COLORADO WATER

Newsletter of the Water Center at Colorado State University

FEBRUARY 2003

See pages 13 and 16 for presentations by Michael Welsh, History Department, University of Northern Colorado, and Robert Aukerman, Department of Natural Resource and Recreation Tourism, Colorado State University at the Colorado Drought Conference held December 4, 2002 at Colorado State University.

Above: Colorado Water Congress Executive Director Dick MacRavey provided scholarships for five CSU students to attend the CWC's 45th Annual Convention January 23-24, 2003 in Northglenn, Colorado. From left to right: Cat Shrier, Civil Engineering Department; Lisa Fardal, Bioresource Engineering; (Dick MacRavey, center); Rose Laflin, Public History; Blair Hurst, Civil Engineering; (and not pictured: Ryan Staychock, Forest Sciences).

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Knowledge to Go Places

WATER ITEMS AND ISSUES . . .

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Writers: Marian Flanagan and Michael Blackledge

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Colorado Water Resources Research Institute
Colorado State University, Fort Collins, CO 80523
Phone 970/491-6308 FAX: 970/491-1636
E-mail: CWRRI@ColoState.EDU

INTERNET SITES

Colorado Water Resources Research Institute: http://cwrri.colostate.edu
CSU Water Center: http://watercenter.colostate.edu
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EDITORIAL

WALKING THE FINE LINE BETWEEN WATER SCIENCE AND POLICY

by Robert Ward, CWRRI Director

The current drought in Colorado forces society to adapt to a much-reduced water supply. As water managers and users search for ways to mitigate impacts due to the drought, they pose questions that challenge our understanding of water science and technology. For example, if Front Range municipalities were to develop a common set of landscape watering restrictions, what is the best strategy? If the drought becomes extremely severe and we must forego watering our lawns this summer, how much water will be required to keep a tree alive? How can we utilize our aquifers to maximum benefit and ensure that the prior appropriation system operates properly? How much are water yields from Colorado's State and National Forests impacted by current forest management practices?

With the severe drought, there is a need to develop new water knowledge to answer difficult questions. This situation encourages scientists, in all types of organizations, to provide scientific facts, where they exist. Unfortunately, there are not ready, sound-science answers to all the new questions.

Where possible, scientists are rapidly summarizing what they know and explaining their understanding of the science within the context of the new questions. (You have seen many of these efforts with the past issues of Colorado Water.) In situations where the science is unavailable, or not well developed, scientists may feel uncomfortable providing a firm answer – the science is simply not definitive. The current crisis, however, does not provide the time needed to develop definitive science; thus, researchers may be asked to share their current understanding and thoughts with water managers and the public, even if it is less than conclusive.

The uncertainty in cutting-edge science is what drives many scientists to constantly explore their understanding of water and water-related topics in an effort to produce 'sound science'. However, it is certainty that water managers and users seek.

It is at this interface between certainty and uncertainty that conflicts often develop within policy-setting negotiations. To illustrate with a question, what if a water manager, or policy maker, finds that a scientist's disciplinary findings do not mesh with the more interdisciplinary scientific assumptions upon which a drought mitigation plan has been formulated? Water managers are hired by society to make the hard water-supply decisions and, thus must consider a wide range of factors, including local economics and politics, along with relevant science.

When a cutting-edge scientific finding differs from one that has been assumed within a water manager's drought plans, a local water decision maker may be forced to contend with competing scientific findings. Unfortunately, water managers rarely have the luxury of time to sort through the science in order to locate the 'truth.'

Within the scientific community, the search for a common understanding of science is the goal of the peer-review process, with which scientists are very familiar. Scientists are accustomed to having their methods, findings, and interpretations questioned and challenged within the rough-and-tumble of peer-reviewed science. When scientists take their disciplinary findings into a decision-making arena, new questions arise regarding their understanding about the practical implications of the science. Scientists may find it difficult to address a water manager's challenge to the scientist's understanding of the relationship between science and the establishment of policy, just as water managers may find it difficult to use scientific findings which sometimes seem to be constantly debated within the scientific community.

Let me put some flesh on the above discussion. Consider the Platte River Cooperative Agreement discussions that have been underway for over 10 years. At the November 2002 meeting of the Colorado Water Conservation Board, the following quote from the Director's Report illustrates the uncertainty that a scientific 'peer review', conducted by the National Academy of Sciences (NAS) in this case, may introduce into what many view as a policy making exercise, of which science is a part.

> "A very serious concern with any NAS review is that one has very little control over where the scientist may focus as they implement their review. In the past they have even ventured into policy issues and many people view their conclusions as the "supreme court" of science."

The quote is questioning how the NAS panel will distinguish policy from science. Should members of the NAS panel question the validity of a management program or should the scientific panel focus its review on the science underpinning the policy setting process?

When water managers attempt to negotiate agreements over contentious issues, science may find itself being 'used' to support one position over another. If one side of a negotiation determines that the policy making process is moving in a direction negative to its interests, one strategy to redirect the process is to request 'better science' or peer reviewed science. In such situations, it is very difficult for science to be independent of policy.

CWRRI, and most, if not all, 'water' faculty in higher education recognize the above conflict and strive to make their findings available within the context of the science-policy debate. As I have attempted to point out in this editorial, this is not always possible. Situations arise that require faculty and water managers to walk a fine line between the uncertainty of science and the certainty sought in setting water policy. Communication between water researchers and policy makers is critical to walking the line successfully.

Science does not pretend to have answers to all the questions asked, but researchers cannot avoid responding when asked about science and its potential impact in certain applications. In fact, some scientists feel compelled to 'advocate' for their scientific findings within the policy setting process. The best way to ensure that science works with policy formation is for scientists, water managers and users to work together. CWRRI is very fortunate to have an outstanding, legislatively mandated, Advisory Committee on Water Research Policy to guide such collaboration and cooperation, and I believe CWRRI has been very successful in walking the fine line.

It is this close relationship between water managers and users, within the research program of all the nation's state-based water institutes, that is the true strength of the national water institutes program (of which CWRRI is a part). Advisory committees provide an excellent connection between the rough-and-tumble -- and uncertainty -- of peer reviewed research and the new information needs of water managers

HSRC Requests Proposals

The Rocky Mountain Regional Hazardous Substance Research Center (HRSC), one of five EPA-funded HSRCs in the U.S., is pleased to announce its Request for Proposals for the 2003-04 funding cycle. A PDF file of the RFP can be downloaded from the HSRC website under the Research button at the bottom of the page. The URL is: www.engr.colostate.edu/hsrc/research/RFP-RMRHSRC_2003-2004.pdf. The RFP includes the following items: General Background, Description of Research Focus Areas, Specific Research Needs, Eligibility, Preparation Guidelines, Evaluation of Proposals, Funding Limits and other information. In general, all faculty at Colorado State University and Colorado School of Mines are eligible to participate, as well as individuals identified as "Other Participants" of the Center in Table 1 of the RFP. Anticipated total funding allocations (direct plus indirect for '03-'04 are approximately$480,000-$490,000 for '03-'04 and $520,000-$530,000 for '04-'05 funding periods. There is a 25 percent matching requirement as dexcribed in the RFP. Proposals are due at the address noted in the RFP by 5:00 p.m. local time, Monday, March 31, 2003.

NIWR/U.S. GEOLOGICAL SURVEY WATER RESOURCES RESEARCH NATIONAL COMPETITIVE GRANTS PROGRAM REQUEST FOR PROPOSALS for FY 2003

The U.S. Geological Survey in cooperation with the National Institutes for Water Resources requests proposals for matching grants to support research on non-point source water pollution, water availability, and water use. For planning purposes, the amount available for research under this program is estimated to be $1,000,000 in federal funds, though there has not been a FY 2003 appropriation of funds for this program as of the date of this Announcement. Any investigator at an institution of higher learning in the United States is eligible to apply for a grant through a Water Research Institute or Center established under the provisions of the Water Resources Research Act of 1984, as amended. Proposals involving substantial collaboration between the USGS and university scientists are encouraged, especially on proposals addressing non-point source pollution. Proposals may be for projects of 1 to 3 years in duration and may request up to $250,000 in federal funds. Successful applicants must match each dollar of the federal grant with one dollar from non-federal sources. Proposals must be filed on the Internet at http://www.niwr.org/ by 5:00 PM, Eastern Standard Time, March 21, 2003 and must be approved for submission to the National Competitive Grants Program not later than 5:00 PM, Eastern Standard Time, March 28, 2003 by the Institute or Center through which they were submitted. The Government's obligation under this program is contingent upon the availability of appropriated funds. The Request for Proposals is available at http://www.niwr.org/. An abstract of the RFP has also been posted at http://water.usgs.gov/wrri/news.html. Proposals under this Announcement will be accepted only through the Internet site at http://www.niwr.org/. Prospective applicants (Principal Investigators) must register at that site prior to submitting a proposal. Registrations and proposals will be accepted on the Internet site beginning January 20, 2003. Registration does not obligate the registrant to submit a proposal.

2003 AWWARF Solicits 2003 Projects--The Awwa Research Foundation (AwwaRF) Board of Trustees has selected 46 projects for 2003 funding and approved $7.78 million to sponsor 30 solicited research projects, which will be competitively procured via a Request for Proposals (RFP) process. RFPs for the 2003 solicited research projects will be available by mid-March. Proposals will be due in either May or July, as specified in the RFP. All project proposals, unless otherwise indicated, must include 25 percent of the total project budget as in-kind or cash contribution. Awards for solicited projects will be determined by an AwwaRF project advisory committee (PAC) appointed for each project. Proposal evaluation will be based on responsiveness to the RFP, scientific and technical merit, and qualifications of the researchers. Interested parties can view RFPs from the What's New section of AwwaRF's homepage (www.awwarf.com), or request RFPs from the AwwaRF RFP Desk, 6666 W. Quincy Avenue, Denver, CO 80235 (303-347-6118). Be sure to indicate the RFP number. RFPs can also be requested and sent through e-mail (info@awwarf.com).

COLORADO STATE LEADS NASA CLOUDSAT SATELLITE MISSION TO LAUNCH WORLD'S MOST ADVANCED WEATHER RADAR TO IMPROVE FORECASTING, CLIMATE MODELS

A Colorado State University researcher is leading a more than $100 million NASA-funded satellite project that will improve weather and climate prediction and develop critical new space technologies. The CloudSat project, a NASA Earth System Science Pathfinder Mission, will launch into orbit the world's most advanced weather radar designed to measure properties of clouds that are essential for accurate understanding of Earth's weather and climate processes. "CloudSat will provide the first global measurements of cloud thickness, height, water and ice content and a wide range of precipitation data linked to cloud development," said principal investigator Graeme Stephens of Colorado State's Department of Atmospheric Science. "These measurements will improve weather forecasting and advance understanding of key climate processes."

According to a paper published in the current Bulletin of the American Meteorological Society, or BAMS, CloudSat's measurements are necessary to improve the way clouds are represented in models used for weather forecasts and climate prediction. The vertical profiles of global cloud properties provided by CloudSat will fill a critical gap in understanding how clouds affect climate and uncover new knowledge about clouds and precipitation and the connection of clouds to the large-scale motions of the atmosphere. "Clouds are a very important part of Earth's weather and climate, and the lack of understanding of cloud feedback is widely acknowledged in the scientific community to be a major obstacle confronting credible prediction of climate change," said co-principal investigator Deborah Vane of the Jet Propulsion Laboratory in Pasadena, Calif. "Despite the fundamental role of clouds in climate and weather, there is much that we do not know. The CloudSat mission aims to provide observations necessary to greatly advance understanding of these climate issues."

CloudSat will help researchers in numerous scientific disciplines to:

- support new, detailed investigations of how clouds determine the Earth's energy balance.
- improve weather prediction models by measuring cloud properties from the top of the atmosphere to the surface of the Earth, filling a gap in existing and planned space observational systems.
- penetrate into and through thick cloud systems, providing new information to increase the accuracy of severe storm, hurricane and flood warnings.
- link climate conditions to hydrological processes that affect occurrences of drought, incidences of severe weather and availability of water.
- spur innovative technology including high-power radar sources, methods of radar signal transmission within spacecraft and integrated geophysical retrieval algorithms.

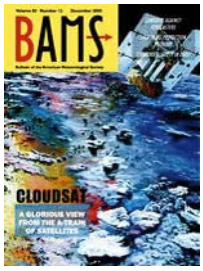
A unique component of the mission design is that the CloudSat spacecraft will fly in orbital formation as part of a constellation of satellites, including NASA's Aqua and Aura satellites, the French Space Agency (CNES) PARASOL satellite and the NASA-CNES CALIPSO satellite. This will be the first time that five research satellites will fly together in formation. CloudSat's radar measurements will overlap those of the other satellites in the constellation. The precision of this overlap creates a unique multi-satellite observing system for studying the atmospheric processes essential to the Earth's hydrological cycle and weather systems and will provide unsurpassed information about the role of clouds in weather and climate.

The collaborative mission draws on the expertise of industries, universities and laboratories in the United States, Canada, Japan and Europe. The CloudSat satellite will use the first-ever space-borne millimeter wavelength cloud profiling radar, developed for NASA by JPL in partnership with the Canadian Space Agency. This highly advanced radar has the ability to measure both the altitude and the physical properties of clouds. Existing space-based systems can observe only the uppermost layer of clouds and cannot reliably detect the presence of multiple cloud layers or determine the cloud water and ice content.

CloudSat was conceived and proposed by Stephens at Colorado State and is one of the largest research projects in the atmospheric sciences ever led by a university principal investigator. The mission is managed and implemented by JPL for NASA's Earth Explorers Program Office at the Goddard Space Flight Center. Ball Aerospace of Boulder, Colo., is building the spacecraft that will be launched in 2004 from California's Vandenberg Air Force Base on the same Delta rocket with the CALIPSO spacecraft.

The U.S. Air Force will operate the CloudSat spacecraft in orbit and will deliver the raw data to the Cooperative Institute for Research in the Atmosphere, or CIRA, located at Colorado State. CIRA will process all CloudSat data and deliver data products to the scientific community. CloudSat data also will be distributed to civilian and military weather forecast agencies.

The U.S. Department of Energy will provide independent verification of the radar performance through its Atmospheric Radiation Measurement Program. Scientists from the United States, Germany, France, Canada and Japan are contributing their facilities and expertise to develop science data products, analyze data and complement the DOE on-orbit verification efforts.



The CloudSat mission is designed for a two-year lifetime to observe more than one seasonal cycle. However, there is no anticipated technical reason why the mission could not last longer as the radar is expected to operate for a minimum of three years.

The paper, "The CloudSat Mission and The A-Train," is available on BAMS' Web site at http://ams.allenpress.com/amsonline/?request=get-toc&issn=1520-0477&volume=083&issue=12. Stephens' painting depicting CloudSat in orbit, "The Useful Pursuit of Shadows," is featured on the bulletin's cover. More information about the CloudSat project is available on the Web at http://cloudsat.atmos.colostate.edu.

From a news release by Brad Bohlander, CSU University Relations. For additional information contact Brad at Brad.Bohlander@colostate.edu.

WATER NEWS DIGEST

Continued from page 36

WATER TRANSFERS

State engineer delays ruling on Aurora's water request

Aurora's application to lease Rocky Ford Ditch water to meet the Denver suburb's emergency supply needs was put on hold by State Engineer Hal Simpson. Simpson did not say when he will act on Aurora's request, which was filed under provisions of House Bill 1414, an emergency substitute water supply bill enacted last year. Sen. Lewis Entz, R-Hooper, carried HB1414 in the Colorado Senate and said he never envisioned temporary substitute water supplies to mean the kind of large-scale river exchange that Aurora and some 50 Rocky Ford Ditch shareholders propose. At a meeting called by Simpson at the Aurora utilities office, but several objectors were on hand to raise the same questions. The city of Pueblo was represented by Christopher Thorne, of the Denver law firm of Holland and Hart, to voice concerns about a drop in water quality if Aurora gets permission to move the point of diversion from Rocky Ford Ditch upstream to Pueblo Reservoir. Although the state engineer's approval would be good for only 90 days, the request is identical in every key respect to Aurora's application in Division 2 Water Court for a permanent transfer decree in the Rocky Ford Ditch II case. Steve Leonhardt, representing the Southeastern Colorado Water Conservancy District in Pueblo, said nothing in the text or legislative hearing record of HB1414 gives the state engineer authority to approve Aurora's kind of emergency water supply plan. The state engineer said he will consult Attorney General Ken Salazar's staff on the legal issues raised by the lawyer. Confusing the issue was a late alternative suggested by an engineering consultant for the La Junta-based Colorado Water Protective and Development Association. The association holds rights to 3,000 acre-feet in Pueblo Reservoir, and would be willing to exchange it with Aurora if Rocky Ford Ditch shares were diverted at the head gate to augment wells serving La Junta, Las Animas, Fowler and other municipalities in the area.

The Pueblo Chieftain, 1/28/03

MISCELLANEOUS

Canadian shares water plan

Faced with its third year of drought, a group in southern Alberta, Canada, took a seemingly elementary approach to water: share it. The Canadian province, which lies north of Montana on the east slope of the Rocky Mountains, gets about 14 inches of precipitation annually, about the same as Colorado's Northern Front Range. Like Colorado, it is subject to weather extremes, especially when it comes to temperature and wind. And like northeastern Colorado, it's an agricultural production center of the province, producing wheat, corn, barley and, in some cases, sugar beets. But after record-setting dry years in 1999 and 2000 and the prospect of a third in 2001, nearly 50 public, private and government entities came together in their quest to mitigate drought and "share a limited resource to the fullest possible degree." The primary tenet of the agreement was to pool the water portfolios of the area's eight irrigation districts. For a year, water rights priorities would fade away. "Nobody's junior, nobody's senior; everybody shares," said Jim Csabay, chairman of Alberta's largest irrigation district, the St. Mary's River Irrigation District. Coincidentally, the group had 517,000 acre-feet of water to divide among 517,000 acres. In short, one acre-foot per acre. Allowing for a cushion, the districts reduced the quota slightly to 10 acre-inches per acre, which, starting May 14, 2001, is what farmers lived on for the summer. A 160-acre farm, for example, got 38 days of water. At season's end, there were 3,527 acre-feet left. "Nobody was shorted, and everybody went away relatively happy," said Csabay, a Lethbridge, Alberta, man whose barley winds up at the Anheuser-Busch brewery in Fort Collins. What Csabay didn't tell farmers in the audience at the Four States Irrigation Council's annual meeting in Fort Collins, where he told of Canada's bout with drought, was how the irrigation districts - St. Mary's, in particular - were able to get senior water right holders to relinquish their prized resource. In an interview after the meeting, Csabay explained: "We held a hammer. We hold the second-most senior right on the river." Translation: If Csabay's district put a call on that water, the rest of its users would have gone dry. Not only that, but government crop insurers made exceptions for the plan, and the Canadian government helped pay crop insurance premiums.

The Loveland Reporter Herald , 1/10/03

CWRRI ADVISORY COMMITTEE SELECTS PROJECTS FOR FY 2003 FUNDING

The Colorado Water Resources Research Institute's Advisory Committee for Water Research Policy (ACWRP) met November 15, 2002, to hear progress reports on FY 2002 research projects and to select projects for FY 2003 funding.

The ACWRP heard updates on the following FY 2002 CWRRI projects:

- Managed Ground Water Recharge for Habitat Restoration: The Development of an Expert System for a Biological Component to the South Platte Mapping and Analysis Program (SPMAP). Luis Garcia (in collaboration with the Lower South Platte Water Conservancy District, South Platte Lower River Group, and Colorado Division of Wildlife)
- Enhancements to the South Platte Mapping and Analysis Program (SPMAP). Luis Garcia (in Collaboration with the Northern Colorado Water Conservancy District, Groundwater Appropriators of the South Platte, Central Colorado Water Conservancy District, South Platte Lower River Group, State Engineers Office, and the Lower South Platte Water Conservancy District)
- Assessing the Effectiveness of Best Management Practices (BMPs) in Controlling Non-Point Source Pollution from Forestland Uses. John Stednick (in collaboration with the U.S. Forest Service)
- Strategies for Mitigating Waterlogging and Salinization in Colorado's Lower Arkansas River Valley. Tim Gates (in collaboration with the Agricultural Experiment Station, Cooperative Extension, Natural Resources Conservation Service, Bureau of Reclamation, U.S. Geological Survey, Bent County Soil Conservation District, The Catlin Canal Company, and the Fort Lyon Canal Company)
- Determining the Fate of Non-Point Source Pollution from Septic Tanks in Turkey Creek Basin, Colorado, and Delineating Improved Management Practices. Eileen Poeter (in collaboration with Jefferson County Department of Health and Environment)

The ACWRP congratulated the faculty and students for producing relevant information for Colorado water managers and users. While the information presented did not always agree with expectations of water managers, ACWRP members acknowledged the value of knowing the facts so they can plan accordingly.

Proposals submitted to the CWRRI FY 2002 research competition were peer reviewed and the proposals and reviews were evaluated by the ACWRP in deciding which projects best met the needs of Colorado water managers and users. The following projects were selected to receive FY 2003 CWRRI funding:

- Enhancements to the South Platte Mapping and Analysis Program. Luis Garcia (in collaboration with the Northern Colorado Water Conservancy District, Groundwater Appropriators of the South Platte, Central Colorado Water Conservancy District, South Platte Lower River Group, State Engineers Office, and the Lower South Platte Water Conservancy District).
- Evaluating Strategies to Mitigate Waterlogging and Salinization in Colorado's Lower Arkansas Valley, Phase 2. Tim Gates (in collaboration with the Agricultural Experiment Station, Cooperative Extension, Natural Resources Conservation Service, Bureau of Reclamation, U.S. Geological Survey, Bent County Soil Conservation District, The Catlin Canal Company, and the Fort Lyon Canal Company).
- Urban Landscape Irrigation with Reclaimed Wastewater: Water Quality Assessment and Community Experience. Yaling Qian (in collaboration with Northern Colorado Water Conservancy District).
- Canal Modernization for Addressing Salinity Issues in the Arkansas Valley, Colorado. John Wilkins-Wells (in collaboration with the WaterWorks Committee and the Catlin Canal).

Funding for the above CWRRI projects is dependent upon approval by Congress of the national water institute's FY 2003 appropriations.

The ACWRP will be assembling water information needs over the spring in preparation for releasing its FY 2004 Call for Proposals in June 2003. To provide input to CWRRI's research planning effort, please contact Robert Ward, CWRRI Director, at (970) 491-6308 or Robert.Ward@Colostate.edu. Or speak with a member of the CWRRI ACWRP: Rep. Diane Hoppe, Sen. Lew Entz, Greg Walcher, Doug Benevento, Don Ament, David Robbins, Fred Anderson, Sara Duncan, David Merritt, Ralph Curtis, and John Porter.

Colorado State University Agricultural Experiment Station

ESTIMATED ECONOMIC IMPACT OF WELL DEPLETIONS BY THE GROUNDWATER APPROPRIATORS OF THE SOUTH PLATTE (GASP)

by James Pritchett, Assistant Professor
Department of Agricultural & Resource Economics
and
Stephan Weiler, Associate Professor
Department of Economics

Water shortages created by a sustained drought impose economic losses on many groups including municipalities, manufacturers and agriculture. During a drought, irrigated agriculture suffers production losses that range from simple yield reduction to outright crop failure because of reduced water supplies. Crop losses hurt Colorado counties directly due to lost revenues, and indirectly according to lost wages and reduced purchases of goods and services.

Economic losses from a drought are not shared proportionately. Rather, Colorado allocates surface water according to a prior appropriation doctrine in which users with the earliest water right are allocated water first. As a result, junior water right holders typically suffer greater drought losses relative to senior water right holders. A water court system typically oversees administration of the prior appropriations doctrine.

Tributary groundwater users who pump from wells were made part of the prior appropriation doctrine in 1969; and must purchase or lease surface water rights to replace depletions that their out-of-priority pumping creates. In the early 1970s, producers organized groups to purchase or lease water rights for replacement of their out-of-priority depletions. As an example, the Central Colorado Water Conservancy District maintains a $50 million portfolio of permanent water rights for replacement. Another organization, the Groundwater Appropriators of the South Platte, primarily leases temporary water rights as a replacement plan. Until recently, Colorado's Division of Water Resources oversaw the replacement plans of these tributary groundwater users.

A recent water court ruling has shifted the oversight of water replacement plans from the Division of Water Resources to the water court system. Consequently, groundwater users will need to file replacement plans with their respective water courts. Groundwater users who do not already have permanent rights will likely be required to purchase expensive water rights or forced to shut down their wells (Jackson).

The purpose of this study is to estimate the economic impact of one augmentation group, the Groundwater Appropriators of the South Platte (GASP), whose members may not be able to pump groundwater in 2003 due to the recent water court ruling. Economic effects quantified in this study include the direct contribution of GASP-member lands to the economies of the five primary counties in which GASP resides, as well as the indirect effects that GASP lands have on the five primary counties' businesses and households.

Groundwater Appropriators of the South Platte (GASP)
GASP handles the depletion replacement plan for approximately 3,500 wells in five primary counties: Adams, Logan, Morgan, Sedgwick and Weld. These wells provide water to roughly 180,000 acres -- 25% of the irrigated acres in the five counties. Corn is grown on a majority of GASP irrigated lands (50%) followed by alfalfa hay (33%), while sugar beets (4%), small grains (7%) and vegetables (7%) comprise the remainder (Garcia).

The analysis focuses on the economic contribution of GASP irrigated lands for Adams, Logan, Morgan, Sedgwick and Weld counties. It is an economic snapshot of the direct and indirect effects that GASP lands have on the five counties. Because it is a snapshot, the economic contribution reported in this study is likely to be greater than the losses that might occur from a GASP well shutdown. As an example, the analysis assumes no cropping alternatives exist for GASP lands when, in truth, dryland crops may be grown mitigating losses from the well shutdown. Furthermore, it's assumed that surface water rights are not available in sufficient quantity to grow irrigated crops on all of the GASP lands if groundwater pumping is disallowed (Garcia). Lastly, the estimated economic activity is not solely attributed to water; rather, other inputs such as land also contribute to the economic activity of the five counties documented in this study.

On a final note, the economic contribution of GASP wells is but one part of society's stake in water use for the South Platte River Basin. If groundwater wells pump without replacement, junior and senior surface water right holders will certainly be harmed,

as will the counties in which they operate. Water right holders include both other irrigating farmers and municipalities, and their losses may outweigh the losses of a GASP well shutdown. Thus, the report does not suggest the highest or best use of water resources in the South Platte River Basin.

Economic Effects of Irrigated Lands Covered by GASP Replacement Plans

Economic contributions can be placed in two categories: direct effects and indirect effects. Direct effects are revenues from the sale of corn, alfalfa hay, vegetables, and other crops. Table 1 shows the direct effects by sector, which total more than $79 million.

Table 1. Direct Contribution of GASP Lands to the Five Counties

Crop Category	Annual Contributed Revenues
Food Grains	$2,242,093
Feed Grains	$33,117,324
Alfalfa Hay	$25,076,684
Vegetable	$14,465,524
Total Effect	$79,406,392

As indicated in Table 1, feed grains (e.g., corn) and alfalfa hay are the greatest contributors to the GASP lands in five counties totaling $58 million. Vegetables and sugar beets also provide significant revenues in spite of being grown on fewer acres. Of course, these contributions are revenues to producers and do not reflect the profits that producers receive.

Agricultural sales create ripples that indirectly affect other businesses in the five counties. These indirect effects belong to sectors related to irrigated agriculture including agricultural services such as crop consultants, wholesalers of irrigation equipment, feedlots that purchase feed ingredients, and similar businesses. The indirect effect of GASP irrigated production on businesses in the five counties is estimated at more than $50 million, and the sectors primarily impacted by GASP lands are listed in Table 2.

Table 2. Indirect Effect of GASP Lands on Selected Sectors

Sector	Yearly Revenue Contribution
Wholesale Trade	$8,183,487
Real Estate Services	$6,309,673
Agricultural Services	$3,778,129
Petroleum Refining	$2,875,815
Transport & Warehouse	$2,814,412
Facility Maintenance	$2,045,865
Livestock	$1,054,424
Farm Machinery & Equip.	$1,034,262
Ag Fertilizers & Chemicals`	$1,032,221
Household Spending	$10,840,100
Total Indirect Effects	$51,526,378

*Some sectors experiencing indirect effects have been omitted for brevity, so the individual sectors in Table 2 do not sum to the total.

The indirect effects listed in Table 2 represent the additional economic value generated by irrigated production of lands under the GASP depletion replacement plans. The wholesale trade experiences significant impacts (more than $8 million), while the agricultural services sector receives more than $3.7 million in revenues. The livestock, farm machinery and agricultural fertilizer/chemical sectors each garner indirect effects greater than $1 million.

GASP lands also induce additional economic activity in the five counties via household spending on goods and services purchased from retailers, grocery stores, restaurants, gas stations, and so on, which are attributed to income and salaries derived from

irrigated agricultural production. The induced economic effect generated by GASP irrigated lands is estimated as $10,840,100 and is listed near the bottom of Table 2.

An estimate of the total economic contribution of irrigated crops from GASP wells can be derived as the sum of its direct and indirect effects. The total contribution is estimated at $130,932,770; that is, the economic contribution of irrigated agricultural production covered by GASP replacement plans is estimated at nearly $131 million.

What's Missing?

Persistent drought creates economic hardship for water users in the South Platte River Basin. These economic losses are not borne equally among groundwater irrigators, surface water irrigators, and municipalities. While this analysis considers the economic contribution of groundwater wells whose depletions fall under GASP, the potential losses to other stakeholders have not been considered. Additional insights can be gained by considering impacts to these stakeholders.

Surface water irrigators will sustain economic losses if GASP wells are allowed to pump without adequate replacement. Their losses are similar to those of groundwater users in effect (i.e. decreased yields or total crop failure), but it is uncertain if the total economic loss of surface water irrigators would be greater than or less than groundwater irrigators. The extent to which their losses are comparable to groundwater users depends on the crop composition for the area (i.e., do senior surface irrigators produce the same crops as the junior groundwater irrigators), the timing of the water shortage, and the severity of the shortage.

Municipalities with junior water rights may be asked to bypass water into the South Platte River during a drought to cover the needs of more senior surface water users, and will certainly have to release relatively more if groundwater users pump without adequate replacement. Municipal governments often respond to water shortages by restricting use and by leasing additional water rights. Water rights are currently at prices ranging between $300 and $400 per acre-foot, and an acre-foot will provide two average households with enough water for one year. The GASP wells pump between 250,000 and 300,000 acre-feet of water each year.

Summary and Conclusions

This study estimates the total economic contribution for Adams, Logan, Morgan, Sedgwick, and Weld Counties of irrigated lands whose depletion replacement plan is covered by the Groundwater Appropriators of the South Platte (GASP). The contribution is estimated at $130,932,770, and the total effect may be decomposed into the direct effects of agricultural sales ($79,406,392) and the indirect effects on sectors related to agricultural production ($51,526,378). The economic contribution is an overstatement of the losses that occur if GASP wells are unable to pump by assuming that no other crops may be grown in lieu of irrigated crops. Finally, the economic activity in this study cannot be solely attributed to water because other inputs are also used generate the $130 million value.

Care must be taken when interpreting these results. The tool used to generate the estimates of the impacts is called a "multiplier." A multiplier is a term referring to the total amount of economic activity or the impact generated by a dollar of export sales. Multipliers are imperfect measures of economic impacts and changes in social welfare; however, they do generate estimates from which policy discussions can take place. In isolation, multipliers do not indicate the opportunity cost of using a scarce resource like water in a particular activity; in other words, they do not indicate the highest and best use.

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Contact:

James.Pritchett@ColoState.edu
T:970-491-5496; F:970-491-2067.

MEETING BRIEFS

COLORADO WATER CONGRESS ANNUAL CONVENTION – A SEARCH FOR WATER LEADERSHIP

The focus was on Colorado's water security -- Seeking solutions and leadership

From left: W.D. Farr, Colorado water legend and former recipient of the Colorado Water Congress Wayne Aspinall Water Leader of the Year award, with CSU President Yates.

Nearly 300 people crowded into the Holiday Inn Northglenn on January 23-24, 2003, for the Colorado Water Congress Annual Convention. Colorado State University President, Al Yates, presented the luncheon address on Thursday entitled "Leadership". After reviewing past Colorado water leadership provided by such people as W.D. Farr, Delph Carpenter, and Wayne Aspinall, President Yates shared some of his observations about the characteristics of leadership. He then challenged the audience with a question regarding who, among the audience, will step forward to take on the type of leadership roles assumed by such people as W.D. Farr, Delph Carpenter, and Wayne Aspinall?

Friday morning, Dick MacRavey, Executive Director of the Colorado Water Congress organized 'A Dialogue of Twenty Water Leaders' during which the search for solutions to Colorado's current water problems was discussed extensively. During the course of the dialogue, the leadership challenge, provided by President Yates the day before, was carefully considered and referred to numerous times. The dialogue, as well as other presentations during the CWC Annual Convention, reflected a very active search for solutions and leadership regarding Colorado's future water security.

For those interested in President Yates' presentation and in the leadership dialogue, the speech and a transcript from the dialogue will be published in the next issue of the Colorado Water Congress newsletter, Colorado Water Rights.

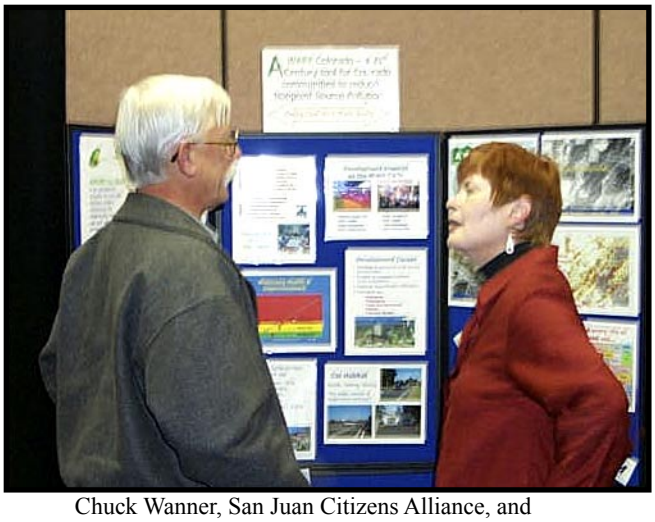
CWRRI organized two workshops for the Convention addressing key aspects of its work with water research, education and outreach. One workshop addressed the importance of properly, and professionally, archiving important Colorado water papers. Presentations were provided by Brian Werner, Northern Colorado Water Conservancy District; John Newman, Colorado State University Water Archives; Jeff Baessler, Colorado Water Conservation Board; and Ken Knox, State Engineer's Office. A robust discussion among the presenters and audience followed covering such topics as legal requirements regarding disposition of water records and papers, professional archival practices, and the huge task involved when a water organization addresses storage, preservation, and access to its water records. Also discussed at the meeting was the need for continued dialogue regarding Colorado water records and archival papers.

From left: Ken Knox, State Engineer's Office; Jeff Baessler, Colorado Water Conservation Board; John Newman, archivist; Morgan Library, CSU; and Brian Werner, Northern Colorado Water Conservancy District.

From left: Luis Garcia, Civil Engineering Department, CSU; John Porter, member of CWRRI's Advisory Committee on Water Research Policy; John Wilkins-Wells, Department of Sociology, CSU, and Tim Gates, Civil Engineering Department, CSU.

Dan Smith, Department of Soil and Crop Sciences, CSU with Matt Cook, CSU graduate now with Coors Brewing Company.

The second CWRRI organized workshop discussed recent developments in irrigation water delivery technology and management. Tim Gates described his salinity monitoring and modeling work in the Arkansas Valley. Luis Garcia described his use of information technology to improve estimates of augmentation flow needs in the South Platte Valley. John Wilkins-Wells discussed new economic strategies for modernizing agricultural water delivery in the Rocky Mountain region. All three speakers are associated with Colorado State University.



Chuck Wanner, San Juan Citizens Alliance, and Loretta Lohman, CSU Cooperative Extension.

Five CSU students were the recipients of Colorado Water Congress Convention Scholarships. The students, representing a wide range of majors, research areas, and water-related interests, were:

Lisa Fardal, a master's student in Bioresource Engineering at CSU. Lisa is studying how irrigators can manage water use to increase streamflow in nearby creeks and rivers that provide habitat for threatened and endangered species.

Blair Hurst, a master's student in Civil Engineering at CSU. Blair is studying in the Hydraulics Program, works at the CSU Stream Office and Hydraulics Lab, and is interested in river restoration techniques.

Rose Laflin, a master's student in Public History at CSU. Rose is working with Professor Mark Fiege on a National Park Service project that looks at the water delivery system on the Cache la Poudre River, and considers how the irrigation system has affected the area over time socially, economically, legally, politically, technologically, and ecologically.

Cat Shrier, a doctoral student in Civil Engineering at CSU. Cat is completing her Ph.D. in CSU's Water Resources Planning and Management program, and is developing a method to assess potential sites for recharge ponds and waterfowl habitat development in the Lower South Platte River basin. Cat is also working part-time as a Legislative Aide to State Representative Bob McCluskey, a member of the House Agriculture, Livestock, and Natural Resources Committee.

Ryan Staychock, a master's student in Forest Sciences at CSU. Ryan is studying in the Natural Resources Policy program, is interested in studying water issues in the West, and is currently applying that interest through his work part-time with the Cache La Poudre River Corridor Project.

Cat Shrier, a member of the Colorado Water Congress Education Committee, worked with Dick MacRavey to organize and promote the 2003 CWC student scholarships. The Annual Convention of the Colorado Water Congress provides an excellent opportunity for students to gain insight into the current workings, and future directions, of Colorado's water management system as well as ideas and contacts for future careers in the field of water resources.

The following two papers, "We've Been Here Before!", HIstoric Responses to Drought in Colorado, by Michael Welsh, and Economic Effects of the Drought on Colorado's Recreation and Tourism, by Robert Aukerman, were presented at the Colorado Drought Conference held at Colorado State University December 4, 2002.

"WE'VE BEEN HERE BEFORE!" HISTORIC RESPONSES TO DROUGHT IN COLORADO

by Michael Welsh
History Department, University of Northern Colorado

The year 2002 will go down in history as the driest twelve-month sequence since records have been kept on Colorado's precipitation (a period that stretches back 150 years to the days of the famed gold rush). Public attention has focused upon the subject of water in ways not seen for six decades and more (at least as far back as the "Dust Bowl" of the 1930s), while the potential for stunting the urban and industrial growth of the Centennial state has worried political and civic leaders as much as the impact upon Colorado's multi-billion-dollar agricultural sector. Streams like the Arkansas River flowed at levels last witnessed in the early 1700s, when the only travelers upon it were Spaniards and Plains Indians. Early winter snows in the high country augured well for the ski industry, but water managers and scientists alike warned that much more moisture needed to fall from the skies to replenish the vast network of reservoirs and lakes from which Colorado's good fortune emanates.

The Spanish, seekers of gold and large civilizations to conquer and convert, found neither in the far northern reaches of their empire. Their words for the Great Plains (El Llano Estacado, or the "Staked Plains")…reflected the ways that nature shaped human existence… It would be the Americans who would find the means to mitigate (if not overcome) the persistence of drought in Colorado, and it would be they who left the most permanent human mark upon the land.

If crises are the trigger for public policy in America, drought in Colorado certainly qualifies as an important feature of historical life. The story of the highest state in the nation is replete with examples of cultures finding opportunity amidst the aridity and harshness of nature, only to face challenges and hardships when nature turned on them and forced them to leave. All of these examples, ironically enough, had links to the cycles of abundance and scarcity of moisture now plaguing the first years of the 21st century. The ancient cultures of what came to be called the "Four Corners" area of southwestern Colorado were attracted to its high mesas and deep canyons in the first millennium because of what scientists claim was a 400-year "wet cycle" (roughly the years 800-1200AD). Their civilizations flourished throughout the interior deserts, only to be devastated with the onset in the 13th century of a prolonged "dry cycle" that raised levels of anxiety and stress. This culminated in violence, death, and the departure of the people whom later generations of archaeologists would call the Anasazi (translated for decades as "the ancient ones," or "those who have vanished").

Not until the return of the 400-year wet cycle in the 17th century would today's Colorado draw renewed attention from outside groups seeking opportunity and stability in a harsh land. The four centuries of European and American control of Colorado (beginning with the early Spanish explorations of the mid-1500s) relied upon a general pattern of moisture that would come and go in 20 to 25-year wet and dry cycles within the larger domain of abundance. The Spanish, seekers of gold and large civilizations to conquer and convert, found neither in the far northern reaches of their empire. Their words for the Great Plains (El Llano Estacado, or the "Staked Plains"), and for the semi-nomadic cultures that inhabited them (Los Indios Bravos, or the "wild and uncontrollable Indians") reflected the ways that nature shaped human existence.

Old Spanish maps showed their preference for the green valleys and Pueblo Indian cultures of northern New Mexico, and the only Spanish reference to Colorado in the years prior to American entry was the term El Cuartelejo (the "far quarter"). Not until the American army moved northward into the San Luis valley in 1851 would a Spanish-speaking settlement appear in today's Colorado (the farming community of San Luis), and the population of southern Colorado remained small because of the high altitude, short growing seasons, and geographic isolation from the Front Range communities spawned by the 1858 gold rush.

It would be the Americans who would find the means to mitigate (if not overcome) the persistence of drought in Colorado, and it would be they who left the most permanent human mark upon the land. Yet even Yankee ingenuity met its match in the years before gold-seekers poured across the Plains. Lieutenant Zebulon Pike, sent by President Thomas Jefferson in 1806

to follow the course of the Arkansas River to its headwaters (much as Jefferson had ordered the more famous party of Lewis and Clark to do for the Missouri and Columbia basins), reported that the landscape of southern Colorado reminded him of "the sands of Africa."

More telling were the comments of Lieutenant Stephen H. Long, who in 1819 journeyed westward along the South Platte River, named a mountain peak for himself, and declared that the 700-mile stretch between Westport Landing, Missouri (outside of today's Kansas City) and the Rockies was the "Great American Desert." The name endured on maps for decades, and the perils of crossing the "dry line" of western Kansas affect people's consciousness today about the eastern plains of Colorado (where less than five percent of the population occupies 40 percent of the land).

Permanent settlement of Colorado's mountains and plains owed its existence to the fortunes of gold (and later silver) mining. The benefits of wealth overcame the limits of nature, abetted in the years 1865-1885 by a substantial wet cycle that led the nation's policy planners to think that it would never end.

Permanent settlement of Colorado's mountains and plains owed its existence to the fortunes of gold (and later silver) mining. The benefits of wealth overcame the limits of nature, abetted in the years 1865-1885 by a substantial wet cycle that led the nation's policy planners to think that it would never end. Communities like Greeley sprang up in the years after the Civil War to draw water from the copious streams of the central Rocky Mountain range, and the "Greeley model" of private irrigation districts became an international standard (emulated from the Central and Imperial valleys of California to the Middle East and Asia). Flattening out the cycles of abundance and scarcity with high-mountain storage, long canals, and divisions of water rights based upon seniority allowed farmers and ranchers to plan for a future that previous generations of Coloradoans had never known.

Then came a cycle of aridity in the 1890s and early 1900s that nearly wiped out the gains of a generation shaped by "wet-cycle consciousness." From the violent blizzards of 1887-1888 that killed over five million head of cattle wandering the open range from Montana to Texas, to the searing heat of the 1890s that gave rise to the radical political movement known as "Populism," climate and weather threatened to restore Stephen Long's "Great American Desert" moniker to maps of Colorado and the interior West.

A senator from the new state of Wyoming, Joseph Carey, convinced his colleagues in 1894 to pass the "Carey Act," which called for funding of irrigation reservoirs with money collected from the sale of public lands in the West. The grip of drought, however, kept many farmers from moving into the region, and the collapse of the silver mining business in the mid-1890s emptied Colorado's mountain towns (and removed the consumers of Colorado agricultural production). Not surprisingly, pressure on political leaders in Washington led in 1902 to the establishment of the U.S. Reclamation Service (later renamed the U.S. Bureau of Reclamation), in which the federal government provided the capital, technology, and engineering expertise to sustain agriculture throughout the interior West.

As would happen so often in Colorado's history of drought and abundance, the return after 1905 of the wet cycle coincided with major gains in population (this time to the urban corridor of the Front Range and also the vast expanses of the eastern plains). Farm prices soared to their highest levels ever in the years preceding and including World War I (1914-1918), as the federal government negotiated contracts with America's farmers to "plant fence to fence for national defense," as posters proclaimed on the walls of post offices and feed and grain stores in farm country.

At the same time, the federal government opened lands on the plains heretofore ignored by homesteaders, including the South Platte River valley. There a group of black residents of Denver followed the call of the Reverend O.T. Jackson in 1909 and started the utopian colony that they named "Dearfield." With profits like farmers had never seen, railroads ran lines across the plains, banks loaned money in record quantities, and communities built schools and other public institutions in hopes that stability and prosperity were there to stay.

W.D. Farr, a banker in Greeley during the Thirties, would witness first-hand the pain and suffering that drought could inflict on his friends and neighbors; a phenomenon that remained fresh in his mind six decades later in a 2002 interview on the history of drought in 20th century Colorado.

If history meant anything to these 20th century pioneers, it was the boom mentality that came with wet-cycle consciousness. Perhaps that explains the shock and trauma visited upon the state when the dry cycle returned in the mid-1920s, aggravated by the end of federal farm contracts after the war's end, the shift of investment capital to the nation's growing cities (which also offered more attractions and amenities than rural America), and the collapse in 1929 of the stock market, which triggered the decade-long "Great Depression." By 1933, farm and ranch production in Colorado had declined by 50 percent (a statistic that mirrored national trends), unemployment stood at one-third of the adult work force, and the value of investments had sunk to a mere ten percent of their 1929 peak.

Making matters worse for Colorado and its neighbors was the added calamity of the Dust Bowl (1931-1940). W.D. Farr, a banker in Greeley during the Thirties, would witness first-hand the pain and suffering that drought could inflict on his friends and neighbors; a phenomenon that remained fresh in his mind six decades later in a 2002 interview on the history of drought in 20th century Colorado. Farr would recall how dust blew down the wide streets of Greeley (a town created to overcome the vagaries of nature on the plains), and how that broke the resolve of people to endure the hardships all around them.

Community leaders like Farr would gather to contemplate radical solutions, among them the novel concept of transferring water from the abundant west-flowing streams of the Colorado River valley to the parched towns and farms of the South Platte drainage basin. Convincing West Slope interests to sign away their claims to water that they did not need was but one of the challenges in the path of the "Colorado-Big Thompson Project," known colloquially as the "C-BT" and "the Big T." Congress approved the project in 1937, and by 1954 water flowed from reservoirs in western Colorado through a 13-mile long pipeline under Rocky Mountain National Park and into the Cache la Poudre and Big Thompson rivers. Farr remarked that the stability and volume of the "Big T" had "created" the modern Front Range, and that its combination of storage reservoirs and supplies from the sparsely populated West Slope would help eastern Coloradoans survive most of the dry cycles that followed.

With the return of the wet cycle in the early 1940s, abundance of another sort came to Colorado: the urban growth associated with military spending in World War II (1941-1945). The population of Denver would expand from 330,000 in 1940 to 2.4 million in the 2000 census, with similar statistics for communities like Colorado Springs (40,000 to 550,000) and Fort Collins (12,000 to 100,000). Agriculture would benefit from these growing markets for food and fiber, just as wartime crop production again brought prosperity to farmers suffering from a decade of drought. The dualities of urban sprawl and increased farming would place a strain upon the state's water supply when the next dry cycle came (the mid-1950s), at which time the strategy of underground pumping for irrigation wells was introduced. The dry cycle of the early 1950s to the late 1970s only had one bad year (1954), and that was mitigated by the flow of C-BT water onto the plains.

Increased use of water in the dry cycle of mid-century would lead in 1969 to another change for water users: the adjudication of water rights. Water courts were established in each river basin of the state, with rural and urban interests competing for claims to stream-flows that fluctuated dramatically in periods of drought. Before this dry period ended, yet another feature of water management entered the Colorado landscape: snowmaking for the state's growing network of resorts. International fascination with Colorado (particularly its snow-covered mountains) had lured a new generation of pleasure-seekers in the 1960s and 1970s, and skiing became their venue for excitement and adventure.

A "year without snow" (the winter of 1976-77) kept many resorts from opening, and their owners responded in the same way that the irrigators of Greeley had done a century before. They applied technology to their operations, and drew water from mountain streams to spray upon their mountainsides. Additional technologies included "cloud-seeding," where airplanes flew into the heart of storms over the Rockies and dropped iodized pellets that would expand the water molecules (and increase the yields of snow).

The late 1970s also witnessed the first attempt to manage drought, rather than merely react to it with despair or public works facilities. Colorado governor Richard Lamm, who had risen to prominence in the early 1970s with his strident message of environmental protection, assembled the first "drought task force" in state history. Lamm had worked in 1972 to block Colorado's bid for the 1976 winter Olympics (the only state to have done so in the 20th century), and he stressed the need for careful stewardship of the state's natural resources. Len Boulas, director of Colorado's office of emergency preparedness, would chair the task force, and Fred Anderson, a state senator from Loveland, would serve as a senior member representing the state legislature.

In interviews in 2002, Boulas and Anderson recalled the many problems facing their committee: a lack of precedent not only in Colorado but nationwide in drought planning (only one state had a similar task force underway in 1979, said Boulas); the desire of urban residents to have green lawns in an arid climate (Denver would not have individual water meters for households until the early 1990s, and people would water their lawns daily to combat the drought); and the need to sustain agricultural production that consumed over 80 percent of all stream-flows in the state.

Confronting the drought task force was one additional feature not known to previous generations of Colorado water managers: the environmental movement. Fred Anderson recalled how representatives of major environmental groups practiced "single-issue" politics: speaking emphatically for their position, with little regard for the complexities of water management in the state. Anderson and his colleagues realized that water policies had to change, but the tensions caused by drought, demand, and environmental activism made their job no easier. Eventually the committee sent Governor Lamm a report offering suggestions for cutbacks (Denver temporarily would restrict lawn-watering in the early 1980s), but their work stalled when the matter of water rights adjudication surfaced.

Then, remembered Boulas, the wet cycle returned, lasting for nearly two decades. Public awareness of the hazards of drought vaporized as easily as water does in desert heat, and

late-1990s, much had changed in Colorado that threatened the state's water resources once more. Census data revealed that the Centennial state ranked third nationally in population growth, with three of the fastest-growing counties in America to be found along the Front Range and in the adjacent foothills. Prosperity had reshaped the economy, with Colorado seen as an attractive option for families and corporations fleeing the high costs and overcrowding of the nation's more-mature urban areas. Farmers also had reconfigured their operations to meet the international markets, and the decline of available water for irrigation made them only more dependent upon underground sources. The inevitable clash of uses that emerged at the turn of the 21st century, then, reminded Farr, Boulas, and Anderson that several lessons of the past needed repeating.

James A. Michener[']s…five-year stint as a professor of history education at Colorado State Teachers College in Greeley (today's University of Northern Colorado) affected his thinking many years later when he returned to write the definitive novel of Colorado's history, Centennial (1974)… Michener marveled at how nature resisted the efforts of farmers and ranchers lured onto the plains in times of abundance.

First, said W.D. Farr, water managers and urban planners alike needed to "be cautious" about their projections for water use. After nearly a century of observing the Colorado water scene, Farr concluded that one must respect the power of nature, and also "remember that people forget the past" as they seek a better future. Fred Anderson then noted how a "balance" must be struck between growth and environmental protection. He and Len Boulas remarked about the visceral distrust of environmentalists regarding multi-purpose water storage facilities, which both individuals claimed would affect the landscape far less than persistent drought.

Boulas closed with the admonition that water managers must learn to work together (a plea echoed by former state senator Anderson) rather than focus upon their particular region of the state or river basin. Finally, said Boulas, water managers need to remember that they are servants of a public in need of explanations of the complexity of western water. Its history and future will shape the plans and dreams of four million Coloradoans, not to mention the generations to come.

Their understanding of the centrality of water would echo that of a former Coloradoan, James A. Michener, whose five-year stint as a professor of history education at Colorado State Teachers College in Greeley (today's University of Northern Colorado) affected his thinking many years later when he returned to write the definitive novel of Colorado's history, Centennial (1974). Coming in 1936 from the humid East in the worst year of the Dust Bowl (Weld County had seen summers with over 100 days of temperatures above 90 degrees, winters with little or no snow, and dust clouds billowing 60,000 feet into the atmosphere), Michener marveled at how nature resisted the efforts of farmers and ranchers lured onto the plains in times of abundance.

Towns like Keota, which became a favorite haunt of Michener's (and the site of his "Line Camp" in Centennial), lost their best and brightest to the wind, drought, and bad markets of the 1930s. By the 1970s, the only reminders of the experiment of the plains were the creaking windmills, sagging structures, and empty town-sites where hopes had risen as rains had fallen, and Michener's gift to Colorado was to reiterate the old lesson that water makes us what we are.

ECONOMIC EFFECTS OF THE DROUGHT ON COLORADO'S RECREATION AND TOURISM

by Chad A. Schneckenburter and Dr. Robert Aukerman
Department of Natural Resource Recreation and Tourism
Colorado State University

Introduction

The summer of 2002 has been one of the driest in the State of Colorado in close to 25 years. The current drought that Colorado is experiencing is in its fourth year and has begun to wreak havoc on a wide range of areas – environmental, social, and economical. When people think of the economic damages occurring as a result of a drought, they most often think of the harm done to the agricultural industry. While the effects on this industry can be disastrous, other industries, such as recreation and tourism, are suffering on a much larger scale than agriculture. As history has shown in Colorado, the recreation and tourism industry often takes a back seat to the interests of agriculture in terms of policy and public support, yet it generates roughly twice as much revenue. Much of this can be attributed to the fragmentation of the industry and lack of a central representative authority. It is an industry that has seen its largest growth occur primarily in the last 20 years.

As more and more people move into the state, they no longer do so to "grab a piece of the frontier" and sow the land, but rather to improve their quality of life by surrounding themselves with the state's abundant natural resources. Additionally, every year more and more people travel to Colorado from out-of-state for these same reasons. Last year the recreation and tourism industry injected over $8.5 billion into the state's economy (Hart 2002) while the agriculture industry in the State of Colorado generated close to $4.3 billion (Christenson 2002). Recreation and tourism clearly represent a significant sector of Colorado's economy that cannot be ignored when considering drought mitigation options.

It must be recognized that the damage drought has brought to the recreation and tourism industry is monumental. The damage involves sectors such as the transportation, hotel and ski industries, as well as many small businesses such as independent river rafting and fishing guides and sporting goods and bait stores, to mention a few. Each and every sector of the tourism and recreation industry within the State of Colorado has been negatively affected by the drought. Likewise, the damage to the recreation and tourism industry extends to include a regional economic impact on indirect services that include gasoline, groceries, restaurants, retail, and more. When recreation and tourism in Colorado suffer, so do the services that depend on this industry. Additionally, the State of Colorado itself has suffered as much as, or more than, any one single industry. For a state park system that depends almost entirely on revenue generated at water-based recreation areas, the damage has been substantial.

Each sector of the industry, including the state park system, will be forced to make some difficult decisions over the next several months in order to cope with the heavy financial losses sustained this year. Consequently, barring a particularly heavy snowpack this winter and a wet spring of 2003, many small businesses may be forced to close their doors, and Coloradoans may see drastic cutbacks in staffing, maintenance and other services within the state park system.

Tourism and Recreation in Colorado

It is estimated that tourism and recreation inject more than 8.5 billion dollars into the state's economy and comprise roughly 8 percent of the state's workforce, or approximately 220,000 jobs. Additionally, the tourism and recreation industry provides approximately $550 million in revenue for both state and local governments each year (Colorado Travel Inputs Study, 1996-2000, June 2002).

In examining recreation and tourism within Colorado, it is important to keep in mind that certain areas of the state are more directly dependent on recreation and tourism than others, and any economic effect on the industry will have a substantially larger effect on their regions. Much of eastern Colorado is involved in agriculture, while the Front Range has a widely diversified economy with a great deal of industry to support local economies. Yet, in many of the mountainous areas of the state, communities are solely dependent on recreation and tourism for both employment and income. The part of the state most dependent on recreation and tourism includes Eagle, Grand, Jackson, Pitkin, and Summit counties. In this region, tourism comprises roughly 51 percent of the resort counties' employment and 76 percent of its income. The second-highest dependent area, encompassing Archuleta, Dolores, La Plata, Montezuma, and San Miguel counties, rely on recreation and tourism for 27 percent of its income and 21 percent of its employment (Colorado Travel Inputs Study, 1996-2000, June 2002). Other high-recreation and tourism regions of the state are equally as dependent on related income and employment.

Another important point about regional economic impact is that it quite often involves small businesses in particular regions rather than single large businesses within an industry. For example, visitors to Colorado who stayed in commercial accommodations, such as hotels, motels, inns and B&Bs, accounted for roughly 60 percent of travel spending within the state. Additionally, retail purchases by travelers accounted for $1.2 billion, and the restaurant and transportation industry (including gas purchases and local fares) garnered roughly $1.6 billion and $1.3 billion in expenditures respectively (Colorado Visitors Study, 2001). Although some large businesses such as hotel chains are sure to be affected, it is the small-business person in the communities surrounding parks and resorts that depend most heavily on recreation and tourism spending.

Effects of Drought on Various Recreation Sectors

What is the impact on each sector of the recreation and tourism industry? Due to a limit in time and resources, a complete research study and analysis was impossible. However, a snapshot of the effects on various sectors of the industry was possible through a series of one-on-one interviews with representatives from these sectors. It was decided to focus primarily on local, recreation-oriented private businesses such as fishing and rafting, as well as locally affected, government-run parks.

Colorado state parks probably have been the most severely affected of all sectors of the recreation and tourism industry due to the drought. The Colorado state park system is largely a water-based recreation system with lakes and reservoirs being the focal point of the bulk of the parks within the state. An interview with the director of the northern region of Colorado state parks revealed a number of interesting and alarming facts. First, the state park system is roughly 75 percent self-sufficient, with the bulk of their revenues coming from user fees. Most of these user fees are from day-use boat launches at state parks and related camping and day-use hiking fees. The northern region also receives a small amount of revenue from concessionaire fees of the marina operators at the parks. Last year, the parks system decided to increase fees across the board approximately 20 percent. In a normal year, a 15 to 20-percent increase in revenue would have been expected as a result. Yet, due to the drought this year, they were forced to close several lakes and reservoirs early due to low water levels and the inability to launch boats.

A typical year would allow lakes and reservoirs to open until around the end of October. Many lakes, such as Boyd Lake and Jackson reservoir, however, were forced to close their water access around the middle of July this year. Additionally, there was the widespread perception from people around the state that all the lakes were dry and many people simply quit coming, even to the parks that had enough water and were open. The statewide ban on fires also impacted use of state parks, national forests, national parks and other public areas. Recreationists do not want to camp in areas where they can not have campfires. Many went out of state to recreate where there was water and campfires were allowed. This leads to a drain of revenue due to residents taking and spending money out of state.

The northern region of Colorado state parks saw a reduction in revenue of between 35 to 40-percent across the board, with some individual areas generating almost 57 percent less than 2001. Another indicator of the situation was the decline in camping reservations at various parks around the state. In general, reservations were down approximately 20 percent across the board. According to the park representative, as Colorado State Parks is largely self-sufficient, drastic measures may have to be taken to meet revenue shortfalls. These measures will include cost-reduction strategies including a hold on all non-essential maintenance, no new equipment purchases, and most importantly, a large reduction in staff, both part-time and possibly full-time.

In addition to Colorado state parks, county parks have also been affected. An interview with the director of Larimer County parks and recreation showed similar problems at Horsetooth Reservoir. The boating season at Horsetooth ended on July 15, with water levels being too low for boats to launch. Horsetooth, even with dam construction, normally has a 100-day boating window. This was reduced by roughly 30-45 days this year. For the two-month period of July15 through September 15, Horsetooth was down approximately $200,000, or roughly 25 percent from normal revenues. Again, as a result of decreased boating, and the ban on fires in Larimer County, camping was down 15-20 percent as well. The representative from Larimer County parks indicated that a large number of people were traveling out-of-state to lakes where water levels might have been higher. Additionally, he stated that the county will have to undertake several cost-cutting measures for next year, including a 20 percent reduction in seasonal employment.

As well as parks within the state, the three major water based recreation industries in Colorado -- the marine/boating industry, the rafting industry, and the fishing industry --have been enormously affected.

The marine/boating industry was one of the hardest hit of the private industries. An interview with two local marine dealers revealed that early closures of parks have seriously strapped their cash intensive industry. They revealed that they saw a reduction in revenues of close to 50 percent by July. The two largest revenue-generating months, July and August, saw their revenue slide even further. New boat sales had virtually stopped while the maintenance side of the business actually saw an increase. They attribute this to the fact that people were not buying new boats, but rather spending money on fixing up what they currently owned. It should be noted that they had a harder time attributing this reduction in new boat sales entirely on the drought, as some of it may have to do with the current state of the economy. However, one representative indicated that in tough economic times people were more likely to spend less money on travel and more on recreational toys such as boats and jet skis. Still, both dealers claim that they would not have been able to hang on financially had it not been for the flexibility of manufacturers working with them on volume-buying programs and inventory control.

The rafting industry has probably received the most press about its situation due to the effects of drought this year. According to an article in the November 6, 2002 edition of the Coloradoan, rafting industry revenues are down as much as 50 percent this year. This information conflicts somewhat with interviews conducted with representatives from two different rafting companies as well as representatives of the Colorado River Outfitters Association (CROA). They claim the numbers to be closer to 35 to 40 percent, which is still a substantial reduction in revenue. The rafting season generally lasts through mid-September, but many rivers were too low to launch by mid-August. Although both companies saw a drastic reduction in adventure rafters, there was still strong interest in the sport by families, church groups, etc. According to both representatives, their biggest problem this summer was fighting the perception of out-of-state visitors about the widespread fires in the state.

Similar to the rafting industry, the fishing industry fought a battle of perception all summer. According to representatives from three separate fishing shops, their biggest obstacle this summer was convincing people that the fishing was actually very good. Low water level and high water temperatures led to some very good fishing in certain areas. Yet, many of their repeat customers opted to travel to other western states where water levels were higher and temperatures were more normal. According to the representatives, gear sales were down close to 30 percent and guided trips were down close to 20 percent. One local bait shop, Dave's Bait and Tackle, saw a 70 percent reduction in revenue and was forced to permanently close its doors. They attributed this directly to the drought.

Lastly, the ski industry had reduced revenues of over 5 percent last season due in part to the drought. Repeated contacts with representatives from individual resorts proved futile, and we found a reluctance from Ski Country Colorado to speak on the issue. However, past numbers indicate that the drought of 1977 caused a 40 percent reduction in lift ticket sales and a 15 percent drop in employment (Hart 2002). It must be remem-

bered, however, that this was before many advances in modern snowmaking ability.

There are two recurring themes found in this research. First, there may be a substantial amount of leakage occurring from the State of Colorado. Defined simply, leakage is the payment for wholesale and retail products and services brought in from outside the region, plus the interests, profits, rents, and taxes paid outside the region (Loomis and Walsh 1997). Conversely, in this case, large numbers of people are leaving the state and out-of-state visitors are bypassing Colorado for other states where they can find substitute recreation areas or activities. Although no solid number has been determined on the amount of leakage occurring, there is consensus among representatives from all the recreation and tourism sectors studied that it most definitely exists. The declines in recreation and tourism revenues that we found in this study do exist and are significant. Even though our study was not scientific and was but a snapshot of the industry, we believe that a safe guess of the revenue decline this year is around 20 percent. This is a decline of $1.7 billion in Colorado's tourism and recreation revenues due directly or indirectly to the drought. Research is needed to verify this estimate; however, many of the actual figures will be coming in the early spring of 2003.

Mitigation Efforts

To date, there has been no single united effort by the recreation and tourism industry to combat the crisis it faces. This may have to do with the fragmented nature of the industry. There is no single, representative authority to speak for the industry as a whole. There is a Colorado Tourism Board run by the state that recognizes the importance of the industry to the state's economy; however, it does not seem to be fully representative of the entire industry, especially some of the smaller, recreation-oriented businesses. Many of the individual sectors of the industry do have associations, such as the Colorado River Outfitters Association (CROA) and the Colorado Marine Dealers Association (CMDA), yet they all seem to be lacking in resources and strength to be able to wage the full-scale assault necessary to fight politically for an agenda that would benefit their businesses. An organized and politically motivated association representing all affected and interested recreation and tourism institutions within the State of Colorado would greatly benefit their cause.

Individually, however, each sector and business is doing what it can to stay afloat. The parks, both state and county, will be taking drastic cost-cutting measures, including a halt on maintenance and staff reductions, both seasonal and possibly even full-time. The marine/boating dealers have had to drastically reduce inventory and work with individual manufacturers on inventory control issues to keep their overhead costs down. The fishing and rafting companies have waged an aggressive PR campaign against the perception that the state was on fire and there was no water anywhere.

Consensus among all the sectors of the industry is that the only sure way to get out of trouble is to have an abundance of snow this winter and heavy rainfall in the spring. Yet all agree that if water levels remain where they were this past summer, or worse, many will not be able to survive another year.

It must be remembered that much of the recreation and tourism industry is on a small scale. A sustained drought of the likes of this past summer will have devastating effects on the small business person. They simply do not have the financial resources that some of the larger sectors have to weather the drought. Additionally, much of the indirect, tertiary business connected to recreation and tourism is on a very small scale. It is these "mom and pop" businesses that have been the first to feel the pressure and financial effects of a sustained drought.

One final consequence that has not been given much attention is the quality of life of Colorado residents. A large percentage of the people who live in Colorado, and those who continue to move here, do so for the opportunity to lead a very active lifestyle in connection with the natural environment. A sustained drought is bound to have an effect on the quality of life enjoyed by residents of this fine state. Although this is much harder to quantify, it is something that should not be ignored.

Conclusion

It is clear that the drought, technically in its fourth year in Colorado, is having an economic impact on the recreation and tourism industry. In the face of tremendous growth, recreation and tourism hold one of the major keys to the prolonged financial stability of Colorado's economy and to its residents' quality of life. Thus, in the face of drought, we must begin to look at ways to help ensure the survival of individual sectors of the recreation and tourist industries. There is no easy answer as to how this should be done. Clearly, agricultural, industrial and municipal uses of water are very important and control the states water. If the recreation and tourism industry could unite and work with these other industries, some cooperative efforts and efficiencies in the use and management of water might be found that would benefit all.

More than anything, the current situation shows the need for future research in this area. This study has been a simple snapshot of a tremendously large problem. A well-organized and funded examination into the direct and indirect economic effects of a prolonged drought on the recreation and tourism industry is needed. This is an issue both private industry and state and local government should be concerned about. The economy and quality of life in Colorado are dependent upon this.

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WATER SUPPLY

The drop in SWSI values during December reflects a poor snowpack accumulation during the month. In contrast to the good snows that most of the state received during November, poor snowfall amounts came in December, resulting in below average snowpack over most of the state by the end of the month.

The drop in SWSI values during December reflects a poor snowpack accumulation during the month. In contrast to the good snows that most of the state received during November, poor snowfall amounts came in December, resulting in below average snowpack over most of the state by the end of the month.

Stream flows continue to be significantly below average, at a time of the year when streams are at their lowest rates of the year anyway. With snowpack currently below average, stream flow forecasts are also far below a normal runoff. Even though the majority of the snowpack accumulation season does lie after December, it would be prudent for water users to at least make plans for another year of low runoff in 2003. The dry soil profile will likely capture a greater portion than normal of the snowpack that does melt in spring. With a cumulative storage of 58 percent of normal for all reservoirs graphed in this report, it is only the rare reservoir that contains above normal amounts.

The Surface Water Supply Index (SWSI) developed by the State Engineer's 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 January 1, 2003, and reflect the conditions during the month of December.

Basin	1/1/03 SWSI Value	Change From Previous Month	Change From Previous Year
South Platte	-2.7	-0.3	-1.1
Arkansas	-0.7	-1.8	+1.1
Rio Grande	-0.8	-0.3	-1.3
Gunnison	0.0	-0.8	-0.6
Colorado	-0.1	-1.1	+1.2
Yampa/White	-0.8	-1.7	+1.0
San Juan/Dolores	-0.7	-1.2	-0.9

SCALE								
-4	-3	-2	-1	0	+1	+2	+3	+4

CSU SEMINARS

Department	Website
Agricultural & Resource Economics	http://dare.agsci.colostate.edu/
Atmospheric Science	http://www.atmos.colostate.edu/dept/seminar/S02seminar.htm
Bioag. Sciences & Pest Mgmt.	http://www.colostate.edu/Depts/bspm/Seminars/seminar_schedule.shtml
Chemical Engineering	http://www.engr.colostate.edu/cheme
Chemistry	http://www.chm.colostate.edu/
Earth Resources	http://www.cnr.colostate.edu/ER/seminars/index.html
Environmental Health	http://www.cvmbs.colostate.edu/cvmbs/thiswk.html
Fishery & Wildlife Biology	http://www.cnr.colostate.edu/FWB/FW692signup.pdf
History	http://www.colostate.edu/Depts/Hist/events.html
Natural Resources Ecology Lab	http://www.nrel.colostate.edu/news/calendar.html
Soil & Crop Sciences	http://www.colostate.edu/Depts/SoilCrop/spring%20seminar2002.htm
Statistics	http://www.stat.colostate.edu/~tlee/Sem02Spr/

Listed below are some seminar highlights. If any of these programs arouse your interest, see the web page listed above for more information.

Spring 2003 Monday Lunch Seminar Series, Dept. of Agricultural and Resource Economics & Department of Economics and U.S. Forest Service Rocky Mountain Research Station, Time: 12:10 to 1:00 p.m., in Room 110 Animal Science. Pizza and Soda served.

Feb. 17	James Pritchett and Stephan Weiler, Dept. of Ag. & Resource Economics	The Economic Effect to the South Platte Region of Court-Ordered Groundwater Restrictions
Mar. 3	Linwood Pendleton, Univ. of Wyoming	Biological Regulation and Weather-Related Risks in a Commercial Fishery
Apr. 7	Tom Brown, U.S. Forest Service	The Value of Water in the West: What 12 Years of Water Transactions Reveal
Apr. 21	Paul Jakus, Utah State University	The Benefits and Costs of Fish Consumption Advisories for Mercury

Atmospheric Science Seminars are located at the Department of Atmospheric Science, Foothills Campus, W. Laporte Ave., Room 101 at 3:30 pm unless otherwise specified.

Mar. 20	Dan Vimont, Dept. of Atmospheric Sciences	Is the El-Nino/Southern Oscillation Initiated by the Mid-latitude Atmosphere?
Apr. 10	Mike Alexander, NOAA Climate Diagnostics Center	The Atmospheric Response to Arctic Sea Ice Anomalies

Fishery and Wildlife Biology -- Graduate Faculty Seminar (FW692v) meets Friday afternoons in the Wagar building (the exact time and location varies by semester. The seminar is open to anyone -- private enterprise and NGO colleagues are especially encouraged to attend.

Mar. 28	Ed Weber, Dept. of FWLB	Interspecific Competition Between Hatchery-Reared and Naturally-Spawned Juvenile Chinook Salmon in the Sacramento River, California
Apr. 4	Susan Stonich, Professor and Chair, Environmental Studies Program, University of California	Distinguished Ecologist Series
Apr. 11	Harry Crockett, Graduate Degree Program in Ecology	Foraging Behavior and Abundance of Lake Trout in a Western Reservoir: Quantifying the Trophic Impact of a Top Predator
Apr. 25	Arriana Brand, Dept. of FWLB	Density and Productivity of Desert Riparian Birds in Relation to Forest Edges and Variation in Hydrologic Systems.
May 9	Meredith Wright, Graduate Degree Program in Ecology	The Relative Importance of Fungi and Bacteria in Predicting Shrimp Feeding Preference and Leaf Decomposition Rates in a Tropical Headwater Stream

CWRRI
CSM water news

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by
Robert L. Siegrist, Ph.D., P.E.
Professor and Division Director, Environmental Science & Engineering,
Colorado School of Mines, Golden, Colorado

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In the Rocky Mountain region, there has been significant development during the past decade, much of which is occurring in suburban fringe, rural and mountain settings. In these areas, wastewater management is commonly achieved by decentralized or onsite wastewater treatment systems (OWS). In Colorado there are over 600,000 onsite systems in operation serving about 25 percent of the State's population and about 7,000 to 10,000 new systems are installed each year. On an annual basis this amounts to over 30 billion gallons of wastewater effluent discharged to the environment. In Wyoming, Montana, and Utah, the situation is similar. In the U.S., about 25 percent of the population is served by decentralized systems and nearly 37 percent of all new housing development is being supported by such systems. In the world, over 2 billion people lack adequate water and sanitation and onsite and decentralized approaches can represent appropriate solutions. There is a clear and recognized need for continued, if not expanded, use of OWS as a component of wastewater system infrastructure in Colorado, the Nation, and the world, not only to protect public health and the environment, but also to enable beneficial reuse of water and nutrients. However, in order for these systems to be widely accepted and properly implemented, the science and engineering supporting their use must continue to advance. This article highlights the basis and need for advancing the science and engineering of decentralized systems and provides an overview of a research program ongoing at the Colorado School of Mines (CSM).

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Domestic wastewater poses inherent risks due to its microbial and chemical constituents (Crites and Tchobanoglous 1998, EPRI 2001, Siegrist et al. 2001). Effective management includes an assessment of the nature and magnitude of any risks in a given situation so that decisions can be made regarding the most appropriate management strategy to mitigate those risks to some agreed upon goal. Figure 1 illustrates a risk framework for a typical decentralized system which includes an onsite wastewater system (OWS) (e.g., one serving a household, multifamily residence, or commercial establishment) that consists of tank-based pretreatment followed by effluent discharge into a subsurface trench where advanced treatment can occur during percolation through soil and ground water recharge. Various risks are portrayed in Figure 1 considering the relevant public health and water quality facets associated with this type of OWS and its application at a single site (although this framework can apply to multiple sites at the subdivision- and watershed-scales as well). For example, pathogenic bacteria, virus, and protozoa are present in wastewater, and disease could result if they are not removed or inactivated before an effluent reaches a receiving environment where humans can contact and ingest the water (e.g., drinking water, bathing beaches, shellfish beds). Also, if excessive levels of nitrogen and phosphorus in wastewater are input to sensitive surface waters (e.g., pristine lakes, estuaries), this could result in undesirable ecosystem changes (e.g., increased productivity and eutrophication).

While simple in concept, risk-based design and application of OWS is quite difficult to implement. For wastewater treatment, one could state the ultimate goal to be that OWS design and implementation is carried out such that that there is no infectious disease caused by an OWS and there is no unacceptable change in an ecosystem attributable to wastewater system inputs. In practice, this ultimate goal would need to be converted to explicit performance goals, the achievement of which would ensure that risk would be managed to an agreed upon and acceptable level. However, this is seldom done. Instead, risk management is presumed to be accomplished by implementing an OWS following prescriptive siting and design practices. Despite the absence of explicit goals, the design practice for an OWS does follow a logic that is underpinned by achieving public health and water quality protection, over a long service life and at an affordable cost. Such a practice often includes a series of inter-related tasks, the flexibility of which are controlled to varying degrees by local prescriptive codes and conservative practices: (1) characterize the wastewater source in the context of the receiving environment, (2) set performance goals (usually implicit, rarely explicit) with respect to treatment efficiency, service life, operation and maintenance needs, and costs, (3) identify the simplest robust OWS options that can achieve performance goals (see Fig. 2), (4) define monitoring for process control and performance assessment, (5) consider and compare routine operation and maintenance needs and OWS costs, (6) consider regulatory and stakeholder frameworks, and (7) select and implement (design, construct, and operate) an "optimal system."

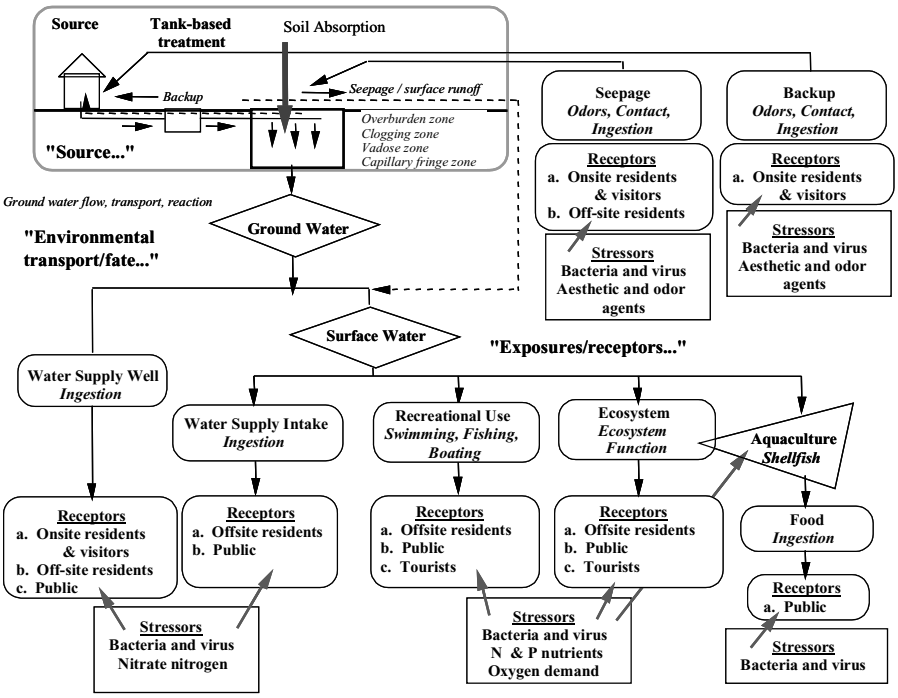

Figure 1. Conceptual framework for risk-based management of OWS (Siegrist et al. 2001.

The 'toolbox' from which to select an 'optimal system' began to be filled with options during the 1970's and 1980's (e.g., SSWMP 1978, USEPA 1980). Today there are more OWS options than ever, including both methodologies (e.g., evaluation practices, modeling tools) and technologies (e.g., treatment units, monitoring devices) (e.g., Crites and Tchobanoglous 1998, EPRI 2001, Siegrist et al. 2001, USEPA 2002). Based on its effectiveness, implementability, and cost, the vast majority of OWS designs include a core unit operation, which is often called a leachfield, drainfield, or soil absorption system, but which more appropriately should be termed an in situ soil porous media biofilter based on purification performance as well as hydraulic function. In the common OWS design, wastewater is pretreated and then discharged into the subsurface via a trench or drip emitter line from which transport occurs through an unsaturated zone with recharge primarily to ground water. During unsaturated flow through as little as 30 to 60 cm of aerobic soil, tertiary treatment can be reliably achieved for many conventional pollutants (e.g., BOD_5, suspended solids, bacteria) by filtration, sorption, biodegradation, and predation processes. With dilution in the ground water and additional removal therein, these pollutants seldom present any concern to a receiving environment. However, nutrient and pathogen removal remain more sensitive to OWS design and site conditions. Wastewater pretreatment is often accomplished by an anaerobic bioreactor (a.k.a., septic tank), which can include enhancements such as effluent filters. Extended aeration units or packed bed reactors (e.g., sand or textile filters) can also be used to improve quality before discharge to the subsurface or to enable surface discharge (e.g., discharge to the land surface for beneficial reuse by landscape irrigation, or to a receiving water like a stream or river). In some cases, small-scale onsite disinfection units are available (e.g., ultraviolet light systems) to remove pathogens before surface discharge.

OWS, and the unit operations that comprise them, have the potential capability to yield treatment performance that can mitigate public health or environmental risks. However, the performance actually achieved by an OWS depends on a number of inter-related factors, including site evaluation and system siting, system design, installation and construction, system usage, and routine operation and maintenance. If all of these activities are properly completed as required, and if the actual conditions and usage are consistent with any assumptions made, then actual performance should match potential capability of the OWS. However, if any of these factors are overlooked or inadequately addressed, or if actual conditions depart from assumptions made in design and implementation, then performance deficiencies can occur either early or late in the system's life and manifest themselves as mechanical, hydraulic, or purification dysfunctions.

Clearly, in a given setting, an OWS that provides no treatment at all (e.g., straight-pipe discharge of raw sewage into a ditch) may present the highest risk, while increasing levels of treatment effectiveness can yield reduced levels of risk. It is important

to note that risk management requires that treatment potential is actually achieved in a reliable fashion throughout the period of anticipated use (e.g., 10 years or more). That is to say, if an OWS has a potential to achieve a high degree of treatment (e.g., for nutrient removal) and such a system is implemented with the expectation that this potential will in fact be realized, somehow this expectation must be assured. The extent to which this requires active management with certified design and installation, routine operation and maintenance, and required performance monitoring depends in large part on the robustness and reliability of the OWS as well as the potential adverse effects if a performance dysfunction occurs. Given this, as well as the fact that risk management requires consideration of nontechnical factors (e.g., socioeconomics), the simplest and most robust solution that is effective, implementable, and affordable will normally provide the best overall risk management solution (e.g., see Fig. 2).

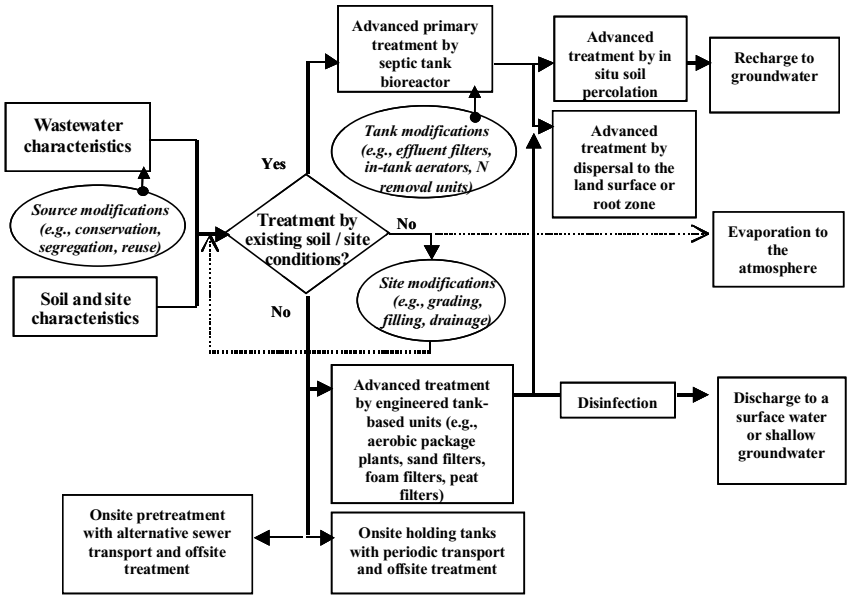

Figure 2. Strategy for system selection for OWS applications.

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There is a clear and recognized need for continued, if not expanded, use of OWS as a component of wastewater system infrastructure in Colorado and the U.S., to protect public health and the environment, but also to enable beneficial reuse of water and nutrients (e.g., USEPA 1997, EPRI 2001, USEPA 2002). Yet, to enable effective and sustainable use of OWS, there is a current and expanding need for quantitative scientific understanding and engineering design tools. For example, dysfunctions of conventional technology in a given setting often spark an interest in knowing the cause of the problem(s) either to mitigate the current failure condition and/or to identify alternatives that will be more successful. In addition, technology vendors are advocating an increasing array of new devices, systems, and design approaches, and the user and regulatory communities are seeking performance understanding to enable approval and widespread acceptance. Furthermore, there are external forces such as ground water disinfection regulations, source water protection initiatives, and watershed total maximum daily load (TMDL) programs that are intensifying the scrutiny of OWS and increasing the need for scientific understanding and rational engineering practice. While much is known about the science and engineering of decentralized systems, there are gaps in the current knowledge base and even where there are not, the existing knowledge base is often not fully understood and accepted by all relevant stakeholders (Siegrist 2001, EPRI 2001). As a result, we often lack the ability to adequately describe in quantitative terms how a system of a given design functions and what can be done to modify design or operation factors to achieve a given performance goal. As a further result, creative practice is often constrained by very conservative prescriptive codes, with a reluctance on the part of those experienced in, or new to, the field to try anything other than what has been done for years.

The Rocky Mountain Onsite and Small Flows Research Program was initiated at the Colorado School of Mines (CSM) to advance the science and engineering of treatment technologies and enhance the long-term viability of decentralized approaches to water infrastructure in Colorado, the U.S. and abroad. This multidisciplinary program involves fundamental and applied research designed to quantify and model key hydraulic and purification processes in decentralized treatment systems. Recent and ongoing

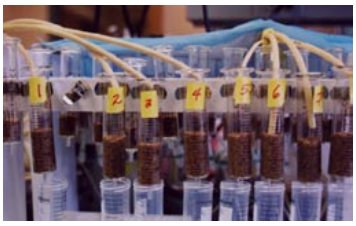
research is focused on natural and engineered porous media biofilters (PMBs) (Fig. 3, Table 1). Bench-scale studies are completed to understand fundamental processes while pilot- scale unit operations and test cells are used to study treatment processes under controlled conditions. For this research, apparatus and facilities exist in laboratories at CSM as well as at a new field test site at Mines Park on the CSM campus (Fig. 3f).

Field investigations occur at operating facilities elsewhere in Colorado and at sites across the U.S. Monitoring and assessment of hydraulic and purification processes involves sampling and analysis combined with in situ sensors and computer-assisted data acquisition and visualization. Multicomponent tracer and surrogate studies as well as DNA fingerprinting are employed to delineate pollutant source and flow and transport behavior. Analytical and numerical models are used to describe pore-scale to watershed-scale processes. The research program involves a team of faculty, staff and students from several departments at CSM and collaborating institutions in the U.S. and abroad. Together, they provide the requisite expertise in environmental engineering, geological engineering, hydrologic sciences, environmental chemistry and microbiology, and socioeconomics. Findings of the research are disseminated through journal articles, conference presentations and proceedings papers, technical reports, and student theses and dissertations. Program sponsors include federal and state agencies (USEPA, USGS, NSF, DoEd) along with private industry. For further information on the research program, contact the Program Director, Dr. Robert L. Siegrist, Professor, Environmental Science & Engineering Division, Coolbaugh Hall, Golden, Colorado, USA. Email: siegrist@mines.edu, Telephone: 303.273.3490, Telefax: 303.273.3413.

Table 1. Highlights of some CSM research in small flows and decentralized systems.

Type	Description	References
Laboratory testing	3-D tank lysimeter experiment to examine hydraulic and purification processes in sandy PMBs as affected by vadose zone depth and infiltrative surface character (Fig. 3c)	Van Cuyk et al. 2001, Masson 1999*, Fisher 1999*
	1-D column study of Cryptosporidium parvum removal during intermittent sand filtration	Logan et al. 2001
	1-D column experiment of accelerated loading methods to provide long-term performance data during shorter-term testing of soil PMBs (Fig. 3b)	Siegrist et al. 2002, Beach 2001*, Lowe et al. 2003#, Beach et al. 2003#, Van Cuyk et al. 2003#
	1-D column experiment to examine virus retardation and removal in soil as affected by matrix conditions (Fig. 3a,b)	Van Cuyk 2003*
	1-D column lysimeter experiment to study flow effects caused by solid-body/infiltrative surface interactions	Diaz 2003*
	3-D visualization of PMB flow regimes and effects of infiltrative surface conditions	Digital movie
Field studies	Field evaluation of 16 full-scale wastewater soil treatment systems in Colorado	Siegrist and Van Cuyk 2001
	Evaluation of virus treatment efficiency in 5 full-scale wastewater soil treatment systems in Colorado using a multicomponent surrogate and tracer	Van Cuyk et al. 2002#
	Water quality assessment of decentralized system impacts in the Blue River watershed (Fig. 3d,e)	Guelfo 2002*
	Application and assessment of DNA finger printing for bacterial source tracking in Mountain watersheds	Albert 2002*
	Field evaluation and virus tracer test of OWS employing textile filters for nitrogen removal	Wren 2003*
Modeling	Analytical and numerical modeling approaches to describe and predict flow and pollutant transport in soil PMBs	Beach and McCray 2003, McCray et al. 2000, 2001, Huntzinger et al. 2001, Beach 2001
	Coupling site-scale fate and transport with watershed-scale modeling to assess the cumulative effects of nutrients from decentralized wastewater systems	Kirkland 2001*, McCray et al. 2001, Kirkland et al. 2002#
	Application of the Watershed Analysis Risk Management Framework (WARMF) model to the Lake Dillon Watershed (Fig. 1d,e)	Chen et al. 2001, Kirkland 2001*
	Application of BASINS and SWAT to the Lake Dillon Watershed (Fig. 1d,e)	Lemonds 2002*

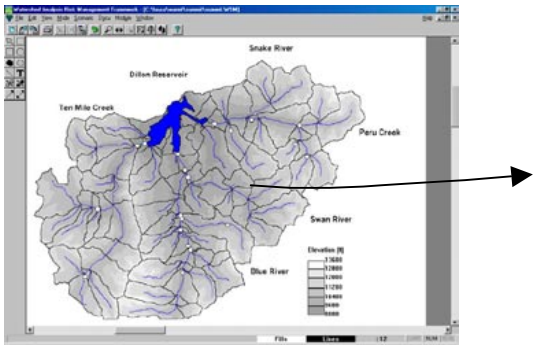
Notes: For selected citations see reference list in Small Flows Research Program highlights document. A "*" indicates that the reference is a CSM student M.S. or Ph.D. thesis. A "#" indicates a pending journal publication.



(a) 1-D minicolumns.

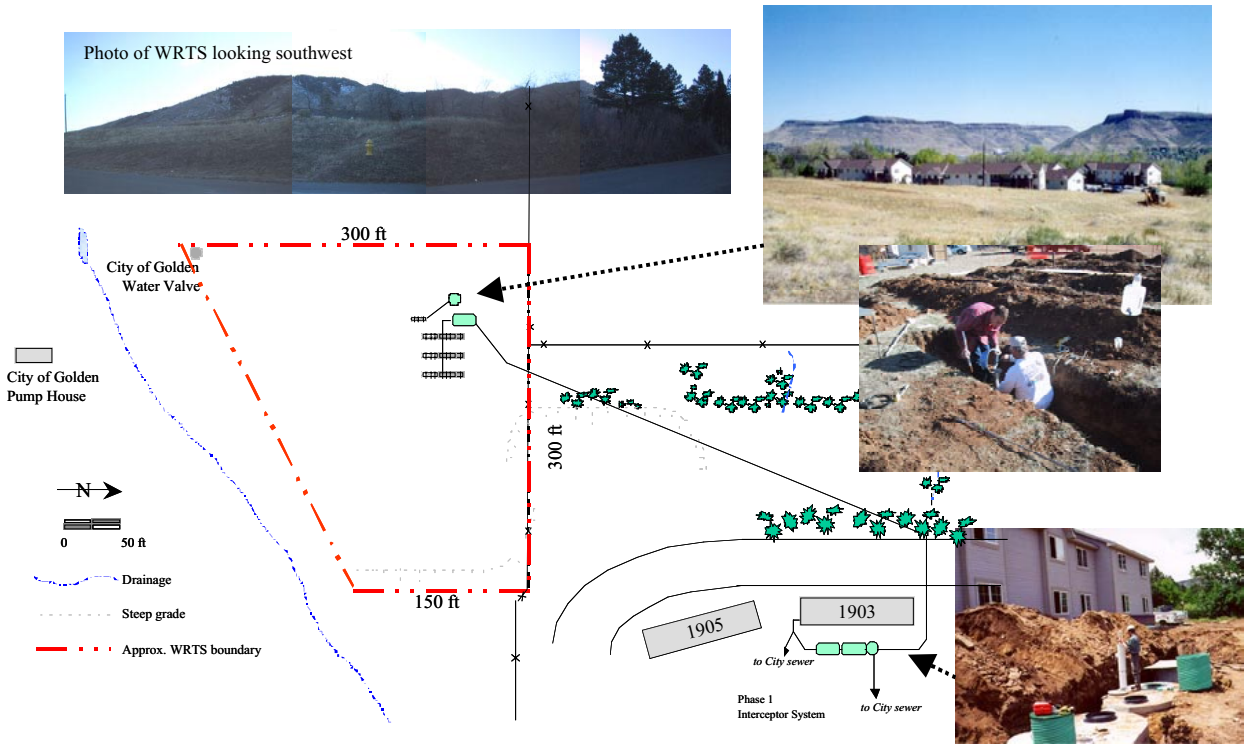
(b) 1-D column apparatus.

(c) 3-D tank lysimeter apparatus.



(d) Lake Dillon watershed as represented in the WARMF watershed model.

(e) Photos of the Lake Dillon study area and typical developments with OWS and CSM monitoring.



(f) Mines Park wastewater reclamation test site on the CSM campus.

Figure 3. Examples of CSM facilities and study sites used for decentralized systems research.

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International Ground-Water Modeling Center
Colorado School of Mines
Golden, Colorado, 80401-1887, USA
Telephone: (303) 273-3103 / Fax: (303) 384-2037
Email: igwmc@mines.edu / URL: http://typhoon.mines.edu/

International Ground-Water Modeling Center
2003 Short Course Schedule

APPLIED ENVIRONMENTAL STATISTICS
June 9 -13, 2003 -- Instructors : Dennis Helsel and Ed Gilroy

This five-day course develops hands-on expertise for all environmental scientists who interpret data and present their findings to others. Hypothesis tests are explained in the light of data with non-detects, outliers, and skewed distributions. Methods for estimation and prediction are illustrated along with their common pitfalls. Hands on exercises follow each lecture. The course emphasizes: when each method is appropriate; how to plot and present data; assumptions behind statistical tests, and their implications; how to build a good regression model, and trend analysis with common pitfalls. Our Goal: for you to make sense of your data.

CALIBRATION AND UNCERTAINTY OF GROUNDWATER AND OTHER MODELS
September 10-12, 2003 -- Instructors : Mary Hill, John Doherty, and Claire Tiedeman

This course teaches methods of nonlinear regression and associated statistics, and a set of fourteen guidelines that describe how those methods can dramatically improve how data are used to calibrate and test models. This course presents a unique opportunity to learn a variety of

approaches to the calibration and predictive uncertainty analysis of groundwater models from leading experts in the field. Attendees will gain a much better appreciation of the importance of calibration in model deployment, the limitations of models in many real-world settings.

MODFLOW: INTRODUCTION TO NUMERICAL MODELING
September 13-16, 2003 -- Instructor : Eileen Poeter

This course is designed for the hydrogeologist and environmental engineer familiar with ground-water flow concepts, but who have limited or no experience with ground-water flow modeling. Basic modeling concepts: conceptual model development, definition of boundary and initial conditions, parameter specification, finite-differencing, gridding, time stepping, and solution control using MODFLOW-2000 and UCODE. Basic modules of MODFLOW are explained and concepts are reinforced with hands-on exercises. Calibration is presented via the public domain universal inversion code, UCODE.

POLISHING YOUR GROUND-WATER MODELING SKILLS
September 14-16, 2003 -- Instructors : Peter Andersen and Robert Greenwald

This course is designed to provide significant detail on practical ground-water flow modeling concepts and techniques. It will explore development of conceptual models for complex sites or regions, how to convert these conceptual models to appropriate ground-water flow models, and how to apply supplemental MODFLOW modules to effectively solve such problems. This course takes the user beyond topics covered in introductory modeling courses and beyond courses that teach the mechanics of applying various pre- and post-processing software.

UCODE: UNIVERSAL INVERSION CODE FOR AUTOMATED CALIBRATION
September 15-16, 2003 -- Instructor : Eileen Poeter

If you have a working knowledge of ground-water flow modeling and some knowledge of basic statistics, you will benefit the most from this short course. This course introduces to ground-water professionals to inverse modeling concepts and their use via UCODE, relying heavily on hands-on exercises for automatic calibration of ground-water models to promote understanding of UCODE and avoid “black-boxing”. If you would like to spend more time being a hydrologist and less time as a “number tweaker”, please join us in the ucode course.

ADVANCED MODELING OF WATER FLOW & SOLUTE TRANSPORT IN THE VADOSE ZONE
September 15-16, 2003 -- Instructors : Rien van Genuchten and Jirka Simunek

This course begins with a detailed conceptual and mathematical description of water flow and solute transport processes in the vadose zone, followed by an brief overview of the use of finite element techniques for solving the governing flow and transport equations. “Hands-on” computer sessions will provide participants an opportunity to become familiar with the Windows-based RETC, STANMOD, HYDRUS-1D and HYDRUS-2D software packages. Emphasis will be on the preparation of input data for a variety of applications, including flow and transport in a vadose zone, variably-saturated flow through a dam, flow and transport to a tile drain, and two-dimensional leachate migration from a landfill through the unsaturated zone into groundwater.

SUBSURFACE MULTIPHASE FLUID FLOW AND REMEDIATION MODELING
September 19-21, 2003 -- Instructors : John McCray

This course covers subsurface multiphase fluid flow modeling concepts and techniques using the multi-dimensional multiphase flow code TOUGH2/T2VOC (with a new graphical user interface for input/output manipulation and visualization). Topics include the development of conceptual models for vadose zone flow and transport, flow and interphase partitioning of nonaqueous-phase liquids (NAPLs) mixtures in the saturated and unsaturated zones, NAPL-contaminated sites, simulation of remediation techniques, and how to apply the models to effectively solve realistic problems associated with these conceptual models.

PHREEQC MODELING: THE BASICS
September 19-21, 2003 -- Instructor : Geoffrey Thyne

This course will provide a review of theoretical background and practical experience in the use of the PHREEQC computer code. We will work with the recent version of PHREEQC program and the accompanying Windows interface using progressively more complex simulations to build user ability. Class exercises will include speciation of water analyses, equilibrium with gas and solid phases, acid-base and redox reactions, sorption reactions, kinetic reactions, mass balances (inverse modeling) and the advection-dispersion-reaction module, time permitting.

MODEL CALIBRATION AND PREDICTIVE UNCERTAINTY ANALYSIS USING PEST-ASP
September 19-21, 2003 -- Instructors : John Doherty

This intensive short course will instruct participants on the application of nonlinear parameter estimation techniques to the calibration of environmental simulation models of all kinds, particularly groundwater flow and transport models, and on the analysis of the predictive uncertainty associated with such models. The course will be based on the use of PEST-ASP; “ASP” stands for “Advanced Spatial

Parameterization". Its advanced regularization and predictive analysis functionality allows models to be used in more flexible and powerful ways (and with greater scientific integrity) than has hitherto been possible. PEST-ASP is complemented by MODFLOW-ASP, a special version of MODFLOW2000 that works best with PEST-ASP.

An International Ground Water Modeling Conference and Workshops
MODFLOW and More 2003: Understanding through Modeling
September 17-19, 2003 -- Ice-Breaker Evening of September 16 Co-sponsored by the U.S. Geological Survey
Those interested in presenting a paper or poster should submit an approximately 200-word abstract via
http://typhoon.mines.edu/events/modflow2003/abstract_form.shtml no later than April 20, 2003.

CWRRI
CU water news

WATER, CLIMATE AND UNCERTAINTY:
Implications for Western Water Law, Policy and Management

June 11-13, 2003 ******** Boulder, Colorado

24TH Summer Conference of the
Natural Resources Law Center, University of Colorado

Both short-term climate variability and long-term climate change can, and do, impact natural resources in a variety of significant ways. In the West, the most obvious concern is the impact on water supplies. While drought has garnered the headlines recently, the prospect of more fundamental long-term climate change poses even more dramatic challenges. Advances in climate science and forecasts offer increasingly valuable insights into what the future may hold for us and how our law, institutions, and societies might have to adapt.

Exploring ways to meet these challenges is the subject of a 3-day conference aimed primarily at political, legal, academic, and resource management professionals seeking to learn from each other and from leading scientists. Conference attendees will:

- Learn how current conditions compare to past climatic eras and to projected regimes of temperature, precipitation, and water runoff.
- Explore how future climatic variability might influence a variety of western water challenges, including the management of transboundary conflicts (both interstate and international), endangered species, water quality, and long-term planning.
- Hear about ongoing experiments, investigations and partnerships in the West linking climate-related expertise and considerations to resource management activities.
- Identify barriers and opportunities regarding the use of climate knowledge in the management of western water resources.
- Learn how climate variability and change could affect tribal interests.
- Explore legal, administrative and market-based mechanisms for dealing with climatic uncertainty.
- Understand ways in which climate science and climatic uncertainty influences the shape of western water law, policy, and management.

Registration Fees: $250 for academics and non-profit/NGO representatives ($295 after May 18), and $325 ($375 after May 18) for all others. CLE credit (approximately 22 hours) is available for an additional $75.

Scholarships: A limited number of full and partial registration scholarships are available to students and others on the basis of need. Contact the NRLC for information.

Contact: To request specific information about the content of the conference and poster session, contact Doug Kenney at 303/492-1296; Douglas.Kenney@Colorado.edu. For logistical information or to register, write or call the Natural Resources Law Center, University of Colorado School of Law, 401 UCB, Boulder, CO 80309-0401, 303/492-1272; 303/492-1297 (FAX) E-mail: nrlc@spot.colorado.edu
Web: www.colorado.edu/Law/NRLC

CALL FOR POSTERS

Researchers, water managers, and others looking to share their work with our mostly law/policy-oriented audience are strongly encouraged to present posters at the June 11th poster session. Posters will remain standing throughout the event. Registration fees are waived for poster presenters who only attend the poster session and do not attend other conference events. For consideration, please submit abstracts by April 23 to Doug Kenney.

Preliminary Agenda Topics

Climate History and Projections

- A History of Climate Variability and Change in the American West.
- Future Water Availability in the West: Will There Be Any:
- Is There a Dust Bowl in our Future? Lessons from the Central Great Plains Assessment.

The Legal and Political Environment

- The Legal and Political Salience of Climate and Water
- How Long do we Look Before we Leap? Scientific Uncertainty and Policy Making.
- Linking Imperfect Science to the Management of Uncertain Water Resources: Is Western Water Law Up to the Challenge?

Case Studies and Partnerships

- Evaluating the Future of the South Platte Basin (Western Water Assessment).
- What Might Climate Change Mean for the Southwest (CLIMAS).
- How Does the World's 7th Largest Economy Avoid Drying Up? Long-Range Water Resources Planning in California (CAP).
- Balancing Drought and Flood in the Pacific Northwest (Climate Impacts Group).
- A Water Manager's Perspective: A View From the Field.

Emerging Issues

- Implications for Interstate Compacts, with an Emphasis on the Colorado River.
- Climate Change and US/Mexico Water Conflicts: Mild, Medium or Hot?
- Policy Responses in the Pacific Northwest: Does Climate Change Force a Choice Between Salmon and Electricity?
- Climate Change and the Rio Grande in New Mexico: Throwing Gasoline on a Fire?
- The Tribal Perspective: Do Tribes Get Left Holding the Bag?
- Will Climate Change or Variability Affect Water Quality?

Poster Session: Water and Sustainability Public Lecture: Water Resources Allocation and Management in an Era of Scarcity.

For listings of seminars scheduled at the University of Colorado, consult the following web sites.

http://instaar.colorado.edu/other/seminar_mon.html — Institute for Arctic & Alpine Research. INSTAAR Noon Seminars are held 12-1 PM Mondays, RL-3, 6th Floor Auditorium, Room 620. For directions to RL-3, see INSTAAR Map pages. These seminars are open to the public. All are welcome!

http://www.mmm.ucar.edu/sem/seminars.html -- Mesoscale and Microscale Meteorology, National Center for Atmospheric Research. Unless otherwise noted, seminars will be held in the Main Auditorium, Foothills Lab, Building 2, Room 1022, 3450 Mitchell Lane, starting at 3:30pm (Coffee and cookies are served at 3:15pm. Come early and talk with the speaker!).

http://bechtel.colorado.edu/web/grad/environ/seminars.htm — Dept. of Civil, Environmental and Architectural Engineering, Spring 2003 Environmental Engineering Seminar Series. Seminars are held Wednesdays, 11 am to 12 pm, Engineering Center CE 1B41.

http://www.colorado.edu/GeolSci/colloquium.html — Geological Sciences Colloquium Schedule: Spring 2003. All talks are held in the Benson Earth Sciences lecture hall (180) at 4pm.. Refreshments are served at 3:30 on the 3rd floor.

http://www.colorado.edu/epob/ -- for links to biology and related subjects.

http://www.colorado.edu/che/homepage/patten/seminar.html — Department of Chemical Engineering James and Catherine Patten Seminar Series, Fall 2001, meets Thursdays and some Tuesdays at 2:00 pm in ECCR 150 in the Engineering Center.

http://www.colorado.edu/Law/NRLC/events.html – click on Calendar

http://www.centerwest.org/calendar.html – Center of the American West calendar

ENVIRONMENT AND BEHAVIOR PROGRAM SPRING WORKSHOP SERIES

All workshops will be in Building IBS #3 on Mondays at 12:00. Bring your colleagues and your bag lunch.
For information contact Professor Charles W. Howe,

Mar. 3rd	Kelly DiNatale, Director of Water Utilities, Westminster, CO	Issues and Economics of Developing a Water Supply to Meet Droughts
Mar. 17	Robert Repetto, World Resources Institute	The Electric Utility Sector's Exposure to Air Quality and Climate Requirements and Related Disclosure Issues

NEW FACULTY PROFILE

Steven R. Fassnacht
Assistant Professor
Department of Forest,
Rangeland and Watershed
Stewardship
Colorado State University

Steven R. Fassnacht
Assistant Professor

In August 2002, Dr. Steven R. Fassnacht joined the CSU faculty as Assistant Professor in the Departments of Earth Resources and Forest Sciences. His department is in the process of reorganizing into the Department of Forest, Rangeland and Watershed Stewardship, which is where Fassnacht can be found, when the Departments of Rangeland and Forest Sciences merge with the Watershed Group from the former Earth Resources Department.

Originally from Canada, Fassnacht was born in Brampton, a town just west of Toronto, Canada. Dr. Fassnacht came to CSU from Arizona after doing Post Doctorate research at the University of Arizona in Tucson. Fassnacht earned his B.A.Sc. in Civil Engineering (with a Water Resources Option) at the University of Waterloo, Waterloo, Ontario, Canada, and graduate degrees from the same institution.

Given the opportunity to do snow research, Fassnacht found snow "a very interesting and difficult medium to deal with," following his earlier work in the water resources field, where he had been working in sediment transport, hydrology, hydraulics, and channel stability. Fassnacht described his expertise as "snow hydrology with a bent on hydrologic modeling; looking at better understanding snow and winter processes and incorporating this understanding into modeling."

Fassnacht first came to Colorado in 2000, and performed snow surveys in the Southern Rockies in 2001 and 2002. His description of working in the Rockies as a hydrologist, measuring peak accumulation of snow in the springtime sounds like very enjoyable work. Currently, Fassnacht is engaged in research working to deliver spatial maps of snow extents and snow volumes to NRCS forecasters as well as to water resources managers.

Fassnacht has worked with the Rio Grande Water District 3 to deliver the same information and to help them make better predictions and management decisions, in terms of how much water to let through the system and how much to retain. He is hoping to further build these relationships. Fassnacht said that he is starting to work more with the people at NRCS, who are interested in some of the modeling that he's done for use by the forecasters. He participated as a speaker last semester in the Front Range Cryospheric Seminar series that he is co-organizing (with CU-Boulder), and we may possibly see him at Hydrology Days in March.

When asked about the top pressing issues related to his work Fassnacht explained that he is looking at improving runoff forecasting as well as improving hydrologic modeling, and trying to decipher results from more complex models to incorporate into simpler models. He is working with a graduate student who is looking at using GIS for water resources users and another graduate student who is looking at using similar spatial data for avalanche forecasting.

Dr. Fassnacht enjoys outdoor activities such as hiking, cycling, camping, snowshoeing, and skiing. He is also a bass player and is looking to put together a new music group, following modest success of the Tucson band "geh nackt" in which he played bass and sang.

"You'll get a lot further in science by standing in the woods than having the biggest computer known," advised Fassnacht. "You can model anything you want, but until you actually go out there and see what's happening, you won't understand what's happening." Dr. Fassnacht is teaching a field course in Snow Hydrology this spring.

RESEARCH AWARDS

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

COLORADO STATE UNIVERSITY, FORT COLLINS, COLORADO
Awards for December 2, 2002 to January 25, 2003

Title	Primary PI	Department	Sponsor
Nonpoint Source Information & Education Coordination Continuation	Gray, Mary Mcphail	Cooperative Extension	CDPHE
Abandoned Mine Land Revegetation Study	Redente, Edward F.	RES	CDNR
Environmental Applications Research Project	Vonderhaar, Thomas H.	Cira	NOAA
Upper Tropospheric Ice Nuclei Measurements in CRYSTAL-FACE	Demott, Paul J.	Atmospheric Science	NASA
Toward Understanding Lifecycle of Tropical Cirrus	Stephens, Graeme L.	Atmospheric Science	NASA
Cumulonimbus/Cirrus Interactions in the Subtropics	Cotton, William R.	Atmospheric Science	NASA
Precision Farming to Protect Water Quality & Conserve Resources	Westfall, Dwayne G.	Soil & Crop Sciences	USDA-ARS
Wetland, Aquatic & Riparian Protocols	Wohl, Ellen E.	Earth Resources	Univ. of Wyoming
Genetic Engineering Approaches for the in Vivo Study of Plant Metabolism of Selenium & Other Oxyanions	Pilon-Smits, Elizabeth A.	Biology	NSF
REU Site: Research Experience for Undergraduates Supplement to CAREER Award	Wickramasinghe, Ranil	Chemical Engineering	NSF
Dynamics of Tropical Cyclones & the Hadley Circulation	Schubert, Wayne H.	Atmospheric Science	NSF
Shipboard Radar Observations of Precipitating Convection in EPIC 2001	Rutledge, Steven A.	Atmospheric Science	NSF
Development of an Advanced Multi-Frequency Radar for Atmospheric Research	Rutledge, Steven A.	Atmospheric Science	Univ.of Mass.
Applying Design-Based Model Assisted Survey-Methodology to Aquatic Resources	Breidt,F.Jay	Statistics	Oregon State Univ.
Fire, Runoff, and Erosion in Forested Areas:Prediction and Validation	Macdonald,Lee H	Earth Resources	USDA-USFS-Pacific SW
Mapping Snow Properties: A Multi-Scale Approach	Smith,Freeman M	Earth Resources	USDA-USFS-RMRS
Bedload Transport in Gravel-bed Rivers & Channel Change	Abt,Steven R	Civil Engineering	USDA-USFS-RMRS

FEDERAL SPONSORS: BLM-Bureau of Land Management, COE-Corps of Engineers, DOA-Dept. of the Army, DOD-Dept. of Defense, DOE-Dept. of Energy, DON-Dept. of the Navy, DOT-Dept. of Transportation, EPA-Environmental Protection Agency, HHS-PHS-Public Health Service, 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, , USAID-US Agency for International Development, USBR-US Bureau of Reclamation, USDA/ARS-Dept. of Agriculture, Agricultural Research Service, USDA/NRS-Dept. of Agriculture, Natural Resources Service, USFS-US Forest Service, USDA-USFS-RMRS-Rocky Mountain Research Station, USFWS-US Fish & Wildlife Service.

STATE/LOCAL SPONSORS: CDA-Colorado Department of Agriculture, CDNR-Colorado Dept. of Natural Resources, CDPHE-Colorado Dept. of Public Health and the Environment, CDWL-Colorado Division of Wildlife, NCWCD-Northern Colorado Water Conservancy District. OTHER SPONSORS: AWWA-American Water Works Assn., CID-Consortium for International Development.

UNIVERSITY DEPARTMENTS, INSTITUTES AND CENTERS: Colorado State: BSPM-Bioagricultural Sciences & Pest Management, CBE-Chemical & Bioresource Engr., CFWLU-Cooperative Fish & Wildlife Unit, CSMTE-Center For Science, Mathematics & Technical Education, CIRA-Cooperative Inst. for Research in the Atmosphere, DARE-Dept. of Agric. & Resource Economics, ECE-Electrical & Computer Engineering, ERHS-Environment & Rad. Health Sciences, FWB-Fishery & Wildlife Biology, HLA-Horticulture & Landscape Architecture, NREL-Natural Resource Ecology Lab, NRRT-Nat. Resources Recreation & Tourism, RES-Rangeland Ecosystem Science, SCS-Soil & Crop Sciences. University of Colorado: ACAR-Aero-Colorado Center for Astrodynamic Research, AOS-Atmospheric & Oceanic Sciences, CADSWES-Center for Advanced Decision Support for Water and Environmental Systems, CEAE-Civil, Environmental, and Architectural Engineering, CIRES-Cooperative Institute for Research in Environmental Sciences, CRCMAST-Cooperative Research Center for Membrane Applied Science & Technology, EPOB-Environmental, Population & Organismic Biology, IAAR-Institute for Arctic & Alpine Research, IBS-Institute of Behavioral Science, ITP-Interdisciplinary Telecommunication Program, LASP-Lab. For Atmos. And Space Physics, PAOS-Program in Atmospheric and Oceanic Sciences.

UNIVERSITY OF COLORADO, BOULDER COLORADO
Awards for November-December, 2002

Title	Primary PI	Department	Sponsor
Analysis and Implementation for Support for Various Water and Environmental Systems	Zagona, Edith	CEAE	DOA
Changes in Freeze-Thaw and Permafrost Dynamics and their Hydrological Implic-ation over the Russian Arctic Drainage Basin	Zhang, Tingjun	CIRES	NSF
Extension of Surface Energy and Water Cycle Flux Measurements Beyong the IHOP Intensive Observation Period	Blanken, Peter	Geography	NSF
High-Resolution Constraints on the Magnitude and Timing of Climate Change in Iceland Over the Past 15 KA	Miller, Gifford	IAAR	NSF
High-Resolution Imagery and Terrain Model for Collaborative Research of Environmental Change at Barrow, Alaska	Manley, William	IAAR	NSF
Center for Integrated Space Weather Modeling (CISM)	Odostrcil, Dusan	CIRES	Boston University
Influence of Climate-Induced Alterations in Dissolved Organic Carbon on UV Radiation and Metal Toxicity in High-Elevation Streams	McKnight, Diane	IAAR	State of Colorado
Development and Dissemination of a Global Magneto-sphere-Ionosphere-Thermosphere Circulation Model	Fuller-Rowell, Timothy	CIRES	Univ. of California at Los Angeles
Hydraulic Geometry of Gravel-Bed Rivers	Pitlick, John	Geography	USFS
Two-Phase Immiscible Fluid Flow in Fractured Rock: The Physics of Two-Phase Flow Process in Single Fractures	Rajaram, Harihar	CEAE	DOE
Infrared and Passive Microwave Radiometric Sea Surface Temperature and Relationship to Atmospheric Forcing	Castro, Sandra	ACAR	NASA
Spatial and Temporal Patterns and Variability of Sea and Ice Surface Temperatures in the Seasonal and Marginal Sea Ice Zones	Maslanik, James	ACAR	NASA
Variability and Forcing of Climatic Parameters on the Green-land Ice Sheet…	Steffen, Konrad	CIRES	NASA
Ice Shelves and Land-fast Ice on the Antarctic Perimeter: Characteristics and the Effects of Climate Change…	Scambos, Theodore	CIRES	NASA
Standard Global Snow Cover Products from Satellite Remote Sensing	Armstrong, Richard	CIRES	NASA
Use of Satellite Gravimetry to Develop and Test a Land-Water and Energy-Balance Model	Wahr, John	CIRES	NASA
A Regional, Integrated Monitoring System for the Hydrology of the Pan-Arctic Land Mass	Serreze, Mark	CIRES	NASA
Regional Atmosphere/Forest Exchange and Concentrations of Carbon Dioxide	Bakwin, Peter	CIRES	Indiana University
An Investigation of Very Low-Frequency Sea Level Change Using Satellite Altimeter Data	Nerem, Robert	ACAR	NASA
Merging Infrared Sea Surface Temperature with Satellite Altimetry to Map Ocean Currents in Two Coastal Domains	Emery, William	ACAR	NASA
Evaluation of Best Management Practices for Highway Runoff Control	Heaney, James	CEAE	Oregon State Univ.
Investigation of Microbe Transport in Filter Sand and Karst Media	Ryan, Joseph	CEAE	Colorado State Univ.
Forest/Atmosphere Carbon Fluxes in a Colorado Subalpine Ecosystem	Monson, Russell	EPOB	Tulane Univ.
Hydrologic Response of Siberian Major Rivers to Climate Change and Variation	Zhang, Tingjun	CIRES	Univ. of Alaska

WATER NEWS DIGEST

by Marian Flanagan

COLORADO RIVER

West Slope water interests put halt to relaxing Shoshone call

Lack of consensus among Western Slope water interests on the "relaxing" of one of the most powerful calls on the Colorado River has left the proposal without the Colorado River Water Conservation District's endorsement. The CRWCD explored the possibility of Xcel Energy loosening the demands of the Shoshone Hydroelectric Power Plant's senior right on the Colorado River, dating back to 1905. Entities benefiting from the storage would have compensated Xcel for power production loss. By relaxing that demand to pull the water downstream, more water could have been stored in upstream reservoirs with rights junior to Shoshone. The reservoirs include Green Mountain, Dillon, Granby and possibly Williams Fork. Although water districts in the Grand Valley had agreed to support the proposal, they admitted that the precedent issue was a concern. Denver Water Raw Water Supply Manager Marc Waage said the CRWCD board's unanimous vote to monitor the issue, without any endorsement, leaves hope for the deal. "At least it means the door's not closed," Waage said.

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The Grand Junction Daily Sentinel, 1/22/03

California facing water shortage after Norton tightens Colorado River faucet

After U.S. Interior Secretary Gale Norton directed California water interests to come up with a plan to lessen their use of Colorado River water last year, water providers tried to work out a deal to shuffle water from farms to homes. The big problem California faced was that Imperial Valley farmers held the majority of water rights, and growing cities were using about 800,000 acre-feet of water more than California's annual limit of 4.4 million acre-feet of Colorado River water. The Imperial Irrigation District claims more than 3 million acre-feet of water, about 75 percent of the state's total allotment. The only way to cut back on water usage and guarantee water for the San Diego area was to transfer water used in the Imperial Valley. The nation's largest irrigation district and three metropolitan districts failed to come to an agreement by New Year's Eve on selling the water to urban areas. The water sale could have impacted the agricultural future of the Imperial Valley and the future of a lake where the agricultural runoff spills — a sanctuary to endangered wildlife. Ironically, the Salton Sea was created by flooding of farmers' irrigation systems in the early 1900s and is maintained through agricultural runoff from the Imperial, Coachella, and Mexicali valleys, according to the Salton Sea Authority. Making matters worse is the high salinity for which the Salton Sea is named. Salinity levels could rise to uninhabitable levels for wildlife if influx to the sea drops, according to the Authority. With sale of agricultural water to cities, a reduction in runoff spilling into the Salton Sea is almost inevitable. Although California missed its deadline to form a plan and cut back on surplus Colorado River water usage, it could be eligible for surplus water again if it gets its act together. If there is more water produced by the Colorado River Basin than that regulated by the Colorado River Compact and other laws governing the river, Interim Surplus Guidelines go into effect. Those guidelines stipulate that the Department of Interior apportions the available water for solely domestic purposes. However, when California failed to meet its deadline in reducing its dependence on the Colorado River, Norton suspended those surplus guidelines. "The surplus guidelines would have allowed California, as well as the other Lower Basin states, to receive surplus water over the next 15 years while California was concurrently reducing its overall Colorado River water use," said Bob Walsh, U.S. Bureau of Reclamation spokesman for the Lower Colorado Regional office in Boulder City, Nev. Not only is California prohibited from using more than its specified share of the Colorado River, Arizona and Nevada are also limited to their allotments, Walsh said. Walsh said Nevada had requested another 37,000 acre-feet of Colorado River water it cannot receive until the guidelines are reinstated. None of the Lower Basin states can partake of water above their allotments until the surplus guidelines are reinstated, which won't happen until California solves its internal problems, Walsh said.

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The Grand Junction Daily Sentinel, 1/26/03

Depletion of Ogallala Aquifer increases

A University of Kansas researcher says drought is speeding up depletion of the Ogallala Aquifer so much that the problem is "as pressing or more pressing" than it ever has been. Eight university scientists recently spent a week in western Kansas to measure the water levels of 500 wells that draw water from the aquifer. They found the water level is dropping faster than it did in the last decade. In addition to the university study, the state's Division of Water Resources tested 700 other wells in the area, reaching similar findings. Rural irrigation in western Kansas has been drawing water from the aquifer faster than nature can replace it, and in some areas the aquifer has dried out. Kansas Senator Stan Clark said the study shows the need to decrease water use before the situation gets worse. "Quite honestly, we need to move to an economy that doesn't require the Ogallala, and we must begin that separation soon," he said.

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The Fort Collins Coloradoan/Associated Press, 1/18/03

DROUGHT

Western Slope-Front Range cities coalition of 58 meets

Powerful Western Slope water users and fast-growing Front Range cities have reached a potentially historic agreement to join forces in coping with the drought. Representatives from the two sides discussed the long-running tensions over water being diverted from the Colorado, Yampa and Fraser rivers to benefit the thirsty cities to the east. During the meeting brokered by Mayor Wellington Webb, Front Range cities acknowledged that past projects have harmed the less populated Western Slope. Representatives tentatively agreed that communities that have water taken from them should be compensated. In addition, representatives of rural communities on the Western Slope acknowledged that future diversions are inevitable and will be considered if city dwellers save more water, agree to share existing supplies and use more water

from Front Range aquifers before more western water is taken. Both sides plan to go to the state Legislature within two weeks and ask for a resolution endorsing the newly agreed upon water principles. The agreements must still receive final approval from the various government boards represented at the meeting. The session was designed to see if a broad-based coalition of 58 rural counties and six urban counties could join forces to solve the state's water crisis.

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The Aurora Sentinel, 1/28/03

Water experts: Plan for possible crisis
Water experts and weather watchers say it's time to plan for a possible crisis. "We need to start thinking about the worst-case scenario," said Brad Lundahl, chairman of the Colorado Water Availability Task Force. "I'm praying for snow, but we need to plan." At the meeting, which will be held monthly through the summer, those who measure snowpack, reservoirs, soil moisture, river flows and the whims of weather all reported that 2003 has started out as dry as last year's record drought year that spawned an extreme fire season. Snowpack, the raw fuel of rivers, reservoirs, farming, recreation and residential greenery, is now 25 percent below normal. But that's not the worst of it. "We are much more at risk than we were at this time last year, and we know what the consequences were last year," said Mike Gillespie, snow survey supervisor for the federal Natural Resources Conservation Service. Gillespie said the reservoirs now hold 51 percent less water than average, and more significantly, they are 40 percent lower than last year, which was a major drought year. "Even if we get a really wet spring, we will still have a long-term drought," he said. "We will not recharge the moisture levels in the soil or the aquifers." Bob Glancy of the National Weather Service said he doesn't see any evidence in moisture patterns of a series of super storms arriving in February to rescue the state. A drop or two of hope came from Klaus Wolter of the National Oceanic and Atmospheric Center in Boulder. He said that El Niño was cooling, which could signal a wet spring in Colorado. "Instead of gambling, we should prepare before it becomes a crisis," said Roger Pielke, state climatologist.

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The Rocky Mountain News, January 29, 2003

GROUNDWATER

With water levels at historic low, drilling permits skyrocket -- Requests for new wells jump 68 percent
Requests to replace water wells soared 68 percent in 2002, as groundwater levels dropped in response to a historic drought. The state issued 1,568 replacement-well permits in 2002, up from 942 in 2001, according to Hal Simpson, state engineer and director of the Division of Water Resources, which issues the permits. The majority of permits - 1,451 - were for residential wells ranging in depth from 200 to 500 feet or more, depending on geography. About 336,000 well permits, for homes and irrigation, are on file with the Division of Water Resources. This month, lawmakers began debating whether to approve Senate Bill 45, which would create a tough well-inspection program, using a new $40 fee to hire inspectors to supervise well construction and requiring that contractors receive ongoing technical training.

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Rocky Mountain News, 1/22/03

WATER CONSERVATION

City wants tougher rules to quench lawns' thirst
A proposed residential landscape ordinance that would let homeowners cover as much as 60 percent of their lawns in bluegrass was deemed too lenient Wednesday by several members of the Colorado Springs City Council. After a two-hour discussion, the council told Colorado Springs Utilities officials to rework the ordinance with three directions: less bluegrass, more inorganic area and an allowance for artificial turf. Council members began talking during last summer's drought about a law to limit the amount of grass with high water consumption that could go in a new lawn. The proposal would not affect lawns already in place unless homeowners replace at least 40 percent of their yards. The proposals will include provisions for homeowners to put in more artificial turf if the turf has properties similar to grass in capturing runoff and reducing heat. The ordinance, if approved, would become a sister law to the commercial landscape ordinance created in the late 1990s. It would take effect March 15. New homeowners would have to pay $75 for a landscape permit, and those reconstructing their lawns would pay $50. Heavy fines could be assessed for those not following guidelines. The rules would require new irrigation systems to have features that limit water waste. Those include master valves that protect systems if they freeze and rain sensors that shut off the system during precipitation. Patricia Kelly, a city attorney, said the law would override any covenants that require new homes to have a higher percentage of bluegrass.

House Bill 1120 from Rep. Paul Weissmann, D-Louisville, would have nullified neighborhood covenants that require grasses and landscaping designs that use a lot of water and created a tax incentive for consumers who buy products that use water efficiently, such as low-flow toilets and dishwashers. Critics said the measure would have trampled on private property rights by overruling covenants Critics said the measure would have trampled on private property rights by overruling covenants….

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The Colorado Springs Gazette, 1/23, 24/03

WATER DEVELOPMENT/SUPPLY

Denver Water will add capacity
Denver Water plans to spend more than $150 million to increase water supplies in the next six years, expanding Gross Reservoir in Boulder County and adding new storage in northwestern Jefferson County, according to a letter to the U.S. Army Corps of Engineers. Denver Water, which serves 1.2 million metro area residents, said it hopes to begin construction on the new storage projects by 2006, after lengthy permit and environmental reviews are complete. The projects, which could be operational in 2008, will allow the agency to expand its water supplies more than 22 percent, adding 72,000 acre-feet to its annual supplies of 325,000 acre-feet. Denver Water Manager Chips Barry said the agency

has been eyeing the projects for years, but put them on the fast track last year after the drought began draining reservoirs. Denver Water is also discussing expanding Antero Reservoir in Park County in a partnership with Aurora. As the drought continues, Denver institutions are considering extraordinary measures to find extra water. The University of Denver notified the water board Wednesday that it hoped to drill at least one super-deep well into the Denver Aquifer. Only owners of at least 150 acres in the city may pump water that way. Denver Water plans to sharply limit outdoor watering this summer and might ban most such watering if the drought deepens.

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The Rocky Mountain News, 1/23/03

Upper Gunnison makes offer for Meridian Lake water
The Upper Gunnison River Water Conservancy District has voted to pursue purchase of the water in Meridian Lake Reservoir, just up-slope from Crested Butte. "The offer (to buy the water rights) includes language to address the unknowns," said UGRWCD Director Kathleen Curry. Those unknowns, she explained, include a quantification of the lake's yield. "You get to base your yield on runoff plus storage," she said. "We know how much it (the lake) holds, but not what flows in." Part of the negotiation process will be to "nail down" that yield. Last year, domestic water users living in north valley subdivisions were spared from being shut off as a result of senior water calls downstream. As the drought continues this year, however, that could change.

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The Gunnison Times, 1/23/03

Douglas County water plan alternates sources
Douglas County is nearing completion of a water plan experts believe can ensure the county a sufficient water supply for 50 years. The plan rests on using more surface water from mountain sources in wet years of high water flow to recharge the shrinking underground aquifers that Douglas County depends on. In dry years, the flow would reverse, using more water from the aquifers and less from mountain sources. The plan has 12 south metro water districts – from Castle Rock north to Highlands Ranch and Centennial – working with Western Slope communities and the Denver Water Board. A component of the plan calls for using existing Denver infrastructure, along with new supply lines. The plan also calls for recovering more surface water from mountain runoff to recharge the aquifers by pumping water back into them.

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The Denver Post, 12/23/02

WATER QUALITY

Local group working to improve the Animas
A local group is trying to improve the quality and the quantity of water in the Animas River by attacking the water at its source on Red Mountain Pass. The Animas River Stakeholders Group has worked since 1998 to buy the water rights and easements for the Carbon Lake Ditch near the summit of Red Mountain Pass, and the purchase was made final in water court earlier this month. The group believes that restoring the North Mineral Creek water flow to its natural state and cleaning the waste from a mine that hasn't operated since the 1940s will help the Animas River, said Bill Simon, the group's coordinator. The stakeholders group formed in 1994 to bring together federal and local agencies and citizens groups in the interest of the Animas River. The Carbon Lake Ditch has been diverting water to the Uncompahgre River – away from Mineral Creek and the Animas River – since the 1950s, when a group of farmers purchased the ditch's water rights. The ditch is designed to irrigate 675 acres of land at 15 cubic feet per second, Simon said. Thirteen people owned water rights to the Carbon Lake Ditch when the Animas River Stakeholders Group began looking into improving the water source. The stakeholders group received an Environmental Protection Agency Non-Point Source grant for $50,000 to purchase the water rights and the ditch's easements. The water rights owners were willing to sell because the ditch was eroding and it was difficult to maintain at a 12,000-foot elevation, Simon said. The Colorado Water Conservation Board approved the water rights donation earlier this month with the stipulation that 6.6 cfs of water must be used for preservation of water flow and 8.4 cfs must be used improve the water quality. The easements will be given back to the Forest Service and the landowners where the water runs. Simon said studies conducted by the group have shown the Kohler Mine, built in the late 1800s and operated periodically until the 1940s, contaminates the water and the wetlands around Mineral Creek with chemical waste, including aluminum, copper and lead. The chemicals have turned the water a bright orange. Simon and other stakeholders have been removing the mounds of mine waste, filling the Carbon Lake Ditch with dirt and planting natural vegetation. Jack Rogers, Durango's Public Works director, said the biggest benefit to city water customers will be the environmental improvements to the water. The city uses the Animas River as a water source during the summer. Because of the drought last summer, the city took 13 cfs of Animas River water – the most it has ever used from the river, Rogers said.

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The Durango Herald, 1/27/03

WATER RIGHTS

BLM, Nature Conservancy near water pact
The Rio Grande Water Conservation District board of directors has given its attorney David Robbins permission to investigate a stipulation being reached between The Nature Conservancy and the Bureau of Land Management involving water rights, particularly a siphon under a dry lake. The lake, located near the Blanca Wildlife Habitat Area, was filled when there was a golf course at the Zapata Ranch along Colorado 150, Robbins said. However, when the BLM put the siphon under the lake, the RGWCD noted that it would not be a permanent feature and allowed to change irrigation practices, Robbins said. When The Nature Conservancy acquired the ranch several years ago, it decided to do away with the golf course and return to historic agricultural practices, allowing the lake to dry up. The Nature Conservancy wants the district to join in the stipulation. It also is considering turning over some of the water rights and recharge rights to the district.

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The Pueblo Chieftain, 1/26/03

Continued on page 6

MEETINGS

HYDROLOGY DAYS 2003
IN HONOR OF PROFESSOR JOSE D. SALAS

On behalf of the Organizing Committee of Hydrology Days, I would like to invite you to participate in the Year 2003 edition of the AGU Hydrology Days, which will be held at Colorado State University during March 30-April 2, 2003.

The Hydrology Days Award is presented each year to an outstanding individual in recognition of his/her contributions to hydrology and related fields. In recognition of his outstanding contributions to hydrologic science in the areas of stochastic modeling and simulation of hydrologic processes, flood prediction and forecasting, and drought analysis, the 2003 Hydrol-ogy Days Award will be presented to Professor Jose D. Salas. The award will be presented during a special technical session in which Professor Salas will present the Borland Lecture titled: "Characterizing the Dynamics of Droughts". For detailed information about the Year 2003 edition of Hydrology Days please point your web browser to our web page at the following URL address: http://HydrologyDays.ColoState.edu/ The web page also provides information about on-line registration, and on-line submission of abstracts and papers. Please share this invitation with your friends and colleagues and encourage them to participate.

Hydrology Days is a unique celebration of multi-disciplinary hydrologic science and its closely related disciplines. The Hydrology Days vision is to provide an annual forum for outstanding scientists, professionals and students involved in basic and applied research on all aspects of water to share ideas, problems, analyses and solutions. The focus includes the water cycle and its interactions with land surface, atmospheric, ecosystem, economic and political processes, and all aspects of water resources engineering, management and policy.

I am looking forward to your participation. Best regards,

Jorge A. Ramirez
Chair, Organizing Committee

ARKANSAS RIVER WATER FORUM 2003
"Watering Your Future"
March 27 & 28, 2003
Location: Colorado State University - Pueblo

The annual Arkansas River Water Forum will focus on those areas of successful cooperation, collaboration, partnering and unusual solutions among the river basin's stakeholders. Presentations include Water Law, Water Banking, Salt Cedar and Ground Water Augmentation. A strong focus will be on education, hoping that elected officials and educators throughout the basin will be able to attend.

For more information or questions contact: Robert Appel: (719)336-9421

DARCA TO HOST CONVENTION FOR DITCH COMPANIES

Urbanization, cash, preservation and computers are among the topics on the agenda for the first ever DARCA convention Feb. 26-28 at the Double Tree Hotel in Durango. The Ditch and Reservoir Company Alliance, a nonprofit organization, was incorporated a year ago. Its purpose is to serve as a resource for mutual ditch and reservoir companies, irrigation districts, and water user and private ditch associations in Colorado. The first fill day of the conference, Feb. 27, will focus on ditch company and irrigation district interests, including how to cope with urbanization, who cash-strapped ditch companies can tap for project funding, how to preserve and manage ditch company documents, and how to develop computerized water accounting systems. Colordo's system to divert and store water existed long before the state's population burgeoned. With continued growth forecast, ditch and reservoir companies and irrigation districts del dily with the shift from rural to urban users.

The cost to attend the convention is $125 for members, $160 for nonmembers. DARCA is based in Longmont. For details about the organization and to obtain registration information, visit http://www.darca.org or call 970/535-0690.

The Association of State Dam Safety Officials, located in Lexington, Kentucky and associated with the Kentucky Water Resources Research Institute, has planned several technical seminars and conferences during 2003. For more information, please see www.damsafety.org, or contact: Susan Sorrell Association of State Dam Safety Officials 450 Old Vine Street, 2nd Floor Lexington, KY 40507; Tel: 859/257-5140, Fax: 859/323-1958, E-mail: info@damsafety.org.

ASDSO Events - 2003

2003 ASDSO West Regional Technical Seminar: Construction Inspections and Plans & Specs Review. February 4-6, Salt Lake City, UT. Seminar registration brochure with agenda available at www.damsafety.org. For more information: info@damsafety.org, or 859/257-5140.

This seminar will focus on two specific areas of a project, plans and specification review and construction inspection. The Plans and Specifications Review component will take the seminar attendants through the different types of specifications used in dam construction, areas of the drawings that need to be carefully reviewed for compliance to regulations and other items to "look for" in overall review. The Construction Inspection component will provide an overview of the organizational and institutional structures of a construction project, the activities that occur during construction and components that are to be inspected and tested to ensure compliance with the designs and the regulations. The target audience for this introductory-level course is persons that are involved in the design and construction of dams and dam rehabilitation projects. Registration Fees: Prior to January 23: $250 for ASDSO members, and $300 for non-members. A late fee of $25 applies to registrations received after January 23. Registration fees include all course materials, coffee breaks, and two luncheons.

Instructors: Daniel L. Johnson P.E., Director of Dams Technology of URS Corporation, Denver, CO. Terrence E. Arnold, P.E., former Vice President and Principal of the Denver office of URS Corporation, now a Project Manager, Hydropower Group, of MWH Global. Mike Zusi, Senior Professional Engineer in the Denver office of URS Corporation, Denver, CO

2003 ASDSO Midwest Regional Technical Seminar: Soil Mechanics for Dam Safety. March 12-14, Butler-Carlton Department of Civil Engineering Building at the University of Missouri-Rolla, Rolla, MO. For more information: info@damsafety.org, or 859/257-5140.
The objective of this course will be to provide a comprehensive presentation of the significant principles and concepts of soil mechanics. The material will be presented with emphasis on the application of soil mechanics to dam safety issues. At the end of the course, the participants will have the knowledge and resources to address soil mechanics issues as they relate to their work in dam safety. The course features workshops whereby essential principles are reinforced in small group activities. Students will be provided with a comprehensive course notebook, complete with solutions to workshop exercises. This notebook will serve as a valuable reference throughout the student's professional career. Registration Fees: Prior to January 23: $250 for ASDSO members, and $300 for non-members. A late fee of $25 applies to registrations received after January 23. Registration fees include all course materials, coffee breaks, and two luncheons.

2003 ASDSO West Regional Conference. May 7-9, Westin Hotel, Oklahoma City, OK. For more information: info@damsafety.org, or 859/257-5140. This educational conference is geared toward dam safety officials, engineers, and owner/operators in the West. If you are interested in making a presentation, please contact: Cecil Bearden, Oklahoma Water Resources Board at 405/530-8800.

2003 ASDSO Northeast Regional Conference. June 4-6, Resort at Split Rock, Lake Harmony, PA. For more information: info@damsafety.org, or 859/257-5140. The conference is geared toward dam safety engineers and dam owner/operators in the Northeast states. One-page abstracts, including full contact information for the primary author or presenter, may be sent by February 12, 2003 to: John Ritchey, New Jersey Department of Environmental Protection, Dam Safety Section, P.O. Box 419, Trenton, NJ, 08625, (609) 984-0859, ritchey@dep.state.nj.us. Topics for consideration include, but are not limited to: Technical Issues: Hydrology & Hydraulics, Geotechnical Issues, Case Studies in Dam Rehabilitation, Innovative Design, Instrumentation; Non-Technical Issues: Financing Dam Repairs, Insurance, Emergency Action Planning, Dam Operations and Maintenance Issues, and Owner/Operator Liability Issues.

Dam Safety 2003, the ASDSO Annual National Conference. September 7-10, Hyatt Regency, Minneapolis, Minnesota. For more information: info@damsafety.org, or 859/257-5140. All those interested in the latest policy and technical information on dam safety in the US should plan to attend and take advantage of the top-notch technical sessions, an abundance of networking opportunities, and a sophisticated urban conference venue. CALL FOR PAPERS NOW UNDERWAY: Share your insight and ideas with more than 600 colleagues by making a presentation at Dam Safety 2003! ASDSO is currently accepting abstracts that showcase educational experiences or provide technical information of importance to the growing dam safety community. The deadline for submittal is February 14, 2003. Go to www.damsafety.org to download the Call for Abstracts brochure with complete details on suggested topics, guidelines for submittal, judging procedures and deadlines.

2003 ASDSO Northeast Regional Technical Seminar: Soil Mechanics for Dam Safety. November, 2003, location TBA. For more information: info@damsafety.org, or 859/257-5140. 2003 ASDSO South Regional Technical Seminar: Soil Mechanics for Dam Safety. December, 2003, location TBA. For more information: info@damsafety.org, or 859/257-5140.

Aug. 21-22	COLORADO WATER CONGRESS Summer Convention, Steamboat Springs, CO. Contact: Dick MacRavey, Executive Director, at Phone 303/837-0812, FAX 303/837-1607, E-mail macravey@cowatercongress.org. Web site: www.cowatercongress.org.

WORKSHOP

Assessing the Impacts of Prolonged Severe Drought on Aquatic Ecosystems and Water Quality of the South Platte River Basin, Colorado

This workshop will explore the potential consequences to aquatic ecosystems and water quality in the context of drought under current and future societal demands on water resources. Objectives are to share scientific understanding of the consequences of severe drought, develop awareness and possibly preparedness for future drought, and build collaboration and trust among participants. The workshop will include speakers, poster sessions, and panel discussions. We invite you to attend, participate, and submit poster topics. There is no registration fee.

Dates: 8:30 am-5:00 pm, April 3-4, 2003
Location: April 3: Ammons Hall, CSU
April 4: 228 Lory Student Center, CSU
Organizers: Jill Baron, USGS and Natural Resource Ecology Laboratory, Colorado State University and
Alan Covich, Department of Fisheries and Wildlife Biology, Colorado State University
Contact: Kristin Reynolds (kreyn7@nrel.colostate.edu) (970)-491-1609

Announcement & Call for Presenters and Philosophers

The 2003 AWRA-Colorado Section's Annual Symposium
The 2002 Drought: A True Watershed Event?
Friday, April 4th, 2003, Mt. Vernon Country Club
Cosponsored by the Colorado Water Wise Council

Without a doubt, the 2002 drought was significant. To many across the state – it was alarming. But will it be a wake-up call? Will it make us come to grips with living in a desert? With attempting to manage significant growth and overdrawn river systems without any comprehensive water planning? Without any state-wide examination of the issues related to both growth and drought? If the worst drought in recorded history isn't a life-changing event for Coloradans, perhaps it should be.

The Council and the Colorado Section is proud to announce an all-day workshop to examine and debate these issues. We invite you to share your experiences, your perspectives and your wisdom on issues related to the drought and its impact on water resources in Colorado. Please submit a 1-page abstract of any related topics to Jeff Clark by February 28th, 2003. You may also contact Jeff or Beorn Courtney for additional information, questions, suggestions, gripes, etc.

Jeff Clark, AWRA Board President
jclark@ci.aurora.co.us
303/739-7533

Beorn Courtney, Program Committee Chair
Courtney@lrcwe.com
303/455-9589

Also check the Colorado Section's website for the latest information and announcements:
http://www.awra.org/state/colorado/

COLORADO WATER CONGRESS FALL 2003 WORKSHOP SCHEDULE

The Colorado Water Congress prepares a series of six to ten workshops each fall for the purpose of increasing and updating water knowledge both for the actively involved water community and general public knowledge.

The following workshops are planned for Fall - 2003: They will all be held in the Colorado Water Congress Conference Room, 1580 Logan Street, Suite 400, Denver, Colorado.

Water Conservation/Conservancy District Leadership; Initiatives - What You Should Know; Compacts - What You Should Know; Water Quality; Groundwater; Public Speaking; Internet, etc. (Technology); Endangered Species; Legislative Process - Advocacy; News Media Relations; Wetlands; Federal Environmental Laws; Ditch Company Operations; Instream Flow; Water Research - Practical or Pie-in-the-Sky; Dam Safety & Liability; Water Financing; International Water Solutions, Experiences, etc.; Water & Recreation; How to Write and Make Sense; Personnel Law; An Advance Course in Water Law by the Veterans (or the School of Hard Knocks in Water Law); and Forest Management.

The Colorado Water Law Seminar is scheduled for September 8 - 9, 2003 in the CWC Conference Room, 1580 Logan St., Ste. 400, Denver. Program and Registration will be posted when available.

CALENDAR

Feb. 27-28	DARCA (Ditch and Reservoir Company Alliance) Convention, Durango, CO. For details and to obtain registration information, visit http://www.darca.org or call 970/535-0690.
Mar. 27-28	WATERING YOUR FUTURE -- 2003 ARKANSAS RIVER BASIN WATER FORUM, University of Southern Colorado, Pueblo, CO. For information, call (719) 336-9421 or e-mail rappel@co.usda.gov.
Mar. 27-28	COLORADO WATER LAW - Drought Protection Strategies, Denver, CO. Register online ate www.cle.com or call 800/873-7130.
Mar. 30-Apr. 2	HYDROLOGY DAYS 2003, Fort Collins, CO. See the website at http://HydrologyDays.ColoState.edu/
Apr. 3-4	WORKSHOP -- Assessing the Impacts of Prolonged Severe Drought on Aquatic Ecosystems and Water Quality of the South Platte River Basin, Colorado, Fort Collins, CO. Contact: Kristin Reynolds (kreyn7@nrel.colostate.edu) (970)-491-1609.
Apr. 4	THE 2002 DROUGHT: A TRUE WATERSHED EVENT? Denver, CO. Contact: Jeff Clark at jclark@ci.aurora.co.us, phone 303/739-7533 or Beorn Courtney at Courtney@lrcwe.com, phone 303/455-9589.
Apr. 7 - 11	INTERNATIONAL WORKSHOP ON INTEGRATED WATER RESOURCE MANAGEMENT, Denver, CO. Contact Ms. Leanna Principe, E-mail: lprincipe@do.usbr.gov.
April 23-25	NATIONAL MITIGATION BANKING CONFERENCE, San Diego, CA. Contact: Carlene Bahler, E-mail Cbahler@erols.com or call 703/837-9763, website http://www.mitigationbankingconference.com.
Apr. 30-May 2	AQUATIC RESOURCES IN ARID LANDS, Las Cruces, NM. For information see website http://leopold.nmsu.edu/dcowley/ARIAL_conference.htm.
May 8	2ND ANNUAL COLORADO STREAMGAGING SYMPOSIUM, Beaver Run, Breckenridge, CO. Contact: Robert Ward at Robert.Ward@ColoState.edu.
June 29-July 2	American Water Resources Association 2003 International Congress, WATERSHED MANAGEMENT FOR WATER SUPPLY SYSTEMS, New York. Contact: AWRA, 4 W. Federal St., Middleburg, VA 20118-1626,
July 23-25	28TH COLORADO WATER WORKSHOP, Western State College, Gunnison, CO. Contact: George Sibley, Western State College,
Aug. 21-22	COLORADO WATER CONGRESS Summer Convention, Steamboat Springs, CO. Contact: Dick MacRavey, Executive Director, at Phone 303/837-0812, FAX 303/837-1607, E0mail macravey@cowatercongress.org. Website: www.cowatercongress.org.
Oct. 12-15	10TH ANNUAL CONFERENCE ON TAILINGS AND MINE WASTE, Vail, CO. Contact: Linda Hinshaw, Coordinator, Dept. of Civil Engr., CSU, Phone 970/491-6081, FAX 970/491-3584, E-mail lhinshaw@engr.colostate.edu.
Oct. 22-23	MARK YOUR CALENDAR! 14th ANNUAL SOUTH PLATTE FORUM. Location: Longmont, CO.

Colorado State University
Colorado Water Resources Research Institute
Colorado State University
Fort Collins, CO 80523

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