the valley width to the channel width, and connectedness, which is the absolute distance from the edge of the channel to the valley edge.

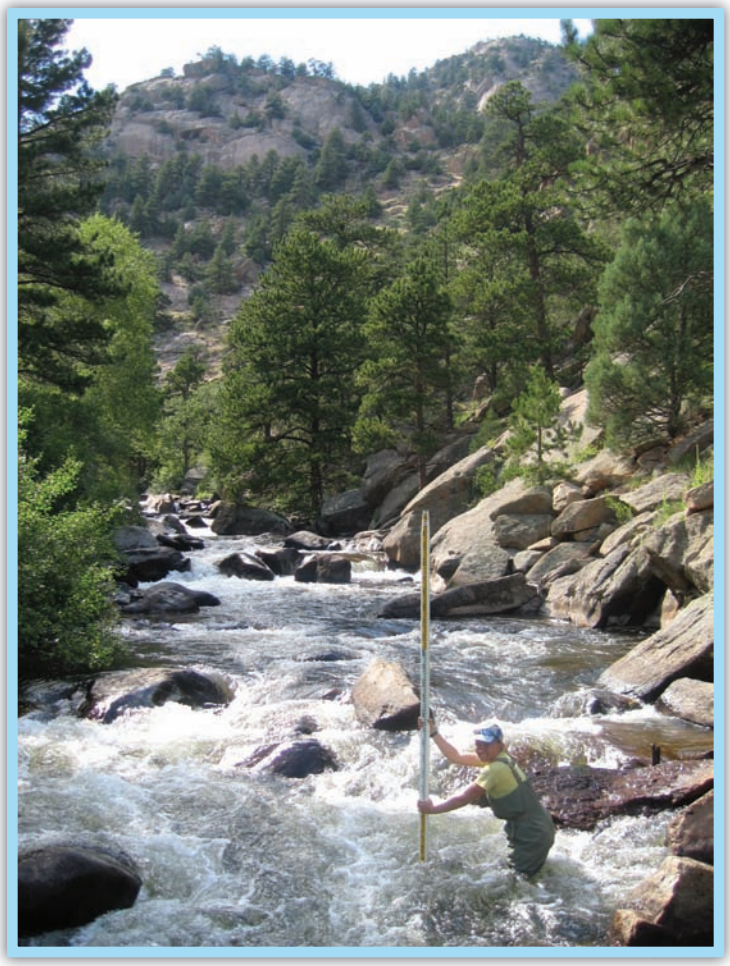
Riparian Zone Delineation

The second objective of this research is to define a consistent riparian edge. The edge of the riparian zone is by definition a fuzzy boundary, a transition zone. Riparian ecologists and geomorphologists tend to disagree among themselves on where to draw the line for the edge of the riparian zone. I like to think of the riparian zone as a probability zone. Next to the channel bank, there is a 100% chance of being in the riparian zone, and as we move away from the channel the probability decreases to zero. Wetlands are defined using a combination of soil characteristics, hydrology, and vegetation indicators. In the same way, I am looking for three lines of evidence for determining the riparian edge:

- geomorphic characteristics, such as topographic indicators like a break in slope or terrace, evidence of river erosion and thus lack of soil formation, and fine sediment deposition
- vegetation characteristics, the presence of obligate riparian plants
- corresponding with a certain recurrence interval flow, such as the 10-year flood

Of course, the best part of doing this research is being in the field where I can see first-hand the processes and variations in the riparian zone. Over the course of my field work I have visited 25 reaches throughout the Colorado Front Range with varying drainage areas, gradients, and valley geometries at various elevations. When arriving at a reach, I first decide where the channel edge, riparian edge, and valley edges are located on river left and right. At each reach a longitudinal profile, which is the profile of the stream bed at the deepest point going downstream, and one or two valley cross-sections were surveyed. From these data, the valley geometry metrics and gradient are calculated. To look at vegetation species' transitions, I conducted plant transects perpendicular to the channel, extending 30 feet past the field-delineated riparian edge. A 1.5 by 3-foot PVC frame was laid down, where all specimens were identified and categorized by the percent cover.

Through statistical analysis, I can analyze the relative importance of potential controls on the riparian width. While multiple regressions cannot determine cause and effect, we can determine which potential controls do the best job of explaining the variation in riparian width within our sample. Interestingly, in all the multiple regressions, several outliers were consistently found. If outliers can be said to be inherently different than the rest of the sample, then they may be removed from the sample size, and other non-measured factors better explain the variability. The outliers in my analysis were those located in unconfined valley types. Without the outliers, two local controls account for over 60% of the variability in riparian width: gradient and valley geometry. The steeper the channel, the narrower the riparian zone will be, and the riparian zone will be narrower the more the channel is confined by the valley. Steeper channels will reduce flow attenuation and thus residence of water on the floodplain. During overbank floods, if the valley is confining the channel, water will simply rise upward rather than flowing out across the floodplain, limiting the possibility for saturating a wide floodplain. The unconfined reaches have yet to be analyzed thoroughly, but other likely explanations for variation in the riparian width are groundwater controls, vegetation community type, and floodplain microtopography.



Lina Polvi surveys a longitudinal profile and valley cross-section in a steep and confined section of the North St. Vrain (west of Lyons, CO).

Relationships between the field-delineated riparian edge and hydrology were analyzed by determining the 10-, 50-, and 100-yr peak flows at the given reach using regional regression equations, which is based on average annual precipitation and the drainage area. Preliminary analyses have shown that the riparian zone is usually capped by the stage of the 10-year flood.

Knowing how to more accurately delineate the riparian edge, land managers can better protect streams by preserving the full width of the riparian zone. In some cases land

Looking at the bankfull edge and the riparian zone on the North St. Vrain in Wild Basin, Rocky Mountain National Park. Unconfined valleys are not as heavily influenced by the hillslope, and very local controls such as floodplain microtopography are more important in determining riparian zone width.

managers, such as the U.S. Forest Service or National Park Service, may have such a large area of land to manage that it is impractical for them to visit every possible stream reach to determine riparian width. However, if they can determine the channel gradient and a metric for valley geometry using remote sensing data, they can easily determine a riparian width that is closer to reality in the field.

Riparian areas both reflect and influence geomorphic and ecologic processes. While it is easy to compartmentalize these disciplines, they interact to form the whole system we see as geomorphic flood features and riparian area on the floodplain. Society has gone from seeing rivers simply as a conduit for water and sediment to now viewing them as a complex interactive system supporting life from the entire watershed. The more we understand about the landscape's effects on the riparian zone, the better we can protect it. And to protect it, we have to know what it is we are protecting by knowing how to accurately delineate the riparian zone.

Suggested Further Reading

- Gregory, S.V., Swanson, F.J., McKee, W.A., & Cummins, K.W. 1991. An ecosystem perspective of riparian zones. BioScience 41: 540-551.
- Hupp, C.R. & Osterkamp, W.R. 1996. Riparian vegetation and fluvial geomorphic processes. Geomorphology 14: 277-295.
- Jarrett, R.D. 1990. Hydrologic and hydraulic research in mountain rivers. Water Resources Bulletin 26: 419-429.
- Montgomery, D.R. 1999. Process domains and the river continuum. Journal of the American Water Resources Association 35: 397-410.
- Montgomery, D.R. & Buffinton, J.M. 1997. Channel-reach morphology in mountain drainage basins. GSA Bulletin 109: 596-611.
- Naiman, R.J., Decamps, H. & McClain, M.E. 2005. Riparia: Ecology, Conservation, and Management of Streamside Communities. Elsevier Academic Press: Amsterdam, 430 pp.

State and Locality: A Case Study of the Uncompahgre Valley Water Users' Association's Relationship with the U.S. Bureau of Reclamation, 1902–Present

by April A. Pratt, MA, Department of Sociology, Colorado State University

Introduction

Common property resource (CPR) theories address how people organize collectively to do what cannot be done individually. Such collective organization is prevalent in situations involving public goods and common property resources, such as irrigation canals and ditches, where individuals organize collectively to construct, operate, and maintain a large water source. In the realm of local irrigation organizations that operate between the individual user and a central state bureaucracy, David Freeman, working within a common property resource tradition, has advanced an empirically researchable conceptual model that addresses one critical aspect of water commons management. The model centers on the types of linkages between local organizations and a central state authority.

In Freeman's Unitary Model of linkage, power is concentrated at the "top" with officials in central state bureaucracies. Information and money move from individual irrigators to a bureaucratic administration. Decisions flow from bureaucratic officials down to irrigators. Local users must gain approval for action from such authorities. Delays are common and conflict runs deep, as between state and local agendas. In the Federal Model of linkage, power is decentralized, with each "link in the chain" maintaining a certain level of autonomy (e.g., control over information and financial resources). Even though organizations are still accountable upward to the bureaucracy, decision-making on behalf of the CPR management is positioned to be more rapidly adaptive, and conflict remains low.

Within southwestern Colorado lies a laboratory ideally suited to examine the CPR theory. The Uncompahgre Irrigation Project, encompassing the towns of Montrose, Delta, and Olathe, Colorado, was one of the first five irrigation projects approved by the newly created U.S. Reclamation Service in 1902. Concurrently, local water users formed the Uncompahgre Valley Water Users' Association (UVWUA) to oversee the project locally and aid in negotiations with the federal government. This mediating organization has served as the buffer between individual members and the central state bureaucracy for over 100 years. The following research question was posed: Based on case study evidence of the Uncompahgre Valley Water Users' Association (UVWUA), to what extent is Freeman's ideal type theoretical model supported, refuted, and/or found in need of modification?

Qualitative data were gathered on the UVWUA and employed to constitute a comparative historical case study. Research on the UVWUA and its relationship with the Bureau of Reclamation was divided into three time periods: the early organization (1902–1931), the years of change (1932–1949), and the current organization (1950–present). Each time period was assessed within the framework of the theory.

The Black Canyon of the Gunnison, near Montrose, CO, houses the six mile-long Gunnison Tunnel. When the Reclamation Service completed the tunnel in 1909, it was the longest irrigation tunnel in the world.

Built by the Reclamation Service over 100 years ago, the office of the Uncompahgre Valley Water Users' Association is one of the best preserved examples of the Reclamation's presence in the West.

Background

In 1906, the Denver and Rio Grand Railroad issued a pamphlet advertising the glorious Uncompahgre Valley in southwestern Colorado with its "permanent water supply". Inviting the "brave and resolute" to "share in Uncle Sam's bounty," the pamphlet praised the federal government for undertaking one of the greatest water projects of all time. The federal government was boring a tunnel six miles long through mountainous rock in order to divert water from the plentiful, but theretofore inaccessible, Gunnison River to the fluctuating, over-utilized Uncompahgre River. The pamphlet predicted the Uncompahgre Project would be able to provide a near-endless water supply to local farmers and would irrigate at least 150,000 acres of fertile soil. The Reclamation Service, recently created and eager to advertise the immensity of one of its first projects, seemed to offer nearly-free water.

By 1924, the project, which succeeded in enticing many, was labeled a "farce." The costs of the project ($3 million at that point) were triple that of estimates given to farmers in 1904 when initial negotiations for the project took place. To partake in "Uncle Sam's feast," farmers were "influenced" to mortgage their land to the federal government as insurance for repaying these costs. At the time, farmers were guaranteed that repayment costs would not exceed $25 per acre of land, but by 1908, the Reclamation Service threatened an increase of $40 an acre or the cessation of work on the project. In addition, the fertile, bountiful lands of the Uncompahgre were fast becoming water-logged, in part because Reclamation engineers had not considered seepage problems when constructing the project. Many Uncompahgre farmers were left with poor producing lands that were heavily mortgaged and were compelled to pay far beyond their means for water. Farmers were fast becoming desperate and distrustful of the Bureau.

In a highly confrontational episode, a number of UVWUA members appeared before Interior Secretary Hubert Work's Fact Finders Commission on January 21, 1924. The Uncompahgre Project had been labeled one of the seven worst Reclamation projects, fast on its way to "financial ruin" because few on the project were repaying construction costs. Previously, the Association had made numerous appeals to the federal government to lessen settler burdens, but the bureaucratic system of the Reclamation Service had proved nearly impossible to penetrate. The Service was overburdened by an increase in new projects, and its lengthy decision-making process stunted aid to all its projects. As more and more Uncompahgre requests for aid reached Washington, Reclamation officials began to see Uncompahgre farmers as uncooperative, ungrateful beneficiaries of their irrigation gift.

The Fact Finder's Conference in Salt Lake City was seen by many locals as their "last stand" with the federal government. At the conference, Uncompahgre members stated unequivocally that the Reclamation Service was responsible for their present woes, in large part due to its mistakes with construction estimates. Members demanded the federal government reassess the project's construction charges to reflect original estimates. The federal government saw this as an impractical request. If it drastically reduced assessments for one project then all other Reclamation settlers would demand the same, leaving the dwindling Reclamation Fund virtually bankrupt. When the denial reached Uncompahgre ears, settlers were in a pitiable state of despair. The resulting bitterness toward the Bureau remained for decades.

With such immense turmoil between the UVWUA and the Bureau of Reclamation, it is astounding to discover that the relationship today is one of the finest examples of water management cooperation in the West. Today, the Uncompahgre Project is seen as a success by many people within and external to the Association. One outsider stated "it is hard to find a better system [than the Uncompahgre]"

The Gunnison Diversion Dam, at the bottom of the Black Canyon, apportions the correct amount of water to send through the Gunnison Tunnel.

(Key Informant Interview). Local Bureau officials have called the UVWUA one of the best groups that they work with and certainly the best in Western Colorado. According to one local Bureau official, "The UVWUA is a first-class organization and they have their act together." Likewise, UVWUA officials see the Bureau of Reclamation as a great ally and have developed numerous project improvements and area-wide improvement campaigns together successfully. The changes between the 1924 conference and today had to be drastic in order to produce such an alteration in the Bureau-Association relationship.

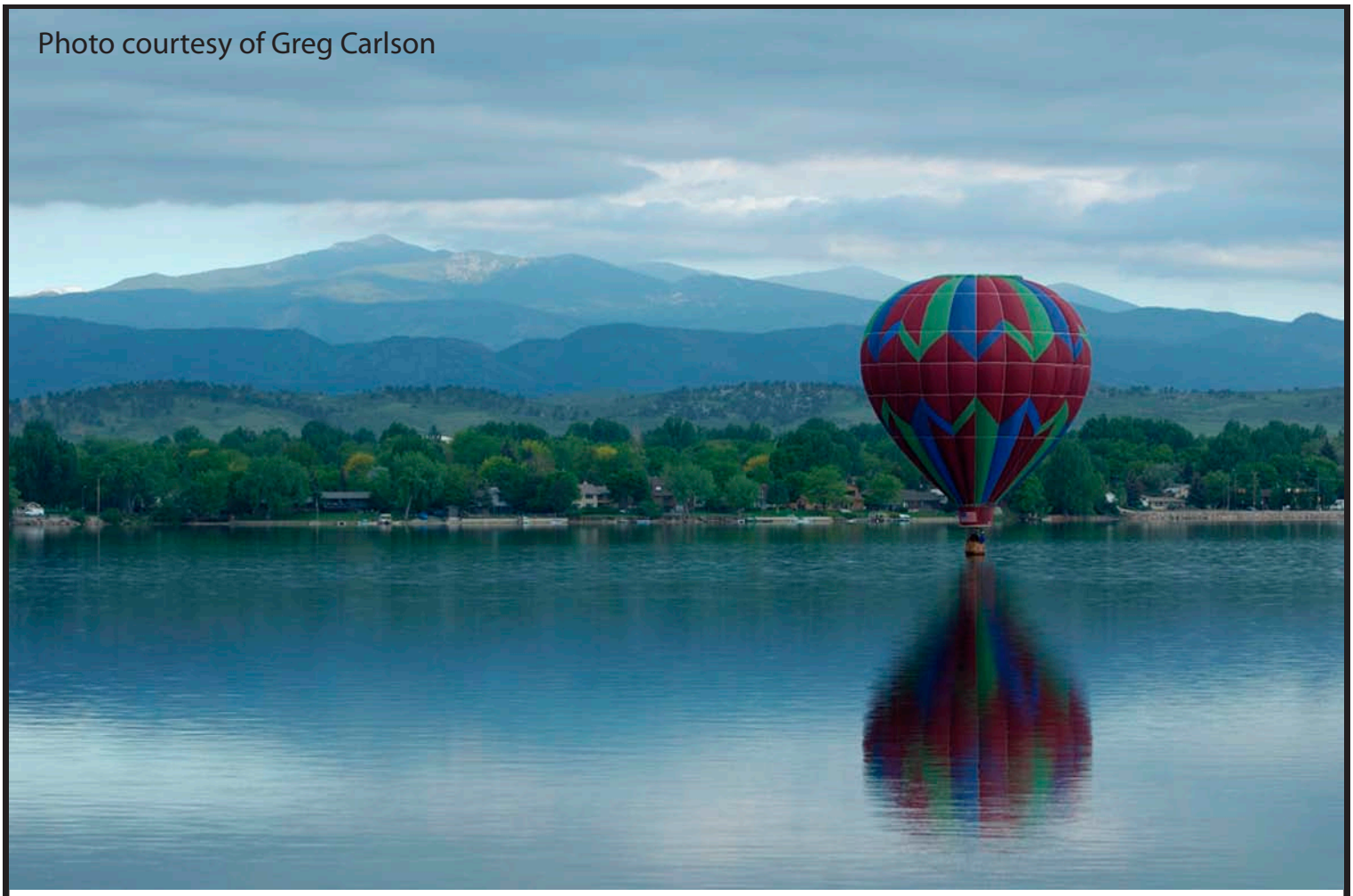
Findings

The research effort examined the organizational changes in the Bureau-Association relationship in order to compare observed historical changes to those predicted by the conceptual model. It found that in the early years (1902-1931), command over the Uncompahgre Project rested with the central bureaucracy instead of with the local settler organization. The decisions were "top-down" and the money flow was "bottom-up" (running from the Association up to the Bureau, leaving local members no means to improve their system when needed). Delays on action were common and neither organization saw the other as legitimate.

During the next time period (1932-1949), major changes occurred. In 1932, the Association was granted control over operation and maintenance of the entire project. Additionally, the Bureau altered its organizational structure to a more regionalized system in 1944. Finally, in 1948, the Association and the Bureau negotiated a mutually beneficial repayment contract. Together, these adjustments resulted in the bulk of decision-making power being transferred to the UVWUA. Most funds were allowed to remain with the Association, which lessened the dependency on the Bureau. Delays were reduced and mutual attributions of legitimacy increased markedly.

The final time period (1950-present) witnessed greater autonomy for the local irrigators, resulting in the successful management of a common property resource. Money is kept and controlled locally more during this period than ever before. Delays on action have remained low. The relationship between the two organizations is now one of cooperation and mutual respect. Questionable or contingent legitimacy has been replaced by open approval on both sides.

The analysis supports the conclusion that in the beginning, the Association lacked attributes of successful linkages with a central state bureaucracy. The UVWUA and Bureau then instituted changes that correspond to what has been posited for greater success by the theory. Today, the UVWUA, as a common property resource organization, still exhibits linkage attributes that theorists have seen as being critically important to successful, long-enduring relationships. This research supports the hypotheses advanced by the ideal type model.



Online...Colorado Water Law for Non-Lawyers

(GSLL 1040 - Noncredit)

For anyone interested in water law, including educators, developers, government officials, realtors, farmers, business people, environmentalists, recreationists, and home owners.

Date: Monday, Aug. 25 - Dec. 12, 2008
Cost: $489
Instructor: Glenn Patterson

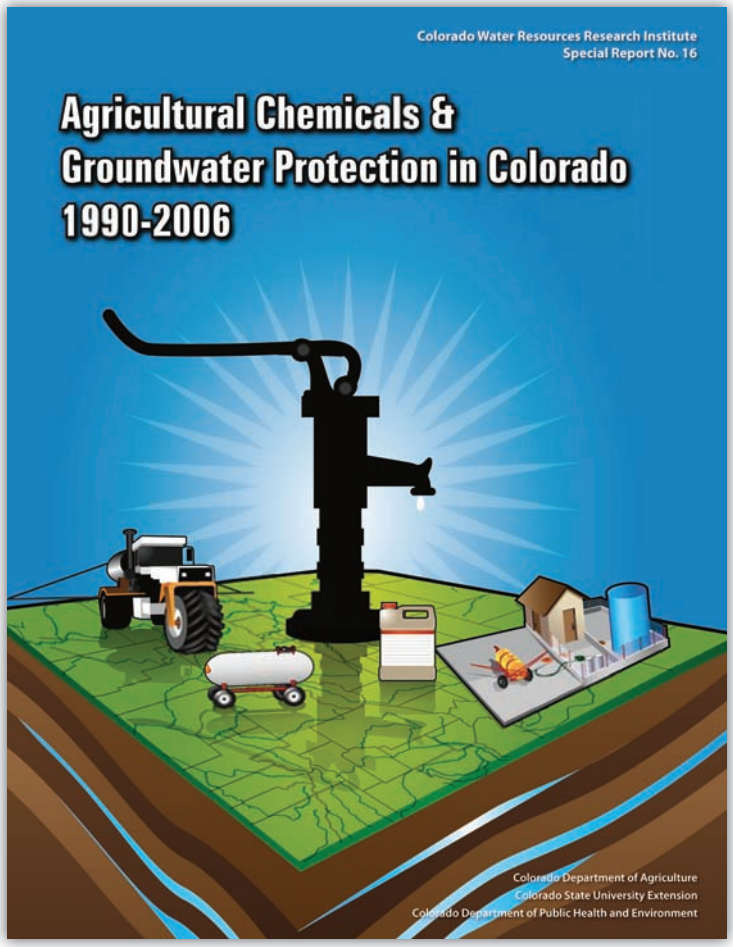
Register Today!

(877) 491-4336
www.learn.colostate.edu/noncreditcourses

Colorado State University

New Special Report on Agricultural Chemicals and Groundwater Protection in Colorado Released

Authors: Troy Bauder, Reagan Waskom, Rob Wawrzynski, Karl Mauch, and Greg Naugle



The Agricultural Chemicals and Groundwater Protection Act took effect on July 1, 1990, and established the Groundwater Protection Program. Its purpose is to reduce agricultural chemicals' negative impacts on groundwater and the environment. Agricultural chemicals covered under this legislation include commercial fertilizers and all pesticides. The goal is to prevent groundwater contamination before it occurs by improving agricultural chemical management. This report summarizes the first 15 years of the Agricultural Chemicals and Groundwater Protection Act and provides an overview of activities and monitoring data.

The program employs three primary functions to protect groundwater in Colorado:

1. Program oversight and regulation
2. Groundwater monitoring
3. Education and training

Program Oversight and Regulation

The Colorado Department of Agriculture (CDA) is the program's lead agency. One of the CDA's responsibilities is to regulate agricultural chemical bulk storage and mixing/ loading areas. Pesticide facility inspections began September 30, 1997, and fertilizer facility inspections began September 30, 1999. By December 2006, approximately 1,300 inspections were performed at 177 facilities around the state.

As part of program oversight, the CDA also manages a waste pesticide collection program. Initiated in 1995, the program has collected more than 100,000 pounds of waste pesticide from public and private sources.

Groundwater Monitoring

The monitoring program has prioritized its sampling in basins where agriculture predominates and rural homes utilize groundwater. These data form the backbone of the Groundwater Protection Program. They determine the need and priority for education and other program resources. The program completed sampling of groundwater systems in the largest agricultural and urban regions of Colorado. The aquifers sampled to date are:

- South Platte alluvial aquifer
- San Luis Valley unconfined aquifer
- Lower Arkansas alluvial aquifer
- Denver Basin aquifer system and alluvial deposits on the Front Range
- High Plains/Ogallala aquifer
- Colorado River and Uncompahgre River alluvial aquifers
- North Platte alluvial and terrace formations in Jackson County
- Gilpin County
- Wet Mountain Valley

Monitoring data, vulnerability assessments, and chemical user survey data indicate there are areas in Colorado where water quality still is susceptible to contamination. Fortunately, the majority of wells sampled thus far are not contaminated at levels deemed unsafe for humans by the Environmental Protection Agency (EPA).

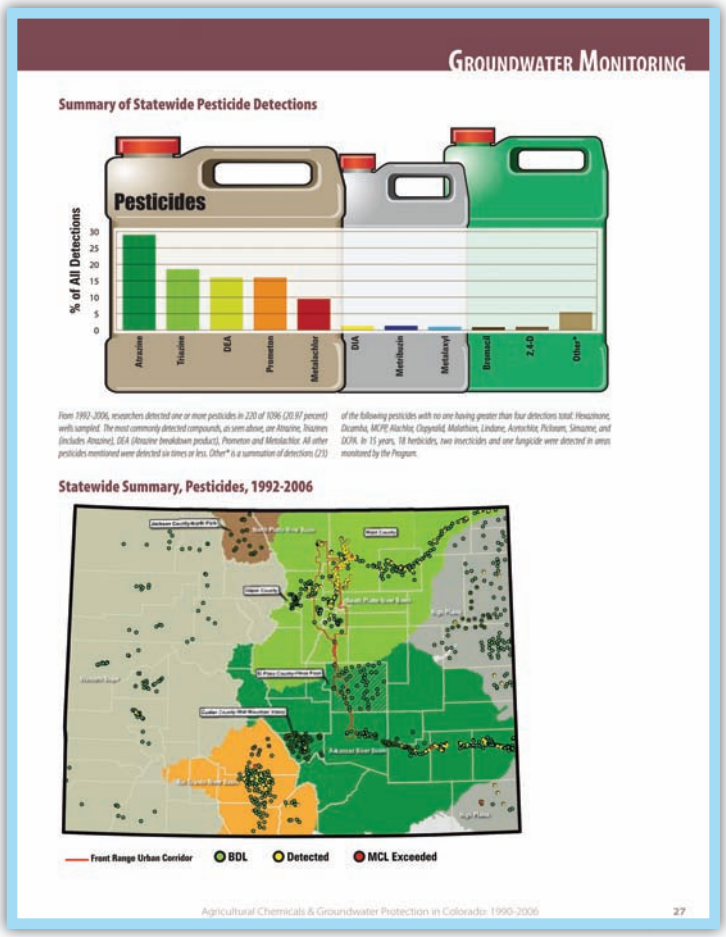
Education and Training

The Agricultural Chemicals and Groundwater Protection Act specifies that Colorado State University Extension (CSUE) provide education and training on how

to reduce groundwater contamination from agricultural chemicals. The CSUE has produced numerous publications on best management practices, or BMPs, and helped pilot the local BMP development process in four areas.

CSUE uses other avenues to provide information, such as applied research, field days, demonstration sites, continuing education through the Certified Crop Advisor program, a display booth, videos, and the Groundwater Protection Program web site.

In order to assess the BMPs adopted by Colorado's agricultural producers, surveys were conducted in February 1997 and December 2001. Overall, results of the two surveys suggest that producers accept many of the irrigation, pesticide, and nutrient management BMPs that help protect water quality and farm profitability. Nutrient and pesticide management BMP adoption is generally higher than irrigation management BMPs. Irrigation system improvements, or structural BMPs, are common in most regions, but adoption of irrigation management BMPs used to determine when and how much to water is not as common.



Future Direction

Predictions are that population growth and urbanization, coupled with increasing land and water values, will reduce the number of acres devoted to irrigated crop production in several river basins. These trends may also change cropping patterns from large acreage, low value crops to smaller acres of higher value crops. Often, these crops require different levels of pesticide and fertilizer inputs.

Like much of the West, Colorado is experiencing an increase of small acreage 'ranchettes' as larger farms and ranches are subdivided. The result is that one landowner may be replaced by many more individuals on the same land area. These land use changes may also affect Groundwater Protection Program activities and resources as the new rural residents also impact water resources through their land management activities. Thus, changes in educational and monitoring efforts will be required to protect groundwater quality under these new land use environments.

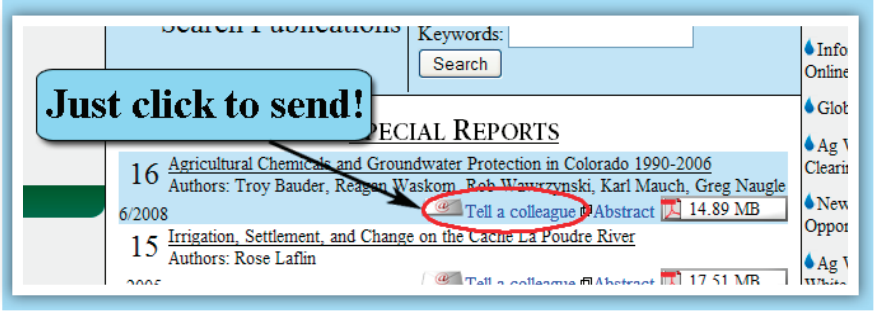
Additionally, the increasing and changing population dynamics in Colorado may refocus the educational and monitoring programs from primarily agricultural to urban and exurban areas. Keeping partnerships with federal, state, and other agencies working in water resource protection will continue to be critical, but other partners also may need to be considered, such as municipalities, the green industry, and other entities that work more in the urban environment.

The Groundwater Protection Program has been working with agricultural producers, the agricultural chemical industry, and several state and federal agencies to prevent contamination of Colorado's groundwater resources from point and non-point source pollution for more than a decade. This cooperation serves as a good model for other programs working to protect Colorado's water for future generations. BMP adoption results and groundwater monitoring data indicate these efforts are working to protect groundwater quality in Colorado.

This publication can be obtained in print from the Colorado Water Institute or can be downloaded online at: http://www.cwi.colostate.edu as Special Report 16 (SR16) under Publications/Reports.

Check out our new feature!

Like a publication on our web site? You can now send it to other people who may be interested.



ICWEHS - Call for Papers

International Conference on Water, Environment and Health Sciences: The Challenges of the Climate Changes
April 13-17, 2009 at Universidad de las Americas, Puebla Cholula, Puebla, Mexico

OBJECTIVE OF ICWEHS

ICWEHS will provide a forum for the interdisciplinary exchange of issues, views, experiences, and needs for research in the areas of water, environment, and health sciences under the influence of climate change.

TECHNICAL PROGRAM HIGHLIGHTS

Suggested conference paper or poster and session categories, trade-offs are not only accepted but encouraged:

- **Water**
  -Precipitation
  -Potential Evaporation
  -Groundwater
  -Surface Water
  -Interaction between Surface and Ground Water
- **Environment**
  -Water and Wastewater Treatment
  -Pesticides
  -Remediation
  -Hazardous Waste
  -Heavy Metals
- **Health Sciences**
  -Epidemiology
  -Toxicology
  -Exposure Assessment
  -Risk Assessment and Communication
- **Education**

ORGANIZING COMMITTEE

Jose A. Raynal, General Conference Chair, Universidad de las Americas, Puebla (UDLAP)
josea.raynal@udlap.mx

Benito Corona, Technical Program Chair, UDLAP
benito.corona@udlap.mx

Erick Bandala, Technical Program Co-Chair, UDLAP
erick.bandala@udlap.mx

Faith Sternlieb, International Relationships Chair, Colorado Water Institute, CSU
faith.sternlieb@colostate.edu

GUIDELINES FOR ABSTRACT SUBMISSION

Abstracts should be sent to the following e-mail addresses:

icwehs@yahoo.com

icwehs@hotmail.com

The abstracts should be in English and no longer that 500 words. Deadlines will be strictly adhered to and authors whose abstracts are accepted for oral or poster presentations and who submit a final paper are expected to attend the Conference, pay the conference registration fees, and make their presentation in person. For questions, contact the Technical Program Chair. The Proceedings will be published on CD.

IMPORTANT DATES

Abstracts Due: Friday September 5, 2008

Authors Notified: Friday November 14, 2008

Final Papers Due: Friday January 30, 2009

THE VENUE

The ancient and beautiful town of Cholula, Mexico, where the Universidad de las Americas, Puebla is located, has been chosen as the site of the celebration of the ICWEHS. The city of Puebla, just three miles away from Cholula, is the 4th largest city in Mexico. The international airport of Puebla is served by an international flight connecting with Houston. Mexico City, Mexico´s capitol city, is just 1.5 hours away by bus. Mexico City's airport has flights connecting to many cities of the world.

Registration is $500* before February 13, 2009 and $600* after February 13, 2009 (* price in U.S. Dollars)
For more information email the ICWEHS Organizing Committee: icwehs@yahoo.com or icwehs@hotmail.com

AgNIC Welcomes the Agricultural Water Conservation Clearinghouse

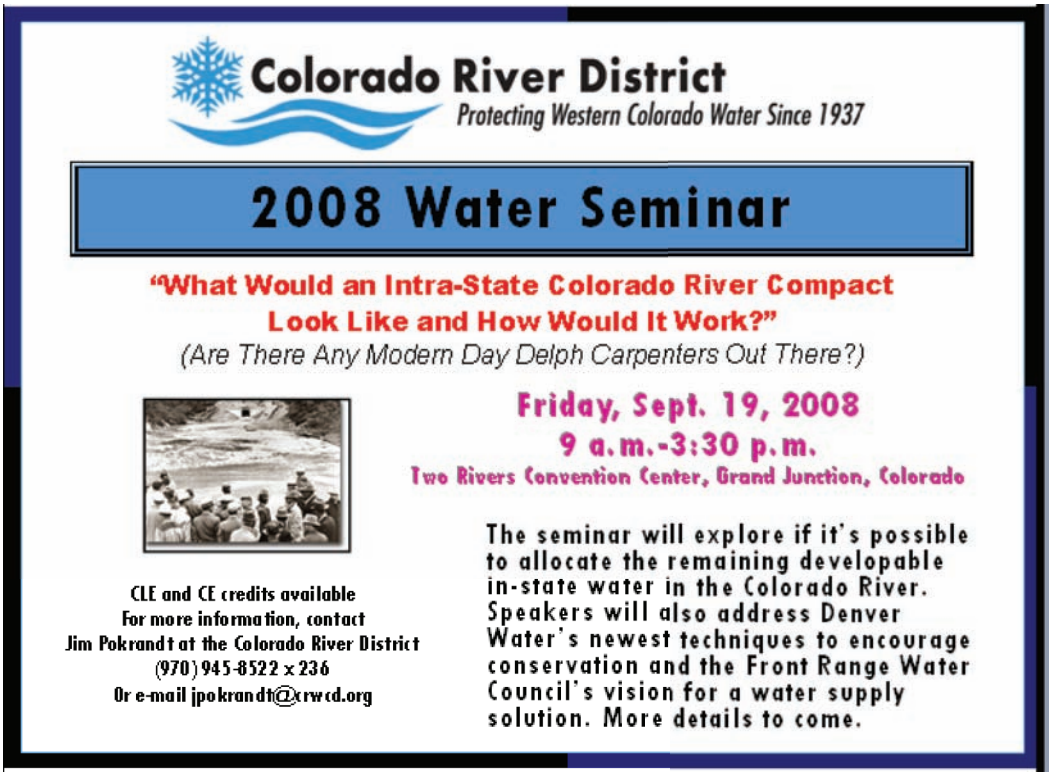
by Faith Sternlieb, Research Associate, Colorado Water Institute

The Colorado Water Institute is pleased to announce that the Agricultural Water Conservation Clearinghouse (agwaterconservation.colostate.edu) has been invited to join the Agriculture Network Information Center (AgNIC). AgNIC (www.agnic.org) is a voluntary alliance of the National Agricultural Library (NAL), land-grant universities, and other agricultural organizations in cooperation with citizen groups and government agencies. AgNIC focuses on providing agricultural information in electronic format over the World Wide Web. The Ag Water Conservation Clearinghouse is a Cooperative Research Education and Extension Service Western Regional project, spearheaded by the Colorado Water Institute.

Socio-geographic changes in population are placing increased demands on water resources. Population growth is occurring where municipal and industrial demands are already great. Much of the increased demand is occurring in arid regions where water is always scarce. Water resources become even less dependable in years of drought. Numbers of intra- and inter-state controversies are emerging as a result of water shortages.

Agricultural water management is increasingly important in the presence of low water supplies because agriculture in the West consumes approximately 87% of the ground and surface water withdrawals.

When agricultural operations are able to incorporate more efficient methods of using water, more water is made available for use by both the environment and the community at large. The Ag Water Conservation Clearinghouse aims to provide current, science-based information for future collaboration regarding the sustainable use, conservation, and development of water in the agricultural sector.



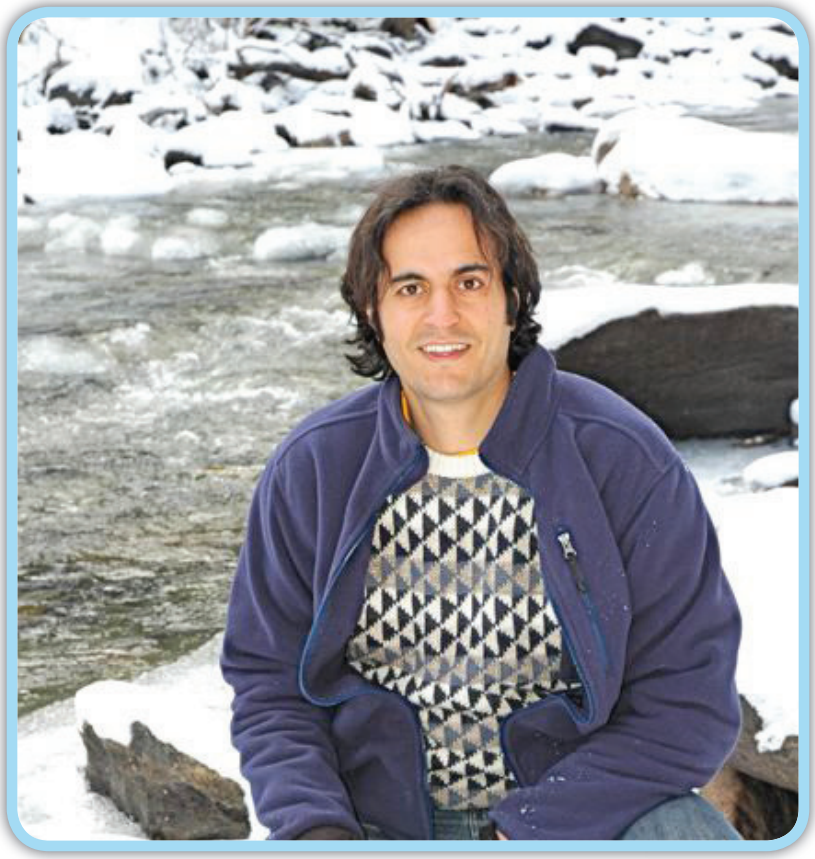
Faculty Profile

Mazdak Arabi, Ph.D, Department of Civil and Environmental Engineering

I am an assistant professor of civil and environmental engineering at CSU focusing on watershed planning and management of water resources. After receiving B.Sc. and M.S. degrees in Civil Engineering from the University of Tehran, I pursued a PhD degree and then a postdoctoral research position at Purdue University, where I developed an optimization tool for cost-effective implementation of watershed plans for sediment, nutrient, and pesticide control. Coming from a semi-arid region of the world, I have always been vigilant about the sustainable management of water resources. What fascinates me the most is the strong interplay between social, economic, and environmental criteria in the decision-making process. A manifestation of such interactions presents itself in the design and implementation of conservation practices (i.e., BMPs) for nonpoint source pollution control and the reduction of unbeneficial consumptive use of water. My research, teaching, and extension activities hinge on development of easy-to-use decision support systems that will assist policy makers in selecting strategies that are environmentally friendly, and will also sustain their benefits under the changing climatic and land use conditions.

Sustainable management of watershed systems will present a challenge in the coming decades. While billions of dollars in federal, state, and local funds are spent on development and implementation of watershed plans, the validity and usefulness of plans over their design lifetime remain uncertain because substantial shifts in climatic and land use conditions are evident in watersheds across the U.S. and globally. For example, the emerging economic impetus provided by the recent upsurge of interest in ethanol and biodiesel fuels will most likely culminate in significant land use changes in Colorado, as well as in the midwestern U.S. In addition, significant shifts in climatic regimes are evident globally. Effective implementation and maintenance of conservation practices is only feasible in partnership with local stakeholders, e.g., landowners, agricultural producers, local managers, etc. While modeling and risk-based approaches are perceived as confounding jargon by most watershed stakeholders, planners are challenged to strike a balance between scientific approaches and their transferability to their respective constituents. It is my goal to develop a framework that provides the interface between science and society for tackling environmental concerns.

In partnership with USDA, NSF, EPA, and Colorado NRCS, I am currently involved in development of a risk-based approach that set within the wider context of



adaptive community learning can integrate the desires and fears of stakeholders—decision makers and ordinary citizens alike—with the latest science in the decision making process. State-of-the–art modeling, risk assessment, and optimization techniques will be integrated with stakeholders' perception of risks and uncertainties, attainability of water quality targets, and cost of watershed plans. In turn, my research and education outputs will incorporate stakeholders' value systems and preferences as guidance for planners to identify key conservation practice types, prioritize placement of key practices in critical areas, and estimate associated costs. A framework is under development facilitating incorporation of desires and fears of stakeholders along with socioeconomic factors, conservation benefits, and reliability of watershed plans in the decision-making process.

For effective dissemination of the risk-based watershed planning tool, a user-friendly GIS-based visualization tool, called the Conservation Impact Assessment Tool (CIAT), has been under development for visualization of the environment benefits and costs of a watershed plan. CIAT aims directly at enhancing adoption of conservation practice by enhancing their understating of BMP performances and their cost-effectiveness. An attractive feature of CIAT is that it does not require any specific hardware or training for its application and also has Google maps in the background. Planners and technologically lay citizens will be easily able to operate the tool. CIAT includes a web-based/online digitizing capacity that facilitates specifying type, location, timing, and physical characteristics of BMPs in the respected land parcels, channel segments, etc. The generated map is intersected with the original land use map, and the resulting map will be used for estimation of costs and environmental impacts of watershed management plans.

I strongly believe that as a faculty member of the Civil and Environmental Engineering Department at CSU, I have a tremendous opportunity to pursue research and education in water-related issues. I intend to establish a partnership with CSU faculty and extension specialists, local stakeholders, managers, and watershed groups in Colorado for finding new solutions for critical water- and energy-related issues. This requires a strong synergy among scientists, planners, and stakeholders. I hope my efforts, as a part of the broader efforts at the local and state level, will address some of these important issues pertaining to nonpoint source pollution control and water conservation.

Contact Information:
Mazdak Arabi, Ph.D.
Colorado State University
Department of Civil & Environmental Engineering
Tel: (970) 491-4639
Fax: (970) 491-7727
Office: A205H
Email: mazdak.arabi@colostate.edu

USGS science for a changing world — Recent Publications

Availability, Sustainability, and Suitability of Ground Water, Rogers Mesa, Delta County, Colorado – Types of Analyses and Data for Use in Subdivision Water-Supply Reports by K.R. Watts, http://pubs.usgs.gov/sir/2008/5020/

Comparisons of Simulated Hydrodynamics and Water Quality for Projected Demands in 2046, Pueblo Reservoir, Southeastern Colorado by R.F. Ortiz, J.M. Galloway, L.D. Miller, and D.P. Mau, http://pubs.usgs.gov/sir/2008/5079/

Rainfall-Runoff and Erosion Data from the Mancos Shale Formation in the Gunnison Gorge National Conservation Area, Southwestern Colorado by J.G Elliott, J.R. Herring, G.P. Ingersoll, J.J. Kosovich, and J. Fahy http://pubs.usgs.gov/of/2007/1002/G/

Simulation of Hydrodynamics and Water Quality in Pueblo Reservoir, Southeastern Colorado, for 1985 through 1987 and 1999 through 2002 by J.M. Galloway, R.F. Ortiz, J.D. Bales, and D.P. Mau http://pubs.usgs.gov/sir/2008/5056/

Analysis of Dissolved Selenium Loading for Selected Sites in the Lower Gunnison River Basin, Colorado, 1978-2005 by J.C. Thomas, K.J. Leib, and J.W. Mayo http://pubs.usgs.gov/sir/2007/5287/

Salinity Trends in the Upper Colorado River Basin Upstream From the Grand Valley Salinity Control Unit, Colorado, 1986-2003 by K.J. Leib, and M.J. Bauch http://pubs.usgs.gov/sir/2007/5288/

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

GRAD592
Interdisciplinary Water Resources Seminar

Fall 2008 Theme: Global Water Issues and Challenges
Mondays at 4:00 pm, Room 206A, Clark Building

The purpose of the 2008 Interdisciplinary Water Resources Seminar (GRAD592), through a series of invited speakers, is to examine the state of global water resources and the institutional responses to water shortage, water quality concerns, drought, and climate change. More specifically, the seminar will:

- Examine water resource case studies from a variety of nations and perspectives
- Understand the global environmental challenges of water management and development
- Discuss various approaches employed by governmental and non-governmental organizations to manage water supply and sanitation challenges
- Explore various opportunities to work and serve in international water management

25 Aug.	No class
1 Sept.	*Labor Day*–No class
8 Sept.	**The Looming Global Water Crisis**–Ellen Wohl, CSU
15 Sept.	**Integrated Water Resources Management in South America**–Neil Grigg, CSU
22 Sept.	**Global Change and Global Water**–CSU Atmospheric Scientist (TBA)
29 Sept.	**Water Organizations and the Developing World** - David Freeman, CSU
6 Oct.	**Water for People**–Colleen Stiles, Executive Director
13 Oct.	**Irrigation Water Management and Agriculture**–Terry Podmore & Ramchand Oad, CSU
20 Oct.	**Engineers Without Borders/CSU Global Impact program**–Brian Bledsoe, CSU
27 Oct.	**Managing Trans-Boundary Water Conflict**–Steven Mumme, CSU
3 Nov.	**Water Quality in a Changing Environment**–KJ Reddy, University of Wyoming
10 Nov.	**Water Development in the Peace Corps**–Ben and Kelly Latham, CSU
17 Nov.	**River Basin Decision Support Systems: the Nile**–Larry Brazile, Riverside Technology
24 Nov.	*Thanksgiving Break*–No class
1 Dec.	**Global Natural Resource and Water Management**–Dennis Child, CSU
8 Dec.	**Service/Career Opportunities in International Water**–Peter McCornick, Duke Univ.
15 Dec.	*Finals Week*–No class

All interested faculty, students, and off-campus water professionals are encouraged to attend.
For more information, contact Reagan Waskom at reagan.waskom@colostate.edu.

New Colorado Water Institute Publication: Colorado Water History: A Bibliography (IS105)

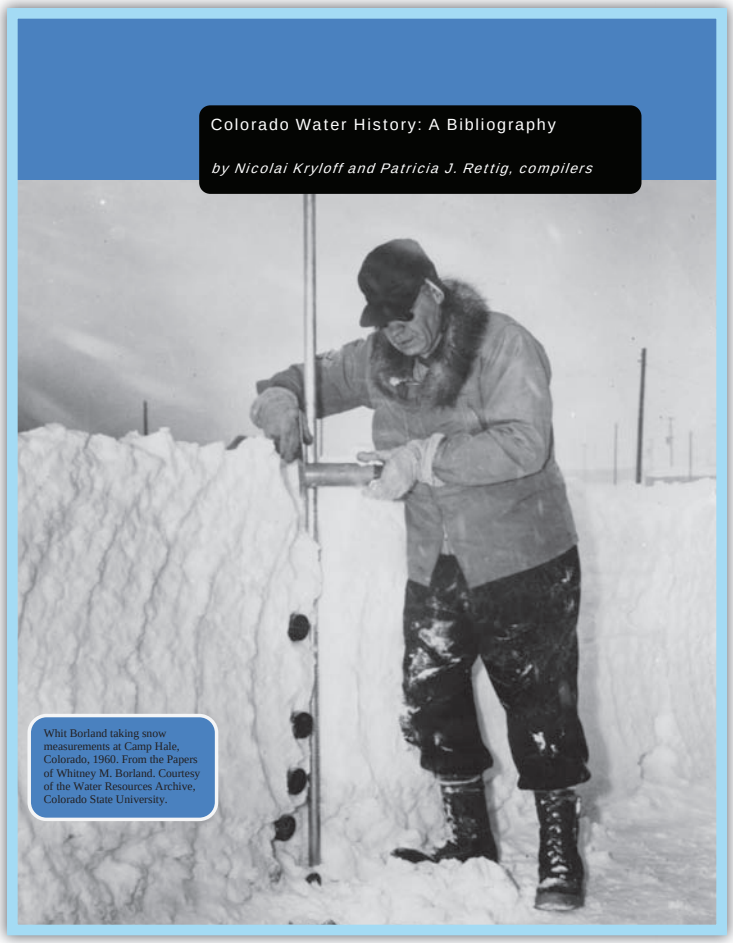
Introduction

Water is at the heart of Colorado's past and future. Ongoing debates—even lawsuits—regarding water show the importance of this vital resource to the state and to the West. Combined with natural disasters such as floods and drought, or human concerns such as pollution and recreation, water issues have drawn an increasing degree of public attention.

For water professionals, students, and interested citizens, knowing the history of our water resources can lead to a better understanding of current issues and events. The Colorado Water History Bibliography is a helpful resource for those wanting to learn more about this timely and significant topic.

This bibliography is not intended to be comprehensive. Rather, it is a selective listing of core books on the topic that are generally accessible to the public, both in terms of content and availability.

In addition to illuminating books already written about Colorado's water, this list reveals areas ripe for research. Clearly there are holes in the writings about our state's rich water history, waiting to be filled in by generations of scholars yet to come.



Purpose

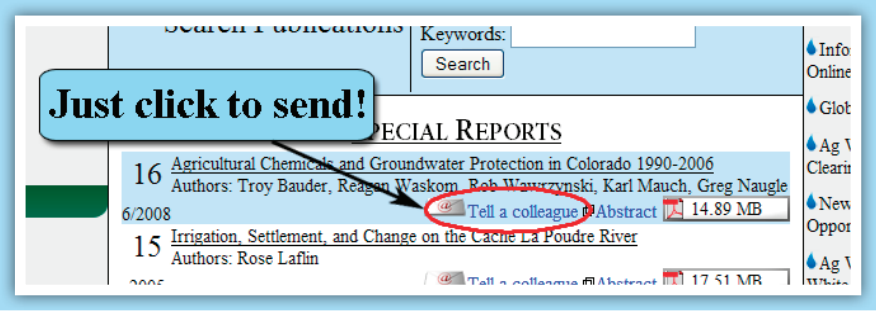
Although much has been written about water in Colorado, never have these various writings been catalogued in a single reference guide. This bibliography brings together, for the first time, the many scattered writings on water's fascinating history in Colorado.

(To read more, please visit our web site for the full version.)

This publication can be obtained in print from the Colorado Water Institute or can be downloaded online at: http://www.cwi.colostate.edu as Information Series 105 (IS105) under Publications/Reports.

Check out our new feature!

Like a publication on our web site? You can now send it to other people who may be interested.



Protecting Front-Range Forest Watersheds from High-Severity Wildfires

by Jeff Jahnke, State Forester and Director, Colorado State Forest Service
Rick Cables, Regional Forester, Rocky Mountain Region, U.S. Forest Service

Impacts of the 1996 Buffalo Creek Fire and the 2002 Hayman Fire illustrate the threat of severe wildfires to Colorado Front Range communities and water supplies. Extensive restoration work has been done, but storms still carry sediment and debris into Strontia Springs and Cheesman Reservoirs. The annual cost to maintain and rehabilitate these reservoirs is enormous.

Severe wildfires can significantly impact watershed function due to loss of tree and vegetative cover and soil heating that creates water-repellent slopes, which exhibit rapid runoff, severe soil erosion, and sediment movement, and organic debris flows in post-fire storms. Water infrastructures such as ditches, pipelines, and reservoirs also are directly threatened by fire, and even more so by post-fire flood events. The probability of severe wildfires is growing. The average annual number of Colorado wildfires has risen from 457 in the 1960s to more than 2,700 today, and the average cumulative acres burned has risen from 8,170 to more than 97,400.

Colorado's population is also increasing, growing by 31 percent in the 1990s—the third fastest in the United States. The current population now numbers 4.7 million and is projected to reach 8 million by 2050. More than 80 percent of the state's population resides in Colorado's 10 contiguous Front Range counties.

The seven major Front Range water providers (Aurora, Boulder, Colorado Springs, Denver Water, Fort Collins, Northern Colorado, and Westminster) draw their water supplies from 10 source watersheds in the mountains, which collectively provide more than two-thirds of Colorado's population with drinking water. Many cities, towns, and villages in the mountains also depend on the 10 source watersheds.

In July 2007, the Pinchot Institute for Conservation released an assessment report titled Protecting Front Range Forest Watersheds from High-Severity Wildfires. The report noted that the number, size, and severity of forest fires have steadily increased as the population of Colorado continues to explode and place higher demands on clean water supplies derived from source watersheds in the forest headwaters. The study concluded that climate factors and forest conditions place Front Range source watersheds at high risk from severe wildfires that threaten water supplies and the integrity of reservoirs with erosion and flood damage. The report urged land management agencies to consider working with communities—including cities along the Front Range that depend on water from the Front Range watersheds—to develop and implement critical watershed-wildfire protection plans to reduce these hazards.

The Pinchot Institute assessed risks and potential impacts of severe wildfires to source watersheds in Boulder, Clear Creek, Douglas, El Paso, Gilpin, Grand, Jefferson, Larimer, Park, and Teller counties. They found that a buildup of forest fuels, combined with increasingly flammable forest conditions caused by drought, aging trees, and beetle kill, have created unprecedented hazards to Front Range water supplies in terms of severe wildfire hazard. The analysis focused on:

- Forest wildfire hazards
- Fire regimes of the various forest types
- Land ownership patterns
- Soil erodibility and erosion hazards
- Water infrastructure in source watersheds

Rick Cables, Regional Forester, Rocky Mountain Region, U.S. Forest Service

Substantial portions of each source watershed within the study area exhibited high to extreme wildfire hazards and high to extreme soil erodibility. Many reservoirs, pipelines, and ditches are located in zones of high to extreme forest wildfire hazards.

If watersheds are not protected through forest treatments, excessive sediment and debris loads can severely impair or destroy reservoirs as a functional part of the

Jeff Jahnke, State Forester and Director, Colorado State Forest Service

water-supply system. Climate change may further increase wildfire severity in the future. The only alternative to pre-fire forest treatments is to install costly post-fire structures, such as sediment basins, that require heavy annual maintenance to keep sediment and debris out of reservoirs.

Water providers can leverage public policy to reduce the impacts of severe wildfires to Front Range water supplies. One way to exercise this leverage is through coordinated development and implementation of Critical Community Watershed Wildfire Protection Plans (CWP)[2] for each vital source watershed. Modeled after Community Wildfire Protection Plans, these watershed plans require the support of key stakeholders and can be readily implemented. Elements of successful (CWP)[2]s include:

- Engagement of federal, state, and local government agencies
- Open participation of all interested parties
- Preparation of base maps showing key terrain, vegetation, and infrastructure features
- Assessment of forest fuels, wildfire hazards, and potential impacts on water supply factors
- Specifically identified treatment locations and methods of treatment
- A prioritized action plan including roles, timelines, and funding needs to reduce fuel hazards

In August 2007, the Colorado State Forest Service and U.S. Forest Service hosted a meeting with Front Range water providers to discuss the report's findings and explore ideas for joint action. All parties made a commitment to develop a strategic action plan for Front Range watersheds. In September 2007, the agencies and water providers met again and crafted the structural outlines of a partnership effort to protect Front Range source watersheds from severe wildfires.

The organizational structure of the partnership effort took shape through a series of meetings in the winter of 2007-08. An oversight group, the Front Range Watershed Wildfire Protection Group, is made up of members from 21 participating organizations and works cooperatively with the Front Range Fuels Treatment Partnership Roundtable. Participating organizations include:

- **Agencies**: Bureau of Land Management, Colorado Division of Emergency Management, Colorado Division of Public Health and Environment, Colorado State Forest Service, Colorado Water Conservation Board, Douglas County Public Works, U.S. Forest Service (Rocky Mountain Region, Arapaho-Roosevelt National Forest, Pike-San Isabel National Forest), U.S. Geological Survey
- **Water Providers**: Aurora Water, Boulder Public Works, Colorado Springs Utilities, Denver Water, Fort Collins Utilities, Loveland Water & Power, Northern Colorado Water Conservancy District, Pueblo Water, Westminster Utilities, Farmers Reservoir & Irrigation Company
- **Others**: American Water Works Association, Colorado Watershed Network, The Nature Conservancy, The Wilderness Society

The Front Range Watershed Wildfire Protection Working Group has focused its efforts on developing a strategic action plan for Front Range watersheds that includes the following major actions:

- Improving watershed data for GIS analysis and creating a model for conducting watershed assessments that identify and prioritize 6th-level watersheds for potential treatment.
- Developing guidelines for Critical Community Watershed Wildfire Protection Plans to promote prompt and effective forest treatments that reduce wildfire hazards in critical source watersheds.
- Developing a strategy for public education that will help build broad support and promote investments in actions that fortify forests against severe wildfires in source watersheds.

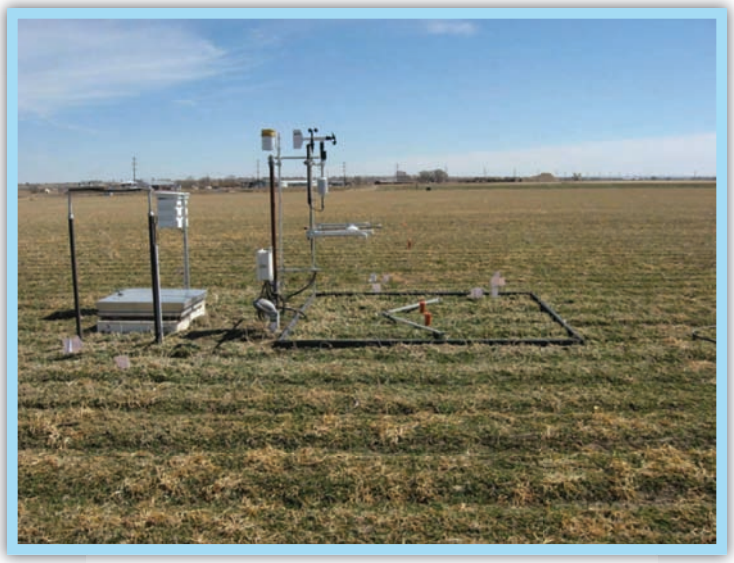
In August 2008, a pilot project in the Upper South Platte Watershed will begin to test the effectiveness and applicability of the watershed assessment model referenced above. The objective of this test is to finalize a model that could be used in any major Colorado watershed or other watersheds throughout the western U.S. Findings from the pilot will be the subject of an article in a future issue of this newsletter.

New Technical Bulletin from the Agricultural Experiment Station

The Large Lysimeter at the Arkansas Valley Research Center: Objectives and Accomplishments

The Kansas v. Colorado Arkansas River Compact litigation recommended that Colorado use the ASCE Standardized Penman-Monteith equation, which calculates the evapotranspiration (ET) of a reference crop, to estimate crop consumptive use in the Arkansas River Valley. Direct measurement of ET is best achieved with weighing lysimeters, which measure water loss from a control volume by the change in mass with accuracy to within a few hundredths of a millimeter.

The lysimeter project at the Arkansas Valley Research Center consists of one large lysimeter that was installed in 2006 and one smaller reference lysimeter to be installed in 2008. A new technical bulletin from the Agricultural Experiment Station (TB08-02), titled *The Large Lysimeter at the Arkansas Valley Research Center: Objectives and Accomplishments* and authored by Abdel Berrada, Lane Simmons, Dale Straw, Michael Bartolo, and Thomas Ley describes the project in detail. The publication can be accessed at http://www.colostate.edu/Depts/AES/Pubs/PDF/tb08-2.pdf.



The large lysimeter at the Arkansas Valley Research Center was installed in 2008.

2008 National Conference in Desert Hot Springs, California

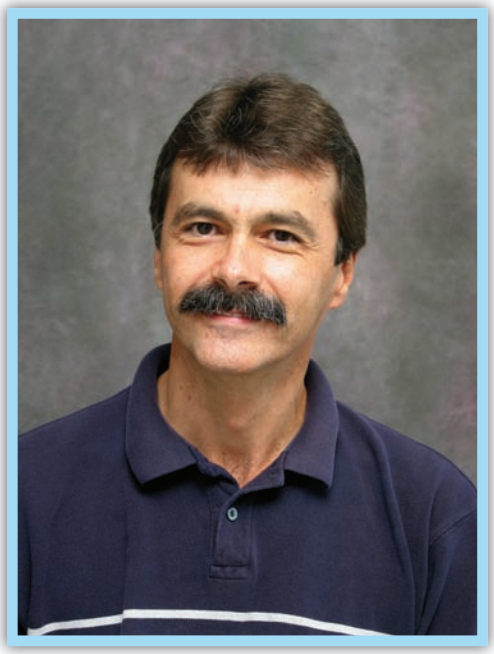
"Going Green for Groundwater"

The 2008 Groundwater Foundation National Conference and Groundwater Guardian Designation Celebration will be held at Miracle Springs Resort and Spa in Desert Hot Springs, California, November 18-20.

The 2008 National Groundwater Foundation Conference is co-sponsored by The Groundwater Foundation and the Awwa Research Foundation. Additional support provided by United States Geological Survey and the W.K. Kellogg Foundation.

Additional details and registration information will be posted at http://www.groundwater.org/pe/conference.html

CSU Professor Jorge Ramirez Honored with AGU Award



Jorge Ramirez, professor in CSU's Department of Civil and Environmental Engineering, has received the 2007 Editors' Citation for Excellence in Refereeing for Water Resources Research from the American Geophysical Union (AGU). One of the most important services performed for AGU is the conscientious reviewing of submitted papers. The purpose of the citation is to express publicly AGU's gratitude to those whose reviews have been particularly thoughtful and constructive, and Dr. Ramirez was recognized for his invaluable contributions to the high standards of the AGU journals program.

In addition to his teaching and research responsibilities, Dr. Ramirez consistently contributes to the field of water resources. Since 1999, he has served as Chair of the Organizing Committee for AGU Hydrology Days, held on the CSU campus each March. He also plays a key role in the Research for Undergraduates (REU) program, which provides students with the opportunity to conduct independent research in water science and engineering for an eight-week period each summer.

2008 Sustaining Colorado Watersheds: Striking a Balance for the Future

Please join us for the 3rd annual Sustaining Colorado Watersheds Conference in Vail on October 1–3, 2008. This year's conference features presentations on balancing science and policy, growth and natural resources, and environment and human needs.

Conference Agenda
http://coloradowater.org/documents/ConferenceAgenda_005.pdf

Pre-Conference Workshop
October 1, 2008, 8:30–12:00: "Capacity building and Nonpoint Source Funding Process Workshop"
http://coloradowater.org/pdf/Pre-Conference Workshop Agenda.pdf

Conference Registration
Registration is $175 for members / $225 for non-members.
Receive an early registration discount of $50 for registrations postmarked by September 5.
Register Today! http://coloradowater.org/documents/2008registration.pdf

Hotel Information
Please don't forget to make your hotel reservations. We've reserved discounted rooms at the Vail Cascade Resort & Spa ($110/night for a room). To ensure a reservation, please call (800) 420-2424 or email vcr-groupres@destinationhotels.com and mention that you are booking a room for the Conference.

Touring and Documenting the South Platte Basin

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

The Colorado Foundation for Water Education's tour of the South Platte Basin provided two days of on-location history lessons to illuminate the current status of and future directions for the region. Steve Lundt of the Metro Wastewater Reclamation District talked about the history of Barr Lake; Bob Longenbaugh, former assistant state engineer, discussed the history of groundwater wells; and Harold Evans of the Greeley Water and Sewer Board outlined the historical development of Greeley's water.

These and other tour speakers provided a good introduction to South Platte history. For more information, visit the Water Resources Archive at Colorado State University, which holds original documentation of the speakers' topics and more. In fact, the South Platte is the river best documented in the Archive, with voluminous materials on its people, places, organizations, and events. A few of the most relevant collections are listed below.

Records of GASP (collection dates: 1912-2006)

The Groundwater Appropriators of the South Platte River Basin, Inc. (GASP) was a non-profit well augmentation company. Founded in 1972, its purpose was to offset depletions to the South Platte River caused by pumping of the aquifer. At its peak, GASP served more than 3,000 wells in the basin. The company ceased operations in 2003 and sold the last of its assets in 2006.

Groundwater Data (collection dates: 1897-1980)

Colorado State University's strength in groundwater research evolved naturally from the state's early residents need for information on irrigated agriculture. The data, maps, charts, drafts, correspondence, photographs, reports, and reference materials that were produced by or collected for these groundwater studies over the years are what comprise the Groundwater Data Collection. Materials relate to the groundwater studies that CSU researchers (including Bob Longenbaugh) conducted, primarily in eastern Colorado (the South Platte Basin, High Plains, and Arkansas Valley). Subjects of particular focus are artificial recharge, observation wells, and irrigation pumping.

Papers of Robert E. Glover (collection dates: 1896-2000)

A civil engineer with the U. S. Bureau of Reclamation, the U. S. Geological Survey, and Colorado State University, Robert Glover (1896-1984) conducted significant research on concrete cooling, dam construction, groundwater flow, and more. The focus of the collection is on the extensive work he did on these subjects, with South Platte groundwater studies being prominent.

2008 South Platte Basin Tour

On June 19–20, 2008, the Colorado Foundation for Water Education sponsored a two-day tour of Colorado's best example of a working river—the South Platte. The tour focused on the lower portion of the river as it winds its way across the urban and rural patchwork of northeastern Colorado.

A diverse group of more than 80 participants included engineers, lawyers, real estate agents, state legislators, teachers, and water managers. The tour highlighted the South Platte's heritage and history, agriculture made possible by the river, and efforts to balance preservation of riverine habitat with increasing water and energy needs.

Tour stops included:

- Metro Wastewater Reclamation District, Denver
- Barr Lake State Park, Brighton
- Xcel Energy's Pawnee Power Plant, Brush
- North Sterling Reservoir, Sterling
- Poudre Learning Center, Greeley
- Northern Colorado Water Conservancy District, Berthoud

Records of the Iliff and Platte Valley Ditch Company (collection dates: 1884-1997)

The collection contains the financial and business records of the Iliff and Platte Valley Ditch Company, which was established in 1884, and irrigated land in Logan County. The tour drove through this area on the way to North Sterling Reservoir. The collection includes several old ledger books with articles of incorporation, meeting minutes, stockholder information, cancelled stock certificates, and financial records.

Records of the Godfrey Ditch Company (collection dates: 1870-1996)

The Section No. 3 Ditch Company was incorporated in March 1870 in Weld County. The company constructed its ditch to divert water from the South Platte River for agriculture, milling, and dairying purposes. In 1910, it was reincorporated as the Godfrey Ditch Company. The collection contains the minute books of both companies, which span the years 1870 to 1986.

Papers of Delph E. Carpenter and Family (collection dates: 1827-1992)

The "Father of Interstate River Compacts," Delph E. Carpenter (1877-1951) served the state of Colorado as a lawyer, state senator, and river commissioner. He wrote, negotiated, and promoted the Colorado River Compact as well as the South Platte River Compact, following his service as lead counsel in the Wyoming vs. Colorado suit. It is the South Platte River Compact that governs the sharing of water between Colorado and Nebraska and affects the recently approved Three States Agreement.

Papers of Charles C. Fisk (collection dates: 1880-2004)

After retiring as an engineer, Charles Fisk (1918-2005) researched and wrote a book about Denver's water. The materials in the collection mostly relate to the book he was completing at the end of his life, The Metro Denver Water Story. Subjects primarily relate to the history of Denver and its water, including focus on the South Platte River and the Two Forks project. The full text of Fisk's book can be found on the Archive's web site.

There are plenty more collections that at least in part touch on the South Platte River or its tributaries (most significantly the Poudre and the Big Thompson Rivers). However, while the Archive's documentation of the South Platte is voluminous, it is not comprehensive. Subject areas that are under documented include recreation, energy, municipal uses, and the environment. Collections on these topics are welcomed as donations to the Archive.

For more information about the Water Resources Archive, visit the web site [http://lib.colostate.edu/archives/water/] or contact the author (970-491-1939; Patricia.Rettig@ColoState.edu).

Research Awards

Colorado State University, Fort Collins, Colorado
Awards for April 2008 to June 2008

Bartolo, Michael E, Colorado Onion Association, Biology of Onion Thrips, Alternative Production Practices and Irrigation Practices - Arkansas Valley, $3,000

Bestgen, Kevin R, DOI-Bureau of Reclamation, Abundance Estimates for Colorado Pikeminnow in the Green River Basin, Utah & Colorado, $87,959

Bestgen, Kevin R, DOI-Bureau of Reclamation, Annual YOY Colorado Pikeminnow Fall Monitoring, $28,547

Bestgen, Kevin R, DOI-Bureau of Reclamation, Evaluating Effects of Non-Native Predator Removal on Native Fishes in the Yampa River, $79,256

Bestgen, Kevin R, DOI-Bureau of Reclamation, Floodplain Inundation & Entrainment Studies, $50,000

Bestgen, Kevin R, DOI-Bureau of Reclamation, Interagency Standardized Monitoring Program Assessment of Endangered Fish Reproduction in Relation to Flaming, $91,508

Brozka, Robert J, DOD-ARMY, Aquatic Ecosystem Monitoring of Jackson Creek, Joliet Training Center, Illinois, $11,736

Clements, William H, DOI-USGS-Geological Survey, Assessment of Remediation of the Arkansas River, $16,272

Fausch, Kurt D, Colorado Division of Wildlife, Effect of Agricultural Water Use & Drought on Groundwater that Sustains Critical Habitats for State-Listed Fish, $5,000

Fausch, Kurt D, DOI-BLM-Bureau of Land Management, A Field Test of Effects of Grazing Management Systems on Invertebrate Prey that Support Trout Populations in Central and Southern Rocky Mountain Streams, $32,000

Fausch, Kurt D, USDA-USFS-Forest Research, Field Test of Riparian Vegetation Elements Needed to Support Trout Populations in Southern & Central Rocky Mountain, $25,000

Garcia, Luis, Colorado State Water Conservation Board, Arkansas Valley Research Center Lysimeter Project, $90,000

Garcia, Luis, Northern Colorado Water Conservancy Dist, A Remote Sensing - GIS Approach to Evaluate the Effects of Soil Salinity on Evapotranspiration, $40,238

Garcia, Luis, Various "Non-Profit" Sponsors, Developing a Decision Support System for the South Platte Basin, $7,500

Gates, Timothy K, Colorado Division of Water Resources, Early-Season Monitoring of Irrigation Practices Under Conventional and Improved Technologies in Colorado's Lower, $74,233

Hawkins, John A, DOI-Bureau of Reclamation, Yampa River Nonnative Fish Control: Translocation of Northern Pike from the Yampa River, $222,900

Lemly, Joanna, Colorado Department of Natural Resources, Survey of Critical Wetlands in Hinsdale County, Colorado, $7,163

Myrick, Christopher A, DOI-Bureau of Reclamation, A Literature & Laboratory Study of Appropriate Fish Loading & Hauling Conditions at the US Bureau of Reclamation, $39,943

Rajagopalan, Balaji, DOI-USGS-Geological Survey, Risk Assessment and Forecasting of Indian Summer Monsoon for Agricultural Drought Impact Planning, $86,646

Roesner, Larry A, Water Environment Research Foundation, Landscape Irrigation Using Household Graywater - Experimental Study, $372,882

Sale, Thomas C, Town of Castle Rock, CO, Studies Supporting Sustainable Use of the Denver Basin Aquifers in the Vicinity of Castle Rock, $25,000

Sanders, Thomas G, DOI-NPS-National Park Service, Integration of NPS/USGS Water Resources Science Applicable to Management of Protected Areas, $147,602

Calendar

September

6 **Ag Day 2008; Fort Collins, Colorado**
The 27th Annual Ag Day at Hughes Stadium, hosted by agricultural organizations and associations.
www.csuagday.com

7-12 **IWA World Water Congress and Exhibition; Vienna, Austria**
Water professionals can advance their common goal of sustainable water management.
http://www.iwa2008vienna.org/i8/

8-11 **Planning for an Uncertain Future: Monitoring, Integration, and Adaptation; Estes Park, Colorado**
Hydrologic resources shift daily in response to changes in population, land use, and climate.
http://www.hydrologicscience.org/icrw/index.html

14-17 **RMSAWWA/RMWEA 2008 Joint Annual Conference; Colorado Springs, Colorado**
Magnificent scenery, educational sessions, and other activities.
www.rmsawwa.net or www.rmwea.org

17-20 **Managing Water in a Climate Changing World: Implications for Irrigation, Drainage, and Flood Control; Portland, Oregon**
This conference is designed to help prepare water managers for global climate changes.
http://www.uscid.org/08gcc.html

19 **Colorado River District Annual Water Seminar; Grand Junction, Colorado**
For more information please visit http://www.crwcd.org/

October

1-3 **Southeast Stormwater Association 2008 Conference; Charleston, South Carolina**
Stormwater managers prepare for the day-to-day challenges in stormwater management.
http://www.seswa.org/Pages/Meetings.htm

1-3 **2008 Sustaining Colorado Watersheds: Striking a Balance for the Future; Vail, Colorado**
Features presentations on balancing science and policy, growth and natural resources, and environment and human needs. http://coloradowater.org/annualconference.php

5-9 **Geological Society of America 2008 Joint Annual Meeting; Houston, Texas**
Connect and collaborate with colleagues from around the world.
https://www.acsmeetings.org/2008/

8-10 **Governor's Conference on Managing Drought and Climate Risk; Denver, Colorado**
Conference goals are to share information and experience on drought preparedness and information services needed, and to identify pathways for adaptation to the impacts of climate change and demand on Colorado's water resources.
http://www.cwcb.state.co.us

22-23 **19th Annual South Platte Forum; Longmont, Colorado**
For more information and registration forms, visit http://www.southplatteforum.org.

28 **Big Thompson Watershed Forum**
10th Annual Meeting theme: "Voices from the Watershed"

November

17-20 **Coastal Cities Summit 2008: Values and Vulnerabilities; St. Petersburg Beach, Florida**
Covers public resource strains, challenges, and viable solutions.
http://www.coastalcities.org/callforpapers.html

17-20 **2008 AWRA Annual Water Resources Conference; New Orleans, Louisiana**
Discuss the blows of Hurricanes Katrina and Rita and the Mississippi River problems.
http://www.awra.org/meetings/NewOrleans2008/index.html

18-20 **Groundwater Foundation 2008 National Conference; Desert Hot Springs, California**
Theme: "Going Green for Groundwater" http://www.groundwater.org/pe/conference.html

Colorado State University
The Water Center of Colorado State University
1033 Campus Delivery
Fort Collins, Colorado 80523-1033

NONPROFIT
ORGANIZATION
U.S. POSTAGE
PAID
Fort Collins, Colorado 80523
Permit Number 19

ATTENTION SUBSCRIBERS

Please help us keep our distribution list up to date. If you prefer to receive the newsletter electronically or have a name/address change, please visit our website and click on Subscriptions.

LOOKING FOR COLOR?

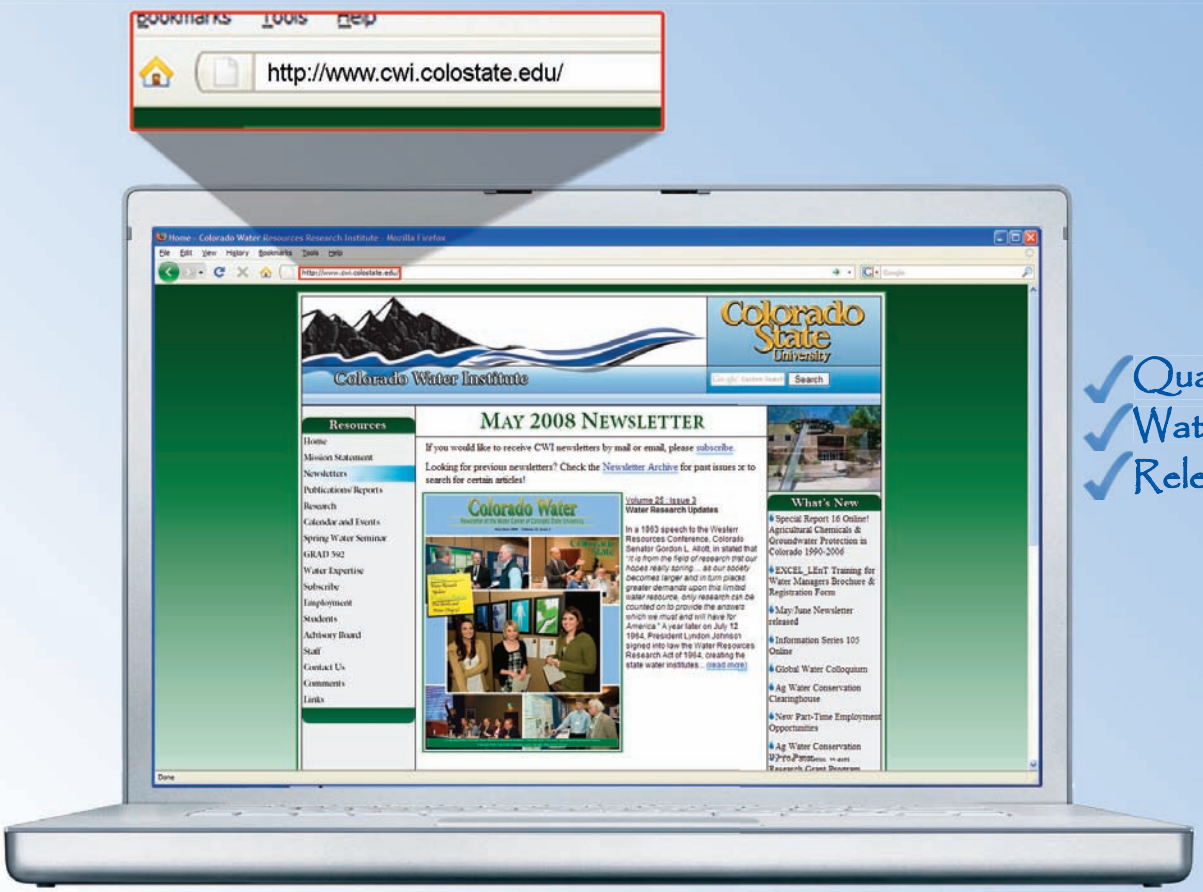
Visit the CWI web site to view a full color issue of our current newsletter. Check out the newsletter archives on the web to download past issues of our newsletter.

VISIT OUR WEB SITES

Colorado Water Institute
http://www.cwi.colostate.edu

CSU Water Center
http://www.watercenter.colostate.edu

Colorado Water Knowledge
http://www.waterknowledge.colostate.edu



✓Quality Content
✓Water Education
✓Relevant Research