COLORADO WATER

Newsletter of the Water Center at Colorado State University

DECEMBER 2003

MEETINGS PROMOTE FACULTY-WATER MANAGER DIALOGUES

WATER 2025 Science & Technology Workshop -- From left: Peter J. Wierenga, John Letey, Robert Hirsch, and Robert Ward. See page 17.

SOUTH PLATTE FORUM -- Patty Rettig and Alan Foutz. See page 18.

COLORADO WATER CONGRESS GROUND WATER WORKSHOP -- From left: Luis Garcia, Dick MacRavey, Tom Sale, and Robert Siegrist.

USBR RIVER SYSTEMS CONFERENCE -- Darrell Fontane and Leslie Stillwell. See page 17.

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WATER ITEMS AND ISSUES . . .

COVER PICTURES:

WATER 2025 -- From left: Peter J. Wierenga, Director, Water Resources Research Center, University of Arizona; John Letey, Director, Center for Water Resources, University of California; Robert M. Hirsch, Associate Director for Water, U.S. Geological Survey; and Robert Ward, CWRRI Director.

SOUTH PLATTE FORUM -- Patty Rettig, CSU Archivist, with Alan Foutz, President, Colorado Farm Bureau.

CWC GROUND WATER WORKSHOP -- From left: Luis Garcia, Dept. of Civil Engr., CSU; Dick MacRavey, Executive Director, Colorado Water Congress; Tom Sale, Dept. of Civil Engr., CSU; and Robert Siegrist, Professor and Director, Environmental Science & Engineering, Colorado School of Mines.

USBR RIVER SYSTEMS CONFERENCE -- Darrell Fontane, Civil Engr. Dept., CSU; and Leslie Stillwell, Bureau of Reclamation.

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EDITORIAL

ET Estimates in the New West

by Robert Ward and Reagan Waskom

The term 'New West' has been used in recent years to refer to developments that are redefining the social, cultural and environmental character of the western United States. Many of the changes bring with them pressures to allocate water, via willing buyer and willing seller and other means, to water uses that are different from those traditionally supported in the 'Old West.' These include a shift in water resources from traditional irrigated agriculture to new urban, recreational and environmental uses.

As with most changes, there are unintended consequences associated with new water uses in the New West. In some places, irrigated agriculture is being greatly reduced with corresponding landscape, social, and cultural changes to the Old West – changes that are increasingly viewed with concern, not only in local communities bearing the brunt of the impact, but also by the larger population. Is there a way to meet emerging New West water needs while not eliminating, or damaging, the economic viability of the Old West uses of water?

To begin to answer the question, it may be helpful to step back from the immediate water shifts and consequences and examine the total water use picture in Colorado; and then, point out the needs for new water knowledge to move toward a better water balance between the New and Old West.

The water resources available for use in Colorado are derived, almost exclusively, from precipitation that falls on the Colorado's land mass – Colorado, truly, is a 'headwaters' state. As noted in the article on page 5 of this issue of Colorado Water, Colorado receives an average 95 million acre-feet of water each year in the form of precipitation falling on the land surface. Yet, most water experts tend to talk of only the 15.6 million acre-feet of water that flows in our streams, and the 2 million acre feet of ground water pumped annually, as the sum total of water used in Colorado. These numbers suggest that before humans have an opportunity to access the 95 million acre-feet of water falling on Colorado, the environment utilizes roughly 78 percent of the total water, on average. How does the environment access this water? -- largely through transpiration from plant communities and evaporation from land and water surfaces (collectively referred to as evapotranspiration).

Furthermore, irrigated agriculture utilizes 84 percent of the water consumed by human activity in the state each year (i.e., 5.5 million acre-feet). As with nature's use of water, agricultural water is consumed by evapotranspiration.

The above view of water availability and use reveals that evapotranspiration, be it by the environment or by agriculture, consumes a lot of the water that falls on our state. Unfortunately, measuring the exact amount of water consumed by evapotranspiration is not nearly as easy as measuring the amount of water diverted from a stream or the amount pumped from a well.

Estimating evapotranspiration is not a new research subject in Colorado. In fact, the State Agricultural College's Bulletin Number 1, published in 1887 and authored by Professor Elwood Mead, is titled: "Experiments in Irrigation and Meteorology" - an early study of evaporation measurements near irrigated fields. CWRRI alone, over the past 39 years, has published the results of a number of studies that address evapotranspiration-related topics (the list of reports is presented on the CWRRI website located at www.cwrri.colostate.edu).

While there has been a considerable amount of effort in the distant past to develop scientifically sound ET estimates in Colorado, there has been a drop off of effort in recent years. As a result, when ET estimates are needed today to settle disputes, they are computed using crop coefficients determined in Kimberly, Idaho and Bushland, Texas (sites of long-term USDA Agricultural Research Service measurement programs). Data from existing weather stations are also required in the estimates. Are these estimates the best we can obtain? Should we be doing more to refine Colorado's ET estimates?

This issue of Colorado Water examines efforts to estimate evapotranspiration (or ET) in Colorado and explores issues that should be considered in any effort to refine ET estimates in the future.

First, to examine why ET estimates are currently important to Colorado, the reader is referred to Dennis Montgomery's South Platte Forum keynote address, presented on page 19. Dennis, using his experience in legal proceedings surrounding compact compliance in the Arkansas River Basin, makes a strong case for improving the science behind today's efforts to estimate ET in Colorado.

Reagan Waskom presents a large overview of water use in Colorado, including the water consumed by Colorado's native landscape. Dan Smith and Grant Cardon, on page 7, explain how plants use water and the effect increased levels of water salinity have on plants' ability to use water

productively. Marvin Jensen shares some thoughts, based on years of experience in developing the science used to estimate ET, regarding how Colorado might approach developing a stronger scientific foundation for future, more precise and Colorado-relevant, ET estimates. Troy Bauder and Nolan Doesken, on page 12, describe Colorado's efforts to obtain the climate data needed to estimate ET, as well as suggesting ways to strengthen the quality and quantity of climate data in Colorado. The article by Ron Gosnell, on page 14, which reviews the recently published CWRRI Forests and Water report, reminds us of the role sound science plays in estimating water use by forests in Colorado, which cover 1/3 of the Colorado land surface.

We hope this issue of Colorado Water enhances understanding of the basic concepts surrounding estimating ET and the issues involved in producing the scientific measurements needed to refine and improve Colorado ET estimates. Balancing water demands and use, between Colorado's Old and New West dimensions, requires the very best science can provide in estimating evapotranspiration.

WATER RESOURCES RESEARCH NATIONAL COMPETITIVE GRANTS PROGRAM FISCAL YEAR 2004 REQUEST FOR PROPOSALS

The Request for Proposals for the FY 2004 National Competitive Grants Program authorized by section 104G of the Water Resources Research Act of 1984 has been released. The RFP may be obtained either by going to https://niwr.org/NIWR and clicking on "View the RFP" under "National Competitive Grants Program" or by going directly to https://niwr.org/2004_104G_RFP.

Proposals are sought in not only the physical dimensions of supply and demand, but also quality trends in raw water supplies, the role of economics in water supply and demand, and institutional arrangements for tracking and reporting water supply and availability.

For planning purposes, the amount available for research under this program is estimated to be $1 million in federal funds, though there has not been a FY2004 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 its State Water Research Institute or Center. Proposals involving substantial collaboration between the USGS and university scientists are encouraged. 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 will be accepted only through the Internet site at https://niwr.org/NIWR/. Prospective applicants must register at that site prior to submitting a proposal. Registrations and proposals will be accepted on the Internet site beginning Dec. 1, 2003. DETAILED INSTRUCTIONS FOR PROPOSAL PREPARATION AND SUBMISSION WILL BE PROVIDED ONLINE AT THAT TIME.

The closing date for proposals to be filed on the web site by principal investigators is 5:00 PM, Eastern Standard Time, March 1, 2004.

NSF FUNDS COLORADO STATE UNIVERSITY CENTER FOR COLLABORATIVE ADAPTIVE SENSING OF THE ATMOSPHERE

October 1, 2003 -- The National Science Foundation has announced that Colorado State University will team with the University of Massachusetts in an Engineering Research Center. The NSF granted $17 million to the lead institution, the University of Massachusetts, in partnership with Colorado State, the University of Oklahoma and the University of Puerto Rico-Mayaguez along with industry including IBM, The Weather Channel and Raytheon. The new $17 million grant will fund a center for Collaborative Adaptive Sensing of the Atmosphere, enabling earlier and more accurate weather emergency forecasts. The center will significantly increase warning time for tornadoes, flash floods and other sever weather disturbances with far greater accuracy than existing technology.

The NSF established four Engineering Research Centers nationwide this week.

For additional information contact Tom Milligan at (970) 491-6432, Tom.Milligan@colostate.edu.

Colorado State University Cooperative Extension

AN ALTERNATIVE PERSPECTIVE ON WATER USE IN COLORADO

by Reagan Waskom
CWRRI Water Resource Specialist

Estimating consumptive use is a science that has been inexactly practiced in Colorado for over a hundred years. Precise knowledge of historic or season-long consumptive use is usually unnecessary in times of plenty. However, during drought or in time of conflict over water rights, in arguments about augmentation, or in court cases with downstream states, this information becomes invaluable.

Farmers have estimated crop water needs by experience, crop appearance, and soil moisture for as long as we've been irrigating in Colorado. And in most day-to-day operations, this approach is sufficient for surface irrigators where adequate water is available. Daily estimates of crop evapotranspiration (ET) that are in error by 10 – 20 percent may represent only several hundredths of an inch and have no practical significance to one farmer irrigating a field. However, a 20 percent difference in the context of a basin-wide court settlement multiplied over a number of years and thousands of acres represents a significant quantity of water.

Measuring water diverted from streams or pumped from groundwater is relatively easy with today's technology. Knowing how much water is evaporated from the soil surface or transpired through growing plants requires a more sophisticated science. Scientists at Colorado State University, the U.S. Department of Agriculture and other agencies have been working to devise accurate methods and equations for determining crop ET or consumptive use since the late 1800's. Today, most scientists agree that crop ET can be estimated using the appropriate crop coefficient and weather data as parameters in the appropriate equation. Unfortunately, there are still disagreements as to the best crop coefficients and equations for use in Colorado and surrounding states.

Published water use information for the state of Colorado is often confusing because it may or may not include both surface and ground water components. Additionally, water use is typically reported in two different ways. Diversion (or withdrawal) is the removal of water from any body of water by canal, pipe or other conduit. Consumptive use is a diversion that results in a reduction of return flow. Non-consumptive use is a diversion that eventually returns most of the water to the stream system.

Agricultural water use is typically reported to account for about 85 percent of all consumptive use in Colorado. Agriculture uses the majority of the water delivered within Colorado largely because the amount of land area devoted to irrigated crops is larger than any other activity requiring water. Additionally, growing plants use a lot of water. Since agricultural consumption makes up such a large fraction of the total, scientists and engineers are called upon by society to accurately measure or calculate how much water is used by each crop in every basin. Although obtaining such information is critical to water management, improving ET estimates is hardly the type of cutting edge research likely to be funded by federal agencies.

TABLE 1. Estimated average annual consumptive use in in Colorado.

	Water Consumed (AF/yr
Irrigation	5,505,272
Lovestock	50,082
Mining	25,326
Thermoelectric Power	47,203
Industrial	47,203
Municipal	172,782
Commercial	17,709
Reservoir Evaporation	707,330
Total	6,571,798

Source: U.S. Geological Survey Circular 1200, Estimated Use of Water in the United States in 1995.

An alternative view of the water balance in our state is that the natural environment, including the 22 million acres of forest and over 30 million acres of rangeland, consumes the vast majority of the water that falls on Colorado. Cropland, by comparison, occupies 10.5 million acres of land in Colorado, including 7 million acres of dryland crops plus the 3 million irrigated acres that utilize 5.5 million AF of irrigation water annually to grow food.

Colorado receives on average approximately 95.5 million acre feet of precipitation annually that falls in a spatially and temporally non-uniform distribution on the State's 66 million acres of land (Grigg, 2003). Yet, most water experts tend to talk only of the 15.6 MAF of water that flows in our streams and the 2 MAF of ground water pumped annually, as the sum total of water used in Colorado. This alternative view of the State's total water balance estimates

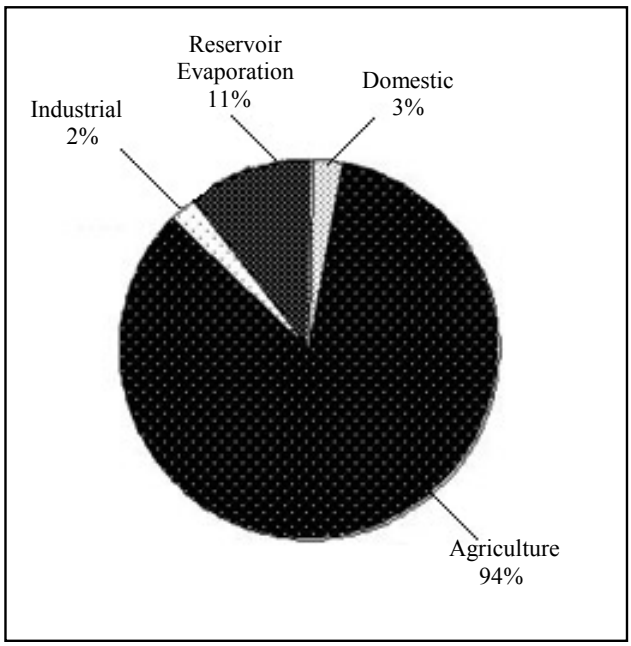

Figure 1. Percent of water consumptively used in Colorado by sector. Data aggregated from: U.S. Geological Survey Circular 1200, Estimated Use of Water in the United States in 1995.

that cropland in Colorado accounts for about 20 percent of the total consumptive use (CU), while occupying 16 percent of the State's total land area. Diversions for livestock watering are essentially negligible at this scale. (Ag CU = 10,500,000 acres x 16/12 inches annual precipitation + 5,505,272 acre-feet for irrigation + 50,082 AF for livestock = 19,555,354 AF annual CU out of 95.5 MAF total). After domestic, commercial, industrial, and reservoir evaporation components are accounted for, the remainder of the water that falls on our state can be said to benefit the natural environment.

While this alternative view of water consumption in Colorado may arguably be subject to interpretation and revision, it is offered to stimulate discussion on several points. First, in assembling data for this large-scale water balance, it can be difficult to make comparisons since the collection of data on water availability and use in Colorado, by various state and federal agencies, is not, across agencies, consistently tabulated and reported each year. Secondly, the fraction of water used in the production of crops and livestock can be calculated in more than one way. And finally, there is a need for agreed upon and consistent data elements and models for calculating plant water use and needs in Colorado.

Given the difficulty and sophistication required to accurately measure ET, whether it is associated with invasive species, urban lawns, irrigated agriculture or native vegetation, a long-term commitment with great attention to detail is required. As we increase the accuracy of our ET calculations for various land uses in Colorado, the understanding of our water balance and the opportunities for water conservation will increase.

Table 2. Average water deliveries in Colorado.

	Percentage of Total
Agriculture	86.5%
Municipal / Domestic	6.7%
Industrial / Commercial	1.9%
Recreation and fisheries	3.0%
Augmentation	1.0%
Ground water recharge	0.9%
Total	100%

Source: Colorado Division of Water Resources

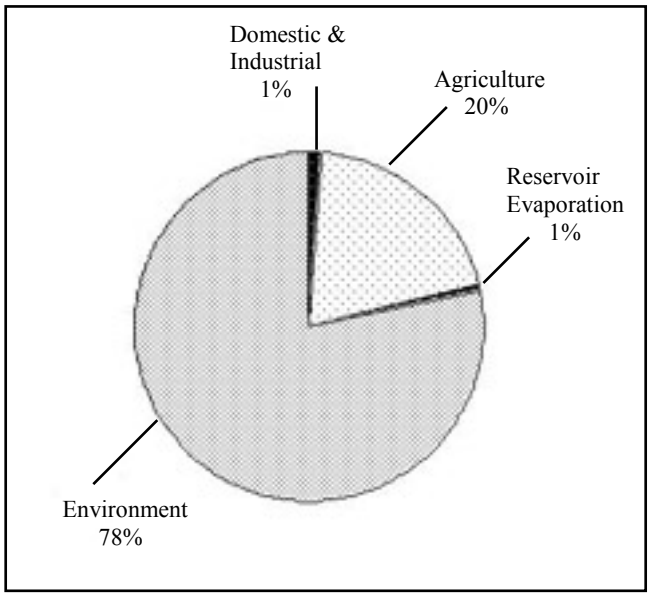

Figure 2. An alternative view of water use in Colorado. Data aggregated from the Colorado Foundation for Water Education and Grigg, 2003.

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FEATURES

HOW DO PLANTS USE WATER?

by Grant Cardon and Dan Smith
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Colorado State University

Estimates of crop consumptive water use are useful for a number of purposes, ranging from site-specific applications, such as irrigation scheduling, to broader uses related to stream or basin depletions. The most accepted method of obtaining these estimates is to use locally derived reference evapotranspiration (ET) values and adjust these values to specific cropping conditions. The water requirement of irrigated crops varies widely depending on a number of factors. Crude studies conducted in the early 1900s using a diverse array of crops revealed that the amount of water used to produce a pound of dry matter varied from 300 to 1000 pounds. The plant tissue associated with each pound of plant dry matter contains only a little over four pounds of water. This amounts to less than one-tenth of one percent of the total water requirement, assuming the best-case scenario of 300 pounds of water use per pound of dry matter. So where does the rest of the water go? The best answer is, "…into thin air." More than 99.9 percent of the total water requirement of an irrigated crop is consumed by evaporation from water occurring on either soil or crop surfaces, and transpiration, the evaporation that occurs from water on internal plant surfaces. The combined water loss from the processes of evaporation and transpiration is called evapotranspiration, or ET. The cumulative amount of ET for a crop over an entire growing season is roughly equivalent to that crop's seasonal water requirement.

Reference ET -- For irrigated crops that reach complete ground cover for most of the growing season, most of the seasonal ET is from transpiration. Transpiration water losses from a crop that completely covers the ground are similar in magnitude to what would be observed from the surface of an open water body such as a pond or lake of comparable area. Although transpiration losses are high, they are directly linked to

The Effect of Soil Salinity on Crop ET Coefficients

Soil salinity is widely recognized for its potential to affect crop water use. Mechanistic relationships between salinity and ET are known to exist, and some attempts have been made to formalize the use of these concepts in practical water management situations. However, little effort has been devoted to developing practical crop coefficients for use under variable saline soil conditions.

Soil salinity can affect plant water use through both direct and indirect effects. Direct effects are those related to physiological responses of plants to salinity. Water moves along a path in the direction of free energy gradient, from a higher energy state to a lower energy state. Crop water uptake is an active, energetic process and is influenced by the energy state of water in the soil. Soil salinity lowers the free energy of water in the soil, thereby reducing the potential uptake of water from the system. Plant responses to soil salinity also have been observed at the leaf-atmosphere interface in the form of reduced stomatal conductance. Because photosynthesis relies directly on leaf gas exchange, salinity can exert a direct effect on dry matter accumulation.

Based on the direct physiological responses noted above, the overall expression of salinity on the plant, except in the less common cases of specific elemental toxicities, is an induced drought, even if soil water content is high enough to otherwise allow for normal water uptake under non-saline conditions. Thus, the indirect effect of soil salinity is to produce stunting of plant growth, which reduces crop water use for either a part or the entire growing season, depending on the sensitivity of the plant to saline soil conditions and other factors related to canopy cover and distribution. In some instances, the stunting can be permanent, even if the saline condition is relieved, if the crop cannot immediately recover to produce compensatory growth or restore transpiration to its potential level.

Soil salinity effects, therefore, are reflected in crop ET through both direct and indirect effects. Conceivably, salinity-induced reductions in crop ET could be accounted for by use of specially calibrated crop coefficients. These coefficients would be especially useful in the Arkansas River valley, where salinity problems are widespread, and water accounting procedures that account for saline soil conditions are needed. The lysimeter studies proposed for this region could provide the data needed to formulate these special crop coefficients.

crop growth and, therefore, yield. This is because the pathway for transpiration water losses in plants is the same one that allows for plant uptake of carbon dioxide, which is the raw material for photosynthesis. Both exchange processes occur through pores called stomates on the leaf surface. When soil water is not limiting, which is usually the case under irrigated conditions, stomates are fully open. When this condition exists, both transpiration and photosynthesis are occurring at maximum rates allowed by current conditions both internal and external to the plant. If soil water becomes limiting, stomates begin to close, limiting both transpiration water losses and photosynthesis.

A key ingredient of irrigation water management is the ability to estimate the magnitude of ET losses for any given set of conditions. The most important factors that have to be accounted for are: 1.) the local weather conditions; and 2.) the cropping system for which estimates are needed (type of crop, planting date, etc.). Local weather conditions are important, because ET is driven by weather factors that determine the drying power of the air. A branch of science known as agricultural meteorology has provided good insight into the variables that drive evaporation of water from soil and crop surfaces. We can accurately predict ET losses in a given area from measurements of four local weather variables; solar radiation, temperature, humidity, and wind. To be useful, these measurements have to be made under a standardized set of conditions. By convention, the variables are measured using instrumentation of specific design located within large areas devoted to stands of irrigated grass or alfalfa. The data from these measurements are then used in specially calibrated equations that accurately predict the daily rate of ET for these standardized conditions. The values obtained from this process provide standardized measurements of ET that are referred to as reference ET. The term, reference, refers to standardization of the entire process including type of crop used under the weather-monitoring instrumentation, the weather variables measured, and the calculations performed. When all these factors are accounted for, the ET of the reference crop, which is designated as reference ET, can be estimated with great accuracy. In most cases, reference ET values are generated on a daily basis. The specific calculations used are from a set of calculations known as combination equations. The common name of Penman is often used to refer to these equations.

Crop/Soil ET Coefficients -- Reference ET values apply to a specific reference crop grown under a set of local weather conditions. To be useful for other crops within the area in which the reference values were obtained, reference ET values have to be adapted to fit these other crops. This is accomplished by adjusting the reference ET values by use of a crop coefficient. As a general rule, crop coefficients must account for factors such as type of crop, stage of development, and all other aspects of culture that might contribute to variability in the extent and distribution of canopy cover. Variation in available soil water also can be used to adjust crop coefficients for any period of the growing season. Locally adapted crop coefficients are available for most kinds of crops that are likely to be grown in a given area. These coefficients provide daily adjustments to the reference ET values generated each day throughout the growing season. In practice, the coefficient is used as a multiplier, such that the actual daily ET for a given crop on a specific day of the season is the product of the reference ET obtained for that date times the crop coefficient for that same date. The procedures described here are for use under conditions where soil moisture is not limiting. If moisture does become limiting, an additional adjustment factor, called the soil coefficient, can be applied in addition to the crop coefficient.

Concentrated Animal Feeding Operations

EPA has developed the "Producers Guide" to help concentrated animal feeding operation (CAFO) owners and operators understand how to comply with federal CAFO regulations. The guide is intended for large or medium facilities, or those which have been designated by a state permitting authority as a CAFO. The guide provides background and other information on: CAFO regulations; determining what facilities are affected; how to apply for a National Pollution Discharge Elimination System (NPDES) permit; requirements that would be contained in a permit; the compliance assurance process; and contact information for each state's NPDES program. The guide will soon be available from EPA regional offices, and is now available online at http://cfpub.epa.gov/npdes/afo/cafofinalrule.cfm.

Western States Water, November 28, 2003

REFINING EVAPOTRANSPIRATION ESTIMATES FOR COLORADO

by Marvin E. Jensen

INTRODUCTION

Dr. Robert Ward, Director of the Colorado Water Resources Institute, requested a brief article describing the current state-of-the-art in estimating evapotranspiration (ET) by crops for use in planning a program for refining estimates of ET for Colorado. Where applicable, he requested a summary of lessons learned, or some of my past experiences, in deriving, developing and using modern technology for estimating crop ET. The following brief comments are based on the points that we discussed.

CURRENT TECHNOLOGY

General Approach

The most common methodology to estimate crop ET that is used in the U.S. and internationally is to first estimate evaporative demand based on climate. Then, a crop coefficient curve that varies by crop growth stage is applied. These procedures were developed in the 1960s and are explained in detail in publications by Jensen et al. (1990), Allen et al. (1996), and Allen et al. (1998).

Emerging technology involves remote sensing of cropped surfaces coupled with surface energy balance calculations (SEBAL) based on local climate to calculate ET over individual fields or large areas (Bastiaanssen et al. 1998; Allen et al., 2002). The SEBAL methodology can also be used to determine crop coefficients for fields under current levels of irrigation management and soil salinity. This approach also has the advantage of delineating areas actually cropped excluding turn areas, ditches etc. and non-uniform irrigation practices.

Reference Crop ET

Reference crop ET is a measure of the evaporative demand under current climatic conditions. The most current and internationally accepted method for estimating reference crop ET is the Penman-Monteith (P-M) equation. Recently, the P-M procedures have been simplified and standardized to estimate reference ET for a standardized short crop (like grass) or a tall crop (like full cover alfalfa) using standardized vegetated surface parameters (Walter et al., 2002a; Walter et al. 2002b). The standardized equation, for hourly or daily values, has been evaluated under a wide range of conditions (Itenfisu, 2003). One of the most significant is an assessment of calculated half-hour ET rates for alfalfa compared with measured alfalfa ET from a 3 x 3 m weighing lysimeter near Bushland, Texas under several high wind days (Howell, 2003). Measured alfalfa ET on June 13, 1998 was 17.4 mm/day (0.685 inch/day) when wind speeds were over 10 m/s (over 22 mi/h) and daytime vapor-pressure deficit exceeded 4.0 kPa. A similar weather pattern occurred on June 20, 1998 when measured alfalfa ET was 16 mm/day (0.63 inch/day). Half-hour estimates using the standardized equation closely tracked measured values. The total estimated daily ET was 5-10% low on these windy days. This example indicates that the standardized equation not only is reliable under normal climatic conditions, but also under severe advective conditions that are often encountered on windy days in eastern Colorado.

Crop Coefficients

Crop coefficients originally were based on measuring soil-water depletion over several days by sampling the soil gravimetrically or using the neutron probe. The ratio of measured ET to reference crop ET is called the crop coefficient (K_c) commonly expressed as a curve for each crop. Most current crop coefficients are based on measured daily ET for a well-watered crop using a large weighing lysimeter surrounded by preferably about 330 ft (100 m) of the same crop grown under the same soil water conditions. The ratio of measured daily ET to measured or estimated daily short or tall crop reference crop ET is the daily K_c value. A set of K_c values must be used with the appropriate reference crop ET. Because of the high initial cost of equipment, annual operating costs and time requirements, only a few large weighing lysimeter systems have been installed in the western U.S. Some were installed in the 1960s at Kimberly, ID, near Fresno, CA in the 1980s, and at Bushland, TX in the late 1980s. Crop coefficient curves developed by Wright (1982) at Kimberly, ID for use with an alfalfa base reference crop have been widely used in the Colorado area. These are currently being updated so that the coefficients can be used with the sum of growing-degree-days (GDD) in addition to a time scale or percentage of the growing period. Generalized procedures for developing crop curves by linear segments for use with a short crop (grass) reference crop ET are available in a recent FAO publication (Allen et al., 1998).

Transferability of Crop Coefficients

Can crop coefficients developed in a climate somewhat different from that in Colorado be used to estimate crop ET? For most applications, crop curves developed in another

area can be used because well-watered crop ET is determined mainly by energy available in the area of interest. The energy available to evaporate water is determined by the calculated reference crop ET using local climate data. Its accuracy depends on whether or not daily climate data measured by automated weather stations have been screened for data quality and consistency. Experienced engineers and scientists generally transfer existing crop coefficients by adjustment of the growing period to an area of interest either directly with reference crop ET, or as input to soil-water-crop models. The models can enable adjustment for level of irrigation management and soil salinity. When coupled with locally determined reference crop ET, transferred crop coefficients derived with weighing lysimeters provide crop ET estimates with sufficient accuracy for irrigation management. Currently, an ASCE task force is refining the procedures for transferring crop coefficients.

Incorporating crop coefficients into soil-water-crop models that separately estimate the components of ET, or transpiration and evaporation, does not always assure greater accuracy of seasonal ET estimates. Some of the models that I have seen overestimate the evaporation component during frequent light rains.

Estimates of daily crop ET using transferred coefficients and summed for seasonal or annual totals of water consumption over many fields may not always have the desired accuracy because ET is also affected by the level of irrigation management. Under such conditions, validation by water balance for the study area is desired, but not always achievable because of complex inflow-outflow conditions and sources and sinks.

Locally or Regionally Determined Crop Coefficients
Having locally, or regionally determined crop coefficients will not necessarily assure greater accuracy of estimated crop ET, but may create greater confidence in the estimates of seasonal or annual water consumption. Improved accuracy will depend on the system and methodology used. Determining crop coefficients using precision weighing lysimeters usually requires several years to establish the site, then one or two years of measurements for each major crop being considered. Crop coefficients can also be determined on existing fields using a Bowen Ratio (BR) energy balance approach. Most previous BR studies have provided limited data over a few days at a time. As mentioned, crop coefficients can also be developed using the SEBAL technology for fields of currently grown crops that represent current irrigation management and soil salinity conditions.

Local Calibration of Reference Crop ET Estimates
In Colorado, transfer of water rights often involves estimating crop ET going back many years before automated weather stations were used and before calculations were being made with the P-M equation. In such cases, another empirical equation based mainly on temperature and extraterrestrial solar radiation data may need to be calibrated during recent years using modern calculation methods to provide improved estimates for earlier years. Likewise, managers operating water systems according to legal regulations are often reluctant to change procedures that have been used, but calibration of methods used can improve the accuracies of ET estimates.

PLANNING A NEW COLORADO SYSTEM FOR ESTIMATING CROP ET

Before installing and implementing a new system for refining ET estimates for Colorado, research leaders should consider organizing a workshop involving scientists and engineers who have had many years of experience installing and operating lysimeter-systems. They should also consider individuals having experience in using remote sensing and surface energy balance modeling technologies. Such a workshop would assure the selection of the most current and practical methodology for developing Colorado crop coefficients as well as provide guidelines as to land area, timetable and expertise required to achieve the desired results. The proceedings of a special ASCE session on lysimeters provide many additional guidelines (Allen et al., 1991).

Equally, or more important, for improved estimates of crop ET in Colorado, climate data collected by various automated weather stations should be subjected to rigorous quality control standards. Important considerations are the site conditions surrounding the automated weather station, which should approximate reference crop conditions. Currently, most Colorado engineers must screen climate data before using them for estimating crop ET. When adjustments are needed in some of data, different procedures may be used to make these adjustments. It would be better to have a central unit review the data and make necessary adjustments before the data are archived. A series of papers on operational experiences with automated weather stations was presented at a recent ASCE Water Resources Engineering conference (Elliott, 1995). The automated climate data network operated by the Northern Colorado Conservancy District has a full-time person dedicated to maintaining the data quality from about 20 automated weather stations along the South Platte River (NCWCD, 1996, 2001). This activity involves calibrating sensors annually, periodically visually checking each station, and checking daily reports for abnormalities by comparison with surrounding stations. Climate data collected at the NCWCD stations back to 1996 are available via the district's web site.

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CALL FOR VOLUNTEERS

The 2004 Stockholm Junior Water Prize, U.S. national competition, is being hosted by the Rocky Mountain Water Environment Association (RMWEA) and the Rocky Mountain Section of the American Water Works Association (RMSAWWA) in Denver, June 10-12, 2004. Tom Dingeman, City of Greeley and the Stockholm Junior Water Prize local hosts coordinator, seeks volunteers to serve as airport greeters. If you would like to volunteer, please contact Tom via e-mail at: dingemat@ci.greeley.co.us or by phone: (970) 350-9365.

NWRI Fellowship Announcement

The National Water Research Institute (NWRI) offers fellowships up to $15,000 to graduate students conducting research related to water resources. To be considered for an NWRI fellowship for the next academic year, you must submit and application by March 1st. The application includes: a letter of inquiry describing your research goals, a resume, a letter of endorsement from your faculty advisor, a research proposal (3-4 pages), Verification of enrollment as a fulltime graduate student. Fellowships will be awarded on July 1st of every year. For details see the NWRI website at:

www.nwri-usa.org
(714)378-3278

New Publications of the U.S. Geological Survey

Important Announcement for Subscribers

Effective with the July-September 2003 issue, the U.S. Geological Survey will no longer print and distribute the quarterly version of "New Publications of the U.S. Geological Survey." The July-September 2003 and October-December 2003 issues will be released online through the USGS at http://pubs.usgs.gov/publications/.

Comments concerning this change may be sent to the U.S. Geological Survey, 903 National Center, Reston, VA 20192.

Colorado State University Agricultural Experiment Station

COAGMET -- Weather Data Helps Colorado Agriculture Manage Water

by Nolan Doesken and Troy Bauder

COAGMET is an acronym for Colorado AGricultural METeorological Network. As the acronym implies, the purpose of this effort is to provide weather data to Colorado agriculture. For over a decade now, an informal but effective partnership that involves several departments at Colorado State University, the U.S. Department of Agriculture, CSU Agricultural Experiment Station, the Northern Colorado Water Conservancy District, commodities groups and other individuals and organizations committed to Colorado agriculture has been working together to collect and share weather data.

Figure 1. COAGMET weather station at the Yuma site.

COAGMET is a great example of what can be accomplished with cooperation and collaboration.

Back in the 1980s, Dr. Harold Duke (retired) and Mike Blue, of the Water Management Unit of the USDA-ARS, were setting up automated weather stations to assist research projects on water-use efficiency.

At the same time, Dr. Howard Schwartz and Mark McMillan, with CSU's Department of BioAgricultural Science and Pest Management, were setting up weather stations to help study insects and diseases affecting crops in Colorado.

The two groups decided to work together, and by 1989 the foundations for COAGMET were in place. The Colorado Climate Center joined the team during the 1990s. Cooperative Extension, the Colorado Agricultural Experiment Station, and several commodity groups are also a part of the team.

COAGMET comprises a network of automated weather stations throughout Colorado (Figures 1 and 2) and the computer system for collecting, archiving, displaying and disseminating the data.

The basic elements automatically observed by COAGMET weather stations include parameters required for calculating daily evapotranspiration (ET) using combination equations: temperature, humidity, wind speed, and solar radiation. The stations also record wind direction, precipitation, and soil temperature. Data are processed locally using CR10 Campbell Scientific data loggers. Currently, most of these weather stations transmit data summaries for one-hour increments to the central processor at Colorado State University once daily. Most stations are equipped with cellular phones programmed to turn on at assigned times.

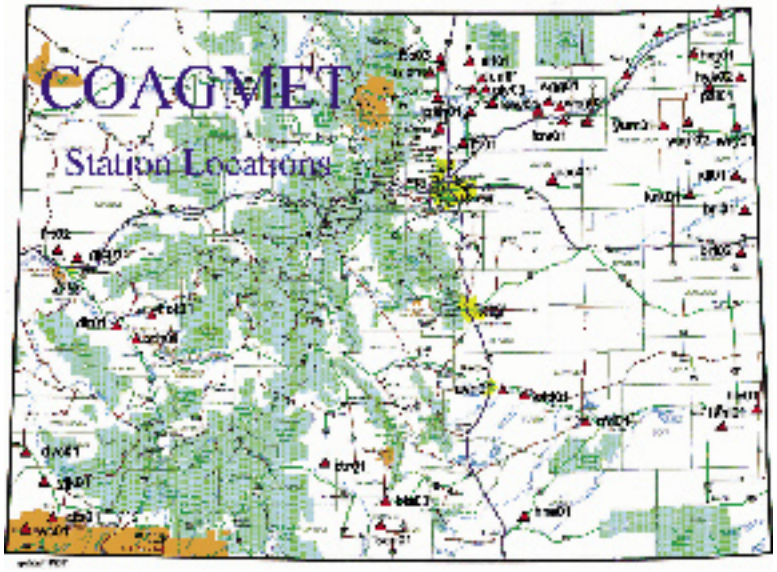


Figure 2. COAGMET weather station distribution in Colorado.

Weather data from COAGMET are currently being used in several ways, one of which is to assist ET-based irrigation scheduling. Irrigators can use ET data to determine past crop water use and to more accurately project irrigation water needs and timing. This helps ensure that adequate water is applied to meet crop need, while avoiding over-application. Dr. Schwartz and his team use the COAGMET data for modeling and prediction of disease outbreaks in high value crops such as onions and potatoes.

Currently, the ET reports provided on the internet (www.coagmet.com), by email and through printed reports and news releases are calculated using the 1982 Kimberly Penman method. Crop ET reports are available in two formats. Crop reports are currently available for alfalfa, corn, dry beans, small grains, sugar beets, potatoes, and onions. A new output format for crop ET reports allows users to select individual stations and the crops of interest. Users can also select their precise planting date to more accurately reflect stage of development and crop canopy (Figure 3). Although these stations are located in predominantly agricultural areas, turf grass was added in 2003 due to the increased interest in landscape water conservation.

A strength, but also a handicap for COAGMET, is the informal nature of the program. The enthusiastic and generous support from a variety of groups and individuals is responsible for keeping a large and effective agricultural weather network functional for a decade with very little exchange of funds and few administrative problems. Several disadvantages exist, however, that may pose problems in the future. With limited resources earmarked specifically for the system, long-term continuity is at risk. Already, data quality and station maintenance do not receive the oversight needed for strict quality assurance. This is a particular concern for COAGMET, because a few key individuals perform most of the station setup, maintenance, and data collection and management functions.

For over ten years the COAGMET participants and partners have been able provide nearly continuous daily data for ET calculations needed for irrigation scheduling, plant disease models, and other purposes. However, maintaining the continuity of this successful program will require renewed support from the University and COAGMET partners to provide high-quality climate data on a daily basis. To access COAGMET, go to www.coagmet.com.

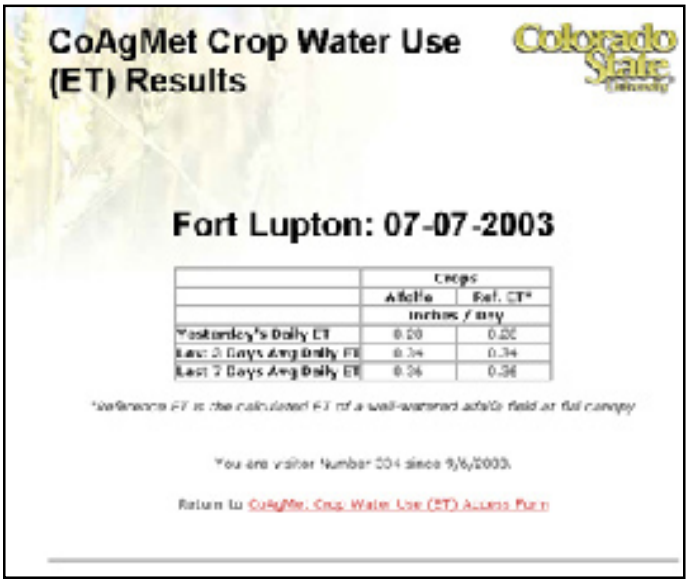


Figure 3. Crop ET report in new format begun in 2002.

Endangered Species Act/Klamath Basin

In a final report issued on Nov. 18, the U.S. Fish and Wildlife Service (USFWS) claims the direct cause of death in the Sept. 2002 Klamath River fish kill was an outbreak of two freshwater pathogens, "Ich and columnaris." The two pathogens are commonly found in the Klamath River and other aquatic systems, so FWS concludes that additional factors combined to stress the fish and render them more susceptible to the pathogens. The report says those factors included: the large size of the fall run of Chinook salmon returning to the Klamath River from the Pacific Ocean; the high densities of fish in the lower river (enabling the pathogen outbreaks to spread quickly); the relatively low flow in the lower Klamath River; and hot weather, which raised water temperatures above that optimal for salmon. The report is consistent with a recent report from the National Research Council (NRC), which concluded that the die off was not principally due to low water levels in the Klamath River, but more likely a combination of numerous factors. Environmentalists, however, insist that the primary factor was the low flow in the Klamath River. The report does not indicate whether releasing more water from the Klamath Irrigation Project would have helped to prevent the fish kill. Reports on the causative factors of the fish kill and the estimate of mortality can be found at http://sacramento.fws.gov/ea/Media-Latestnews.htm.

Western States Water, 11/21/03

OPINION

FORESTER GRADES PROFESSORS' REPORT: "A" FOR CONTENT; "C-" for PRESENTATION

Ron Gosnell, a forester with 31 years experience working in Colorado's woods says of a new Colorado State University report, "You sure can't judge this one by its cover! I hope people will read it." Gosnell, who was on the advisory panel, says that, unfortunately, one of the cover photographs may perpetuate misunderstanding. He goes on to say, "We only get one chance at first impressions and people see the cover first. A county commissioner, city manager, environmental leader, water board member or forest supervisor may pick up this report, look at it and say, 'If this is what they mean, then no thanks.'" Despite his disappointment with the cover photo, Gosnell is encouraged by the report's content. If people read it, he thinks it will help them understand most of what is known about Colorado forests and water. "Maybe it will help people take appropriate action," he adds. Gosnell offers the following comments about the recently published Colorado Water Resources Research Institute Report No. 196, Forests and Water: A State-of-the-Art Review for Colorado.

At Last, the All-Inclusive and Up-To-Date Colorado Forests and Water Report

by Ron Gosnell, Lyons, Colorado
(retired, Colorado State Forest Service)

Finally, Colorado has a state-of-the- art review of forestry and water. So promising are the new report's findings, that this document may serve to bring people together on previously controversial and misunderstood forestry and water issues.

Colorado State University's Lee MacDonald and John Stednick successfully teamed with Colorado watershed expert Charles T. Troendle and others. The product that the two professors produced is extensive and well documented. Reference literature cited will help anyone who wishes to further his or her knowledge on specific subject matter.

However, in my opinion, their publication has a major shortcoming. Most glaring is the selection of one of the cover photographs, which shows an unattractive and regimented patchwork of forest clearings used in some research. As a result of this photo and some others like it that have appeared in Colorado newspapers, a negative perception about forestry for water is perpetuated. Colorado citizens will not permit their forests to receive this kind of visually drastic forest treatment. Other similar research phographs have incited emotional opposition to forestry. Seeing this again, some important decision-makers may think that nothing else matters if this photo is what it's all about!
The offending photograph is a communications shortcoming because it does not convey the most critical concept about forestry and water to come out of research in the last decade. The breakthrough that I am referring to is by Troendle with others, and is explained in chapter two of the report. Stark forest clearings, as shown in the cover photograph, are not necessary to produce greater water yields.

The report tells us that additional water from a managed forest is inversely proportional to forest density. We can artistically thin or selectively harvest trees and produce more water. In the extreme, one tree removed from a forest in snow country creates one small opening, and the tiny bit more water that is produced goes undetected. In a thinning; when you have many one-tree openings, you quickly achieve an effective threshold percent of open canopy that measurably increases water yield.

A more appropriate cover photograph would be one that shows accumulated snow on a thinned forest's floor and immediately adjacent bare ground in an unthinned forest. Foresters encounter this scene quite often in Colorado snow country. The reason is that a dense forest canopy intercepts falling snow and holds it up high in the tree crowns (branches). Here, much of the snow's moisture sublimates back into the atmosphere before the snow has a chance to melt. A thinned forest, on the other hand, permits more snow to fall through the canopy openings and reach the ground where it accumulates in depth and stores water for later release during snow melt.

The report also documents that a thinned forest helps protect water quality. And the report emphasizes the beneficial effect of retaining forests to encourage infiltration and reduce overland flows. These facts will help antagonists see what they have in common about forests and water. Finding common ground helps people come together.

Also inside the report, an important misconception is debunked when it is explained why increased water flows resulting from forestry sometimes cannot be measured. Measurement limitations, the report says, does not mean that additional water is not there. It is. However, natural streams and wetlands do not perform like engineered pipes and valves and concrete ditches.

The report explains how increased water yields in an upper drainage may end up hidden in the lower reaches of the drainage as it raises underground water tables and expands the boundaries of wetlands, or extends a period of inundation beneficial to some wildlife. Many people outside of the narrowly focused water community can embrace these hidden benefits of forestry. Again, there are partnership possibilities in watershed management that, up to this point, may have been considered impossible.

Forestry for favorable water flows is a good fit with many other forest initiatives already started or in development stages. For example, thinning to produce more water and to protect forest from too-intense wildfire can be the same project that restores a forest condition in a recreational forest, where the primary goal is safety of visitors and serenity.

The report recognizes a recurring question water agencies face when it comes to funding. Because additional water sometimes may not end up in a claimant's pipe or reservoir, the question of who benefits and who pays must be addressed. The report gives hope, however, by eliminating negative arguments and misconceptions that previously cast enough doubt that inaction was reasonable. Now it is not. With this report, instead of wondering if forestry for water is worth it, people can understand why it is. The report eliminates previous ambiguity.

There is another significant question raised in the report and it is one that the report did not address. How should Colorado deal with the myriad of issues that must be examined before an alternative is chosen and a project becomes operational? I offer this. Make sure that every proposed forestry project is a local one.

By working together at a community level, people quickly determine which of many different issues are important and appropriate. Unnecessary problems and time consuming complications are eliminated. Each potential forestry project becomes unique and worthwhile to its own set of stakeholders.

Furthermore, community-based forestry usually incorporates private ownerships. The report reminds us that of Colorado's 35,300 square miles of forests, 28 percent is privately owned by almost 200,000 people. Private forest land is subject to the goals and decisions of each private landowner. The large number of individual decision-makers and fractured forest ownership patterns are not necessarily a deterrent. Landowners represent an opportunity to share responsibility for appropriate action.

My own experience working with private forest owners proved this: people choose to conduct forestry for many reasons. When their choice is of free will, and they achieve understanding first, most people take action to improve their forests. People want to leave their forest in a little bit better condition than when they got it.

With this new report, more people can achieve understanding about the tremendous water improvement opportunities that forestry provides, consistent with private property and community values. Public and private decision-makers have a new tool to help them see why the forests under their own jurisdiction are important for water, and how individual actions on a small scale help achieve positive results on a large scale.

We learn from the report that small increments of additional water per unit of forest can become significant. The opportunity to reverse the trend of reduced water yields from dense forest growth exists on a very, very large landscape scale. Small increments of additional water over whole areas of forest result in almost unbelievably large volumes of additional water over time.

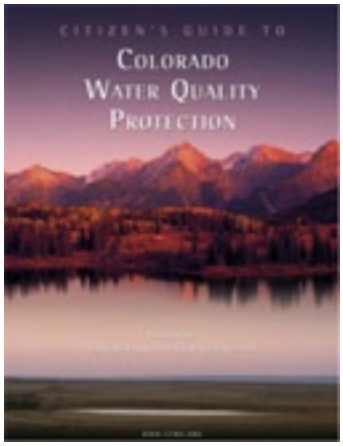
It took almost 100 years for Colorado forests to grow into their present condition—one that yields reduced amounts of water with high risk for intense and damaging wildfires. Expecting extensive changes to correct this unnatural condition immediately is unreasonable.

Priority projects can be conducted incrementally over time. In a society that expects immediate gratification, restoration forestry for water must be explained in the context of long-term forest care. Water benefits are so important that people need to understand that forest improvement started in one generation will continue into the next.

The authors of the report are to be commended for their work. Except for one photo on the cover, the report is an information source and a tool for learning. With its help, people can see what they have in common, come together and say, "Yes, we understand. Let's get started!"

That is my expectation.

COLORADO FOUNDATION FOR WATER EDUCATION ANNOUNCES NEW PUBLICATION, POSTER



Citizen's Guide to Colorado Water Quality Protection -- Curious how the state decides what rivers are healthy for fish, or what lakes are safe to swim in? The Citizen's Guide to Colorado Water Quality Protection summarizes how national and state regulations determine "how clean is clean." Authored by Paul D. Frohardt of the Colorado Water Quality Control Commission, this 33-page booklet tackles our complex system of water quality laws and regulations. Colorado is blessed with high-quality water originating in mountain streams. In fact, over 90 percent of our lakes, reservoirs, and rivers meet or exceed their water quality goals. However, development and population growth increase water pollution risks. From the headwaters to the plains, this desk reference helps explain the risks and investigates the solutions to our water quality problems.

Colorado: the Headwaters State Poster -- Recently revised, the Foundation's poster, Colorado: the Headwaters State, provides an eye-catching summary of the major surface waters in the state, including lakes, reservoirs and rivers. Illustrations show how precipitation varies across the state, from less than 12 inches on the plains to more than 45 inches in the mountains. Other graphics trace the state's history of drought and flood over the last 100 years. Statewide water use percentages show how water is divided between agriculture, commerce and industry, municipal, and other uses.

This attractive 24x36 inch wall hanging makes a useful addition to any business, school, or office – showcasing the beauty of our state and illustrating important water facts and figures in an accessible and easy-to-read format.

Copies of the guide are $7 each, or $5 if ordering ten or more. Booklets may be ordered online at www.cfwe.org or by contacting the Foundation office at 303-377-4433.

American Water Resources Association, Colorado Section
January Luncheon Program
Section 309 Water Quality Control Act
January 25, 2004
12:00 Lunch, 12:30 Program
Denver Water

American Water Resources Association, Colorado Section
2004 Annual Symposium
Interstate Compacts and Treaties: Then and Now
Friday, April 30th, 2004, at the Arvada Center

Additional information will be coming soon!!
Website: http://www.awra.org/state/Colorado/

MEETING BRIEFS

BUREAU OF RECLAMATION EXAMINES NEW DEVELOPMENTS IN WATER MANAGEMENT

The Bureau of Reclamation's Technical Service Center hosted a Workshop on River Systems Management, November 4-6, 2003, at the University Park Holiday Inn in Fort Collins. The workshop, the eighth in a series held at intervals of one to-two years, focused on priorities and new developments that affect how Reclamation manages water resources. This year, specifically, the focus was on how to reduce conflict in water resources management.

Over 100 Reclamation managers, technical staff and invited speakers from other government agencies, universities, stakeholder organizations and the private sector participated in both technical sessions and breakout workshops on such topics as water resources modeling and optimization; collaboration in water data collection and sharing; legal issues impacting water allocations; ecologically based system developments; and real-time flow forecast modeling.

Daniel P. Loucks, Cornell University, described the use of new operations developments in reducing conflict in two case studies: Lake Ontario-St. Lawrence River flow and lake level operating policy study; and operation of Lake Okeechobee to meet multiple objectives in real time, continuously on a weekly basis, throughout the year. Aaron Wolf, Oregon State University, discussed lessons learned in resolving water conflicts in the international arena.

Daniel Loucks, left, and Marshall Flug share perspectives on river systems management. Flug is a hydrologist with the U.S. Geological Survey's Biological Resources Division.

Information from the workshop will be posted at www.usbr.gov/pmts/rivers/rsm in the near future. Contact Don Frevert (DFREVERT@do/usbr/gov) for additional information regarding the workshop.

WATER 2025 WORKSHOP HELD IN DENVER

The Adams Mark Hotel was the venue for a workshop, on November 4, 2003, on science and technology in support of the Department of the Interior's Water 2025 initiative to reduce conflict and crisis in western water management. Chip Groat, Director, U.S. Geological Survey, noted that to reduce water conflicts we need to understand the water resource base, agree on what we know and what we don't know, and determine how to fill in the knowledge gaps.

From left: John Letey, Director, Center for Water Resources, University of California, and Peter J. Wierenga, Director, Water Resources Research Center, University of Arizona.

Pat Tyrrell, Wyoming State Engineer, seconded the need to closely measure available water supplies and uses, especially to ensure that requirements of river compacts can be met.

Don Wilhite, Director, National Drought Mitigation Center, University of Nebraska, called for enhanced translation of drought forecasts into information that readily fits water resources planning practices.

In the discussion session titled, "Predictability of

Water Availability, there were calls for a "language of model certainty" as well as for a "language of data consistency." Participants felt that efforts to model water availability are not well understood and, therefore, are not able to support reduced conflict in water management as much as desired.

For additional information about the workshop findings, please refer to the website at http://www.doi.gov/water2025/.

Right, from left: Mike Applegate, Northern Colorado Water Conservancy District, and James Broderick, Southeastern Colorado Water Conservancy District.

SOUTH PLATTE FORUM 2003: PLANNING FOR UNCERTAINTY

The current drought in Colorado reminds us all that we live in a semi-arid climate with all the water supply uncertainties associated with such climates. The 2003 South Platte Forum, held October 22-23 in Longmont, Colorado, examined the implications of water supply uncertainty, paying particular attention to current efforts to plan for uncertainty. Rod Kuharich, Director of the Colorado Water Conservation Board, updated the 120 attendees on the Statewide Water Supply Initiative, currently underway.

Attorney General Ken Salazar updated the audience on efforts to better integrate ground and surface water management in Colorado.

Dennis Montgomery, Hill and Robbins, described lessons learned in resolving interstate water disputes, including developing scientifically sound water use date (Dennis Montgomery's talk is presented in the following pages).

Peter Binney, City of Aurora, summarized efforts of a Front Range municipality to meet its growing need for water (Peter Binney's talk is also provided).

Other topics addressed dealt with the economic impacts on rural economies of water transfers from agriculture, biological responses to water development, the interface between aggregate mining and water management, landscape industry

PICTURES; From top clockwise: Rod Kuharich, Director, Colorado Water Conservation Board; (from left) Dan Merriman, Colorado Water Conservation Board; Dennis Montgomery, Hill & Robbins; Marc Johnson, Vice Provost, CSU; and Ken Salazar, Colorado Attorney General.

plans to prepare for future droughts, the emerging role of water banks, and an examination of future trends in water management in the South Platte Basin.

The 2004 South Platte Forum is scheduled for October 27-28, 2004. Please plan to join us for this annual dialogue on the South Platte.

LESSONS LEARNED FROM THE ARKANSAS RIVER CASE

KEYNOTE PRESENTATION
South Platte Forum – October 23, 2003

by Dennis Montgomery
Hill and Robbins

It is a pleasure to be here. I am filling in for my partner, David Robbins, who was invited to speak today. David had to go to Minneapolis. His wife serves on the board of a foundation, and she requested his presence for the meeting. David came into my office a few weeks ago and, rather sheepishly, asked if I could fill in for him today. It was very hard for me to say no, because over the last 12 years, David and I have spent a total of 270 days of trial in California in Kansas vs. Colorado. That works out to 54 solid weeks of trial. Obviously, we didn't do that all at one time, it was broken up into three-week segments over the last 12 years; but, when you are away from home that frequently, you build up some large debts to your family.

The Special Master in Kansas vs. Colorado issued a draft fourth report in August. It is a 148-page report and contains 13 recommendations on how to resolve the remaining issues in the case. Some of the recommendations are a great significance to well owners in the Arkansas River Valley, and they will be vitally interested in those recommendations, but they are not of general significance to water users in the rest of the state or the South Platte River Basin. So, I am going to concentrate on a few recommendations that I think are of general interest, and one in particular that I think will be of interest to water users in the South Platte River Basin, and that is the Special Master's recommendation that the Penman-Monteith equation be used to determine potential evapotranspiration in the model that is being used to determine compact compliance in the Arkansas River Basin. But, before I get to the recommendations, I thought it would be helpful for those of you who are not familiar with Kansas v. Colorado to give you a brief history of the lawsuit.

The case began in 1985, when Kansas filed a motion for leave to file a complaint against Colorado in the U.S. Supreme Court. The U.S. Supreme Court is the only court that has jurisdiction of cases between states. The Supreme Court's rules require the filing of a motion for leave to file a complaint, because the Court likes to determine at an early stage whether the case is truly within its original jurisdiction and whether the case can be resolved at an early stage. In this case, the Court granted the Kansas motion for leave to file a complaint against Colorado. The complaint alleged three violations of the Arkansas River Compact between Colorado and Kansas. The first was that the operation of the Trinidad Project on the Purgatoire River, a tributary of the Arkansas River, had depleted usable flows of the Arkansas River in violation of the Arkansas River Compact of 1948. The second claim involved the Winter Water Storage Program, which is operated in part in Pueblo Reservoir, as part of the Fryingpan-Arkansas project. The complaint alleged that the operating principles for the Winter Water Storage Program had not been approved by the Arkansas River Compact Administration, which Kansas alleged was required under a 1951 resolution of the Compact Administration and, further, that the operation of the program had depleted the usable flows of the Arkansas River in violation of the Compact. Finally, Kansas alleged that post-Compact well pumping by hundreds of wells that had been drilled in the Arkansas River Valley in Colorado in the years after the Compact had been adopted had depleted the usable Stateline flows that were available to Kansas under the Arkansas River Compact.

In 1986, the Court gave Colorado an opportunity to file an answer, and then appointed a Special Master to take evidence and prepare such reports as he deemed necessary. That is the usual practice in original actions before the U.S. Supreme Court. The Constitution originally envisioned that the U.S. Supreme Court would sit as a trial court in cases between states, but today the Court's appellate jurisdiction is so pressing that it doesn't have time to act as a trial court. So, in original actions the Court appoints a Special Master to take evidence and prepare reports. The Special Master functions very much like a federal district judge, with the exception that a Special Master probably has less discretion to exclude evidence than a federal judge. The Special Master prepares reports that are submitted to the Court. The parties are allowed to file exceptions, which are argued to the Court very much like any other appeal heard by the Court.

The Court appointed Wade McCree as the first Special Master.

Judge McCree was a retired federal court judge who was teaching at the University of Michigan Law School at that time. He had also been the Solicitor General during the Carter Administration. The Solicitor General is responsible for all litigation by the United States in the U.S. Supreme Court.

After Judge McCree was appointed, we had a conference in Ann Arbor and worked out a proposed order for discovery in the case. But, unfortunately Judge McCree was diagnosed with cancer and died at the end of the year. The Court then appointed Arthur Littleworth as the Special Master in 1987. Mr. Littleworth was a very well-respected water lawyer from Southern California. He was 63 years old at the time of his appointment and, I suspect, viewed the appointment as the capstone to his career and had no idea that the case would still be going on 17 years later.

A major compromise or agreement that was reached between water users in the Arkansas River Basin was that the rules would not simply address depletions to usable Stateline flows, but would also address the impacts of junior wells on senior surface water rights in Colorado.

When Mr. Littleworth took over the case, he ruled on several pending motions. He then decided to bifurcate the case into a "liability" phase and a "remedy" phase so that he could first determine if there had been any violations of the Arkansas River Compact, and if there were, then determine an appropriate remedy.

The trial on the liability phase of the case began in September of 1990. At that time, the lawyers in the case estimated that the trial would last between six and twelve weeks. Ha! The trial went on for a period of more than two years, with 160 days of trial. The primary reason for the long trial was that one of Kansas' experts had to withdraw. Kansas was allowed to designate replacement experts, and the trial on the liability phase was finally completed in 1992.

The Special Master issued his first report in 1994, in which he recommended dismissal of the claims involving the Trinidad Project and the Winter Water Storage Program. However, on the claim involving post-Compact well development, he found that regardless of which State's evidence was considered, post-Compact well pumping had depleted usable Stateline flows in violation of the Compact.

Both states filed exceptions to the Special Master's first report, which were argued to the Court in early 1995. The Court then issued an opinion in May of 1995 which overruled the exceptions and remanded the case back to the Special Master for proceedings consistent with its opinion. As a result of the finding that Colorado was in violation of the Compact, the State Engineer took a number of actions. The Special Master had been critical of the fact that Colorado had very limited data on the number of wells that existed in the Arkansas River Basin and the amounts of ground water that had been pumped. So, the first thing the State Engineer did after the issuance of the first report was to conduct an inventory of wells in the Arkansas River Valley. Ground water commissioners went out into the field to find every well that existed and placed a tag on each one.

The State Engineer also adopted rules and regulations that required well owners to install a totalizing flow meter on their wells to determine how much ground water was pumped, or, if the wells were powered by electricity, which most of the wells in the Arkansas River Valley are, they could have it tested to determine a power conversion coefficient to relate the number of kilowatt hours used to pump an acre foot of ground water. Those rules were adopted in 1994 and later amended in 1996.

At the same time, Governor Romer appointed a coordinating committee, which included representatives of well users, surface users, county commissioners, and the Southeastern Colorado Water Conservancy District, to recommend what should be done in response to the Supreme Court's decision, and how wells should be brought into compliance with the Arkansas River Compact. The committee met on numerous occasions over the course of more than a year, and agreed on some principles that became the basis of rules and regulations that the State Engineer adopted in 1995 with the intention of bringing post-Compact well pumping into compliance with the Compact.

A major compromise or agreement that was reached between water users in the Arkansas River Basin was that the rules would not simply address depletions to usable Stateline flows, but would also address the impacts of junior wells on senior surface water rights in Colorado. The Rules provided that all well pumping in the Arkansas River Valley would be discontinued unless the wells were included in replacement plans. The replacement plans had to do two things: they had to replace out-of-priority depletions to senior surface rights in Colorado, and, for wells along the river between Pueblo and the Stateline, they also had to replace depletions to usable Stateline flows. In those rules, the Colorado State Engineer provided that the hydrologic model that had been developed by Kansas to determine depletions to usable Stateline flows would be used to determine deletions to usable Stateline flows.

Following the Supreme Court's decision in 1995, Kansas filed a motion for an injunction to prohibit pumping by post-Compact wells until Colorado had demonstrated that the depletions to usable Stateline flows would be replaced. The Special Master denied the request for injunction and said that the Colorado State Engineer was in the process of adopting rules and regulations. He thought that Colorado should be given a period of time to implement replacement plans to see if it could come into compliance with the Compact. The Special

Master then conducted a series of hearings to consider additional evidence to quantify the amount of depletions that had occurred to usable Stateline flows and to bring the evidence up-to-date, because the evidence in the first trial segment only went through 1985. The States stipulated to the depletions for the period 1950-1985 and the Master determined the amount of the additional depletions through 1994; he also determined an appropriate remedy for the past depletions to usable Stateline flows.

In the Master's second and third reports, which came out in 1997 and 2000 respectively, he recommended that a suitable remedy for the past depletions was money damages, not repayment in water. He also determined that the damages should be based on the value of the water to Kansas. In other words, the damages could be based, in part, on the losses suffered by Kansas water users as a result of the depletions to usable Stateline flows. He also ruled that prejudgment interest could be awarded on those damages, but that prejudgment interest should not be awarded until 1969, the date he concluded that Colorado knew, or should have known, that post-Compact well pumping was depleting usable Stateline flows in violation of the Compact.

> The Special Master accepted a new method to determine potential evapotranspiration in the model that is being used to determine Compact compliance.

Colorado filed exceptions to the Master's recommendations on damages and prejudgment interest. The exceptions were argued to the U.S. Supreme Court in 2001, and in June 2001 the Supreme Court issued an opinion in which it denied Colorado's exceptions, with the exception of the date for the commencement of prejudgment interest. The Court agreed with Colorado that the date for awarding prejudgment interest should be moved back from 1969 to 1985, the date Kansas filed the lawsuit. The Court pointed out that in previous rulings it had concluded that Kansas had not unreasonably delayed filing an action against Colorado until 1985 because no one really knew there were depletions to usable Stateline flows, and, in the early years nobody thought that wells were depleting usable Stateline flows in violation of the Compact. Even after it became clear that there was quite a bit of pumping in Colorado, trying to determine the impact of that pumping on Stateline flows was difficult. That was a very significant decision for Colorado, because it reduced the amount of prejudgment interest by about $18 million.

That set the stage for the final trial segment that began in June 2002. There were several issues that remained to be resolved after the remand, which included the amount of the damages and prejudgment interest. Colorado and Kansas agreed on the amount of the damages, which were about $7 million, but disagreed on how to calculate prejudgment interest on the damages in accordance with the Supreme Court's opinion. Colorado's calculation of damages and prejudgment interest was $28.9 million in 2002 dollars. Kansas' calculation of damages and prejudgment damages was $53 million in 2002 dollars. The difference is simply based on a difference in the interpretation of the Supreme Court's decision. The Special Master agreed with Colorado's interpretation, so at least for now, the damages and prejudgment interest, in 2002 dollars, are $28.9 million.

Another issue that had to be determined is whether the rules and regulations that had been adopted by the State Engineer, which became effective June 1, 1996, and the replacement plans implemented under those rules and regulations were sufficient to bring Colorado into compliance with the Compact. The Special Master determined that for the period 1997 through 1999, the implementation of the rules and regulations and the replacement plans were sufficient to bring Colorado into compliance with the Compact. That was an important finding, because it relieves Colorado from other remedies that might have been imposed if Colorado's plans had not been sufficient to prevent further depletions.

Another issue was whether a River Master should be appointed to continue to determine Compact compliance in the future. Colorado opposed the appointment of a River Master on the basis that it would continue the litigation into the future indefinitely. The Special Master rejected Kansas's request to appoint a River Master; however, as you heard yesterday, the period 1997 through 1999 was a wet period in Colorado. The Special Master found that although Colorado's plans were sufficient to prevent depletions in that period, it wasn't clear that the plans would be sufficient in a dry period. Therefore, he has recommended that the Court retain jurisdiction for a limited period of time, but he also recommended that before either state could invoke the jurisdiction of the Court, it should be required to first take the dispute to the Arkansas River Compact Administration.

Another recommendation was that Compact compliance should be determined over a 10-year period and that the results of the model would be used over that period to see whether there were depletions to usable Stateline flows. Colorado's position was that the model was not sufficiently accurate to use on a year-by-year basis. The Special Master agreed, which is a significant finding.

Hydrologic models are commonly used today to determine many water resources issues, particularly those involving the use of ground water. These models can give very precise answers, but the question that must be asked is whether those answers are reasonable and reliable, particularly over a short time frame. The Special Master agreed with Colorado that the model was not reliable on a short-term basis, and that a 10-year period was reasonable to look at Compact compliance. That is a significant finding for well owners in the Arkansas

River Valley; it gives them the ability to predict whether depletions are likely over a 10-year period; and, if there are, they can take actions to replace those depletions, such as putting more water into storage in an offset account in John Martin Reservoir.

Finally, I want to address a recommendation that I think is of interest to water users in the South Platte River Basin. The Special Master accepted a new method to determine potential evapotranspiration in the model that is being used to determine Compact compliance. In previous versions of the model, the modified Blaney-Criddle method developed by the Soil Conservation Service was used to determine the potential evapotranspiration of crops in the Arkansas River Valley. It is a widely used method, and it has been used to determine historical consumptive use for water rights transfers in Colorado and has been widely accepted as giving reasonable results.

In my opinion, there needs to be additional research of the type that Dr. Wright conducted at the Agricultural Research Station in Kimberly, Idaho, to determine whether the Penman-Monteith equation is, in fact, reasonable for use in Colorado and whether the crop coefficients developed by Dr. Wright need to be adjusted for conditions in Colorado, in particular, for salinity...I believe that additional research is important for water users throughout the state, including the South Platte River Basin, and urge your support for such research.

However, the scientific and engineering communities are committed to using more physically-based equations to determine potential evapotranspiration, using what are called "reference crop ET" methods, which use crop coefficients that are multiplied times a reference crop ET to determine the potential evapotranspiration of crops. Such methods are now widely used for irrigation scheduling. The Special Master accepted the Kansas position that the Penman-Monteith equation is the most accurate method to determine reference crop ET. He also accepted the Kansas position that crop coefficients developed by Dr. James Wright of the Agricultural Research Service in Kimberly, Idaho, were appropriate to determine the potential evapotranspiration of crops in the Arkansas River Valley. After hearing the experts testify, I remain somewhat skeptical about the use of the Penman-Monteith equation and, in particular, the crop coefficients that Dr. Wright developed to determine potential evapotranspiration. Those crop coefficients were developed under what I would describe as ideal conditions. Dr. Wright has published a number of papers that describe the research he conducted to determine those crop coefficients. He placed a lysimeter in an alfalfa field near the Agricultural Research Station in Kimberly, Idaho, to determine the consumptive use of alfalfa. However, he noted that the alfalfa yield in the lysimeter was slightly greater than in the surrounding field. The alfalfa in the lysimeter was hand-harvested. The alfalfa in the surrounding field was mechanically harvested, and he thought that the mechanical harvesting equipment and lower producing areas in the field resulted in slightly lower yields than in the lysimeter.

He also noted that the alfalfa yields from the lysimeter were 40 percent higher than the Twin Falls county average, but noted that the county crop averages included several large areas that were water-short in most years. So, some of that yield reduction was due to the fact that there was a limited water supply, but he also noted that these were areas where alfalfa was not considered a high priority crop. Those comments concern me in applying those crop coefficients in the Arkansas River or in the South Platte River Basin to determine the potential consumptive use of crops like alfalfa, which is the largest crop in the Arkansas Valley and a large crop in the South Platte Basin.

In my opinion, there needs to be additional research of the type that Dr. Wright conducted at the Agricultural Research Station in Kimberly, Idaho, to determine whether the Penman-Monteith equation is, in fact, reasonable for use in Colorado and whether the crop coefficients developed by Dr. Wright need to be adjusted for conditions in Colorado, in particular, for salinity. We have higher salinity levels in the Arkansas River Basin than in the Snake River near Twin Falls, Idaho, which can reduce the amount of crop consumptive use. So, I am here to make a pitch to those of you attending the South Platte River Forum today to support research on the use of the Penman-Monteith equation in Colorado.

The scientific and engineering communities are clearly moving in the direction of using reference crop ET methods to determine crop consumptive use, and continued use of the modified Blaney-Criddle method will be challenged. A U.S. Supreme Court Special Master has accepted Penman-Monteith equation and he has accepted crop coefficients developed by Dr. Wright. The Penman-Monteith equation with the crop coefficients developed by Dr. Wright will calculate higher potential evapotranspiration for some crops, which in many cases will result in higher transferable consumptive use and a reduction in the amount of return flows that applicants are obligated to replace in water rights transfers. For that reason, I believe that additional research is important for water users throughout the state, including the South Platte River Basin, and urge your support for such research.

THE FUTURE OF MUNICIPAL WATER USE

by Peter Binney
City of Aurora Water Utilities

I am going to talk about water supply uncertainty from the municipal perspective. I want to try to put in context a lot of the rhetoric and hyperbole that you hear about when cities are planning their future water development programs. What does the future hold for municipal water suppliers along the Front Range? It all depends – it depends on where you are located in the basin, it depends on what your water supplies include.

We have very diverse municipal water systems in the South Platte basin: at one end of the spectrum, we have mature regional water systems such as the Denver Water system which has been established for over 100 years; and we have the Colorado Big Thompson system. It happens that both of these systems were developed before the environmental awareness of the 1960s and the 1970s and include significant infrastructure and reliable water rights portfolios. At the other end of the spectrum you have metro districts and water and sanitation districts, and this is where a lot of urban development is occurring here in Colorado. These districts are primarily governmental entities that were set up to provide access to local water supplies, many of which are using the water resources in the Denver Basin Aquifer. These entities have a major issue coming up in the near future about how to continue to meet water demand as the productivity of aquifer supplies are reduced because of changing aquifer conditions.

Then you have the less developed integrated regional water systems like Aurora. Aurora has been developing its water system since the early 1950s when Denver Water pulled us off their system. Significant investments in infrastructure and water supply acquisition are needed to meet the demands of these growing communities. These various water systems will have different strategies as they compete for water to meet their customers' needs for the future.

You have heard about the Three States Agreement. Not only do we have increasing population and competition from the water system users. We also have new users coming in to compete for a fixed water supply. That can come from additional demands for environmental benefits but also from an increasing desire for instream recreational diversions. A lot of what we're going to have to deal with is affected by how the State of Colorado administers its water.

Population and water demand projections over the next 50 years illustrate some of the burdens we will have to deal with in the South Platte. We can solve our problems this year and next year; we will come out of this drought. But as you go further out, to 2030, 2040, 2050, you will see that some very significant changes will have to occur in the basin.

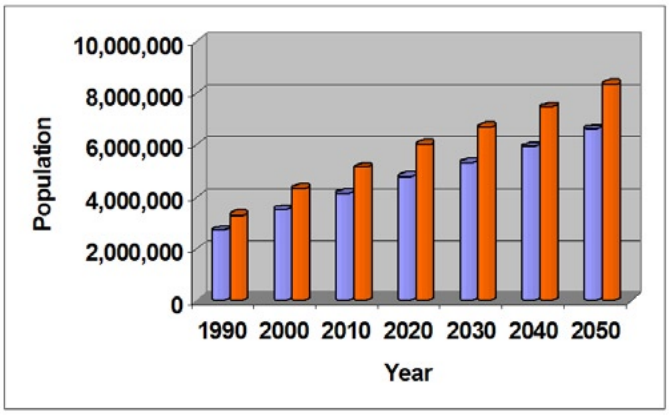


Figure 1. Front Range and Colorado Population Growth.

We have to answer the core question, as we are responding to this drought -- Why do we continue to have population growth? Why do we continue to build if we can't meet the water supply needs of our current customers?

Many of you have seen the snake diagram of annual river flows. We see here in the South Platte, from the water resources management standpoint, probably the last place you would want to put a population center in Colorado, but that is where urban growth is centered. We ended up with all of our people in perhaps one of the driest parts of the state. So, we have a classic supply and demand problem.

Trans-basin diversions -- A lot of what we hear as municipalities is the need for legislated basin-of-origin protection -- this begs the question about the rights of cities to bring water into the Front Range. That fact is certainly provided for in the State's water rights administration codes. Figure 2 is a representation of all the current diversions along the Continental Divide that deliver water into the South Platte River basin These trans-basin diversions, constructed and operated over the last 100 years, have significantly modified the hydrology of the South Platte River basin. I fully expect these diversions will continue to operate and be expanded in the future.

Another thing we hear about is the absolute sanctity of agricultural water uses and how they should be preserved and protected against transfers to municipal uses. Given the provisions of the State's water rights administration codes and the property rights aspects of water rights, it should be expected that transfers of agricultural rights will continue to be a viable alternative for meeting future water needs in the cities. One of the biggest areas of urbanization being supported by conversion of agricultural rights happens to be in the Colorado-Big Thomson system. The Rocky Ford system is a canal system where Aurora has

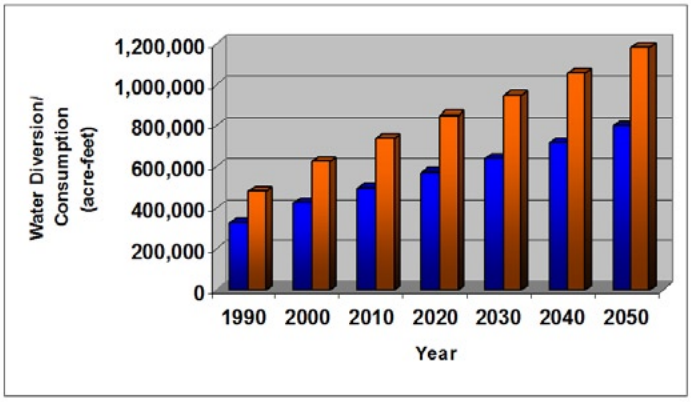


Figure 2. Front Range Municipal Water Consumption and Diversion

certain water rights in the Arkansas basin, and we're moving that transferred agricultural water into the City of Aurora.

What do the projections of population growth mean for the Front Range and for Colorado? The Commissioner of Agriculture, Don Ament, talked about 4 million people being in the State of Colorado. He cited the state's demographics, saying that by the year 2050 we will have 8.3 million people in the state. The Front Range communities now have about 3.5 million people between Pueblo and Fort Collins. By the year 2050, that same area will have 6.5 million people. In terms of water consumption, the municipalities will have to increase their water deliveries from 620,000 acre-ft. to 1.18 million acre-ft. of water by the year 2050.

Now, on the other side of the water balance are return flows. Cities currently consume around 420,000 acre-ft.; the rest of what is diverted is the return flows that the Commissioner of Agriculture identified as the opportunity for how farms can work with cities in an integrated way. And, as water diversions increase, the amount of water that will return to the river basin will increase as well. By the year 2050, cities will consume around 800,000 acre-ft. of water. Between the years 2000 and 2050, these municipalities will have to find a way to bring 400,000 acre-ft. more of consumable water into the Front Range.

Some people say, "Let's stop growing." What is lost on that statement is the fact that about 40 percent of the projected growth come from natural birthrates. It's not just that people are coming from California, from Chicago, or anywhere else. It's because we continue to have births at a higher rate than deaths.

Another factor that is often lost is the importance of the economic engine in the cities and Metropolitan Denver area. This state is becoming urban-centric, and increasingly the State's economy is dependent on the added value generated in the cities. If you look at just the metropolitan area itself, that represents 56 percent of the state's population; 70 percent of the state's wages within the six-county metropolitan area, and 61 percent of the state income tax. If population growth is continuing and if economic growth is desirable, then the State must facilitate the delivery of additional water into the cities.

One of the things that I think our legislators and policy makers will have to address is sustaining the state's economy, because that will affect how we address some of the issues in Colorado. Another thing that previous speakers have recognized is that municipalities don't just stand out there by themselves, just as agriculture and the environmental groups don't stand out there by themselves. We as policy makers must find a way to appreciate that if the population is growing, the municipal water demand is going to grow, and how can that growth be accommodated with existing agricultural and developing environmental values?

The bottom line here is, while I have talked a lot about uncertainty, one thing is certain: change is happening.

As a municipal water provider, we're going to have to find the water to meet the needs of another 3.7 million people. That represents 550,000 acre-ft. of municipal diversions, and we will provide 355,000 acre-ft. of additional return flows back to the rivers. This to me says, opportunity. While the numbers are large, while they are overwhelming, this is the opportunity and the challenge we must meet if we are going to deal with the issue. Where is that water going to come from?

I will share with you here in a few minutes what the City of Aurora does from a conservation standpoint as a short-term response to get us through drought.

Reclamation -- We are expanding our reclamation systems; Denver is doing this as well. Significant demands for outdoor use are now being met through treated sewage. In a 50-year time frame, we will have indirect potable and direct potable systems. We could be drinking our treated sewage and technology can accomplish that goal already.

We will have additional trans-basin importations, whether it is from the Arkansas, the Colorado, the Gunnison, perhaps even the San Luis Valley. We have to find a way to maintain this ability for the water that we have in the South Platte whether it's used for agricultural or municipal use. To me, this is not stated as a threat; it is rather an opportunity – a massive opportunity because of the upstream location of the metropolitan areas that could develop and transfer water to municipalities and then provide return flows to downstream agriculture areas.

South Platte Water – In 2002 the majority of the basin's water was used for irrigation. A lot of what you hear about in this debate is if the cities continue to grow, agriculture will be out of business. Commissioner Don Ament talked about 85 percent of the water in Colorado being used for agricultural purposes. That represents about 15 million

acre-ft. of water that is committed to irrigation. Recall the forecasted 550,000 acre-ft. that I have identified before that would be needed to accommodate future municipal water needs. If all that water came from the state's agriculture sector, then its relative use of water would change from about 85 percent to 81 percent. In other words, we will still primarily be an agricultural water user within the state.

It was interesting when I was listening to the conversation this morning from the Arkansas Valley. We just completed an IGA with the Southeastern District, and one of the provisos is that Aurora would no longer pursue claims for agricultural water use that would be permanently transferred out of the basin for a forty year period.

Figure 3. Homestake Reservoir.

Now, you would expect that everyone would say, "Hooray, that's great. You are out of our hair". But one group concerned about that agreement is the farmers who won't be able to sell their water to Aurora. They are very disappointed that they will not be able to participate in the "water rush" that we have to find water for Aurora. I think that this is part of the policy change that we are going to have to go through as we realize that a lot of past practices will change. That is now the case in terms of the water reality and water planning on the South Platte.

As we look at the current drought conditions, we see that the centroid has just moved over to Utah and up into Alberta. The federal forecasters confirmed again just last week the severity of the ongoing drought conditions. What's happened is the drought moved over about 500 miles to the west. But the State is still in drought conditions. We are going to have to deal with drought and we are going to have to deal with the water demands associated with population growth.

Aurora's water supply system – We have water projects for municipal water along the Front Range. This is the Homestake Reservoir on the upper east fork of the Eagle. It is a facility we co-own with Colorado Springs Utilities. We also have water in Spinney Mountain Reservoir – one of twelve reservoirs where Aurora stores its water. While we designed our municipal water supply systems to take us through three to four years of drought, drought conditions brought our water reserves down to 26 percent of capacity last year. We were almost down to the lifeline for delivering a reliable supply of water just to the City of Aurora.

With water trades and the short-term leases that we acquired, we were able to get our reservoirs up to 62 percent of capacity this year; that will be down to around 40 percent in April of next year. When we talk about stresses on the water supply system, I think this is representative of what you are going to see in the South Platte in the future unless additional water sources are developed.

Aurora purchased the City of Thornton's water rights in the South Platte, water off eleven ranches; we gave them $51 million and also gave them the return flows and other traded water sources, which they will now use for their peoples' water supply. So, I think what we have been doing over the last several years, these trades, we will see more of in the future, and we'll have comprehensive demand management of water.

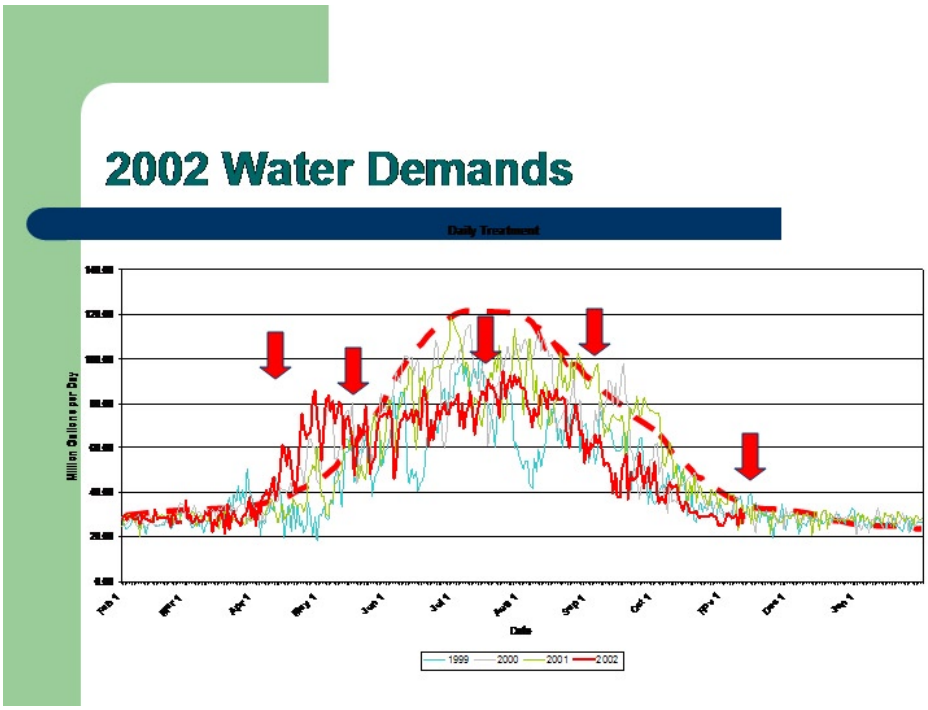
The Denver Basin aquifers -- Everybody thought there were hundreds of millions of acre-ft. of groundwater available to us. I was severely disappointed to spend $5 million of our water revenues for about 85 gallons of water per minute in each of ten wells' production capability. There is no city of 300,000 people with that type of financial resource. We need to go back and redo some of the Denver Basin regulations that are not based on the theory of one- percent withdrawal per year. Rather, those regulations should focus on how to get water out of that aquifer at economic and sustainable rates.

Trans-basin Diversions -- Fifty percent of our water comes from trans-basin diversions. I get very upset when I see legislators considering bills relative to trans-basin diversions, because that means I'm going to look at water from agricultural lands along the Front Range. Our future municipal water will either come from other river basins or from water uses in the South Platte River basin. If we make trans-basin diversions so onerous, the only avenue left is transfer of agricultural water in our backyards, and that will come from either permanent transfers or from leases.

Eighty percent of our water comes from snowmelt in a six-week period from May through July 31. You will therefore see Aurora looking to develop additional storage. That is what we need, more reservoirs. It's not just to keep water from California. It is the only way we are going to capture peak flows or wet-year flows for use in urban areas and provide drought protection without massively oversizing direct flow or pump-back systems.

Water Conservation -- Part of how municipalities can meet their needs will be water conservation – we will change the ethic of water use in municipalities to be more representative of a semiarid area. When people talk about water conservation, what does that mean?

Below you see the actual water demands on our water supply system in 2002. You see a very traditional bell-shaped curve. You can see the demand coming on to our system about April 1. We found that people use the greenness of their grass as a barometer, and that was the primary determinant on how much additional water demand we had coming onto our system. We implemented a tiered price-rate structure, so as of July 6 we anticipated that 20 percent of our water would be sold at double the rate, and 20 percent at triple the rate. We had people in the City of Aurora paying over $3000 per acre-ft. per year for the right to water their lawns. Actually, less water was sold at the higher block rates as overall water demand was sold. The difference between the two lines represents water conservation. The effect of rate structures and outdoor water conservation resulted in about a 35 percent decrease in water delivered to our customers from the levels delivered in 2000 and 2001. It is very stressful on a community, but it can be done for short periods of time. Water conservation certainly does work along the Front Range.



How will additional water supplies be developed? -- The basic premise here is that our population will grow; therefore, our need for additional urban water sources will also continue to grow.

We will see hydrologic additions coming from out of the basin by way of additional trans-basin diversions. Some, and I emphasize some, existing agricultural rights will be transferred either permanently or as interruptible supplies to city water systems, and I think one of the things that you will hear from Aurora is strong advocacy for city-farm relationships that will allow more prudent use of water by both groups.

You'll see increased programs for using reclamation of sewage and expansion of nonpotable water systems. Eventually, you will see the first planned, indirect potable water systems. The technology is there now, but we have not engaged in the policy debate over the use of treated effluent for drinking water purposes. But I would expect it to move into consideration as we consider the alternatives of additional trans-basin diversions and transfers of water from agricultural uses.

For those of you on municipal water supply systems, you are going to pay more for it. This year, our customers will pay $3,300 per acre-ft. per year for the right to water their lawns. This glaring difference between values of water used for different purposes will drive some of the hard decisions that will have to be made as municipalities develop their future water sources.

I thought I would try and find some interesting metaphors to wrap up this presentation, because there has to be some way to simplify this highly complex public-policy question we are wrestling with.

I would characterize our current approaches as a bunch of starlings flying around without any rhyme or reason. There is a randomness and chaos to the pattern. In contrast, I would paint the picture of a flock of geese flying in formation. No one has been able to explain to me how these birds are able to cooperate in such harmony, and when the signal is given to change their pattern or direction, the entire flock works in sync. Nature has a way of maintaining a harmony and order, and if we could ever find a way for our water policy to work with that kind of synchronicity, we would take a lot of the uncertainty out of water planning in the South Platte River basin.

CWRRI University Water News

University of Colorado

CENTER OF THE AMERICAN WEST PRESENTS:
Inside Interior -- Conversations with Secretaries of the Interior
On Their Roles in Shaping the West
The 2003-04 Wren and Tim Wirth Forum

The Center of the American West announces a series of exciting events that illuminate the role of Secretary of the Interior in managing public lands. The series will take place over the course of the 2003-2004 academic year, and will feature former Secretaries of the Interior, as well as current Secretary Gale Norton. The Secretaries of Interior events are free and open to the public, and reservations are not required. Seating is limited, and will be filled on a first-come, first-served basis. See the Center of the American West Website at: http://www.centerwest.org.

SPRING SERIES

Feb 11, 2004 7:00 p.m., Glenn Miller Ballroom
James G. Watt – Watt served as Secretary for three years (1981-1983) under President Reagan, during which time the Sagebrush Rebellion was in full swing. Watt implemented a Good Neighbor Policy to quell the rebellion. He also oversaw a complete rewriting of water reclamation law.

Mar. 17, 2004 7:00 p.m., Location TBA
Manuel Lujan, Jr. – Lujan served as Secretary for four years (1989-1993) under President George W. Bush. He helped implement the President's "no net loss" of wetlands.

Apr. 20, 2004 7:00 p.m., Glenn Miller Ballroom
Bruce Babbitt – Babbitt served as Secretary for eight years (1993-2000) under President Clinton. Among his accomplishments were promulgation of new grazing policies and regulations for public lands, a new consultative use of the Antiquities Act, resulting in Presidential monument decress of some 4 million acres, reorganization of the U.S. Geological Survey, and development of multi-species Habitat Conservation Planning.

Calendar 2004
June 16 -18 (Tentative dates)

NATURAL RESOURCES LAW CENTER 25th Summer Conference
Western Groundwater Resources, Law and Policy
Boulder Colorado

Contact NRLC at phone 303/492-1286, fax 303-492-1297, E-mail NRLC@colorado.edu; Website (coming soon) http://www.colorado.edu/Law/centers/nrlc/events.htm

CU-DENVER water news

University of Colorado at Denver
Continuing Engineering Education Program, Spring 2004

Refresher courses for the EIT and Civil, Electrical, and Mechanical Professional Engineers Exams and additional engineering short courses are being scheduled for Spring 2004. If you would like a course catalog mailed to you and/or our monthly E-News e-mailed to you, contact us at 303-556-4907 or csanders@carbon.cudenver.edu with your Name, Company, Title, Mailing Address (home or work), Phone (home and work), and E-mail. We will place you in our database and notify you of professional development courses that will be offered in Spring 2004. We also have an online reply form at: www.cudenver.edu/engineer/cont

THE TREEFLOW PROJECT: APPLICATION OF TREE-RING DATA TO SUSTAINABLE WATER MANAGEMENT IN COLORADO

by Jeff Lukas [1], Connie Woodhouse [1,2], and Robert S. Webb [3]
[1]INSTAAR, University of Colorado, [2]NOAA/NCDC Paleoclimatology Branch,
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Introduction

Sustainable water management requires knowledge of the natural variability in streamflow over time. What is the lowest annual streamflow one might expect over a given period of time? What is the highest? What is the long-term average? How many below-average years in a row might be expected? What is the probable return period of a low-flow event of a given length and intensity?

The main, if not sole, basis for this knowledge has been gaged records of streamflow, which are usually 20 to 50 years long and at best 100 years long—too short to capture the full range of the variability in water supply. Reconstructions of streamflow derived from the ring-widths of moisture-sensitive trees, however, can span 300 years or more and thus more fully describe the natural variability in streamflow, including the extreme low-flow events of most concern to water managers. With the TreeFlow project, we are working in partnership with water managers to develop new tree-ring reconstructions of streamflow in Colorado and enhance their utility to water management. Part of the project is to make these data as accessible as possible through a project website (see sidebar below). In this article, we provide background on the project, outline the process of developing the reconstructions, and describe how several water providers are using the data in their planning and operations.

Background

The first studies to examine the relationship between tree growth and streamflow in the western U.S. were carried out in the 1930s and 1940s (e.g., Schulman 1945), including work by Denver Water Board engineer H.L. Potts, who correlated the growth of trees in South Park with South Platte annual flow. Over the next 50 years, streamflow was reconstructed for a numbere of watersheds across the U.S. The most notable of these was the reconstruction of annual streamflow for the Colorado River at Lees Ferry (Stockton and Jacoby 1976). In Colorado, however, extended records of streamflow from tree rings had not been applied to water resource management, largely because a sparse network of suitable tree-ring collections hampered the reconstruction of key gages.

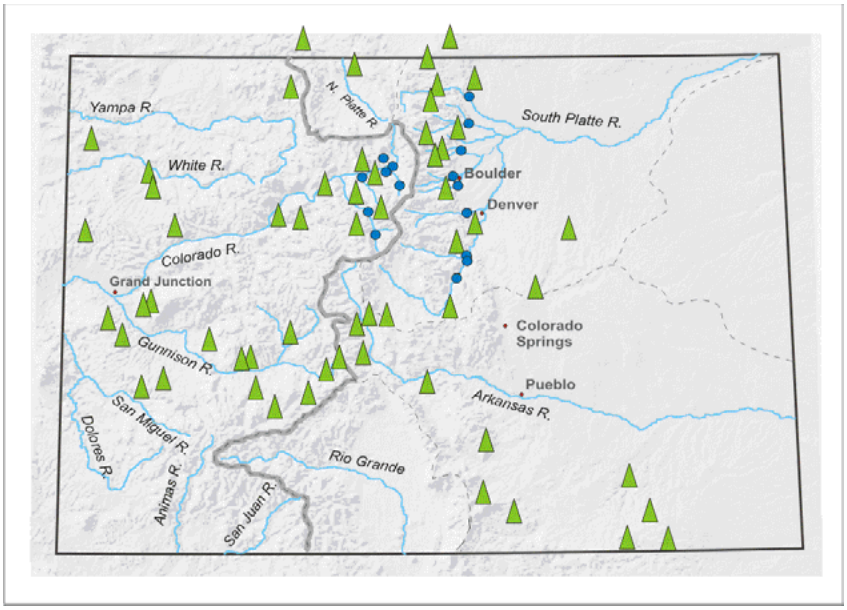


Figure 1. Locations of new moisture-sensitive tree-ring chronologies (triangles) and new streamflow reconstructions (circles) in Colorado.

To address this problem, since summer 2000, we have systematically collected tree-ring samples in western Colorado and the Front Range, from which we have developed about 50 site chronologies (Figure 1). These chronologies complement another 20 collected in eastern Colorado and adjacent states in 1998 for a National Science Foundation-funded project reconstructing the climate of the western Great Plains.

In spring 2002, we received funding from the NOAA Office of Global Programs to use our new chronologies to develop reconstructions of streamflow and work with water resource managers to make these reconstructions more applicable to their needs. The extreme drought event in 2002 spurred interest in our work, and by spring 2003 a number of entities had

become partners in the project, including the Northern Colorado Water Conservancy District (NCWCD), Denver Water, and the U.S. Bureau of Reclamation, Aspinall Unit (Gunnison Basin).

The physical basis for the reconstructions

Tree growth is primarily controlled by climate conditions during the year prior to and including the growing season. At lower elevations in Colorado, variations in tree growth closely reflect the amount of soil moisture at the onset of the growing season, which is controlled by variations in precipitation, and, to a lesser degree, temperature, humidity, and evaporation. Since annual streamflow integrates both precipitation and temperature over the course of the previous seasons (similar to tree rings), it is closely correlated with annual tree growth. Trees that provide the best information about streamflow variability—those particularly sensitive to variations in moisture—include species such as ponderosa pine, pinyon pine, and Douglas-fir, growing in open stands on dry and rocky sites where soil moisture storage is minimal (Figure 2). Trees growing in these sites are also less likely to be subject to non-climatic disturbances, such as fires and insect infestation, and the effects of competition from nearby trees. In addition, the oldest individuals (up to 900 years old) of these species tend to be found on these sites.

Developing the reconstructions

Tree-ring reconstructions of streamflow are developed from multiple tree-ring chronologies. A tree-ring chronology is a time-series of annual values derived from the ring-width measurements of 10 or more trees of the same species at a single site. To create a tree-ring chronology, cores from the sampled trees at each site are crossdated (patterns of narrow and wide rings are matched from tree to tree) to account for missing or false rings, so that every annual ring is absolutely dated to the correct year. Then all rings are measured to the nearest 0.001mm using a computer-assisted measuring device. After age-related trends in growth are statistically removed, the ring-width values from all sampled trees for each year are averaged to create a time series of annual ring-width indices. The complete series of ring-width indices from a site is called a tree-ring chronology.

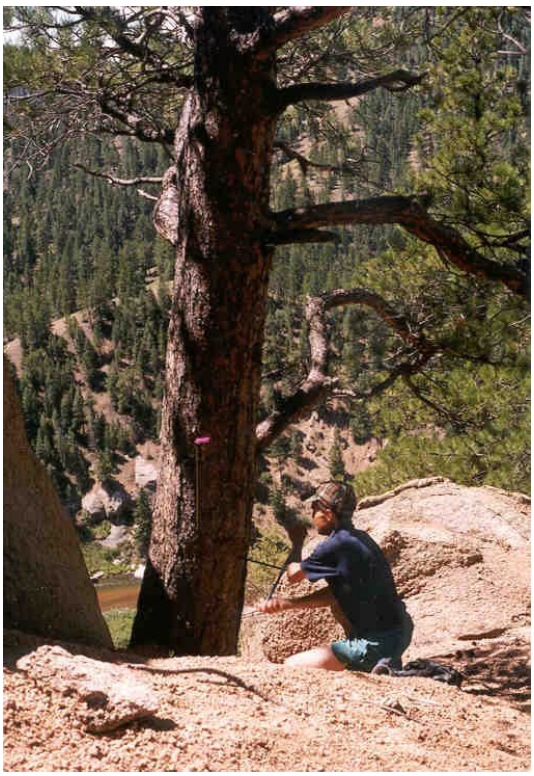


Figure 2. Sampling a 400-year-old ponderosa pine near Deckers, Colorado

Once a gaged natural flow record of interest is selected for reconstruction, a set of chronologies from the region near the gage is calibrated with the gage record to form a reconstruction model. A statistical technique called multiple linear regression is commonly used. The reconstruction is evaluated by comparing the observed gage values with the reconstructed values and assessing the amount of variance in the gage record that is explained by the reconstruction. The reconstruction model is then validated by testing it on a portion of the gage data that was withheld from the calibration process.

What the reconstructions show

So far, we have developed reconstructions, extending back to the 1400s to 1600s, of the 15 stream gages that comprise the water supply systems for Denver Water, NCWCD, and the city of Boulder (Figure 1). Our tree-ring reconstructions match the variability in the gaged records of streamflow very well (Figure 3). Statistically speaking, 60% to 75% of the variance in the gaged records is explained by the

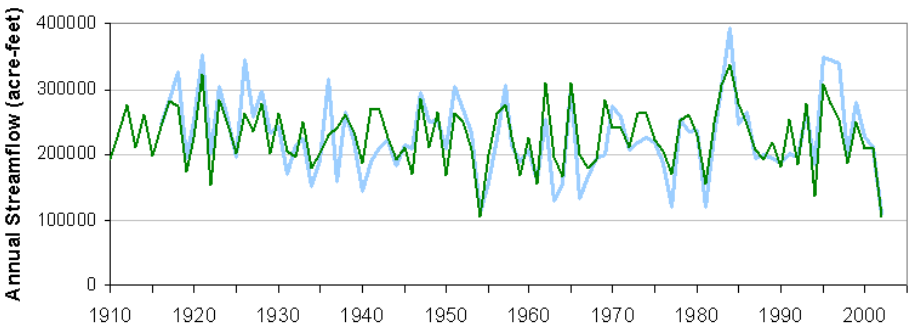


Figure 3. Blue River at Dillon Reservoir undepleted gaged annual flow, 1916-2002 (light) and tree-ring reconstructed flow (dark). Note the close fit of the two time series ($R^2 = 0.63$), especially for the most extreme low-flow events (1954, 2002).

reconstructions. The trees capture both year-to-year variations and multi-year anomalies. All of the reconstructions show a broader range of variability in streamflow than that seen in the much shorter gaged flow records, including one-year droughts similar to or worse than 2002 and multi-year events worse than those of the 1930s or 1950s (Figure 4).

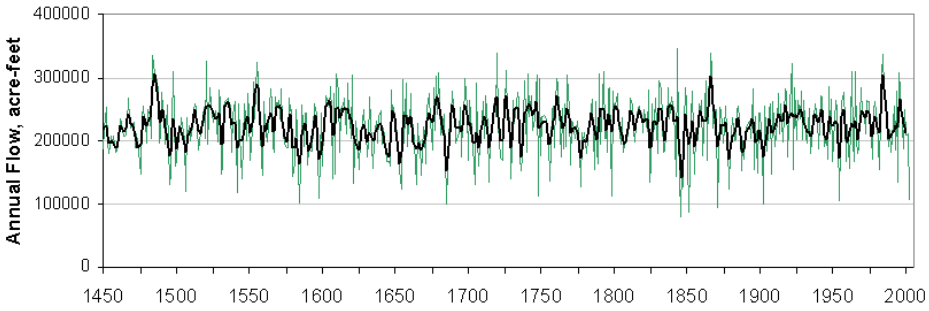


Figure 4. Blue River at Dillon Reservoir tree-ring reconstructed annual streamflow, 1450-2002 (thin line) with a 5-year filter (thick line) showing multi-year events. Several years (e.g., 1685, 1845) have reconstructed flows lower than the reconstructed and gaged flow for 2002 (~105,000 acre feet).

Application of the reconstructions

The reconstructed streamflows are used by our partners as inputs for their water supply models to test the ability of their systems to meet demand under the broader range of flow conditions represented by the reconstructions. Even with the inherent uncertainties in any paleoclimate reconstruction, and the understanding that past conditions are not direct analogs of future conditions, the tree-ring derived streamflow reconstructions are considered valuable information and have been incorporated into the decision-making process for water management in the region.

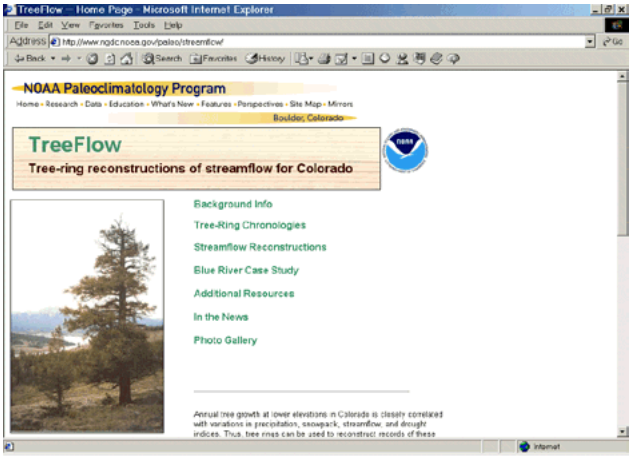
Future work

Over the next year, we plan to expand the spatial coverage of our reconstructions to include other major river basins in Colorado. We will also expand the range of data products available. We have had promising results in using latewood—the part of the annual ring more responsive to summer conditions—in reconstructing summer drought and thus overall water demand. We are also applying an approach from short-term climate forecasting—the ensemble method—to better understand the uncertainty in our tree-ring reconstructions. With the ensemble method, many model solutions, each based on a different calibration period and using a different set of predictors, are generated. The spread of the solutions for each annual value varies and thus provides insight into the temporal variability of uncertainty in the tree-ring data.

The TreeFlow web pages

http://www.ncdc.noaa.gov/paleo/streamflow
- introduce and describe the project,
- explain the reconstruction process in detail, and
- provide access to the reconstructed and gaged flow data.

We intend the site to be a general resource for the water resources community, and the data are freely available. The website provides our contact information if you have questions about the project.



References

Schulman, E. 1945. Tree-ring hydrology of the Colorado Basin. University of Arizona Bulletin 16(4). Laboratory of Tree-Ring Research Bul letin No. 2. 51 pp.

Stockton, C., and G. Jacoby. 1976. Long-term surface water supply and streamflow levels in the Upper Colorado River Basin. Lake Powell Research Project Bulletin No. 18, University of California, 70 pp.

Acknowledgments

Funding was provided by National Science Foundation grants ATM-9729571 and ATM-0080889; NOAA Office of Global Programs grant GC02-046; Regional Integrated Sciences and Assessments Program - Western Water Assessment; and Denver Water. Undepleted gaged streamflow data for the Blue River provided by Denver Water.

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 supplements to existing awards. The new projects are highlighted in bold type.

COLORADO STATE UNIVERSITY, FORT COLLINS, COLORADO
Awards for July 26, 2003 to Sept. 25, 2003

PI	Dept.	Sponsor	Title
Vivanco, Jorge M.	HLA	CDOA	Towards an Eco-friendly Herbicide
White, Gary C.	FWB	CDOW	Modeling, Design, & Analysis
Johnson, James B.	Biology	DNR	Reference Conditions in Rocky Mountain Wetlands
Khosla, Rajiv	SCS	ADEC	Interactive & Educational Online Modules on Precision Agriculture
Khosla, Rajiv	SCS	Wash. State Univ.	Risk Management Education for Farmers Practicing New Production Technologies in Colorado
Theobald, David M.	NREL	USDA-CSREES	Maximizing Protection of Ecological, Agricultural & Community Values……
Child, R. Dennis	FRWS	DOI-USGS	Sustainable Rangelands Roundtable
Omi, Philip N.	FRWS	DOI-BLM	Optimizing Landscape Treatments for Reducing Wildlife Risk & Improving Ecological Sustainability of Ponderosa …
Warren, Steven D.	CEMML	DOI-BLM	Effects of Fire on Biological Soil Crusts & Their Subsequent Recovery
Snyder, Darrel E.	FWB	DOI-NPS	Larval Fish Cataloging Project for Canyonlands National Parks, Dinosaur National Monument
Pielke, Roger A.	Atmos. Sci.	NASA	Sensitivity of the Arctic Climate System to Changes in Shrub Stature & Distribution
Ojima, Dennis	NREL	NASA	Land-Use & Change in Temperature in East Asia: Land Cover Change Impacts on Carbon Fluxes & Land Productivity
Denning, A. Scott	Atmos. Sci.	NASA	Global & Regional Carbon Flux Estimation Using Atmospheric CO2 Measurements from Spaceborne & Airborne Platforms

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.

OTHER SPONSORS: ADEC-American Distance Education Consortium.

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, EEB-Ecology & Environmental Biology, 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.

PI	Dept.	Sponsor	Title
Johnson, Richard H.	Atmos. Sci.	NASA	Studies of Rainfall & Convection for Tropical Rainfall Measuring Mission and Global Precipitation Measurement
Kummerow, Christian	Atmos. Sci.	NASA	A Next Generation Microwave Rainfall Retrieval Algorithm for Use by Tropical Rainfall Measuring Mission & Global …
Venkatachalam, C.	ECE	NASA	Tropical Rainfall Measuring Mission Observations & Precipitation Microphysics: Interpretation, Precipitation …
Garcia, Luis	Civil Engr.	USDA-ARS	Apply & Enhance the Object Modeling System for Building New Models for Field, Farm, & Watershed Scales
Westfall, Dwayne G.	SCS	USDA-ARS	Precision Farming to Protect Water Quality & Conserve Resources
Sale, Thomas C.	Civil Engr.	DOD	Electrically Induced Redox Barriers for the In- Situ Treatment of Contaminated Groundwater
Gates, Timothy K.	Civil Engr.	DOI-USBR	Identification, Public Awareness, & Solution of Water-logging & Salinity in the Arkansas River Valley
Wilkins-Wells, John	Sociology	DOI-USBR	Management Practice Study II - County Land Use Impacts on Irrigation Districts
Venkatachalam, C.	ECE	NSF	Polarimetric Radar Observations of Precipitation: Measurements, Analysis, Modeling & Retrievals
Cotton, William R.	Atmos. Sci.	NSF	Numerical Simulation & Analysis of Severe Storms & Mesoscale Convective Systems
Cotton, William R.	Atmos. Sci.	NSF	Urban Influences on Clouds, Precipitation & Lightning
Rutledge, Steven A.	Atmos. Sci.	UMASS	Development of an Advanced Multi-Frequency Radar for Atmospheric Research
Bestgen, Kevin R.	FWB	DOI-USBR	Larval Fish Laboratory Involvement in Recovery Actions for the Endangered Fish in the Upper Colorado River Basin
Julien, Pierre Y.	Civil Engr.	DOI-USBR	Rio Grande River Sediment Modelling
Ward, Robert C.	CWRRI	Various Non-Profit	Developing a Decision Support System for the South Platte Basin
Ippolito, James	SCS	AWWARF	The Effect of Long-Term Water Treatment Residuals-Biosolids Co-applications on Native Rangeland Soil...
Fontane, Darrell G.	Civil Engr.	Korean Water Res. Corp.	Development of Real-Time Water Resources Management System
Shackelford, Charles	Civil Engr.	EPA	Microbial Reduction of Uranium in Mine Leachate by Fermentative & Iron-reducing Bacteria
Shackelford, Charles	Civil Engr.	EPA	Evaluation of Hydrologic Models for Alternative Covers
Carlson, Kenneth	Civil Engr.	EPA	Assessment of Electrokinetic Injection of Amendments for Remediation of Acid Mine Drainage
Thornton, Christopher	Civil Engr.	DOT	Development of Guidelines & Specifications for Using Culvert Pipe Liners

UNIVERSITY OF COLORADO, BOULDER, COLORADO
Awards for June, 2003

PI	Dept.	Sponsor	Title
Nerem, Robert S.	ACAR	Jet Propulsion Lab	Using Global Terrestrial GPS Measurements to Unravel the Emerging Altimetric Record of Global Sea-Level Change
Emery, William	ACAR	Jet Propulsion Lab	A Prototype System for Improving Satellite-Derived Sea Surface Temperature Through Enhanced In-Situ Validation Measurements
Veblen, Thomas	Geography	NSF	Climate Variation and Disturbance Interactions in Subalpine Rocky Mountain Forests

PI	Dept.	Sponsor	Title
Serreze, Mark	CIRES	NSF	A Land Surface Model Hind-Cast for the Terrestrial Arctic Drainage System
Crimaldi, John	CEAE	NSF	Chemical Orientation in Turbulent Environments Above Natural Stream Substrates: The Role of Bed Roughness and Turbulence Structure on Search Mechanisms
Jimenez, Joe	CIRES	NSF	Physical and Chemical Impacts on the Ice Nucleating Properties of Atmospheric Particles in Springtime
Cassano, John	CIRES	NSF	Detection and Attribution of Changes in the Hydrologic Regimes of MacKenzie, the Kuparuk and Lena River Basins
Serreze, Mark	CIRES	NSF	An Integrated Assessment of the Arctic Freshwater System - Analysis of Retrospective and Contemporary Conditions
Steffen, Konrad	CIRES	NASA	Variability and Forcing of Climatic Parameters on the Greenland Ice Sheet: Greenland Climate Network
Steffen, Konrad	CIRES	NASA	Assessment of Basal Melt of Petermann Gletscher in NW Greenland
Helmig, Detlev	IAAR	NASA	Ozone Fluxes into Snowpacks and Their Role in the Tropospheric Ozsone Budget
Stallard, Robert	IAAR	NPS	Central Alaska Network Parks Hydrologic Assessment
Norris, David	Integrative Physiology	EPA	Field Studies of the Extent and Magnitude of Gender Disrup-tion in Native Fishes in the South Platte and Arkansas River…
Martin, Andrew	EEB	NPS	Describe Existing Populations and Determine Appropriate Source Populations for Restoration of Native Trout Subspecies..
Barrett, Andrew	CIRES	NOAA	One-Way and Two-Way Coupling of Atmospheric and Hydrologic Models
Small, Eric	Geol. Sci.	Univ. of AZ	Sustainability of Semiarid Hydrology and Riparian Areas
Anderson, Suzanne	IAAR`	NSF	Linkages Between Soil Water and Stream Water: Hydrology and Dydrochemistry in a Dissected Terraced Landscape
Pincus, Robert	CIRES	NSF	Climate Process Team on Low-Latitude Cloud Feedbacks on Climate Sensitivity
Dyurgerov, Mark	IAAR	NASA	Updating the Results of Glacier Contribution to the Sea Level Change
Pfeffer, Tad	IAAR	NASA	Snow Slope Stability: Modeling and Investigations
Gupta, V.K.	CIRES	NASA	Scaling and Allometry in River Networks Coupling Rainfall, Topo-graphy, and Vegetation with Hydrological Extremes
Balaji, R.	CADSWES	NOAA	Understanding the Spatio-Temporal Variability of the North American Monsoon: Implications for Water Resources Management in the Southwestern U.S.
Clark, M.P.	CIRES	NOAA	Development of Operational Hydrologic Forecasting Capabilities
Avery, Susan	CIRES	NOAA	Western Water Assessment
Woodhouse, Connie	IAAR	NOAA	Extended Hydroclimatic Records for the Upper Colorado Basin
Zagona, Edith	CADSWES	DOA	Analysis and Implementation for Support for Various Water and Environmental Systems
Gin, Douglas	Chem. & Biochem.	DON	Preparation and Charactereization of Nanoporous, Composite Liquid Crystal Membranes for Reverse Osmosis and Desalination
Zagona, Edith	CADSWES	USBR	Watershed and River System Management Program
Peckham, Scott	IAAR	USGS	Modeling Sediment Transport to Molokai's Coral Reef
Summers, R. Scott	CEAE	EPA	Center for Drinking Water Optimization

WATER SUPPLY

All basins reported lower than normal precipitation during October, dropping the SWSI value compared to last month. The dry conditions are maintaining lower than normal stream flows in most all drainages, with a few record low flows reported in the Yampa/White basin. However, conditions are generally not as bad as they were in 2002.

The end of October typically represents the end of the irrigation season with diversions direct to irrigation ceasing. Many irrigation reservoirs, especially off-channel reservoirs in the South Platte basin, begin to store water as the senior direct-flow irrigation rightss stop calling. Diversions to recharge ground water also begin in the South Platte basin. The Rio Grande basin experienced a bit longer demand for direct-flow irrigation water due to the dry conditions. All water users are hoping for a good snowpack accumulation over the winter, which will be the key to adequate water supplies in 2004.

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 streamflow, reservoir storage, and precipitation for the summer period (May through October). During the summer period, streamflow 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 September 1, 2003, and reflect the conditions during the month of October.

Basin	11/1/03 SWSI Value	Change From Previous Month	Change From Previous Year
South Platte	-0.3	-1.3	+1.9
Arkansas	-1.8	-1.0	+0.7
Rio Grande	-2.0	-2.8	+0.9
Gunnison	-3.4	-1.0	-0.6
Colorado	+0.1	-0.9	+3.6
Yampa/White	-3.2	-1.9	0.0
San Juan/Dolores	-1.7	-4.0	-0.5

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

Severe Drought — Moderate Drought — Near Normal Supply — Above Normal Supply — Abundant Supply

WATER NEWS DIGEST

by Marian Flanagan

CLOUD SEEDING

CSU researches cloud-seeding

Colorado State University researchers will try to determine once and for all this winter if Denver Water's cloud-seeding efforts effectively enhance snowfall, boosting snowpack and reservoir levels. They will compare predicted and actual snowfall accumulations in areas targeted by seeding and in control areas where there is no seeding. The researchers will use computer-generated weather models to predict anticipated snowfall from a given storm, and then will factor in cloud-seeding data and snowfall tallies to try to detect whether the seeding is working. "This is the first time this type of study will be done on a real-time basis," said Western Weather Consultants manager Larry Hjermstad. Two studies completed last summer showed conflicting results. A statistical analysis of snowfall data indicated the seeding was effective, boosting accumulations by about 14 percent. But a second study did not find significant traces of silver iodide in the intended target areas, indicating "a failure to routinely seed the intended cloud regions."

Denver Post / October 20, 2003

DAM SAFETY

Recreationists return to Horsetooth

After nearly 4 years, $77 million and almost 26,000 truckloads of sand and gravel, the U.S. Bureau of Reclamation project to renovate Horsetooth Reservoir's four earthen dams is basically complete. That means the water level will be allowed to return to its capacity for the first time since 1999. To reduce seepage from the dam, USGR originally intended to install a concrete cutoff wall through Horsetooth Dam's middle but later scrapped that plan in favor of a 2- to 3-foot clay and synthetic "blanket" covering the base of the dam. It's designed to prevent seepage through the foundation of the dam and also comes at a savings of $19 million. The entire project comes in $28 million under its $105 million budget. Monitoring and surveillance of the dams will continue. Gauges known as piezometers have been installed in each of the dams – including more than 20 in Horsetooth Dam along – to track water pressure.

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Fort Collins Coloradoan, October 22, 2003

Senator seeks dam safety funds

A measure has been introduced in the U.S. Senate that would authorize nearly a five-fold funding increase – exceeding $500 million a year – to improve the safety of aging dams in Colorado and across the West. The measure by Sen. Pete Domenici, R-N.M., would amend the 1978 Safety-of-Dams Act by increasing authorized appropriation levels to $540 million annually for USBR dam safety projects. The Act funded the nearly complete $77 million renovation of four dams at Horsetooth Reservoir west of Fort Collins.

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Fort Collins Coloradoan, October 22, 2003

DROUGHT

Three-quarters of American West still considered in drought

Water experts attending a national conference in Denver say more than 75 percent of the American West still is deep in a drought, and no one knows how long it will last. The conference, Water 2025, was part of a federal initiative launched by Interior Secretary Gale Norton in June. So far, more than 3,000 people have gathered at nine conferences to identify ways to better manage and share the West's water supplies. One of the concerns discussed was a forecast from the U.S. Geological Survey that temperatures could rise an average of 5.4 degrees by as early as 2025. That would change the spring runoff from the mountains, affecting supplies, evaporation, stream flow and temperatures and fish health.

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Associated Press / Durango Herald / November 5, 2003

Global warming could overburden city system

A recent city-sponsored study by Hydrosphere Resource Consultants concluded that a little conservation would give Boulder enough water to meet the demand of future growth in non-drought years. But if global warming dries the area, the city's current system won't be able to quench the population's thirst. The study completed for the city's water utility and Planning Department in September looked at Boulder's water rights, typical stream flows, 300 years of tree ring data and various levels of future population and job growth in the city. It calculated whether Boulder would have enough water to meet city service standards under historic weather averages and if global warming cut stream flows by at least 15 percent. If Boulder grew to a population of 126,300 residents and was home to 216,700 jobs — the "build out" levels under current zoning — some conservation measures would give the city a reliable enough water supply to meet its minimum service standards. In a climate made hotter, drier and with more dramatic weather swings due to global warming, the city would need to increase its reservoir storage space or cut the typical household's use, the study found. "The chance that climate change could overburden Boulder's current water supply is enough to warrant beginning to plan for it," said Steve Pomerance, a former City Council member long concerned about water resources and future growth in the city.

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Boulder Daily Camera / November 3, 2003

SALINITY

River salinity study / Too much salt for maximum yields

Tim Gates of Colorado State University has been studying salinity in the soil and water of the Arkansas Valley for five years, with sometimes surprising results. Gates began his study in the area between Manzanola and John Martin Reservoir for the first three years, and last year expanded it to include the area downstream from John Martin to the Kansas border. The problems being studied are high water tables which create waterlogged and saline soils and reduce the yield of farm crops; and dissolution of salts within the aquifer, which carries salts and other pollutants back into the river. Salinity increases from west to east along the Arkansas Valley, but the bulk of the salts are inherent in the soil rather than being transported from upstream reaches of the valley, Gates told the Southeastern Colorado Water Conservancy District board. In the blistering drought of 2002, both the depth of the water table and the salinity level in ground water diminished. "It's interesting that as the water table falls the salinity also falls," Gates said. "The (geologic) formations where the salts are being dissolved are in the upper levels of the water table." But even the drought-reduced levels of salinity, and even in the least saline areas, the soil salts are too high for maximum crop yields, he said. He estimates crop yield reduction at 13 percent, or $68 lost per acre, between 1999 and 2001 in the upstream study area. The yield reduction ranges to 20 percent loss in higher-salinity areas. Some possible solutions, he said, may lie in more efficient irrigation systems such as drip irrigation; lining canals to reduce seepage; and installing subsurface drainage systems. "We need to study further what will be the effect if more farmers go to drip systems, trading their canal water for well Pumping," Gates said.

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Pueblo Chieftain / October 19, 2003

TAMARISK

Beetles to feast on tamarisk

The U.S. Department of Agriculture plans to release Asian beetles in 13 Western states next spring to combat the tamarisk shrub that is clogging riverbanks and sucking up water faster than any weed in the West. The Diorhabda elongata, otherwise known as the saltcedar leaf beetle, is a pencil-eraser-size yellow bug that gobbles its way through the thick vegetation of tough-to-kill tamarisk but does not eat other plants. The beetle is native to China and Kazakhstan, areas where tamarisk is native and the beetles keep it in check. Tamarisk now covers nearly 2 million acres and guzzles enough water to supply 20 million people. The plan sidesteps one of the biggest controversies over using beetles for tamarisk control. The bugs will be released only above the 38th parallel, which corresponds to the southern border of Colorado. That means the endangered Southwest willow flycatcher - the only species that is known to use tamarisk for a habitat - is not expected to be affected. The birds have not been found this far north. And the species of beetle being released does not survive and multiply below that latitude. The beetle has been studied in its native habitat in Asia since the 1950s. In the United States, it has been studied in cages built around tamarisk stands since 1998 at a handful of research sites around the West, including one Colorado site near Pueblo. U.S. Bureau of Reclamation slides from those sites show tamarisks stripped of most of their leaves, while nearby cottonwoods and Russian olive trees were green and untouched.

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The Denver Post / October 23, 2003

WATER QUALITY

Contamination threat / Missile sites may be leaking chemicals

Thirteen Atlas Series D and E missile sites in Northern Colorado, Wyoming and Nebraska are being investigated and could be slated for cleanup. Petroleum chemicals and cleaning solvents associated with missile drills conducted by troops are believed to have contaminated soil and groundwater at many of the sites. Five Colorado sites have been identified as contaminated or possibly contaminated. They are in Bellvue in Larimer County; Windsor, Nunn and Hereford in Weld County; and Briggsdale in the Pawnee National Grasslands. All are Atlas Series E sites, where chemicals were used to clean surfaces and flush fuel tanks and then dumped on the ground, Skog said. Investigators, who have spent more than $6 million on analysis, in 1995 at a former Atlas site near Kimball, Neb., discovered trichloro-ethylene, or TCE, a powerful cleaning solvent used by troops, Skog said. "We have a one-mile-long plume there," he added. A plume indicates that chemicals are traveling underground in groundwater, posing a potential public health hazard. Former Site 13 in Bellvue, north of Fort Collins off U.S. Highway 287 about a mile north of Ted's Place, is in the opening stages of investigation. There are about 25 homes within a mile of the site, which is undergoing well water testing for contamination. According to the Environmental Protection Agency, so far none of the sites are known to have contaminated drinking water.

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Coloradoan / October 19, 2003

Boulder Creek study finds traces of caffeine, ibuprofen, hormones in water

When Boulder Creek flows from its headwaters high in the mountains, it's nearly pristine. But by the time it reaches east Boulder County, the creek has picked up some strange microscopic passengers — ranging from caffeine to trace amounts of prescription drugs. Scientists studied water-quality levels all along the Boulder Creek to try to figure out where contaminants are introduced. They also hope their research can be used to develop better water-safety standards. Scientists are still trying to figure out what impact those chemicals could have on water quality, said Sheila Murphy, a U.S. Geological Survey scientist who worked on a three-year study. Chris Rudkin, water-quality coordinator for the city of Boulder, said the first-of-its-kind study would give politicians and scientists the information they need to keep water safe. Using new technology unavailable until only recently, scientists were able to detect sometimes bizarre H2O additives at very low levels — a few parts per billion or trillion, something they haven't been able to do before, Murphy said. "A lot of these technologies are new within the last 10 years," she said. And the chemicals they're finding aren't things you'd expect to find in drinking water: EDTA, a "metal complexing agent" found in mayonnaise, shampoo and vitamin supplements; Tylenol; nicotine; hormones; and prescription drugs. But the chemical scientists really didn't expect to find was gadolinium, a very rare substance injected into patients receiving magnetic resonance imaging scans. While the creek's water quality levels meet current water quality standards, Murphy said those standards were written before scientists could detect chemicals like gadolinium. Murphy and other USGS scientists hope their research gives politicians better information to use when they draw up water quality standards.

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Boulder Daily Camera / October 29, 2003

EPA to ease sewage treatment rules

The Bush administration is shifting policy so cities and towns can skip a required treatment procedure for sewage they pump into rivers, lakes and coastal waters during high rains. The change aims to settle years of disputes over how municipal sewage plants handle the increased flow of waste – mainly storm runoff – that comes during wet weather. At issue is whether local governments should have to spend billions of tax dollars upgrading those plants so peak flows of sewage can get all the sanitary treatment that federal law demands in normal conditions. The administration's plan would let hundreds of communities big and small escape that expense by partially treating sewage surges in big storms. Environmental groups and some federal regulators say those flows should be treated completely to keep disease-carrying microbes out of recreational waters. The Environmental protection Agency plans to propose the policy change this week, and there will be 60 days for public comment before it can be finalized.

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USA TODAY / November 3, 2003

WATER SUPPLY and DEVELOPMENT

Denver Water OKs 5.4% rate increase
The Denver Water board approved a 5.4 percent rate hike in their bills for next year - the largest increase since 1996. The rate increase will pay for major projects that had to be accelerated to provide water for its growing service area and to cover costs associated with water treatment and delivery. The rate increase is expected to generate about $8 million in revenue. The new rates for Denver Water's 1.2 million customers will take effect Jan. 4. In a related matter, the board decided not to impose new tap fees on new houses. The board also agreed to a $400,000 contract with Western Weather Consultants to continue Denver Water's cloud seeding and Denver Water will cover about 80 percent of the contract while other entities will cover the rest. Though it has not been proven that the cloud seeding program worked last season, Denver Water received 12 percent more volume of water - largely from snowfall in areas where the seeders operated. For more detailed information about the rate plans, go to www.denverwater.org/rateinfo/rateinfoframe.html.

Rocky Mt News / October 2, 2003

Norton 'disappointed' with higher A-LP costs
A 48-percent increase in costs for the Animas-La Plata Project likely won't derail construction, Interior Secretary Gale Norton says. Still, Norton said she, too, wants to get to the bottom of why project costs jumped from about $338 million to more than $500 million only four months after construction began. Currently, the Bureau of Reclamation is building a 120,000-acre-foot Ridges Basin dam and reservoir south of Durango, a pumping plant and a pipeline. The plant will be used to pump water from the Animas River into the new reservoir. The pipeline will be used to deliver some of that water to New Mexico. Water from the project will go to the Ute Mountain Ute, Southern Ute, Navajo Nation and three water districts in Colorado and New Mexico, including the cities of Durango and Farmington. As far as the cost increases jeopardizing the project, Norton said she's not expecting that to happen.

Durango Herald / October 18, 2003

Wells failing at 'tip of saucer' in Denver Basin Aquifer
Running out of water isn't a theoretical danger in some parts of Douglas County. It's already happening. Many of the 45 homeowners in Chatfield Acres already spent up to $15,000 each to drill new wells a decade ago to replace those that had gone dry. Now, the water levels in the new wells are dropping. Chatfield Acres homeowners have asked Highlands Ranch to let them hook up to its water system, one of the few in Douglas County that uses surface water in addition to well water. But Highlands Ranch says it has no water to spare right now, and if it does eventually relent, the residents would have to pay $30,000 each to connect. Some scientists say dropping water pressure and dwindling wells are a harbinger of what the rest of the county can expect. "West Douglas County is experiencing today what central Douglas County will experience in the future. We just don't know when," said Robert Raynolds, a geologist with the Denver Museum of Nature and Science.

Rocky Mountain News / November 22, 2003

Eagle Valley reservoir planned
The Colorado River Water Conservation District wants to look at building a 60,000-100,000 acre foot reservoir on land owned by Denver Water in Eagle Valley. Denver Water originally bought the Eagle Ranch site in the Valley as the site for a 350,000-acre reservoir that would have supplied water via a pipeline under Vail Pass to Dillon Reservoir. Negotiations between the CRWCD and Denver Water over the voluntary surrender of Denver Water's Eagle Valley water rights and support for a new, smaller reservoir are underway. The new reservoir would allow Denver and Aurora to release water to downstream users when required.

Denver Post / October 23, 2003

Jeffco developers could face water requirement
Faced with findings from a groundwater study and foothills residents' wells running dry, Jefferson County Commissioners have agreed to make having sufficient water a development requirement. Three experts will be asked to develop criteria to ensure that proposed development has enough water without affecting existing wells. The area to be studied would be outside public water and sanitation systems where residential development is proposed on lots of less than 12 acres and for all other development that requires ground water.

Denver Post, October 23, 2003

Arvada pumping water into old mine
On Oct. 12, the City of Arvada began pumping drinking water into an old coal mine, replacing the natural gas that a local utility had stored there. City officials have said they are convinced the plan is safe. Converting the old Leyden mine would save millions over building another reservoir, they said.

Denver Post, October 12, 2003

Fort Collins looks at Halligan Reservoir expansion
Fort Collins is considering its first new water-storage facility in nearly 25 years with a large-scale expansion of Halligan Reservoir. The reservoir is northwest of town on the North Fork of the Poudre River, and city officials say it offers the most cost-effective, environmentally friendly

way to meet the city's future water needs. City staff are recommending a 33,600 acre-foot expansion for Halligan. Under that proposal, a new concrete dam would be built about 1,000 feet downstream from the reservoir's existing dam. The presence of Preble's mice around Halligan could mean more habitat mitigation, but shouldn't halt the project. Two city council members would like conditions placed on any agreement with three partner water districts to ensure mitigation for lost habitat and that proper stream flows are maintained for the Poudre river. The new dam would be built by 2009 or 2010, with bonds sold to fund the project. The city's share of the cost would be repaid through development fees.

Fort Collins Coloradoan, November 2, 2003

High court Oks pact on Republican River

The U.S. Supreme Court has approved a special master's report and recommendation for settlement of the Kansas-Nebraska-Colorado Republican River dispute. Colorado Attorney General Ken Salazar said the agreement, approved by the Supreme Court on October 20, will save Colorado $5 million in litigation costs. Kansas sued Nebraska in 1998 over a 1943 compact that gave Nebraska 49 percent of the water, Kansas 40 percent and Colorado 11 percent. Kansas argued Nebraska breached the compact by allowing the proliferation of thousands of wells connected to the river and its tributaries. Nebraska said ground water use was not regulated by the compact. Colordo became a party to the suit to protect its entitlement. In August 2001, the states agreed not to press claims against each other for violations of the compact from 1943 to 1994.

Denver Post / October 29, 2003

Call for Papers
Special Issue of the International Journal of Water Resources Development On "Water and Disasters"

Date of Publication: June 2005 -- Guest Editors: Chennat Gopalakrishnan, University of Hawai'i at Manoa, Norio Okada, Kyoto University

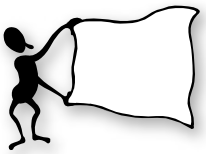
Papers are invited for possible publication in the special issue of the International Journal of Water Resources Development (IJWRD), a leading journal in the water resources field, dealing with water and disasters. Contributions could be empirical studies, case histories, conceptual-theoretical investigations, policy perspectives, institutional analysis, and risk analysis, among others. All papers selected for consideration will be peer-reviewed. Papers dealing with the following topics are of special interest, although this is by no means a complete list. We welcome contributions on other topics that are of interest and relevance to the theme of this special issue.

1. Integrated Disaster Risk Management (IDRM): Application to Floods and Famines.
2. Institutional Dimensions of Flood Risk Management.
3. Case Histories of Major Flood Disasters.
4. Case Histories of Major Famines.
5. Public-Private Partnership in Flood and Famine Mitigation Policies.
6. Global Warming and Its Impacts e.g. sea level rise.
7. Water impacts of Earthquakes, Hurricanes, and Typhoons.
8. Soil Impacts of Floods and Droughts e.g. soil erosion, soil contamination, land slides, land subsidence.
9. Human and Societal Hazards of Floods and Famines.
10. Information Dissemination and Moral Hazards.
11. Flood Insurance.
12. Cultural Context of Floods and Famines.

Deadline for submission of full-fledged papers, prepared in accordance with the guidelines of IJWRD, is June 1, 2004. Please limit your paper to a maximum length of 25 double-spaced pages. Submit your paper in triplicate (1 electronic version and 2 hardcopies) to:

Professor Chennat Gopalakrishnan
Special Issue Guest Editor
Department of Natural Resources and Environmental Management
College of Tropical Agriculture and Human Resources
1910 East-West Road, Sherman Lab 118
Honolulu, HI 96822-2279 USA

If there are any questions concerning the submission of papers or any other aspects of the special issue, please email Professor Gopalakrishnan at chennat@hawaii.edu



CALLS FOR PAPERS

Rocky Mountain Regional Lake & Reservoir Management Conference
"Lakes and Reservoirs: The Aquatic 'Gold' of the Western Landscape"
May 12-14, 2004, Sheraton Denver West Hotel, Denver, CO

Guidelines for Abstracts	Tentative Session Topics	Other Useful Information
Content: Title reflects subject of presentation Name & affiliations of ALL authors (mailing address, telephone, & e-mail Indicate in parenthesis following name if senior author is a student Bold and underline presenting author Single spaced Use Word (MS Office 2000, or earlier versions) or WordPerfect (Suite 7 or earlier versions) Font: Times Roman 12 preferred 250 word limit State purpose, significant results, and main conclusions of work Indicate preference for oral or poster presentation. Poster session submissions are encouraged. Submission: Submit via email as an attachment to: cknudhansen@att.net or Mail two printed copies and a diskette file (IBM compatible) to: Chris Knud-Hansen, Attn: RMRC, Aquatic Solutions LLC, 3215 Heidelberg Dr., Boulder, CO 80305 Presentation: Oral presentations limited to 20 minutes, including time for questions PowerPoint software encouraged. LCD projectors will be provided. Neither overhead nor slide projectors will be available Posters can be up to 4' x 8' (landscape format)	Watershed Management: Forest Thinning Shoreline Development Drought & Wildfires Stormwater Management Animal Waste Management HACCP Approach Nutrient Management: In-lake Treatments Sedimentation & Dredging Nutrient Criteria & TMDL's Non-Point Source Control Water Quality Monitoring Drinking Water Reservoirs: Eutrophication Cyanobacteria Control Treatment Costs & Alternatives Water Supply Security Fisheries Management: Sport Fisheries Endangered Species Whirling Disease Aquatic Nuisance Species Lake & Reservoir Case Studies: Urban Lakes & Reservoirs Effluent Dominated Systems Mountain Versus Plains Lakes Long-Term Studies Public Participation: Recreational Issues Lake Homeowners Associations Public Perception & Policy Education & Outreach	General Conference Information: Hosted by the Colorado Lake and Reservoir Management Association and the South Dakota Lakes and Streams Association, State Chapters of the North American Lake Management Society. www.clrma.org www.sdlakes.org www.nalms.org Deadlines: Abstract: February 1, 2004 Registration: April 1, 2004 Specific Questions: Technical Program Chairs Chris Knud-Hansen 303.494.5343 cknudhansen@att.net Jerry Meyers 605.756.4195 sdlakes@dailypost.com Poster Presentations Steve Lundt 303.286.3272 slundt@mwrd.dst.co.us Other Conference Questions Conference Chair Sharon Campbell 970.226.9331 Sharon_g_Campbell@usgs.gov Hotel Info Sheraton Denver West Hotel, 360 Union Boulevard, Lakewood, CO 80228, Phone 303.987.2000, www.sheraton.com/denverwest

EPA 2004 Community Involvement Conference and Training

The 2004 Community Involvement Conference and Training sponsored by the U.S. Environmental Protection Agency will be in Denver, Colorado, June 15-18, 2004. In its 7th year, this conference has proven to be an excellent opportunity to share lessons learned and to establish and monitor EPA's standards for community involvement. The conference covers the entire scope of public participation, community involvement, partnership building, and outreach and education related to all aspects of environmental protection. The Call for Presenters is now available online and all proposals are due by December 19, 2003!!! To learn more about the conference and the Call for Presenters, please visit http://www.epancic.org/2004

AGU HYDROLOGY DAYS 2004

On behalf of the Organizing Committee of Hydrology Days, I would like to invite you to participate in the Year 2004 edition of the AGU Hydrology Days, which will be held at Colorado State University during March 10 - March 12, 2004. For detailed information about the Year 2004 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

16TH HIGH ALTITUDE REVEGETATION WORKSHOP
March 3-4, 2004
University Park Holiday Inn
Fort Collins, Colorado

The High Altitude Revegetation Committee, through Colorado State University, organizes this biennial Worksho and an annual Summer Field Tour. All speakers are specially invited. Presentations stress "nuts and bolts" reclamation and restoration and include the full gamut of current problems, solutions and case studies presented by speakers from academia, government and industry. Keynote speaker will be Dr. W. Carter Johnson, widely noted plant ecologist from South Dakota State University. He will speak about his research work along the central Platte River Valley in Nebraska. The workshop will include poster papers and commercial exhibitor displays. Poster papers regarding any aspect of high-altitude regetation are invited. Contact Russ Haas, Phone 701/530-2026, E-mail russ_haas@nps.gov; Mindy Wheeler, Phone 801/699-5459, mindywheeler@cs.com; or Krystyna Urbanska in Switzerland, FAX 632-1215, E-mail urbanska@geobot.umnw.ethz.ch. To reserve a commercial exhibit space, contact Mark Schuster, Phone 303/572-5523 or Mark Phillips, Phone 303/665-2618. Cost is $195, which includes lunches, banquet and published proceedings. Full-time student is $25, which includes proceedings but no meals.

ANNOUNCEMENT
2004 WATER WELL TESTING CLASS

The Colorado Division of Water Resources is planning a workshop/class on Water Well Testing intended for well drillers, pump installers and other persons interested in performing water well measurement tests pursuant to Well Measurement Rules of the State Engineer for the Arkansas River Basin, Designated Ground Water Basins, and for well measurement programs in other areas of the State. The class is scheduled to be held in Pueblo in from May 5th through May 7th, 2004. The cost of the class is $250 for three days of classroom instruction and field exercises.

The class is designed to give an overview of groundwater hydrology, well hydraulics, water measurement methods, methods of collecting and analyzing data for determining power coefficients, well efficiency, system head considerations, reporting requirements, totalizing flow meter verification and more. Attendees will be allowed to take a test at the end of the class to obtain Division of Water Resources approval as a water well tester.

Interested individuals may respond to be placed on the mailing list to receive the upcoming formal announcement and registration packet by writing Ms. Janet Kuzmiak, at the Colorado Division of Water Resources, 310 E. Abriendo Ave, Suite B, Pueblo, Colo. 81004 or by e-mail at janet.kuzmiak@state.co.us, or by telephone at 719-542-3368 x 2101.

MEETINGS

CWC 2004 CONVENTION PROGRAM
(Registration Form in Separate Document)

WEDNESDAY, JANUARY 28, 2004

10:00 a.m.	Colorado Water Conservation Board Meeting
7:00 p.m.	CWC Board of Directors' Meeting

THURSDAY, JANUARY 29, 2004
THEME: 'Where there is no vision, the people perish" – Proverbs

7:30 a.m.	Registration Opens
8:00 a.m.	Colorado Water Conservation Board Meeting
8:30 a.m.	Five Concurrent Workshops – i.e., (1) Water Development; (2) Engineering & Management Developments; (3) CWRRI Workshop; (4) CWRRI Workshop; and, (5) Water Conservation
10:15 a.m.	Four Concurrent Workshops – i.e., (1) Engineering & Management Developments; (2) Endangered Species Issues; (3) Water Education; and, Water Conservation/Conservancy District Issues.
12:15 p.m.	GENERAL SESSION LUNCHEON – "Title to be Announced" – (Invited) Governor Bill Owens of Colorado
2:45 p.m.	"Title to be Announced" – (Invited) Mayor John Hickenlooper of Denver
3:15 p.m.	"Wayne Aspinall and the Shaping of the American West: - (Invited) Steven C. Shulte, Ph.D., Professor of History, Mesa State College, Grand Junction, and author of Wayne Aspinall and the Shaping of the American West.
4:00 p.m.	Five Concurrent Workshops: (1) Engineering & Management Developments; (2) The Colorado Water Conservation Board Issues; (3) Ground Water Issues; (4) Water Quality & Drinking Water Issues; and (5) Colorado Water Trust.
5:30 p.m.	CWC Annual Business Meeting. --Proposed 2004 Water Congress Policies -- CWC Board elections
5:45 p.m.	CWC Board of Directors' meeting.
6:30 p.m.	RECEPTION – Music by "Reckless Abandon"

FRIDAY, JANUARY 30, 2004

7:00 a.m.	LEGISLATIVE BREAKFAST – Speakers will be Senators Lewis H. Entz, Jim Dyer and Jim Isgar and Representatives Diane Hoppe, John Salazar, Gregg Rippy and Al White. Ag Commissioner Don Ament will serve as moderator.
8:30 a.m.	GENERAL SESSION II – A Dialogue on the Importance of Water Development --This Dialogue will be facilitated by (Invited) Dr. Robert P. McGowan, Chair of the Department of Management, University of Denver, and the session will be taped and recorded for future historical record.

The participants are: To be Announced

12:15 p.m.	THE WAYNE N. ASPINALL LEADERSHIP LUNCHEON – "To be Announced." – (Invited) Gale Norton, Secretary of Interior, U.S. Department of the Interior, Washington, D.C. The Twenty-fourth Annual "Wayne N Aspinall Water Leader of the Year" award will be presented at this luncheon. In addition, several other awards will be made at the luncheon.

The registration form for the CWC 2004 Convention can be found at the Colorado Water Congress website at http://www.cowatercongress.org or contact Dick MacRavey, Executive Director at Phone 303/837-0812, Fax: 303/837-1607, E-mail macravey@cowatercongress.org.

Profits Outside the Box

Agri-Energy and Beyond

2004 COLORADO AGRICULTURAL OUTLOOK FORUM

Renaissance Denver Hotel – 3801 Quebec Street
Thursday, February 19, 2004

Colorado AGRICULTURAL Outlook Forum

MORNING GENERAL SESSION TOPICS

- Colorado Water Supply/Drought Update
- Colorado Agriculture's Energy Use and Renewable Energy Potential
- Agri-Energy Profitability and Rural Economic Development—The Minnesota Story
- Promoting Renewable Energy in Agriculture and Rural Colorado—Two Views

AFTERNOON BREAKOUT SESSION TOPICS

- Large scale wind energy and community economic development
- Small scale wind and solar energy
- Biofuels & bioproducts
- Agri-energy cooperatives
- Carbon sequestration
- Financing agri-energy projects
- Innovations for profitability
- Mitigating inter-basin water transfers
- Creative approaches to ag water protection
- Legislative and state fiscal update

Sponsored by the Colorado Department of Agriculture, Colorado State University Cooperative Extension, and graduates of the Colorado Agricultural and Rural Leadership Program, with support from more than 50 organizations, businesses, and agencies interested in the future of Colorado agriculture.

"Information and ideas for tomorrow's agriculture"

30 FEATURED SPEAKERS INCLUDE:

- **Don Ament**, Commissioner of Agriculture
- **Jim Nichols**, Minnesota agricultural producer and former Commissioner of Agriculture
- **Larry Penley**, President of Colorado State University
- **Lola Spradley**, Speaker of the House, Colorado General Assembly (invited)
- **Glenn English**, Chief Executive Officer, National Rural Electric Cooperative Association (invited)

For more information about the 2004 Ag Outlook Forum agenda, speakers and registration, please visit our website at:

www.coloradoagforum.com

or call 303-477-0076 x210.

THREE WAYS TO REGISTER:

1. Visit www.coloradoagforum.com/register and have the option of paying by credit card or check.
2. Mail this form with payment by check to CAOF, 2331 W. 31st Avenue, Denver, CO 80211-3859.
3. Fax the completed form below to CAOF at 303-480-9236 and send payment by check separately.

Registration is $90 per person registered before February 6, $100 thereafter. Makes checks payable to **Colorado Agricultural Outlook Forum**. This fee includes the pre-forum reception.

FOR HOTEL RESERVATIONS:

Please call the Renaissance Denver Hotel at 800-468-3571 and mention ***Colorado Agriculture*** for a room rate of $89/night. Reservations must be made by February 4 to guarantee rates and availability. All registrants are responsible for their own hotel reservations.

2004 COLORADO AGRICULTURAL OUTLOOK FORUM

Profits Outside the Box

Agri-Energy and Beyond

First Name: _____ Last Name: _____

Organization: _____

Title: _____

Address: _____

City: _____ State: _____ Zip: _____

Telephone: _____ Fax: _____

E-mail: _____

Colorado AGRICULTURAL Outlook Forum

How many people plan to attend the pre-forum reception February 18, 5:30-7:30 P.M.? _____

☐ Payment is enclosed ☐ Payment will follow

CALENDAR

Jan. 11-15	USDA-CSREES NATIONAL WATER QUALITY CONFERENCE: INTEGRATING RESEARCH, EXTENSION AND EDUCATION, Clearwater, FL. For More Information contact: Local Arrangements Coordinator Dr. Thomas Obreza, Professor, Soil & Water Science Department, University of Florida/IFAS, PO Box 110290, Gainesville, FL 32611-0290, Phone: 352/392-1951 ext. 243, FAX: 352/392-3902, E-Mail taob@ifas.ufl.edu; or Conference Coordinator Ms. Shelby Tatlock, Office of Conferences and Institutes (OCI), University of Florida/IFAS, Phone: 1-352/392-5930, FAX: 1-352/392-9734, EMAIL: mktatlock@ifas.ufl.edu.
Jan. 14-16	4 STATES IRRIGATION COUNCIL 51st ANNUAL MEETING, Fort Collins, CO. Contact: Brian Werner at 970/622-2229 or Michelle Patrick by phone at 970/622-2247, by email at mpatrick@ncwcd.org, or by fax at 970/532-0942.
Jan. 29-30	COLORADO WATER CONGRESS ANNUAL CONVENTION, Northglenn, CO. See Colorado Water Congress Website at www.cowatercongress.org, Phone 303/837-0812, FAX 303/837-1607, E-mail macravey@cowatercongress.org.
Feb. 25-26	APPLICATION OF TECHNOLOGY TO WATER MEASUREMENT AND MANAGEMENT, Scottsdale, AZ. Contact USCID by phone at 303/628-5430 or e-mail Larry Stephens at stephens@uscid.org Final program and online registration form will be available on the USCID website -- www.uscid.org.
Feb. 26-27	2ND ANNUAL CONVENTION, DITCH & RESERVOIR COMPANY ALLIANCE (DARCA), Greeley, CO. Registration begins soon. For details, visit www.darca.org or contact: Karen Rademacher, 970/535-0690, karen@darca.org.
Mar. 3-4	16TH HIGH ALTITUDE REVEGETATION WORKSHOP, Fort Collins, CO. Contact: Gary Thor, Phone 970/484-4999, E-mail garythor@colostate.edu.
Mar. 3-5	7TH NATIONAL MITIGATION & CONSERVATION BANKING CONFERENCE, New Orleans, LA. For more information, visit www.mitigationbankingconference.com.
Mar. 10-12	2004 AGU Hydrology Days, Colorado State University, Fort Collins, CO. For detailed information, point your web browser to 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.
Mar. 11-12	COLORADO WATER LAW SUPERCONFERENCE, Denver, CO. Contact: Water Law Institute, CLE International. Register online at www.cle.com or call (800) 873-7130.
May 17-20	BUILDING AND SUSTAINING SUCCESSFUL MONITORING PROGRAMS, Chattanooga, TN. For information see the NWQMC website at www.nwqmc.org.
July 20-22	UCOWR/NIWR 2004 ANNUAL CONFERENCE, Portland, OR. Contact: Gary Johnson, Idaho Water Resources Research Institute, Phone 208/282-7985 or E-mail johnson@if.uidaho.edu or Ari Michelsen, Texas A&M University, 915/859-9111 or E-mail a-michelsen@tamu.edu. Website: www.uwin.siu.edu/ucowr.

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Colorado Water Resources Research Institute
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