



COLORADO WATER

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at Colorado State University*

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From left: Sara Rathburn, Graduate Student in Earth Resources, CSU; Bill Horak, Colorado District Chief, U.S. Geological Survey; and Rita Schmidt Sudman, Executive Director, California Water Education Foundation take a break at the Colorado Water Congress Meeting.

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EDITORIAL

WESTERN WATER INFRASTRUCTURE –
SUSTAINING THE LIFE BLOOD OF THE NEW WEST IN THE 21ST CENTURY

by Robert Ward, Director

As Director of a water research institute, I am often challenged as to why we need more ‘water’ research. Don’t we know enough to manage water in an effective and efficient manner? If the needs and values of the citizens, in relationship to water, did not change (e.g., no population growth and no change in values), perhaps we could obtain, at some point, all the information needed to optimally manage water. However, the context within which water managers operate is not static. The following remarks describe my perspective on the basic water infrastructure of the West and how the changing demands being placed upon it are driving a need for new water research and education. At the end of the editorial, I ask for your perspective on changes taking place in Colorado and the resulting pressures being placed upon our water infrastructure.

Water management in the Western United States is constantly evolving to meet the needs of people living in an arid region. On a very broad scale, the human relationship to water in the West can be summarized as subsistence in the 19th century, development in the 20th century, and sustainability in the 21st century.

The 19th century, from the Lewis and Clark Expedition in 1804-1806 to the closing of the western frontier in 1890, saw the western United States broadly settled by Europeans. The subsistence nature of the settlement, combined with the arid climate, led to efforts to assure more dependable water supplies. Attempts were made to develop water storage and delivery systems in the late 1800s. However, the attempts, generally, met with failure due to the high financial costs involved and the low returns from subsistence agriculture. John Wesley Powell, and others, argued that the United States government needed to work with the settlers to develop a water infrastructure that matched the human needs with the arid reality of the West. In 1902, the United States government accepted this argument with creation of the forerunner of the Bureau of Reclamation, and initiated large-scale water infrastructure development in the West.

The 20th century witnessed massive development of water infrastructure for the western United States, driven by local boosters and federal funds. Beginning in 1902 and, some would argue, ending with the veto of the Two Forks project in 1990, western water development, based on federal funding, has created an extensive water infrastructure designed to meet the water supply needs of irrigated agriculture, municipalities, and

power generation. Beginning in the 1960s, people began to question the economics and ecological impacts of such a large water infrastructure in the West. This questioning led a rapid decrease in development of new western water infrastructure in the late 20th century.

Most of the West’s water infrastructure was constructed between 30 and 70 years ago, the height of the ‘dam building era’. During the past 30 years, few new federally funded water projects have been developed, while the West has experienced rapid population and economic growth over this period of time. The ‘New West’, as defined by Bill Riebsame, Geography professor at the University of Colorado, represents a major urbanization in human settlement of the West and brings with it both increasing demands for traditional consumptive uses and a new set of values and uses related to western water.

Beyond traditional uses of western water (e.g., irrigation, municipal water supply, and power generation), the ‘New West’ is demanding additional uses of western water

(e.g., restoration of endangered species, water quality protection, and intense water-based recreational development). These new uses include ‘instream’ uses, such as rafting past the peak runoff season and water quality protection, as well as the ‘beneficial uses’ when the water is removed from the stream, such as meeting the water supply demands of the increasing population. The infrastructure established to support removal of water from streams for human benefit can simultaneously meet some of the new values, but the water demands of the New West are, at times, incompatible with the existing infrastructure.

In addition, existing reservoirs are facing major maintenance costs. The water infrastructure (e.g., reservoirs, canals, pipelines, and hydropower installations) is aging. There is concern that the water quality in reservoirs is changing as reservoirs age. Sediment continues to reduce the storage capacity of western reservoirs. The layout and capacity of the system (location of reservoirs, canals and pipes) are not being updated quickly as water demands change in time and location. Updating the West’s water infrastructure may involve removing some reservoirs, but the science and technology in this area is almost nonexistent. New reservoirs and canals may be needed, along with new operating procedures and new flow regimes.

The water demands of the ‘New West’ are being met, at the end

... the human relationship to water in the West can be summarized as subsistence in the 19th century, development in the 20th century, and sustainability in the 21st century.

of the 20th century, by transferring water from more traditional uses (primarily food production) to 'New West'-dictated uses (primarily municipal, recreation and ecosystem protection). Also, water conservation and efficiency improvements (e.g., canal lining) are helping meet the new water demands. There are limits, however, to the ability of water transfers and efficiency improvements to meet the new needs. At some point the aging water infrastructure must be updated and modified to meet the emerging needs.

Thus, there are a number of complex issues related to the aging of the western water infrastructure that need to be examined and addressed in a well coordinated manner by all agencies and disciplines concerned with the sustainability of the West's water infrastructure through the 21st century.

Unfortunately, many of the agencies and disciplines working on water-related issues today were created independently for specific resource management missions. Those involved with the management of western water resources, and those who support such management via education and research, will need to examine the methods used to address the emerging, highly complex water infrastructure issues of the 21st century.

CWRRI is bringing Colorado's higher-education scientists and Colorado water managers together to develop innovative scientific approaches for addressing the complex sustainability issues facing the western water infrastructure. To illustrate, CWRRI's new research projects that began March 1, 2000, and described in this issue of Colorado Water, represent the employment of science to ensure a sustainable water infrastructure in Colorado. The new projects address salinity concerns in the Arkansas Valley, water needs for threatened fish in the South Platte Basin, protection of raw water supplies for municipalities along the Front Range, and the relationship of forest and water management practices in the Colorado mountains.

Concerns about impacts of weather changes due to large water distribution systems and related changes in land use in the west are discussed on page 10 of this newsletter. An Agricultural Experiment Station project examining the use of recycled water to irrigate turf grass is described on page 13. New staffing by Cooperative Extension is described on page 15, and reflects the increasing water quality issues facing western water managers. Use of GIS technology by the Colorado State Forest Service to enhance watershed management discussions is described on page 17.

Thus, there are efforts underway to better understand the infrastructure adjustments needed to move toward a more sustainable future, but more understanding is needed to make

the adjustments fair and equitable. For example, the re-operation and 'modernization' efforts being developed for the western water infrastructure in Colorado (e.g., Pueblo Dam and Horesetooth Dam), while addressing dam safety and physical system integrity, represent opportunities to better integrate the water infrastructure into the broad water management needs of the New West. While reservoir water levels are lowered for safety and modernization activities, opportunities are often available to adapt the reservoir to new uses with minimum impact on existing uses as well as better understand the water quality changes taking place in the reservoir.

As the construction of dams initially provided the opportunity to integrate enhanced water management into local economies, via irrigation, better flood control, power generation, drought protection and flat-water recreation, upgrading of the infrastructure presents opportunities to integrate enhanced water management into sustainable ecosystems, new economic activities (such as rafting and snow making), and enhanced water quality protection. The Wolford Mountain project is a good example of integrating needs into a successful addition to Colorado's water infrastructure.

Colorado Water, which does not normally print letters to the editor, will accept letters in the next issue from those who want to share their views on the future of the West's water infrastructure and what is needed . . .

It is not easy to resolve conflicting uses of water in an arid landscape. However, it is easier if the information available for decision-making is based on sound science and clearly understood by all involved. CWRRI is working with Colorado water managers

and university researchers to determine ways to ensure that the sound science and education needed to successfully move into a sustainable water infrastructure in the 21st century are available. Those who had the foresight to initially develop Colorado's water infrastructure would expect today's citizens to not only maintain the infrastructure, but to also adapt it to meet the evolving 21st century values and needs.

The above perspective of the changes and opportunities facing the West's water infrastructure are those of one individual. What are the perspectives of other faculty and water managers in Colorado? Colorado Water, which does not normally print letters to the editor, will accept letters in the next issue from those who want to share their views on the future of the West's water infrastructure and what is needed, in terms of new knowledge for facility modification, re-operation, removal and new construction, to ensure plentiful water for future human and ecosystem needs. The letters must be limited to 250 words. Given the different perspectives of water infrastructure from different parts of Colorado, it is hoped that all areas of the state will be represented in the letters. Please share your thoughts regarding the future of the West's water infrastructure with Colorado Water readers.



RESEARCH



CWRRI'S FY2000 PROJECTS BEGIN MARCH 1, 2000

Water research projects selected for funding by CWRRI's Advisory Committee on Water Research Policy (ACWRP) at its October 13, 1999 meeting in Denver have been approved by the U.S. Geological Survey and will commence on March 1, 2000. The ACWRP recommended that two projects funded in FY1999 continue through FY2000, and chose two new research projects for funding that they deemed of highest priority. The projects are described below.

Description and Interpretation of Salinization in the Lower Arkansas River Valley, Colorado (Second Year)

A growing body of evidence indicates that the irrigated lands of the lower Arkansas are subjected to forces that are elevating the severity of waterlogging and salinization. The evidence includes salt crusting on soil surfaces, seepage and wet spots in selected fields, stunted growth of crops, and reduced crop yields. Without sound and timely intervention, it appears the valley would eventually succumb, at least in large part, to the ill effects of salinization.

Solutions based upon accurate knowledge of field conditions would help ensure sustainability of the valley's productive agricultural base and preservation of its rural communities. This research will prove a valuable resource in support of decision-making and intervention in the valley. Investigators are considering soil salinity, water-table depth and salinity; river level, flow and salinity; water levels, flows and salinity in canals and drains; irrigation practices; hydraulic conductivity of surface soils; well pumping and crop yields in an effort to find plausible causes and promising directions for addressing the salinity problems.

During the 1999 cropping season, extensive data were collected in Otero and Bent counties. A battery of monitoring wells was installed over a representative region of about 50,000 acres. Preliminary analysis of data from more than 80 wells reveals average water table depths less than 5 feet below ground surface over about 70 percent of the region. The average measured salinity (as electrical



Monitoring Salinity in the Arkansas River Basin.

conductivity, EC) of the water table in the study region was about 4 dS/m (3200 mg/l). Surface-water salinity was measured weekly throughout most of the season at more than 160 locations, including points in the Arkansas River, in seven major canals, in seven drains, and in two reservoirs. The average salinity of the water in the irrigation canals was 0.93 dS/m (700 mg/l), indicating low to moderate restriction in use for irrigation. Global positioning equipment was used to accurately locate each of the ground-water and surface-water sampling sites for use in a geographic information system.

The salinity of the soil (to a depth of about 3.3 feet) was measured in early June and again in mid-August on 68 different fields distributed over the region. On each field, soil salinity (as electrical conductivity of saturated extract, EC_e) was measured during each sampling using electromagnetic probes at an average of 64 locations (about 1 to 10 locations per acre). In addition, about 2000 soil samples were collected for use in calibrating the electromagnetic probes. The overall average soil salinity has been estimated as 2.8 dS/m (2000 mg/l). The average measured salinity exceeded the threshold level (level above which crop yield reductions are expected) on at least 70% of the fields, indicating significant soil degradation and declining yield. Actual yield losses currently are being estimated through harvest records on many of the fields that were studied.

A project report will be accompanied by a digital, spatially-referenced

(ArcView™GIS format) database. The data collection effort focuses on a representative region of the valley between Manzanola in Otero County to Las Animas in Bent County.

The Colorado State University Agricultural Research Station and Colorado State University Cooperative Extension are providing project assistance. In addition, a

Distribution, Habitat, and Life History of Brassy Minnow (*Hybognathus hankinsoni*) in Eastern Colorado Streams (Second Year)

Field sampling done by this project's principal investigator and graduate students will provide updated information on the current status of the brassy minnow in Colorado, as well as some of the first data on its habitat and life history. Understanding the historical distribution will require analyzing museum collections to separate the brassy minnow from plains minnow, with which it is often confused. A field study in reaches that contrast in hydrology (more vs. less flow fluctuation), location (foothills vs. plains), and channel morphology (natural stream channels vs. irrigation canals) will be used to relate habitat use of brassy minnow through time to flows, the dynamics of available habitat, and water quality.

Because reproduction is the key to population persistence for fishes living in fluctuating plains streams, the field research will also focus on reproductive ecology (timing and habitat for spawning and rearing) as well as the basic life history characteristics of age and growth. Combining data on habitat use and life history will allow investigators to define what habitats brassy minnow use at what life stage, when and where they spawn, how long they live and how fast they grow, and what features of habitats and flow regimes favor their reproduction, survival, and growth. This information is expected to lead to recommendations about habitats and flow regimes that

Bureau of Reclamation-sponsored project by the principal investigators will complement the project and establish a measurement and record-keeping system for both water quantity and quality to help assess the severity and extent of salinization in the study area. The Southeastern Colorado Water Conservancy District, the Arkansas River Channel Restoration Study (Colorado Water Conservation Board), and the USDA's Natural Resources Conservation Service have expressed support for this project. Principal Investigators are Tim Gates and John Labadie, Department of Civil Engineering, Colorado State University.



Julie Scheurer and Mark Minner seining in an Eastern Plains stream to study the life cycle and habitat needs of the Brassy Minnow. Photo by Kurt Fausch.

should be protected or restored to allow historic and transplanted populations of these species to thrive.

A project update to the ACWRP indicated that sampling was completed on 5 of the 9 South Platte sites as well as on several additional sites upstream and downstream of these. In addition, two sites on the South Fork of the Republican River were sampled, for a total of 14 sites thus far. With the help of Dr. Kevin Bestgen, head of CSU's Larval Fish Laboratory, the project's research assistant identified juvenile fishes that could not be identified in the field. Brassy minnow were found at 8 of 9 sites on Lone Tree Creek and at both Republican River sites. None were found in Wood's Lake Creek or Dry Creek. Sampling of the remaining sites will be completed in the fall. In addition, about half of the samples requested from museums have been received and are being identified with Kevin Bestgen's help.

The Colorado Division of Wildlife has provided support for this project. The Principal Investi-

gator is Kurt Fausch, Department of Fishery and Wildlife Biology, Colorado State University.

Water Quality Monitoring System Effectiveness Evaluation: Denver Water Case Study

Many municipalities along Colorado's Front Range are under pressure to expand their raw-water monitoring programs as development occurs in watersheds, municipal water demand increases, and Safe Drinking Water Act regulations tighten. This project will assemble existing water quality monitoring system design theory, develop a means to use such theory to evaluate the information effectiveness of existing municipal watershed monitoring programs, and apply the theory to Denver Water's watershed monitoring program as a case study.

Denver Water operates a far-ranging water-quality monitoring program that extends over its entire source water area to the terminal reservoirs that feed the treatment plants. This raw-water monitoring system evolved over the years as operational needs and various regulatory information requirements were placed on Denver.

As a means of testing the existing technology for evaluating the effectiveness of water



From left: CSU professor Jim Loftis, graduate student Justin Twenter, and Denver Water representatives Steve Lohman and Bruce Hale develop project research plan.

quality monitoring programs, Denver Water has agreed to have this monitoring program reviewed. A graduate student, faculty member, and personnel from Denver Water's monitoring staff will form a 'Monitoring Evaluation Team' that will meet regularly during the project. Denver Water also will provide support for the project. The Principal Investigator is Jim Loftis, Department of Chemical and Bioresource Engineering, Colorado State University.

Forest Management, Water Yield, and Water Quality: A State-of-the-Art Assessment

Left: Excessive sediment resulting from forest fires will be evaluated as part of a project approved by the ACWRP. Photo of Buffalo Creek courtesy of Ellen Wohl, Department of Earth Resources, CSU.



A long history of fire suppression in Colorado, combined with reductions in logging and grazing, has resulted in increased forest density and fuel loadings. These changes now are recognized as being detrimental to forest health as well as increasing the risk of catastrophic forest fires. Such wildfires in the Front Range

and elsewhere pose a severe threat to water quality, aquatic resources, air quality, and human health. The Buffalo Creek and Storm King fires are examples of the current hazard.

On many public lands there is now more emphasis on recreation, preservation, and ecosystem management. Since most of Colorado's water supply originates on forestlands, the management of these lands cannot be separated from issues of water quality, water quantity, and downstream aquatic ecosystems. The growing list of water-related issues is leading to a renewed focus on the management of Colorado's forests. This project, under the guidance of a

Forest Water Panel comprised of water managers, forest managers, and scientists, will identify key questions about the interactions between forest management, water quantity and water quality; provide a state-of-the-art summary of these questions; and identify gaps in knowledge that can guide future research.

Support for the project is provided by the Northern Colorado Water Conservancy District, the Colorado River Water Conservation District, and Denver Water. The Principal Investigator is Lee MacDonald, Department of Earth Resources, Colorado State University.

AWWARF ISSUES REQUEST FOR PROPOSALS

The AWWA Research Foundation (Aware), a non-profit organization dedicated to advancing the science of water, announces the selection of 36 new research projects approved for funding in 2000. AwwaRF sponsors practical, applied research for the drinking water community and, since 1986, has managed research projects worth over \$140 million. Requests for proposals (RFPs) for 30 projects will be available on the AwwaRF web site (www.awwarf.com). Proposals submitted in response to RFPs must be postmarked by May 8 for projects with budgets up to \$250,000 in AwwaRF funds. Proposals seeking \$250,000 or more in AwwaRF funds must be postmarked by July 17. Contract awards for all projects will be determined by an AwwaRF Project Advisory Committee appointed for each project. Proposal evaluations will be based on responsiveness to the RFP, scientific and technical merit, and qualifications of the researchers.



WATER SUPPLY

The statewide average snowpack climbed from 66 percent of normal to 80 percent of normal during February. Water supplies

are at near normal to above normal levels in the South Platte, the Arkansas, the Colorado, and the Yampa/White due to increased storage and snowpack. The Rio Grande, Gunnison, and San Juan/Dolores basins continue to have below normal water supplies, primarily attributable to low snowpack. However, early March SNOWTEL data indicates the snowpack in the Rio Grande Basin has improved, having increased from 45 percent to 61 percent already. And snowpack in the San Juan/Dolores basin has increased by 10 percent to 73 percent of normal. In spite of low snowpacks, stream flow levels remain adequate statewide and reservoir storage is average to above average in most of the reservoirs across the state.

(SWSI) developed by this office and the USDA Natural Resources Conservation Service is used as an indicator of mountain based water supply conditions in the major river basins of the state. It is based on

snowpack, reservoir storage, and precipitation for the winter period (November through April). During the winter period snowpack is the primary component in all basins except the South Platte basin, where reservoir storage is given the most weight. The following SWSI values were computed for each of the seven major basins for March 1, 2000, and reflect conditions during the month of February.

Basin	3/1/00 SWSI Value	Change from the Previous Month	Change from the Previous Year
South Platte	+1.6	+0.5	-0.1
Arkansas	-1.2	-0.1	-1.4
Rio Grande	-2.7	+0.5	-3.2
Gunnison	-1.8	+0.5	-1.6
Colorado	-0.9	+0.2	-0.9
Yampa/White	-0.7	-0.1	-0.6
San Juan/Dolores	-2.5	+0.4	-2.5

SCALE

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



EFFECTS OF LAND COVER, WATER REDISTRIBUTION, AND TEMPERATURE ON ECOSYSTEM PROCESSES IN THE SOUTH PLATTE BASIN

by

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***Ecological Applications 8:1037-1051, 1998**

***synopsis of technical paper, by Cat Shrier**

There has been a 30-year trend of increasing temperatures throughout the Great Plains and the western United States, consistent with global warming due to increases in carbon dioxide in the atmosphere (Laurenroth and Sala 1992, Karl et al 1993, Watson et al 1996). Over the past 120 years, there have additionally been changes in land cover as shortgrass steppe has been converted to dryland and irrigated croplands. These changes in land use also can cause changes in temperature and hydrology on a regional scale.

Both greenhouse forcing and temperature changes due to land cover can influence regional ecosystem processes, although not necessarily in the same way or with the same magnitude. For example, while there has been a warming trend on the plains, there has been a cooling trend in the mountains. These temperature changes (whether from global changes,

land cover changes, or both) can cause both direct and indirect changes in plant productivity and hydrology.

The impacts of global climate and land cover changes combine in unexpected ways. The net impact of the global changes in temperature and the local changes in temperature may depend upon a combination of factors, including vegetation and elevation. To better understand how climate and land cover changes affect evapotranspiration, plant productivity, and stream discharge, a team of scientists at the Natural Resources Ecology Laboratory at Colorado State University, in conjunction with scientists at the University of North Carolina and the University of New Hampshire, developed a model of the South Platte Basin, and simulated different temperatures and land covers. The authors applied

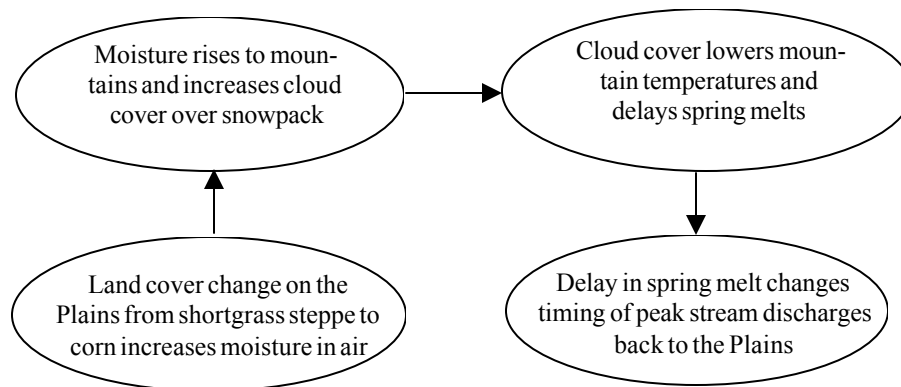


Figure 1. Example of the relationship between land cover change and local climate change.

a model that looked at combinations of forcing factors over an area that includes several types of land cover and elevation changes, in order to address how sensitive regional ecosystem dynamics were to both land cover change and climate alteration.

One example of the complicated effects of land cover and hydrologic changes is illustrated in Figure 1. Replacement of

shortgrass steppe with an irrigated crop, such as corn, increases the amount of moisture in the air due to greater evapotranspiration from corn than native grasses. The moist air rises to higher elevations, increasing the amount of cloud cover over mountain snowpacks. If cloud cover decreases temperatures, snowmelt will be delayed. The delay in snowmelt will impact the hydrology on the plains and how water storage and delivery structures will be operated.

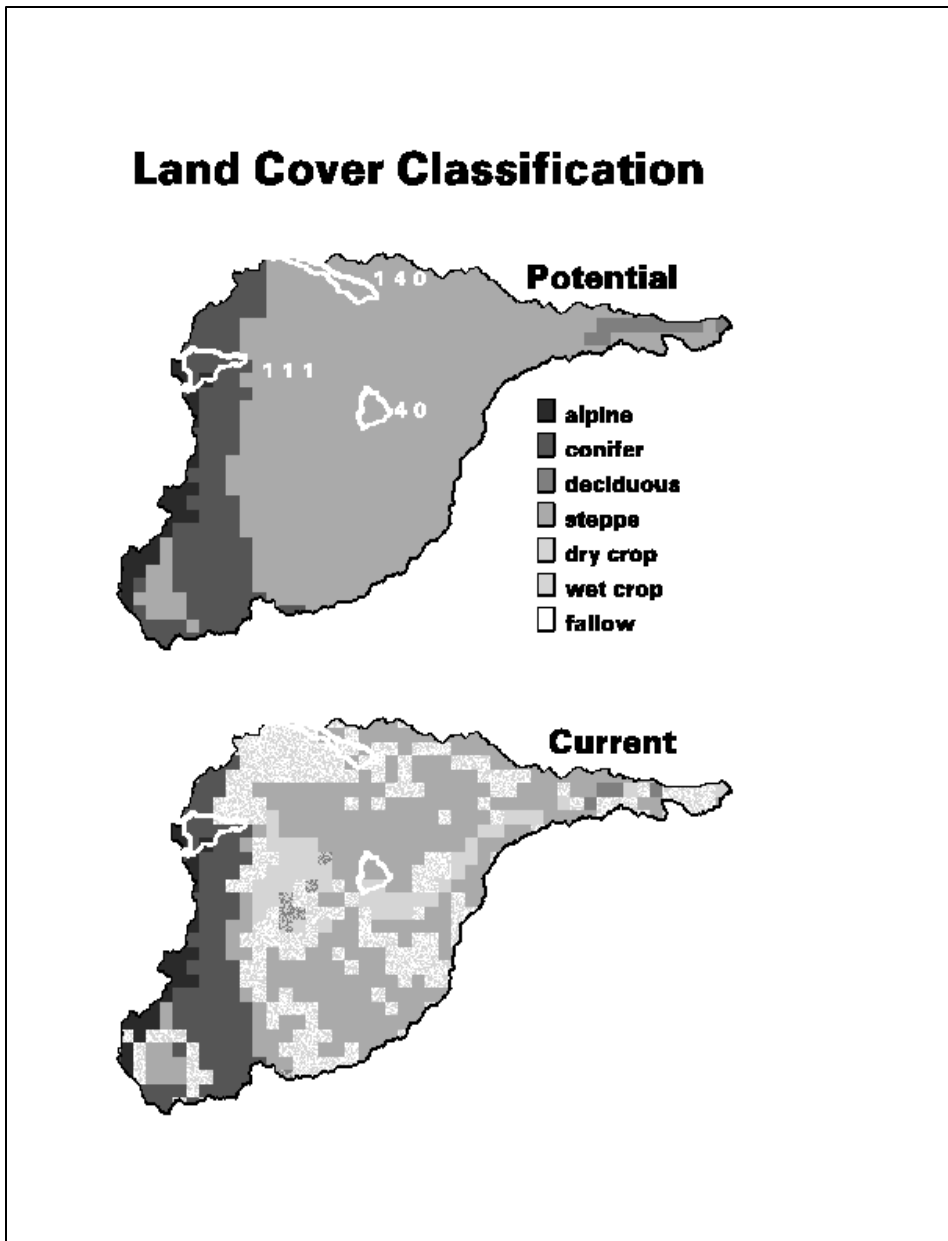


Figure 2. Potential (historic) and current land cover classifications for the South Platte Basin.

The South Platte Basin covers an area from the Rocky Mountains to the Great Plains, and includes a large change in elevation from west to east. The basin encompasses great changes in topographic complexity, vegetation type, and climate. The region has seen many changes in vegetative land cover, as more than one third of the land area has been converted from the original vegetation (mostly shortgrass steppe, with coniferous forest and tundra at the higher elevations) to croplands, particularly in the lower elevations. The basin now includes 8% irrigated cropland (mostly corn) and 31% dry croplands (typically rotated between wheat and fallow land).

The South Platte Basin model was developed using a spatial data and simulation system, called RHESSys (Regional Hydro-Ecological Simulation System), that uses geographic information system (GIS) techniques to transform spatial data into a landform description. RHESSys includes process models that compute water and carbon flux for both forest and grassland vegetation (FOREST-BGC) and to simulate watershed hydrologic processes (TOPMODEL). A weather generator, MTCLIM-3D, was used to determine daily weather (temperature highs and lows and precipitation) for each grid cell.

The model was developed using both current land cover maps from the U.S. Geological Survey and potential natural vegetation cover based on vegetation maps developed by Küchler. Using

model output of photosynthesis, transpiration, and hydrologic parameters, the authors compared the differences between land cover change and temperature change scenarios. Figure 2 shows land cover classifications for the current and historic land use.

To evaluate the impacts of changes in land use, the model was used to determine how the net photosynthesis and transpiration changed between the current and historic land cover. To evaluate the impacts of global climate changes, the model was also used to determine changes in net photosynthesis and transpiration with an increase in temperature of 4°C and a decrease in temperature of 2°C. Model evaluations were made for the basin as a whole, as well as for three individual hillslope grid cells:

- ◆ one (no. 111) in a high elevation alpine and coniferous forest;
- ◆ one (no. 140) that currently is mostly wheat/fallow but originally was shortgrass steppe; and
- ◆ one (no. 40) that currently is irrigated corn, also converted from shortgrass steppe.

Conclusions

The simulations found higher elevations to be more sensitive to changes in temperature, while lower elevations were more sensitive to changes in land cover. However, changes in land cover lead to changes in temperature at a regional scale, by releasing more latent heat via evapotranspiration. Annually, the amount of water released back to the atmosphere via evapotranspiration was increased by 37% with current land cover compared with natural vegetation. The research has important implications regarding the feedback of changes in land cover to regional climate. There is no question that human activity has altered landscapes through deforestation, grazing, and agriculture for thousands of years. There is increasing evidence that, in addition to altering processes occurring at the land surface, irrigated agriculture can alter regional climate.

It is important to note that water use change, more than land cover change, is driving the responses observed in these

simulations. Much of this water is not locally obtained. In 1987, Wallace Stegner wrote, "The West is defined ... by inadequate rainfall. We can't create water, or increase the supply. We can only hold back and redistribute what there is." Irrigation in the western United States leads to significant seasonal and spatial redistribution of water, and this influences the flux of water vapor into the atmosphere. Water for irrigation, and increasingly, for urban growth, is redirected from the South Platte headwaters and from the Colorado and Arkansas River basins. Many studies have shown the complex ecological repercussions of these water transfers. High elevation and western slope aquatic and riparian communities have suffered from inadequate volumes, while irrigation return flows have changed the South Platte from seasonally dry to perennial. The results from RHESSys simulations suggest yet one more environmental change cause by water redistribution: transpiration losses of water that are sufficient to change the regional climate.

If you have any questions on this research, please contact the principal author, Jill Baron, at the CSU Natural Resource Ecology Laboratory, at (970) 491-1968 or jill@nrel.colostate.edu.

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**TURFGRASS WATER USE AND
SALINITY TOLERANCE RESEARCH**

by
Yaling Qian and Tony Koski

Department of Horticulture and Landscape Architecture
Colorado State University

**Agricultural Experiment Station
Project 780**

The major objectives of this project are:

- 1. To determine turfgrass inter-specific and intra-specific differences in water use and evaluate the effects of irrigation regimes on turf performance.**
- 2. To identify turfgrass species and cultivars that retain acceptable turf quality under high salinity conditions. Elucidate the salt-coping mechanisms of selected turfgrasses.**

Objective 1: *To determine turfgrass inter-specific and intra-specific differences in water use and evaluate the effects of irrigation regimes on turf performance.*

The arid and semi-arid conditions under which turfgrass is cultured in Colorado necessitates the use of large amounts of irrigation water to maintain adequate quality on the most commonly planted grass species, such as Kentucky bluegrass. Although annual landscape water use is estimated to comprise only 4-5% of all water used in the state, about 35 to 60% of potable water used in metropolitan areas during the summer is applied to landscaped areas, including turfgrass lawns. The use of potable water for landscape, especially the turfgrass industry, is increasingly criticized. This criticism exists despite the economic, environmental and aesthetic benefits of the turfgrass and landscape industry to our society. To be wise stewards of water, turf managers and scientists have to seek approaches to reduce irrigation requirements of turfgrass.

One approach to reduce turfgrass irrigation requirements is to develop and use turfgrass species and cultivars that have good drought resistance. A study was recently completed to compare the irrigation requirements of Kentucky bluegrass, tall fescue, and buffalograss using underground line source irrigation systems (LSIS) at CSU's Horticulture Research Center near Fort Collins (Fig. 1). Our results demonstrated that these latter species have enhanced abilities to resist drought and to provide a quality turf cover with reduced (as compared to Kentucky bluegrass) irrigation requirements.

Meanwhile, efforts were taken to examine intra-specific differences in water use and drought resistance and to select best-adapted cultivars of each species. Participation in the National Turfgrass Evaluation Program (NTEP), operated in cooperatively with the USDA and ARS, allows individual states to evaluate established, newly introduced, and experimental cultivars for potential use under growing conditions that may be unique

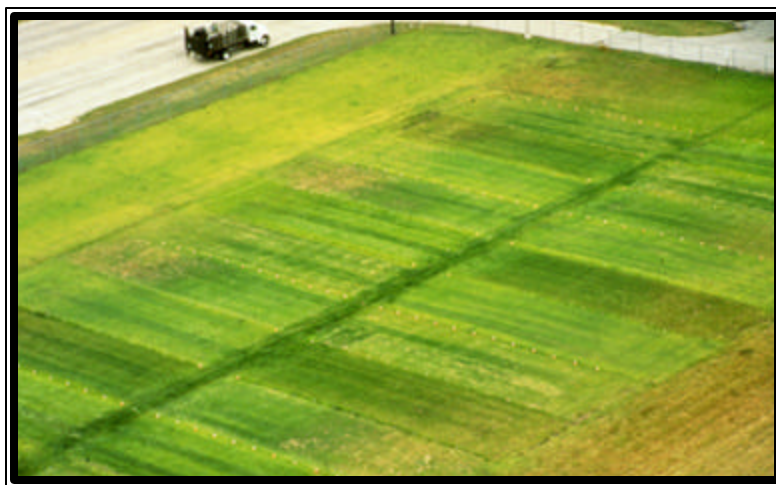


Fig. 1. Comparing the irrigation requirements of Kentucky bluegrass, tall fescue, and buffalograss.

to that individual state. Colorado's unique and varied climatic zones make it attractive for the evaluation of all cool-season turfgrass species, as well as many of the warm-season species.



Objective 2: To identify turfgrass species and cultivars that retain acceptable turf quality under high salinity conditions. Elucidate the salt-coping mechanisms of selected turfgrasses.

Another important approach to reduce the use of potable water in turfgrass irrigation is to irrigate with non-potable water, such as well water, ditch water, and/or effluent water. Irrigating landscape with non-potable waters will significantly reduce the turf industry's dependence on potable water. Although effluent water is generally suitable for irrigation, it is usually saltier than potable water. Some localized well and ditch waters also can exhibit high total dissolved salt, sodium absorption ratios, and electrical conductivity. Problems associated with saline soil and saline irrigation water may increase in the future as more effluent or poor quality water is applied to turf sites and more turf is planted in arid and semiarid regions where soil and water salinity problems are common. Research is needed to select and develop salinity-tolerant turfgrasses and to define proper management practices to prevent loss of turf from high salinity conditions.

A study was initiated with Agricultural Experimental Station funding to investigate the relative salt tolerance and salt tolerance mechanisms of 'Challenger' Kentucky bluegrass (*Poa pratensis*), 'Arid' tall fescue (*Festuca arundinacea*), 'Fults' alkaligrass (*Puccinellia distans*), and a saltgrass (*Distichlis spicata*) collection. Preliminary results indicated that the salinity-tolerance ranking was Alkaligrass = Saltgrass > tall fescue > Kentucky bluegrass. Bicellular, salt-secreting glands were only observed by scanning electron microscopy on leaves of saltgrass, indicating salt secretion is one of the important salt-tolerance mechanisms adopted by saltgrass. Ion contents (Na, Cl, and Ca) in both shoots and roots of all grasses increased with increasing salinity levels. However, alkaligrass maintained much lower Na⁺, Ca⁺⁺, and Cl⁻ contents in roots and shoots than other grasses, suggesting that ion exclusion is one of the major salt-tolerance mechanisms in alkaligrass. Tall fescue did not appear to restrict the uptake and translocation of salt in shoot tissues, but maintained a lower Na/K ratio than all other grasses under saline conditions. This result suggests tall fescue has a higher K uptake ability, which may play an important role in salinity tolerance of tall fescue.

An additional study was initiated in the fall of 1999 to evaluate salinity tolerance among different bluegrasses (including Kentucky bluegrass, Texas bluegrass, and hybrid bluegrass). This experiment is conducted in the Plant Environmental Research Center greenhouse facilities at CSU in a solution culture system (Fig. 2). A total of fifteen 50-L tanks are used with each, accommodating 18 entries. Each tank contains constantly aerated full-strength Hoagland solution, which is replaced weekly. Five salinity treatments are imposed by adding salt into nutrient solutions. Preliminary results indicate that considerable variability in salt tolerance exists among bluegrass species and genotypes. At the completion of this project, we will be able to identify salt tolerant bluegrass germplasm that would be incorporated into the turfgrass breeding program.

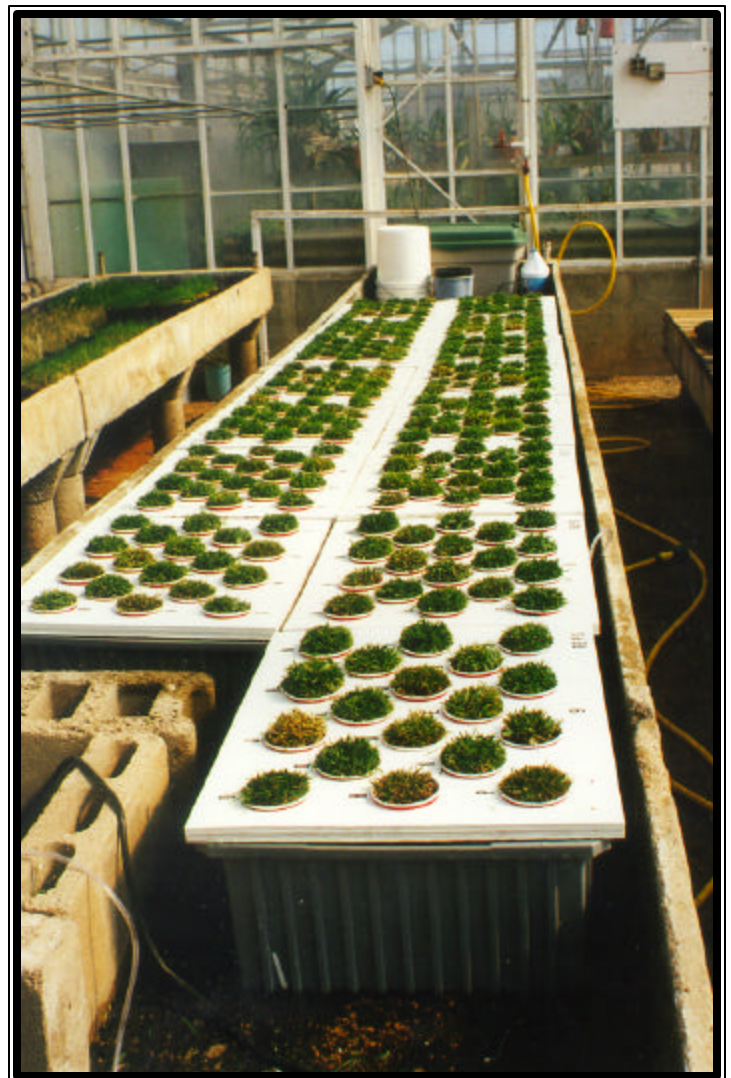


Fig. 2. Evaluating salinity tolerance among different bluegrasses (including Kentucky bluegrass, Texas bluegrass, and hybrid bluegrass).



COOPERATIVE EXTENSION HAS TWO NEW WATER QUALITY SPECIALISTS

Cooperative Extension has developed new working partnerships with Colorado water organizations through innovative funding opportunities.

Loretta Lohman Colorado Nonpoint Source Information and Education Coordinator



Colorado State University's Cooperative Extension has employed Loretta Lohman to coordinate the information and education component of the Colorado Nonpoint Source Program. The position is funded by a grant from the Environmental Protection Agency to the Colorado Department of Public Health and Environment (CDPHE) through the Clean Water Act, Section 319. Loretta will provide proactive leadership in informing and educating Colorado citizens about the prevention of nonpoint source water pollution and related issues.

Her responsibilities include assuring that all funded nonpoint source projects have an information and education (I/E) component reflecting the goals of the Colorado Nonpoint Source Program, managing the I/E small grant project program, providing staff assistance to the I/E committee of the Colorado Nonpoint Source Council to accomplish its goals and objectives, coordinat-

ing program activities of the I/E committee, the Nonpoint Source Council, the CDPHE Water Quality Control Division, and Colorado State University's Cooperative Extension (CSUCE), and developing working relationships with Cooperative Extension Water Quality Team members and Extension's Water Quality Program.

The position, located in the Denver County office of Colorado State University Cooperative Extension, responds to the direction of a panel comprised of the CSUCE Water Quality Program Coordinator, the CDPHE Nonpoint Source Program Coordinator, and the chair of the Colorado Nonpoint Source Council Information and Education Committee.

Loretta has been a self-employed consultant since 1986. While at the University of Denver Research Institute, from 1971 to 1986, she served as project manager and principal investigator for a three-year study examining public attitudes to potable wastewater reuse in the Denver metropolitan area.. Her background also includes teaching, research, and editing and writing about water issues and natural resources policy. She obtained a Ph.D. degree in American History from the University of Denver, an M.A. in Social Science from the University of Northern Colorado in Greeley, and a B.A. in Political Science from the University of Denver. She served on the Board of Directors of Metro Water Conservation, Inc. from 1988-89 and was on the Technical Advisory Committee for the Denver Potable Wastewater Reuse Demonstration Plant. Loretta can be contacted at:

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Karla Brown
Tri-River Area Water Quality
Extension Specialist

Karla Brown is the new Tri River Area Water Quality Specialist based in the Montrose Extension office. Her position is funded by the U.S. Department of Agriculture. Originally from Maine, Karla spent the previous part of her career on the Eastern Slope working for an environmental consulting group. "The Uncompahgre Valley has unique water quality problems and an interesting history of water use," says Karla. "In 1902, the Uncompahgre Valley Water Users Association was organized to help develop a plan to divert the Gunnison River into the Valley. Drilling of the Gunnison Tunnel began in 1902 and was completed in 1909. Agriculture in this area took off immediately, and it has been an integral part of this area's economy ever since. This legacy of water use, however, has created some unique water quality concerns."

Currently, segments of the Uncompahgre River are on the Colorado 303d list of impaired waters for elevated selenium and fecal coliform concentrations. Segments of the Gunnison River are also listed for high selenium levels. Selenium in Mancos Shale, common to this region, is a natural part of the local geology. "Figuring out how to prevent selenium from percolating into our surface and groundwaters is the general problem," Karla says, "but our solutions have larger implications for fish and wildlife, as well as the future of irrigated agriculture in the area."

To address the selenium water quality problem, in 1997 the Gunnison Basin Selenium Task Force (GBSTF), was created. This local group of private, state and federal agencies is working towards finding solutions to the selenium problem, using locally-driven alternatives and grassroots input. "A large portion of my current Extension program involves working with the GBSTF," says Karla, "including educational outreach to local organizations describing our activities, as well as organization and coordination of our grant-funded projects. We currently are collecting water quality and soils data from various areas within the Valley to better characterize selenium levels and distribution. We also recently have received monies to study the impacts of increasing suburban development on selenium loading to the Gunnison River, and to develop a 'Phytoremediation Project' using poplar trees and other selenium-accumulating crop species to remove selenium from local agricultural soils."

Karla's program also addresses the high level of fecal coliforms in the Uncompahgre River. With the Colorado Department of Public Health and Environment, she is writing a grant to further monitor and characterize fecal coliform loading to the Uncompahgre River. She also will conduct several water quality demonstration projects at local dairies that are constructing new and improved waste management structures. By monitoring the water quality of the adjoining drainages, she will try to document the water quality improvements associated with installation of waste management BMPs and containment structures.

A large part of Karla's program involves basic educational outreach concerning water issues in the local community. "This Spring, I will participate in local water festivals for 5th-grade students that are offered in the Tri-County area. Children will hear a brief presentation on selenium and water quality, and then will be invited to play an interactive game of 'Selenium Plinko,'" she says. "I am also planning a Water Education Workshop for local teachers grades 5-8 in mid-April." "Water is a hot issue here," says Karla, "and I have the opportunity to work with a lot of concerned and committed people."

Karla can be contacted at:

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**THE UPPER SOUTH PLATTE WATERSHED PROTECTION AND RESTORATION PROJECT:
FINDINGS OF THE LANDSCAPE ASSESSMENT**

by David L. Hessel

The Upper South Platte Watershed Protection and Restoration Project was proposed in August of 1998 by Denver Water, Colorado State Forest Service, the Environmental Protection Agency, Colorado State University and USDA Forest Service. The project responds to concerns about future catastrophic disturbances in the watershed as well as natural resources in need of restoration. Three issues are being addressed to respond to these concerns:

- landscape patterns of vegetation:
- soil development and movement:
- and water quality, quantity and aquatic habitats.

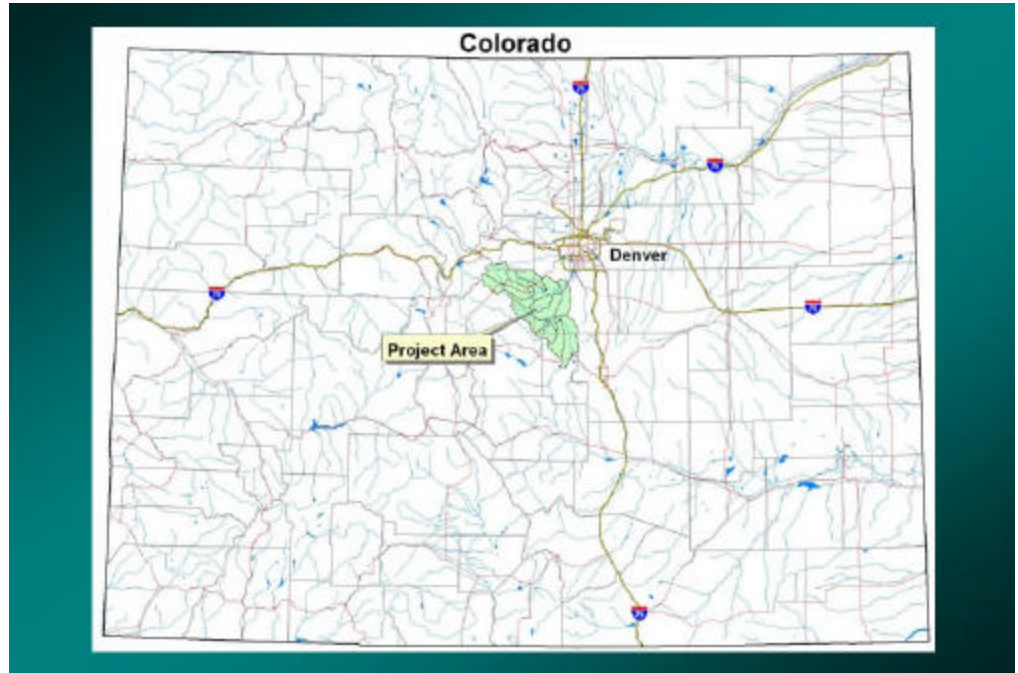
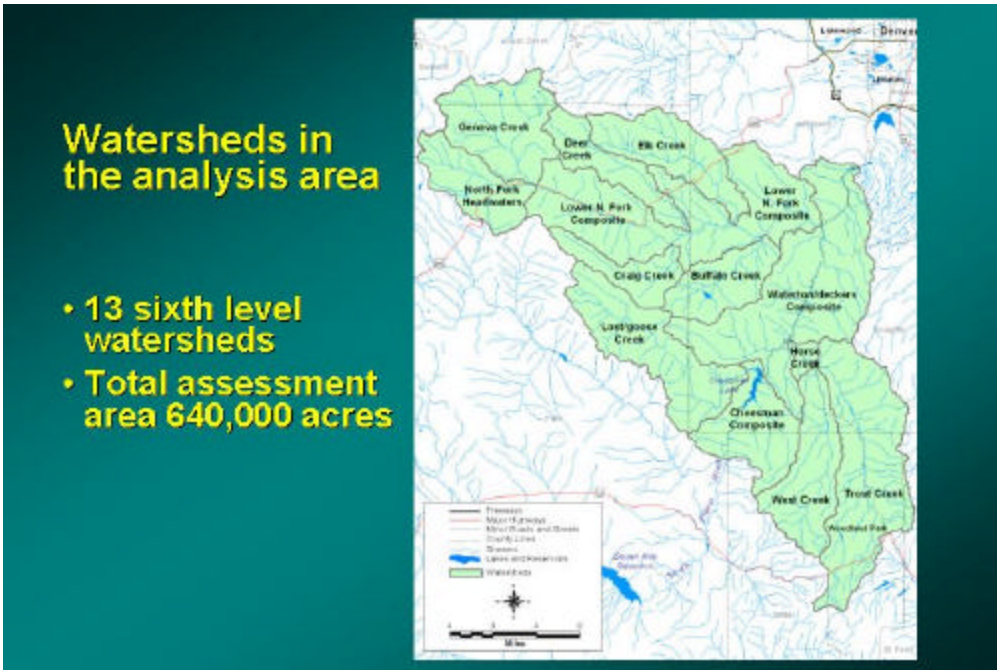


Fig. 1. Assessment area location within Colorado



The first project objective was to develop a landscape assessment for a 640,000-acre area, involving 13 sixth-level watersheds in the Upper South Platte Basin. This assessment was accomplished in just three months through a Colorado State University contract to Foster Wheeler Environmental Corporation. The contract was completed in August of 1999.

The initial article in the *Colorado Water* February 2000 newsletter presented an overview of the project. This article will focus on the assessment's findings and recommendations.

Fig. 2. The landscape assessment area, with the thirteen sixth level watersheds



THE LANDSCAPE ASSESSMENT

The goal of the assessment was to identify and prioritize restoration opportunities that can be used to plan management of the watershed resources. Because forest vegetation appears to not be in a sustainable condition in portions of the Upper South Platte Watershed, the landscape assessment focused on identifying areas where forest vegetative restoration opportunities exist.

The next step was to recommend forest restoration activities to maintain or restore watershed functions, particularly to reduce the extent and intensity of disturbances such as the Buffalo Creek Fire, and to strengthen the resilience of the watershed when such events should occur.

The focus for the identification of restoration opportunities was to look for areas that are not functioning in a manner that could be sustained as evidenced by their historical or pre-European condition. The recommended management strategies will be to reduce the extent of catastrophic

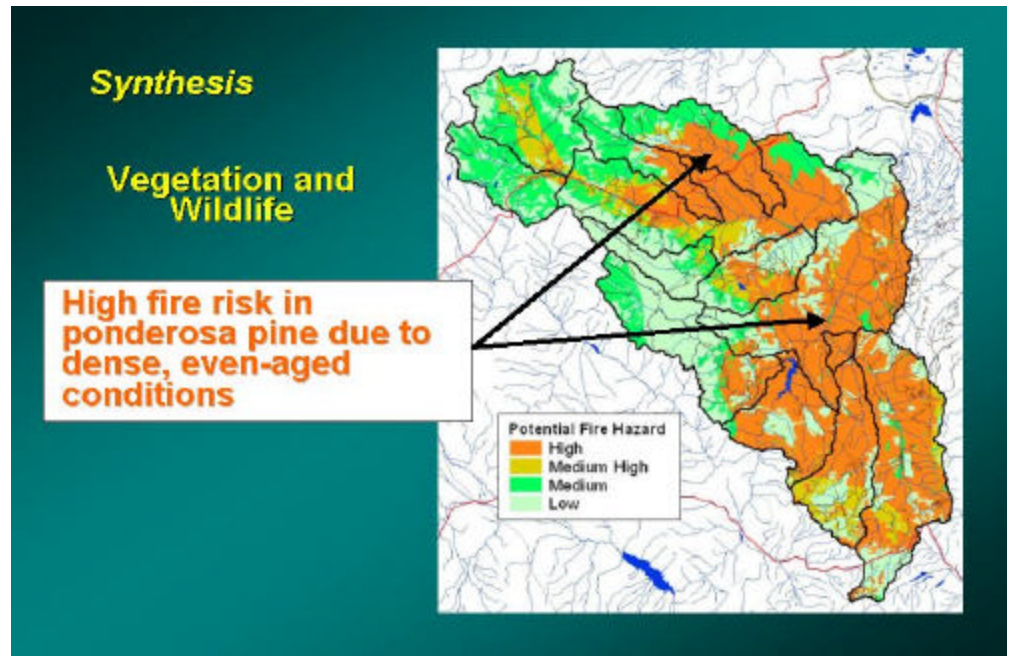


Fig. 3. Synthesis map of vegetation/wildlife .

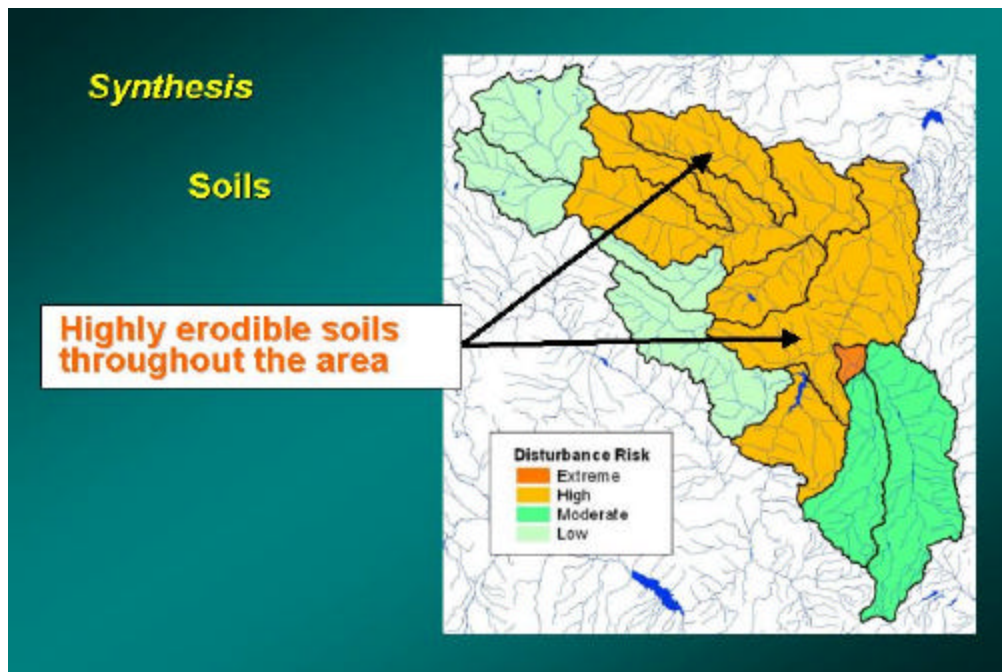


Fig. 4. Synthesis map of soils

events, prevent excessive erosion, and to both protect and improve the current watershed condition.

The Upper South Platte Watershed Landscape Assessment focused on issues that had been defined by the interagency partners as most critical to protection of the watershed. These issues concerned forest vegetation, soil erosion and transport. The assessment was limited to these concerns and not intended to address all resource issues.

The issues studied in detail in the landscaped assessment included:

Landscape patterns of forest vegetation;

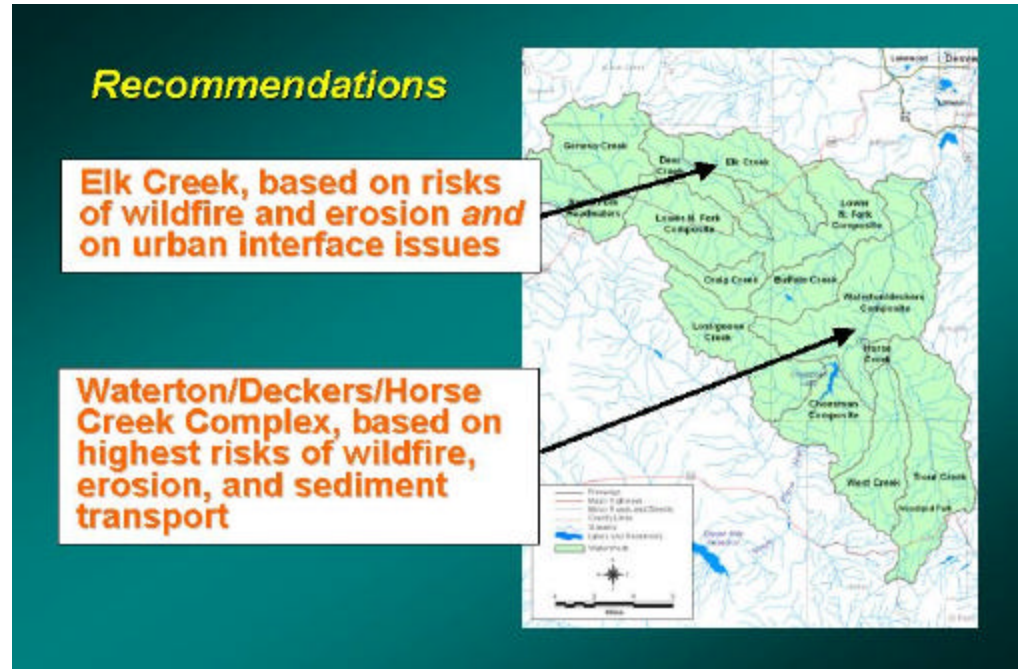


Soil development and movement; and
Water quality, quantity and aquatic habitats.

The Assessment consisted of six planning steps:

- ◆ Step 1. Characterization of the Watershed.
- ◆ Step 2. Issues and Key Questions.
- ◆ Step 3. Current Conditions.
- ◆ Step 4. Reference Condition.
- ◆ Step 5. Synthesis.
- ◆ Step 6. Recommendations.

Fig. 5. Synthesis map of water-recommended project areas



FINDINGS AND RECOMMENDATIONS

The landscape recommendations had two goals:

- ◆ Reduce the probability of fires of the magnitude of Buffalo Creek or larger, and
- ◆ Create/restore forest conditions that are sustainable.

The assessment ranked the thirteen sixth-level watersheds by combining the three issues into a landscape synthesis resulting in prioritization of watersheds for restoration management. The synthesis clearly showed that the Waterton/Deckers (Wigwam Creek watershed area was not included) and Horse Creek Watersheds consistently ranked higher than the others did. These watersheds were followed in order by the Lower North Fork, Cheesman, and Elk Creek sixth level watersheds.

The Steering Committee for the Upper South Platte Watershed Project recommended to the Forest Service Regional Forester Lyle Laverty and State Forester Jim Hubbard that the project (over next 4 to 5 years) be in the Waterton/Deckers and Horse Creek sixth level watersheds. The Committee also recommended a separate project effort be initiated in the Elk Creek sixth level watershed. This watershed not only had a high ranking in the assessment for restoration but also includes urban interface issues. This watershed involves mostly state and private lands. Thus the issue of public safety and private development was added as a risk element, not addressed in the assessment. The Regional and State Foresters excepted these recommendations.

The three volumes of the Upper South Platte Watershed Landscape Assessment can be found on the Web site at <http://www.colostate.edu/depts/csfs/>. For more information contact either Fred Patten, Pike National Forest, Phone 303/275-5639, email fpatten/r2psicc@fs.fed.us or Dave Hessel, Colorado State Forest Service, Phone 970/491-7546, email dhessel@lamar.colostate.edu

MEETING BRIEFS

A New Millennium of Miracles or ??? was the theme of the Colorado Water Congress Annual Meeting held in Northglenn January 26-28, 2000. Water managers and users from across the state assembled to attend issue-oriented workshops and to hear the perspectives of local, state and national water leaders as a new year and a new millennium begins.

Sara Rathburn, graduate student in the Department of Earth Resources at Colorado State, attended the meeting and presents her views below as a student of water resources and prospective future water professional.



THE VALUE OF ATTENDING CWC MEETINGS: A STUDENT'S PERSPECTIVE

*by Sara Rathburn, Graduate Student
Earth Resources, Colorado State University*

In January I attended one day of the three-day 42nd Annual Colorado Congress (CWC) Convention in Northglenn, Colorado. Prior to the meeting, I had no knowledge of CWC, and the word 'congress' conjured images of elected individuals legislating water laws that were outside my realm of thinking as a graduate student in the Department of Earth Resources at CSU. Dr. Robert Ward suggested I attend, thinking that my dissertation research would be of interest to meeting participants and that the session topics were pertinent to my growth as an emerging water resource professional.

The drive to Northglenn with Dr. Ward furnished me with another interpretation of the word 'congress,' and a history of CWC, which is a lobbying organization that strives to resolve water issues on the state level. CWC is comprised of members that range in profession from engineers to educators, with the common interest being water issues within the state of Colorado. Included in the meeting sponsors is the Colorado Water Conservation Board, comprised of state-appointed individuals with one representative from each of the state's drainage basins.



Peter Evans, Director, Colorado Water Conservation Board, and Jennifer Gimbel, Attorney General's Office, at the New Millennium CWC Annual Meeting.

Approximately 275 people were in attendance at the annual meeting. In the morning, I attended sessions discussing water challenges of the new century, and storing water in gravel pits, an alternative to building additional storage sites requiring dams. During lunch I enjoyed conversations with my table members from the Bureau of Reclamation, currently involved in EIS preparation and outreach education (an area I don't automatically associate with the USBR), and employees of the Colorado River Water Conservation District, participating in water projects in 15 counties in western Colorado.

The luncheon speaker was Governor Bill Owens. The keynote address by Attorney General Ken Salazar described fascinating water court cases. Following the keynote address, there were presentations by Rita Schmidt Sudman, Executive Director of

California's Water Education Foundation; and Dan Smith, University of Denver law professor; who discussed the referendum process and its effect on state-level legislation. In the afternoon, I attended a Colorado Water Conservation Board planning-issues session.

The evening social provided a comfortable forum for meeting people and exchanging ideas. It was clear that the individuals attending the meeting are knowledgeable about the many critical issues affecting Colorado water, and everyone I talked with was pleased to discuss their area of expertise and asked questions about mine. It was also clear that too few students, undergraduate and graduate, were present at the meeting, particularly given the strong water

research that is conducted within Colorado universities. Students working in any aspect of water need to know of the existence of the Colorado Water Congress and the Colorado Water Conservation Board, first as vast sources of information, then as key contact people for job possibilities and in-depth understanding of water management in Colorado.

I would like to thank Dick MacRavey, Executive Director of the Colorado Water Congress, and Dr. Robert Ward for encouraging student participation at the CWC meeting. The next annual meeting is January 2001. Check the web site (www.cowatercongress.org) for information and plan on attending!



GROUNDWATER ISSUES EXAMINED AT OGALLALA AQUIFER SYMPOSIUM – 2000

The Ogallala Aquifer Symposium 2000 was held February 18, 2000, on the campus of Northeastern Junior College in Sterling, Colorado. Sessions had titles such as "Why do we need to manage our water?" and "What is the future of our water?". In the opening session, Justice Greg Hobbs and State Engineer Hal Simpson presented excellent summaries of Colorado's groundwater laws and administration. Below are summaries of the two presentations.

GROUND WATER LAW IN COLORADO

by Greg Hobbs

Colorado Supreme Court Justice

Between 1943 and 1969, the use of tributary groundwater rose dramatically as surface irrigators and municipalities (particularly in the South Platte and Arkansas River Basins) discovered that wells were an efficient means of diversion and were not then subject to curtailment administration in the same manner as surface diversions.

The 1943 Adjudication Act¹ recodified the provisions of Colorado's adjudication law, provided a mechanism for supplementary adjudication and transfers of water rights to



Mahdi al Khasi, Jon Altenhofen and Mike Gross share light moment during the Ogallala Aquifer Symposium

changed uses, but made no specific mention of adjudicating rights to groundwater. In contrast, the 1969 Water Right Determination and Administration Act declared "it is the policy of this state to integrate the appropriation, use and administration of underground water tributary to a stream with the use of surface water in such a way as to maximize the beneficial use of all of the waters of this state."²

Knowledge of groundwater and its impact on surface rights grew in the years between the 1943 and the 1969 Adjudication Acts. As out-of-priority pumping of groundwater connected to surface streams came to be recognized as a significant detriment to surface supply, the Colorado Supreme Court, in 1951, articulated a presumption that all groundwater finds its way to a surface stream and is subject to administration in priority in times of short supply. One claiming that groundwater is not tributary has the burden of proving that fact by clear and convincing evidence.³ The Court also held that a well user must sink a tributary well to a reasonable depth and cannot command the level of the aquifer by fixing the point of withdrawal at a shallow depth. However, when the well is at a reasonable depth, a junior may be required by decree to bear the expense of providing the senior with an adequate means of diversion if the junior's lowering of the water table will cause the senior well to fail.⁴



In 1965, the General Assembly adopted the Groundwater Management Act,⁵ thereby providing the State Engineer with the authority to issue, condition against injury, or deny permits for any diversion effectuated by means of a well. The Act also established the means for designating groundwater basins to be managed by local groundwater districts, subject to the authority of the Ground Water Commission. Designated groundwater basins are those wherein aquifers with modest recharge and attenuated connection to the stream system are the main source of an area's water supply, such as the Ogallala Aquifer.⁶

The legislature authorized the Commission to create designated ground water basins⁷ for the purpose of: (1) allocating water for economic development that is essentially unavailable to fill decreed surface rights; (2) restricting depletions of this ground water to reasonable conservation levels; and (3) establishing priorities through operation of completed permitted wells to the extent of actual beneficial use. See *Peterson V. Ground Water Comm'n*, 195 Colo. 508, 513, 579 P.2d 629, 632-33 (1978); *Thompson v. Colorado Ground Water Comm'n*, 194 Colo. 489, 494, 499, 575 P.2d 372, 376, 380 (1978).

The General Assembly chose a modified system of prior appropriation for the establishment and administration of rights to use designated ground water. See § 37-90-102(1), 10 C.R.S. (1999). It intended this modified appropriation system to: (1) permit full economic development of designated ground water resources; (2) protect prior appropriations of designated ground water; and (3) protect

and maintain reasonable ground water pumping levels, but not to require the maintenance of historical water levels.

In contrast to the constitutional doctrine of prior appropriation, whereby the appropriators of the waters of the natural stream themselves allocate the available supply by making beneficial use of unappropriated water, the Commission allocates the waters of designated ground water basins by permit, pursuant to the 1965 Act, and, in particular, sections 37-90-107 and 37-90-108, 10 C.R.S. (1999). See *Larrick v. District Court*, 177 Colo. 237, 239-40, 493 P.2d 647, 648 (1972).



Greg Hobbs

With the advent of conjunctive use of tributary groundwater and surface water, the maximum utilization of the waters of the state, through vested rights, was heralded as Colorado's constitutional water law doctrine.⁷ Wells which make out-of-priority diversions must replace their depletions by an approved substitute supply or augmentation plan to enable continued operation.⁸

Non-tributary water is not part of the "natural stream" to which the Colorado Constitution's appropriation provisions apply. It is subject instead to the plenary power of the Legislature with regard to its allocation and use.⁹ The General Assembly has provided for the establishment of non-tributary groundwater rights according to surface land ownership. Non-tributary ground-water rights become vested rights either by construction of a well or an adjudication, with the amount of authorized withdrawals based upon a 100-year life of the non-tributary supply and the acreage amount of surface ownership.¹⁰ Certain Denver Basin deep groundwater formations are the subject of provisions requiring some augmentation of the surface stream; these bear the confusing designation "not non-tributary."¹¹

The Legislature has provided that small-capacity wells, which draw from tributary aquifers for domestic single household purposes, may divert under a presumption of non-injurious effect to other rights. These wells may be adjudicated with a date of priority relating back to issuance of their permit for the purpose of seeking protection vis-à-vis water rights that are junior to them.



References

- ¹ Adjudication Act of 1943, ch. 190, 1943 Colo. Sess. Laws 613 (codified at COLO.REV.STAT. §§ 148-9-1 to 27 (1963), repealed by The Water Right Determination and Administration Act of 1969, ch. 373, 1969 Colo. Sess. Laws 1200, 1223.) § 37-92-102(1)(a)(1997).
- ² The Water Right Determination and Administration Act of 1969, ch. 373, 1969 Colo. Sess. Laws 1200, 1220 (codified as amended at COLO. REV. STAT.
- ³ See Safranek v. Town of Limon, 228 P.2d 975,977 (Colo. 1951).
- ⁴ See City of Colorado Springs v. Bender, 366 P.2d 552,555 (Colo. 1961).
- ⁵ COLO. REV. STAT. 126 §§ 37-90-101 to -143 (1997).
- ⁶ See Colorado Ground Water Comm'n v. Eagle Peak Farms, Ltd., 919 P.2d 212, 215 (Colo. 1996); Danielson v. Vickroy, 627 P.2d 752, 756 (Colo. 1981).
- ⁷ See Fellhauer v. People, 447 P.2d 986, 994-95 (Colo. 1968).
- ⁸ See COLO REV. STAT. §§ 37-90-137(2), 37-92-305(5),(6),(8)(1997).
- ⁹ See State v. Southwestern Colo. Water Conservation Dist; 671 P.2d 1294, 1316 (Colo. 1983).
- ¹⁰ See COLO. REV. STAT. § 37-90-137(4)(1997); Bayou Land Co. v. Talley, 924 P.2d 136 (Colo. 1996).
- ¹¹ See COLO. REV. STAT. § 37-90-137(9)(c)(1)(1997). (The definition of 'not non-tributary' is found at COLO. REV. STAT. § 37-90-103(10.7). "Not non-tributary ground water" means ground water located within those portions of the Dawson, Denver, Arapahoe, and Laramie-Fox Hills aquifers that outside the boundaries of any designated ground water basin in existence on January 1, 1985, the withdrawal of which will, within one hundred years, deplete the flow of a natural stream, including a natural stream as defined in sections 37-82-101(2) and 37-92-102(1)(b), at an annual rate of greater than one-tenth of one percent of the annual rate of withdrawal").

ADMINISTRATION OF GROUND WATER IN COLORADO

by Hal D. Simpson

**Colorado State Engineer and Executive Director,
Colorado Ground Water Commission**

Under the 1965 law, the Colorado Ground Water Commission now has 12 members. Nine of those are appointed by the Governor and confirmed by the Senate. Six of them are to be resident agriculturists from within the designated basins, one from Water Division 3, and two to represent municipal and industrial interests, one of these to be from Western Colorado. The three ex-officio members on the Commission are: the Executive Director of the Department of Natural Resources, the State Engineer (non-voting), and the Director of the Colorado Water Conservation Board (non-voting).

The Commission, to date, has created eight designated ground water basins. The Kiowa-Bijou Basin is the first basin formed in February 1966. Upper Crow Creek Basin is the last basin formed in February 1987. Within these eight basins, the Commission has approved a total of 13 ground water management districts.

The Commission formed the Northern High Plains Designated Ground Water Basin in May, 1966. A total of eight management districts are formed within the Basin. Six districts were formed by 1967. The East Cheyenne District was formed in 1973 and the Marks Butte District was formed in 1977. This basin has about 4,400 large-capacity wells.

The Southern High Plains Designated Ground Water Basin

was formed in September 1967. The Southern High Plains District was formed in 1974. This basin has about 1,250 large-capacity wells.

Management of the Ogallala Aquifer

The Commission has the authority to issue conditional and final well permits for all large-capacity wells. The Commission is the adjudicating entity for designated ground water while the Water Courts adjudicate surface water rights and tributary ground water rights. To appropriate ground water and to promote economic development in the Northern High Plains Basin, the Commission in 1967 adopted a depletion policy criteria to allow 40 percent depletion of the aquifer over 25 years. The Commission also adopted the three-mile radius circle approach to implement this policy. The Commission revised the depletion policy in 1990, which for new appropriations limited the aquifer depletion to 40 percent over 100 years. Under this revised criterion, this aquifer is now considered over-appropriated at most places within the basin resulting in no new large-capacity well permits being available.



Hal Simpson

The Southern High Plains Basin is still considered open for new appropriations in some areas. The Commission may grant a new large-capacity well permit in this basin, provided the well will be more than one-half mile from all other large-capacity wells withdrawing water from the same aquifer. The Southern High Plains District is beginning a study to analyze the need for a policy change to declare the basin over-appropriated.

The Act authorizes the State Engineer, and not the Commission, to grant small-capacity well permits up to 50 gpm for domestic, commercial and livestock uses. House Bill 98-1151 limited the annual volume of these well permits to five acre-feet per year, but allowed the local management district to adopt rules to lower or raise this acre-feet limit. All front-range management districts have rules limiting either gpm or annual withdrawal or both on such permits. The Arickaree, Frenchman, and W-Y Districts have rules or are in the rulemaking process to increase the five acre-feet limit.

The Northern High Plains Basin has about 4,300 irrigation wells irrigating about 500,000 acres of cropland. On an average, the aquifer is depleted about 450,000 acre-feet annually. The average water level decline is about 0.5 feet per year. Natural discharge including underflow out of the aquifer is estimated to be 340,000 acre-feet per year, whereas the natural recharge to the aquifer is estimated to be 430,000 acre-feet per year, resulting in a net natural recharge to the aquifer of 90,000 acre-feet per year. The total consumptive use, including aquifer depletion, is estimated to be 540,000 acre-feet per year. Assuming a 15-percent return flow back to the aquifer from irrigation use, gross withdrawal by the irrigation wells is estimated to be 635,000 acre-feet per year. Due to the rate of decline and the variability of saturated thickness, it is estimated that nearly 50,000 acres of irrigated land will convert to dryland farming by the year 2015. These areas will be around the edges of the aquifer where the saturated thickness is less than near the center of the aquifer.

The Commission promotes water conservation and limits any new appropriations. It is estimated that the aquifer has declined about 20 percent over a 25-year period. The Commission policy to allow only 40 percent depletion over 100 years basically eliminates granting any new large-capacity well permits within the Northern High Plains Basin. For any new ground water uses, for example, to find water for the growing swine industry in the area, an applicant may have to apply to change the use of an irrigation well to commercial use. The Commission will allow such a change of use of a well, provided the change

does not result in an increased consumptive use of water.

The Commission is making a strong effort to stay away from the "use it or lose it" philosophy. The Commission has created a water conservation program, which prevents the owner of a well from being penalized for lack of use of the well. In any given year by registering the well in this program, the well owner will exclude that year's low or zero use in computing the average historic use of the well. Economics generally controls the water usage. Increasing power costs have encouraged irrigators to switch to LEPA sprinkler systems, resulting in large savings of energy and some saving of water by way of reduced evaporation. The Federal Farm Program may have a major impact in the future on what lands are irrigated and what crops are raised. Also, the 1965 Act allows the local management districts to adopt rules to curtail future withdrawals from existing wells in order to manage the ground water resources in the District. It is hoped that ongoing water conservation measures, the Federal Farm Program, and if necessary, the future water curtailment measures, would all help to prolong the aquifer's life.

The Colorado Water Quality Control Commission within the Colorado Department of Public Health and Environment is the state agency responsible for water quality policy and rulemaking. The Ground Water Commission, the State Engineer and the local ground water management districts are also the interested parties to preserve the water quality of the Ogallala aquifer. Under the Senate Bill 126 program, the state, in cooperation with the local ground water management districts, completed a water quality monitoring study in 1999 to provide baseline data. This survey of water quality indicates that the aquifer has good-quality water with a few samples having nitrates in excess of 10 ppm. Furthermore, these entities hope to develop an ongoing water quality-monitoring program for the Ogallala aquifer in the near future to monitor water quality changes.

Future Issues

A serious issue that is now just developing is the litigation now underway in the U.S. Supreme Court, where Kansas has alleged that Nebraska violated the Republican River Compact by allowing post-compact wells to consume more water than allowed under the Compact. The main allegation is that the use of the Ogallala aquifer water depletes the flows of the Republican River and its tributaries in Nebraska. If Kansas is successful in its litigation, the use of the Ogallala aquifer in Colorado and Kansas also could be impacted. This action was brought by Kansas last year and the Supreme Court appointed a Special Master on

November 15, 1999 to conduct hearings and provide the Court with his recommendations. Special Master Vincent McKusick will establish a schedule for this litigation to move forward. He will have to hold hearings on the motion by Nebraska to dismiss the litigation, because Nebraska argues the Compact did not apportion that ground water. Depending on the outcome of this motion, we will know how to proceed in protecting Colorado's water users in the Republican River Basin, including the large number of Ogallala well owners.

There has been considerable discussion in recent years about the long-term sustainability of the Ogallala aquifer, which provides water to primarily agricultural uses in the eight states it underlies. This is a difficult issue that has not been addressed to any degree in any state. In Colorado, a large number of the wells in the Ogallala aquifer were constructed prior to the 1965 Ground Water Management Act, and a significant economy was developed dependent upon irrigation of lands that were previously dry farms. Wells constructed since 1967, after the formation of the Northern High Plains Basin, were limited by the 40-percent decline in 25 years policy, which included considering the preexisting well appropriations. By this policy, the Ground Water Commission at least made an effort to extend the life of the aquifer to some degree, which is more than most of the states using this important water resource could say.

The tightening of the policy to 40 percent

decline in 100 years was a further effort to extend the life of the aquifer. Any effort to reduce pumping and consumptive use in Colorado to the net inflow to the aquifer (90,000 acre-feet per year) will be difficult and contentious. To achieve this balance with net inflow would require that the current estimate of irrigated acres of 500,000 would have to be reduced to 83,000 acres. This is made even more difficult when the uses and actions in other states are considered. Since Colorado is on the western edge of the aquifer and is higher in elevation, ground water will flow to the east in response to pumping in down-gradient areas. It would appear that any significant effort to manage this resource for sustainability would require cooperation or consistent beneficial use policies among the eight states using this important resource.

Some states do not have any appropriation or allocation policies, which make any discussion on sustainability of the entire Ogallala aquifer most difficult.

Conclusion

The Colorado Ground Water Commission, through its allocation policies dating back to 1967 and its efforts to encourage conservation of ground water, has been recognized as one of the leading state agencies in the eight-state area for encouraging the careful management of this resource. These policies take into consideration the importance of the Ogallala water to the local communities and citizens dependent on this aquifer.



UPDATE ON WATER LEVELS IN THE HIGH PLAINS (OGALLALA) AQUIFER

by Emile Hall

The High Plains aquifer is one of the largest underground water reserves in the world. It underlies and supplies water to parts of eight states in one of the major agricultural regions worldwide. Approximately 95 percent of the water withdrawn from the High Plains aquifer is used for irrigation. The ground water levels began to decline in the 1940s when extensive ground-water irrigation began.

The amount of water in storage in the aquifer is dependent upon the formation's saturated thickness and varies from year to year depending upon discharge and recharge in a particular area. Various groups and agencies measure water

levels in the winter or early spring, when irrigation wells are not pumping, to determine current water availability and supply from the aquifer. The data from those measurements is typically available in late February.

Overall (1980 - 1997)

Each winter depth-to-water measurements are made on 5,233 wells obtaining water from the High Plains aquifer. The USGS recently issued a summary of water-level changes in the High Plains aquifer from 1980 to 1997. Overall, the declines in water level from 1980 to 1997 were less than those from predevelopment to 1980; the average

area-weighted water level in the High Plains aquifer declined 2.7 feet from 1980 to 1997 compared to a decline of 9.9 feet from predevelopment to 1980. However, declines in water levels vary on a regional scale and there are two areas showing decline of more than 40 feet between 1980 and 1997; the northern part of the Southern High Plains aquifer in Texas and New Mexico and an area south of the Arkansas River in Kansas exhibited the most drastic decreases in water levels. Still, the average rate of decline in the Southern High Plains before 1980 of 3.7 feet per year decreased to an average rate of 1.6 feet per year from 1980 to 1997. A decrease in water withdrawals for irrigation (18.0 million acre feet in 1980 and 15.7 million acre feet in 1990) and an increase in precipitation contributed to the smaller rate of decline. For more information see USGS fact sheet 124-99, December 1999.

Colorado (Northern High Plains Designated Ground Water Basin)

Between late December 1999 and February 15, 2000, 656 wells in eastern Colorado were measured. (See <http://waterknowledge.colostate.edu/hiplains.htm> for a map). Measurements are made each year in approximately the same month and over a short time span to more accurately reflect the true groundwater conditions. Throughout the Northern High Plains water levels continue to show a regional decline. Overall, between 1998-1999 the water levels fell 0.33 feet as compared with a decrease of 0.51 feet between 1999-2000. Since 1991 water levels decreased 4.58 feet with an average decrease each year of 0.46 feet. According to the Office of the State Engineer's report, a decline of 1 foot is equal to a depletion from storage of approximately 900,000 acre-feet. The report states that, "Over the past 10 years (1991 to 2000), the basin-wide water level has declined approximately 4.58 feet, representing a depletion of approximately 4,500,000 acre-feet or 4 percent of the estimated 1965 storage in the aquifer." In the past year, the overall decline of 0.51 feet means that approximately 460,000 acre-feet have been removed from storage in the Northern High Plains Designated Basin since the last measurement in December 1999.

Kansas

Each January the Division of Water Resources of the Kansas Department of Agriculture and the Kansas Geological Survey measure water levels on 1,400 wells. This year's raw data from those measurements is available on the net at

<http://magellan.kgs.ukans.edu/WaterLevels/CD/index.htm>, and a technical report will be produced later this year.

Texas

The High Plains Underground Conservation District No. 1 covers portions of 15 counties in the upper part of the Southern High Plains aquifer in the Texas panhandle. The district makes depth-to-water measurements in a network of more than 1,200 wells in the Spring of each year. The average annual change in water levels within the fifteen county area was a decrease of 0.34 feet in 1997 (1998 measurements) and a decrease of 2.15 feet in 1998 (1999 measurements). The 1999 (growing season, early 2000 measurements) values are being tabulated and will be published in the district's newsletter. Contact info@hpwd.com for 1999 water levels.

*To order the USGS fact sheet 124-99 contact USGS, Water Resources Division, 100 Centennial Mall North, 406 Federal Building, Lincoln, NE 68508, telephone - 402/437-5663. Obtain **Ground water levels: Northern High Plains Designated Ground Water Basin** by contacting the Colorado State Records Section at 303/866-3447.*

*Sources: **Water Levels in the Northern High Plains Designated Ground Water Basin**, by George VanSlyke, Project Manager, Colorado Division of Water Resources, Office of the State Engineer. February 2000; USGS fact sheet 124-99; Kansas water website:*

<http://magellan.kgs.ukans.edu/WaterLevels;>

High Plains Underground Water Conservation District:
info@hpwd.com or

<http://www.hpwd.com>

Find out about watershed efforts in Colorado –

Access the Colorado Water Knowledge homepage at <http://waterknowledge.colostate.edu> and learn about Colorado's watershed efforts across the state. If you have information about a watershed effort that is not on the webpage, contact the Colorado Water Resources Research Institute by phone 970/491-6308, fax 970/491-2293 or e-mail at cwrri.colostate.edu.



Colorado Water
Resources Research Institute

CU Water News



RESEARCHERS SEEK ANSWERS TO COMBAT WORLD'S STRESSED FRESHWATER SUPPLY

A multi-pronged analysis of global water resources indicates the supply of clean freshwater for use by humans and natural ecosystems is shrinking by the year, according to Ken Strzepek, a University of Colorado researcher. Strzepek, of the Civil, Architectural and Environmental Engineering Department, said the analysis indicates one-third of the world's population is currently living in regions that are classified as "water stressed." And, as the human population grows, more water will be needed for irrigation, livestock, industry and to sustain natural ecosystems. He estimates that under a 'business as usual' scenario, by the year 2025, almost one-half of the population will be living in water-stressed regions.

Strzepek and his colleagues have used sophisticated computer models and geographical information systems to look at river

basins around the world and identify those that are the most stressed. Some of the "hot spots" include China's Yellow River basin, Africa's Zambeze River basin, the Syr Darya and Amu Darya River basins leading to Russia's Aral Sea and the Colorado River basin.

The modeling tools have allowed Strzepek and his colleagues to look at the vegetation, soils and climate from the headwaters to the mouths of the world's major river systems in 25 mile-square chunks to model runoff and streamflow. They also have been able to use past temperature and precipitation data to reconstruct runoff and streamflow data for major river basins going back 100 years.

His research is part of a background analysis for the World Water Commission's "World Water Vision for the 21st

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UNIVERSITY OF COLORADO NATURAL RESOURCES LAW CENTER

**ENVIRONMENTAL JUSTICE
IN NATURAL RESOURCES WORKSHOP**
Tattered Cover Bookstore, LODO (Denver)

Public Presentations/Forum

Friday, April 14, 2000

9:30 a.m. - 5:30 p.m. Presentation of Papers

7:30 a.m. - 9:30 p.m.

Working Session

Saturday, April 15, 2000

9:30 a.m. - 5:30 p.m. Discussion of papers and project

7:30 p.m. - 9:00 p.m. Keynote Address

*Worlds of Possibility: Exploring Ethnicity
in Environmental Thought*

Patricia Limerick, Center of the American West

Workshop is free except for optional box lunch on Friday (\$10); 6 General CLE Credits (\$30) (applied for). Please contact the Center for details, (303) 492-1286.

**"WATER AND GROWTH
IN THE WEST"**
Boulder, Colorado
June 7-9, 2000

The 21st annual summer conference of the Natural Resources Law Center at the University of Colorado-Boulder will focus on Water and Growth in the West. The event, scheduled for June 7-9, will cover a breadth of issues, including demographics and water-use trends, improved planning and efficient use, implementation of TMDL and ESA requirements, groundwater management, tribal water resources, environmental protection, social costs of water transfers, climatic variability, and related issues. The third day of the event focuses exclusively on Colorado water issues, and is available for separate registration.

For more information, contact the Natural Resources Law Center: at 303/492-1272; e-mail to nrlc@colorado.edu, or see the NRLC webpage at <http://www.colorado.edu/Law/NRLC>.



Colorado Water
Resources Research Institute

CU Water News



UNIVERSITY OF COLORADO
NATURAL RESOURCES LAW CENTER

'HOT TOPICS' Luncheon Program Series

Friday, May 5, 2000

Prairie Wind Power for the 21st Century: Renewable Energy Development on Indian Reservations

Bob Gough, El Paso Energy Corporation Law Fellow, Natural Resources Law Center

Cost: \$13 by May 2, \$16 after May 2, CLE credit is \$5 additional.

Program will be held at the offices of Holland & Hart, 555 17th Street, Denver, beginning at noon. Box lunches are provided, one hour of CLE credit is offered. Call the Natural Resources Law Center to register at (303) 492-1272.

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Century" report. The commission is a government and privately funded organization seeking global solutions to water problems.

Strzepek gave an invited talk on the subject at the annual fall meeting of the American Geophysical Union held Dec. 13 to Dec. 17 in San Francisco. He has been working on the project with CU graduates Alyssa Holt of the Stockholm Environmental Institute and Jeff Bandy of the University of Leuven in Belgium.

While reservoirs have long been used to change the distribution of river flows, evaporation can result in losses up to 25 percent of a river's annual flow in arid and semi-arid years. Today, 70 percent of the world's freshwater withdrawn by humans is used to irrigate crops, he said. Unfortunately, much of the irrigation water takes up pesticides, herbicides and salts from cropland soil and returns to the river system, polluting the water and adversely affecting humans and the environment.

"In the Nile Delta in Egypt, water quality is a major problem for human and agricultural use due to upstream pollution from agricultural, industrial and municipal uses," Strzepek said. "Similar situations are found in other river systems like the Indus River in Pakistan and the Yellow River in China."

A sustainable water supply is determined by the nature of a river basin's hydrology and storage capacity. While more

dams provide more water for humans, they cause environmental impacts, he said. Researchers factoring in some knowledge of aquatic ecosystems have set a goal that no more than 40 percent of a river basin's water should be diverted for human use in order for the environment to be adequately protected, he said.

"In the Colorado River basin, however, 100 percent of the water is used," Strzepek said. While the average flow in the basin is 15 million acre-feet per year, only 1.5 million acre feet is delivered annually to Mexico and only a trickle remains as the Colorado River enters the Gulf of California in Mexico.

Strzepek said that developing sustainable water policy requires experts to gain input from "stakeholders" in the river basins regarding their own cultural and social values on sustainability. "In developing countries, especially in arid and semi-arid regions, this means involving women more in the water-management decision process. They are the primary water-gatherers and often bear the heaviest load in agricultural labor," he said.

"The goal of the World Water Commission is to make water everybody's business in the 21st century and to see that the needs of nature and humans are met as we pursue the task of sustainable economic growth," Strzepek said.

Source: University of Colorado at Boulder
Contact: Ken Strzepek, (303) 492-7111

CWRRI Colorado Water
Resources Research Institute

CU Water News

WSTB Issues Report on Colorado River Ecosystem

A new report from the Water Science and Technology Board comments on the Grand Canyon Monitoring and Research Center's 1997 "Long-Term Monitoring and Research Plan." The report, "Downstream: Adaptive Management of Glen Canyon Dam and the Colorado River Ecosystem," comments on the plan's likely effectiveness. The study was funded by the U.S. Department of the Interior and chaired by James Westcoat of the University of Colorado. To order, contact the National Academy Press at 800/624-6242 or visit the website at <http://www.nap.edu>.

UNC Water News



UNIVERSITY OF NORTHERN COLORADO

During June, Dr. Jared Morrow, Assistant Professor of Geology, and Dr. Lee Shropshire, Emeritus Professor of Geology, will co-teach GEOLOGY OF THE RED ROCKS COUNTRY. The graduate-level course features a week-long canoe trip down the Gunnison and Colorado Rivers in western Colorado and eastern Utah. No previous canoeing experience is necessary. For further information contact Dr. Morrow at jrmorro@unco.edu, 970/351-2483, Department of Earth Sciences, or Dr. Lee Shropshire at klshrop@unco.edu, University of Colorado, Greeley, Colorado 80639.

Also, on some Saturdays this spring, training seminars will be presented for teachers at the Poudre Learning Center on the River west of Greeley. Contact Ray Tschillard, rltschi@unco.edu, 970/351-2291, Lab School, University of Northern Colorado, Greeley, Colorado, 80639.

CSM Water News 

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



Calibration and Uncertainty of Ground-Water Models Short Course - May 22-25, 2000

Instructor : Mary Hill, Richard Cooley, Eileen Poeter,
and Claire Tiedeman

Numerical models are used extensively to evaluate ground-water systems and to predict their response to such things as changes in pumpage and proposed remediation efforts. Because many aspects of ground-water systems are unknown, most ground-water models need to be calibrated. Calibration has historically been conducted using trial and error alone, but these methods provide less insight than can be achieved. This course teaches use of nonlinear regression and associated statistics to dramatically improve how data are used to calibrate and test ground-water models.

Polishing Your Groundwater Modeling Skills Short Course – June 6-7, 2000

Instructor : Peter Anderson and Robert Greenwald

This course is designed to provide significant detail on practical ground-water flow modeling concepts and techniques. It will explore development of conceptual models for complex sites or regions, how to convert these conceptual models to appropriate ground-water flow models, and how to apply supplemental MODFLOW modules to effectively solve such problems. This course takes the user beyond topics covered in introductory modeling courses and beyond courses that teach the mechanics of applying various pre- and post-processing software. It revolves around a series of realistic problem sets that highlight practical aspects of ground-water flow modeling. These exercises serve as a basis for comparing alternative approaches to solving various types of problems.

Applied Environmental Statistics Short Course - June 19-23, 2000

Instructors : Dennis Helsel and Ed Gilroy

This five day course develops hands on expertise for all environmental scientists who interpret data and present their findings to others. The course emphasizes: when each statistical method is appropriate; plotting and presenting data; assumptions and implications behind statistical tests; how to build a good regression model, and trend analysis with common pitfalls. Our Goal: for you to make sense of your data.

FOR INFORMATION CALL (303) 273-3103
FOR REGISTRATION CALL (303) 273-3321
VISIT <http://www.mines.edu/igwmc/>



Colorado Water
Resources Research Institute

SEMINARS AND COLLOQUIA



For listings of seminars and colloquia scheduled at Colorado State University, the University of Colorado, and the Colorado School of Mines during Spring Semester, 2000, consult the following web pages.

COLORADO STATE UNIVERSITY

Atmospheric Science	http://www.atmos.colostate.edu/seminar/semscheds00.html
Earth Resources	http://www.cnr.colostate.edu/ER/seminars/index.html
Environmental Health	http://www.cvmbs.colostate.edu/enhealth/departments/seminars2000.html
Fishery and Wildlife Biology	http://www.cnr.colostate.edu/FWB/
Forest Sciences	http://www.cnr.colostate.edu/orgs/saf/index.html http://www.cnr.colostate.edu/ASPRS/index.html
History	http://www.colostate.edu/Depts/Hist/events.html
Hydrologic and Environmental Sciences and Engineering	http://www.engr.colostate.edu/depts/ce/ , click on New & Notable.
Microbiology	http://www.cvmbs.colostate.edu/microbiology/seminar.htm
Natural Resources Ecology Lab	http://www.nrel.colostate.edu/grad_student/seminars.html
Soil and Crop Sciences	http://www.colostate.edu/Depts/SoilCrop/extension/Soils/SoilCalendar.html#Upcoming
Statistics	http://www.stat.colostate.edu/seminars.html

UNIVERSITY OF COLORADO

Center for Drinking Water Optimization	http://www.cdwo.org/
CenterWest	http://www.centerwest.org/inside/calendar.html
College of Engineering and Applied Science	http://ecad100.colorado.edu/event_calendar/results.cfm
Cooperative Institute for Research in Environmental Sciences	http://cires.colorado.edu/announcements.html
Environmental Engineering	http://civil.colorado.edu/web/grad/environ/announce/index.html
Environmental Population and Organismic Biology	http://www.colorado.edu/epob/events/colloq_s00.html
Geography Department	http://www.colorado.edu/geography/gif/colloq.gif
Geological Sciences	http://www.colorado.edu/IBS/news/colloquia.html
Institute of Arctic and Alpine Research	http://instaar.colorado.edu/events/gradtalk.html
Institute of Behavioral Science	http://www.colorado.edu/IBS/news/colloquia.html
Natural Resources Law Center	http://www.colorado.edu/law/NRLC/events.html

COLORADO SCHOOL OF MINES

Chemical Engineering	http://www.mines.edu/Academic/chemeng/seminar.shtml
Geology and Geological Engineering	http://www.mines.edu/Academic/geology/van_tuyl/van_tuyl.shtml
Economic Geology	http://www.mines.edu/Stu_life/organ/seg/

RESEARCH AWARDS AT COLORADO UNIVERSITIES

A summary of research awards and projects is given below for those who would like to contact investigators. Direct inquiries to investigators 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, CO 80523

Title	PI	Dept	Sponsor
The Wyoming Basins Ecoregional Plan (TNC)	Klein, Mary	FWB	Nature Conservancy
USDA National Needs Fellowships in Water Science	Loftis, Jim C.	CWRRI	USDA-CSREES
Long-term Ecological Research on the Luquillo 'Experiment Forest	Parton, William J	NREL	Univ. of Puerto Rico
TRMM Precipitation Radar & Microphysics: 'Interpretation & Precipitation Estimation	Venkatachalam, C.	Elec.&Computer Engr.	NASA
Studies of Ice Nucleating Aerosol 'Particles in Arctic Cloud Systems	Rogers, David C	Atmos. Science	NASA
Application of LES to Understanding and 'Parameterizing the Arctic Cloudy Boundary Layer	Cotton, William R	Atmos. Science	NASA
Spatial Integration of Regional Carbon Balance 'in Amazonia	Denning, A Scott	Atmos. Science	NASA
Ecological Effects of Reservoir 'Operations on Blue Mesa Reservoir	Johnson, Brett M	FWB	DOI-USBR
Relations Between Ice Nuclei and Ice 'Formation in Clouds	Rogers, David C	Atmos. Science	NSF
Stochastic Analysis Modeling & Simulation	Salas, Jose D	Civil Engr.	DOI-USBR
Arkansas River Basin Watershed Forum	Valliant, James C	Cooperative Ext.	DOI-USBR
Towards a Multisensor Approach to Improve on 'Current Tropical Rainfall Measurement Mission . . .	Stephens, Graeme L	Atmos.Science	NASA
TRMM Precipitation Radar & Microphysics: 'Interpretation & Precipitation Estimation	Venkatachalam, C.	Elec.&Computer Engr.	NASA
Joint Research Studies on Earth-Atmospheric 'Problems	Stephens, Graeme L	Atmos. Science	NASA
Tropical Tropospheric Dynamics	Schubert, Wayne H	Atmos. Science	NSF
Use Improved Cloud Parameterization for Use in . . . f ARM Data to Develop & Test	Randall, David A	Atmos.Science	DOE
Application of Sewage Sludge to Dryland 'Wheat	Barbarick, Kenneth A	Soil & Crop Sciences	City of Littleton
Assessment of Sediment Quality Criteria for Heavy 'Metals	Clements, William H	FWB	Wright State Univ.
Cloud Studies with an Airborne Cloud 'Radar	Stephens, Graeme L	Atmos. Science	Calif. Inst. of Tech/ Jet Propulsion Lab
Altered Channel Morphology as a Result of 'Increased Urbanization & Other Land Use Changes in Watersheds	Watson, Chester C	Civil Engr.	DOD-ARMY

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

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

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

UNIVERSITY DEPARTMENTS, INSTITUTES AND CENTERS: Colorado State: BSPM-Bioagricultural Sciences & Pest Management, CBE-Chemical & Bioresource Engr., CIRA-Cooperative Inst. for Research in the Atmosphere, DARE-Dept. of Agric. & Resource Economics, FWB-Fishery & Wildlife Biology, HLA-Horticulture & Landscape Architecture, NREL-Natural Resource Ecology Lab, NRRT-Nat. Resources Recreation & Tourism, RES-Rangeland Ecosystem Science. University of Colorado: 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, 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.

Title	PI	Dept	Sponsor
Modeling Flows for Fish Habitat Maintenance - Hydraulic Modeling	Wohl, Ellen E	Earth Resources	CDOW
Chemical Heterogeneity among Fog Drop Populations & its Influence on Aerosol Processing by Fogs	Collett, Jeffrey L. Jr	Atmos. Science	NSF
State Trail Grants Review	Grunau, Lee	FWB	CO State Parks
Guidelines for Developing State & Area Long-Term Projections	Weiler, Stephan A	Economics	CO Dept of Labor
Retrieval of Properties of High Clouds from LITE data	Stephens, Graeme L	Atmos. Science	NASA
CloudSat	Stephens, Graeme L	Atmos. Science	NASA
Demonstration Erosion Control Monitoring Program 2000-2002	Watson, Chester C	Civil Engr.	DOD-ARMY-COE
Mapping Ocean Surface Winds and Current with Over the Horizon Radar	Vonderhaar, Thomas	CIRA	NOAA
Developing a Mesoscale Observing Network over the North Atlantic Continent and Adjacent Ocean Areas...	Vonderhaar, Thomas	CIRA	NOAA
Interaction of the Cloudy Arctic Boundary Layer with Variable Surface Conditions & ...	Randall, David A	Atmos. Science	NASA
Tamarisk Removal & Riparian Restoration Along Reaches of the Green River, Colorado	Cooper, David J	Earth Resources	DOI
A Modeling & Remote Sensing Study of the Radiative Heating of Clouds in Support of ARM	Stephens, Graeme L	Atmos. Science	DOE
Strategies to Reduce the Effects of Brook Trout on Cutthroat Trout Restorations	Fausch, Kurt D	FWB	DOI
Upland Irrigation Training	Podmore, Terence H	Civil Engr.	Agrodev Canada, Inc.
Developing a Decision Support System for the South Platte Basin	Ward, Robert C	CWRRRI	Various
Rio Grande & Conejos Counties Biological Assessment	Kettler, Stephan M	FWB	USFWS
Great Outdoors Colorado Program (GOCO) Fiscal Year 2000 Open Space & Local Government	Klein, Mary	FWB	Nature Conservancy
Interdisciplinary Science Investigation of Clouds & the Earth's Radiant Energy System	Randall, David A	Atmos. Science	NASA
Gulkana River Data Analysis - Alaska	Vaske, Jerry J	NRRT	DOI-BLM
The CSU-CHILL Radar Facility	Rutledge, Steven A	Atmospheric Science	NSF
Arkansas River Basin Research Study	Clements, William H	FWB	CDOW
Support for Fort McCoy Fisheries Program	Shaw, Robert B	Forest Sciences	USDA-USFS-RMRS

**UNIVERSITY OF COLORADO
BOULDER, COLORADO 80309**

Title	PI	Dept	Sponsor
A Hydro-Economic Approach to Representing Water Resources Impacts in Integrated Assessment Models	Strzepek, Kenneth	CEAE	Tufts University
Theoretical Investigations of Clouds and Aerosols in the Stratosphere and Upper Troposphere	Toon, Owen B.	LASP	NASA
A Modeling Study of Atmospheric Response to Perturbations in Greenhouse Gases with a Spectral Mesosphere/Lower Thermosphere Model	Akmaev, Rashid	Aerospace Engr.	NSF
Variations in GPS Time Series: A Study of Hydrological Loading Effects	Larson, Kristine	CIRES	NASA
Land and Land-Use Change in the Climate Sensitive High Plains: An Automated Approach with LANDSAT	Goetz, Alexander	CIRES	NASA

Title	PI	Dept	Sponsor
Enhanced Antarctic Research with LANDSAT: Ice-Sheet Dynamics, History, and Cartography	Scambos, Theodore	CIRES	NASA
Validation Studies/Sensitivity Analysis for Retrievals of Snow Albedo and Snow-Covered Area from EOS AM-1 Instruments	Nolin, Anne	CIRES	NASA
Predicting Sediment Delivery and Stratigraphy on Marginal Slopes and Shelf Basins	Syvitski, James	Geological Sciences	DOD-DON
Vernal Pool Mitigation and Endangered Species Habitat Mitigation	Collinge, Sharon	EPOB	DOD-DON
Predictability of the Coupled Ocean-Atmosphere System on Intraseasonal and Interannual Time Scales...	Webster, Peter	PAOS	NASA
Temperature Variability Since Ad 1000 in the Western US from Tree Rings	Woodhouse, Connie	IAAR	Univ. of AZ
Collaborative Research: Did the Laurentide Ice Sheet Cause Abrupt Climate Changes?	Lynch, Amanda	CIRES	Ohio State Univ.
Expanded and Lengthened Dendroclimatic Reconstructions of Great Plains Drought	Brown, Peter	IAAR	NSF
Developing a 480,000-Year Climate Record for West Antarctica	White, James	IAAR	NSF
Scaling Theories of the 3-D Geometry and Flows of River Networks	Gupta, V.K.	CIRES	NSF
Vertical Profiling of Ozone Within the Planetary Boundary Layer at Summit, Greenland	Helwig, Detlev	CIRES	NSF
A Study of the Spatial and Temporal Transitions of Climate and Ecosystems in the Circumpolar Arctic	Lunch, Amanda	CIRES	NSF
Improving the Accuracy of Satellite Sea-Surface Temperature Measurements by Explicitly Accounting for the Bulk-Skin Temperature Difference	Emery, William	CIRES	NSF
Greenland Ice Sheet Climatology and Surface Energy Balance Modeling: Greenland Climate Network	Steffen, Konrad	CIRES	NSF
Passive Microwave Snow Civer Algorithm Intercomparison and Validation	Armstrong, Richard	CIRES	NSF
Small-Grant Watershed Iniatives Program	Kenney, Douglas	Law	EPA
Two-Phase Immiscible Fluid Flow in Fractured Rock: The Physics of Two-Phase Flow Process in Single Fractures	Rajaram, Harihar	CEAE	DOE
Theoretical and Experimental Studies of Hydrological Properties of Rock Fractures During Active Deformation	Spetzler, Hartmut	CIRES	DOE
Impact of Air-Sea Interaction on Tropical Cloud Life-Cycles and Radiative Processes	Webster, Peter	PAOS	DOE
Towards the Understanding and Parameterization of High-Latitude Cloud and Radiation Processes	Curry, Judith	PAOS	DOE
Large Eddy Simulations of Coupled Atmosphere-Ocean Boundary Layers	Kosovic, Branko	PAOS	DOD-DON
Reservoir Stratigraphy and its Controls on Reservoir Architecture and Performance: An Investigation of Key Surfaces and Fabrics in Marginal Marine Environments	Pulham, Andrew	Geological Sciences	Various Oil Companies



WATER NEWS DIGEST

by Emile Hall



ALAMOSA RIVER

Returning the Alamosa to its natural course.—A section of the Alamosa River near Capulin has been rechanneled to restore its natural course. Hundreds of tons of rock were put into the streambed and shaped into weirs — formations designed to slow the river's flow and channel it back into its historic meanders. Farmers and ranchers who live along the river have, for many years, battled spring flooding and erosion, but this year they hope things will be different.

Denver Post 2/3/00



CLIMATE CHANGE

Study: World's Oceans Warming.—The oceans have warmed significantly over the past four decades, providing new evidence that the Earth may be undergoing long-term climate change, a study by government scientists says. The study shows average temperatures have increased from one-tenth to one-half degree, depending on depth, since the 1950s, an amount described as surprising. The findings, reported by scientists at the National Oceanic and Atmospheric Administration, also may support the findings of computer models that have produced temperature increases larger than those observed by surface and atmospheric monitors. The NOAA study has uncovered significant warming over the past 40 years in the oceans in depths of as much as 10,000 feet, suggesting this "missing heat" may explain the difference between the computer simulations and actual readings. The greatest warming occurred from the surface to a depth of about 900 feet, where the average heat content increased by 0.56 degrees Fahrenheit. Water as far down as 10,000 feet was found to have gained on average 0.11 degrees Fahrenheit. The study said both natural and human-induced causes were likely. Short-term climate phenomena such as the El Nino effect were discounted as a significant factor, because scientists are seeing a 35-year warming trend and El Nino occurs on a time scale of two to seven years. A U.N.-sponsored panel of more than 200 scientists has predicted that average global temperatures will increase 2 degrees to 6 degrees Fahrenheit by the end of the century if current greenhouse gas emissions are not curtailed. The Earth has warmed about 1 degree Fahrenheit over the last 100 years, according to scientists. The panel's predicted future warming is believed by many scientists to have broad economic and environmental impact including sea level rise as well as changes in agriculture and human health.

Denver Post, Associated Press 3/24/00



GROUNDWATER

Court rules groundwater management districts can enforce permits/priorities of wells.—The Colorado Supreme Court has ruled that the state's groundwater water management districts have the authority to enforce permits and priorities of wells involving the state's groundwater. Under the system outlined, the state's Ground Water Commission decides whether there is water available for a new well and whether a well permit can be issued. The local management districts then have the authority to referee disputes between well owners in their districts. The Ground Water Commission has established eight water basins in Colorado and made specific rules for each.

Denver Post 2/23/00



INSTREAM FLOW/WATER RIGHTS

Protecting the San Luis Valley.—State and federal officials have signed an agreement that protects water users and two national forests in the San Luis Valley. The settlement resolves claims filed in 1979 by the U.S. Forest Service for instream flow water rights on 303 portions of streams in the Rio Grande and Gunnison National Forests. The settlement requires the Forest Service to relinquish its earlier claims to water and accept a 1999 priority date, which would protect current water users from future claims on their water by the agency.

Associated Press, Denver Post 3/16/00

San Luis accord little help in White River water dispute.—Resolution of a water dispute regarding the Forest Service in the San Luis Valley apparently will not help those in a similar controversy involving the White River National Forest (WRNF) and others across Colorado. Officials for both the WRNF and the Colorado River Water Conservation District said the bypass-flows accord in the San Luis Valley involves circumstances unique to that region which probably would not work on other forests. The agreement, billed as the first of its kind nationally, is apparently also one of a kind. USFS claims for flows have become a contentious issue on several national forests, and resulted in a series of court decisions that leave both proponents and opponents of those flows claiming some level of victory. The issue also has become a key concern regarding the WRNF's preferred draft long-term management alternative. WRNF traditionally hasn't sought such flows but proposes them in its plan, known as Alternative D. CRWCD and other Colorado water interests oppose the bypass flows, arguing USFS should have to go through the state legal process for obtaining water rights. USFS has been demanding the bypass flows as special use permits for such purposes as ditch- and dam-building come up for renewal on forest property. Potentially, this could affect

water users, including Glenwood Springs and other cities. USFS seeks bypass flows to protect fisheries and wildlife, recreational considerations, stream ecosystems, scenery, soil conservation, range needs and fire prevention and control activities. With the San Luis agreement, most of the water sought is from the valley aquifer rather than the forest streams. Skip Underwood, director of physical resources for the Rocky Mountain Region of USFS, said demand for water is higher in other forests, which results in more USFS involvement in seeking bypass flows as part of the special use permitting process. Also, the San Luis Valley situation involved USFS claims of federal reserved water rights, in contrast to its attempts in other places merely to seek bypass flows in connection with permit issues. "It's a regulatory approach rather than a water right" in these other forests, Underwood said. Some Colorado River district board members dispute the Forest Service's argument, saying it is indeed seeking a water right even in these cases. District attorney David Hallford has said bypass flows aren't the same as a water right, but board members contend the result of the USFS action would still be that senior water rights holders would lose water. District officials, Hallford included, say legal action is likely under the water language included in Alternative D. It proposes to "acquire instream flow water rights or establish instream flow protection measures in special use authorizations which protect 10 percent of all perennial streams." Forest Service officials have said the 10 percent figure is arbitrary and suggested it is up for negotiation.

Glenwood Post 2/29/00

◆◆ WATER QUALITY

Colorado Springs will add fluoride to its water.—Citing a growing concern about tooth decay in children, the Colorado Springs City Council has approved a controversial plan to add fluoride to city water. The plan calls for Colorado Springs Utilities to add fluoride to two treatment plants that pump water to residents in the north and east areas of the city by February 2001. About two-thirds of the city's roughly 350,000 residents will receive the treated water. The City Council, which also sits as the utility board, decided fluoride's benefits outweigh any problems. The council approved the plan last fall and said it would proceed unless the public provided overwhelming evidence against it.

Colorado Springs Gazette 3/23/00

State not liable in Summitville cleanup.—So far, state and federal governments together have spent \$150 million cleaning up the Summitville Superfund site. The closed mine has poisoned stretches of the nearby Alamosa River with runoff carrying cyanide and heavy metals. The state and nation are jointly suing the mining companies for relief in the cleanup cost. Summitville Consolidated Mining Co., Inc. is only one of several defendants in the government's suit for compensation. While the state has been absolved of financial obligation, the federal government still could end up footing part of the cleanup. The suit could now be headed for a trial. Some local farmers and ranchers say a \$150 million cleanup of the polluted Summitville mine Superfund site has done little to restore the Alamosa River, which they use to sustain their crops and livestock. "We want to see the draft address the entire watershed," said Cindy Medina, head of the Alamosa Riverkeepers Alliance. Medina contended the report doesn't address contaminated sediments in area reservoirs, contaminated water downstream of the reservoirs or groundwater pollution at the mine. A state report says water quality in the Alamosa River downstream from Summitville has improved significantly since cleanup began, but fish and other forms of aquatic life remain at risk. Area ranchers and farmers, however, said there are other problems. "Summitville acid ate all my culverts, and I don't even want to put the water on my alfalfa," farmer Pete Quintana said.

Associated Press-Loveland Reporter Herald 4/2/00, *Denver Post* 2/19/00

Agencies can't agree on bill for Rifle water.—Local and federal officials cannot agree on which agencies should pay to bring clean water to west Rifle landowners whose groundwater is contaminated with uranium and vanadium, elements left there when uranium was mined to build nuclear bombs. While the tailings have been removed, uranium and vanadium have seeped into the groundwater, causing radiation levels at test wells to now exceed safe drinking water standards set by the U.S. Environmental Protection Agency. Local, state and federal officials have agreed to allow natural dilution to clean the underground aquifer, but the agreement leaves unstated which agency should pay to bring clean water to the area and whether sewer service should be part of the deal. The U.S. Department of Energy, responsible for the uranium cleanup, has offered to pay \$850,000 to help build a five-mile-long looped water line, but Garfield County Administrator Ed Green and Rifle City Manager Selby Myers said they think that's not enough cash and the federal government should pay for a sewer line in addition to the water line. An engineering study revealed four options that ranged from installing a simple water line loop for \$1.2 million to a water and sewer system, complete with treatment facilities, for \$14 million, Green said. "We're not asking they pay for treatment facilities for water or sewer," Myers said. Instead, Myers proposed installing a sewer line and system that would pump used water to the existing sewer, which would cost about \$2.2 million. Department of Energy Project Manager Don Metzler said he wants to amicably negotiate with the local officials, but he added, "My engineers tell me we have no basis to go over \$850,000."

Grand Junction Daily Sentinel 4/2/00

◆◆ WATER DEVELOPMENT

River District says no to additional transmountain diversions.—The Colorado River Water Conservation District maintained in a unanimously adopted policy statement released March 16 that nearly 400,000 acre-feet of water, enough for 2 million additional residents, are available to the Front Range without any new transmountain diversions such as the Union Park project. The statement asserted that despite exploding growth, Front Range interests have no current or foreseeable need to divert West Slope water eastward. The CRWCD statement was offered in part as a response to the formation of the Colorado Water Partnership (CWP), also announced on March 16. The CWP, a consortium of Front Range counties and municipalities, declared its goal -

securing reliable sources of West Slope water to keep the Front Range economic engine in high gear. Arapahoe County Commissioner Marie Mackenzie, who is spearheading the CWP, is circulating a letter “personally ask(ing) you to join the CWP,” which seeks support for proposed legislation to fund a study of new projects that could yield up to 120,000 acre feet of West Slope water. Recently that figure was identified as the amount of mainstem Colorado River water available in excess of what is needed to sustain the mainstem’s endangered fish recovery program. It is in the upper range of the yield expected from Arapahoe’s Union Park project. Presently, more than 500,000 acre feet are piped through the Continental Divide to Front Range water users. The Union Park project would call for a 900,000-acre-foot headwaters reservoir (about the size of Blue Mesa Reservoir) to be located approximately 28 miles northeast of Gunnison and to the south of Taylor Park. Arapahoe hoped to divert up to 100,000 acre-feet of water per year through the Continental Divide to the Front Range. Union Park would be fed from a far-flung system of collection pipelines tapping Lottis, Spring, Brush, Cement and Texas creeks and the East and Taylor rivers. A ruling on Union Park is expected from the Colorado Supreme Court sometime this year. CWP membership includes Adams County, Arapahoe County, Aurora, Colorado Springs, Elbert County, El Paso County, Lafayette and Northglenn. Absent are Denver and Douglas County, which along with the Douglas County Water Resource Authority and the CRWCD, will conduct the South Metro Water Study (SMWS). Douglas County explained its rationale for staying out of the CWP in a March 14 letter to Mackenzie written by Douglas County Commissioner James Sullivan. In it he pointed out that the South Metro Water Study’s goal is to discover which water strategies will meet near and long-term Front Range water needs in ways that delay and minimize the need for additional imports of water from the Colorado River Basin. Its mission statement sets as a primary goal the protection of existing water uses while preserving future economic opportunities within the Colorado River Basin, of which the Gunnison River is a part.

Gunnison Country Times 3/30/00

River district: Protecting West Slope water is in East Slope’s interests.—Front Range residents would be ill-advised to drain more water from a region that has become important recreationally for the entire state, the Colorado River Water Conservation District said this week. CRWCD cited western Colorado’s increasing dependence on tourism-related construction and recreation industries as reasons for trying to protect its water. CRWCD also is worried about protecting Western Slope present and future water use needs for domestic, agricultural and industrial purposes. “Adequate protections for West Slope environmental and recreational values benefit all Colorado citizens. Western Colorado has become a vital recreation resource for the entire state,” says the CRWCD. The district does not rule out the possibility of transmountain diversions altogether, as long as it occurs in a cooperative fashion. The district is involved with several East Slope-West Slope cooperative water supply investigations. One seeks to identify and develop more Eagle River water supplies for Colorado Springs and Aurora, along with Eagle River basin water providers. Douglas County and Denver are involved in a second cooperative project, and a third consists of studying the Upper Colorado River water supply and quality, instream flow and recreation needs. “The River District acknowledges that any or all of these efforts may result in some additional transmountain water use, but any required diversion will be accomplished only with the acceptance and involvement and to the mutual benefit of both East Slope and West Slope interests,” the district’s policy states.

Glenwood Post 3/18/00

Conservancy District calls for elections.—An election is looming to fill three seats on the Upper Gunnison River Water Conservancy District. High Country Citizens’ Alliance (HCCA) member Steve Schechter told UGRWCD members that petitions calling for an election in water divisions 4 and 8 have been delivered to the District Court offices. Division 8 encompasses the city of Gunnison, while Division 4 includes Almont and Crested Butte South. This marks the second year petitions calling for citizen choice rather than court appointment to fill seats on the local Upper Gunnison River Water Conservancy District were circulated. If the latest petition drive is successful and an election is called, it will be the third water district election in the history of Colorado conservancy districts. One was held in Weld County nearly 20 years ago and the other in Gunnison County last year. If the Upper Gunnison finds sufficient valid signatures, it will meet in a special meeting April 4 to adopt a resolution calling for an election on June 20. Water board hopefuls will have until April 19 to file a nomination petition. The Upper Gunnison will reorganize its districts next year. Since its eight district boundaries generally don’t match Gunnison County’s 15 voter precincts, determining the number of signatures required and establishing district boundaries have required extra expense and effort by the UGRWCD.

The Bureau of Reclamation has released the final environmental assessment of the Upper Gunnison’s long-standing-but-never-formalized subordination agreement. The USBR area manager says the agency will prepare a finding of no significant impact, in essence saying USBR has found no reason why the subordination agreement should not be ratified. The 60,000-acre-foot subordination was part of the economic rationale presented by USBR to Congress to substantiate construction of Blue Mesa, Morrow Point and Crystal reservoirs. It was designed to protect in-basin junior water right holders from the senior hydropower rights held by USBR.

In the Union Park trial, Arapahoe County lawyers John Henderson and Paul Zilis argued that the entire Aspinall Unit subordination was available for the Union Park project. They correctly maintained that the 60,000 acre feet had been reserved for junior appropriators. However, District Judge Robert Brown, who presided over the Union Park water rights trial, ruled the subordination was set aside for in-basin users only. Arapahoe County lawyers had petitioned the Supreme Court asking it not to consider the subordination in their examination of the Union Park. The justices rejected Arapahoe’s petition.

Gunnison Country Times 3/30/00

Compromise on South Platte may benefit Douglas County.—Colorado water leaders, the Forest Service and environmentalists are trying to agree on a way to let the state’s fastest-growing county use South Platte flows to replenish the rapidly shrinking aquifer that supplies 65 percent of Douglas County’s water. Crucial to the proposal is agreement on the level of protection for the South Platte River corridor near Deckers. That’s where Denver wanted to

build the Two Forks Dam. The Forest Service, which owns the land in the area, proposed federal Wild and Scenic status protection for the 71 miles of river near Deckers. This would bar any dams or diversions. Denver and Douglas County oppose that designation, but all parties say they may be able to work out a compromise. Under the water use plan, high-water flows from above-average snowfalls would go into the aquifer that Douglas County's wells tap, and that's fine with environmental groups as long as the South Platte between Bailey and Denver's Elevenmile Reservoir is protected from dams, diversions and other tinkering. David Nickum, of Trout Unlimited, said, "There is nothing definite, but we want to find a way to use the water in the least damaging way." "The river merits protection," said Dan Luecke of Environmental Defense. "We're open to a designation that doesn't incorporate federal protection, but fully protects the natural resources of the South Platte." This all signals a rare state of agreement between water users and river protectors. The plan to recharge the aquifer is a cooperative venture of Douglas County, 18 water districts, the Denver Water Board and the Colorado River Water Conservation District. Douglas County water interests, Denver and CRWCD recently funded a study on the aquifer recharge idea to determine costs, environmental impacts and effects if South Platte water were pumped into the aquifer. Chips Barry, Denver's water manager, said in dry years, Denver could reverse the pumps and take water out of the aquifer to meet customer needs. Because Douglas County is out of Denver's legal supply area, the "shared" use would be allowed, said Barry. "There's still a lot of work to be done to see if it makes hydrological and legal sense," said Barry. Brooke Fox, director of natural resources for Douglas County, said, "We don't know what the outcome is going to be, but it's helpful to have everyone sitting at the same table."

Rocky Mountain News 3/28/00, Pueblo Chieftain 4/2/00

◆◆ WATER EDUCATION

Elementary school students soak up lessons about water.—Colorado Springs' Water's Way science curriculum teaches third-graders about the water cycle. The curriculum was developed through Colorado Springs Utilities' outreach program. Third-graders learn about the water cycle, and fourth-graders learn about watersheds. The Utilities department started outreach education programs as a part of a penalty imposed in 1994 by the U.S. Environmental Protection Agency. The city failed to meet a deadline for supplying filtered drinking water to the southwest portion of town and agreed to pay a \$100,000 fine and devote \$2 million to environmental projects. One of those projects was developing an educational curriculum. The utilities department doesn't charge the schools for the \$650 classroom kits or the teacher training.

Colorado Springs Gazette 3/9/00

COLORADO CLIMATE

Start the millennium by taking a look at the new, color version of *COLORADO CLIMATE!* In each issue, the reader will find climate-related topics of interest to the citizens of Colorado. The first issue has articles on Is Our Weather Today "Normal?", What is Climate?, the 1999 Water Year Review, Climate on the Web, and Drought in Colorado. There are also traditional descriptions of Colorado's monthly climate patterns and water-year wrap-ups.

COLORADO CLIMATE, by Colorado State Climatologist Roger A. Pielke, Sr. and Colorado Assistant State Climatologist Nolan J. Doesken, is an updated version of an earlier publication with the same name. It was published monthly from 1977 through 1996 with the support of the Colorado Agricultural Experiment Station and the Colorado State University College of Engineering. The new version will appear four times per year.

For teachers, climate information is now packaged in a manner that can easily be used as a resource or in classrooms. The Colorado Climate Center is planning training workshops for teachers interested in learning about the importance of rain and hail. The CoCo RaHS project (Colorado Collaborative Rain and Hail Study), which began as a local community project, is growing into a major research and science educa-

tion project for all ages. Several science teachers have been helping the Colorado Climate Center with this project. Volunteers are currently being recruited to help gather rain and hail data during spring and summer of 2000. By the spring of 2000, the Climate Center will have several lesson plans written geared primarily for middle school/junior high school earth science classes available for teachers. Topics will include:

- The importance of rain.
- The history of rain gauges.
- How to make and test your own rain gauge.
- Rainfall patterns -- how to map rainfall.
- What do the clouds tell us?
- Hail from the sky -- demonstrating hail damage.
- Drought -- what happens when it doesn't rain enough?
- Floods -- what happens when it rains too much?
- Storm patterns -- what CoCo RaHS data tell us.

For more information, call 970/491-8545 or visit the CoCo RaHS website at <http://ccc.atmos.colostate.edu/-hail/>

Subscriptions: Colorado Climate newsletter is published quarterly. \$15/year for four issues. Contact the Colorado Climate Center at 970/491-8545 for more information.

CALLS FOR PAPERS



11th Annual South Platte Forum

Oct. 24-25, 2000, Raintree Plaza Conference Center, Longmont, Colorado

This forum will focus on the business and economics of water in the South Platte Basin and include oral sessions on growth, habitat, agriculture and water brokers. **Poster abstracts are due by Aug. 1, 2000.** Authors whose posters are selected will be notified by Sept. 1, 2000. All accepted abstracts will be published in the conference proceedings. To submit abstracts or request information about the conference, please call or write:

Jennifer Brown

Colorado Water Resources Research Institute

410N University Services Center

Fort Collins, CO 80523-2018

Phone: (970) 587-4778 or (970) 491-6308 Fax: (970) 491-2293



Ground Water Protection Council 2000 Annual Forum

Ground Water, Source Water and Underground Injection Forum and Technical Exchange Exposition

Sept. 24-27, 2000, Ft. Walton Beach, Florida

The conference will focus on technical advancements and practical approaches to underground injection practices, ground water-source water protection, deep injection as an alternative to other waste disposal options, resource management through aquifer storage and recovery; injection as pollution prevention practice, and Class I, II, III and V injection well issues and technology. For information contact Ben Grunewald at 405/516-4972, E-mail ben@gwpc.site.net, or see the Council webpage <http://www.gwpc.site.net/meetings.htm>.



North American Lake Management Society 20th International Symposium

Nov. 8-10, 2000, Miami, Florida

You are invited to submit oral and poster presentation abstracts that deal with all aspects of the management, protection and restoration of lakes, reservoirs and watersheds. For information phone 727/464-4425, FAX 727/464-4420, E-mail pleasure@pinllas.fl.us, or see the NALMS webpage at <http://www.nalms.org/>.



Asking the right Questions: Evaluating the Impact of Groundwater Education, 2000 Groundwater Foundation Fall Conference

Nov. 13-15, 2000, Nebraska City, Nebraska

The conference program will focus on: Assessing behavioral and environmental impacts as well as program implementation, building evaluation techniques directly into program design, applying social marketing strategies to environmental education, and meeting specific educational goals such as environmental literacy through testing and focus groups. **Abstract deadline: May 28, 2000.** For information phone 1-800-858-4844, 402-434-2740, Fax 402/434-2742, or E-mail cindy@groundwater.org.



Ground Water: A Transboundary, Strategic and Geopolitical Resource,

Association of Ground Water Scientists and Engineers Annual Meeting

December 13-14, 2000, Las Vegas, Nevada, USA

The Call for Abstracts and submission information is online at: <http://www.ngwa.org/education/agwse2.html>. **Abstracts are due: May 5, 2000.** No papers are required.



Tailings and Mine Waste

Jan. 15-18, 2001, Colorado State University, Fort Collins, Colorado

See the webpage at <http://www.engr.colostate.edu/depts/ce/conferences/tailings/index.html> or contact Linda I. Hinshaw, Dept. of Civil Engr., Colorado State University, Fort Collins, CO 80523-1372. Phone 970/491-6081, FAX 970/491-3584, E-mail Lhinshaw@engr.colostate.edu. **Deadline: June 2, 2000.**

MEETINGS

◆ ◆

National Mitigation Banking Conference -- A How-To for Both Bankers and Newcomers to Banking
May 27-30, 2000, Denver, Colorado

The conference offers general sessions on mitigation banking for wetlands, habitat and conservation, as well as introductory sessions for people wanting to know more about mitigation banking and advanced sessions for practicing bankers. For more information contact the Terrene Institute at <http://www.terrene.org>, or terrinst@aolmcom, or 1-800-726-4853.

◆ ◆

The Culture, Economics, and Ecology of Ranching West of the 100th Meridian
Thursday-Saturday, May 4-6, Colorado State University, Fort Collins, CO

National experts and policy makers will address the culture, economics, and ecology of western ranching as it undergoes enormous changes and pressures from many directions. Speakers include [Professor Tom Bartlett](#) of the CSU Rangeland Ecosystem Science Department. Registration costs: \$60, \$40 for students. Contact the CSU Office of Conference Services (970) 491-6714. For content information, contact [Wendell Gilgert](#) (970) 491-4340, [Rick Knight](#) (970) 491-6714, or [Ed Marston](#) (970) 527-4898.

◆ ◆

Colorado State University ALUMNI/AE & FRIENDS WATER SYMPOSIUM
June 20, 2000 (Tuesday)

Colorado State University alumni working worldwide are making significant contributions in the water industry. To enjoy and recognize their contributions, Colorado State University will hold a one-day Water Symposium that will blend Alumni, Alumnae, Friends and the University. The Water Symposium will focus on projects to include achievements in all aspects of water research, development, and management. The Symposium program is expected to address issues of technology projects, a reception and dinner. The Symposium will take advantage of the large number of water professionals who will be on campus for two other significant concurrent events:

International Conference on the "Challenges Facing Irrigation and Drainage in the New Millennium," June 21-24, 2000 -- http://www2.privatei.com/-uscid/id_2000c.html

"Watershed Management 2000: Science and Engineering Technology for the New Millennium," June 21-24, 2000 -- <http://www.asce.org/gsd/sections/colorado/wm2000/>

Contact: Marilee Rowe, Department of Civil Engineering, Colorado State University, Fort Collins, CO 80523-1372
 FAX: 970/491-7727, e-mail: mrowe@engr.colostate.edu, Website: <http://www.engr.colostate.edu/depts/ce/conferences/index.html>

◆ ◆

CELEBRATING OUR 25TH ANNIVERSARY! -- COLORADO WATER WORKSHOP
 Western State College, Gunnison, Colorado July 26-28, 2000
"CLEAN AND FLOWING WATER"

The Colorado Constitution guarantees that the right to divert shall never be denied, but recent developments in water quality, instream uses, and federal flow requirements are making new demands on our water resources. How do these demands fit into Colorado's prior appropriation system? Can Colorado water law protect historic uses and meet the demands of the 21st century? Topics will include: the latest federal water quality initiatives, impacts of TMDL regulations on water users, water quality implications in exchanges, stream flows for environmental protection, reserved rights for the USFS, and bypass flow requirements.

Registration materials will be mailed in May. For more information: Lucy High at 970-641-8766 or water@western.edu. Scholarships are available for students!

◆ ◆
**American Water Resources Association Annual Summer Specialty Conference
International Conference on Riparian Ecology and Management In Multi-Lane Use Watersheds
Portland, Oregon — August 27-31, 2000**

Monday through Wednesday will feature plenary speakers, oral and poster presentations, and discussion sessions. Poster sessions will be a key portion of the conference and will have featured times for review and discussion. For further information contact Mike Kowalski, AWRA Director of Operations, Phone 540/687-8390, FAX 540/687-8395, E-mail mike@awra.org, or visit the AWRA home page at <http://www.awra.org>.

◆ ◆
Assessing Riparian Condition: Training Sessions for 2000

Session Dates:

Denver, Colorado: May 23-24, 2000

Salida, Colorado: June 13-14, 2000

Steamboat Springs, Colorado: July 12-13, 2000

Who should attend: Private landowners, ranchers, state or federal agency employees, and others who are involved with or interested in the values and functions associated with riparian areas and in learning some basic ways of determining their condition.

What is it?: The Colorado Riparian Training Cadre, an interagency, interdisciplinary team, is inviting private landowners, state/federal/county employees, or other interested individuals in Colorado to attend a 2-day training session on how to assess riparian/wetland condition. A primary objective of this training is to develop a common vocabulary and understanding of riparian areas among people who work on the land. The session includes one day in a classroom setting and one day visiting streams in the field. There is no tuition, but space is limited. The class size will be kept low (maximum of 25) to facilitate meaningful interaction.

Benefits to Participants: After attending this workshop, you will have a better understanding of the values associated with riparian/wetland areas. Participants will learn methods for assessing the condition of riparian/wetland sites on their land, and where to go for assistance in improving or restoring sites, if necessary. The assessment method is straightforward and involves completing a checklist with 17 yes/no questions. Landowners will be able to conduct assessments on their own land after completing the workshop.

Enrollment information/deadline: If you would like to register to attend or find out more about these workshops, please contact: Jay Thompson (303)-239-3724 or Paula Guenther-Gloss (970)-498-1222. **Deadline is May 1, 2000.**

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**Colorado Water Congress Summer Convention
Manor Vail Lodge, 595 East Vail Valley Drive, Vail, CO 81657
August 24-25, 2000**

Two days of information and education on water issues in the beautiful Vail Valley.

**Colorado Water Congress 43rd Annual Convention
Holiday Inn - Northglenn, I-25 & 120th Avenue, Northglenn, CO
January 25-26, 2001**

Two full days of information and educational workshops regarding water issues in Colorado.

Full details and registration forms will be published on the CWC web page at <http://www.cowatercongress.org> as they become available.
Check this page for information on upcoming CWC specialty conferences.

CALENDAR



Apr. 25-27	NWQMC NATIONAL MONITORING CONFERENCE 2000, Monitoring for the Millennium, Austin, TX. See NWQMC webpage at http://nwqmc.site.net/NationalConference/2000Conference/agenda.htm .
April 27-28	7TH ANNUAL CONFERENCE, WESTERN WATER LAW, Denver, CO. Phone 303/377-6600 or (800)873-7130, Fax 303/321-6320, E-mail registrar@cle.com, or see website at http://www.cle.com .
Apr. 30-May 4	WATER RESOURCES IN EXTREME ENVIRONMENTS, Anchorage, Alaska. See AWWA webpage at http://www.awwa.org .
May 4-6	THE CULTURE, ECONOMICS AND ECOLOGY OF RANCHING WEST OF THE 100TH MERIDIAN, Fort Collins, CO. Contact CSU Office of Conference Services at 970/491-6714.
May 17-18	SOUTHWEST FOCUS GROUNDWATER CONFERENCE 2000, Austin, TX. Information and on-line registration at http://www.ngwa.org/education ; or contact an NGWA representative at 800/551-7379.
May 27-30	National Mitigation Banking Conference -- A How-to for Both Bankers and Newcomers to Banking, Denver, CO. For information contact the Terrene Institute at 1-800-726-4853, E-mail terrinst@aol.com, or see webpage at http://www.terrene.org .
June 7-9	WATER AND GROWTH IN THE WEST, Boulder, CO. See Natural Resources Law Center, Univ. of Colorado webpage at http://www.colorado.edu/Law/NRLC/ , Phone 303/492-1272, FAX 303/492-1297, or e-mail RLC@spot.Colorado.edu.
June 15-16	DRINKING WATER QUALITY CONFERENCE, Denver, CO. Contact: National Environmental Health Assn., Phone 303/756-9090, FAX 303/691-9490. Internet http://www.neha.org , e-mail staff@neha.org.
June 15-18	ONSITE WASTEWATER SYSTEMS CONFERENCE, Denver, CO. Phone 303/756-9090, FAX 303/691-9490, E-mail staff@neha.org, or see webpage at http://www.neha.org .
June 20-24	COLORADO STATE UNIVERSITY ALUMNI/AE & FRIENDS, Fort Collins, CO. Contact: Marilee Rowe, Civil Engr. Dept., FAX 970/491-7727, e-mail mrowe@engr.colostate.edu, or see webpage at http://www.engr.colostate.edu/depts/ce/conferences/index.html .
June 20-24	INTERNATIONAL CONFERENCE ON THE CHALLENGES FACING IRRIGATION AND DRAINAGE IN THE NEW MILLENIUM, Fort Collins, CO. Contact: Larry Stephens at e-mail stephens@uscid.org, Phone 303/628-5430, FAX 303/628-5431, or see webpage at http://www.uscid.org/~uscid .
June 21-24	WATERSHED MANAGEMENT 2000 CONFERENCE, Science and Engineering Technology for the New Millenium, Fort Collins, CO. Contact Marshall Flug at Phone 970/226-9391, FAX 970/226-9230, e-mail marshall_flug@usgs.gov, or see ASCE website: http://www.asce.org .
July 10-14	USCOLD 20TH ANNUAL MEETING AND LECTURE, DAM O&M ISSUES - THE CHALLENGE OF THE 21ST CENTURY, Seattle, WA. Contact: Larry Stephens, Phone 303/628-5430, FAX 303/628-5431, e-mail stephens@uscold.org, or see webpage at http://www.uscold.org/~uscold .
July 26-28	CELEBRATING OUR 25TH ANNIVERSARY! COLORADO WATER WORKSHOP, Gunnison, CO. Contact: Lucy High at 970/641-8766 or E-mail water@western.edu.
Aug. 27-31	INTERNATIONAL CONFERENCE ON RIPARIAN ECOLOGY AND MANAGEMENT IN MULTI-LAND USE WATERSHEDS, Portland, OR. See AWRA webpage http://www.awra.org/meetings/Portland/Portland.html .
Sept. 24-27	2000 ANNUAL FORUM, Ground Water, Source Water and Underground Injection Forum and Technical Exchange Exposition, Ft. Walton Beach, FL. See online conference information at http://gwpc.site.net/meetings.htm .
Oct. 24-25	11TH ANNUAL SOUTH PLATTE FORUM, Longmont, CO. Contact: Jennifer Brown, CWRRI, at Phone 970/491-1141, FAX 970/491-2293.

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

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