Colorado Water

Newsletter of the Water Center at Colorado State University

June 2005

INSIDE:

Confluence of the Gunnison and Uncompahgre Rivers at Delta, CO

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Colorado Water Resources Research Institute
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WATER ITEMS AND ISSUES . . .

COLORADO WATER

Volume 22, Issue 3 **June 2005**

Editor: Gloria Blumanhourst

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

Published by the
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EDITORIAL

Energy and Water

by Robert Ward (Director, CWRRI)

Energy and water are inextricably bound in our economy and other social institutions. The nexus between energy and water can be viewed from a variety of perspectives--taking on several meanings--as recent events have shown. First, water is associated with the production of energy (e.g. in producing hydropower, cooling coal-fired electric generating plants, and production of coalbed methane, see articles beginning on page 4). Energy, on the other hand, is associated with the acquisition, treatment and distribution of water (e.g. desalination, wastewater treatment and potable water delivery). The relationship between water and energy is much more closely linked than many people realize.

The close linkage between water and energy was discussed at a National Renewable Energy Laboratory (NREL) workshop in February (a summary of the workshop is presented on page 16 in this issue of *Colorado Water*). The workshop explored the water-energy nexus, pointing out relationships that could be troubling. For example, the recent move toward more ‘off mainstem’ dams, to address environmental concerns, may introduce a larger dependence upon energy to store and deliver water at an acceptable cost. In addition, the relationship between water and energy can also compound an impact of drought (shortage of water) or an energy crisis (shortage of energy).

The workshop concluded by noting opportunities to further examine the water-energy nexus with the goal of improving management and planning. These opportunities include fully integrating water-energy management strategies; using more cost/benefit and risk/return information in integrating water-energy management; and improve the demand side of water-energy planning and management.

Patty Rettig, on page 12, notes evidence of the the water-energy nexus in the collections contained in Morgan Library’s Water Resources Archive. In particular, she describes the Goslin Collection plans for water projects funded under the Colorado Water Resources and Power Development Authority – an agency name that, in itself, recognizes the water-energy nexus.

A second meaning arising from the combination of energy and water can be the human energy needed to allocate, and reallocate, water in a semi-arid state where the difference between demand and supply continues to grow and shift as population increases. The Colorado Legislature recently passed HB 05-1177 – legislation that creates a series of Water Roundtables to harness human energy, in a constructive manner, to seek options for solving future water supply shortages in Colorado.

While the conflict over water is not new to the West, neither is the value of dialogue and negotiation in resolving water disputes. Delph Carpenter realized in the early 1900s that water conflicts between states, resolved in the Supreme Court, reduced, if not eliminated, the ability of local citizens to have an influence over the future of their water resources. The value of good data, in supporting water negotiations, was also highlighted in the Colorado River Compact negotiations (when the long-term water availability was over estimated). The Statewide Water Supply Initiative’s (SWSI) overview of Colorado’s water supply, current and future demands, as well as current plans to meet the demand as input, provides a firm factual basis for the proposed new Roundtables. Thus, Colorado is well positioned to appreciate, again, the value of dialogue and negotiation in attempting to bring all parties to recognize and address new water demands, values, and solutions in creating an agreed upon water future for Colorado.

Colorado Water provides its readers insight into the emerging science, technology, thought, and policy that is produced by Colorado’s higher education system. As an example, on page 24, an article by Mesa State College History Professor Steven Schulte, discusses lessons learned in seeking East Slope – West Slope agreement in the 20th century to solve earlier water supply shortages.

As the Water Roundtables are organized and implemented, CWRRI stands ready, as does all of higher education, to contribute to the dialogue in a constructive manner. Hopefully, new insight, combined with constructive dialogue in the Roundtables, can energize the search for consensus in resolving water allocation and use conflicts in Colorado.

Colorado State University Cooperative Extension

Cooperative Extension Working With Landowners in Areas of Coal Bed Methane Development

by Matt Neibauer (Department Soil and Crop Sciences, Colorado State University)

Although coal bed methane (CBM) development has been occurring in Colorado for the past several decades, recent developments in energy prices and national security, along with national and local politics have revitalized efforts to extract coal bed methane in the Raton, San Juan and Gunnison Basins of Colorado. Overall, there are approximately 2,300 coal bed methane wells in Colorado (See Figure 1).

Some of the benefits of coal bed methane development include the creation of jobs and the inflow of capital into local economies of Colorado and the West. In addition, landowners who own the mineral rights beneath their property often have an economic incentive to allow development to occur on their land. Landowners who do not own the mineral rights to their land and/or people living downstream of development, however, often have significant challenges to address with regard to the potential impacts to land and water resources posed by coal bed methane production.

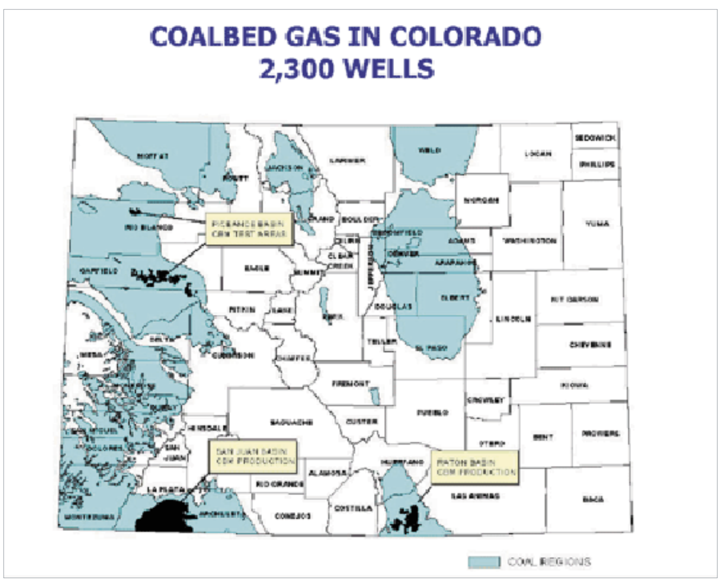

Figure 1. Coalbed gas in Colorado. (Source: Dick Wolfe, D. & Glenn Graham. Hydrogeology and Beneficial Use of CBM Produced Water in Colorado. Western Colorado Congress Forum Glenwood Springs, Colorado November 15, 2003.)

Coal bed methane gas is found in the fractures of coal deposits beneath the earth's surface. Extracting methane gas from these coal seams involves the removal of water from the seam by a well. This reduces the pressure in the coal bed seam that holds the methane gas in place and releases gas for extraction. Initially, a substantial amount of water must be pumped out of the coal seam (co-produced) before significant levels of gas are produced. For instance, billions of gallons of water have been extracted in Wyoming's Powder River basin so that methane gas could be recovered. Over time, the amount of gas produced increases and the amount of co-produced water decreases.

The most common methods of managing co-produced water include direct discharge of the water into perennial streams, surface impoundment and evaporation, and use as water for dust suppression, irrigation, and livestock. In some places like the San Juan basin of Colorado and New Mexico, co-produced water is often re-injected into aquifer formations below the coal seam. These various management practices illustrate that the extraction of coal bed methane gas directly influences water and land resource management because of its potential for impact on both land and water resources.

One example of these impacts is that coal bed methane co-produced water is often of low quality because it contains elevated amounts of sodium salts and other minerals, along with drilling lubricants and oils. This water typically contains sodium bicarbonate (in the Powder River Basin) or sodium sulfate-chloride (in the San Juan, Green River, and Raton Basins). These sodium/salt concentrations vary according to region and basin and are often not suitable for land application (i.e., irrigation, dust suppression). The most significant concern related to the potential poor water quality of co-produced water is the contamination of ground water used for drinking water wells. Another significant potential impact of coal bed methane development involves land surface disturbance from the construction of well pads, roads, pipelines, and power lines. Additional potential impacts include noise pollution from compressor stations and drilling rigs, aesthetic impacts and resulting property value decline, and wildlife habitat disturbance.

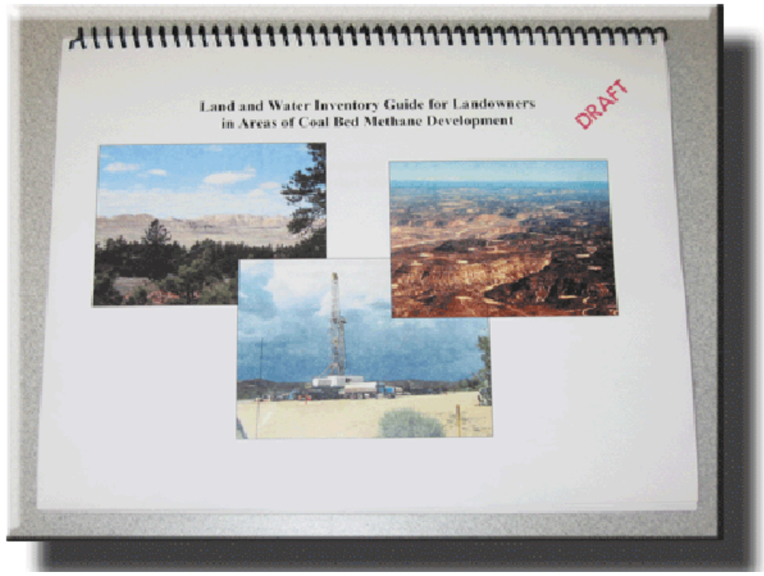

Figure 2. Land and Water Inventory Guided for Landowners in Areas of Coal Bed Methane Development

Recently, the Cooperative Extension Water Quality team in the Northern Plains and Mountains Region (EPA Region 8) has prepared a publication entitled, "Land and Water Inventory Guide for Landowners in Areas of Coal Bed Methane Development" (See Figure 2). Overall, the purpose of this manual is to empower landowners and tribal members in CBM development areas by providing them with instruction and examples of how to document and monitor changes in their land and water resources. The manual is designed to assist landowners in developing a planning process and strategy for the management of their natural resources in order to help them maximize the benefits and minimize impacts of CBM development.

This resource guide outlines the processes involved in the development of coal bed methane, including a section describing the rights and responsibilities of landowners and CBM developers. Included in the manual is a section demonstrating how to inventory current conditions of land and water resources, as well as how use this inventory for negotiation purposes prior to and during CBM development. This resource tool also discusses various best management practices designed to protect land and water resources, along with instructions on how to perform more detailed monitoring if a landowner decides that is appropriate. Furthermore, the manual has a glossary of terms related to coal bed methane development and a list of additional resources so that landowners can access more in depth information.

The Land and Water Inventory Guide for Landowners in Areas of Coal Bed Methane Development was produced by a partnership of Cooperative Extension personnel and university faculty from the states of Montana, Wyoming, Colorado, and Utah. Authors of this document include Kristen Keith (MSU), Quentin Skinner (UW), James Bauder (MSU), Holly Sessoms (MSU), Matt Neibauer (CSU), Reagan Waskom (CSU), and Nancy Mesner (USU). Additional funding for this project came from the U.S. EPA Region 8 Geographic Initiative Program, the Montana DNRC, and the USDA-CSREES. Ten people from various organizations including consulting firms, Bureau of Land Management, non-profit organizations, universities, and Departments of Agriculture reviewed this manual. In addition, this resource guide was pilot tested with 12 landowners in Montana, Wyoming, Colorado, and New Mexico. It is scheduled to be published and available to the public in June of 2005. For more information on coal bed methane

Surface And Groundwater Interactions In Coalbed Methane Waters In The Powder River Basin, Wyoming

by
John D. Stednick
(Department of Forest, Rangeland, and Watershed Stewardship, Colorado State University)
and
William E. Sanford
(Department of Geosciences, Colorado State University)

Coalbed methane (CBM) gas is formed in confined coalbed aquifers through biogenic processes and remains trapped in coal fractures by overlying water pressure. Pumping water from the coalbed aquifer decreases the water pressure and allows methane gas to be released, collected and subsequently distributed via pipelines. It is estimated that a single CBM well in the Powder River Basin (PRB) produces from 2 to 40 gallons of water per minute, but varies with the aquifer pumped and the density of wells. Approximately 0.6 trillion gallons of product water eventually will be produced from CBM extraction in Wyoming (DeBruin et al., 2000).

The variability of water chemistry produced by CBM wells in the Powder River Basin is not clearly understood. In general, the total dissolved solids in CBM discharge waters increases from the southeast to the northwest in the Powder River Basin as deeper coal seams produce more saline and alkaline waters (Rice, 2000). CBM extraction wells are placed together in a manifold system discharging to a single point and releasing often into ephemeral stream channel systems, constructed unlined retention ponds and/or, re-injected to the groundwater, or recently treated on site to reduce salinity before discharge. A careful evaluation of CBM chemistry to better determine potential uses of CBM produced water and the ability to maintain state water quality standards is needed.

The objective of this study was to examine CBM discharge water chemistry as water moves from the wellhead downstream in ephemeral stream channels and to examine surface-groundwater interactions. We collected CBM discharge water samples from discharge points and analyzed for pH, major element concentrations, and calculated the sodium adsorption ratio (SAR). High SAR levels can increase the soil salinity, increase the soil pH, decrease infiltration rates, and decrease soil productivity. These parameters were analyzed in surface and shallow groundwater samples collected downstream of wellhead discharges to determine changes in CBM discharge water.

The coalbed methane discharge waters are generally alkaline, high in sodium (Na) and bicarbonate (HCO_3) concentrations (Table 1). The chemical composition of the discharge waters did not vary over time, similar to other PRB studies (McBeth et al., 2003). Mean pH increased from 7.4 to 8.8 in the stream from precipitation of calcite, with a decrease in calcium and increase in sulfate. The decreased calcium increased the SAR. In general, the water chemistry of the surface water sampled at different points downstream did not vary, but differences in groundwater chemistry were observed. Discharge and surface waters are a Na-HCO_3 type water.

Groundwater chemistry as sampled at 2 and 4 foot depths, near the channel, showed significantly higher concentrations of all salts. Sodium concentrations in particular tended to increase with soil depth, and are a Na-SO_4 type water. As the wellhead water is discharged into the channel, water soluble salts are being dissolved and leached laterally into the soil. Once the channel discharge decreases or is stopped the soil reservoir of salts will migrate back to the channel. This process has been confirmed when comparing water chemistries in channels that no longer receive CBM discharge, their waters have higher salt concentrations and SARs. Changes in soil chemistry confirm this salt migration (Neuhart, 2003). Study results show that the interaction of CBM water and groundwaters are changing the chemical composition of the CBM discharge water and these water and soil interactions should be considered in the planning and management of CBM activities. The ability to comply with state water quality standards requires an understanding of the surface and groundwater interactions.

This research was funded by the U.S. Environmental Protection Agency under the Clean Water Act 104(b)(3) water quality grant program.

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Beaver Creek	Wellhead	Surface	2 foot depth	4 foot depth
pH	7.4	8.8	7.7	7.7
Electrical conductivity (dS/m)	1.8	2.1	5.9	18.4
Ca (mg/L)	12	6	230	250
Mg (mg/L)	13	45	142	278
Na (mg/L)	370	375	791	3200
Sodium adsorption ratio	17.4	11.4	10.1	33.1
Cl (mg/L)	21	21	77	91
HCO_3 and CO_3 (mg/L)	900	900	744	760
SO_4 (mg/L)	48	144	2700	4400

Table 1. Mean concentrations for surface and groundwaters collected from Beaver Creek, Powder River Basin, Wyoming.

Salt Chemistry Effects on Indirect Field Salinity Assessment in the Arkansas River Valley, Colorado

by Curtis Cooper (USDA Graduate Fellow, Colorado State University) and Grant Cardon (Extension Soil Specialist, Utah State University)

Salinity in the Arkansas River Basin is causing decreased productivity; with potential salinity sources being geologic, waterlogging, urban and agricultural return flows. However, there was little chemical soil data to describe accurately and specifically, the type of salinity. Field observation suggested that the primary soil salinity is calcium-based (gypsum or calcite), and this type of salinity may be a factor in the difficulty of calibrating electromagnetic induction probes for in-field salinity assessment.

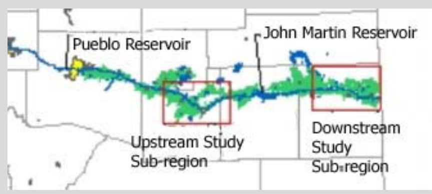

Figure 1. Upstream and downstream study sub-regions on the Lower Arkansas River

Project goals to collect baseline soil chemical data have been completed. Field sampling in the Arkansas River Valley was completed in the summer of 2004. Overall, 24 fields were sampled in the upstream region and 27 fields in the downstream region. Samples were typically collected to a depth of 1.2 meters, spanning a range of salinities. Samples were then processed for saturated paste extracts with the extract waters being tested at the Soil, Water and Plant Testing Lab on the Colorado State University Campus. Additionally, chemical analysis was run on pore water extract waters and for a multiple extract testing. Method tests are also being conducted for in-laboratory procedures and the effects on the electrical conductivities.

Data for the baseline chemistry are currently being analyzed, but preliminary results reveal that there are relationships between extract water electrical conductivity (EC) and the sodium concentrations (Figure 2), which is also true for the magnesium, and sulfate concentrations. This relationship is not found in the calcium concentrations in the extract waters. It is surmised that this is because $CaSO_4$ (typically as gypsum) and $CaCO_3$ (typically as calcite) are slightly to limited in their solubilities in near neutral pH conditions (Figure 2). However, some soils also appear to have a reserve of calcium attached either to colloids or in the soil solution that influences the EC/calcium relationship above an EC of approximately 3.0 dS m^{-1}.

The chloride relationship to EC is also unclear, presumably due to the different hydrological regimes on how the soils were "salted up." In fields in which the salt source is from the top down it is expected that chloride, which typically behaves as a conservative chemical species, should be leached to the deeper samples or to below the rootzone. However, in waterlogged fields it is expected that with an upwelling gradient for groundwater flow that the chloride will become concentrated near the soil surface due to evapotranspiration. Statistical analysis of these hydrologic regimes is planned for the summer of 2005.

Pore water extract waters were sampled from the Research Station in Rocky Ford, CO. Irrigation was applied on Day 0, and with in-situ extractions occurring on Days 1 – 4. Pore waters were sampled through multiple tubes each with a ceramic cup at either 1, 2, 3, and 4 foot depths using suction induced with a pump. Sample waters were not available at the 3 and 4 foot depths on Day 1. In Figure 3. the irrigation water sodium concentration and the saturated paste extract concentrations are presented as reference points. A combination of leaching, dilution of the pore waters and the movement of the wetting front through the soil profile are shown in Figure 3. These data are also paired with EM-38 measurements which suggest that there is a change in the overall bulk conductivity as the wetting front expands through the soil profile.

Multiple extracts of a single soil sample were completed in January 2005. This sample was repeatedly processed in a manner equivalent to all the other soil samples for saturated paste extracts. The chemical results of the repeated testing are in Figure 4. From these results the initial flush of sodium from the soil and a subsequent decrease in the EC of the extract waters are apparent in the first six extractions. This result suggests that the EC is strongly influenced by sodium, which is highly soluble. As the multiple extracts proceeded, minor decreases in the magnesium concentrations occurred, but the calcium concentrations are essentially the same between the first extract and the 14th extract, which suggests that the soils and EC are "buffered" by gypsum and calcite mineral precipitates that cannot be readily leached from agricultural fields. Fourteen extractions were not sufficient to decrease the extract EC significantly below 4 dS m^{-1}. Implications of this research support leaching studies of soil cores by David Huber and Dr. Greg Butters. The data have not yet been completely examined for management recommendations of calcium-salt affected fields.

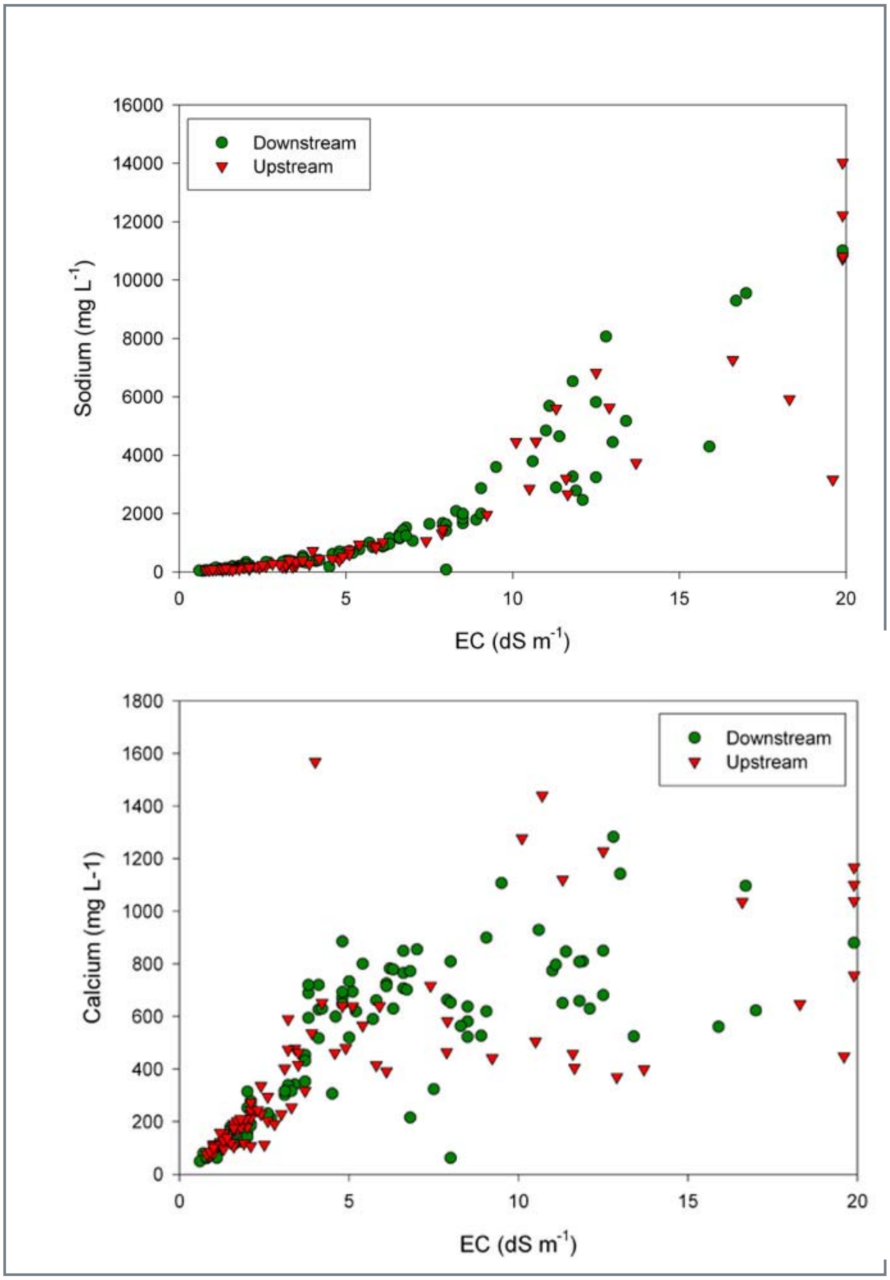

Figure 2. Sodium and calcium extract concentrations (mg/L)

Testing of the EC laboratory methods is on-going. Since there are manipulations to collected soil samples as part of developing saturated paste extracts, such as drying, grinding and mixing of soils and pastes, there is a potential to influence the EC measurements. Grinding of nodules of calcium sulfate, calcium carbonate minerals/precipitates and of soil aggregates can increase the surface area available for dissolution and thereby change the overall EC measurement by making more salts available for dissolution than are available in-situ under typically irrigation processes. Preliminary data suggests that extract waters taken from soil samples retaining their aggregates, and not stirred during the saturation process, have a lower EC than those samples that are manipulated. The use of surrogate irrigation water in creating the saturated paste has preliminary results suggesting that the EC between the soils and the water is not additive. It is expected that the additional tests may offer clues/answers as to the why and how the two EC's become intermixed.

Planned analysis for Summer 2005, include, but are not limited to:

1) Beta testing of an updated WATSUIT model by Dr. Jim Oster, Emeritus Soil and Water Specialist, University of California, Riverside.
2) Refining the calibration equations to the EM-38 electromagnetic sensor by utilizing chemical data. Equations were created by James Wittler as part of an ongoing Masters research at Colorado State University.
3) Continue working with other researchers on efforts related to salinity in the Arkansas River Basin. Data has already been used to direct monitoring and modeling efforts of Yaun-Win Lin and Roberto Arranz (graduate students of Dr. Garcia). The implication of the calcium chemistry/mineralogy in the soils has

impacted assumptions of chemical transport and removal mechanisms.

4) Spatial statistically analysis of the chemical data regionally and between regions to determine locations with greater concentrations of salts, being sodium, calcium, magnesium, etc.
5) Normal versus inverted soil salinity profiles to determine the effects of waterlogging.
6) Variability in the chemical constituent concentrations as a function of EC groupings.
7) Chemical data is providing clues as to why current EC-Crop guidance manuals are not accurate for these saline systems and research/analysis will following up on this information.
8) Examination of available models, including Hydrus 1D 3.0 (with Unsatchem), and continuing use of Visual Minteq to help model chemical changes with the removal of pure water through evapotranspiration.

Assistance in this research came from five undergraduates working in the Irrigation Laboratory in Plant Sciences Building on the Colorado State University Campus. Additional assistance was provided by Dr. Tim Gates in Civil Engineering, Dr. Luis Garcia, Eric Morway and others involved directly with the Arkansas River Valley

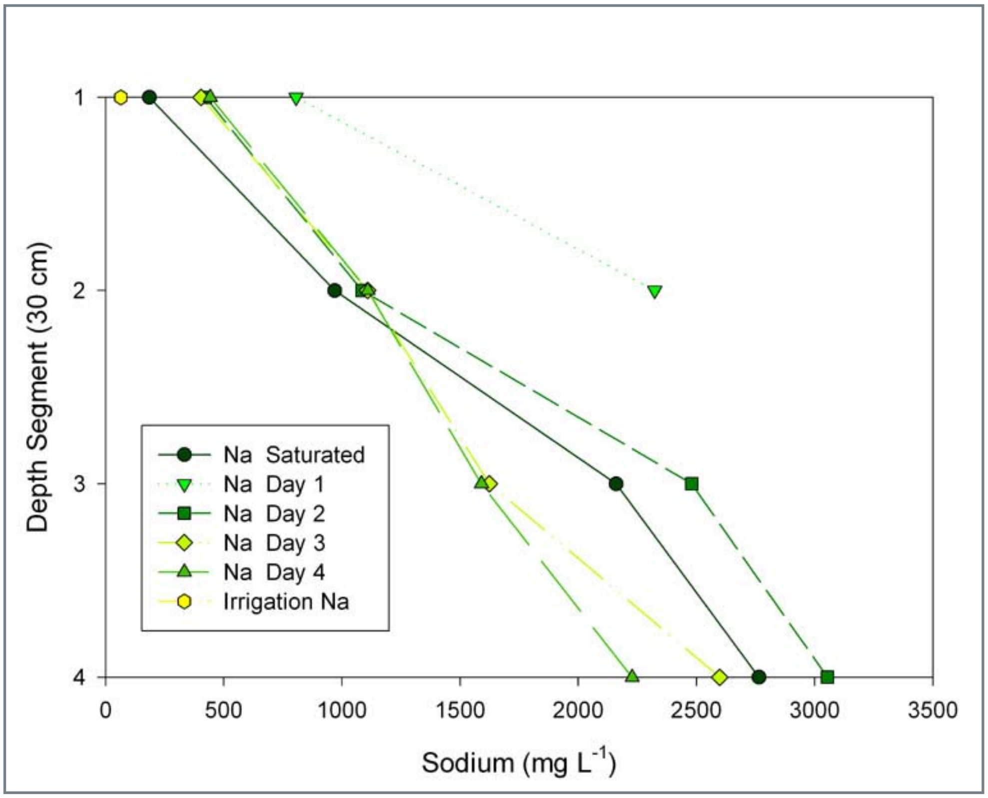

Figure 3. Sodium concentrations in pore water extracts

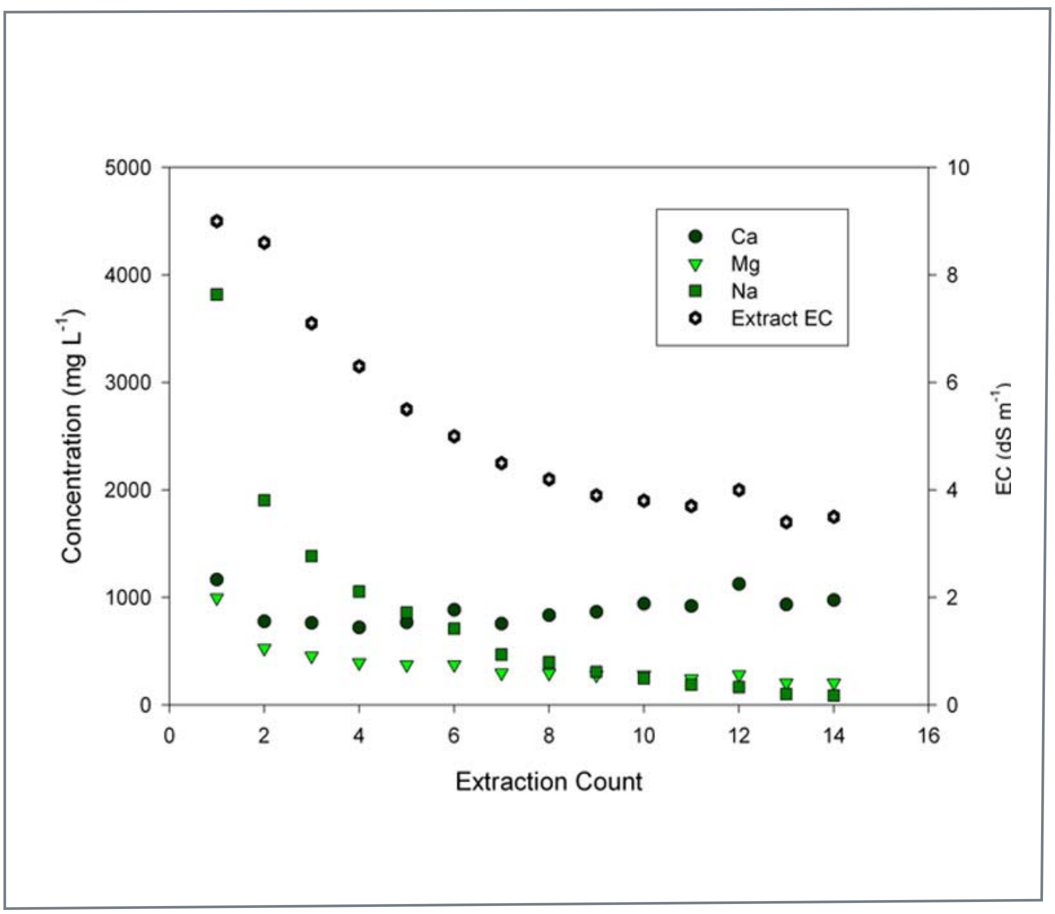

Figure 4. Multiple extraction results

Project examining salinity and waterlogging. In particular, much of this current work is only possible because of the work done by James Wittler in examining and calibrating the EM-38 sensor and developing the pore water study.

Salary for Curtis Cooper was provided by the USDA, in the form of a three year National Needs Fellowship. The Colorado Water Resources Research Institute provided funding for the presentation of abbreviated forms of this research at the Soil Science Society of America, 68th Annual Meeting, Seattle, WA (November 2004) and at International Salinity Forum, Riverside, CA (April 2005). In April 2005, Curtis Cooper was offered a position in the 2005 Summer Doctoral Fellows Program at Washington State University, Pullman WA, in part due to his research of salinity.

Funding for the research was supplied by the Colorado Water Resources Research Institute and Agricultural Experiment Station.

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Upper Yampa Water Conservancy District Scholarship Awarded At CSU

The Upper Yampa Water Conservancy District (UYWCD) continues to fund a scholarship in support of CSU students preparing for careers in water-related fields. The scholarship program is administered by the CSU Water Center.

The scholarship provides financial assistance to committed and talented students who are pursuing water-related careers at CSU. The UYWCD $2,500 scholarship is open to any major at CSU. Criteria for the scholarships require the recipient to be a full-time student enrolled at CSU; financial need may be considered; preference is given to students from the Yampa Valley area; and a minimum GPA of 3.0 is required. The scholarships are for one year.

Robert Ward (left), chair of the CSU Water Center Scholarship Committee, congratulates Morgan Cate for receiving 2003-04 Upper Yampa Water Conservancy District

The Upper Yampa Water Conservancy District Scholarship Recipient for the 2005-06 academic year is R. Morgan Cate. A senior majoring in Construction Management at CSU, Cate is from Steamboat Springs. He is interested in designing and constructing high performance buildings which contribute to sustainability and shape a high quality, healthy living environment. Cate has taken courses in sustainable construction at CSU and worked for McStain Neighborhoods as a student intern on high performance residential construction. He also serves as Vice President of the Design Build Club at CSU. He'll graduate December, 2005.

For the summer of 2005, Cate interns for R.A. Nelson of Vail, Colorado. The construction company is currently involved with two LEED certified projects that promote sustainable construction and utilize resource efficient technology. Cate says that all construction has an environmental impact, and his long term goal is to practice and employ appropriate technologies for sustainable development/construction in both the residential and commercial sectors.

The Water/Energy Nexus in the Water Resources Archive

By Patricia J. Rettig
(Head Archivist, Water Resources Archive, Colorado State University Libraries)

The relationship between water and energy is an important aspect in Colorado's water resources history. As detailed in other articles in this issue, water is essential to the creation of several forms of energy, and energy is essential both to treat and distribute water. Documentation of this interrelationship appears in a number of the collections held in Colorado State University's Water Resources Archive. The collections reflect organizations which have studied or sponsored studies of related issues as well as people who have consulted on the topic, locally, nationally and internationally. A sampling of how the topic of the water/energy nexus is documented in the Water Resources Archive follows.

Perhaps the best place to begin in reviewing related collections is with that of Ival V. Goslin. As the first executive director of the Colorado Water Resources and Power Development Authority, Goslin oversaw the establishment of this organization, which began with assisting in the planning, design and construction of water supply projects in the state. Goslin served as executive director from 1982 to 1985 and continued his relationship with the Authority as a special consultant until his death in 1991.

The Colorado legislature initially created the Authority to conduct feasibility studies on various water resource projects and basin-wide studies. In 1988, the Authority's mandate was expanded to incorporate the funding of wastewater treatment projects by creating the Water Pollution Control Revolving Fund to make loans from Environmental Protection Agency grants under the federal Clean Water Act of 1987. In 1989, the Authority's statute was again revised to give its Board of Directors sole responsibility for funding projects of $10 million or less. By this time, it was clear the Authority had changed direction from conducting water project feasibility studies to creating and implementing the funding programs for water and wastewater infrastructure.

The Goslin Collection is largely comprised of engineering reports and basic data from the Authority-funded water planning studies of the 1980s. They contain a great deal of information about hydropower projects in relation to proposed dams in the state. Though only one of the projects studied and documented in the Goslin Collection was ever built, the rest of the reports, maps and data give a good sense of what was being investigated and why the projects were not constructed. It is an excellent set of documents showing water and power development issues across the state in the 1980s. Selected reports from the Goslin Collection are among the first items from the Water Resources Archive being scanned for sharing on the Internet.

One collection in the Water Resources Archive that has a substantial amount of information on water/energy relationships is the Groundwater Data Collection. This collection is a compilation of various studies conducted by CSU engineers over several decades, mainly the 1940s through the 1970s. One portion of the collection is a study of power consumption by irrigation pumps conducted from 1957 through 1978. The study was done in relation to groundwater fluctuation investigations and focused mainly on the Front Range and eastern plains. Data was collected directly from power and gas companies on the amount of power consumed by irrigation pumps and is found here in raw form as well as in annual summaries. In addition to the reports and data, there are also maps, charts and correspondence.

Another important section of the Groundwater Data Collection contains the field books of William E. Code. An irrigation engineer, Code worked for the Agricultural Experiment Station from 1928 until his retirement in 1958. He spent a great deal of time investigating groundwater and irrigation issues, including pumping water for irrigation. More than fifty of the field books in which he collected data exist in the Groundwater Data Collection, and fifteen of them relate to pump tests and pumping plant data, dating from 1928 to 1954.

These notebooks contain a wealth of detailed information, including where the pumping plants were located, what they were being used for, their capacity, the type of pump used, and more. They are a unique source of information regarding mid-twentieth century use of energy for water distribution.

A few other collections in the Water Resources Archive have materials on water/energy relationships, though found in limited amounts. The Papers of Daryl B. Simons contain materials from his time at CSU as well as from his consulting companies. Water/energy subjects are found among his consulting materials; substantial information related to these issues in the countries now called Pakistan and Bangladesh is present in sections on the West Pakistan Water and Power Development Authority and the East Pakistan Water and Power Development Authority, respectively.

The Papers of Whitney M. Borland, a U.S. Bureau of Reclamation engineer, relates to the water/energy nexus in two ways. One is that Borland saved numerous American Society of Civil Engineers papers and other reports on topics that interested him, one of which was power plants. The materials he collected on the topic span forty years. Also, his consulting work involved him in the power arena, including the examination of pumping plants. The work was in the U.S. as well as other countries, such as Nicaragua, and largely focused on sedimentation situations at the plants in addition to the intake systems.

The Colorado Water Resources Research Institute's records are largely made up of proposals, reports and studies on water problems in Colorado and the West, and problems related to energy are included. These largely involve water pollution as part of the energy creation process. One prominent example in this collection that is not present in others in the Water Resources Archive relates to oil shale. Extraction of oil from rock was a major topic during the 1970s energy crisis, and it would have had a significant impact on streams if it had been carried out to the extent proposed.

As can be seen from this brief review, collections in the Water Resources Archive document the water/energy nexus in important ways. However, this is certainly an area that the Water Resources Archive can continue to build on. If any reader knows of collections along these lines that could be made part of the Archive, please contact the archivist (970-491-1939 or Patricia.Rettig@ColoState.edu).

Engineering Research Center circa 1963.
Photo courtesy Morgan Library, Water Archives

Engineering Research Center Renamed to Honor Daryl Simons

The CSU Engineering Research Center, which includes research space for hydrology and hydraulics (among other topics), was recently named to honor Daryl B. Simons by the Board of Governors of the Colorado State University System.

The 110,000-square-foot Simons Engineering Research Center, located on the Foothills Research Campus in Fort Collins, provides large-scale laboratory space for faculty and student projects. Simons helped secure the funding that led to the facility being constructed in 1961 and expanded in 1969.

Simons, who died in March 2005, was the College of Engineering's first associate dean for research. During his 18-year tenure, he guided efforts to increase research funding and forge research associations with other universities.

His work in the areas of watershed management, river mechanics, and sedimentology encompassed every major river system in the world and involved agencies such as the World Bank, United Nations, and the United States Department of Defense. Papers documenting his work are now contained in the Water Resources Archives at the Morgan Library on campus. To view a finding guide for materials in the collection, go to http://lib.colostate.edu/archives/water/collections.html .

$1 Billion Annually on River Restoration in U.S.: What Role for Colorado Higher Education?

The National River Restoration Science Synthesis (NRRSS) Project, in the April 29, 2005 issue of Science Magazine, estimates that $1 billion is being spent annually on stream restoration projects in the U.S. The finding portrays growing economic activity associated with 'manipulating' river systems. The exact nature and purpose of the manipulation is not clear in 20% of the projects contained in the NRRSS database. For projects with a stated purpose, the most common goals are:

- Enhance water quality;
- Manage riparian zones;
- Improve in-stream habitat;
- Fish passage; and,
- Bank stabilization.

Projects with the above goals are small, with median costs of less than $45,000. A large portion of the $1 billion is spent on a few large projects reconnecting floodplains, modifying flows, reconfiguring river and stream channels, and improving recreation and/or aesthetics. Two examples of large restoration efforts are the Kissimmee River and Grand Canyon.

The study notes the difficulty in gaining an accurate picture of river restoration in the U.S., due to lack of documentation, as well as the difficulty in agreeing on criteria for judging a successful river or stream restoration effort, particularly with respect to judging ecological success.

Colorado's higher education system has a number of scientists developing the science and technology needed to restore rivers and streams. To provide insight into the nature of the efforts supporting restoration, several recent and current Colorado efforts to improve the science behind river and stream restoration, are summarized below.

Ellen Wohl (Colorado State University, Department of Geosciences) and colleagues contend that while river restoration is at the forefront of applied hydrologic science, many river restoration projects are conducted with minimal scientific context. They suggest that projects aiming to restore natural biophysical processes are more likely to succeed than projects with a fixed endpoint in mind. Additionally, they propose that physical, chemical, and biological processes are interconnected across watersheds and time scales, so restoration projects are more likely to be successful if planned in context of entire watersheds across time. In assessing the lack of success of river restoration projects, Wohl et al. cite these key limitations:

- a lack of scientific knowledge of watershed-scale process dynamics
- institutional structures that are poorly suited to large-scale adaptive management
- and a lack of political support to reestablish delivery of the ecosystem amenities lost through river degradation.

In an article to be published in Water Resources Research, Wohl and colleagues outline an approach for addressing these shortcomings.

Planning river restoration projects based on observations of the whole watershed over time is illustrated by a particular river study conducted by Wohl and others. The North Fork Gunnison River project utilized historical sources, aerial photographs, and comparison of bankfull discharge and gradient to compare the river's braided planform to standards published for braided and meandering rivers. They determined that land use in the past few hundred years was not the primary cause for the braiding as originally assumed, but that it decreased channel stability and that rehabilitation efforts should focus on reducing the effects of land use.

John Pitlick (University of Colorado, Department of Geography) and his colleagues have examined flow-sediment-biota relations along different segments of the Colorado River in western Colorado and eastern Utah. According to their work, native fishes of the Colorado River, including the endangered Colorado pikeminnow, are generally more abundant in shallow channel reaches near Grand Junction than they are downstream; the biomass of native prey fishes, benthic invertebrates and algae is likewise much higher in upstream reaches. Additional work done to model relations between flow and sediment transport indicates that habitats used by the native fish community are formed and maintained by flows ranging from about half the bankfull discharge up to the bankfull discharge. The research has identified the target flow where some of the bed material begins to move – this flow is considered important for restoring primary and secondary productivity across a range of habitats, including riffles and runs. A higher target flow marks the point at which most all of the channel bed material moves and is important for maintaining an active river channel with some morphologic complexity. Without these flows, the channel of the Colorado River is likely to become narrower and less complex overall, leading to further losses in riverine habitat. Pitlick's work suggests that unless the broader-scale importance of sediment input and output is recognized and quantified, restoration efforts that focus on site-specific issues or single-species enhancement are likely to fall short of their objectives.

An effort to integrate habitat enhancement into stream restoration projects led to the development of the Riverine Community Habitat Assessment and Restoration Concept (RCHARC) in the mid 1990s. Since then, Steve Abt (Colorado State University, Civil Engineering) and his colleagues have been engaged in the task of quantifying the flow of various streambed components. They developed a portable bedload trap as a method for measuring the transport of coarse gravel and cobble, and it is explained in Bunte et.al (2004). The traps were designed to create reliable and replicable particle selection and measurement.

Brian Bledsoe (Colorado State University, Civil Engineering) and his colleagues have been involved in several restoration related projects. Development of an extensive restoration project on the Little Snake River in northwestern Colorado. A five-year monitoring program resulted in permission to carry out the restoration activities along 14.4 miles of the river and its tributaries. A monitoring project will document the effectiveness of the plan in terms of stream stability and fish habitat improvement as well as identify any necessary corrections in the plan.

Bledsoe was also involved in the Eagle River Inventory and assessment which was a systematic, watershed wide inventory of channel, riparian, and upland characteristics controlling the ecological integrity of the Eagle River. They collected and assessed previous work in the watershed by other agencies, used exiting water quality data to determine sources of pollution and degradation, and identified, described and prioritized potential restoration projects within the watershed. In addition, Bledsoe is involved with development of computer models and the GIS analysis of watersheds.

At Mesa State College, the Environmental Science program has been involved in stream restoration education since 2000. The catalyst for their involvement was a community-based restoration project on the North Fork of the Gunnison. In partnership with the North Fork River Improvement Association (NFRIA), thirty-five Environmental Science majors attended a day-long seminar on bioengineering restoration techniques given by Robbin Sotir and Jeff Crane, and then devoted two days to implementing the techniques they had learned on a freshly re-shaped channel in the North Fork at Hotchkiss. Students found this work exciting and greatly satisfying. Building on the initial excitement of engagement, faculty developed a series of special topics courses which have culminated in ENVS 433 Restoration of Aquatic Systems, taught by Prof. Russ Walker. Students learn stream classification, assessment of riparian condition, approaches to designing riparian improvement projects, techniques for bank stabilization and habitat improvement, and monitoring. Field work on stream classification and assessment has been a vital component of their efforts. Students participate in bank stabilization efforts on the North Fork of the Gunnison, tour other West Slope projects, and many of them build on the course knowledge by completing projects for the Bureau of Land Management, the City of Fruita, and NFRIA.

Colorado Water will devote an entire issue to the science and economics behind river and stream restoration in an upcoming issue.

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MEETING BRIEFS

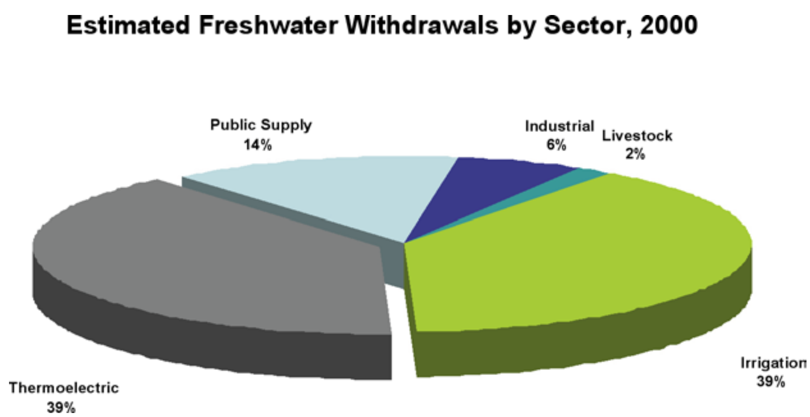
Exploring the Energy/Water Nexus: A Stakeholder Dialogue for Identification of Critical Issues

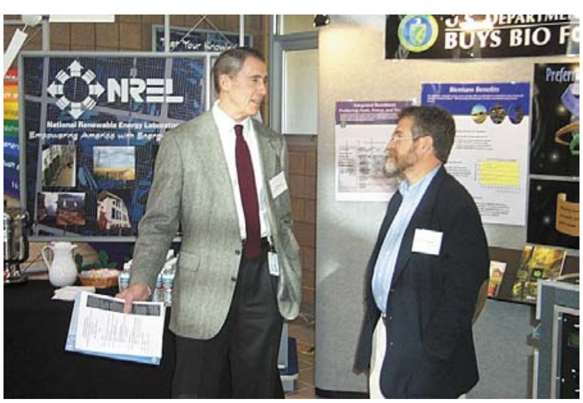
National Renewable Energy Laboratory (NREL) Stakeholder Technology Forum Summary

February 25, 2005

Reliable and secure energy – as well as freshwater supplies – are vital to the prosperity of our nation, and are a growing challenge in the American West. Energy and water are increasingly interdependent, with electric power generation requiring large quantities of water, while oil and gas production produces large quantities of wastewater. The electricity industry is second to agriculture as the largest user of water in the United States. Similarly, potable water sourcing, treatment, and distribution require considerable amounts of energy.

The National Renewable Energy Laboratory (NREL) recently hosted a technology forum, which included about 50 stakeholders, to discuss some of the issues surrounding energy and water. Organized with the U.S. Environmental Protection Agency, U.S. Geological Survey, U.S. Bureau of Reclamation, Western Area Power Administration, and Colorado Water Resource Research Institute, the workshop explored the energy/water nexus with a focus on energy's impact in water development and quality, and water use and quality in energy production and delivery. Participants identified issues that are critical to ensuring that our energy supply supports water availability and quality; reduces water use in the supply of energy; and advances energy and water sustainability for Colorado, the Rocky Mountains, and the Great Plains.





Bob Wilkinson (U. of California, Santa Barbara and Bill Karsell (Chief of Environmental Services, USGS) discuss posters.

The two primary sessions discussed energy demand for the public water supply and exploration of water and energy supply linkages.

Questions discussed included:
1. What are critical issues related to ensuring adequate energy supply to support water availability and quality?
2. What are the critical issues related to reduced energy demand in water supply, treatment, and transportation?
3. What are the critical issues related to reducing water use in the supply of energy from the range of fuel sources?
4. What are the critical issues related to energy and water security for Colorado, the Rocky Mountains, the Great Plains?
5. How might increased use of renewable energy technologies and energy efficiency measures impact water availability and quality?

Stan Bull of NREL opened the forum, outlining the goals for the event. With the ever-increasing link between energy and water (functionally and geographically), the Lab realized the critical need for research and solutions, and the importance of building new relationships among key organizations.

The keynote, titled "Critical Issues in the West," was presented by Pam Inmann of the Western Governors' Association. Her talk emphasized the Governors' commitments to water issues, drought preparedness, and clean energy. Through the joint efforts of the Western States Water Council and the Western Interstate Energy Board, the Western Governors' Association has multiple forums to address the energy-water nexus.

The first session, titled "Energy Demands for Public Water Supply," included four speakers/panelists:

- Bob Wilkinson, University of California (Santa Barbara), moderator
- Linda Reekie, AWWA Research Foundation
- Todd Bartholf, CH2M Hill
- Larry Flowers, NREL

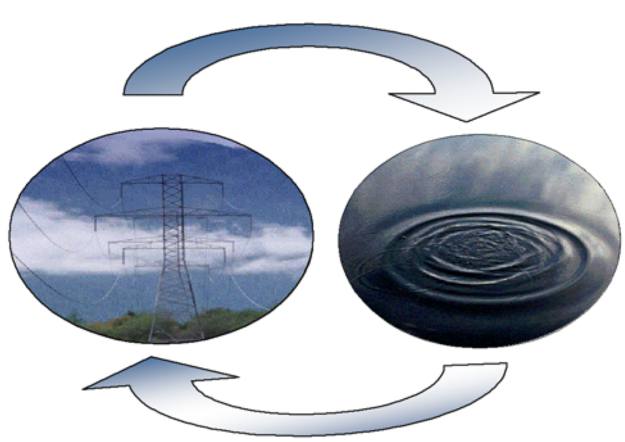
The panelists highlighted an increasing body of work that is focused on municipal and agricultural water and energy issues. Key drivers include: emerging technologies, security, marginal water supply, regulation, costs, and economic opportunities.

> ***"The new paradigm of this century is water supply issues will no longer be driven by droughts. We will have conflict in normal years, and that conflict will affect economies of national importance. The demands for water in many basins of the West exceed the available supply even in normal years."***
>
> ***Bennett Raley***
>
> ***Assistant Interior Secretary for Water and Science***

In the second session, "Water for Energy: Exploring Water and Energy Supply," speakers/panelists included:

- Maryanne Bach, U.S. Bureau of Reclamation, moderator
- Bill Karsell, U.S. Bureau of Reclamation
- Wayne Vanderschuere, Colorado Springs Utilities

Karsell highlighted a new approach to life-cycle assessment of energy generation, while Vanderschuere highlighted an integrated approach to managing energy and water, which allows for new opportunities for cross-fertilization when viewed from a holistic approach.



Energy/Water Nexus:
Similarities in the Context for Policy

General links and relationships: energy intensity of water and water intensity of energy. Electricity and water do mix: Electricity is used to move water, and electricity is made from falling waters. Energy intensity, or embodied energy, is the total amount of energy, calculated on a whole-system basis, required for the use of a given amount of water in a specific location.

There are four principle energy elements in water systems. Pumping water in each of these four stages is energy-intensive and constitutes a major use of energy:

- primary water extraction, conveyance, storage (in some cases), and supply delivery (imported and local)
- treatment and distribution within service areas
- on-site water pumping, treatment, and thermal inputs (heating and cooling)
- wastewater collection and treatment

Two primary areas were discussed. The first was the need for informing policy and management. Specifically, the participants discussed questions related to the information needed to inform policy, including:

- Where and when will water systems use more energy (e.g. desalination)?
- Where and when will water systems use less energy (e.g. efficiency improvements, reuse, shift is supply options, etc.)?
- What information and data do we need to support good policy?

Further discussions focused on "new" management approaches, where the group addressed possible areas for improvement in managing water issues:

- Integrated management (water, wastewater, stormwater, energy, …)
- Multiple benefits (policy and investments)
- Portfolio strategies (supply, management, risk, cost)

Members of the group found they had similar challenges for water and energy management:

- Reliability (supply)
- Cost (supply and quality)
- Quality (for various uses)
- Environmental Impacts

They also agreed that there were similarities in policy context:

- Historic supply-side orientation
- Infrastructure is important
- Huge end-use efficiency opportunities
- New technologies are changing our notions of optimal scale
- Market distortions and disconnect between pricing and cost

Bill Horak (Assoc Hydrologist, Central Region, USGS), Rod Kuharich (Exec. Dir., Colorado Water Conservation Board), and Wayne Vanderschuere (Colorado Springs Utilities) visit during break.

NOTE: The Energy Policy Act of 1992 established national standards set for plumbing fixtures, although many states had already adopted similar standards on their own. (The Act sets minimum water efficiency standards at the federal level for plumbing fixtures.)

Outcome and Action Plan

Four major topic areas were identified:
1. Policy and legal issues
2. Technology issues (from infrastructure to treatment/filtering technology, end-use technologies, etc.)
3. Economic issues (capital and operating cost factors, life-cycle cost/benefit, pricing, etc.)
4. Science issues (from hydrology and impacts of climate change to water quality issues and measurement of pollutants)

Management and planning opportunities include:

- Fully integrated management strategies (building on integrated resource management efforts in energy and water management, develop management strategies that incorporate water, wastewater, stormwater, energy, and other elements)
- Use of portfolio approaches for management (beyond diversification, to include cost/benefit and risk/return information)
- Planning and forecasting (understanding both energy and water demands – as a function of price and what people are willing to pay, and as it related to technology developments, particularly on the end-use side)

The group reached consensus that further effort is warranted in each of the topical areas identified above, and agreed to address them through specific case studies and further research and publication of analysis of

"During the last decade, the arena of long-term water resources planning has been broadened to include conservation as a promising management alternative. Water supplies are currently undergoing the same change which took place in the energy industry during the 1970s."

Metropolitan Water District, 1990 Water Management Plan

More Information

Participants can access more background information on NREL's Energy Analysis Web site at http://www.nrel.gov/analysis/workshops/water_nexus_workshop.html, as well as the presentations at http://www.nrel.gov/analysis/workshops/water_nexus_pres.html.

Colorado School of Mines Short Courses 2005

Course Title	Instructors	Begin	End	Location
Modflow: Introduction to Numerical Modeling	**Eileen Poeter**	Oct. 13 8am	Oct. 15 5pm	CSM BH 201 Colorado School of Mines Golden, CO
UCODE: Universal Inversion Code For Automated Calibration	**Eileen Poeter**	Nov. 3 8am	Nov. 5 5pm	CSM BH 201 Colorado School of Mines Golden, CO

For more information go to: http://www.mines.edu/igwmc/short-course/

MEETING BRIEFS

Arkansas River Basin Water Forum Held in Trinidad

Over 100 people attended the 2005 Arkansas River Basin Water Forum April 7-8 in Trinidad. The Forum serves as a conduit for information about the Arkansas River Basin in Colorado, particularly related to water allocation and management. The objective of the Forum is to promote open dialogue among water users and the general public, thereby creating a greater understanding of Colorado water law, beneficial water use, and principals of water conservation.

Topics discussed during the 2005 Forum included coalbed methane drilling impacts on water resources; ground water well permits and augmentation plans; water conservation; instream flows; good Samaritan law update; salinity and selenium; and tamarisk removal planning. An April 7th afternoon tour of Trinidad Lake State Park included lakeside discussions of water acquisition for flat-water recreation.

The 2005 Forum Planning Committee was co-chaired by Thelma Lujan and Erma Evans, both associated with the Purgatorie River Water Conservancy District. The 2006 Forum will be held in Salida. When plans for the 2006 meeting are finalized they will be provided at the following website: http://www.arbwf.info .

Clockwise from top:

Forum Banner

Dick Wolfe (State Engineer's office), Nolan Doesken (Colorado State Climatologists' office and CSU) and Lyn Kathlene (Colorado Institute for Public Policy at CSU) discuss Nolan's presentation.

Tour of Trinidad Lake

Lorenz Sutherland (NRCS) and Luis Garcia (CSU) visit between sessions.

Forum theme banner

Tim Gates (CSU), Jim Broderick (Southeast Colorado Water Conservancy District), and Jim Valliant (retired CSU Extension Specialist) pause for a photo op.

MEETING BRIEFS

Words and Water Mix at the Confluence of the Uncompahgre and Gunnison Rivers in Delta, Colorado

A one-day conference at the Heddles Center in Delta, Colorado, explored the changes taking place in water management as a result of drought and a growing population in the Upper Colorado River Basin in Colorado. Using the theme "Beyond a Shadow of a Drought", 80 people examined the conflicts between growing urban uses of water and traditional agricultural uses. The targeted audience was the leaders (boards, city councils, county commissioners, managers) of the organizations that provide water to meet the of all water users in the rapidly growing Montrose, Delta, Grand Junction area of Colorado.

Don Crabtree (USBR) uses apples to demonstrate the limited amount of water in the Colorado River and the process of sharing that water.

In a morning session (entitled: "Who Invited Them?"), Marc Catlin, with the Umcompahgre Water Users Association, and Dick Proctor, with the Grand Valley Water Users Association discussed the impacts of population growth. Dick noted that droughts come and go, but it does not seem that people come and go, they just come! This is unlike the boom and bust cycle Colorado has often experienced in the past. Marc noted that you can't deal with change if you aren't willing to change. Both noted the amount of time they must devote to issues beyond their main job - delivering water. The issues include selenium concerns, Endangered Species Act implementation, government regulations, easement disputes, development reviews, and Homeowner Associations.

David Merritt (Colorado River Water Conservancy District) provides the keynote talk.

David Merritt, Colorado River Water Conservation District, presented the keynote talk in which he noted the uncertainty associated with scientifically predicting future water supplies in the Colorado River Basin.

Martin Howell, with the City of Greeley, helped the attendees compare the urban-agricultural interface concerns with those on the eastern slope. While there are a number of similarities, there are critical differences. For example, the geological setting, in what the USGS classifies as 'salt desert'. When the 'desert' is irrigated selenium may be a factor in return flows to rivers in the region. Ken Leib, USGS, discussed these concerns using pictures to highlight the salt migration when new urban and 'lifestyle' land uses are established.

Karen Rademacher, with the Ditch and Reservoir Company Alliance (DARCA) wrapped up the day's water dialogue with suggestions on how to minimize economic damages to traditional irrigation organizations experiencing rapid urbanization. For more information about DARCA, please refer to http://www.darca.org/ .

The meeting organizing committee was led by Dan Crabtree and Mike Baker, U.S. Bureau of Reclamation; Greg Trainor, City of Grand Junction; Aung Hla, CSU Cooperative Extension; Rita Crumpton, Orchard Mesa Irrigation District; and Peter Roessmann, Colorado River Water Conservation District.

Left: Mike Baker (USBR) sets up PowerPoint equipment for Karen Rademacher (DARCA).

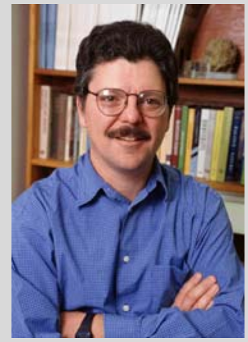
Above: Greg Trainor (Grand Junction), Dick Margetts (Project 7), Dick Procter (Grand Valley Water Users Association), Marc Catlin (UVWUA) and Don Crabtree (USBR) make their panel presentation.

Right: Steve Smith (Aqua Engineers) reviews prior session with Martin Howell (City of Greeley) during break.

Below Right: John Wilkin-Wells (CSU) discusses sociological implications of water policies with Chrisene Turpin (Overland Ditch Co).

Right: Dick Proctor (Grand Valley Water Users Association) speaks.

Congratulations



N. LeRoy Poff, Associate Professor in the Department of Biology, was designated Monfort Professor by Colorado State University. The prestigious award, one of the university's top honors, was established through a gift from the Monfort Family Foundation to recruit and retain top-quality faculty. Poff will receive and additional $150,000 over two years to support innovative teaching and research activities.

Poff's research in riverine and freshwater ecology focuses on testing how the structure and functional organization of biological communities are shaped by the natural dynamic variation in patterns of water flow characteristics of streams and rivers. The research provides a basis for predicting how species populations and whole aquatic communities respond to landscape-scale alterations of the hydrologic cycle, such as land-use change and damming of rivers, as well as to regional climate changes.

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Jared Orsi's book, Hazardous Metropolis: Flooding and Urban Ecology in Los Angeles, was recently awarded the Abel Wolman Award by the Public Works Historical Society. The Wolman Award designates the best new book on public works history. The criteria used in the selection process include: academic significance to the historical community; practical application to the public works profession; dissemination of information not provided by other means; and unique or innovative presentation of topic.

MEETING BRIEFS

Colorado Water Supply and Sustainability

On April 15, 2005, over 140 people gathered at the Mount Vernon Country Club for the 2005 annual symposium of the Colorado Section of the American Water Resources Association (AWRA). The symposium focused on the objectives and findings of the Statewide Water Supply Initiative (SWSI) and the challenges facing Colorado in striving to develop a sustainable water supply for all water users. Chris Sanchez, President of the Colorado Section of AWRA, welcomed the attendees and introduced the keynote speaker, Justice Greg Hobbs. Justice Hobbs noted that Colorado is entering an era of limits and markets and wondered if Colorado is ready for the change.

Panels discussed balancing limited water resources among competing uses; in pursuit of innovation solutions; providing a sustainable water supply for the south Denver metro area; future water project potential; and reactions to SWSI findings. At the end of the day, there seemed to be widespread agreement that limited money makes it harder to address the problems of limited water in semi-arid Colorado.

Counterclockwise from top: Lyn Kathlene (Colorado Institute for Public Policy, CSU) and Andy Pineda (Northern Colorado Water Conservation District) relax for a moment before the next session starts.

Don Ament (Colorado Commissioner of Agriculture) and Rick Brown (Colorado Water Conservation District) take a break.

T. Wright Dickinson (Yampa SWSI Roundtable Representative) speaks while (left to right) David Nickum (Colorado Trout Unlimited), Frank Jaeger (Parker Water and Sanitation District) and Rick Brown (Colorado Water Conservation Board) await their turns during the roundtable on "Reactions to the Statewide Water Supply Index."

The house is packed for the American Water Research Association Colorado Section annual meeting.

Lyn Kathlene (CIPP, CSU) meets up with Tom Cech (Central Colorado Water Conservancy Distrcit) on a tour of the posters.

Justic Greg Hobbs and Julie McKenna (Brandebeery-McKenna Public Affairs) discuss the sustainability from a legal perspective.

MEETING BRIEFS

'Water Resources in the Colorado River Basin' at the Annual Meeting of the Rocky Mountain Section of GSA

The Rocky Mountain Section of the Geological Survey of America held its 57th annual meeting at Mesa State College in Grand Junction May 23-25, 2005. Over 50 people attended the water resources session which examined past lessons and emerging issues regarding water resources in the Colorado River Basin. Prof. Gigi Richard, with Mesa State College, was the lead organizer of the water resources session.

Colorado Supreme Court Justice Greg Hobbs opened the session with an overview of the legal and institutional setting within which Colorado River water resources are managed. He also explained a number of connections between historical and scientific water knowledge and the legal and institutional setting, particularly as today's water managers address new issues and concerns.

Connie Woodhouse, with the NOAA's National Climatic Data Center in Boulder, and Eric Kuhn, General Manager of the Colorado River Water Conservation District, elaborated on the role of water research, particularly tree ring and stochastic hydrology studies, in expanding our understanding of past drought history. Such understanding is critical to managing the Colorado River's water resources/reservoirs during periods of abundance and drought.

Tony Willardson, with the Western States Water Council, and John McClow, with Bratton & McClow LLC in Gunnison, Colorado, provided an overview of Colorado River water issues from regional and Western Colorado perspectives. They both noted that population growth is influencing water resource development and management in a number of complex and challenging ways.

Steven Schulte concluded the half-day session by providing insight into the lessons learned from past efforts to resolve water conflicts in Colorado, particularly the agreements developed around the Colorado River Storage Project Act of 1956. A copy of his remarks follows.

Top: Colorado River at Glenwood Springs, May 23, 2005.
Middle: Justice Greg Hobbs, Eric Kuhn, Gigi Richard and Connie Woodhouse
Left: Jim Spehor, Gigi Richard, and Greg Hobbs.

MEETING BRIEFS

Water for the Upper Basin and Western Slope: The Colorado River Storage Project of 1956

by Steven C. Schulte
Professor of History, Mesa State College

Presented at Geological Society of America - Rocky Mountain Section Annual Meeting, 2005

When I agreed to write a few remarks for this conference, I was asked to address aspects of the history of the twentieth century Upper Basin and Colorado water infrastructure. So, needing a title, immediately, I chose the one that is in your programs. Now that the short paper is written, I will slightly re-tailor my remarks to the topic of the hydraulic politics of Colorado and the Upper Basin's water infrastructure.

The major water delivery infrastructure for the Upper Colorado River Basin was authorized and built in the twenty years after World War II. The Second World War represented the turning point in the political and economic development of the West in general and the Upper Colorado River basin in particular.

Before this time, the sparsely populated Upper Basin states could not envision a time when they would be able to gather enough political clout to begin authorizing massive reclamation storage projects. It was this fear, and an equal or greater fear of deep federal involvement in water apportionment that originally drove Upper Basin water statesmen to suggest, in the World War I era, a water treaty that resulted in the Colorado River Compact of 1922. The genesis of the Compact came from the realization that under Western water law, California had the political clout to put much of the West's free flowing water to beneficial use and this could endanger the future growth of several Upper Basin states.

Early twentieth century Colorado water attorney Delph Carpenter hatched the plan to use the U.S. Constitution's Compact Clause that provided for the negotiation of interstate agreements, subject to Congressional approval. California had the political clout to put much of the West's free flowing water to beneficial use and if that large and growing state could not be limited in some way, this could endanger the future growth of several Upper Basin states.1

Steve Schulte, Tonny Willardson and John McCloud during panel presentation.

The Colorado River Compact divided the river's water into two basins, each with roughly the same amount of available water. It required the Upper Basin states to deliver 75 million acre feet to pass by the division point at Lee's Ferry, Arizona every ten years. While this is not the place to point out the shortcomings of the Compact, suffice it to say that the Compact was based on a much higher annual flow than has actually materialized in most years, and that the Upper Basin's obligation to the Lower Basin was a major reason why the Upper Basin needed to get serious about storing water after World War II–both for its own economic growth and to meet its legal obligations to the Lower Basin regions.[2]

Last year, I wrote an article for the Citizens Guide to Colorado's Water Heritage where I stressed the role of two giants who have shaped Colorado's distinctive Western Slope political culture–Edward T. Taylor and Wayne N. Aspinall. I want to spend a little time describing some of my conclusions where they shed light on the ultimate construction of the Upper Basin's water infrastructure. [3]

Edward T. Taylor is truly one of the forgotten giants in Western water and resource history. Born in Illinois in 1858, Taylor ventured to Colorado in 1881 to the rowdy mining camp town of Leadville, then in the throes of the silver boom. After serving as principal of the local school for two years, he decided to attend law school at the University of Michigan, then returning to the Western Slope, where he held a variety of local political offices before being elected to the U.S. House of Representatives in 1908. He won election to Congress by taking a strong position against the growing federal presence in the management of the West's public lands. Taylor would serve as the Western Slope of Colorado's sole Congressman until his death in 1941.[4]

Taylor's lengthy career has several themes and lessons where Western water development is concerned. He is the forerunner of a strategy of protecting what is termed today, basin or basins of origin from the politics of inter-basin water transfers. He was the first major Western Colorado politician to point the way toward a strategy for protecting the Western Slope from the water machinations of the Eastern Slope. Taylor had always suspected the Eastern Slope of wanting to divert the waters of the Western Slope without adequate compensation. His worst fears became reality in the movement for the Colorado-Big Thompson Project (C-BT). The Eastern Slope had distinct political advantages–a growing population, political strength and the need to put the water to immediate beneficial use. The Western Slope's advantages were natural–it had the headwaters of some of the intermountain West's major rivers, but had a small population with little apparent political strength.

As far back as the 1880s, residents of the South Platte Valley on Colorado's Front Range had shown an interest in tapping the headwaters of the Grand River (late renamed the Colorado) for use on the thirsty eastern plains. In the early 1930s, East Slope newspaper editors, politicians, and water users organized into what would become the Northern Colorado Water Conservancy District to propose the C-BT. The project would take water from the headwaters of the Colorado River through a maze of tunnels, reservoirs, and ditches to bring about 300,000 acre feet if water annually to the Front Range. While the engineering challenges of the project were nothing short of amazing, its major political obstacles would be presented by Congressman Edward T. Taylor.[5]

Taylor paternalistically regarded every drop of water on the Western Slope as his to protect and control. As the voice of the Western Slope's twenty-two counties, he argued that since 70 percent of all the annual flow of the Colorado River originated high in the mountains of his Congressional District, he could insist that every drop of water taken from the Western Slope should be replaced by the construction of additional storage facilities for that part of the state. This became known as the "acre foot for acre foot" provision, or strategy. More importantly, Taylor was in a position to make good upon his demands. By the late 1930s he was Chairman of the House Appropriations Committee and in a strong position to block almost any legislation deemed damaging to his Congressional District.[6]

When the Colorado-Big Thompson Project became law in 1937, Taylor did not quite get his acre-foot for acre foot demand, but he did get his request for compensatory storage recognized. Two lessons were learned from Taylor's experience that were instructional for later generations of Colorado and Western water politicians: to insist on compensatory storage in inter-basin transfers and be in a strong political position to be able to effect the outcome of water legislation. Taylor's example would continue to hover over future East and West Slope water negotiations to the present day.

The other Western Slope Colorado water leader who influenced both the regional and national water debate was Wayne Norviel Aspinall. Born in Ohio, he moved to Colorado at age eight in 1904 and was raised near the small town of Palisade where his parents bought and operated a peach orchard. From early in life, Wayne Aspinall learned the importance of diverting and applying water to make things grow in the arid West. After graduating first from Denver University, he earned a law degree at the same school, owned his own peach orchard, taught school, practiced law, and set his sights on a career in politics. After serving in both houses of the Colorado General Assembly for every year but two between 1930 and 1948, the enterprising Aspinall was elected to the U.S. Congress.[7]

Once in Congress, Aspinall consciously followed in the footsteps of Edward T. Taylor. Specifically, Aspinall learned that to remain in Washington, D.C., he would need to advocate the case for enhancing both the Western Slope and the Upper Colorado River Basin's water storage capacity. At a time when most Congressmen aspired to more nationally prestigious seats on committees such as Ways and Means Judiciary, or Appropriations, Aspinall made an early decision to gain a seat and remain on the House Interior Committee, the committee that handled almost every important piece of legislation dealing with Western issues, including water, public lands, national parks, Indian affairs, and mining. In six years, Aspinall's decision to remain on Interior proved wise; by 1955, he chaired the House Interior Subcommittee on Reclamation and Irrigation. From 1959 to 1973, he chaired the entire Interior Committee, placing him in a position to influence and shape every piece of legislation vital to his state and region.[8]

In many ways, the most significant piece of legislation crafted by Aspinall was the 1956 Colorado River Storage Project. This landmark legislation was a by-product of many influences, including the long pent-up dreams of the Upper Colorado Basin states for significant reclamation development. Of course, it was only made possible by the Colorado River Compact, which allowed the Upper Basin the luxury of affording to wait until it was politically ready to begin a large reclamation program. What had happened by the 1950s to make this possible? And what new events would threaten the Upper Basin's dreams of an ample water supply for its future?

World War II had started a population rush to the entire West, but most certainly into the Upper Colorado River Basin in particular.[9] World War II and the early Cold War era also inspired an incredible burst of economic activity to the West. Regions like Colorado's Front Range and Western Slope, Utah's Wasatch Front, and New Mexico's Albuquerque and Los Alamos areas were transformed by the needs of the nation's defense programs, military bases, advanced technology, and the fevered search for raw materials like uranium. As the region's economy boomed, political leaders began asking the nervous question: did the region have enough water to meet the growing population's urban, industrial, and agricultural needs? A finite, and seemingly dwindling water supply could cast a pall over the post-World War II era's boom-born optimism. Increased water storage would emerge as the top priority for political action. The Colorado River Storage Project (CRSP), a long-studied program for Upper Basin water development, would be shaped and reshaped to meet the region's water needs.

While this is the context for the Colorado River Storage Project (which became law in 1956), the actual legislation faced a series of new challenges that foreshadowed the difficulties the federal reclamation program would have in the decades ahead. From the 1930s to the early 1950s the Bureau of Reclamation and the Army Corp of Engineers was busy constructing not only the largest series of dams in world history, but also the greatest number of them in a short period of time. The New Deal era had made the Bureau of Reclamation an extremely powerful federal agency. It became a capital development "machine," a virtual free-wheeling job creation agency at a time when signs of economic progress were welcomed by all Americans.[10] By the early 1950s, however, a new series of challenges began to pose a potential threat to federal reclamation's progress. The problem began not with the overall concept of a comprehensive Upper Basin Reclamation Program but where some of the dams would be located. Two of them were slated in early drafts of the legislation for the largely unknown canyons of Dinosaur National Monument, at Split Mountain and Echo Park, on the Colorado-Utah border.

It would soon be revealed that the Bureau of Reclamation had plans to build dams and flood other scenic wonders, which led to a revival of some of the spirit and emotion of the great Progressive era conservation war over the flooding of Yosemite National Park's Hetch Hetchy Valley. If the federal government was going to flood Dinosaur, what other scenic wonders will be threatened, conservationists asked? A national campaign evolved with dozens of conservation organizations writing tens of thousands of letters against the CRSP with the scenery-destroying dams on NPS lands. By 1956, a compromise had been worked out, still allowing for a massive CRSP bill, but without the hated dams at Split Mountain and Echo Park . Much of the Upper Basin's reclamation infrastructure would be constructed in CRSP's wake: Navajo Dam, Flaming Gorge, Glen Canyon Dam, and the Curecanti Unit, to name only the most prominent structures.[11]

The post-World War II conservation movement had come close to threatening the entire project. Congressman Wayne Aspinall, who had chaired the House Irrigation and Reclamation Subcommittee during the Echo Park and Colorado River Storage Project fight had experienced first-hand the power of the emerging conservation movement. While he did not admire that power, he understood the West was in a minority position politically and that a new era had dawned in reclamation politics. Water projects would never sail through to Congressional authorization again without close public scrutiny. Henceforth, reclamation projects would be forced to deal and bargain with a new political force, that of the conservation movement reborn and energized as the emerging environmental movement. Wayne

Aspinall would become known as the environmental movement's most stubborn opponent for his unstinting advocacy of public land and reclamation prerogatives in the face of environmentalist criticism.[12]

Both Edward Taylor and Aspinall shaped the Mountain West's irrigation infrastructure as well as its reclamation political values. Taylor's contributions were several. He provided a model for later politicians in terms of constructing a political career based upon hydraulic values. "Fight for every drop of water that originates on the Western Slope," was Taylor's clear message. Because of the Western Slope's small population, its political power would always be minimal. One way to maximize its political leverage was to find key Congressional committee assignments where political strength could be exerted. Wayne Aspinall, who grew up idolizing Taylor, took the older man's advice to heart. Aspinall became the nation's foremost authority on reclamation politics, a master legislative technician, and the environmental movement's "most durable foe."[13]

Together, Aspinall, Taylor and the story of the Colorado River Storage Project bear witness to some of the most significant reclamation developments in twentieth century Western American history. The strategies and legacies of both men addressed the needs of a region where water needed to be managed. As the citizens of Colorado and the larger American West in the twenty-first century continue to debate the merits of additional water storage, or perhaps revisit the Colorado River Compact, or devise other water division strategies, they will be doing so in the shadow of the political precedents and visions articulated by water statesmen like Edward Taylor and Wayne Aspinall in the early to mid-twentieth century.

(Endnotes)

[1]Daniel Tyler, Silver Fox of the Rockies: *Delphus E. Carpenter and Western Water Compact*s (Norman: University of Oklahoma Press, 1993), 9.

[2]Duane Vandenbusche and Duane A. Smith, *A Land Alone: Colorado's Western Slope* (Boulder, CO: Pruett Publishing Company, 1981), 190-91.

[3]Steven C. Schulte, "Building the Vision: Taylor, Aspinall, and Water for Western Colorado, 28-31 in Colorado Foundation for Water Education, *Citizen's Guide to Colorado's Water Heritage* (Denver, CO: Colorado Foundation for Water Education, 2004).

[4]Ibid.

[5]See Daniel Tyler, *The Last Water Hole in the West: The Colorado-Big Thompson Project and the Northern Colorado Water Conservancy District* (Niwott: University Press of Colorado, 1992).

[6]Schulte, "Building the Vision," 28-31.

[7]Steven C. Schulte, *Wayne Aspinall and the Shaping of the Modern West* (Boulder, CO: University Press of Colorado, 2002). See especially Chapter One, 1-36.

[8]Ibid., 37-83.

[9]See Richard White, *It's Your Misfortune and None of My Own: A New History of the American West* (Norman: University of Oklahoma Press, 1991), 503-04. White points out that eight million people migrated across the Mississippi between 1940 and 1950. Of the nine states with the highest rates of population growth between 1940 and 1950, six were in the American West. Also see White's population table, 515.

[10]Hal K. Rothman, *The Greening of a Nation?: Environmentalism in the United States Since 1945* (Fort Worth: Harcourt Brace College Publishers, 1998), 36.

[11]See Mark W.T. Harvey, *Symbol of Wilderness: Echo Park and the American Conservation Movement* (Albuquerque: University of New Mexico Press, 1994). Harvey tells the Echo Park story well and places it in the context of both environmental and Western American history.

[12]Schulte, *Wayne Aspinall*, 227-260.

[13]Ibid.

Research Reveals High Altitude Aquifers

New research shows that high-altitude aquifers honeycomb parts of the Colorado Rockies, trapping snow melt and debunking the myth that high mountain valleys act as "Teflon basins" to rush water downstream. Mark Williams (University of Colorado at Boulder) conducted geochemical studies that show that less than half of the annual snow melt in the Green Lakes Valley in the mountains west of Boulder arrives at a downstream watershed treatment facility as "new water." He found that most of the water sampled from North Boulder Creek during runoff months was "old groundwater" that had been stored in subterranean mountain catchments.

For the complete article, go to: http://www.nsf.gov/news/

AWRA Scholarships to Raby, Ritter, Triana and Zarter

The 2004-2005 Academic Year recipients of the AWRA Colorado Section Rich Herbert Scholarship were selected from among an outstanding field of applicants. These students will present the results of their work at the May Program of the Colorado Section of AWRA. A brief description of the scholarship recipients follows, in alphabetical order:

Kim Raby is a MS student in the Department of Environmental Studies at the University of Colorado. Her advisor is Dr. Mark Williams and the topic of research is Using a Watershed Approach to Develop Land Use Planning Tools in San Juan County, Colorado. The research will provide a scientifically-based, user friendly tool for watershed management that can be used in the local land use planning process.

Kaylene Ritter is a PhD student in the Department of Chemistry and Geochemistry at the Colorado School of Mines. Her advisor is Dr. Donald Macalady and the topic of research is The Influence of Natural Organic Matter (NOM) on Arsenic Adsorption to Iron Oxides: Implications for the Mobility and Remediation of Arsenic in Colorado. The purpose of this work is to discern the properties of NOM that influence arsenic adsorption to Fe oxides. This understanding will allow rapid and effective assessment of the threat of NOM posed to an arsenic treatment system.

Enrique Triana is a PhD student in the Department of Civil Engineering at Colorado State University. His advisor is Dr. John Labadie and the general direction of research is Enhancement to the MODSIM River Reservoir Operation Model. The goal of this work is to develop an enhanced version of MODSIM with greater graphical user interface capabilities and additional ability to handle water allocation in an administrative/institutional framework when water routing in short time intervals is invoked.

Charlotte Zarter is a MS student in the Department of Environmental Science and Engineering at the Colorado School of Mines. Her advisor is Dr. Robert Siegrist and the topic of research is Field Evaluation of Vadose Zone Purification and the Effects of Applied Water Quality and Hydraulic Loading Rate. The results of this work will directly support development of guidelines regarding the design and operation of engineered pretreatment units to cost-effectively treat domestic wastewater at a given site.

30th Colorado Water Workshop
"Thirty Years Ago, Who Would Ever Have Imagined?"
July 27-29, 2005
Gunnison, CO

When the Water Workshop began 20 years ago, Colorado's population was less than 60% what it is today, big water projects were still under construction throughout the West, recreation was barely recognized as a "beneficial use," the dry winter of '76 and Carter's Hit List still lay in the future, "75,000,000 acre-feet over any 10-year period" was still the Law of the Colorado River, and almost no one had heard of global warming.

Time for a "30-year Reality Check". Have we gained, lost of just held our own in the challenges of developing Water in the West? And what can we imagine we will be looking at in 2035?

Keep posted via the website at www.western.edu/water or contact George Sibley at 970-943-2055 or water@western.edu for more information.

RESEARCH AWARDS

COLORADO STATE UNIVERSITY, FORT COLLINS, COLORADO
Awards for April and May 2005

Received 5/31/2005--Trlica,Milton J Jr--1472--USDA-USFS-Rocky Mtn. Rsrch Station - CO--*Patterns of Vegetation Recovery following Control of Invasive Plants*--**$49,231.00**

Received 5/26/2005--Clements,William H--1474--DOI-USGS-Geological Survey--*Effects of heavy metals in Rocky Mountain strems* --**$1,500.00**

Received 5/25/2005--Wohl,Ellen E--1482--USDA-USFS-Rocky Mtn. Rsrch Station - CO--*Assessing Snow-Making Impacts to Stream Channels* --**$2,500.00**

Received 5/24/2005--Rathburn,Sara L--1482--DOI-NPS-National Park Service--*Channel Restoration of Lulu Creek and the Colorado River, RMNP, CO, Phase II*--**$16,776.00**

Received 5/24/2005--Cooper,David Jonathan--1472--DOI-NPS-National Park Service--*Developing a Restoration Plan for Fan Lake* --**$18,248.00**

Received 5/24/2005--Baron,Jill--1499--DOI-NPS-National Park Service--*A Survey of the Impacts of Fish Introduction and Removal on Zooplankton of Alpine Lakes in Rocky Mountain National ...*--**$17,276.00**

Received 5/16/2005--Oad,Ramchand--1372--S. S. Papadopulos & Associates, Inc.--*Decision-Support for Improving Water Management in the Middle Rio Grande Irrigation System*--**$122,626.00**

Received 5/12/2005--Culver,Denise R--1474--Colorado Division of Wildlife--*Survey and Assessment of Critical Wetlands of Archuleta County*--**$10,000.00**

Received 5/11/2005--Kalkhan,Mohammed--1499--DOI-USGS-Geological Survey--*Invasive Species Survey and Report* --**$105,000.00**

Received 5/9/2005--Roath,Leonard Roy--1472--Colorado Division of Wildlife--*Republican Rivers Watershed Project* --**$40,000.00**

Received 5/9/2005--Rocchio,Joseph F--1474--NatureServe--*Performance Standards For Mitigation & Monitoring of Wetlands in the United States (Phase I Pilot)*--**$9,405.00**

Received 5/9/2005--Hittle,Douglas C--1374--NSF - National Science Foundation--*Robust Learning Control for Building Energy Systems*--**$116,698.00**

Received 5/3/2005--Kummerow,Christian D--1371--NASA - Natl Aeronautics & Space Admin.--*A Physical Validation Approach for Precipitation* --**$100,000.00**

Received 5/3/2005--Rutledge,Steven A--1371--NASA - Natl Aeronautics & Space Admin.--*Physically-based Observational Studies for Tropical Rainfall Measuring Mission & Concept Development for …*--**$64,999.00**

Received 5/3/2005--Cifelli,Robert C--1371--Various "Non-Profit" Sponsors--*CoCoRaHS Charter Members Cost Share* --**$363.00**

Received 5/3/2005--Venkatachalam,Chandrasekaran--1371--UMASS-University of Massachusetts--*ERC: The Center for Collaborative Adapative Sensing of the Atmosphere*--**$14,124.00**

Received 5/3/2005--Newman,Peter--1480--DOI-NPS-National Park Service--*Developing Sampling & Data Analysis Methodology for Merced River Monitoring Field Guide, Yosemite National Park, Ph...*--**$11,300.00**

Received 5/2/2005--Simmons,Mark--1878--NSF - National Science Foundation--*2004 REU Supplement to the Vascular Flora of the Southern Rocky Mountain Region*--**$7,590.00**

Received 4/29/2005--Fausch,Kurt D--1474--Fisheries Conservation Foundation--*A Documentary Video Exploring Interconnections Between Imperiled Stream & Forest Food Webs*--**$13,000.00**

Received 4/25/2005--Vukicevic,Tomislava--1375--University of New Hampshire--*Fast Fluxes Slow Pools: Integrating Eddy Covariance, Remote Sensing & Ecosystem Processes Data within…*--**$31,568.00**

Received 4/22/2005--Jacobi,William R--1177--Larimer County--*Effects of Chloride Salts on Roadside Vegetation & Water*--**$186,811.00**

Received 4/19/2005--Stephens,Graeme L--1371--NASA - Natl Aeronautics & Space Admin.--*Combing Model & Observations to Study Cloud Feedbacks in the Climate System*--**$173,268.00**

Received 4/19/2005--Ramirez,Jorge A--1372--DOD-ARMY-ARO-Army Research Office--*Quantifying the complex hydrologic response of an ephemeral desert wash*--**$210,147.00**

Received 4/14/2005--Ramirez,Jorge A--1372--DOD-ARMY-ARO-Army Research Office--*Request for Instrumentation for Continued Hydrologic Research in Yuma Wash, Arizona*--**$122,950.00**

Received 4/14/2005--Venkatachalam,Chandrasekaran--1373--NASA - Natl Aeronautics & Space Admin.--*Tropical Rainfall Measuring Mission Observations & Precipitation*

Received 4/8/2005--Rutledge,Steven A--1371--NSF - National Science Foundation--*Dynamical, Microphysical & Electrification Studies in Mid Latitude Convection*--**$192,832.00**

Received 4/6/2005--Hicke,Jeffrey A--1499--University of Vermont--*Biomass and NPP in the Delaware River Basin* --**$9,575.00**

Received 4/6/2005--Anderson,David G--1474--DOI-USFWS-Fish & Wildlife Service--*Noxious Weed Monitoring at the US Air Force Academy*--**$30,276.00**

Received 3/31/2005--Hicke,Jeffrey A--1499--DOI-USGS-Geological Survey--*Western Mountain Initiative: Response of Western Mountain Ecosystems to Climatic Variability & Change*--**$161,500.00**

Received 3/29/2005--Child,R Dennis--1472--USDA-USFS-Rocky Mtn. Rsrch Station - CO--*Criteria & Indicators of Sustainable Rangeland Management*--**$40,000.00**

Received 3/24/2005--Reising,Steven C--1373--NSF - National Science Foundation--*CAREER: Three-Dimensional Measurements of Atmospheric Water Vapor Using Miniaturized Microwave Radiometers*--**$93,092.00**

Due to changes in the way we access this information through Colorado State University, the appearance and content of this listing have changed.

No information is available for grants received at University of Colorado or Colorado School of Mines.

CALENDAR

Jun. 14-16	**Hazardous Materials/Waste Management Training Course.** Fort Collins, CO. For more information contact: ocsreg@lamar.colostate.edu.
Jun. 22-24	**2005 Colorado Foundation for Water Education Annual River Tour: Yampa, Green, and White River Basins. For more information and registration go to http://cfwe.org/ .**
Jul. 12-14	**2004 NIWR Annual Conference. River and Lake Restoration: Changing Landscapes.** Portland, Maine. For more information go to: www.ucowr.siu.edu.
Jul. 20-22	**Western Water History, Law and Politics (1 credit course).** Western State College of Colorado, Gunnison, CO. For fee and schedule information contact George Sibley at 970-943-2055 or gsibley@western.edu.
Jul. 22-26	**Natural History of the Gunnison River Basin (2 credit course).** Western State College of Colorado, Gunnison, CO. For fee and schedule information contact George Sibley at 970-943-2055 or gsibley@western.edu.
July 25-29,	**17th Annual Activated Sludge Process Control Short Course.** Estes Park Holiday Inn, Estes Park, CO. For more information contact: ocsreg@lamar.colostate.edu.
Jul. 27-29	**30th Colorado Water Workshop: Thirty Years Ago, Who Would Ever Have Imagined?** Western State College of Colorado, Gunnison, CO. For fee, college credit, and schedule information contact George Sibley at 970-943-2055 or gsibley@western.edu.
Aug. 8-19	**Dam Safety, Operation, and Maintenance International Technical Seminar and Study Tour**, Denver, CO. For more information go to www.usbr.gov/international.
Aug. 25-26	**Colorado Water Congress 2005 Summer Convention.** Steamboat Springs, CO. For more information go to: www.cowatercongress.org, or phone 303/837-0812, or email macravey@cowatercongress.org .
Sep. 26-27	**Colorado Water Congress Colorado Water Law Seminar.** Denver, CO**.** For more information go to: www.cowatercongress.org, or phone 303/837-0812, or email macravey @cowatercongress.org.

Oct. 12	**Colorado Water Congress Water Quality Workshop.** Denver, CO. For more information go to: www.cowatercongress.org, or phone 303/837-0812, or email macravey@cowatercongress.org.
Oct. 13	**Colorado Water Congress Endangered Species Conference.** Denver, CO. For more information go to: www.cowatercongress.org, or phone 303/837-0812, or email macravey @cowatercongress.org.
Oct. 13-15	**MODFLOW: Introduction to Numerical Modeling** ID # 05-2 with Eileen Poeter Colorado School of Mines, Golden, CO. For more information go to: http://typhoon.mines.edu/short-course/.
Oct. 17-18	**UCODE: Universal Inversion Code for Automated Calibration** ID # 05-3 with Eileen Poeter. Colorado School of Mines, Golden, CO For more information go to: http://typhoon.mines.edu/short-course/.
Oct. 19-20	**A Water Conservation Training and Certification Class.** Westminster, CO. For more information go to www.coloradowaterwise.org.
Oct. 20	**Colorado Water Congress The Initiative Process: What You Need To Know.** Denver, CO. For more information go to: www.cowatercongress.org, or phone 303/837-0812, or email macravey@cowatercongress.org.
Oct. 26-29	**SCADA and Related Technologies Irrigation Distribution Modernization.** Portland Oregon. For more information go to http://www.uscid.org/05scada.html .
Nov. 3-5	**UCODE: Universal Inversion Code for Automated Calibration.** Golden, CO. For more information go to: http://www.mines.edu/igwmc/short-course/
Nov. 6-10	**American Water Resources Association 2005 Annual Conference.** Seattle, WA. For more information go to: http://www.awra.org/ .
Nov. 8	**Colorado Water Congress Legal Ethics in Water and Environmental Law**. Denver, CO. For more information go to: www.cowatercongress.org, or phone 303/837-0812, or email macravey@cowatercongress.org.
Dec. 5	Call for papers: Proposals for MODFLOW and More 2006: Managing Ground-Water Systems (May 22-24, 2006). For submittal criteria go to http://typhoon.mines.edu/events/modflow2006/abstract_form.shtml.
2006	2006
Jan. 26-27	**Colorado Water Congress 48th Annual Convention.** Denver, CO. For more information go to: www.cowatercongress.org, or phone 303/837-0812, or email macravey@cowatercongress.org .
May 8-10	**American Water Resources Association 2005 Spring Specialty Conference: Geographic Information Systems (GIS) and Water Resources IV.** Houston, TX. For more information go to: http://www.awra.org/meetings/Houston2006/index.html .
May 19-21	**Polishing Your Ground-Water Modelling Skills.** Golden, CO. For more information go to http://www.mines.edu/igwmc/short-course/
May 19-21	**Introduction to ArcGIS.** Golden, CO. For more information go to http://www.mines.edu/igwmc/short-course/
May 19-21	**Finite Element Ground Water Modeling using FEFLOW.** International Ground Water Modeling Center, Golden, CO. For more information go to http://www.mines.edu/igwmc/short-course/
May 19-21	**MODFLOW-2000: Introduction to Numerical Modelling.** International Ground Water Modeling Center, Golden, CO. For more information go to http://www.mines.edu/igwmc/short-course/

May 19-21	**Analysis of Surface Water-Groundwater Flow Systems Using Integrated Codes.** International Ground Water Modeling Center, Golden, CO. For more information go to http://www.mines.edu/igwmc/short-course/
May 22-24	**MODFLOW and More 2005: Managing Ground-Water Systems**. International Ground Water Modeling Center, Golden, CO. For more information go to http://typhoon.mines.edu/events/modflow2006/modflow2006.shtml
May 24-26	**Modeling Water Flow and Contaminant Transport in Soils and Groundwater Using the HYDRUS Computer Software Packages.** International Ground Water Modeling Center, Golden, CO. For more information go to http://www.mines.edu/igwmc/short-course/
May 24-26	**Subsurface Multiphase Fluid Flow and Remediation Modeling.** International Ground Water Modeling Center, Golden, CO. For more information go to http://www.mines.edu/igwmc/short-course/
May 24-26	**Phreeqc Modeling: The Basics.** International Ground Water Modeling Center, Golden, CO. For more information go to http://www.mines.edu/igwmc/short-course/
May 24-26	**GIS for Water Resources.** International Ground Water Modeling Center, Golden, CO. For more information go to http://www.mines.edu/igwmc/short-course/
May 24-26	**UCODE-2005: Universal Inversion Code for Automated Calibration**. International Ground Water Modeling Center, Golden, CO. For more information go to http://www.mines.edu/igwmc/short-course/

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Colorado Water Resources Research Institute
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