

COLORADO WATER

Newsletter of the Water Center at Colorado State University

JUNE 1999

On May 27th Colorado State University signed an International Memorandum of Understanding with the New Zealand National Institute of Water and Atmospheric Research, Ltd. The MOU enhances opportunities for collaboration on water research and recognizes a 17-year CSU/NIWA relationship.

SEE PAGE 4



Left to right: Dick MacRavey, Executive Director, Colorado Water Congress; Fred Anderson, Member, CWRRI Advisory Committee; The Right Honorable James Bolger, New Zealand Ambassador to the United States; and Robert Ward, Director of the Water Center and CWRRI at MOU signing May 27th.

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HUMAN BONDS BETWEEN THE IVORY TOWER AND THE DITCH BANK

by Robert C. Ward, Director

Western water institutes (such as the Colorado Water Resources Research Institute), with a mission to serve the research and education needs of water managers and users, operate, figuratively, between the “ivory tower” and the “ditch bank.” Expressing the water research and education needs of water managers in a way that is relevant to university faculty requires careful interpretation and wording on the part of water managers. Likewise, expressing higher education’s research and education results in a form readily useful to water managers also requires careful interpretation and expression on the part of faculty.

The Colorado Water Resources Research Institute (CWRRI) utilizes an Advisory Committee to assist in the communication between faculty and water managers/users. Members of the advisory committee have to ‘walk with comfort’ from the ditch bank to the ivory tower and back again. In the process, they greatly facilitate the success of CWRRI’s water education and research programs.

On March 3, 1999, one of the strong human bonds between the ivory tower and ditch bank was broken with CWRRI Advisory Committee member Bart Woodward’s untimely passing. In representing agriculture on CWRRI’s advisory committee, Bart explained the views and needs of the agricultural community in ways that related extremely well to the operations of a university water research program. I came to greatly value his insights about the needs of agriculture and the role of university water research and education in addressing those needs. I will sorely miss his ability to, with humor, point out problems within our research program in a way that put a smile on my face.

Bart was a farmer. He was a very proud Colorado farmer. During the planning for the 1997 South Platte Forum, Bart was invited to address the topic of ‘Buying and Selling Water Rights’ as part of a session titled, “Show Me the

Money.” The goal of the Forum organizers was to capture the views of agriculture regarding selling of water rights as development overtakes farming along Colorado’s Front Range. Bart’s talk was recorded, but not published. On page 26 of this newsletter, we present Bart’s views as expressed in his words that day. The words express a passion for agriculture that permeated everything I saw Bart do in life.

Bart was a scholar. He deeply felt the traditions and history of farming and water use in the South Platte River basin and was able to describe these in writing and in talks he presented to water meetings. He documented this history in a form that related well to faculty and students as they studied water use in the South Platte River.

Beyond his service to CWRRI, Bart was active in many water organizations in Colorado. For example, he served as Superintendent of the Riverside Irrigation District and President of the Groundwater Appropriators of the South Platte (GASP). He served as President of the Colorado Water Congress in 1990 and on its Board of Directors for many years.

Bart also knew the value of helping university students learn about the real world of water management. For example, in the 1997/98 academic year, Bart served as mentor to a group of six CSU Civil Engineering students who tackled the problem of reducing sediment movement into irrigation canals for their senior design project. He helped the students define the problem and reviewed the practicality of their design ideas. His patience with the students, while maintaining his own very busy schedule, was a true devotion to the next generation of water managers in Colorado.

Bart was a strong connection between Colorado’s higher education system and Colorado’s water managers and users. His ability to easily move between the ivory tower and ditch bank will be greatly missed.



 **COLORADO STATE UNIVERSITY AND NEW ZEALAND'S
WATER AND ATMOSPHERIC RESEARCH INSTITUTE
SIGN COOPERATIVE AGREEMENT**

On May 27, 1999, Colorado State University (CSU) and the New Zealand National Institute for Water and Atmospheric Research, Ltd. (NIWA), signed an International Memorandum of Understanding in recognition of the mutual research interests and capabilities of their researchers. The signing took place in Ammons Hall on the CSU campus and was led by the Right Honorable James Bolger, New Zealand Ambassador to the United States, and CSU's Provost, Loren Crabtree. Ambassador Bolger served as New Zealand's Prime Minister from 1990-1997.

During the signing ceremony, Ambassador Bolger noted the increasing public awareness of water by observing the large number of people who, today, walk through life clutching a bottle of water. He also noted the trend toward opening of 'water bars' in large cities and com-



CSU Provost, Loren Crabtree, and New Zealand Ambassador to the United States, The Right Honorable James Bolger, signing the NIWA-CSU MOU.

mented, "Can you imagine going to a bar for water? Sounds exciting, doesn't it?" This increasing public awareness of water puts pressure on our water research organizations to produce the knowledge that assures the public of abundant and clean water. Collaborations, as represented by the NIWA-CSU MOU, will permit the best minds in the world to work together to solve tomorrow's water problems.

Provost Crabtree described CSU's goal of maintaining and, when possible, increasing its strong international connections. The NIWA-CSU MOU is viewed as recognizing CSU's past international collaborations and positioning CSU to further strengthen its international programs in the future.

NIWA is a Crown Research Institute (CRI) that provides a scientific basis for the sustainable management of New Zealand's atmospheric, marine and freshwater systems and associated resources. As a CRI, NIWA operates as a 'stand alone'



CSU Provost Lauren Crabtree discusses the MOU with Paul M. Hargreaves, NIWA CEO.

company with its own board of directors and its shares held by the Crown. The company has a staff of 600 and annual revenue of \$60 million derived from commercial enterprise and competition-based research grants. While NIWA's corporate headquarters are located in Auckland, its research campuses are located in Auckland, Hamilton, Wellington, Nelson, Christchurch and Lauder, with a number of smaller centers where hydrometric teams are located. NIWA has a project management-based structure, which enables synergies from strong multidisciplinary research and the ability to work in large integrated teams.

CSU researchers have collaborated with NIWA (and other New Zealand scientists) for many years. This collaboration has occurred in such areas as water quality monitoring, environmental statistics, fish toxicology, modeling, and forest hydrology. Robert Ward, Director of the CSU Water Center and CWRRI, noted that the MOU recognizes a 17-year relationship with NIWA while also providing an opportunity to expand the relationship in the future.



From left: Paul M. Hargreaves, NIWA CEO; Loren Crabtree, CSU Provost; The Right Honorable James Bolger, New Zealand Ambassador to the United States; and Robert C. Ward, Director, CWRRI.

The CSU-NIWA agreement enhances the opportunity for top level researchers from CSU and NIWA to find solutions for environmental problems common to both countries.



Robert Ward (right,) CWRRI Director, and New Zealand Ambassador to the United States Jim Bolger (left) toured the Larval Fish Laboratory.

Prior to signing the MOU, Ambassador Bolger, Paul Hargreaves, NIWA CEO, Rick Pridmore, NIWA Research Director, and Graham McBride, Senior NIWA Scientist toured several CSU water-related research laboratories. During the tour, Dr. Kevin Bestgen, Director, and Dr. Dan Beyers, Research Associate with the Larval Fish Laboratory, described the lab's work, including work with selenium toxicity in fish. Professor Melinda Laituri, Earth Resources Department, who spent three years on a post doc with the University of Auckland prior to joining the CSU faculty, described her work in social geography. Prof. Lee MacDonald, Earth Resources Department, described his research in forest hydrology.

Of the many collaborative efforts, specifically between CSU and NIWA over the years, two examples were presented as representative. CSU Professor Will Clements and NIWA

Scientist Chris Hickey have jointly investigated the fate and effects of heavy metals in streams. While on sabbatical in New Zealand in 1997, Professor Clements worked with Dr. Hickey on a large-scale project that compared the effects of metals on 20 streams sampled on the North and South Islands of New Zealand. During Dr. Hickey's visit to Colorado in the fall of 1998, they collaborated on a project that evaluated the potential for recovery from mining pollution in the Animas River in Southwestern Colorado. The ultimate goal of these projects is to determine if responses observed in metal-polluted streams in the western U.S. can be used to predict responses in New Zealand.

CSU Professor Jim Loftis and NIWA Scientist Graham McBride have collaborated over the past 13 years, examining appropriate use of statistical methods to convert water quality data into information. In the late 1980s this work led

to the development of a data analysis software package (WQStat) designed specifically for water quality data. Today this package has been commercialized as WQStat Plus, available from Intelligent Decision Technologies in Longmont, Colorado.

In 1989 Graham helped Jim and Robert Ward develop a new course on the design of water quality monitoring systems. The three then collaborated to produce a book on the topic that was published by Van Nostrand Reinhold in 1990. During a sabbatical in New Zealand, Jim developed a short course on environmental statistics that has since evolved into a regular graduate course on the topic at CSU. Jim and Graham's research is producing the data analysis 'tools' that will improve the acquisition of water quality information from monitoring programs.



WATER CENTER AWARDS FELLOWSHIPS

Water Center first-year, full-support fellowships (3F program) for 1999-2000 have been awarded to graduate students Scott Cooney, Department of Fishery and Wildlife Biology, and Brian McKenna, Department of Civil Engineering. The University provided 48 of these nine-month awards at \$13,500 each for the 1999-2000 academic year, and two were designated for award by the CSU Water Center. The 3F fellowships are non-service fellowships awarded on the basis of academic merit, however, all 3F fellows must simultaneously be appointed to a quarter-time research or teaching assistantship.

Scott Cooney **Department of Fishery and Wildlife Biology**

Scott graduated from Virginia Polytechnic Institute and State University in 1997 magna cum laude, with an "In honors" B.S. in Biology, and with minors in Chemistry and Psychology. The "In honors" degree is the most prestigious awarded by Virginia Tech. Scott's other honors include being on the Academic Dean's List every semester, membership in Phi Sigma Pi (National Honor Fraternity) and winning the first-ever Alpha Rho Tripod Excellence Scholarship.

Scott served as a researcher at the University Center for Environmental Studies from April 1994 to May 1997. He was employed as a field biologist for the Environmental Protection Agency the summer of 1997. He also has experience with the Virginia Tech Fisheries Department and the Virginia Department of Game and Inland Fisheries where he worked as a fisheries technician (1998-99).

Scott had part-time employment throughout high school and college, including serving as a Senior Supervisor for the Virginia Tech Center for Survey Research.

Brian McKenna **Department of Civil Engineering**

Brian graduated from the University of Evansville, Indiana with a 3.86 GPA. His honors include Dean's List, Engineering Merit Scholarship recipient, and Academic GTA All-American District football team member.

Brian describes himself as "fascinated with the behavior of water and man's attempt to manipulate and utilize water." In 1997 he was employed full-time in the permit division of the City of Indianapolis. His responsibilities included working with sanitary sewer as-builts, storm sewer as-builts, FEMA floodway maps, and other permitting issues related to sanitary sewer, drainage and transportation structures.

Brian also interned in the private sector for Paul I. Cripe, Inc., a mid-sized private design firm located in Indianapolis. There he performed a wide variety of work including drainage, transportation, architecture, land planning, landscape architecture and surveying. He describes his experience there as one of "learning first-hand how projects make the transition from design to construction."





AGRICULTURAL EXPERIMENT STATION

PROJECT HELPS COLORADO FARMERS MAINTAIN EFFICIENT AGRICULTURAL WATER SYSTEMS

by James F. Ruff, Professor, Hydraulics Program
Tom Gill and Jason Ward, Graduate Research Assistants
Department of Civil Engineering

Colorado State University Agricultural Experiment Station Project 157081

The ongoing purpose of this project is to upgrade operation and maintenance of farmer-owned-and-operated water supply, storage, conveyance, and irrigation systems. Emphasis is on infrastructure and associated structural components. The project began with two major tasks: (1) protection of both earth and concrete dams against overtopping; and (2) a cooperative effort with the Julesburg Irrigation District to evaluate its specific conveyance system and to provide input for decisions regarding operation, maintenance and rehabilitation. The project evolved to include an additional task: (3) evaluation of the benefits of the Sedgwick Sand Draws Project to the Irrigation District and the local farmers.

Task #1: Earth dams and canal embankments are subject to failure as a result of overtopping. Ditch, canal and reservoir companies organized as farmer cooperatives or associations own and operate most of these structures. Often, inadequate spillway capacity causes dams to be overtopped by extreme flood flows, resulting in embankment erosion and potential breach and failure. Urban areas encroach on canals and ditches, impacting them with increased ditch discharges as a result of additional runoff during storms. During the irrigation season, this additional discharge may result in overtopped em-

bankments that erode and breach. A study was initiated with Agricultural Experiment Station (AES) funding to investigate breaching of embankments (AlQaser, 1991). The initial study investigated the mechanics of breaching, which provided data to develop design criteria for protecting earth embankments exposed to overtopping. It also prompted interest from some federal agencies.

As a result of the breach study, Colorado State University, supported by the Colorado Agricultural Experiment



Figure 1. Overtopping Research Facility

Station, signed a cooperative agreement with the United States Bureau of Reclamation Water Resources Research Laboratory to investigate earth embankment protection. In 1992 we completed the Overtopping Research Facility shown in Figure 1.

Colorado State University Agricultural Experiment Station

Located on the Foothills Campus near the Engineering Research Center, the facility allows testing of embankment protection at near-prototype scale. The facility simulates a section of a 50 foot-high dam.

Engineers from Colorado State University and Reclamation began testing a Reclamation-designed concrete block that can be used as an alternative to riprap or roller compacted concrete for embankment protection.

The block contains unique drains, formed in the overlapping section of the blocks, that aspirate water from the filter layer below the blocks into the separation

zone at the downstream face of the blocks. This aspiration creates a negative pressure beneath the block and "sucks" the block down onto the embankment, resulting in a very stable protective matrix. The tapered block system was tested beyond the limits of other revetment systems (Slovensky, 1993 and Gaston, 1995) and is applicable to dams and embankments in remote or environmentally sensitive areas where the use of batch plants or large machinery is limited. As a result of the tests, a design for a low cost overflow dam has been proposed. A key component of the dam is the interlocking concrete block system developed by the United States Bureau of Reclamation.

The proposed design is a diaphragm-type embankment dam armored with the USBR block system. The embankment material would be native river sand. Sheet piling walls would be placed at the crest and toe of the structure, acting as diaphragms for the highly pervious embankment material. These would function to reduce the head gradient driving seepage under the dam. Figure 2 is a cross section sketch of the dam. It is estimated that the cost of this dam will be less than one-third the cost of a concrete overflow dam. Researchers from CSU and USBR along with Julesburg Irrigation District are working

on a proposal for a demonstration structure and are seeking funding for it.

As part of Task #1, we also investigated riprap protection. Prior to the construction of the Embankment Overtopping Facility, riprap designs were based on small-scale model studies that predicted riprap sizes that varied by an order of magnitude based on various available equations. Reclamation was concerned about riprap revetment on existing dams if a flood caused the embankment to be overtopped. Using the data and results of the riprap

testing programs, new design criteria were developed. These new design criteria can be used to evaluate (Mishra, 1998).

existing riprap revetment on embankments and to design riprap protection for new embankments.

Another part of the dam protection study is evaluation of scour of concrete dam foundations. This study is the second cooperative effort involving Colorado State University; Colorado Agricultural Experiment Station; the U.S. Bureau of Reclamation; Pacific Gas and Electric; Golder Associates, a geotechnical consulting firm; and the Electric Power Research Institute. A second facility seen in Figure 3 was built to conduct this study. Discharges up to 120 cfs can be conveyed through the facility. The jet issuing from the nozzle simulates the water overtopping a concrete dam and plunging into the foundation below. Tests were conducted using road base as one foundation material and then using concrete blocks to simulate fractured rocks as another foundation material (Kuroiwa, 1999). Results indicate that air entrainment in the jet affects the scouring capacity of the jet. Different expressions were developed for compact jets with little entrained air and for highly aerated jets relating scour depth to unit discharge, tailwater depth, the angle of impingement of the jet on the bed, bed material or particle size, and the degree of aeration. Golder Associates is developing a computer program to determine the time rate of erosion of earth and rock foundations based on the results of this study.

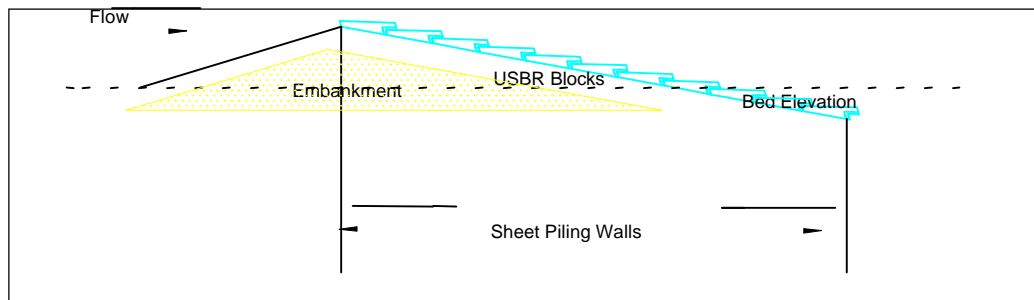


Figure 2. Cross section sketch of dam.

**Colorado
State**
University
Agricultural
Experiment
Station

Task #2: This task develops decision support assistance for the Julesburg Irrigation District. Since the Julesburg system has the last major diversions in Colorado from the South Platte River, water is diverted from the river through Harmony Ditch #1 to Julesburg Reservoir. Water also is diverted directly from the river to fields through the Peterson Ditch during

the irrigation season. Water from the reservoir is released to the Highline and/or Settlers Ditch where it also can be conveyed from Settlers to the Peterson Ditch.

We began the decision support project by evaluating records of irrigation water deliveries to the various farms. Records showed very specific allotments, representing flow demands. Unfortunately, flows had not been measured, and discharges were based on estimates and the experience of the ditch rider. In 1996, flumes were installed by the Julesburg Irrigation District at three locations as a start toward improved water management. In addition, flows and diversions in six reaches of the Highline Canal, covering 21.6 miles, were measured to evaluate seepage losses (Strand, 1997). Canal loss rates ranged from a gain of about one percent to a loss of 25 percent with a daily water loss of about 90 acre-feet over the 21.6 miles. This work has contributed to a data base for evaluating discharge versus water travel time and seepage losses in canals in eastern Colorado, and is essential to providing better water management through operational control and timely water deliveries as well as to indicate ways to conserve water.

We developed a software tool to assist with data collection and record keeping. At the outset of this project, the District had not utilized computers in any phase of its operations. Water delivery records were kept in a ledger



Figure 3. Dam Foundation Erosion Facility

book with a separate page for each of the 300 land parcels in the District. With software tools, updating delivery records is simplified, the ability to provide information to water users is improved, and the District now has the capability to track recorded flows to analyze system performance (Gill and Ruff, 1998).

Task #3: The Sedgwick Sand Draws Project is a flood control project completed in 1992 to provide floodwater damage protection for agricultural and municipal lands in Sedgwick County, which lies in extreme northeastern Colorado along the South Platte River. Funding and technical support for the project were provided by the U.S. Soil Conservation Service (SCS) under the Watershed Protection and Flood Prevention Act, commonly referred to as The Small Watershed Program. Short duration, high intensity thunderstorms occur in mid to late summer in the upland portions of the Sand Draws Watershed near the Colorado-Nebraska border. Runoff from these storms is channeled into upland sand draws, draining into the developed alluvial floodplain which comprises a major part of the Julesburg Irrigation District. Before-project average annual floodwater damages were estimated at \$220,050 by the SCS.

An ex post facto method was used to evaluate the damage reduction benefits of a watershed flood control project (Ward, 1999). Estimates are made by adjusting damage-



frequency curves to reflect a current economic time base and evaluating damages produced by hydrologic events that have occurred during the period of analysis. Seven damage-producing

rainfall events occurred during this period of analysis, from completion of the project in June 1992 to the latest date of available data, September 1997. It was estimated that the project has produced a total of \$3,556,628 in damage reduction benefits resulting in average annual benefits of \$592,771 during this period.

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- Water-Quality and Biological Community Characterization at Selected Sites on the Eagle River, Colorado, September 1997**, by Nancy E. Driver. Publication of Water-Resources Investigation Report 98-4235. 1998.
- Simulated Effects of Water Exchanges on Streamflow and Specific Conductance in the Arkansas River Upstream from Avondale, Colorado**, by Michael E. Lewis, Water-Resources Investigations Report 98-4140.
- Evaluation of Water Quality and Bulk Atmospheric Depositin in the Guanella Pass Area, Clear Creek and Park Counties, Colorado, Water Year 1995**, by Michael R. Stevens. Water-Resources Investigations Report 98-4193.
- An Index of NSFC's Publications on Small Community Wastewater Issues**, the National Small Flows Clearinghouse (NSFC). Free upon request. Call 1-800-624-8301 or (303) 293-3161 or e-mail nsfc_orders@wvu.edu.



COOPERATIVE EXTENSION



IRRIGATION WATER NITRATE CREDITING IMPROVES GROUNDWATER QUALITY

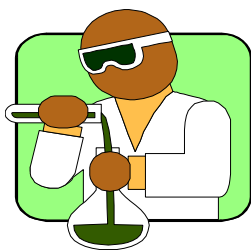
by Dell Rae Moellenberg

Water is the basis of life for all things, so it's a precious commodity. In Colorado, groundwater is a source of water for human consumption and for farming, one of the state's most important industries. Colorado State University Cooperative Extension encourages good water management to maintain the quality and quantity of Colorado's water.

As part of that practice, Troy Bauder, assistant water quality and agronomy specialist, Colorado State Cooperative Extension, encourages farmers to take advantage of free fertilizer — the nitrogen already available in groundwater. Bauder said water used to irrigate a field can be an excellent source of nitrogen for crops.

"This process, called nitrogen crediting, helps producers cut their fertilizer bill, is a more effective use of natural resources, and helps protect unneeded fertilizer nutrients from leaching into groundwater. In addition, it actually cleans groundwater, because the nitrogen is used by the crop and doesn't leach back into the water supply," said Bauder. "Not all groundwater has high enough concentrations of nitrogen to qualify as a fertilizer, but areas along the South

Platte River, Arkansas River and San Luis Valley do."



Bauder said a simple test of irrigation wells can tell farmers if nitrogen crediting

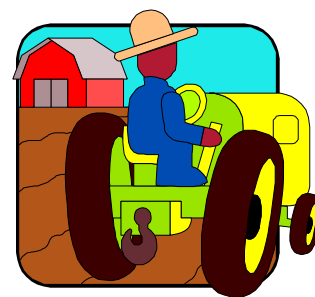
will work on their fields. A nitrate test from a commercial lab costs between \$10 and \$20. Because nitrogen in irrigation water is

applied throughout the growing season and is immediately available to the crop, it can be used to meet the crop's nitrogen requirements. Each inch of water applied to a field has 0.225 pounds of nitrogen for every 1 part-per-million (ppm) of nitrate. Corn, a crop with a high nitrogen requirement, typically uses about 15 inches of water during the growth stages that require the most nitrogen. A corn field irrigated with a 20 ppm nitrate well will get about 65 pounds of nitrogen from the water — a significant savings in fertilizer costs.



Several on-farm trial fields in Weld County during the 1997-1998 growing season compared crop yields in fields fertilized after nitrogen crediting with those that did not account for the additional levels of nitrogen in water. Researchers tested irrigation wells for nitrogen levels before and during the growing season and tracked the amount of water applied.

"In the majority of fields, we found that the amount of nitrogen the tests predicted the field would receive from irrigation water was met," said Bauder. "In fact, in some fields, the irrigation water provided more nitrogen than expected, sometimes more than double the amount.



"After two years of trials, crop yields show that nitrogen crediting does save producers money," Bauder added. "Profit margins in irrigated agriculture are shrinking, and nitrogen crediting offers some relief from declining numbers because producers don't have to purchase and apply as much fertilizer. It's a legitimate way to improve your bottom line. And it's certainly beneficial to groundwater quality."

In test plots, virtually all of the producers who credited nitrogen in irrigation water saved between \$6.50 and \$83.26 per acre, and most met or exceeded yield goals.

Bauder said the groundwater in some areas has a high enough concentration of nitrate to make nitrogen crediting viable for up to 20 years, which makes long-term savings to producers even more impressive. However, he cautions producers against implementing nitrogen crediting on wells that are only used in dry years, because if a fertilizer rate is reduced and the well is not used when rainfall is average or good, the crop yield may not be as high. Bauder also recommends that producers think conservatively the first few years they practice nitrogen crediting.



Nitrogen crediting is a Best Management Practice, a series of recommendations developed by Colorado State Cooperative Extension and the Colorado Department of Agriculture. For more information on nitrogen crediting, contact Bauder at (970) 491-4923.

Using irrigation nitrogen crediting on your farm

- ◆◆ Find out the nitrate-nitrogen content of your irrigation well water (reported as NO₃-N). Field and laboratory testing are the only reliable sources to accurately identify nitrate content in irrigation water. A nitrate test from a commercial lab costs between \$10 and \$20.
- ◆◆ Estimate the amount of water you'll irrigate when the crop is taking up the majority of its nitrogen. Historical consumptive use, often called evapotranspiration, values can be used to determine the approximate amount of water you'll use and the amount of nitrogen you can credit in a field. Remember that the majority of nitrogen your crop needs for optimum yields is taken up during the vegetative growth stages of the growing season. This means you can only credit nitrogen in water applied during that part of the growing season.
- ◆◆ Only credit 60 to 70 percent of seasonal evapotranspiration for most crops (about 15 inches for corn). Your local Colorado State Cooperative Extension office, Natural Resources Conservation Service office or water district can provide values for crop water use in your area.
- ◆◆ Don't reduce fertilizer nitrogen rates without testing your soil to identify a crop's nitrogen needs. It may also be wise to test nitrogen crediting on a few strips or a portion of a field before cutting back nitrogen fertilizer applied over a large acreage.
- ◆◆ Formula for nitrogen credit:

$$(\text{NO}_3\text{-N in water parts per millions (ppm)}) \times 0.225 \times (\text{Inches of water to credit}) = \text{amount of nitrogen to credit.}$$

(from Agricultural Chemicals and Groundwater Protection fact sheet #15; Colorado State University Cooperative Extension, Colorado Department of Agriculture and Colorado Department of Public Health and Environment; April 1998.)

National Small Flows

Fact Sheets on Wastewater Technologies to Help People Weigh Treatment Options -- Fact sheets on domestic wastewater technologies/practices are now available through the National Small Flow Clearinghouse (NSFC). Funded by the U.S. Environmental Protection Agency (EPA), the fact sheets are part of EPA's Environmental Technology Initiative (ETI) project, which gathers, assesses and disseminates information about innovative and alternative wastewater technologies, as well as some onsite technologies. The fact sheets were designed to be used as a *preliminary process selection tool* in identifying an appropriate wastewater technology/practice for single-family residences, clusters of homes, subdivisions, or communities. Two versions of fact sheets are available for each technology:

- 1) a four-page technical overview for engineers, manufacturers, regulators, and other technical audiences, and
- 2) a two-page general overview for elected officials and the public.

Both fact sheets provide an overview of how the technology works, its advantages and disadvantages, operation and maintenance, and costs. The technical fact sheets also include design/process specifications, performance characteristics, and application results in the form of case studies.

For information contact: The National Small Flow Clearinghouse, P.O. Box 6064, West Virginia University, Morgantown, WV 26506-6064 or Colleen Mackne by phone 800/624-8311 or 304/293-4191; FAX 304/293-3161; e-mail cmackne@wvu.edu.



COLORADO STATE FOREST SERVICE



COLORADO WILDFIRE!

by Bob Sturtevant, Colorado State Forest Service

The CSFS Fire Division's program activities have two goals: 1) protection of people and the environment from damaging wildfires, and 2) the safe use of fire to help meet the needs of the resources and society. The program covers over 25 million acres of private and state watershed lands. Service is provided through outreach, technical assistance, and support. The program operates on a highly coordinated, cooperative basis with local, private, state, federal, and tribal partners. Specific program areas include Wildland/Urban Interface, Prescribed Fire, Fire Training, Suppression Coordination, Fire Information and Education, and Wildfire Equipment.

Preface

Each year as summer approaches, the Colorado State Forest Service (CSFS) prepares for "fire season". Colorado wildfires are most common July through October; however, they do occur throughout the year as well. The incidence of wildfires depends upon several factors. Among these factors are: fuel moisture, ignition source, and fuel availability. In Colorado, both fuel moisture and ignition source are weather-related and difficult for humans to manage. Rainfall determines the water content in both living and dead materials and lightning is our major source of fire starts (90 percent).

Where we do have a great deal of influence is in the amount of fuel available for wildfires. We have allowed grasses, shrubs and trees to grow with little disturbance (due to active fire suppression and other management practices), which in turn has created a situation favoring large, destructive and sometimes catastrophic wildfires.

In addition to concerns for the high level of fuels buildup in Colorado, over the past several decades, thousands of homes have been built in areas of high fire potential. This high fire potential is identified by the combination of fire-prone vegetation and history of fire occurrences. Not only do we have vast areas of forest land ready to burn, we have homes and people to protect from these natural events.

Thus with these types of fire-risk factors combined with predictions for a summer of warm, dry weather in 1999, CSFS foresters have been preparing for a potentially serious and active fire season. After a dry winter and early spring, interagency coordination meetings were held two months early and provisions were made to be able to activate

firefighting resources at a moment's notice. A special request was also initiated for prevention money that would be used to promote state-wide fire safety. However, as is often the case with weather predictions, early concerns were abated with late spring snow and rainfalls, and instead of fires, we were dealing with floods. Colorado wildfire concerns were no longer front page news or, unfortunately, no longer newsworthy at all...

This loss of the limelight was unfortunate, because Colorado's fire risks and concerns have not gone away and fire season is not over – simply postponed. This summer is still being predicted to have warmer and dryer than normal weather conditions, and it only takes a few days of warm, dry weather to move the fire danger meters into the high and extreme categories.

Fire As A Natural Force

Fire has long been a natural force in our Rocky Mountain ecosystems. Plant communities from the plains to timberline are a result of adaptations to regular fire occurrences. In the montane zone (6000-9000 ft.), for example, fires historically burned every 4-40 years. Small trees and shrubs (ladder fuels), low growing vegetation and dead or decaying organic matter (ground fuels) were burned, leaving the widely-spaced larger trees with a grass understory. As European settlers began to inhabit the





region, these cleansing fires were no longer allowed to burn. The formerly disturbance-controlled vegetation was able to grow unchecked beneath the existing canopy. Houses were then built under this forest canopy as well, screened from their neighbor's homes by the increasingly thick vegetation.

With 130 years of population growth and wildfire suppression, Colorado now has the potential for catastrophic losses to wildfires. The historic, low-intensity ground fires of the past now have more ground and ladder fuels (which transport fire up to the forest canopy), which in turn results in high-intensity and usually fast-moving (wind-driven) wildfires. Extensive natural resource damage, destroyed homes, and quite possibly loss of human life are the realities of these types of fires. Colorado's wildland-urban interface regions (the fastest-growing areas of the state) are the most susceptible to these wildfires. The combination of people moving into these areas, the risk factors delineated above AND a general lack of awareness concerning wildfire and wildfire prevention (defensible space, etc.) represents a tragedy waiting to happen.



The 1996 Buffalo Creek Fire, which burned 12,000 acres in one afternoon, incinerated most of the vegetation in its path – including large, mature trees. The fire was driven by a wind which allowed it to cover over 10 miles in less than five hours. Fortunately no injuries occurred, nor were homes lost; however, if the same acreage had burned 10 miles north of Buffalo Creek, the fire would have involved over 800 home sites.

The greatest resource damage from this fire was the creation of hydrophobic soils which are created by high intensity fires fusing the soil particles together to form an impermeable layer. Thus, when Buffalo Creek received several heavy rainfalls following the fire, the result was excessive flooding and erosion because the soil could no longer absorb the moisture. At least three major floods have occurred since the initial fire event, destroying road systems and filling Strontia Springs Reservoir (Denver's drinking water supply) with logs, ash and gravel. In the first flood event,

13 years worth of sediment was deposited in the reservoir. The cleanup and repair efforts put forth in response to the floods have been five times more expensive than the initial firefighting expenses, and more water damage is expected due to the slow recovery of the watershed's vegetation.



CSFS considers reducing the risks of and from catastrophic wildfire its number one priority and is addressing the various risk factors from several different directions:

- Providing information and education to existing and new landowners in the interface regions;
- Creating demonstration areas depicting how thinning trees and shrubs can create defensible space around forest homes;
- Working with homeowner groups to "fire-safe" (create defensible space) their communities ;
- Developing new, more effective literature and presentations concerning the wildland-urban interface and defensible space;
- Training CSFS volunteers to present "defensible space" information to a wide variety of groups
- Providing over 140 fire trucks to rural fire departments ;
- Developing new technology for adapting trucks for more effective wildland firefighting;
- Training volunteer firefighters in wildfire suppression techniques; and
- Initiating and cooperating in prescribed fires.



CSFS foresters believe fuels reduction is critical to proactively diminishing the risks of wildfire. We know from research what forest conditions were like before we actively suppressed fire. There were fewer trees and less understory vegetation. We probably had fewer insect and disease problems in our forests.

To return Colorado's forests to this healthy and safe condition we need to "thin" the vegetation. This can be done mechanically by cutting the trees or through the use of "controlled" burns. Because of the density of some of the forests, a combination of the two techniques may be needed.

Thinning, whether through cutting or prescribed fire, is not a popular activity – especially in a subdivision. People move to the "country" because of the natural landscape and the trees. Trees create a wonderful environment in which to live and "get away from the concrete, urban world." And yet, as unpopular as thinning may be, the reduction of heavy fuels is no longer an option – it has become a life and death matter.

In Conclusion...

We have allowed the forests and their fuels to grow undisturbed for well over a hundred years, and making the necessary changes is no small task. It will take the active cooperation and improved awareness of numerous agencies, private landowners, politicians, legislators, governmental bodies and many other publics as well. Education, prevention, preparedness and cooperative/interagency mitigation efforts are the tools CSFS is utilizing to reduce the daunting risks of catastrophic wildfire. We have placed these efforts at the top of our priority list and we are dedicating a great deal of our time, energy and resources to increasing public awareness and decreasing Colorado's susceptibility to wildfire. *See the Fire Division's website at <http://www.colostate.edu/Depts/CSFS/fire/csfsfire.html>.*



CWRPDA DONATES IVAL V. GOSLIN COLLECTION TO CWRRI

The Colorado Water Resources and Power Development Authority has donated the Ival V. Goslin Water Resources Collection to CWRRI to include in its Library Collection. Ival V. Goslin was the first Director of the Colorado Water Resources and Power Development Authority, established in 1981 by the Colorado Legislature to provide financing for state and local water projects.

The Goslin collection is a very valuable resource for engineers, hydrologists and historians. It includes engineering working documents used in the 1980s to develop plans for water projects in a number of Colorado river basins, collected as a result of engineering feasibility studies performed by the Authority. These papers are described as representing a distinct step -- the end of an era, or pause in development that is still debated.

The collection consists of about 30 boxes of reports, maps and computer data files on the following projects and basins: Cache la Poudre, Cherry Creek, Clear Creek, Gunnison River, Fraser River, Turkey Creek, the St. Vrain Basin Reconnaissance Study, and the San Luis Valley Confined Aquifer Study.

**IRRIGATION MANAGEMENT PRACTICES:
WHAT ARE COLORADO PRODUCERS DOING?**

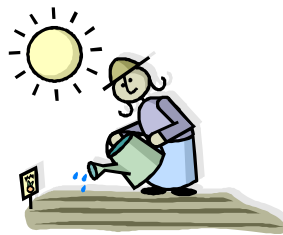
By Reagan Waskom, Marshall Frasier, Troy Bauder and Dana Hoag

A mail survey of Colorado irrigators was recently conducted to determine the irrigation management practices that producers are currently using, how management decisions are made, and the relative importance of various factors in irrigation management decisions. Knowledge of the actual irrigation practices used by producers is needed to help focus research and extension programs to maximize benefits. Our intent was to find out what Colorado irrigators are doing and what factors drive their management decisions. The surveys were mailed in 1997 to 3,281 known irrigators identified through the Colorado Agricultural Statistics annual crop production survey with over 40% being returned as useable responses.

Characteristics of Colorado Irrigators

The survey shows that Colorado irrigators are highly experienced with an average of 31 years of irrigation experience (Table 1). Producers' educational experiences were divided by near even thirds among those with a high school background, those with some college or vocational degree, and those earning a college degree. Over one-third of respondents had gross farm sales of less than \$50,000 annually, while only 4% grossed over \$1,000,000. Collectively, 43% of the respondents grossed between \$50,000 and \$250,000. Over one-third of respondents had some off-farm employment. Respondents leased or rented an average of 29% of their irrigated acres.

Many irrigators reported reliance on water from both surface and ground water sources. Statewide, gravity (flood, siphon tubes, gated pipe, and other gravity) and sprinkler systems (center pivot and other sprinkler) account for nearly equal proportions of irrigated acreage, but differences among regions are great. Center pivots dominated sprinkler usage while flood systems account for over half of the gravity-served acres in the state. On the average field, flood and siphon tube systems were installed nearly 75 and 35 years ago, respectively. The average age of all other systems falls below 20 years.



Characteristics of Irrigation Systems and Management

Each respondent was asked to identify a specific field that was representative of their farm to facilitate detailed questioning of how specific irrigation management decision are made. The average "representative field" was 67 acres with nearly one-quarter of the fields identified as rented or leased. Sixty-five percent of respondents described their water supply as highly reliable, providing adequate water ten years out of ten (Table 2, next page). Regions with higher reliance on ground water sources were found to have higher water reliability, while regions more reliant upon a ditch company, especially in the Arkansas Valley, have lower water reliability.

Pump depth and well capacity for ground water pumpers varied across the state. Pump lifts exceeded 100 feet for the majority of representative fields using ground water in the Eastern Plains, whereas they were less than 100 feet for the majority of representative fields in other regions of the state. Pumping yields were greatest for those in the San Luis Valley, South Platte, and Eastern Plains. Producers using sprinkler systems cited average nozzle pressures of 35 psi.

Fifteen percent of respondents cited concerns about their irrigation water quality, with those in the South Platte and

Table 1. Average irrigation experience of respondents and age of system installed on respondents' "Representative Field".

	Center Pivot	Side Roll	Gated Pipe	Siphon Tubes	Flood	All Systems
	----- Average Years-----					
Irrigation experience	28	26	30	32	33	31
Age of system	14	10	11	35	74	32



Table 2. Regional differences in water supply reliability on respondents' "Representative Field".

Number of Years out of 10*	Region						Colorado
	South Platte	Eastern Plains	Arkansas Valley	San Luis Valley	Mountains	Western Slope	
	-----% of Respondents-----						
10	74	82	46	63	59	54	65
9	7	4	6	9	7	10	7
8	7	4	14	8	13	13	9
7	5	2	14	6	4	7	6
6	2	2	2	4	7	4	3
5	1	1	9	4	4	3	3
Fewer than 5	4	5	10	7	6	9	6

*Number of years out of 10 that the water source provides a full water supply for the crop grown on the representative field.

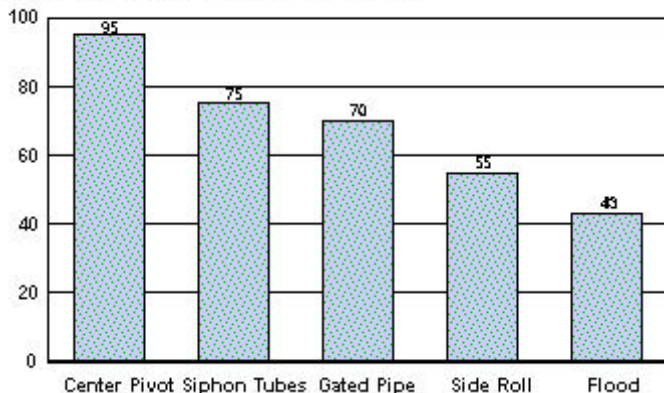
the Arkansas Valley indicating concern most frequently. The most common water quality concern that producers mentioned was salinity, with sediment, sewage, and nitrate contamination also cited with some frequency.

Nearly all center pivot users have upgraded their system in some manner, with low-pressure systems and drop nozzles widely used (Figure 1). Eighty-four percent of survey respondents reported at least one irrigation system upgrade somewhere on their farm. Among gravity systems, flood irrigation components are least frequently improved. Less than 40% of the flood systems in any of the three western regions have received an upgrade. Field leveling and lining ditches occurs frequently among flood systems in the eastern regions and for siphon tube systems across the state. Among gated pipe users, field leveling and surge valves were the most frequent upgrades. Very few producers have adopted flow meters for their representative field.

Figure 1. Results of the following question: Check all irrigation upgrades used on the system identified for this field. Options given in survey for selecting irrigation system upgrades:

LEPA	Corner Catcher	Surge Valves
Drop Nozzles	Flow Meters	None Apply
Low Pressure Sprinklers	Lined Ditches	Other
Computer Controller	Field Leveling	

% of Systems Using an Upgrade Listed Above



Irrigation Efficiency and Scheduling

When asked to estimate the field level irrigation efficiency on their representative field, the majority of respondents indicated they knew system efficiency. Estimates of application efficiency among surface irrigators, however, tended to be much higher than values commonly reported from research (Figure 2, next page). Just over one-quarter of respondents indicated knowledge of the amount of water applied to their representative field (Table 3, next page). Less than one-sixth of respondents indicated keeping records of water applied to their representative field.

Half of all producers indicated that "crop appearance" was the primary method used to determine when to irrigate their crops (Figure 3, next page). Nearly one-third cited a "fixed number of days" between irrigations as their method used. Rule based irrigation scheduling methods such as accumulated ET or available soil moisture were cited by about one-quarter of respondents, but most frequently by those pumping ground water and using center pivots. One in ten producers cited using crop consultants used to

Table 3. Percent of respondents knowing and keeping records on the amount of water applied*.

	Region						
	South Platte	Eastern Plains	Arkansas Valley	San Luis Valley	Mountains	Western Slope	Statewide Average
	-----% Respondents per Region-----						
Know Amount Applied	36	38	25	30	17	17	28
Keep Records	16	19	15	25	12	12	16

*Questions read: *Do you know how much water was applied to the representative field in 1996? Did you keep written or computerized records of water applied throughout the season?*

Figure 2. Result of the following question: Check your best estimate of the system's average field application efficiency.

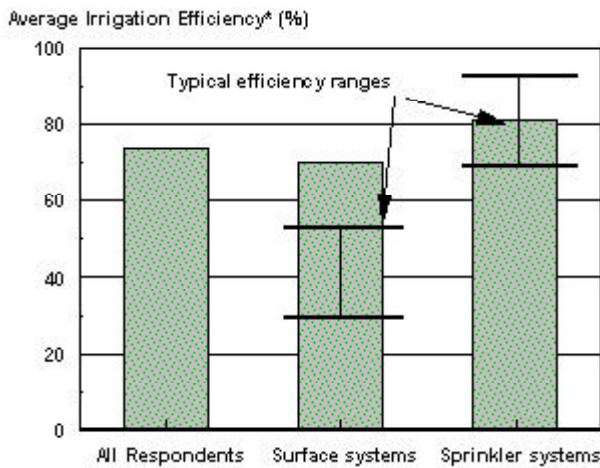
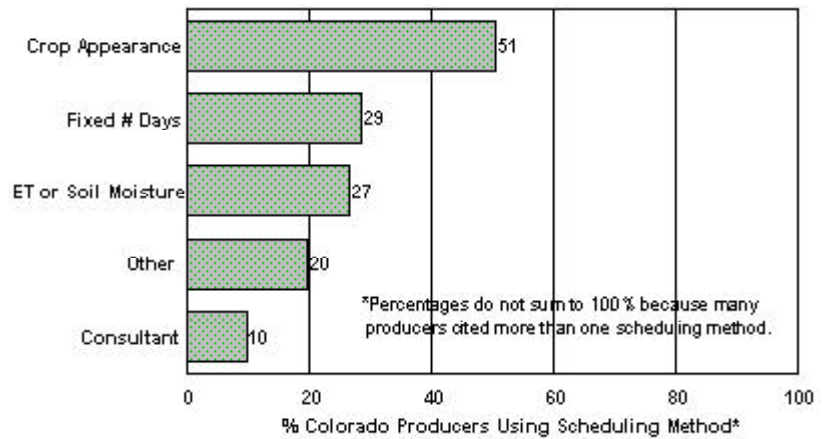


Figure 3. Results of the following question: Check the ONE primary method that you used in 1996 to decide WHEN to irrigate.



determine when to irrigate their crops. Among all users of the soil moisture decision rule, the shovel or feel method was used most frequently with the soil probe cited second most frequently. A number of producers indicated that they determine soil moisture through some visual means, but it was not clear how this was accomplished. Gypsum blocks or consultants are very seldom used to determine when to irrigate. Only one-quarter of all producers using soil moisture methods provided a quantified level of available soil moisture that would trigger an irrigation event.

When asked how they determine how much later to apply once they have decided to irrigate, producers most often cited “same amount each time” or “experience and tradition” (Figure 4, next page). This was particularly true for alfalfa, hay, small grains, and most flood irrigation systems.

Over one-quarter of all producers reported changing some aspect of management in the last five years. Among the irrigation systems, center pivot, side roll, and gated pipe users reported the most changes. Respondents with ground water sources showed the most change. Most changes involved the water application system, with improving water use efficiency the most frequent reason given for the management change.

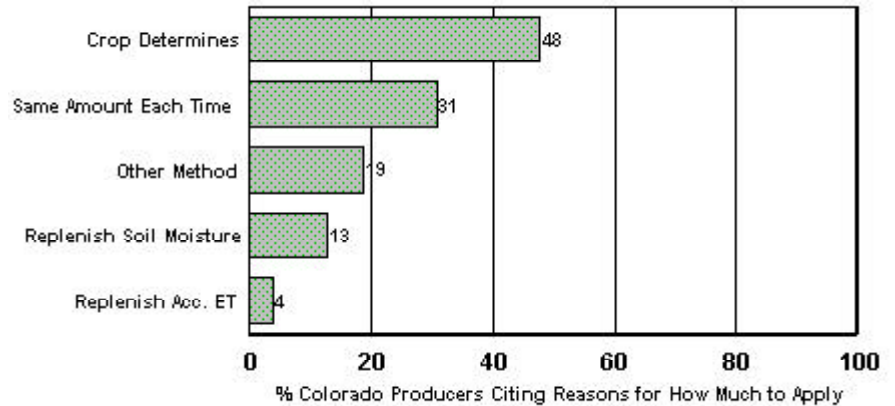
Survey Significance

These survey results suggest that stretching water supplies is not a significant incentive to change irrigation management for the majority of Colorado irrigators. Adoption of new irrigation technology is progressing in Colorado, but many producers have not incorporated improved irrigation management practices in their operations. There are many

old irrigation systems in Colorado that have not been updated as technology has changed. In addition, most Colorado irrigators have many years of experience with their current systems. Research and extension programs must recognize the validity of this experience and must demonstrate a clear advantage of any new technology or management system before we can rationally expect widespread producer adoption. Most Colorado irrigators do not keep precise records of crop water use and irrigation water applied. This may be partially explained by the fact that many irrigators feel their water supplies are adequate during most years. The management time and costs required to keep better records or implement higher levels of water management may not be justified or economically feasible for these irrigators.

However, the results of this irrigation survey also show that Colorado irrigators will implement technology when it is practical, economical, or

Figure 4. Results of the following question: Check the ONE primary method used in 1996 to decide HOW MUCH water to apply for each irrigation application.



when other significant incentives exist. It may be inferred that higher levels of irrigation water management will be adopted as farmers perceive an incentive to do so.



Complete results of this survey may be obtained in the CSU Agricultural Experiment Station technical report entitled "Irrigation Management in Colorado – Survey Data and Findings" (Colo. AES TR-99-5). This report may also be accessed at <http://www.colostate.edu/Depts/AES/pubs.htm>.

Web Update

The Colorado Water Knowledge web site (<http://waterknowledge.colostate.edu>) was recently selected as a featured site in StudyWeb (<http://www.studyweb.com>) as one of the best educational resources on the web. StudyWeb is one of the Internet's premiere sites for educational resources for students and teachers. Since 1996 StudyWeb has been selecting sites to be included in StudyWeb's reviews. Each site in StudyWeb includes a detailed review describing its merits.

Since its development in 1996 by Freeman Smith and Anna Perea, the Colorado Water Knowledge site has received over 55,165 visits. The site is a valuable resource for anyone interested in virtually all aspects of Colorado water.

The sites maintained by the Water Center are:

The Water Center at <http://watercenter.colostate.edu>

The Colorado Water Resources Research Institute at <http://cwrrri.colostate.edu>

Colorado Water Knowledge at <http://waterknowledge.colostate.edu>

Dave Bartecchi
Website Administrator



COLLECTING HIGH-QUALITY DATA IN THE ARKANSAS RIVER VALLEY TO UNDERSTAND AND SOLVE SALINE-HIGH-WATER-TABLE PROBLEMS

by Timothy K. Gates

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◆◆ *The Problems at Hand*

Salinity and drainage problems usually appear in intensively-irrigated alluvial valleys within a few decades to a few hundred years of the commencement of large-scale irrigation. Sooner or later, the artificially high rate of application of water to land exceeds the natural rate of drainage, the water table rises, and artificial drainage is needed to regain an acceptable water and salt balance (Gates and Grismer 1989). In the lower Arkansas river valley in Colorado, irrigated since the 1870s, saline high water tables began to appear in the early part of the twentieth century. Installation of subsurface drains in the 1930s seemed to assuage the problems for awhile (USDA-NRCS, Rocky Ford Field Office, personal communication). However, water tables began to rise again in the late 1970s. Watts and Lindner-Lundsford (1992) suggested that the blame be placed on increased diversions from the river for irrigation application and associated reduction in groundwater pumping. Indeed, in the 1950-70's, two reservoirs began operations that have drastically changed the river. Flushing from floods was substantially reduced and controlled releases were made from the reservoirs. This allowed year-round, or at least prolonged, supplies of water to the canals on the perimeter of the valley. Lower velocities in the river have caused the river channel to widen, sediments to deposit on the bed, and the river level to rise. Recent investigations by the principal investigators of water levels in the reach of the Arkansas river upstream of John Martin reservoir indicate an increasing trend since about 1989. The overall rise in the river level (of about 0.6 m) may have significantly reduced the gradient that drives drainage flows from the irrigated land to the river. Since 1991, irrigation water supplies from snow pack and rainfall have been far above average. Many of the large supply canals in the area have diverted more water in each of the last three years than in their 100+ year histories and have increased seepage throughout the basin. Also, in response to the recent Kansas-Colorado court ruling, groundwater pumping in the valley, which serves to reduce water table levels, has diminished.

These factors contribute to a growing body of evidence that the irrigated lands of the lower Arkansas are subjected to forces that are elevating the severity of waterlogging and salinization. At a time when conjecture about the main causes and prognosis of the problems is growing, some people feel that conditions already have reached a crisis stage. Informal and anecdotal evidence abounds: salt crusting on soil surfaces, seepage and wet spots in selected fields, stunted growth of crops, and reduced crop yields. Such losses threaten the economic wellbeing of the rural communities in the valley and, by extension, diminish the agricultural base of the state. Until recently, however, scientific investigations of the problems have been sparse. Furthermore, studies often are limited in their scopes and piecemeal in their approaches, failing to provide a coherent understanding of the extent and severity of the problems.

◆◆ *The Crucial Role of Quality Data*

There is an acute need to place the diagnosis of salinity and waterlogging problems in the Arkansas valley on a sound scientific footing. Furthermore, beyond the need to accurately describe the problems for farmers and for state and regional agencies, a reliable database is needed to help prescribe the best possible solutions through the use of advanced simulation models. The author, along with Dr. John Labadie of the Civil Engineering Department at Colorado State University, serves as a principal investigator for a suite of projects that come under the major heading of "Identification and Solution of Waterlogging and Salinity Problems in the Lower Arkansas River Valley, Colorado". This work is funded by the Colorado Agricultural Experiment Station, the United States Bureau of Reclamation (USBR), the Colorado Water Resources Research Institute, the United States Geological Survey, and the Colorado State Soil Conservation Board. Cooperating agencies include the USDA-NRCS Area Office in La Junta, Southeastern Colorado Water Conservancy District, the Pueblo Subdistrict Office of the USGS, the Eastern Colorado Area Office of the USBR, the District-II Office of the Colorado Division of Water Resources, the USDA Farm Services Agency, and the Bent County Soil Conservation Board.

At the heart of our research effort are activities aimed at gathering accurate and sufficient information (data) to estimate state variables and parameters of the stream-shallow aquifer system of the lower Arkansas river valley. State variables of interest include water table depth, water table salinity, soil salinity, and crop yields. Parameters include elements of system topology, boundary and initial conditions on flow and salt transport, material properties of the aquifer and river, local and areal sinks and sources of flow and salts, and related properties that affect sinks and sources.

There are several obstacles to the design and execution of data collection activities in the field. Foremost among these are issues of scale, heterogeneity, and measurement error. Scale is the characteristic time period or length over which a system is observed or



modeled with respect to the variables and parameters of interest. Heterogeneity is the degree of inherent variability (space and time) in variables and parameters of the system. Measurement error is the lack of accuracy in quantifying variables and parameters at defined space-time points within the system. In this brief article, we describe these issues and present some ways we are attempting to grapple with them in our research in the Arkansas river valley.

◆◆ *Data and Scale*

Concerns about observation scale provoke the following questions: (a) how large an extent (spatial and temporal) should the data set encompass? (i.e. the concern of coverage), (b) how should the samples be spaced? (the concern of resolution), and (c) how large should the individual samples be? (the concern of point definition) (Kalma and Sivapalan 1995). These concerns about scales for data collection are linked to concerns about scales used in modeling. When observation scales are smaller than model scales, “upscaling” is required. When observation scales are larger than model scales, “downscaling” is required (Sposito 1998). In most environmental systems, like a hydrosystem (water system that encompasses both natural and man-made features), the need to upscale is encountered more frequently than the need to downscale. This is because the scales convenient to human observation are usually smaller than the scales of interest for analysis and simulation. A common example of upscaling is the use of a point measurement of rainfall measured with a rain gage (having diameters on the order of 10^{-1} m) and assuming it applies over a surrounding polygonal subregion of a watershed (with dimensions on the order of 10^3 m).

◆◆ *Data and Heterogeneity*

If hydrosystems were uniform in their characteristics and behavior, our attempts to describe them would be much easier. A single accurate measurement of a variable or parameter at any space-time point would be sufficient to describe the entire system with respect to that variable or parameter. Of course, such is not the case. Instead, variables and parameters of hydrosystems display rich contours in space and time. Such complexity poses an ambiguity that proves both intriguing and challenging at the same time. The questions arise: (a) how many samples should be taken?, and (b) where and when should they be taken? Fairly elaborate statistical schemes have been developed to provide guidance in addressing these questions (Ward et al. 1990, Christakos 1992, Berthouex and Brown 1994), but they are always constrained by the cold, hard realities of available resources, time and accessibility. Rarely will research budgets, personnel and time allow enough samples to characterize a system with a statistical confidence level as high as researchers might desire. Also, as we have discovered in the Arkansas valley, physical impediments or unwilling landowners sometimes prevent access to desired sampling locations.

◆◆ *Data and Measurement Error*

When a point in space-time has been selected for estimation of a variable or parameter, the researcher faces the limitations inherent to the instrument or the methodology used to make the measurement. Often physical samples, water or soil for example, are taken and the properties of interest are estimated through laboratory analysis. Even standard laboratory techniques yield estimates within expected error bounds of plus or minus some percentage of the true value. Often, surrogate measures are made that can be related to the properties of interest through calibrated relationships. For example, in the Arkansas valley we measure the electrical conductivity (EC) of water bodies using conductivity meters. Linear relationships are then used to estimate the corresponding total dissolved solids that effect that conductivity. Such relationships must be established and periodically checked through carefully designed calibration procedures. Even when direct field measurements are possible, accuracy is still limited. For example, in the measurement of surface water or groundwater levels, the use of pressure bulbs provides accuracy to within 20 mm, bubble gages to within 10 mm, tape measures to within 1 mm, and point gauges to within 0.1 mm (Bos et al. 1991). In any field measurement, the careful use of standard protocol and, where possible, the use of a variety of cross-checking techniques, will minimize measurement error.

◆◆ *Grappling with Scale, Heterogeneity and Measurement Error in the Arkansas River Valley Project*

In our research in the Arkansas valley, we are interested in describing and modeling flow and salt transport process over coverages that encompass the regional scale (order of 10^3 - 10^4 m) and the larger basin scale (order of 10^4 - 10^5 m). In the current phase of the work, we are focusing on a representative regional coverage extending eastward about 50 km along the valley between the town of Manzanola in Otero county and the Adobe creek in western Bent County. This study area covers about 22,000 ha (55,000 acres). It is large enough to capture the variety of soils, hydrogeology, irrigation and drainage infrastructure, and crops that are characteristic of the valley but small enough to be manageable, given available resources.

We are developing and using a finite-difference model to analyze and predict water table elevation and salinity; elevation and salinity of the river, canals, and drains; and flow of water and salts in and between the shallow aquifer, the river, and the irrigation-drainage system (Gates et al 1999). The region to be initially modeled ends eastward at the Otero-Bent county line. The finite-

difference grid blocks define “points” in the model and have an average size of about 5 ha (close to the average field size in the region). The vertical dimension extends across subsurface layers to total depths of 3 to 20 m. Lines that define streams, canals, and drains are discretized at scales of about 200 to 300 m. Hence, variables and parameters are defined as average values over model point-definition scales on the order of 10^1 - 10^2 m.

There are thousands of points (grid blocks) where variables and parameters need estimation. Field data, however, can be collected only from a limited subset of the system. In the current project, much of the data will be collected directly by project personnel, while some will be collected by, or in cooperation with, partnering agencies. The data we are collecting directly includes water table depth and salinity, soil salinity, hydraulic conductivity and soil texture, topographic and hydrographic features, and crop yields. Constraints of budget, time, accessibility, equipment, and expertise pose challenges in addressing the issues of scale, heterogeneity, and measurement error. For brevity, these issues are discussed only for water table depth and salinity, soil salinity, and hydraulic conductivity and soil texture.

◆ *Water Table Depth and Salinity*

The focus of this study is on the behavior of the shallow unconfined aquifer within the top three meters below ground surface; although consideration also must be given to flow and transport at greater depths. Hence, we decided to drill observation wells to a depth of three meters at sample locations distributed throughout the study region. Data on deeper aquifer characteristics will be obtained from the USGS. Perforated PVC pipe with 0.06-m inside diameter was used to case the wells, yielding a point-definition scale on the order of 10^{-1} to 10^0 m. Selecting well locations for an initial study of this type is an example of the classical “chicken-egg” problem. We initially knew little about the heterogeneity of the subsurface geology, piezometric head contours, and salinity distribution; hence, there was little information to guide initial placement. Using statistical guidelines, and given the constraints on budget and timing, a total of about 75 wells were to be installed and monitored in the first year (1999-2000). This would provide a resolution scale of about one well per 300 ha of land with distance between wells of closest proximity on the order of 10^3 m.

To minimize bias in placement of the wells, while still accounting for an expected salinity gradient along the river, stratified random sampling was used. The study region was divided into five zones along the river. Each zone extended north and south of the river and encompassed about the same total number of fields. Inside each of the five zones, ten fields were selected for well installation using a uniform random number generator. This provided target locations for 50 sites internal to the region. Twenty additional sites were selected for placement along the boundaries of the region. In about 20% of the cases, site locations had to be shifted to nearby fields due to problems with accessibility or due to lack of cooperation from landowners. Also, in some cases, target locations were substituted with existing wells that were discovered in the field. To date, a total of 68 wells are in place, with an additional five wells targeted for placement (see Figure 1, showing well locations and fields in the study region). Data collected during the first year will guide in placement of additional wells next year.

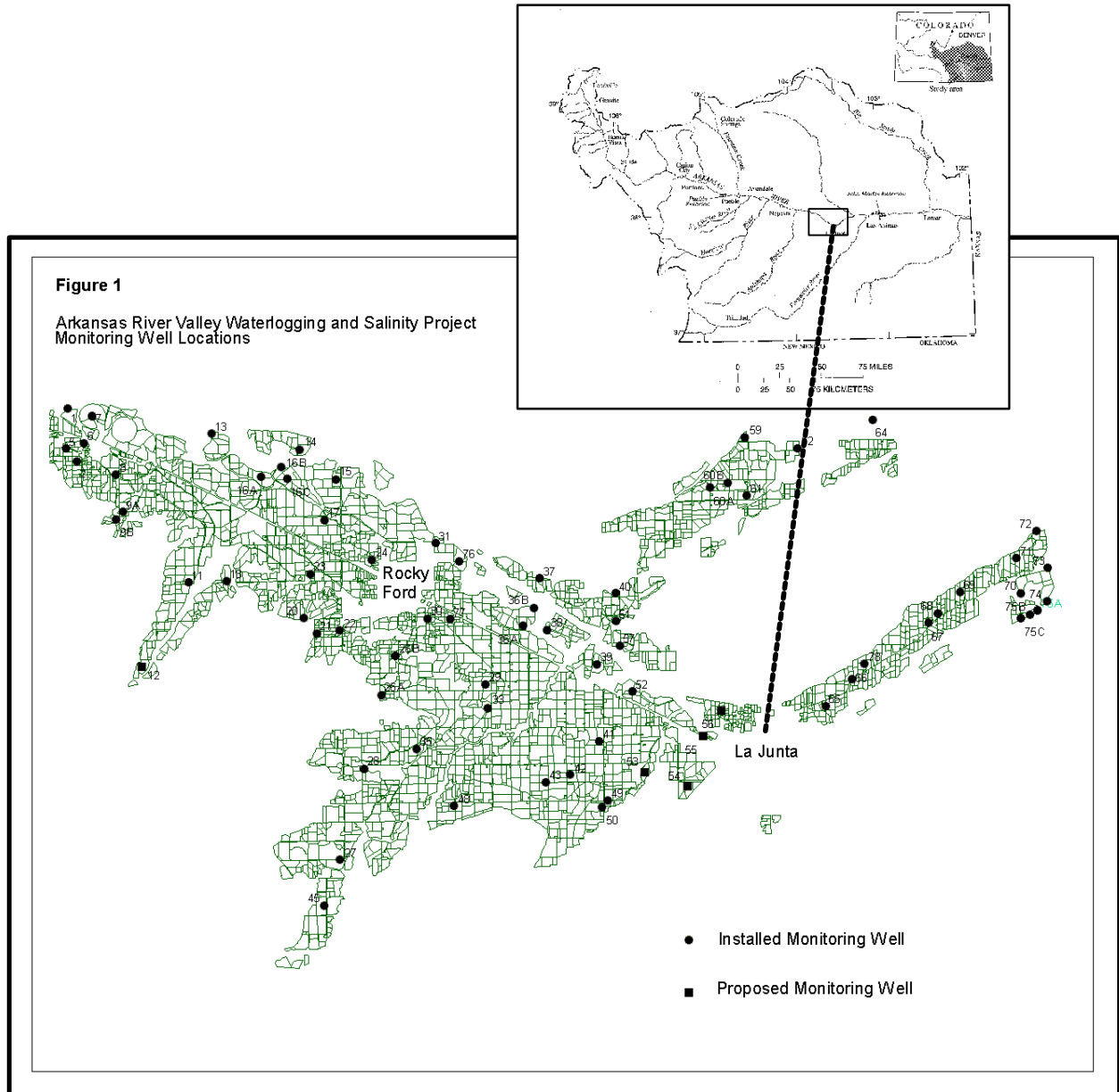
Each of the wells will be monitored periodically for water table depth and groundwater salinity. In the early and later parts of the irrigation season, measurements are to be taken every 10 to 14 days. Beginning in mid June, when regular irrigation commences, measurements will be taken every 7 days. This resolution scale in time corresponds to the peak irrigation interval on fields in the region. This design provides a fairly dense sample grid for defining spatial and temporal heterogeneity, including the assessment of correlation between measured values.

To reduce measurement error, water levels in the wells will be read manually with tape measures (accurate within a few mm). The distance from top of well casing to ground surface will be recorded at each reading. Elevation of the ground surface at the wells will be measured using a survey-quality global positioning system (GPS) (Trimble™ Model 4600 LS Surveyor), checked against registered benchmarks in the region. Measurements of EC of the groundwater will be measured just below the water table, at the bottom of well casing, and midway between using a conductivity meter. Corresponding water temperature measurements also will be recorded. Conversion of EC values to salinity (total dissolved solids) will be achieved through the use of calibration relations developed from periodic laboratory analysis of samples extracted from the wells.

Each observation well within this battery lies within a single field having average size about 8-10 ha. Measurements at these locations will provide insight into large-scale trends of variability across the region. However, since the



measurements are taken over point- definition (observation) scales on the order of 10^{-1} to 10^0 , they do not provide insight into averages over the point-definition scale of 10^2 for the model grid blocks. To study variability and averages within the model grids, three to five fields have been selected for detailed investigation. Inside these fields, ten to twelve observation wells will be placed and monitored on hourly intervals with continuous water level recording devices. Salinity also will be measured in the wells every few days. This will allow assessment of the uncertainty associated with upscaling measurements taken from points at the observation scale to the larger grid blocks at the model scale.



💧 **Soil Salinity**

Within the modeled region, shown in Figure 1, about 50 of the fields that contain observation wells will be surveyed intensively for soil salinity to a depth of about 1.2 m below the soil surface (i.e. the active root zone of the crops). Ten additional fields will be surveyed in the Horse Creek and Adobe Creek watersheds in Bent County, just west of the modeled region. It is expected that this area will be adjoined to the modeled region next year. Available budget

and time allow for only two surveys to be conducted during the season. Each of the 60 fields will be surveyed once during the early part of the irrigation season (early to mid June) and once during the late part of the season (late August to early September). This will allow examination of changes in soil salinity over the irrigation season due to irrigation practices and upflux of salts from the high water table. The average of these two observations are expected to be sufficiently reflective of the salinity concentration affecting crop growth and production through the season. To check this assumption, salinity measurements will be taken at two additional times during the season on 3 to 5 of the fields.

Each time a field is surveyed, about 50 to 60 measurements will be made at random points distributed throughout the field. Readings will be taken with electromagnetic induction probes (Geonics™ EM-38) which are calibrated to render relations between secondary electromagnetic field strength related to salinity-dependent current in the soil water (induced by the instrument's primary electromagnetic field) and the electrical conductivity of the soil-water extract. The salinity represented by the reading is an average over a 1.2-m-diameter spheroid beneath the probe. Three sets of four soil samples (dimensions on the order of 10^{-2} to 10^{-1} m) will be extracted with depth at three points (making a total of 12 samples) under each of two EM-38 measurement sites inside each field. These samples will be analyzed in the laboratory for electrical conductivity of the saturated extract, water content, and texture. To reduce observation error, salinity of saturated extract will be determined using both the standard USDA laboratory procedure and the new Hach™ SIW-1 test kit. These data will be used to develop calibration equations for the EM-38 measurements. In most cases, measurements taken in the field will not be recorded. However, in a subset of three to five fields, each sample will be located with a survey-quality GPS. This will allow calculation of spatially-referenced correlation of salinity to crop yield measurements taken at the end of the season.

These soil salinity measurements will allow an assessment of heterogeneity among observation point-definition scales of order 10^0 m within fields. These fields represent the point-definition scale (order 10^2 m) for the regional model. Thus, point values of soil salinity for the model will be determined by averaging the measurements made within each field.

◆ *Hydraulic Conductivity and Soil Texture*

Estimates of horizontal hydraulic conductivity (K_h) are needed to predict flow and salt transport in the shallow aquifer. Our work focuses on the characteristics of the top three meters below the ground surface, where drainage systems will be employed. Data on the hydraulic characteristics of the deeper strata are to be provided by the USGS. To estimate K_h within the top three meters, we plan to conduct auger hole tests in each of the 73 observation wells over the region. Auger hole tests are conducted by removing the water from the well with a battery-operated submersible pump, measuring the rate of rise of the water table in the well (and the associated time-varying hydraulic gradient), and calculating the approximate average K_h around the annulus of the well. This constitutes an observation point-definition scale on the order of 10^0 m for K_h . To reduce measurement error, the rate of rise in the well will be recorded using a pressure transducer placed at the bottom of the well. These transducers can measure pressure head changes of a fraction of a centimeter over time steps of a second or less. Readings will be recorded using a data logger.

Large-scale variability in K_h over the regional model should be captured well by the measurements made at the 73 locations. Variability within fields will be studied by conducting auger hole tests at about 12 locations within each of the three to five fields where smaller-scale studies will be conducted.

To allow examination of the correlation of measured K_h values to soil texture, six soil core samples were collected on 0.6-m depth increments near the location of each observation well that was dug. Soil texture will be determined for each of these samples using hydrometer analysis. Hopefully, the results will allow K_h to be estimated (with associated reliability) at additional locations in the region where soil texture data are available but limited resources preclude direct measurement of K_h (Elfeki et al 1997).



Summary

On-going research proposes to strengthen the data foundation needed to characterize salinization problems in the lower Arkansas river valley and to guide the search for answers. Results should prove a valuable resource in support of decision-making and intervention in the Valley. Without sound and timely intervention, it appears that the Valley will eventually succumb, at least in a large part, to the ill effects of salinization. Solutions based upon accurate knowledge of field conditions will be needed to insure sustainability of the Valley's productive agricultural base and preservation of its rural communities. Data that addresses concerns of scale, heterogeneity, and measurement error, is essential to building a sound knowledge base. In this article, we have discussed efforts we are taking to obtain such high-quality data.

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WATER SUPPLY

Significant precipitation across the entire state during the second half of April greatly improved the outlook for the spring/summer runoff. On April 1 the only basin with a positive SWSI value was the South Platte basin, and a tight water year was expected. The only basin with a May 1 SWSI value below zero is the Yampa/White basin. It now appears that this year's water supply will be near normal. At the end of April, the Natural Resources Conservation Service reported that the statewide snowpack averaged 91 percent of normal. The increase from 65 percent of normal at the end of March over one month is unusually large, and a great relief to water users, especially the agricultural community. End of April reservoir storage is also good, at a statewide average approximately 125 percent of normal.

The surface Water Supply Index (SWSI) developed by this office and the USDA. Natural Resources Conservation Service is used as an indicator of mountain based water supply conditions in the major river basins of the state. It is based on snowpack, reservoir storage, and precipitation for the winter period (November through April). During the winter period snowpack is the primary component in all basins except the South Platte basin, where reservoir storage is given the most weight. The following SWSI values were computed for each of the seven major basins for May 1, 1999, and reflect conditions during the month of April.

Basin	5/1/99 SWSI Value	Change from the Previous Month	Change from the Previous Year
South Platte	2.4	+2.0	+0.2
Arkansas	1.1	+2.2	+1.0
Rio Grande	1.2	+2.8	-0.5
Gunnison	1.1	+2.3	-0.9
Colorado	1.0	+1.7	+0.9
Yampa/White	-0.3	+2.4	+1.3
San Juan/Dolores	0.4	+2.0	+0.3

SCALE								
-4	-3	-2	-1	0	+1	+2	+3	+4
Severe Drought		Moderate Drought		Near Normal Supply		Above Normal Supply		Abundant Supply

FEATURES



BUYING AND SELLING OF WATER RIGHTS

by Bart Woodward

The following talk was presented by Bart Woodward at the 1997 South Platte Forum. The theme was "Grow with the Flow: Growth and Water in the South Platte Basin." Bart's talk was presented in a session entitled "Show Me the Money" held immediately after lunch on the first day of the Forum. Bart was asked to address the agricultural perspective of the changes sweeping over water management in the basin, particularly with respect to the market for agricultural water rights.

I don't know how to start something like this. It seems like every time I get to speak somewhere, which doesn't happen often and you'll understand why when I'm finished, my talk always comes after a nice meal of heavy cream sauce. And our calisthenics instructor has already been here in the morning, so we can't go through that routine again. So probably the only way I'll keep you awake is to make you mad, and hopefully I can accomplish that today.

Does anybody know what this is (holding a water bottle)? I like to call it "storage." You know, if you're going to take a little trip out into the wilderness or the desert, the length of time you're going to be gone determines how well you get prepared. If you're going to go for an hour or two, you might take something this size (holding small water bottle). If you're going to go for two or three hours, you might take something this size (holding a larger water bottle). But what are you going to do if you decide to settle down, raise a family, and grow an economy...in a desert? Are you going to depend on this? I don't think so.

That's what Hank Brown was talking about today. That's what Lee Rozaklis was talking about this morning (referring to talk that was summarized in the December 1997 issue of *Colorado Water*). Lee did a fantastic job of giving you an inventory of the assets of the state of Colorado. He didn't talk much about the political problems of developing those assets, but he gave you a tremendous inventory. But since we live in a desert, the only way you're going to grow an economy and survive is to do it through storage. You can call this storage (holding a water bottle) if you want to; I like to call it storage. I know that a lot of people who like to use these kinds of bottles don't like the word storage. They don't like the word dam. But that's what this is. It's simple storage. It has to do with the time element. If it's a short period of time, this works fine. If it's a lifetime, or a generation, it needs to be something of a different size.

As I was listening to Lee Rozaklis this morning, I almost

jumped up and ran out of the room, thinking:

I'll run and find some unsuspecting city person and sell them my water for half of what I think it's worth right now, because obviously there aren't going to be any more agricultural transfers, since we have such a rosy picture of the inventory.

Well, I sat there for a little while asking myself if I should go now and embarrass him or if I should go a little bit later. And while I was thinking about it, the speaker from the Environmental Protection Agency reminded us of the veto of the Two Forks project, and I remembered the panic that set in with the 47 or 48 entities that were involved in the Two Forks process. They went off in about 115 different directions trying to buy agricultural water so fast that it made your head swim.

So with a little more comfort, I sat through the rest of the meeting. And I'm going to do something today that I've never done before in my life. I wrote a speech, and I'm going to read it. I generally write speeches, go off to a meeting or an event, start commenting on things, and forget about the speech. But I do have some comments today, and I did take the time to write them down.

I certainly want to express my appreciation to the South Platte Forum for inviting me. It's certainly a benefit to many in the water community to assemble at a meeting like this and exchange thoughts, ideas, and perhaps a few new jokes. Speaking of which...early in the development of the state of Colorado, there was an old homesteader who came out of the east someplace and landed in Colorado. He began to develop a little farm site and as time went on, it became a garden spot. He had the assets and the water available to him to buy a nice little comfortable home. He had a beautiful garden that his wife tended, and he had a beautiful farm that — like those of many of my German neighbors — was wheat free. Well, this farm was just an absolute picture of

perfection. And along came a preacher who stopped in during the noon hour, as preachers tend to do. That's not a slam on preachers, is it? I have preachers in my family, so it's okay for me to say that. Anyway, during the course of the conversation, the old preacher said, "You know, it's amazing what you and god have done here on this piece of property. It's just absolutely beautiful." The old farmer thought for a minute and looked at the preacher and said, "You know, you should have seen this place when god owned it all by himself." If that isn't a description of what's happening in the state of Colorado, I don't know what is. Hank Brown made reference to it this morning, and certainly it's a process that has taken about 150 years, but it's here — and it's here to stay.

But I really didn't come here to entertain you or to make light of the responsibilities that each of the people involved here today must face in their day-to-day lives. Many provide water for agriculture, many provide water for industrial processing, many have the responsibility of providing good, clean tap water for those who expect to get it when they turn on the faucet. And if you can make it taste good, they think you're a genius. There are always many viewpoints to every argument. Each one is founded by a particular set of circumstances, rules, and perhaps even a few regulations. I'm here today to express the viewpoint of a farmer. I know that there are opposing viewpoints, which may or may not have merit, but I will let the proponents of those viewpoints speak and defend them.

I will give you, as clearly as I can, my views concerning the acquisition of municipal and industrial water supplies. Let me first say that I believe that water, when properly decreed and put to beneficial use, is a private property right. I will defend to the end the right of the farmer to sell his water or to change its use to the limits of its historical consumptive use as he or she sees fit. But I hope they don't do it. Let's not forget about the land. The land that's out there is equally as coveted as water. Some people covet that land to build houses. Some people covet it to build factories. And some people covet it to leave it the way it is as open space. But the land is equally as valuable and I defend their right to sell it or to use it as they see fit, just as I defend their water right. And if things such as zoning laws restrict some of those rights, I think that's a taking, and I think they should be compensated for it as a taking.

I wish there were some other way that growing cities and suburbs could meet their needs without presiding over the mortal wounding of agriculture.

I wish there were some other way that growing cities and suburbs could meet their needs without presiding over the mortal wounding of agriculture. Arizona, particularly around the Phoenix area, has a plan to phase out agriculture in the near future. They've come to the realization that they have got to sell water by the gallon, not by the acre-foot. And there isn't much agriculture that can survive on buying water by the gallon. Where is our state headed? Are we headed in the same direction as California? Arizona?

Florida? And many of the other desirable spots in this great land of ours? Does anyone in this room believe that agriculture will survive the influx of faucets, showers, hot tubs, bluegrass lawns, swimming pools, water slides, golf courses, and even an occasional decorative fountain? If you do, I don't think the

word reality is in your vocabulary, and it's probably not in your dictionary.

Since the demise of Two Forks, the emphasis of many municipalities along the Front Range is to get to the best agricultural water rights first and tie them up, before somebody else can get there. There have been many outright purchases of agricultural water, and there have been some rather ingenious attempts at city-agricultural partnerships which, when applied to the light of day, reveal a win-win/lose-lose situation. Win-win for the city. They're able to tie up agricultural rights with someone, usually that same farmer who will continue to put the water to beneficial use until it's needed by the city. These arrangements are usually made during times of agricultural market depression when some banker is insisting that the farmer pay down some debt. The price of such transactions is usually less than half the real value of the water right. So the city wins. The farmer loses — but there's more. Another side benefit for the city with this arrangement is that now the farmer cannot sell his land for development because he has agreed to continue to put the water to beneficial use, so he must keep his farm intact. Voila! Green space, open space — and usually at no additional cost to the city, but at a tremendous cost to the farmer. Again, the city wins, and the farmer loses. Now don't get me wrong. I'm not against these arrangements. I just think the price is wrong.

Is this where I say, "Show me the money"? The price for

agricultural water should be in the range of \$6,000-8,000/acre-feet of consumptive use, if you can compare it to what it costs you to develop water on the same basis today. And what about the price of the land that's left for open space? How do you compensate for that? An additional yearly fee should be paid as long as that farm remains as open space. Farmers aren't negotiating these types of things, because most of these negotiations take place during agricultural depression. There's some banker with a gun at his head saying, "Pay down the debt or sell the farm." I think that has to change. A lot of the fees based around this type of arrangement are based on a dry year buyout, and they're based on the price of corn that the farmer can't raise during that buyout. That isn't the way to price this type of thing. Base it on the value of the water...what it would cost you to develop it, and what you're getting in return.

In light of this, Mr. Sullivan (Douglas County Commissioner who spoke earlier) was talking about a 25-cent surcharge on their water. I think he ought to make it 75 cents, because I think agriculture ought to wake up. And if the plan of the municipalities is to buy agricultural water, then agriculture ought to get its worth. What is the value of agricultural water? Obviously there are a lot of factors that have bearing on the final outcome — location, quality, decree date. We all think about those, but there is something out there that we've learned is perhaps even more valuable than that. And that's the permits associated with the facilities. In this day of regulation and recovery, they may well be worth as much as the water, because you can't get them anymore.

Folks, we live in a desert. Our ancestors built a superstructure that has made this desert bloom with amber waves of

grain...with generations of families... with thousands of dreams come true...and memories too special and unique to be forgotten. We must not be satisfied with solutions that last until we retire. How many times have you heard..."Give me 15 years, I'll be gone." We must, with the

We must not be satisfied with solutions that last until we retire. How many times have you heard..."Give me 15 years, I'll be gone." We must, with the Bill FARRS of the world, look to the next generation.

Bill FARRS of the world, look to the next generation. You know, today is yesterday's tomorrow. Tomorrow will be today before this conference is over. Time goes by awfully fast. If you don't believe me, sign a 90-day note.

So where do we go from here? Well, the short-term answer is to buy agricultural water. Unfortunately, that also will be the long-term answer. Even if every city changed its policy and developed unused resources, eventually agriculture would again stand as the last and only resort. Trans-basin diversion is going to be more and more difficult, if not impossible. Agriculture is going to become more and more important in the acquisition supplies to take care of

the thirsty people who are moving to this state. We do need to develop the remaining sources left to us, and we need to do it in such a way that we include the fish and the critters that live there. The Endangered Species Act is here to stay, but reality will bring it into proper focus. As the city limits push farther and farther into the surrounding farms and ranches, the farmers — like the elk, the antelope, and the American Indian — will be pushed to poorer and poorer land. But, they will be expected to feed more and more people, despite increasing regulations. There's one thing we can do, and I think it's something we all should do. I think we should all go home, gather our families together, and eat a fantastic meal. And then pray that it's not our last.

Thank you.

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NEW FACULTY**Janis M. Carey***Assistant Professor
Division of Economics and Business
Colorado School of Mines*

Janis M. Carey has joined the faculty of the Division of Economics and Business at the Colorado School of Mines in Golden, Colorado. Janis's teaching interests include microeconomics, environmental and natural resource economics, energy economics and industrial organization. Her research interests center on emerging markets in water and electric utility restructuring.

Janis received an A.B. in Political Economy from Princeton University in 1990 with honors; a M.S. in Agricultural and Resource Economics from the University of California, Davis in 1993; and a Ph.D in Agricultural and Resource Economics from the University of California, Berkeley in 1998. Her Doctoral Dissertation was titled, *Emerging Markets in Water: Investments in Institutional and Technological Change*. Janis is working to submit the following papers, based on work from her dissertation, for publication this summer:

A Model of Investment Under Uncertainty: Modern Irrigation Technology and Emerging Markets in Water – develops a dynamic technology adoption model with input supply and price uncertainty to examine the effect of a water market on a farm's decision to adopt modern water-conserving irrigation technology. Due to the uncertainty of future water supplies and prices and the quasi-irreversible nature of an investment in modern technology, the option to delay investment provided by a water market can be valuable (submitted to AJAE);

The Effects of Transaction Costs on Market Trading Behavior: Theory and Application to Westlands Water Market – develops a theoretical model to examine the effect of fixed transaction costs on water market trading patterns. The model is tested empirically using unique farm-level water trading data from Westlands Water District, located in California's Central Valley. The paper analyzes a farm's decision to engage in "internal trades," within networks of affiliated farms, versus "market trades" which involve search and negotiation costs;

A Comparative Institutional Analysis of Emerging Markets in Water: The Central Valley Project and the Colorado-Big Thompson – an analysis of how the rate of transition toward water markets has varied. The paper compares the variation found in two Bureau of Reclamation water projects: the California Central Valley Project (CVP) and the Colorado-Big Thompson Project (C-BT). Most CVP water transactions are limited to short-term rental markets within the agricultural sector, and a significant number of the transactions are informal barter exchanges between families and friends. In contrast, C-BT water is transferred in both short-term rental markets and long-term sales markets within and between agricultural and urban areas.

**Janis M. Carey**

CWRRI

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Janis was one of the creators of **WaterLink**, an electronic marketing system that allows water users to buy and sell water using their home computers. To use the electronic marketing system, a water user needs only a computer, a modem and the WaterLink software. The prototype WaterLink system was a self-contained "client-server" network that connected a water district (the server) and water users (the clients). A newer internet-based system is being developed that will offer more services and include more users.

The Development of

WaterLink — The system was established in the most active California agricultural water market, located in Westlands Water District near the city of Fresno. The largest water district in the Central Valley Project (CVP), Westlands includes 600 farms covering nearly 600,000 acres. In a given year, thousands of water transfers are made and hundreds of thousands of acre-feet change hands. For example, during the 1994-95 season, 2,563 trades were made and 284,480 acre-feet of water were transferred.

Unlike most markets, the water market in Westlands had no centralized trading location and no publicly posted market price. Potential traders spent considerable resources gathering market information, finding potential trading partners, and negotiating deals. WaterLink was designed to increase the flow of information between farmers and the water district and to facilitate trades.

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URL: <http://www.mines.edu/igwmc/>



International Ground-Water Modeling Center 1999 Short Course Schedule

Advanced Groundwater Modeling	JUN	15-18	\$1345	<i>\$1545 after 6/4</i>
Applied Environmental Statistics	JUN	21-25	\$1295	<i>\$1495 after 6/4</i>
PHREEQC: Geochemical and Reaction Transport Modeling	OCT	21-23	\$1095	<i>\$1295 after 10/9</i>
MODFLOW: Introduction to Ground Water Modeling	OCT	20-23	\$1345	<i>\$1545 after 10/9</i>
UCODE – Universal Inversion Code Automated Calibration of "Any" Code	OCT	22-23	\$ 995	<i>\$1195 after 10/10</i>
Subsurface Multiphase Fluid Flow and Remediation Modeling	OCT	28-30	\$1095	<i>\$1295 after 10/15</i>

FOR INFORMATION CALL (303) 273-3103

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VISIT <http://www.mines.edu/igwmc/> FOR MORE INFORMATION

WaterLink went on-line in Westlands Water District in March 1996, after training sessions with district staff members and water users. WaterLink users have access to weekly and seasonal market statistics on the number of transactions and the volume of transactions. They can post offers to buy and sell water, and they can read offers that have been posted by other users. To post a water-wanted or water-for-sale ad, they simply fill out a form and e-mail it to the WaterLink administrator. The administrator reviews the form and then posts the ad to an electronic bulletin board that all WaterLink users can access. Water users can still negotiate deals and communicate with the water district by phone, fax, or in person; however, e-mail is in many ways more convenient.

WaterLink also provides other services: users can place water delivery orders electronically and

Where in Colorado are you, if the water quality is ... ?

Answers: 1,D; 2,C; 3,B; 4,F; 5,E; 6,A

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obtain their water account balances much like one obtains a bank account balance at an ATM. This feature enables water users to manage their water supplies more effectively and helps streamline water district operations. Also, as with other network technologies, the worth of WaterLink will increase as the number of e-mail users increases.

Recently, the system's capabilities have expanded to include more water districts in the Central Valley. In addition, the Bureau of Reclamation in Sacramento can use the system to buy water for instream flows. Soon the Santa Clara Municipal Water District may be on the system as well, allowing water transactions among agricultural, urban and environmental sectors in California.

CU Water News

CENTER WELCOMES NEW DIRECTOR

The Natural Resources Law Center is extremely pleased to announce the hiring of a new Director. Gary C. Bryner comes to the Center from Brigham Young University, where he has been a Professor of Political Science, serving as Director of the Public Policy Program since 1991. Gary's academic background is ideally suited to the modern incarnation of the Center. In addition to holding a law degree from BYU, he also possesses a Ph.D. in Government from Cornell University and a B.A. and M.S. in Economics from the University of Utah. This interdisciplinary training is evident in many of Gary's publications, including his work in the areas of air pollution and global environmental issues, and his more thematic works examining the interplay of science, law, markets, administrative behavior, and regulatory policy.

Gary is well known to the Center, having served as the Center's El Paso Energy Corporation Fellow in the Spring of 1997, during which he studied issues of wilderness development in federal protected areas. Gary has also been involved in various ways with several other research institutions, including the Brookings Institution, the National Academy of Public Administration, and the Natural Resources Defense Council. In these and many other positions, Gary has not only distinguished himself as a gifted scholar and teacher, but as a thoughtful and responsible colleague. These personal qualities were of particular interest to the Search Committee, who sought a candidate capable of building upon the Center's tradition of honest



Gary C. Bryner

and balanced research, broadly-focused collaborations, and service to diverse constituencies.

Due to previous commitments to Brigham Young University, Gary and his family will not complete their relocation to Boulder until August. Until then, Kathryn Mutz will continue to handle the day-to-day administrative duties as interim director. As the transitional process enters its final stages, the Center wishes to extend thanks to the many parties who have provided assistance during this interim period, including the Center's Advisory Board, the Law School Faculty and Dean, members of the Search Committee, cooperating foundations, and the many other friends of the Center. Special recognition and thanks are extended to Kevin Reitz, director of the Search Committee. This process has again demonstrated that the strength of the Center lies in its vast network of friends and collaborators, an asset that was highly useful in attracting an impressive group of applicants.

RESEARCH AWARDS AT COLORADO UNIVERSITIES

A summary of research awards and projects is given below for those who would like to contact investigators. Direct inquiries to investigators in care of the indicated department and university. The list includes new projects and supplements to existing awards. The new projects are highlighted in bold type.

COLORADO STATE UNIVERSITY FORT COLLINS, CO 80523

Title	PI	Dept.	Sponsor
Development of New Methodologies for Determining Extreme Precipitation	Cotton,William R	Atmospheric Science	CWCB
Preble's Mouse Surveys for the U.S. Forest Service, Trout Creek	Schorr,Robert	Fishery & Wildlife Biology	USDA/USFS
Coordination of Central U.S. National Institute for Global Environmental Change Integrated Assessment	Elliott,Edward T	Soil & Crop Sciences	UC Davis
Cutthroat Trout Response to Invasions by Brook Trout	Fausch,Kurt D	Fishery & Wildlife Biology	USDA/USFS
Evaluating risks of extinction from habitat Fragmentation for native cutthroat trout in Colorado	Fausch,Kurt D	Fishery & Wildlife Biology	USDA/USFS
Cutthroat Trout Response to Invasions by Brook Trout	Fausch,Kurt D	Fishery & Wildlife Biology	USDA/USFS
Coupling Atmospheric, Ecologic, & Hydrologic Processes in a Regional Climate Model	Pielke,Roger A	Atmospheric Science	NASA
Dynamical Studies in Hurricane IntensityChange	Montgomery,Michael T	Atmospheric Science	DOD-NAVY-ONR
Sediment Basin Hydrograph Simulations	Gessler,Daniel	Civil Engineering	DOD
Upper Arkansas Contract	Fayette,Kimberly	Fishery & Wildlife Biology	TNC
Salinity Studies	Gates,Timothy K	Civil Engineering	BSCB
Studies of Ice Nucleating Aerosol Particles in Arctic Cloud	Rogers,David C	Atmospheric Science	NASA
MoFlo Flow Cytometer	Orme,Ian M	Microbiology	HHS-NIH
Stream Water Quality Modeling Technology Development	Garcia,Luis	Chem. & Bioresource Engr.	DOI
Atmosphere Biosphere Interactions	Denning,A Scott	Atmospheric Science	NASA
Strategies to Reduce the Effects of Brook Trout and Cutthroat	Fausch,Kurt D	Fishery & Wildlife Biology	DOI
Regional Forest-ABL Coupling: Influence on CO2 & Climax	Denning,A Scott	Atmospheric Science	Uof Minn.
Large Eddy Simulation of Cirrus Clouds	Cotton,William R	Atmospheric Science	NASA
Arkansas Valley Project	Schweissing,Frank C	Arkansas Valley Research	Various "for profit"
Effects of Water Developments on Breeding Birds in the Little Missouri National Grassland	Kennedy,Patricia L	Fishery & Wildlife Biology	DOI
East Anatolia Watershed Training Project -Administration	Cook,Alicia Skinner	International Programs	CID
East Anatolia Watershed Training Project -Communication	Niehaus,Merle H	International Programs	CID

*FEDERAL SPONSORS: BLM-Bureau of Land Management, COE-Corps of Engineers, DOA-Department of the Army, DOE-Department of Energy, DON-Department of the Navy, DOT-Department of Transportation, EPA-Environmental Protection Agency, NASA-National Aeronautics & Space Administration, NBS-National Biological Survey, NOAA-National Oceanic & Atmospheric Admin., NPS-National Park Service, NRCS-Natural Resources Conservation Service, NSF-National Science Foundation, , USBR-US Bureau of Reclamation, USDA/ARS-Department of Agriculture, Agricultural Research Service, USDA/NRS-Department of Agriculture, Natural Resources Service, USFS-US Forest Service, USFWS-US Fish & Wildlife Service.

STATE SPONSORS: CDNR-Colorado Department of Natural Resources, NCWCD-Northern Colorado Water Conservancy District, CDWL-Colorado Division of Wildlife, CDA-Colorado Department of Agriculture, CDPHE-Colorado Department of Public Health and the Environment.

OTHER SPONSORS: CID-Consortium for International Development, AWWA-American Water Works Assn.

UNIVERSITY OF COLORADO
BOULDER, COLORADO 80309

Title	PI	Dept.	Sponsor
Investigation of Soil Aquifer Treatment for Sustainable Reuse: Characterization of Effluent Organic Matter	Amy, Gary	Civil, Environmental, and Architectural Engineering	ASU
Late Quaternary History of the Western and East-Central Ross Sea, Antarctica: A Contribution to the West Antarctic Ice Sheet Initiative	Andrews, John	Geological Sciences	IAAR
Collaborative Research: Transitions-A Study of the Spatial and Temporal Transitions of Climate and Ecosystems in the Circumpolar Arctic	Lynch, Amanda, Mark	Coop. Inst. for Research in Environmental Sciences	NSF
Feedback Coupling Between Flow and Reactions in Heterogeneous Porous and Fractured Media: Computational and Experimental Studies	Rajaram, Harihar	Civil, Environmental, and Architectural Engineering	NSF
Land and Land-Use Change in the Climate Sensitive High Plains: An Automated Approach with LANDSAT	Goetz, Alexander	Coop. Ins.for Research in Environmental Sciences	NASA
Sea Ice and Ocean Processes in Baffin Bay: A Study Using RADARSAT Data and Numerical Modeling	Steffen, Konrad	Cooperative Institute for Research in Environmental Sciences	NASA
Greenland Ice Sheet Climatology and Surface Energy Balance Modeling: Greenland Climate Network	Steffen, Konrad	Coop. Inst.for Research in Environmental Sciences	NASA
Green River Temp. Study: Simulation and Optimization of a Coupled Flow and Water Temperature Model	Rajaram, Harihar	Civil, Environmental, and Architectural Engineering	BOR
Cultural Resource Management: Tech. Support to the Remediation Venture Office, Rocky Mtn. Arsenal	Hoffecker, John	Institute of Arctic and Alpine Research	NPS
Extending the GTAP Data Base for the Analysis of Climate Change Policies	Rutherford, Thomas	Economics	DOE
Reservoir Stratigraphy and Its Controls on Reservoir Architecture and Performance: An Investigation of Key Surfaces and Fabrics in Marginal Marine Environments	Pulham, Andrew	Geological Sciences	Various Oil Com.
A Hierarchical GIS and Electronic Geobotanical Atlas for the Kuparuk River Basin, Alaska	Walker, Donald	Institute of Arctic and Alpine Research	Marine Bio. Lab.
Collaborative Research: Experimental Study of Basin Stratigraphy	Syvitski, James	Institute of Arctic and Alpine Research/Geological Sciences	Duke Uni.
Seasonal Differences in Air-Snow Chemical Relationships at Summit, Greenland	Steig, Eric	Institute of Arctic and Alpine Research/Geological Sciences	NSF
Labrador Sea Variability Over Decade to Millennial Time Scales	Overpeck, Johnatan	Institute of Arctic and Alpine	NSF
Niwot Ridge Long Term Ecological Research Program 1998-2004: Control on the Structure, Function, and Interactions of Alpine and Subalpine Ecosystems	Seastedt, Timothy	Institute of Arctic and Alpine Research/Environ., Pop. And Organismic Biology/Geography	NFS
A Framework to Reassess Basin Research and Educational Priorities in Hydrological Sci.	Gupta, V.K.	Coop. Inst. for Research in Environmental Sciences	NSF
An Archive and Data Distribution Sys. For Glaciological and Cryospheric System Data from the Glaciological Data Center	Scharfen, Gregory	Cooperative Institute for Research in Environmental Sciences	NSF
Development of a 3-D Sea Ice Model for Climate Applications	Curry, Judith	Program in Atmospheric and Oceanic Sciences	NSF
Ultrasonic Assessment of Damage in Concrete Materials	Willam, Kaspar	Civil, Environmental, and	NSF
Development of an Embedded Crack Method for the Shear Behavior of Reinforced Concrete Structures	Shing, P.S. Benson	Civil, Environmental, and Architectural Engineering	NSF
Observations and Modeling of Flow and Fracture Processes Leading to Iceberg Calving	Amadei, Bernard	Civil, Environmental, and Architectural Engineering/Inst. Of	NSF
Measurements of C10 and CO2 for Accent	Toohey, Darin	Coop. Inst. for Research in Environmental Sciences	NASA
In Situ Measurements of Halogen Oxides	Toohey, Darin	Coop. Inst. for Research in Environmental Sciences	NASA
Atmospheric Studies Using POAM II Data	Rusch, David	Lab. For Atmos. And Space Physics	DON



CHILDREN'S WATER FESTIVALS—MAKING WATER MORE FUN!

by Jamie Miller

On March 29 the Central Colorado Water Conservancy District (CCWCD) held its ninth annual Children's Water Festival at Aims Community College in Greeley. The festival brought together 5th graders from area elementary schools to educate them about Colorado's liquid gold, WATER. Water Festivals began nine years ago in Greeley, under Tom Cech's leadership, and are now held around the state. Cech is Manager of the CCWCD. The festivals educate children with workshops and exhibits presented by private industries, educational institutions, federal and state agencies, and conservancy districts.

Classes participate in classroom activities, exhibition hall activities and the water wizard. Each activity is aimed at educating the children about specific areas of water resources. Activities include learning about erosion, water rights, groundwater, water quality, recycling, meteorology and much, much more. In classroom activities children can resolve disputes in water court, or learn to fly fish.



Ralph, the water dog, greets students to The Ninth Annual Greeley Children's Water Festival.

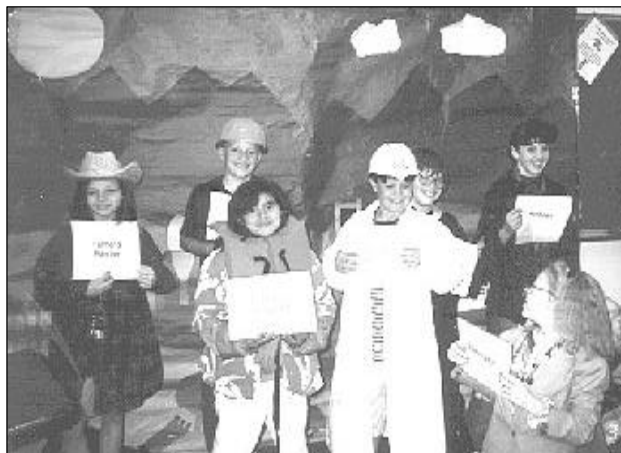


Brian Cohn and Domi Fellerf from the CSU Watershed Science Club explain Careers in Water.

This year the Water Resources Research Institute participated in the festival in collaboration with the Colorado State Watershed Science Club. Club representatives Brian Cohn and Domi Fellerf taught children about Careers in Water. The student's dressed in attire for their profession and taught other members of their class about their Career in Water.

Children's Water Festivals are fun for both students and presenters. These festivals are an excellent way to educate Colorado's children about one of our most precious resources, WATER.

Exhibition hall activities include some of the children's favorite activities from getting their hands dirty learning about erosion to standing in the center of a giant bubble. The water wizard creates an intense competition between classes to test their water knowledge. The festival also provides a resource room to teach teachers more about water curriculum materials.



Fifth graders from Greeley dress to fit their future Careers in Water.



WATER NEWS DIGEST

by Jamie Miller

AGRICULTURAL WATER CONSERVATION

Water conservation effort targets Arkansas Valley farmers

A federal program is under way to help farmers pay for better water management practices and help the environment. The Highline Breaks Watershed Project will provide \$3 million in cost-share money over five years to farmers in Pueblo and Otero counties who make irrigation improvements to their land. Farmers and the government will share the cost of replacing dirt irrigation ditches with pipelines, leveling fields, installing surge-irrigation valves, lining dirt ditches with concrete and installing gated-irrigation pipe. The 15-year project will be administered from the Natural Resources Conservation Service office, according to the area's district conservationist. The money will be paid during the next five years, with certain amounts allotted for each year. The project has a lengthy timetable so growers don't have to pay for all of the improvements at once. Replacing old dirt ditches with pipelines and concrete-lined ditches can save as much as 30 percent of the water used for irrigation. Some of the improvements also may save work for farmers.

The Pueblo Chieftain 03/31/99

DAM SAFETY

Pueblo Dam declared safe

Pueblo Dam is safe enough to store flood water, and Southeastern Colorado Water Conservancy District officials wonder if it should be enlarged as part of a plan to increase water supply along the Arkansas River. The dam enlargement is one option in the district's attempt to fit water storage needs with supply for the next 40 years.

The Fort Collins Coloradoan 5/22/99

Horsetooth Dam still has seepage problems

Dam expert Beth Boaz, Chief of Civil Engineering for the Bureau of Reclamation in Loveland, believes the seepage at Horsetooth Dam is caused by a bed of porous limestone underneath the reservoir. The weight of the lake is forcing water to travel underneath Horsetooth Dam through the limestone, she said. The water seeping under the dam is clear and not cloudy with sediment, so the earthen dam is not weakening because of seepage-caused erosion. Core samplings from 16 drillings up to 300 feet deep are being analyzed at the USBR's Technical Service Center. Results of the samples should be available in September.

The Fort Collins Coloradoan 5/13/99

FLOOD MANAGEMENT

More counties get federal flood aid

Pueblo and six other counties were added May 21 to President Clinton's declaration of Colorado flood disaster areas eligible for federal assistance. A spokesman for the Federal Emergency Management Agency, said Pueblo, Crowley, Custer, Fremont, Kiowa, Las Animas and Elbert counties could apply for 75 percent reimbursement of eligible public costs. The other five — already identified as Bent, Otero, El Paso, Larimer and Weld counties — qualified for both public assistance and individual relief specific to owners of private homes, businesses and agricultural properties. The three counties not yet recommended for assistance were Baca, Teller and Morgan.

Pueblo Chieftain 5/22/99

CSU study to test corps' weather data

A three-year project by Colorado State University will test science used by the U.S. Army Corps of Engineers in its study of Cherry Creek Dam, which has declared the dam unsafe. Congressional officials said CSU's project will serve as the peer review for which they and local residents have been asking. But some local officials said the three-year time frame is too long. The corps plans to finish its environmental study of several possible dam upgrades and choose a solution by year's end. The corps plan hinges on a NWS estimate of a "probable maximum precipitation" for the 390-mile Cherry Creek basin: 25 inches of rain over three days. That would flood Cherry Creek and cause the dam to fail, which corps officials say would kill thousands of people downstream and cause billions of dollars in damage. Several preliminary solutions have been proposed by the corps, including one or more dry-dam sites in Douglas County that could displace dozens of residents. Douglas County officials say they will move forward on plans for a separate review of the NWS data — one that could be done in 9 months. The Colorado Water Conservation Board has committed \$75,000 toward a independent review, which is estimated to cost \$150,000. The board has requested matching funds on the local level for the balance. Greenwood Village has committed \$25,000 and Arapahoe County last week OK'd up to \$20,000 to go toward a peer review. Although Douglas

County Commissioner Jim Sullivan has said the board of county commissioners would be willing to fund up to \$25,000 for a review, the board has not taken any official action. CSU Professor of Atmospheric Science William Cotton, who will oversee the project, said his study is an effort to find a new method for determining "extreme precipitation estimates." The traditional method used by the weather service, he said, takes historical weather data from lower elevations and transposes them over higher elevations, which Cotton said might affect the validity of probable maximum precipitation estimates.

Douglas County News Press 5/26/99

GROWTH

Metro-area population takes a leap —23% rise to 2.3 million in a decade blows forecast of slowdown

The Denver area grew by nearly 54,000 people in 1998, surprising forecasters who had expected a slowdown in the decade-long population boom. The population has grown 23 percent since 1990. Arapahoe had the largest population increase, adding 14,725 people in 1998. Douglas County continued its booming growth in 1998 adding 11,300 people for a total population of 154,300 and the region's highest growth rate, 7.9 percent. Douglas has more than doubled its 1990 population of 60,391. Larry Mugler, DRCOG, said as the south metro area fills in, he expects to see growth swing to the north.

Denver Rocky Mountain News May 25, 1999

LITIGATION

Kansas/Colorado dispute now in 15th year – cooperative solutions urged

Unless Colorado can patch up its differences with Kansas, the two states will be spending many more years in court. That's the message the state's top water officials delivered at a meeting of the Southeastern Colorado Water Conservancy District in May. Kansas and Colorado have been in court for nearly 15 years over the Arkansas River Compact. Kansas won the case, but the amount of damages is still being determined. Kansas wants about \$79 million in cash damages paid to farmers in three western counties. Colorado is arguing that it should instead repay with water. Colorado denied Kansas about 420,000 acre-feet of water over a 45-year period, according to a U.S. Supreme Court decision. The states will return to the courtroom in November, and expect to spend three months defending their positions before special master Arthur Littleworth. His decision will then be reviewed by the Supreme Court, which will decide whether more judicial intervention is needed and whether water, money or both will be used to repay the debt. The process could take another 18 months.

Pueblo Chieftain 5/21/99

RIVER RESTORATION/HABITAT IMPROVEMENT

Project hopes to improve Conejos River trout habitat

Quality of trout habitat on the upper Conejos River will get a boost from a partnership project involving the Colorado Division of Wildlife, the Rio Grande National Forest, Natural Resource Conservation Service and the San Luis Valley Chapter of Trout Unlimited. The president of the local Trout Unlimited chapter said it has been awarded a \$10,000 grant from the national Trout Unlimited "Embrace-a-Stream" program to assist with the project. The project will cost more than \$56,000 with the DOW bearing about 55 percent of the cost. The National Forest will contribute 13 percent and TU will contribute amounts to about 32 percent. The initial phase of the project involves the strategic placement of boulders throughout the 1-mile stretch of river to create a deeper channel and deeper pools and to provide protective structure for fish. Some bank stabilization work also will be done. The goal is to enable the section of river to sustain a healthy, wild trout population year-round and eliminate the dependence on hatchery fish.

Pueblo Chieftain 04/20/99

Colorado River will be flooded

Water will flood the 15-mile reach of the Colorado River above its confluence with the Gunnison River, home to the endangered razorback sucker and Colorado pike minnow. So much snow fell this spring that the Bureau renewed plans to release water simultaneously from more than a half-dozen dams in early June. Dams at the Dillon, Granby, Wolford Mountain, Homestake, Ruedi and Green Mountain reservoirs voluntarily will allow peak flows to head downstream.

The Fort Collins Coloradoan 5/22/99

WATER MARKETS

River board says no to downstream sales

Selling water downstream to California is not only illegal, but unethical as well, say officials from the Upper Colorado River Commission. James Lochhead, former executive director for the Colorado Department of Natural Resources and current Colorado representative on the commission, and commission Executive Director Wayne Cook were adamant in their opinion that selling water to downstream states would violate the 1922 Colorado



River Water Compact. Both Lochhead and Cook addressed members of the Colorado Water Conservation Board, who were gathered at Grand Junction for the Board's bimonthly meeting. In the compact, Colorado received a perpetual right to develop the water, and by selling its resource to California, "We'd break the fundamental principle," and potentially jeopardize the compact, Lochhead said. "Even if someone in a lower basin state were to lease an acre-foot from an upper basin state, the secretary (of the Interior) could not deliver it without being in contempt of court," Cook said, citing a landmark case between Arizona and California.

Grand Junction Daily Sentinel 5/26/99

WATER QUALITY

GAO report doubts Flats plant can meet 2006 or 2010 cleanup deadlines

A new federal report casts doubt on plans to clean up and close the Rocky Flats site by 2006. In fact, the General Accounting Office study questions whether the defunct nuclear weapons plant 8 miles southeast of Boulder can even close by 2010, the federally mandated deadline. The Energy Department, which oversees the plant, hopes to save at least \$1 billion by closing it four years early, at a cost of between \$6.5 billion and \$7 billion. Last summer, the GAO looked specifically at deadlines involving the removal of all the plutonium. That report said officials may be "overly optimistic" about plans to remove the plutonium by 2002 — a key date on the path to a complete shutdown in 2006. Two months earlier, the Energy Department released its own report indicating the plant probably won't be shut down before 2010. Employees of Rocky Flats told GAO investigators that "even the 2010 date" is "ambitious." Kaiser-Hill, the cleanup contractor, is expected to complete a detailed plan for the 2006 closure within weeks. The GAO report, requested by Sen. John Warner, R-Va., chairman of the Armed Services Committee, mirrors other recent assessments. Kaiser-Hill's own recent analysis on the 2010 closing date said Rocky Flats has a "1 percent chance of closing" by that date unless officials resolve technical problems and other uncertainties over its stockpile of radioactive materials.

Scripps Howard News Service -Boulder Daily Camera 5/19/999

Fish emulate coal mine canaries to test Big Thompson water

Mike Tesar was inspired to act when large numbers of trout died in the vicinity of Chasteen's Grove in 1990 and again in 1992. The lab coordinator at the Chasteen's Grove Water Treatment Plant 10 miles west of Loveland diverted a small flow of water from the plant's main 48-inch diameter supply line to an aquarium full of trout. The water runs through the tank in a continuous flow before heading back into the plant for treatment. Trout, very sensitive to organic compounds such as gasoline and other chemical spills that could otherwise enter undetected into the city's water supply, provide a quality check for the treatment plant's water. "We all look at them every time we walk by," Tesar said.

The Coloradoan 5/24/99

WATERSUPPLY/DEVELOPMENT/PLANNING

Plan to utilize Gunnison Basin water presented

Former water board member Butch Clark has forwarded a plan to directors of the Upper Gunnison River Water Conservancy District to utilize unused Gunnison Basin water. Called the Cochetopa to Tomichi Pumped Diversion Project or CoTom, Clark claims that his project can do everything the Upper Gunnison's Monarch No. 5 reservoir can do for about one-tenth the price. Monarch No. 5 is one of several projects the Upper Gunnison proposed in March to Judge Robert Brown's water court to satisfy diligence requirements on the district's sizable conditional water rights. Unless Brown is convinced Upper Gunnison board members are moving projects forward which would use their conditional rights, he could strip them away. The cost of CoTom is estimated by Clark to be \$15.5 million. District engineers pegged Monarch No. 5, near the base of Monarch Pass, at \$144 million. Clark asked the district for a memorandum of agreement for 2 percent of the cost savings, more than \$2.5 million, if it decided to use CoTom. The district hopes to demonstrate to Brown this year that it has made significant progress toward putting its conditional rights to use. Once put to use, conditional rights become absolute.

The Gunnison Country Times 04/08/99

Timeline set for A-LP Project

During a 2-day meeting during the week of May 22, the Colorado Water Conservation Board laid out plans of action for the Animas-La Plata Project over the next year-and-a-half. If environmental studies are not delayed, and A-LP legislation survives Congress, construction on the project is tentatively scheduled to begin sometime in 2001. Action begins with defining and analyzing the 10 project alternatives put forward in the Bureau of Reclamation's January notice of intent, including Interior Secretary Bruce Babbitt's A-LP Ultra-Lite. Alternatives range from no action to the construction of a 135,000-acre-foot reservoir in Ridges Basin. In the meantime, repayment negotiations will begin among the bureau and the Southern Ute Indian Tribe, the Ute Mountain Ute Tribe, the Navajo Nation, the Animas-La Plata Water Conservancy District and the San Juan Water Commission.

Durango Herald 5/27/99



Dam possible for Poudre's North Fork?

For years the Northern Colorado Water Conservancy District has pursued the possibility of a lower-canyon dam on the Cache la Poudre. Now, however, district officials are exploring the possibility of damming the North Fork of the Poudre and leaving the main stem of the river free-flowing. After completing initial ecological and geological assessments, no flaws have been found in this alternative. Set up for the sole purpose of providing water for people in northeast Colorado, NCWCD won rights to water in the Poudre River in the 1960s. As long as district officials proceed "with due diligence" on plans to develop those rights, they are protected for future water needs in Fort Collins, Greeley and other downstream communities. If the right is lost Thorton is the next in line for use.

This alternative would expand Seaman Reservoir on the North Fork of the Poudre and eliminate the need for a main-stem dam. Because much of the water comes during spring runoff, it will have to be pumped to the North Fork reservoir for storage—a costly venture. Even if the district officials decided tomorrow they wanted to build the project, federal regulations would require years of studies and permit applications before any soil would be moved. The NCWCD would not move ahead with the application process unless area water users, such as the city of Fort Collins, wanted a dam and agreed to participate in its construction.

The Fort Collins Coloradoan, 06/03/99

Lake Dillon may see higher than usual levels this season

Water levels in Dillon Reservoir will soon be back to normal, it was announced May 26 at a public forum on water in Silverthorne. Dillon Reservoir water is used as a seasonal water supply and drought reserve by Denver Water. Marc Waage, manager of raw water supply for Denver Water, said late-season precipitation brought water flow estimates back to normal levels after relatively low snow fall during the winter months. Currently, Dillon is 85 percent full and fill date is estimated to be middle to late June.

Breckenridge Journal 5/27/99

WETLANDS

Flats prairie protected —Richardson announces protection of wetlands in buffer zone

In the first official move to protect the Rocky Flats buffer zone from future development, U.S. Secretary of Energy Bill Richardson, Gov. Bill Owens and U.S. Fish and Wildlife Service regional director Ralph Morganweck have signed an agreement to preserve the portion of wetland along Rock Creek. The newly protected land is home to the federally protected Preble's meadow jumping mouse, loggerhead shrikes, coyotes and deer. It may someday become a national wildlife refuge, Richardson said. He and the Rocky Flats site manager said that they expect to draw local governments into all future decisions about the area, such as when the public may be allowed to visit. The Energy Department will continue to own the property. It will manage it in cooperation with the Fish and Wildlife Service.

Boulder Daily Camera May 18, 1999

Region's first wetlands bank planned in Erie

A 90-acre parcel straddling Colo. 52 near Weld County Road 5 was approved in May by the U.S. Army Corps of Engineers as the region's first wetlands bank — a place for developers to account for destruction of marshy land in other areas. The method of profiting through preservation is largely untested in areas where water is relatively rare and expensive. The Erie site is the first in this corps district, which includes northeast Colorado, North and South Dakota, Montana, Nebraska and Wyoming. With careful management, the project is planned to be a diverse, balanced preserve where builders of all kinds can purchase credits — in the form of land amounts set by the corps of engineers — to make amends for harming wetlands in another area.

Boulder Daily Camera 5/27/99

WHIRLING DISEASE

Whirling Disease found in Animas River

Whirling disease, which has shut down stocking from the Durango Fish Hatchery over the past two years, has now been found in the Animas River. "It's not a good sign," said Colorado Division of Wildlife fisheries biologist Mike Japhet. "The only thing we can do is stock the river to make sure there are still good fishing opportunities." Lab tests found whirling disease in a "significant" number of the 20 fish tested during last September's fish census of two stretches in the Animas. Japhet did not know the exact numbers of infected fish. He said it may be two or three years before the disease completely takes hold in the river. He also said little can be done to stop its spread; the only recourse is to increase stocking efforts. The overall effect on the Animas may not be known for years. Presence of the parasite in the Durango Fish Hatchery in March 1997 forced officials to drain and disinfect the hatchery and ship about 150,000 10-inch rainbows to the Front Range instead of stocking them in local waters, which had been

free of whirling disease. At the time of last September's fish census, which surveyed fish on the Gold Medal stretch of the Animas, Japhet was optimistic that the disease had not reached the river, citing a lack of tell-tale signs. But he now says the Animas likely was infected by runoff from the fish hatchery in 1997. Japhet isn't planning to conduct another sampling of the river until September 2000. In the meantime, the Durango Fish Hatchery will begin stocking trout again if it tests negative for whirling disease early next month. In that case, the DOW would begin stocking the Animas with 3-to-5-inch trout for the first time since September 1996. Though still young, trout of that length appear less susceptible to whirling disease, Japhet said. "There's nothing we can do except to try to control the spread of the disease," Japhet said. "We're going to bend over backwards to try to do that."

Durango Herald May 15, 1999

MISCELLANEOUS

Yampa Valley to get \$3 million face lift

The Yampa River Legacy Project was awarded another \$3 million by GOCO. The project is sponsored by Steamboat Springs, Routt County, Craig, Moffat County and a partnership of nonprofit organizations, state agencies, agricultural and business interests. This will be the third Legacy Grant the project has received bringing the total to \$9.4 million to date. GOCO money, through the Yampa Valley Legacy Project, has funded the Yampa Valley Land and Cattle Company project that worked for the protection of more than 4,000 acres along the Yampa River and Lower Elk River through voluntary conservation easements. The project included six river access sites and building a Colorado State Parks campground.

Craig Daily Press 5/24/99

River District grants total \$137,000

The Colorado River District Board recently awarded over \$137,000 in grants to 12 water-related projects throughout the Western Slope. This was the second year of an annual grant program adopted by the board to assist smaller water efficiency, water quality and water supply programs within the 15-county River District area. Those receiving grants include the Kermel Owens #2 Headgate Improvement, \$8,300; Brock Ditch Headgate Relocation and Improvement, \$15,000; Roaring Fork Water Quality Inventory, \$9,905; Sheephorn Demonstration Project, \$9,400; Upper Colorado Environmental Plant Center Expansion, \$15,000; Canal Leakage Polymer Sealant, Uncompaghere Valley Water Users Assoc., \$13,500; Mesa Water Treatment System Improvements, \$15,000; North Fork Irrigation Diversion Demonstration Project, \$15,000; Westside Diversion #3 Headgate Improvement and Erosion Control, \$3,108; Anderson Ditch and Pipeline Efficiency Project, \$9,130; Bassett Reservoir #2 Outlet Works Improvement, \$5,000; Alsbury Reservoir Satellite Monitoring System, \$6,759; Four Mile Creek Basin-wide Augmentation Implementation and Measuring Devices, \$5,420; Sopris View Apartments Non-Potable Irrigation System, \$6,850.

Glenwood Springs Post 4/22/1999

Wyoming Legislature Funds Water Planning

For the first time in over 25 years, Wyoming is about to launch a new state-wide water planning process. The Green and Bear River Basins were selected for the first planning efforts. The Wyoming Water Development Association (WWDA) will reactivate the Bear River Basin Advisory Group that advised WWDC and the State Engineer's Office during the two-year feasibility study. WWDC and the SEO will use the Colorado River Basin Advisory Council to assist in the formation of an advisory group for the Green River Basin. WWDC has initiated the consultant selection process for data collection in the two basins, and plans to have the full-time planning staff on board by July 1. The tentative planning schedule calls for the first two basin plans to be completed in the fall of 2000. The WWDC will probably request funding to initiate the planning process in two more of the five remaining basins from the 2000 legislature. WWDC Director Mike Besson said he intends for the process to complete plans for all seven basins in the next five years. Permanent full-time staff authorized by Omnibus Water Bill HB93 will supervise activities of the contract consultants, provide support for the basin advisory groups, and ensure continuity as the process advances from basin to basin. The Water Resources Data System at the University of Wyoming will be the repository of the water planning data.

Wyoming Water Flow April, 1999



CALLS FOR PAPERS



ANNOUNCEMENT & CALL FOR PAPERS

WATERSHED MANAGEMENT 2000 CONFERENCE

Science and Engineering Technology for the New Millennium

June 21-24, 2000

Colorado State University, Fort Collins, Colorado

Colorado State University, Fort Collins, Colorado, will host the eighth in a series of American Society of Civil Engineers Watershed Management Symposia. The focus will be on state of the art advancements in watershed management for the more challenging problems decisionmakers will face in the 21st century and beyond. The symposia will coincide with a major conference of the U.S. Committee on Irrigation and Drainage and an international conference of alumni of the Colorado State University Water Resources program.

The symposia is sponsored by American Society of Civil Engineers Water Resources Engineering Division and Water Resources Planning and Management Division. Numerous other professional societies and government agencies will participate, including: the American Water Resources Association, the American Society of Agricultural Engineers, the Society for Range Management, the Society of American Foresters, the Soil and Water Conservation Society, the International Erosion Control Association, the Bureau of Reclamation, the Corps of Engineers, the Bureau of Land Management, the Natural Resources Conservation Service, the Forest Service, the US Geological Survey, the Environmental Protection Agency, the National Park Service and the Office of Surface Mining, Regulation and Enforcement. Abstracts for technical papers are solicited. Topic areas will include but not be limited to:

State of the Art Studies in Watershed Management	Sharing Watershed Information by Internet
Watershed Analysis and Planning	Channel Hydrology and Watershed Management
Modeling of Runoff, Sedimentation and Pollutants	Stormwater Runoff Management Regulation
Conservation at the Watershed Level	Design and Maintenance of Irrigation and Drainage Systems in Western Watersheds
Impacts of Urbanization and Vegetation Change	Watershed Management - Historical Program Reviews
Watershed Management Education	Watertable Management
Decision Support Systems in Watershed Management	Design Criteria for Wetlands to Treat Water Quality and Drainage
GIS Applications in Watershed Sciences	Governmental Policy and Actions: Riparian and Wetlands Management
Land Use Effects on Hydrology	ESA, TMDLs, NAWQA and NPRES

Abstracts should not exceed 500 words and should be typed in a double spaced format. If dual or multiple authors submit an abstract, one should be designated as the contact. The mailing address, daytime phone number, fax number and e-mail address for all authors should be provided. Three copies of the abstracts should be submitted by mail no later than August 31, 1999, to either address below:

Donald K. Frevert, Mail Code D-8510
 US Bureau of Reclamation - Technical Service Center
 PO Box 25007
 Denver, Colorado 80225
 phone: 303-445-2473
 fax: 303-445-6351
 e-mail: dfrevert@do.usbr.gov

Marshall Flug
 US Geological Survey - Midcontinent Ecological Science Center
 4512 McMurry Avenue
 Fort Collins, Colorado 80525 - 3400
 phone: 970-226-9391
 fax: 970-226-9230
 e-mail: marshall_flug@usgs.gov

Notification of Acceptance for the conference will be sent out by October 31, 1999. Authors whose papers are declined will also be notified by this date. Decisions on acceptance will be based on the information provided in the abstract. Authors whose abstracts are accepted will be required to submit their papers by February 28, 2000. A non refundable \$100 preregistration fee will be due for all accepted abstracts by December 15, 1999. This fee will be credited toward the conference registration fee. All published materials and presentations will be in English.

Questions? Contact the American Society of Civil Engineers, 1801 Alexander Bell Drive, Reston, VA 20191-4400, Phone: 800-548-2723 or 703-295-6300, Fax: 703-295-6144.

Author Policy: ASCE does not normally reimburse authors for expenses incurred - either in the preparation of abstracts or final papers, or for travel to the conference. Authors who submit final papers for the conference proceedings imply agreement to register for the conference at the appropriate fee, to attend the conference and to present their papers in person.





CALL FOR ABSTRACTS
ROCKY MOUNTAIN HYDROLOGIC RESEARCH CENTER
54TH ANNUAL MEETING
HYDROINFORMATICS OF MOUNTAIN AND PLAINS WATERSHEDS AND RIVERS
August 20, 1999
Colorado State University, Fort Collins, Colorado

GOALS OF THE MEETING: To provide researchers, practitioners and students an opportunity to share information in a relaxed, and scientifically stimulating atmosphere. The meeting will encourage interdisciplinary communication among a variety of professionals representing hydrology, engineering, environmental science, and other related professionals in the Rocky Mountain Region. The meeting is being held in conjunction with the Nineteenth Annual Hydrology Days, which will be August 16-20, 1999. Separate registration will be required for Hydrology Days. Contact Marilee Rowe at mrowe@engr.colostate.edu for general information about Hydrology Days.

TOPICS FOR THE MEETING: Any paper that relates to hydrologic, engineering, ecological or environmental considerations in the Rocky Mountains. Especially encouraged are papers on (1) stream and riparian vegetation management; (2) hydraulics, sediment transport, and 3) geomorphology; and paleohydrology, paleoclimatology, and palohydraulics.

TO SUBMIT ABSTRACTS: Abstracts of no more than one page in length should be submitted by 10 June 1999 to:

Robert T. Milhous
 Midcontinent Ecological Research Center
 Biological Resources Division
 U.S. Geological Survey
 4512 McMurry Ave.
 Fort Collins, Colorado 80525-3400

FOR INFORMATION Contact : Bob Milhous by phone (970-226-9233), FAX(970-226-9230), or via e-mail (robert_milhous@usgs.gov).



USGS SYMPOSIUM ANNOUNCEMENT AND CALL FOR ABSTRACTS
On Research Related To
ENVIRONMENTAL EFFECTS OF ANIMAL FEEDING OPERATIONS (AFOs)
Fort Collins, August 30 – September 1, 1999

The U.S. Geological Survey will hold an open symposium to examine the complex issues related to if and how waste products from AFOs may be affecting water resources and ecological health. Scientists from the Colorado State University, Ft. Collins, are collaborating to provide a field trip to livestock operations and discuss some of their research. All scientists from universities, the USGS, and other agencies and organizations who are involved with AFOs research are invited to attend and to submit abstracts.

Plenary session speakers include:

Don Ament, Commissioner, Colorado Department of Agriculture
 Paul Johnson, Director, Iowa Department of Natural Resources
 Paul Hitch, Cattle Rancher, Oklahoma

Carol Rubin, Chief, Environmental Exposures and Health Effects, CDC
 Mary Henry, Chief, Branch of Ecosystem Health, USFWS
 Roberta Parry, Office of Policy, USEPA

An objective of this meeting is to provide an interactive forum for information and discussion on the latest research dealing with the effects of AFOs on water resources and human and ecological health, including information on state-of-the-art methods and tools that are being used or developed to aid AFO research. Presentations will cover a wide range of multidisciplinary research and field studies in order to gain an understanding of what is and is not known on this topic. Areas to be covered include:

Nutrients, Antibiotics and other pharmaceuticals, Bacteria, viruses and protozoa, Trace elements, Source finger-printing methods, Air quality

For additional information, log on to < <http://water.usgs.gov/owq/AFO/index.html> >

MEETINGS



24th Annual COLORADO WATER WORKSHOP
 GARDEN OF DREAMS vs. HIGH-DESERT REALITY:
***Can We Save Everything, Keep Our Lawns Green
 ...AND Have Enough Water For Everyone?***

July 28-30, 1999

Western State College
 Gunnison, Colorado

Website:

<http://www.waterinfo.org/workshop.html>

We've transformed the western landscape and harnessed its waters in ways that John Wesley Powell never imagined possible. But now, with more people moving into the interior West than moving away from it, how do we maintain Colorado's largely manmade 'garden' as the number of demands on our water rapidly grows along with our net population? Is "having it all" still a possibility? Or is it just the wishful thinking of a post-WWII generation that has never experienced one of nature's biggest trump cards – a major drought - in the high stakes game of taming the West? Join us at the 24th annual Colorado Water Workshop as we take an intensive look at our needs and desires as they relate to water. We'll explore some creative options for supplying precious water to users and interests old and new. We'll hear from the experts on drought forecasting, drought planning and preparedness. We'll also weigh the myriad impacts of the choices before us now – impacts that can turn the future into one person's dreamland and another's nightmare. This summer's conference will be rich with philosophy, technology, legal perspectives, environmental ethics, and politics. Bring your thinking cap, your voice, and your sense of humor. We'll provide the

Keynote Address by L. RICHARD BRATTON, Attorney at Law
'Living Legends of Western Water' Series at Aspinall-Wilson Center

This Year's Special Guests: JOHN M. SAYRE (in person) and FELIX L. SPARKS (in an exclusive video interview)

At the I-BAR RANCH on Thursday night, July 29th

MICHAEL MARTIN MURPHEY and his Rio Grande Band in an ALL-NEW SHOW!

EXHIBITOR OPPORTUNITIES

For more information and an Exhibitor Registration Form, call Robin Helken at 970-641-6215, fax your request to 970-641-6219, or e-mail water@western.edu

Undergraduate/Graduate Credit: One hour of undergraduate credit (BUAD 497) from Western State College is an additional \$115. One hour of graduate credit (ED 589) from Adams State College is an additional \$150. Either amount must be a separate payment (not included in conference registration remittance) to Western State College. Students must be registered for the conference prior to enrolling for credit. (For financial assistance to attend conference, see website or e-mail: jlanson@western.edu.)

*** Full scholarship waives the \$225 conference registration fee, and two (2) nights dorm lodging on campus for students beyond a 50-mile radius of Western. Scholarship does NOT include undergraduate/graduate credit fees (offered through Western's Continuing Education Department). See website for SCHOLARSHIP APPLICATION REQUIREMENTS.**

IMPORTANT INFO: PLEASE READ FULLY – THERE ARE CHANGES FOR 1999!

CONFERENCE REGISTRATION FEES

The following schedule applies without exception (all prices include book of bound proceedings):

- \$225 per person for PAID* registrations postmarked or faxed by July 5th.
- \$275 per person for PAID* registrations postmarked or faxed July 6th through July 27th.
- \$300 per person at the door.



19th ANNUAL HYDROLOGY DAYS
August 16-20, 1999
Colorado State University — Fort Collins, CO

The objective of the Annual Hydrology Days is to provide a forum for hydrologists and hydrology students to get acquainted and to share problems, analyses, and solutions. Hydrology Days 1999 will be dedicated to the former students and worldwide professional colleagues of Hubert Morel-Seytoux. This will be the last year that Professor Morel-Seytoux will be the primary organizer of the group. The conference provides an opportunity for students to present papers in a friendly atmosphere, within the structures of a fully professional conference. The five-day program will include volunteered papers, invited papers, student papers, and a poster session. Awards and prizes will be given for the best student papers as oral or poster presentations in the following categories: B.S., M.S. and Ph.D.

For program information and registration forms contact H.J. Morel-Seytoux at HYDROLOGY DAYS, 57 Selby Lane, Atherton, CA 94027-3926; Phone and FAX 650/365-4080; or e-mail hydroprose@batnet.com. For registration/general information contact: Ms. Marilee Rowe (Hydrology Days), Dept. of Civil Engr., Colorado State University, Fort Collins, CO 80523-1372; Phone 970/491-5247; FAX 970/491-6787; e-mail mrowe@engr.colostate.edu. REGISTRATION FEES: \$240 by June 30, 1999; \$270 after June 30, 1999. Registration includes technical sessions, exhibits, posters, two lunches, refreshment breaks and two copies of the proceedings. One-day packages are available. DEADLINE: May 3, 1999. Website: <http://www.engr.colostate.edu/depts/ce/>.



Where in Colorado are you, if the Water Quality is?

By John Carillo

The quality of water in Colorado varies as you move about the state. The quality is measured by many organizations including the U.S. Geological Survey. Below are six locations identified with a number and several measurements of water quality made at each location, during the month of September. Using your knowledge of flows and quality, match the water quality to the location. (Answers are given on page 30.)

Locations, throughout Colorado, where water quality data was taken.

- 1) South Platte River at Julesburg, Colorado
- 2) Colorado River near Grand Lakes, Colorado
- 3) French Gulch at Breckenridge, Colorado
- 4) Gore Creek near Minturn, Colorado
- 5) Uncompangre River near Ridge Way, Colorado
- 6) Gunnison River near Grand Junction, Colorado

Water quality data that were taken

Location	Discharge cubic ft./s	PH	Temperature degrees C	Oxygen dissolved mg/L	Chloride dissolved mg/L	Total Dis. Solids mg/L	Nitrogen Dissolved mg/L
A	1500	8.4	18.0	7.5	7.1	749	1.5
B	5.1	7.8	8.0	8.8	1.0	164	0.07
C	16	7.7	9.5	8.7	<0.1	47	0.07
D	1130	8.4	15.5	10.0	61	978	5.8
E	69	8.0	15.0	8.2	4.9	512	0.12
F	28	7.8	9.0	8.9	6.3	201	0.43



CALENDAR

June 29-July 2	WATER: LESSONS OF WORLD DEVELOPMENT -- WATER AND ENVIRONMENTAL RESOURCE MANAGEMENT: Focus on Asia and the Pacific, International Water and Resource Economics Consortium 6th Biennial Meeting and Universities Council on Water Resources 1999 Annual Meeting, Kamuela, Hawaii. Contact: Margaret Skerly, UCOWR, So. Illinois Univ., Phone 618/536-7571, FAX 618/453-2671, e-mail mskerly@uwin.siu.edu.
June 30-July 2	SUMMER SPECIALTY CONFERENCE, AWRA -- Two tracks: Science Into Policy: Water in the Public Realm -- contact Vivian Drake, Phone 406-447-1668, FAX 406/447-1665, e-mail: drake@co.lewis-clark.mt.us. Wildland Hydrology: Contact Darren Olsen, Phone 801/752-4202, FAX 801/752-0507, e-mail: dolsen@bio-west.com.
July 7-9	WATER POWER '99 -- Hydro's Future: Technology, Markets and Policy, Las Vegas, NV. Contact: Liz Sigler, Phone 800/548-ASCE, ext. 6078 or 703/295-6078, FAX 703/295-6144 or e-mail lsigler@asce.org. Waterpower home page: www.waterpower.org.
July 19-21	OPPORTUNITIES AND ALTERNATIVES IN WATER AND AGRICULTURE, 1999 Neb. Summer Water Tour. Contact: Kearney Area Chamber of Commerce/Water Tour, PO Box 607, Kearney, NE 68848, Phone 800/652-9435.
Aug. 4-6	4 STATES IRRIGATION COUNCIL 1999 SUMMER TOUR. Contact: Norm DeMott at 307/532-7031 or Brian Werner at 970/667-2437.
Aug. 30 Sept. 1	ENVIRONMENTAL EFFECTS OF ANIMAL FEEDING OPERATIONS (AFOs), Fort Collins, CO. For information see Website http://water.usgs.gov/owq/AFO/index.html .
Sept. 1-3	EMERGING TECHNOLOGIES FOR SUSTAINABLE LAND USE AND WATER MANAGEMENT, 2nd Inter-Regional Conference on Environment-Water, Lausanne, Switzerland. Sponsored by ICID-CID. Contact EPF-Lausanne Institute of Soil and Water Mgmt., Phone +41.21.693 37 25/37 35, FAX +41.21.693 37 39, e-mail enviowater99@epfl.ch. (For Coloradans: Luis Garcia, Dept. of Chem. & Bioresource Engr., CSU, is U.S. representative on the Scientific Committee. Contact him at lgarcia@enr.colostate.edu.) The URL for the conference is http://dgrwww.enfl.ch/HYDRAM/enviowater99/ .
Sept. 8-10	SETTLEMENT OF INDIAN RESERVED WATER RIGHTS CLAIMS, Missoula, MT. Contact: Western States Water Council, Phone 801/561-5300, FAX 801/255-9642, Website: http://www.westgov.org/wswc/ .
Sept. 27-28	CONNECTIONS '99: Ground Water Technical Workshop, Boise, ID. Contact: Peggy Hammel, Idaho Water Resources Research Inst., Phone 208/885-6429, FAX 208/885-6431, e-mail: iwri@uidaho.edu.
Oct. 10-13	DAM SAFETY '99, Sponsored by Assoc. of State Dam Safety Officials, Inc., 450 Old Vine, 2nd Floor, Lexington, KY 40507. Phone 606/257-5140, FAX 606/323-1958, e-mail: damsafety@aol.com.
Nov. 7-10	4TH USA/CIS JOINT CONFERENCE ON ENVIRONMENTAL HYDROLOGY AND HYDROGEOLOGY, Sponsored by American Institute of Hydrology, San Francisco, CA. Contact: AIH, Phone 651/484-8169, FAX 651/484-8357, e-mail: AIHydro@aol.com, Website http://www.aihydro.org/ .
Nov. 8-9	RESTORING NATIVE ECOSYSTEMS, 3rd Annual Conference, National Arbor Day Foundation, Nebraska City, NE. Contact: June Parsons, National Arbor Day Fdn., Phone 402/474-5655, FAX 402/474-0820, e-mail: jparsons@arborday.org.
Nov. 8-10	NASULGC '99, San Francisco, CA. Contact NASULGC AT Phone 202/478-6040, FAX 202/478-6046, Website at http://www.nasulgc.org .
Nov. 15-17	UNDERSTANDING & ADDRESSING RISKS TO GROUNDWATER, 5th Annual Groundwater Foundation Symposium, Atlanta, GA. Contact: Cindy Kreifels or Zoe McManaman at 1/800/858-4844, or e-mail at info@groundwater.org.

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