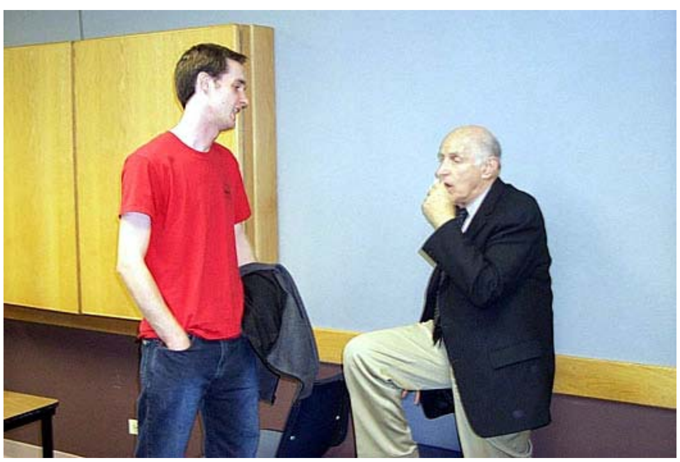
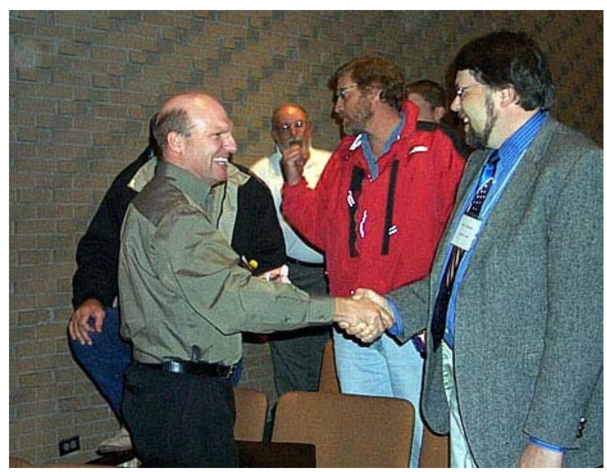
COLORADO WATER

Newsletter of the Water Center of Colorado State University

April 2005





INSIDE: Conversations on Water

Clockwise from top right: Luis Garcia talks with Dmitry Kurtener (Russia) at Hydrology days, see page 30. Joel Schneekloth (CSU Cooperative Extension) thanks Jim Hall (Colorado State Engineer) for his presentation at Lower South Platte Forum, see page 16. Joseph Sax (UC Berkeley) ponders Western water law with Dan DeLaughter (CSU student), see page 21. John Schefter (USGS) and Joan Ehrenfeld (NJ) discuss water research policy at NIWR meeting in Washington DC, see page 22.

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WATER ITEMS AND ISSUES . . .

COLORADO WATER
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EDITORIAL

Understanding Ground Water

by Robert C. Ward
Director, CWRRI

The incorporation of ground water into a conjunctive management relationship with surface water has been occurring in the Western U.S. for a number of years. Tellman (1994) described the variety of conjunctive ground and surface water management systems employed in the U.S. She noted, in particular, that each state has a unique program that is undergoing development over time.

Recent events in Colorado (e.g. court cases, drought, new legislation, and compact settlements) are spurring rapid evolution in the way Colorado conjunctively manages surface and ground water. Managing ground water in a sustainable relationship with surface water, in the real world, is multifaceted and complex. The effects of human activities, and how these effects transmit themselves through the hydrologic system, need to be better understood.

In this issue several articles describe research that improves our understanding of ground water quality and quantity. On page 14, Dano, Poeter, and Thyne describe the role of septic tank effluent in the degradation of the Turkey Creek Basin's water quality by investigating the flow path and chemical evolution of the effluent after it leaves the infiltration area of one individual sewage treatment system. The chemical fingerprint of the effluent is similar to the surface water near the mouth of the basin suggesting that the effluent contributes to decreased water quality.

On page 10, Miller and Durnford examine questions surrounding use of the Stream Depletion Factor (SDF) method to assess stream depletion and accretion caused by ground water pumping and recharge. In the case studied, it is concluded that the SDF maps remain a widely available reference for use at sites where there is limited data.

At the recent AWRA Water Policy Dialogue in Tucson, Arizona, Bob Hirsch, Associate Director for Water, U.S. Geological Survey, discussed water availability being complicated by depletion of ground water in storage. In his presentation (provided on page 30 of this issue of *Colorado Water*) he noted that current levels of water use in many parts of the country are dependent on withdrawing ground water at rates that exceed average recharge. As the amount of water in storage in aquifers decreases and the vertical distance water must be pumped to the land surface increases, the overall availability of ground water decreases.

Hirsch further notes that ground-water depletion can have negative consequences for streamflow, riparian vegetation, land-surface subsidence, water quality, water temperature, flow to wells, and the quality of life for future generations. To understand and manage for sustainable ground-water use, it is crucial to understand ground-water/surface-water interactions and subsequent effects on biota. To obtain this understanding requires well-designed monitoring programs and computer models that can accurately simulate both ground-water and surface-water flow systems, with some additional paradigm shifts, as outlined below.

Paradigm Shift for Ground-Water-Surface-Water Interaction models

Old paradigm		New paradigm
Effects tens of meters away	to	Effects tens of kilometers away
Effects over hours to weeks	to	Effects over months to centuries
How much can be withdrawn and at what rate?	to	How much does the ecosystem need?

On page 4, Garcia updates *Colorado Water* readers on developments with the South Platte Mapping and Analysis Program (SPMAP) – a set of software tools being used to establish augmentation plans for wells along the South Platte River. SPMAP provides the type of science that Hirsch notes, above, is needed. Development of SPMAP has been underway for a number of years, but the true value of this research effort became painfully obvious as the drought of 2002 unfolded. The SPMAP article provides an overview of the history of the research and insight into recent efforts to improve the ET estimation module.

Before closing, I must note that on page 13 Susan Hyatt, Development Officer for the Morgan Library at CSU, reports that the campaign to raise funds to remove mold from the Delph Carpenter Collection in the CSU Water Archives has reached its target. This brings the Carpenter Papers closer to public access.

References
Tellman, Barbara. 1994. My Well v. Your Surface Water Rights: How Western States Manage Interconnected Groundwater and Surface Water. Issue Paper 15, Water Resources Research Center, University of Arizona, Tucson, Arizona.

South Platte Mapping and Analysis Program Completes Current Phase and Begins New Improvement Phase

by Luis A. Garcia and David Patterson
Colorado State University

The science behind conjunctive management of ground and surface water has received renewed interest in recent years as court approved augmentation plans must be in place to insure that well pumping does not damage senior water rights. Development of augmentation plans requires an ability to estimate the impact well pumping has on stream flows over time. Such relationships can be complex, requiring models and extensive data to develop estimates that are widely accepted by all parties involved.

The South Platte Mapping and Analysis Program's (SPMAP) primary function is to accurately determine the timing and amounts of groundwater withdrawals used for irrigated agriculture. Accurate accounting of groundwater withdrawals allows water managers to meet the challenges of new court decrees and legislation related to the South Platte.

The SPMAP project began in 1995 with the formation of an advisory group comprised of representatives from the Northern Colorado Water Conservancy District (NCWCD), the South Platte Lower River Group, Inc. (SPLRG), the Colorado State Engineers Office (SEO), Groundwater Appropriators of the South Platte (GASP), the Central Colorado Water Conservancy District (CCWCD), the Lower South Platte Water Conservancy District (LSPWCD), the City of Greeley, and the City of Fort Collins. Over the years, some of the participants have changed, but the core group of advisors has continued to meet regularly. The tools developed on the advice of these meetings are increasingly being used throughout the state.

SPMAP, as a set of computer tools, has been developed by the Integrated Decision Support (IDS) Group at Colorado State University (www.ids.colostate.edu). SPMAP matches data acquisition, system design, modeling, and user interfaces with the needs of area water managers. SPMAP software consists of three main components including Geographic Information System data and analysis tools (SPGIS), a consumptive use model (IDSCU), and stream depletion model (IDS AWAS) which calculate the time elapsed between when a groundwater recharge or withdrawal event occurs and when an accretion or depletion happens in the river.

Funding for this project was provided by the water organizations participating in the advisory committee listed above, the Colorado Water Resources Research Institute, Colorado State University Cooperative Extension, Colorado State Experiment Station and the US Bureau of Reclamation.

In order to manage the conjunctive use of ground and surface water resources, tools need to be developed to evaluate four issues: 1) water demands, 2) water supplies, 3) depletions of groundwater and resulting augmentation requirements, and 4) impacts to rivers. Furthermore, managers require tools that can work with both large and small areas and over different time scales.

Decision support systems, such as SPMAP, have been employed in other Colorado river basins to model water supply, and the Lower South Platte River basin has been a testing ground for decision support systems since the early eighties. Due to the complex nature of the South Platte, computer tools promise significant benefits for improving water management.

Tools such as SPWRMS (South Platte Water Rights Management System), SAMSON (Stream Aquifer Model for Management by Simulation and Optimization), and others have been evaluated and presented in a number of CWRRI publications (Raymond et al., 1996; McCarthy and Light, 1995; Kuhnhardt and Fontane, 1995; Warner et al., 1994; and Klein, 1994). In addition to these efforts, the State of Colorado has begun to implement a decision support system for the entire South Platte River Basin (CWCB, 2000).

The initial goal of the SPMPAP project was to identify gaps in water management tools available in the Lower South Platte River Basin and implement computer systems that could be incorporated into a future decision support framework. The goal of the continued project was to improve on the tools developed. A new user-centered approach to water research has been an essential part of the project. The approach expressly elicits information from water managers to develop data acquisition, modeling, and user interfaces that meet managers' needs.

SPMAP has been developed according to the following timeline:
• 1995-96 Project efforts focused on spatial data collection and evaluation. A GIS tool was developed as an extension to ArcView 3.0+ to provide users with the capability of viewing and using spatial data, such as themes for irrigated lands, well locations, stream depletion factors, hydrography, weather stations, county boundaries, roads, and cities.
• 1997-98 A Consumptive Use model called the South Platte Consumptive Use (SPCU) Model and an interface for a Stream Depletion Factor (SDF) model began development.

Satellite images were purchased to determine irrigated land area, field delineation, and crop type classifications.

• 1999-00 The Stream Depletion Factor (SDF) interface called SDF View was released with documentation. Using stream depletion factors, SDF View estimates the lag time between when irrigation well water is pumped from, or water is recharged to, an alluvial unconfined river aquifer and when a depletion or accretion happens in the river. SDF View has been used in developing managed groundwater recharge as a water supply for a future Platte Basin Endangered Species Recovery Program in Colorado, Nebraska and Wyoming. The SPCU Model was released and documentation was provided. An important function of the SPCU Model was the capability to retrieve well, weather, and ditch diversion data from the state engineer's HYDROBASE database. This concluded the initial SPMAP project and provided a well-defined set of deliverables

• 2001-02 Additional layers were added to SPGIS. Also, the ArcView interface was improved by developing the capabilities to locate wells using footing calls, to generate well locations using GPS data, and to determine the SDF value of a well by interpolating from the SDF coverage. The SPCU model was enhanced by allowing users to generate input and output displays for all year types (calendar, irrigation, and water) and to generate weather scenarios as compute daily CU using the Penman-Monteith method. The development of a new stream depletion model with a daily time-step was begun because farms with wells close to a river need higher accuracy. The daily stream depletion model was tested and improved.

• 2003-04 Due to the severe drought which reinforced the value of the SPMAP tools. As more and more user groups around the state (or other states) began using the CU Model, the decision was made to change the tool's name to the IDSCU Model to show that the tool is data driven and can be used anywhere, not only to the South Platte Basin. The IDSCU Model expanded options for computing monthly CU by adding the Pochop and Hargreaves methods. Daily options were expanded to include the Kimberly-Penman and ASCE methods. The IDSCU Model now allows users to calculate monthly well pumping from annual records. Tools for reading input data from Access or dBase files were developed to enable user groups to automatically build datasets from their databases. The daily depletion model was also released and dubbed the IDS Alluvial Water Accounting System (AWAS). IDS AWAS gives users the option of calculating river depletions using The Analytical Stream Depletion method developed in 1987 by Dewayne R. Schroeder, a method which uses analytical equations described by Glover (Glover 1977) and others. IDS AWAS substantially increased the options available to the user for calculating stream depletions (e.g. boundary conditions), an important consideration in conforming to the demands posed by new water legislation. Both of these models are being used by a number of augmentation plans and consultants.

> ***"Our collaborative efforts since 1995 on developing the modules of the SPMAP computer software are an excellent example of what can be accomplished when water user organizations and the CSU community work together on a worthwhile and needed project....Having consistent user-friendly software developed by IDS as a neutral third party has assisted in negotiations surrounding recent Water Court groundwater augmentation plans. With the increasing pressures to maintain and secure augmentation supplies, the computer software modules of SPMAP have become indispensable. The reliance on the IDS Group for its services and development / support of the SPMAP software, illustrates how a university group can truly meet the needs of an important component of Colorado society-the water users."***
> -Jon Altenhofen,
> Northern Colorado Water Conservancy District
> Supervisory Water Resources Engineer

Major deliverables

GIS

A number of GIS coverages have been developed and are available for download at www.ids.colostate.edu/projects/spgis. A few of the GIS coverages that we would like to highlight are: 1) PLSS coverage for Division 1 that matches the PLSS displayed on quads, 2) a 200 meter lattice of points attributed with most of the information required to run the IDS AWAS model (for the alluvial aquifer in the Lower South Platte Basin), 3) a transmissivity grid and contour coverage for the alluvial aquifer in the Lower South Platte Basin.

A couple of ArcView 3.2x extension (SPMAP and Welltools) that provide the user with GIS capabilities to view different coverages and to locate point features using legal descriptions or to determine the legal description for a point feature.

PLSS Locator - A standalone tool that allows the user to view GIS (shapefiles) files and allows users to locate point features when either the Public Land Survey System (PLSS) information is known or UTM coordinates are known.

ArcIMS Server – In the web page for the GIS (www.ids.colostate.edu/projects/spgis) the user has access to an ArcIMS server that display the GIS layers for the South Platte via the web.

IDSCU
The IDSCU Model is a data driven model that allows the users to calculate the ET using a number of different ET methods (monthly and daily). Some of the capabilities of the model are: 1) allows the user to project ET into the future or the past based on historical data, 2) allows the user to access HYDROBASE to develop diversion records, 3) can use access or dbase tables to create input datasets, 4) computes a complete water budget, 5) allows the users to compare CU values computed with different ET methods (this information can be used to develop calibrated Blaney-Criddle crop coefficients), 5) evaluates the application efficiencies of wells by comparing depletions of groundwater computed using a water budget with pumping records multiplied by a presumptive depletion factor, and 6) allows user to export the CU of groundwater into IDS AWAS.

IDS AWAS
IDS Alluvial Water Accounting System (IDS AWAS). IDS AWAS provides users the option of calculating river depletions using The Analytical Stream Depletion method developed in 1987 by Dewayne R. Schroeder, a method which uses analytical equations described by Glover (Glover 1977) and others. The model allows users to calculate depletions using daily or monthly time steps. The user has the option to evaluate a number of different boundary conditions (alluvial, infinite, no flow and effective SDF). IDS AWAS can create model input in two ways: 1) each well has a list of pumping records consisting of a pumping rate and duration (original mode), or 2) input records consist of net consumptive use or recharge in a daily or monthly time step. Year type can be set to calendar, irrigation, or USGS. Data can be projected into the future or past based on historical data, and the effect of turning off the well by specifying an end date beyond the period of record can be simulated.

Conclusions

This collaborative effort involving water user groups and IDS is an excellent example of how a number of diverse users can contribute to the development and use of common computer tools which can benefit all. The Lower South Platte is a critical resource for agricultural production and for overall Colorado water policy. The alluvial South Platte aquifer conjunctive use systems (ground and surface water) have a history of use that is unique in the United States. The SPMAP project with its unique approach provides a set of tools that can be used for a myriad of applications required by water managers on the Lower South Platte. A completion report for the current phase of SPMAP development is being published by CWRRI and will be available soon.

A new phase of the project will be started this year to further identify data and tool development needs, as well as improving the usefulness of existing tools. The tools developed as part of this project can easily be incorporated into a larger structure or additional modules/models can be incorporated into the existing structure developed for this project.

SPMAP tools provide practical tools for water managers to meet future challenges in managing a complex system to meet increasingly complex goals. The software and documentation is provided on the internet at: http://www.ids.colostate.edu/projects

References

Colorado Water Conservation Board (2000b). South Platte Decision Support System (SPDSS): An Overview. HTML document, viewed from http://cdss.state.co.us on December 20, 2000.

Kuhnhardt, H. and Darrell G. Fontane, (1995). “Initiating a Water Management Decision Support System for the South Platte River Basin”, Colorado Water Resources Research Institute Water in the Balance Report, No. 2.

Klein, Kathleen C., ed. (1994). “Seeking an Integrated Approach to Watershed Management in the South Platte Basin”, Proc. of the 1993 South Platte Forum. 26-27 Oct. 1994, Greeley. Colorado Water Resources Research Institute.

McCarthy, Paddy and Adam Light, (1995). “South Platte Water Rights Management System”, Colorado Water Resources Research Institute Water in the Balance Report, No. 4.

Raymond, John H., Luis A. Garcia, and Robert Lange (1996). “Evaluation of SAMSON for Use in a South Platte Decision Support System”, Colorado Water Resources Research Institute Completion Report No. 191.

Warner, James W., Jon Altenhofen, Jack Odor, and Brandon Welch (1994). “Recharge as Augmentation in the South Platte River Basin”, Colorado Water Resources Research Institute Technical Report, No. 21.

Grigg Honored by CSU Alumni Association as 2005 Distinguished Faculty

Neil Grigg received the Distinguished Faculty Award from the Colorado State University Alumni Association. He earned his doctorate in civil engineering in 1969 and joined the CSU faculty in 1972. His research and expertise in water resource planning and management, public works infrastructure management, water law, urban water systems and disaster preparedness have earned him the respect and recognition of professional organizations and international colleagues. His network of previous graduate advisees extends to more than 30 nations.

Integrated Decision Support Consumptive Use and Alluvial Water Accounting System

One Day Training Course

May 19, 2005 Colorado State University

The Integrated Decision Support Group at Colorado State University will conduct a one day hands-on training course on the use of the IDS Consumptive Use model (IDSCU) and the IDS Alluvial Water Accounting System model (IDS AWAS). These models were developed as a part of the South Platte Mapping and Analysis Program (SPMAP), a collaborative effort between IDS and water users in the South Platte Basin. The models are data driven and being used around Colorado.

This training course will instruct users on how to create and use templates to develop data sets; use diversion records from HYDROBASE; and access weather data from HYDROBASE, COAGMET, and NCWCD. Features of the IDSCU model that will be discussed include: 1) computing a complete water budget, 2) using the model to compare CU values computed with different ET methods (this will be used to demonstrate how a user might develop calibrated Blaney-Criddle crop coefficients), and 3) evaluating the application efficiencies of wells by comparing depletions of groundwater computed using a water budget with pumping records multiplied by a presumptive depletion factor.

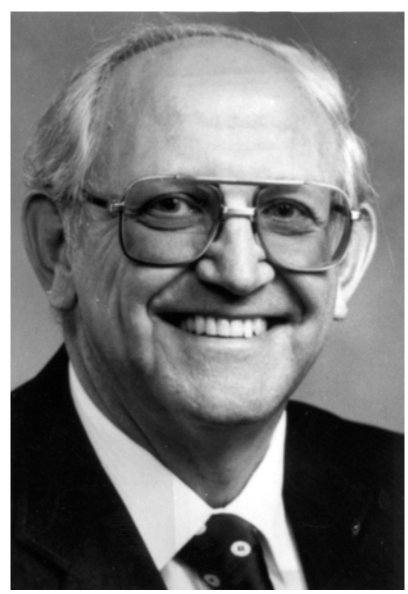
The training course will include an introduction on how to export depletion of groundwater information to the IDS AWAS model or generate input files for the IDS AWAS model. Participants will then be shown the major features of the IDS AWAS model. The participants will be introduced to a number of GIS tools that IDS has developed to calculate the input parameters for the IDS AWAS model such as distance to river, distance to boundary, and transmissivity. The training course will be conducted on Thursday May 19, 2005 at Colorado State University.

The cost of the registration is $200. Course registration will be limited due to the availability of computers for hands-on training.

You can obtain more information and register at www.ids.colostate.edu.

Heermann Retires from USDA-ARS in May

Dr. Dale F. Heermann, Agricultural Engineer, (Water Management Research Unit) will retire on May 3, 2005 after 38 of years with the USDA-ARS in Fort Collins, CO.



Celebrations include a reception on May 3 from 2:30 – 5:30 p.m. in the North and South Platte Conference Room, Building D, Natural Resources Research Center, 2150 Centre Drive, Fort Collins and a dinner on June 10th at the Fort Collins Senior Center. For more information about either of these events, contact Harold Duke at hrduke@asae.org.

Dale Heermann grew up in Scribner, NE and graduated from University of Nebraska where he served an internship with the USDA-ARS. After a stint in the U.S. Air Force, he completed his Ph.D at Colorado State University and joined ARS in 1968, where, in 1981, he became Research Leader of the Water Management Unit.

Heermann derived the mathematical formulation to describe the hydraulics of center pivot irrigation systems, developed a computer program for pivot evaluation and design, and derived methodology for computing uniformity of irrigation by center pivots. With more than 150 technical publications and more than 100 technical presentations at national and international meetings, Heermann is recognized internationally as an authority on center pivot irrigation and precision farming.

Water Level Changes in the High Plains Aquifer

Three recent reports on ground water levels in the High Plains Aquifer are summarized below. The reader is cautioned that the timeframes covered by the reports are not the same.

The High Plains Aquifer underlies eight states and, since the 1930s and 1940s, has provided irrigation water for one of the major agricultural regions in the world. According to USGS Fact Sheet 2004-3097, water-level changes in the high plains aquifer, from predevelopment to 2003, ranged from a rise of 86 feet to a decline of 223 feet. The average change across the High Plains has been a decline of 12.6 feet. Approximately 24 % of the aquifer area had more than 10 feet of decline; 17 % had more than 25 feet of decline; and 9 % had more than 50 feet of decline. The largest areas with greater than 50 feet of decline occurred in southwest Kansas, east-central New Mexico, the central part of the Oklahoma Panhandle, and the western part of the Texas Panhandle.

What have been recent changes in water levels? The USGS Fact Sheet 2004-3097 also compares 2002 ground water levels to 2003 levels. The findings indicate a range between a rise of 9 feet to a decline of 14 feet. A decline of 3 feet or greater occurred in 19 % of the wells measured. A State-by-State examination revealed a range between a decline of 1.7 feet in Kansas to a decline of 0.3 feet in Wyoming. The average change across the High Plains, from 2002 to 2003, was a decline of 1.2 feet.

How much water is associated with the above water level changes? USGS Fact Sheet 2004-3097 states that total water in storage in 2003 was about 2,940 million acre-feet, which was a decline of about 235 million acre-feet since predevelopment. For Colorado, the change in water storage from predevelopment to 2003 was a decline of 13.9 million acre-feet. From 2002 to 2003, the change in storage was a decline of 1.1 million acre-feet.

Water levels are recovering in some areas due to management by State and local agencies and improved irrigation efficiency among other factors. Portions of the aquifer below Texas and Kansas, where the aquifer is thinner and deeper below the surface, have the most significant depletion rates.

You can view USGS Fact Sheet 2004-3097 at http://water.usgs.gov/pubs/fs/2004/3097/

Colorado: Southern High Plains Designated Ground Water District

VanSlyke (2004) presents the results of water level measurements of wells in the southern High Plains Designated Basin made during the months of February and March 2004. This project was done in cooperation with the Southern High Plains Ground Water Management District and local well owners. Funding for this project was supplied in part from well permit fees collected and managed by the Office of the State Engineer as a result of the passage of Senate Bill 200 during the 1987 legislative session.

A total of 95 well sites were visited with 84 wells being measured, recorded and data entered. A review of the 2004 measurements, as compared to the 2003 measurements, reveals that the following water level changes have occurred since the last measurement period.

- Water levels declined in 32 wells, as compared to 44 wells in 2003
- Water levels rose in 52 wells, as compared to 35 wells in 2003
- Water levels remained constant in 4 wells, as compared to 9 wells in 2003
- The average water level change of all wells in 2004 was a rise of 0.74 feet.

You can order the complete report, *Ground Water Levels in the Southern High Plains Designated Ground Water Basin, 2004,* by George VanSlyke, from the Colorado Department of Natural Resources, Records Department at 303-866-3447 between 10 a.m. and 3 p.m.

Colorado: Northern High Plains Designated Ground Water Basin

During the winter of 2004-5, water levels were obtained for approximately 650 wells in the Northern High Plains Ground Water Basin (Schaubs, 2005). An attempt was made to measure all the wells within an eight-week period beginning in mid-December 2004. Most wells were measured by mid-February 2005. By measuring the wells in a short time period, it is hoped that seasonal fluctuations will be dampened and that the hydrographs and comparison of water level change will more accurately reflect true ground water conditions. Throughout the Northern High Plains, the water levels continue to show the regional decline that is to be expected when water is being "mined."

The average rate of decline for the past year was almost one and one-half times the ten-year average and was nearly double that of last year. The 2003-4 decline was 0.79 feet, while the 2004-5 rate is 1.31 feet. The well hydrographs contained in the report show water level trends throughout the basin. Based on previous work, the overall decline of 1.31 feet indicates that approximately 1,200,000 acre-feet have been removed from storage. A decline of one foot is equal to a depletion from storage of approximately 900,000 acre-feet. Over the past five years (2000 to 2005), the basin-wide water level has declined approximately 6.08 feet, representing a depletion of approximately 5,472,000 acre-feet or more than five percent of the estimated 1965 storage in the aquifer. The depletion for the past ten years (1995 to 2005) indicates that more than 8,660,000 acre-feet have been removed from storage (decline of 9.62 feet). This equates to a rate of depletion of little more than one-half percent per year.

The original basin designation allowed for a depletion of 40 percent in 25 years. This was amended in 1990 to allow a depletion of 40 percent in 100 years. This figure is somewhat misleading in that some areas in the basin are experiencing much higher rates of depletion due to a lesser saturated thickness and the fact that 2000 to 2003 were extremely dry years.

You can order the complete report, *Ground Water Levels in the Northern High Plains Designated Groundwater Basin, February 2005*, by Michael Schaubs, from the Colorado Department of Natural Resources, Records Department at 303-866-3447 between 10 a.m. and 3 p.m.

For information about aquifer conditions in other states try these websites:
Kansas: http://magellan.kgs.ukans.edu/WaterLevels/CD/index.htm
Nebraska: http://csd.unl.edu/general/newpub-gwmaps.asp
New Mexico: http://nm.water.usgs.gov/water_data_QL.htm
South Dakota: http://sd.water.usgs.gov/public/realtime.html
Texas: http://tx.usgs.gov/
Wyoming: http://waterplan.state.wy.us and http://wy.water.usgs.gov/data.htm#GroundWater

References

___________. (2003). *Ground-Water Depletion Across the Nation, U.S. Geological Survey Fact Sheet 103-03.* Denver, CO: U.S. Geological Survey.

McGuire, V. L. (2004). *Water-Level Changes in the High Plains Aquifer, Predevelopment to 2003 and 2002 to 2003, U.S. Geological Survey Fact Sheet 2004-3097*. Denver, CO: U.S. Geological Survey.

Schaubs, Michael. (2005). *Ground Water Levels in the Northern High Plains Designated Ground Water Basin, February , 2005.* Denver, CO: Colorado Division of Water Resources, Department of Natural Resources.

Van Slyke, George. (2004). *Ground Water levels in the Southern High Plains Designated Groundwater Basin, October 2004.* Denver, CO: Colorado Division of Water Resources, Department of Natural Resources.

Yampa / White River Tour Scheduled June 22-24, 2005

A tour of the beautiful Yampa and White River Basins, expert speakers discussing the latest issues in regional water management, and networking opportunities are included in the Colorado Foundation for Water Education's second annual professional development river tour. Last year, almost 90 participants (including real estate agents, state legislators, engineers, utility employees and county commissioners) from Colorado and the West attended the professional development river tour. The schedule (subject to change) includes:

June 22
River restoration on the Lower Elk River
Lunch at a local ranch, agricultural flood irrigation
Steamboat Springs Whitewater Park
Stagecoach Reservoir Hydroelectric Facility

June 23
Globally rare riparian forest at the Nature Conservancy's Carpenter Ranch
Elkhead Reservoir expansion and endangered fish issues
Rafting trip through Juniper Canyon on the Yampa River
Local history of the Meeker Valley

June 24
Oil and gas issues in the Piceance Basin: tour a drill rig
Kenney Reservoir and water quality issues in the White River
Visit Dinosaur National Monument
Green River/Flaming Gorge Reservoir operations

Tour seats are limited, so early registration is recommended. Tour registration costs are all-inclusive, covering tour transportation, lodging, meals, activities and background materials. For registrations forms, call the CFWE offices at (303) 377-4433 or download a printable form at www.cfwe.org

Early Registration – Before June 3
CFWE Members: $425 single occupancy room -- $325 double occupancy room
Non-Members: $475 single occupancy room -- $375 double occupancy room

Late Registration – After June 3
$550 single or double occupancy

Research at the Tamarack Recharge Project and a Review of the SDF Method

by Calvin Miller and Deanna Durnford
Civil Engineering Department, Colorado State University

The Colorado Division of Wildlife (CDOW) and the Northern Colorado Water Conservancy District (NCWCD) are participating in developing an augmentation project on the Lower South Platte River near Crook, Colorado. The project currently recharges groundwater at the Tamarack State Wildlife Area (Figures 1 and 2) during late winter to provide increased groundwater return flows at later times. Ten recharge wells and three recharge ponds are currently in operation with plans to add additional capacity.

Figure 1. Tamarack State Wildlife Area, viewing the river (among the trees) from a groundwater recharge pond on the sand hills approximately 60 feet above and 3500 feet away from the river.

Colorado State University has had the opportunity to use the Tamarack project to study recharge operations and their effects on the aquifer and riparian water bodies. The study is being conducted by Deanna Durnford in Civil Engineering, Bill Sanford in Geosciences, and John Stednick in Watershed Stewardship, along with cooperation from CDOW and NCWCD. The ongoing study includes geophysical surveys, aquifer pumping tests to examine stream-aquifer connection parameters, modeling assessments, tracer tests, and several years of water quality tracking.

As part of the Tamarack project, we reviewed the Stream Depletion Factor (SDF) method used to assess stream depletion and accretion caused by groundwater pumping and recharge. We compared the method in bounded aquifers to a numerical model constructed for the Tamarack site by CDOW. This review can be downloaded from www.hydrologydays.colostate.edu (Miller and Durnford 2005) and is summarized here.

Jenkins (1968a) published charts and examples of typical stream depletion computations based on the Glover method (Glover and Balmer 1954; Glover 1960) and he proposed a modified approach in which modeling would be used to determine an alternative input parameter that would incorporate complex aquifer behavior not accounted for by the analytical Glover parameters (Jenkins 1968b; Jenkins and Taylor 1974). In essence, model results would be used to adjust Glover's stream-aquifer response curve to best match actual (as modeled) response curves. To this end, the aquifers along the South Platte and Arkansas rivers in Colorado were modeled by the USGS and the values of this input—the SDF, which has units of time—were mapped (Figure 3, for example). Use of this model-derived input in Glover's equations is referred to as the SDF method. The two methods use the same mathemati-

Figure 2. A project pond recharging at approximately 40 acre-feet/day.

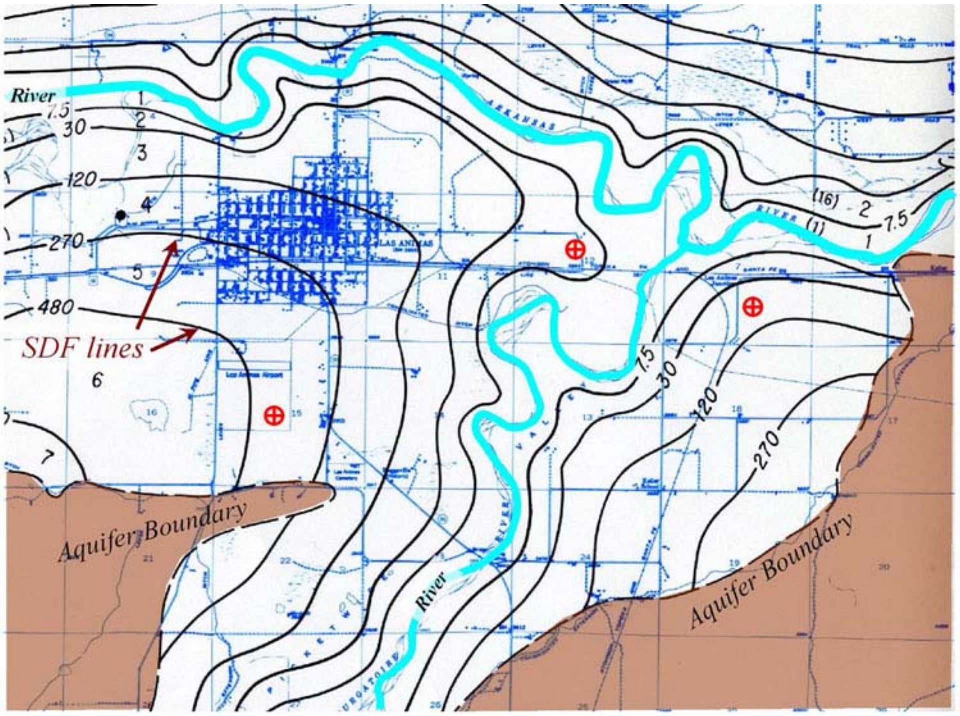


Figure 3. Example of an SDF map (after Jenkins and Taylor, 1974).

cal model; the difference is really a question of where the user obtains inputs to the model and what effects are accounted for by the selected inputs.

Although the modeling improved and streamlined estimates over purely analytical methods, the SDF method is still an approximation since the response curve is calibrated to one point only: the time given by the SDF. By definition, the SDF method matches complex response curves exactly at the SDF time. And, in a number of modeling tests, Jenkins observed that the method matched with "acceptable accuracy" in the time range between ½ SDF and 2 SDF.

We constructed response curves for bounded aquifers using the image well method (e.g., Glover 1978) to illustrate the SDF method's approximation of boundary effects (Figure 4). Plotted against nondimensionalized time (time/SDF), the curves are a function of the relative well position between the stream and the aquifer boundary (distance "*a*" as a fraction of aquifer width "*W*"). The SDF approximation is good for wells closer to the stream until times much larger than the SDF (t>2SDF), but for wells closer to the boundary the approximation departs from the bounded curves sooner.

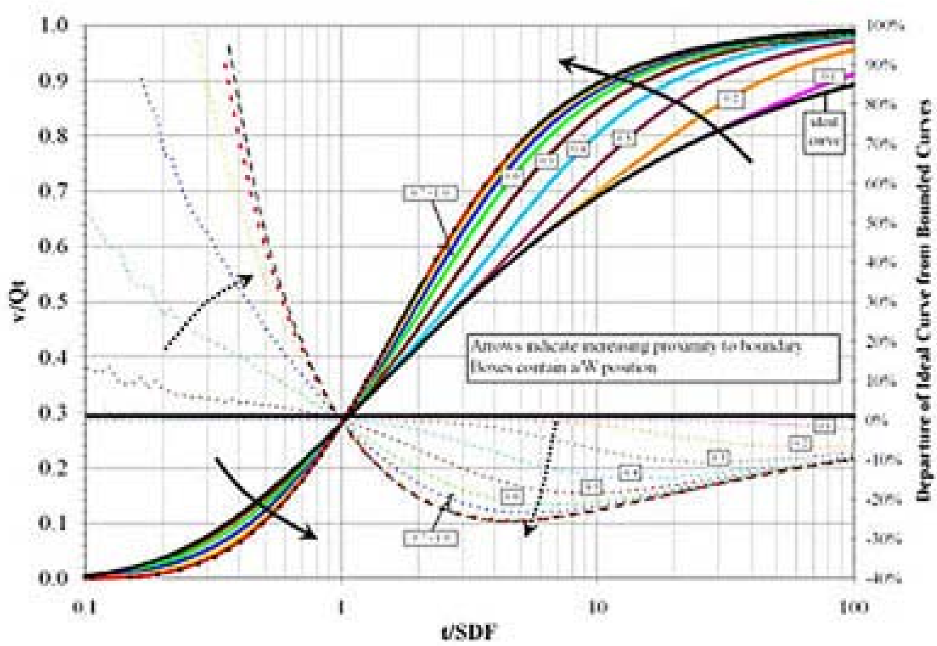


Figure 4. Response curves for bounded aquifers.

Combining the image method with the SDF method can significantly improve estimates, but it raises a question about over-accounting for boundary effects since SDF's already account for boundaries. However, from our review, it is apparent that SDF's in the stream-half of the aquifer do not account for boundary effects. The SDF modeling did account for them, but for these locations the calibration point is reached before the boundary effects are significant. Consequently, these SDF values can be legitimately combined with the image method. For the other half of the aquifer, the boundary effects follow a predictable adjustment that can be removed to allow these mapped values to be used with images as well. This conclusion and the small adjustment were evaluated against the numerical model of the Tamarack site and they compared well.

Awareness that the SDF method only partially accounts for boundaries has prompted some water professionals to use alternatives. These alternatives have value, but continuing to use the SDF method by combining it with the image method also has benefits: SDF maps are valuable since they integrate multiple effects in addition to aquifer boundaries (e.g., spatially variable transmissivities and irregular boundary shapes). Using the maps compared well to a relatively detailed numerical model of our field site, and modeling studies are not feasible for the majority of groundwater users. Also, the SDF maps are a widely available reference for sites that may otherwise have limited data and they provide a consistent reference for sites that have a wide range of possible data inputs.

References

Glover, R.E., 1960: Ground water-surface water relationships. In Western Resources Conference, Boulder, Colorado, Colorado Ground Water Commission, Dept. of Natural Resources. Paper CER60REG45, 8 pp.

Glover, R.E., 1978: Transient Ground Water Hydraulics. Water Res. Publications, Fort Collins, CO, 413 pp.

Glover, R.E., and C.G. Balmer, 1954: River depletion resulting from pumping a well near a river. *AGU Transactions*, **35**(3), 468-470.

Jenkins, C.T., 1968a: Techniques for computing rate and volume of stream depletion by wells, *Ground Water*, **6**(2), 37-46.

Jenkins, C.T., 1968b: Electric-analog and digital computer model analysis of stream depletion by wells, *Ground Water*, **6**(6), 27-34.

Jenkins, C.T., and O.J. Taylor, 1974: A special planning technique for stream-aquifer systems. Colorado District, US DOI Geological Survey, Lakewood, Colorado, Open-File Report No. 74-242.

Miller, C.D., and D.S. Durnford, 2005, "Modified use of the 'SDF' semi-analytical stream depletion model in bounded alluvial aquifers," Proceedings of AGU Hydrology Days 2005, Fort Collins, Colorado, 146-159.

American Water Works Association Research Foundation RFPs Available

Current American Water Works Association Research Foundation requests for proposals are available online at http://www.awwarf.org/research/plansAwardsFunding/rfp.aspx in .pdf format. The deadlines and topics are:

May 6, 2005:
Critical Information Policies for Water Utilities
Improving Sample Preparation Methods for Molecular Techniques for Drinking Water Applications
Strategies for Controlling and Mitigating Algal Growth within Water Treatment Plants
Performance and Metal Release of Non-Leaded Brass Meters
Components, and Fittings, Decision Tools to help Utilities Develop Simultaneous Compliance Strategies
Development of a UV Disinfection Knowledge Base
Methods to Assess GWUDI and Bank Filtration Performance
Enhancement of Water Utility Self-Assessment Tools to Improve Utility Operations

July 15, 2005:
Assessment of Physical Security Technologies for Water and Wastewater Utilities
Integrating Worker Health And Safety Into Water Utility Operation, Management, And Facility Design
Challenge Organisms for Inactivation of Viruses by UV Treatment
Impact of the Change in Disinfectants on Lead, Brass, and Copper Components in the Distribution System
Non-Uniform Internal Corrosion in Copper Piping – Monitoring Techniques
Synthesis Document on the State of Science of Molecular Techniques for Application to the Drinking Water Industry
Communicating the Value of Water
Innovative Applications of Treatment Processes for Spent Filter Backwash
Strategy to Manage and Respond to Total Coliforms and E. Coli in the Distribution System
Assessment of Inorganics Accumulation in Drinking Water System Scales and Sediments
Improving Water Utility Capital Efficiency
Strategies To Help Drinking Water Utilities Ensure Effective Retention Of Knowledge
Microbiological Degradation of HAAs in Distribution Systems
Biological Destruction Of Perchlorate And Nitrate In Ion Exchange Concentrate

Carpenter Collection Mold Remediation Effort Draws Flood of Donor Support

Thanks to an outpouring of support from wide ranging sources, the papers and other significant materials of Delph Carpenter will soon be available for consultation. Contributions have come from the McKee Charitable Trust, NORLARCO, the State of Colorado Department of Natural Resources, many of Colorado's water conservancy and conservation districts, water engineering firms, water law practitioners and scores of individuals committed to preserving Colorado's water history.

Soon after the historic papers were donated to CSU Libraries' Water Resources Archive in June 2004, archives staff discovered the presence of mold on a substantial portion of the papers. Before any processing and cataloging could occur, the mold, though not actively growing, had to be removed.

When CSU Emeritus Professor, Dan Tyler learned of the papers' plight, he jumped into action. If anyone appreciates Delph Carpenter's prominence in Western water history, it's Dan Tyler. Tyler immersed himself in Carpenter's life and work to author the biography *The Silver Fox of the Rockies: Delphus E. Carpenter and Western Water Compacts*. The book highlighted Carpenter's role in negotiating the Colorado River Compact and other contributions to Western water law.

Learning that the Delph Carpenter papers required treatment costing $35,000, Tyler volunteered to assist the Libraries in raising the funds by raising awareness among his friends and colleagues in the Colorado water community.

"The many storms brewing over Colorado's waters make us all realize that Carpenter's work is essential to understanding the meaning and intent of agreements drawn up in the first half of the 20th century," Tyler wrote to his colleagues. "It is essential to open the Carpenter papers for research as soon as possible."

Tyler and other donors gave lead gifts totaling just under $10,000 to support the preservation efforts. In the few months since then, the Libraries have exceeded their goal, raising $43,735. Former State Senator and water rights leader Fred E. Anderson joined the effort to conserve the Carpenter collection, and was instrumental in bringing the need to the attention of the McKee Charitable Trust, which awarded $15,000 to the project in March.

The contributions have funded the purchase of mold cleaning equipment and supplies and staffing assistance. The cleaning of each box varies depending upon its contents. For example, the first box involved cleaning and rehousing 1300 items. Materials subsequently have been checked by Doug Rice of CSU's Environmental Health Services, who has declared them clear of mold. Cleaning of the affected boxes could be complete as early as this fall, after which a finding aid for the collection will be created in print and electronic formats.

Programs and activities to showcase the collection, including development of virtual and physical exhibits, are in the planning stages. Watch for details in the coming months. To support the continuing work with the Carpenter collection, please contact Susan Hyatt at (970) 491-6823 or by e-mail at shyatt@manta.colostate.edu.

Water on Table of Contents 2005 Menu

Once again, CSU Libraries Tables of Content will have several topics of interest to people concerned about water issues. Among the 13 table hosts/topics will be water expert LeRoy Salazar with the topic of "The Struggle for Water: Protecting our Rural Communities"; CSU geology professor Ellen Wohl, author of "Disconnected Rivers: Linking Rivers to Landscapes" on the topic of "Rivers at Risk"; and CSU emeritus civil engineering professor, Maurice Albertson on the topic of "Village Earth: Sustainable International Development."

This year's Tables of Content banquet will take place in Morgan Library on Saturday, June 4. If you would like to receive a full invitation, or learn more about the program, contact CSU Libraries Director of Development, Susan Hyatt at 970-491-6823, or shyatt@manta.colostate.edu.

Parshall Finding Guide Available Online

An on-line finding guide is now available to help locate materials in the Ralph L. Parshall collection held by the Water Resources Archive in Morgan Library at CSU. The finding guide can be accessed from the webpage http://lib.colostate.edu/water/ . Parshall contributed significantly to the field of irrigation engineering with the development of a flow-measuring device that became commonly known as the Parshall flume and continues to be widely used today. Materials in the collection include Parshall's patent on his "Venturi flume water stage recording instruments," awards that Parshall received, publications, and texts of radio talks.

Investigation of the Fate of Individual Sewage Disposal System Effluent in Turkey Creek Basin, Colorado

Excerpted from CWRRI Completion Report No. 200, May 13, 2004

By Kathy Dano, Eileen Poeter, and Geoff Thyne
Colorado School of Mines

With rapid development and population growth in the Turkey Creek Basin (TCB) of Jefferson County, Colorado, the degradation of water quality has become a pressing issue. Residents of TCB are served by a fractured, crystalline-rock-aquifer, typical of those in the western US that provide water to residential users through individual domestic wells and treat wastewater with individual sewage disposal systems (ISDSs). Comparison to basin-scale geochemical data from the 1970s and recent geochemical data from TCB reveals that specific conductivity (an indicator of water quality) in the surface water has increased by a factor of 3.3 (see Table 1) over the past 30 years. Specific conductivity in the majority of the ground water has increased by a factor of only 1.2 over the same time period. However, specific conductivity of ground water in localized areas has increased by a larger factor. This study investigates the role of ISDS effluent in the degradation of the basin's water quality by investigating the flow path and chemical evolution of ISDS effluent after it leaves the infiltration area of one individual sewage treatment system.

Geophysical methods located the ISDS effluent plume of a single home at the regolith-bedrock interface beneath and adjacent to an ISDS infiltration area. Shallow piesometers were installed to measure hydraulic properties and monitor water level and quality. A water budget was calculated for the ISDS system to estimate the bedrock infiltration rate. The home had a typical household pumpage of 644 L/day (170 gallons/day) of which ~72%, an average of 444L/day (123 gallons/day), was dosed into the infiltration area from the septic tank. The low return rate is unexpected; an ongoing study is evaluating this finding.

Ground Water		1975			1999		
Parameter	unit	mean	median	# of samples	mean	median	# of samples
Specific Conductivity	µS/cm	288	256	291	330	313	363
Calcium	mg/L	40	34	40	39	36	269
Magnesium	mg/L	10	8	40	9	8	270
Sodium	mg/L	26	16	40	16	11	270
Potassium	mg/L	2	2	259	2	2	142
Alkalinity	mg/L	181	173	6	118	120	273
Sulfate	mg/L	16	11	40	22	12	273
Chloride	mg/L	9	4	291	25	7	269
Fluoride	mg/L	1	0	40	1	1	242
Nitrogen (NO3 + NO2)	mg/L	2	1	288	2	1	309
Surface Water			1975			1999	
Parameter	unit	mean	median	# of samples	mean	median	# of samples
Specific Conductivity	µS/cm	179	139	25	596	457	78
Calcium	mg/L	16	14	24	72	42	56
Magnesium	mg/L	4	3	24	16	10	56
Sodium	mg/L	8	7	24	36	28	56
Potassium	mg/L	2	1	24	3	3	34
Alkalinity	mg/L	75	61	28	115	99	58
Sulfate	mg/L	8	8	24	71	13	58
Chloride	mg/L	9	6	24	79	65	58
Fluoride	mg/L	1	0	24	1	0	55
Nitrogen (NO3 + NO2)	mg/L	0	0	23	1	0	47

Table 1. Comparison of water chemistry data from the 1970s (Hostra and Hall, 1975) and the late 1990s (Bossong et al., 2003).

Under typical conditions, the effluent infiltrates the fractured bedrock within 5 meters of the infiltration area, rather than migrating laterally through the regolith to the closest surface water, North Turkey Creek, which is 500 m away. During an unusually high spring runoff the plume migrated 50 to 100 m within the regolith before infiltrating the fractured bedrock.

The chemical fingerprint of the effluent is similar to the anthropogenic component required to account for the ground water quality decline as indicated by other studies. The chemical fingerprint of the effluent has a chemical signature similar to surface water near the mouth of the basin suggesting that it contributes to the decreased surface water quality.

References

Bossong, C., Caine, J., Stannard, D., Flynn, J., Stevens, M., and Heiny-Dash, J., 2003. Hydrologic Conditions and Assessment of Water Resources in the Turkey Creek Watershed, Jefferson County, Colorado, 1998-2001. USGS Water-Resources Investigations Report 03-4034. 140 p.

Dano, K., Poeter, E., and Thyne, G., 2004. Investigation of the Fate of Individual Sewage Disposal system Effluent in Turkey Creek Basin, Colorado. Completion Report No. 200. Colorado Water Resources Research Institute.

Hofstra, W., and Hall, D., 1975. Geologic control of supply and quality of water in the mountainous part of Jefferson County, Colorado. Colorado Geological Survey Bulletin 36, 51 p.

Morgan, K., 2000. Spatial Analysis and Modeling of Geochemical Distribution to Assess Fracture Flow in Turkey Creek Basin, Jefferson County, Colorado. Colorado School of Mines MS thesis. 194 p. 71.

Yacob, S., 2004. Using Multivariate Statistical Analyses to Characterize the Effects of Population Growth on Water Quality in a Mountain Watershed. Colorado School of Mines MS thesis. 108 p.

		Surface Waters			Ground Waters			Piezometer Samples			ISDS Effluent	
Parameter	units	A	B	N	A	B	N	A	B	N	A	N
Aluminum	µg/L	104	2.34	34	0.56	0.44	7	69.4	13.5	33	0.47	2
Arsenic	µg/L	0.95	0.69	34	0.76	0.69	7	0.99	1.5	33	1.44	2
Bicarbonate	mg/L	70.6	71	34	122	114	7	104	91.7	31	386	2
Bromide	mg/L	0.13	0.09	34	0.06	0.06	7	0.11	0.07	33	0.44	2
Cadmium	mg/L	0.04	0.03	30	0.05	0.06	7	0.24	0.24	2	0.04	2
Calci	mg/L	38.4	39.8	34	13.3	0.06	7	85.4	49	33	79.8	2
Chloride	mg/L	95.7	82	34	33	20.5	7	284	126	33	1100	2
Chromium	µg/L	7.23	7.71	34	13.7	13.8	7	5.52	3.89	33	43.5	2
Copper	µg/L	1.68	1.5	34	101	72.1	7	7.09	5.7	33	2.14	2
Fluoride	mg/L	0.55	0.48	34	0.41	0.37	7	0.23	0.2	33	0.25	2
Iron	mg/L	0.01	0.01	34	0.01	0.01	7	0.28	0.02	33	1.66	2
Lead	µg/L	0.09	0.05	34	0.75	0.27	7	0.15	0.06	33	0.37	2
Magnesium	mg/L	10.6	10.3	34	1.96	0.01	7	20.4	11.9	33	13.5	2
Manganese	µg/L	19.7	0.76	34	0.45	0.22	7	523	214	33	786	2
Nickel	µg/L	6.92	6	34	3.4	0.6	7	20.7	11.7	33	17.8	2
Nitrate	mg/L	2.05	0.41	34	23.2	31.8	7	20.5	17.3	33	0.39	2
Nitrite	mg/L	0.01	0.01	26	0.01	0.01	6	0.01	0.01	31	N/A	1
Phosphate	mg/L	0.07	0.06	34	0.09	0.06	7	0.13	0.08	33	6.74	2
Potassium	mg/L	3.39	2.62	34	80.3	131	7	32.1	12.8	33	1100	2
Selenium	µg/L	2.8	2.26	30	2.33	2.26	7	5.62	5.62	2	3.94	2
Silica (as SiO2)	mg/L	5.86	5.25	34	11	11.4	7	16.4	16.5	33	12.1	2
Silver	µg/L	0.48	0.53	30	0.46	0.53	7	0.58	0.58	2	0.47	2
Sodium	mg/L	31.5	30.6	34	27	1.58	7	80.8	61.3	33	41.2	2
Sulfate	mg/L	17.4	12.3	34	10.2	12.2	7	24.9	22.1	33	1.3	2
Zinc	mg/L	4.69	4.69	34	80.4	44.7	7	7.35	5.76	33	6.69	2
Specific Conductivity	µg/L	288	205	23	353	308	7	807	675	30	2623	15

Table 2. Mean and median values for each chemical parameter in the four kinds of water samples collected. A = concentration mean, B = concentration median, N is number of samples. No median value is calculated for the ISDS effluent samples because only two samples were collected. When the reported value for a parameter was "below detection limit" a value midway between the detection limit and zero was used to calculate the mean and median.

MEETING BRIEFS

Lower South Platte Forum: Valuing Your Water

Higher demands for water and prioritization of water use along with concerns about a drought situation prompted approximately 140 participants to attend the Lower South Platte Water Symposium held in February at Northeastern Junior College in Sterling.

This year's theme, Valuing Your Water, included a variety of topics.

Mike Gabaldon (Deputy Director of Operations, U.S. Department of Interior, Denver), keynote speaker, presented an historical review of water use in the West as well as future proposed policy on water availability to municipalities. Noting the growing population and the drought conditions in the West, he said that water management is critical. Citing tree ring studies and the all-time low levels at Lake Powell, Gabaldon said that the current drought is one of the worst in 500 years. Reviewing Secretary Gale Norton's Water 2025 project—designed to recognize and prevent conflict and crisis in water issues in the West – he emphasized the importance of water management in preventing critical shortages and pointed out that President Bush's budget reflects an interest in Water 2025.

Rick Brown (Colorado Water Conservancy Board) reviewed water demands in Colorado in general and in the Lower South Platte River. Citing population increase, he noted that water demands will increase by 2030, and conservation measures by farmers will be necessary. He spoke of a decrease in irrigated acreages in future, and the conversion of agricultural land to residential development.

Alan Berryman (Northern Colorado Water Conservancy District) summarized the three-state water agreement between Colorado, Nebraska, and Kansas. He emphasized the necessity of meeting future water use goals, and pointed out the necessity of long-range water management in addressing endangered species such as Pallid Sturgeon, Whooping Crane, Least Terns, and Piping Plover.

Other speakers included Jim Hall (Office of the State Engineer) who reported on Colorado's water in 2004. Referring to the snow pack information gathered annually by the Natural Resources Conservation Service, he said "Local reservoirs are in better shape than last year at this time. Most reservoirs are or will be filled prior to the end of March."

Well augmentation, the replacement of river water depletions caused by out-of-priority pumping of a well, was discussed by Scott Cuthbertson (Office of the State Engineer). He reviewed the impact of well depletion on the Lower South Platte River, with a focus on compliance with current well augmentation regulations.

Justice Gregory Hobbs completed the symposium by addressing the value of water rights. His presentation is reprinted following this article.

How to Value Your Water Right, The Legal Framework

Justice Greg Hobbs

Lower South Platte Forum,
Sterling, Colorado
February 23, 2005

Thank you for your invitation. I attended your forum in 2003 in the midst of a devastating drought. In 2002, river flows in Colorado had fallen to historic lows based on recorded gauge data. A hydrograph of measured flows at the Kersey gauge below Denver for the years 1977 to 2002 shows that the 2002 levels were at rock bottom.

As they must under Colorado's prior appropriation doctrine, our water enforcement officials—the State Engineer, the Division Engineer, and the local water commissioners—responded to senior water rights calls by curtailing junior diversions; water flows were so low that direct flow ditches with priorities dating to the early 1860's were the only surface diversions able to enjoy the use of their water rights.

Yet, wells drilled into the tributary aquifers of the South Platte River with priorities as junior as the 1950s were continuing to divert. Was this pumping legal? Should it be allowed to continue? These huge and divisive questions sounded everywhere along the river and pushed upstream to the Water Court, the Colorado Supreme Court and the General Assembly.

Under Colorado law, all ground water is presumed to be part of the surface stream system unless proved to be nontributary. In 1951, the Colorado Supreme Court stated this fundamental principle as follows:

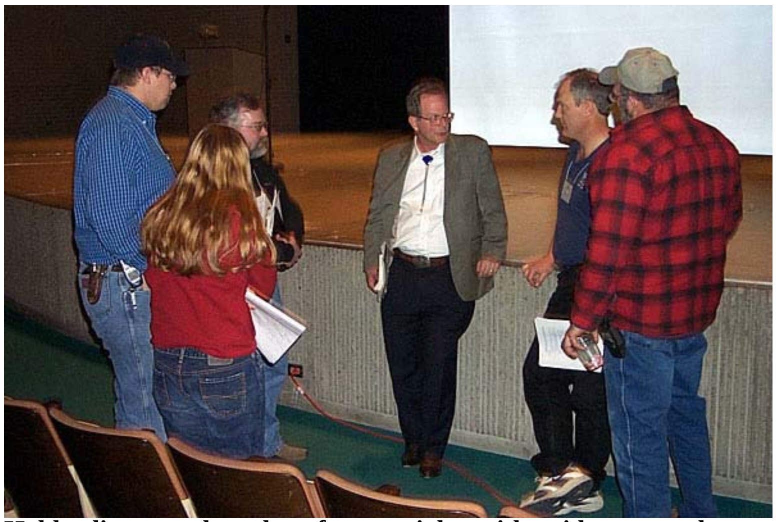
> Under our Colorado law, it is the presumption that all ground water . . . finds its way to the stream in the watershed of which it lies, is tributary thereto,

> and subject to appropriation as part of the waters of the stream. The burden of proof is on one asserting that such ground water is not so tributary, to prove that fact by clear and satisfactory evidence.
> Safranek v. Town of Limon, 228 P.2d 975, 977 (Colo. 1951).

Under the General Assembly's definition of the "hundred year rule," section 37-90-103, C.R.S. (2004), the bench line for finding ground water to be nontributary is that its withdrawal will not deplete the flow of a natural stream at an annual rate greater than one-tenth of one percent of the annual rate of withdrawal.

In 1968, the Supreme Court in Fellhauer said that an injured water user need not show which particular well withdrawal injured the exercise of his or her water right. In an over-appropriated stream system—the South Platte and the Arkansas Basins having long been recognized as over-appropriated—the General Assembly may delegate to water officials the power to protect the stream against unreasonable injury by junior wells when senior appropriators are not receiving, but are in need of and are asking for their decreed rights. Here's what the Court said:

> (W)e hold that, whenever a court or water administration official can make a finding that the pumping of a junior well materially injures senior appropriators who are calling generally for more water, there exists a legitimate and constitutional ground and reason for the regulation of the well, and a showing of a call against the well by a particular senior user is not necessary.
> Fellhauer v. People, 447 P.2d 986, 991 (Colo. 1968).



Hobbs discusses the value of water rights with auidence members after his presentation at the Lower South Platte Forum.

In the 1969 Water Right Adjudication and Administration Act, the Colorado General Assembly authorized the water courts to review and approve augmentation plans that adequately protect senior water rights from the effects of junior well pumping. Under an augmentation plan, the well is allowed to operate out of priority by replacing the amount of its injurious depletions to the stream. If depletions by juniors will deprive seniors of a quantity of water that would have available to them were it not for the juniors' water use, the depletions must be replaced through some source of legally-obtained water. If the depletions are not replaced, seniors suffer material injury to their water use rights, contrary to Colorado water law. Simpson v. Bijou Irrigation Co., 69 P.3d 50, 60 (Colo. 2003).

Under section 37-92-308(2), the General Assembly has provided the State Engineer with authority to approve annual substitute supply plans on a limited basis while augmentation plans are proceeding to and in the water court. A fundamental function of a substitute supply plan, like an augmentation plan, is to replace the amount of the injurious depletion to the stream to meet senior water right needs.

All of these legislative acts and Colorado Supreme Court decisions implement the prior appropriation system applicable to all natural streams in this state under the provisions of the Colorado Constitution adopted in 1876.

All water in Colorado is a public resource whose ownership remains in the public. So, what is a water right? It is a right to use waters of the natural stream—which includes surface water and tributary groundwater—when water would be naturally available to it in order of priority for diversion at its decreed location under its decreed priority in the amount of its decreed beneficial use.

Since 1879, just three years after statehood, the General Assembly assigned Colorado Courts the authority to decree water right priorities that the water officials administer when there is not enough natural supply to satisfy all decreed diversions and senior water users "call" for their rights. Essentially, the "call" is for curtailment of junior rights that would interfere with the ability of senior rights to enjoy their share of the natural available supply.

So the most basic of all truths about Colorado water law is that nature dictates water availability. No farmer can make it rain or snow. So we might as well recognize that governors, legislators, and supreme court justices can't open up the heavens either.

In 1982 the Colorado Supreme Court said what the court had been saying about Colorado's arid climate since the first 1872 decision of the Territorial Supreme Court, no one can "warrant that it will snow or rain" or that senior appropriators will not withdraw all the available water before junior appropriators get theirs; rather, the "value of a water right is its priority and the expectations which that right provides." Navajo Development Co. v. Sanderson, 655 P.2d 1374, 1379 (Colo. 1982).

Nature has a way of exceeding expectations in some years, and bitterly depriving hopes in other years.

What governors, legislators, and supreme court justices can do is to honor and enforce the water law of the State of Colorado as firmly and as fairly as they can when water scarcity occurs. Water scarcity invented prior appropriation law in the first place. Having a ditch or a well or a decreed water right for that ditch or that well has never guaranteed that water will be available to it. Ever since the founding of Colorado Territory, ditches have been built and wells have been dug on the hope that nature will provide enough water to supply them.

And there have been many decades of senior water user complaints about the building of junior ditches and the sinking of junior wells that have no reasonable expectation of getting water in water-short times. The answer to the seniors has been that the juniors take the risk of being curtailed until the seniors are satisfied in their rights.

Ditch digger and well digger beware! has always been Colorado law.

So let's revisit how these complaints were actually being made in the 1800s along the South Platte River—long-before the proliferation of wells in the tributary aquifers of the South Platte basin in the 1950s – 60s – and 70s. The following quotations are from an 1894 Department of Interior Report:

> The earliest large enterprise conducted by English speaking farmers was probably the irrigation system at Greeley built by the Union Colony, work being begun about 1870. As the population of the state has increased and the demand for agricultural products has become greater, farmers have gradually brought under cultivation strips or patches of arable land wherever water can be diverted to cover it at moderate expense. Thus all the easily available sources of water have been utilized, and with increase in the number of farmers still more land has been cultivated until the area far exceeds that which can be irrigated in ordinary seasons.
> F.H. Newell, Report on Agriculture by Irrigation in the Western Part of the United States at the Eleventh Census: 1890, 91 (1894).

Drought had settled into Colorado in the last decade of the 19th Century, and farmers were recognizing that the only relief for firming up then-existing water rights was by building reservoirs to catch excess flows in high years.

> From a careful examination of the census statistics and of replies from thousands of farmers it would appear that the great need at least for the eastern half of the state is for a more careful use of the water and for its increase by flood storage. Far larger areas could be cultivated with the amount now at hand if the water were used with greater skill and economy, and, as is well known, great quantities run to waste each year in time of flood. As the matter now stands there is a deficiency of supply for the land now cultivated and reported as irrigated, and in addition there are far larger areas without water, although under ditch.
> Id. at 93.

Now here is an extended passage in the report written in 1894 that easily could have been written in 2002. Nothing is ever new when it comes to the grief water scarcity will cause, and nothing is ever old when the community is called upon to abide by the law that governs all.

> The Colorado laws regarding irrigation have grown much as has the ditch system, by adding here and there, and as a result they are far from perfect, although better than those of many of the other irrigating states. The farmers complain of the inefficiency of present methods of distributing water, of the apparent injustice that sometimes arises, and of the legal costs involved in protecting their property. In the districts where the demand for water is especially great, where old ditches have been enlarged and new canals built, continual vigilance on the part of irrigators and of state officials must be practiced in order to secure and maintain a legal distribution of water.
>
> The theory upon which the law is based is simple, but the details for enforcing this are complicated and not always efficient. The primary object is to secure to each irrigator the use of an amount of water equivalent to that originally employed by him according to the date at which such employment was made. That is to say, the first settler on a stream should be secure in the use ever after of the amount of water originally diverted and used, and if there is a surplus the next settler should have an amount equivalent to that originally used by him, and so on. At times of drought the persons utilizing the water last in order of time should be deprived of it, and this shutting out should continue in the reverse order of the dates of appropriation until those holding what are known as prior rights have a full supply. . . .
>
> Questions concerning priorities of right are especially perplexing in Division I, where many of the adjudications were made before matters of that kind

were as well understood by the public as at present. The distribution of water in some of the districts is surrounded by almost insurmountable difficulties, requiring great tact and experience on the part of the commissioners, superintendent, and state engineer in order to avoid personal conflicts or litigation. Even then in time of drought there is more or less unavoidable friction, and injunctions have been issued restraining the state engineer and his assistants from interference. Each year, however, as the irrigators come to understand the necessity and value of state interference and questions of detail are settled some of the obstacles are overcome, but at the best there are many hardships connected with the matter.

Few persons outside of the irrigating states comprehend the full significance of the statement that certain ditches have been shut down, or that the greater part of some district has been deprived of water in order to satisfy prior claims. To the irrigators under these particular ditches this deprivation may mean the almost complete loss of the results of the season's work and the jeopardizing of trees, shrubs, and other plants upon which years of care have been bestowed. Of course there are many complaints, and state officials are accused of partiality and unfairness by some of the sufferers, but the community as a whole sees in this the unavoidable operations of necessary laws. The doctrine of priority of rights has been so well established that it is not probable that it can be overthrown, although individuals often attack it bitterly.

Owing to unusual droughts and the shutting down of certain canals and ditches there were heavy losses of crops during the census year, especially under some of the larger canals. The condition of farmers thus deprived of water was deplorable, from the fact they had mortgaged their property to pay for the water rights and paid in advance their annual rates. By being deprived of water their crops were not profitable and interest and partial payments on the mortgage could not be made.
Id. at 94.

One hundred and ten years later we are reminded once again by the drought of the early 21st Century that our water supply is limited and that we are most in need of our grace and patience and our willingness to be governed by the law when the inevitable truth of living in the arid country settles back in our midst.

In Praise of Fair Colorado
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We try our best to remember that the good years will be followed by the lean years. Smart and efficient water conservation is always necessary in all years. Storage is the primary means by which Twentieth Century water uses, most notably by municipalities, have been able to come onto the river without injury to other water uses.
In the 1901 Congressional hearings regarding the bill that became the 1902 Reclamation Act, Congressman Shafroth of Colorado spoke about the over-appropriated South Platte Basin and the need for reservoirs.

> Now, the Platte River in Colorado has been appropriated eight times over, and on account of the increase of the population the claims on the waters of the Platte River have increased eight times beyond what it is possible for the river with its ordinary flow to supply, and there is not a drop of water for any new lands . . . (I)f you construct reservoirs and put them in direct connection with the reclamation of government lands and designate that the water is to be utilized in that connection, the water turned into the stream from the reservoir can be taken out at a lower point and taken to the land the Government owns.
> Statement of Hon. John F. Shafroth, of Colorado, The Reclamation and Disposal of the Arid Public Lands of the West: Hearings Before the House Committee on the Public Lands, 56th Cong., 33 (1901).

As the testimony unfolded before Congress, it turned out that firming up the water supply for existing agricultural lands was even more compelling than breaking out new lands into irrigation throughout the West. Direct flow ditches simply could not bring the crops in during many years because the natural hydrograph of mountain watersheds supplies snowmelt to the streams only during the early part of the growing season.

Let us remember that the Colorado Big-Thompson Reclamation Project resulted from the drought of the 1930s and came on line in the drought of the 1950s. It's purpose was to bring a supplemental supply of water into the South Platte Basin from the Colorado River Basin. The term "supplemental" is highly cautionary. This new water supply was largely meant to firm up the agricultural rights of water- short systems in existence by the mid-1930s and to allow for new municipal and industrial uses. This additional water supply was brought in because enough supply was not naturally available in the native South Platte system, and because part of the native South Platte Supply must be delivered to Nebraska under the 1922 South Platte River Compact.

Then let us remember that the large scale drilling of irrigation wells into the tributary aquifers of the South Platte River occurred in the 1940s to the 1960s. Much productivity has occurred because of this and many of the water years we had in the late Twentieth Century, being extraordinary, put off the inevitable reckoning. When there's enough water for all, there is no "call."

But the prior appropriation system is designed to respond to nature's skimpy bounty. That's when the value of a water right resides in its priority and reliable administration of the priority system.

When it comes to water, rights are definitely not equal under the prior appropriation system. Some have far greater value than others. The market for agriculture water in Colorado, which is quite active in transferring water to municipal use, demonstrates that rights with greater reliability of supply under "call" conditions over an historical period of time have much better value. You know this. The value of a farm with a good water right is greater than one with an unreliable supply.

When a water right is changed to another use through the water court process, it can be valued by the amount of water the buyer can realize from the transfer. This is determined from diversion records, use records, the amount of historic beneficial consumptive use actually made of the water right over an historic period of time, and, most notably, the security of the water right within the priority system when the call comes on the river.

A good practical article on the subject of ascertaining the value of a water right in planning a water supply for a client is Daniel S. Young and Duane D. Helton, Developing a Water Supply in Colorado: The Role of An Engineer, 3. U. Denv. Water L. Rev. 373 (2000). I like this statement, in particular, from a user's perspective as seen through the eyes of the person valuing the water right: "In order for a water supply to meet the client's objectives, it must provide enough water to meet the client's water requirements while not injuring existing water rights." Id. at 382.

Farmers have always been innovative about increasing the value of their water. Augmentation plans and recharge projects have been pioneered by Coloradans right here on the South Platte River. I had the privilege of recognizing this in a 2002 opinion I wrote.

> The General Assembly intended the 1969 Act's provision for augmentation plans to allow out-of-priority diversions to facilitate new water uses in over-appropriated stream systems. See Empire Lodge, 39 P.3d at 1155. Augmentation plans include filling subsurface porous spaces with water by injection or artificial water spreading structures, such as unlined ditches and recharge ponds that utilize water appropriated for that purpose, and then re-extracting the stored water or taking credit for the appropriated water's return to the natural river system through underground formations extending through the lands of others. See, e.g., James W. Warner, Jon Altenhofen, Jack Odor, & Brandon Welch, Recharge as Augmentation in the South Platte River Basin, Department of Civil Engineering, Groundwater Program Technical Report No. 21, Colorado State University (March 1994).
>
> Board of County Commissioners v. Park County Sportsmen's Ranch, 45 P.3d 693, 609 (2002).

A junior water right properly augmented is a very valuable water right because it allows well pumping to be made out of priority and therefore exempt from curtailment. Sure it will cost, and whether it can be done for everyone is surely an economic and water availability question. But, whether the cost is worth it has always been the ultimate test of the utility of any ditch, reservoir, or well since the founding of Colorado Territory in 1861, especially in eastern Colorado.

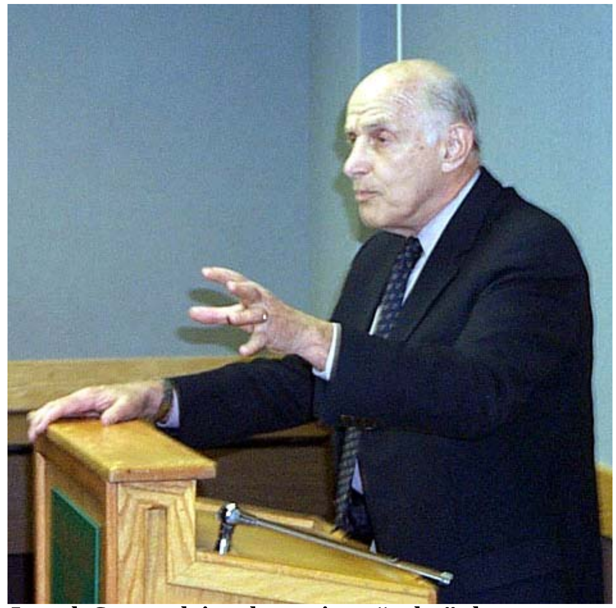
Colorado's water scarcity is both natural and legal.

The **Statewide Water Supply Index** for March is available on line at:
http://www.water.state.co.us/pubs/swsi.asp

For current **news** items concerning water, visit:
http://www.npscolorado.com/news.html

Joe Sax Discusses Transitions in Society and Accompanying Reallocation of Water

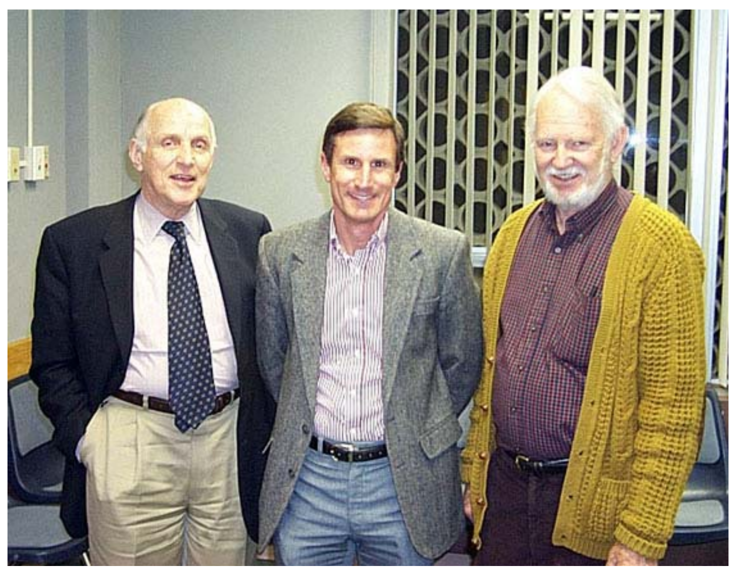
Joe Sax, Professor Emeritus at the University of California-Berkeley Boalt Law School, presented a seminar to 60 students, faculty and water professionals on the evening of March 3, 2005, at Colorado State University. The seminar was sponsored by the Mac Foundation.



Joseph Sax explains the various "rules" that govern water rights.

Professor Sax began his talk by defining how the ownership of water rights is subject to public oversight (the 'rules' that govern allocation and administration of water rights). He observed that this situation exists with a number of water-related aspects of our society – for example, the rights to navigation, public fishery, and environmental protection. He also observed that water is always 'going somewhere' – it is on the move. Thus, the same molecule of water may be shared by a number of people with water rights, as is the case in Colorado where return flows have water rights filed on them further downstream.

Prof. Sax described transitions impacting the West, such as rapid urban growth, changing social values, and quantification of Indian water rights. He asked the question: "How do we manage transitions in the use of water amid social transitions, when the supply of water is basically fixed?"



Joseph Sax, John Loomis, and Bob Young take a break from analyzing Colorado water law and its impact on economics.

He noted that a number of transitions have occurred in our society in the past where the transition's impact of property value was not compensated. For example, during the industrial revolution, there was a huge displacement of traditional activities that were not compensated. He suggested, however, that it will not be possible to transition water allocation (reallocation) to match the new needs of society without some contribution by the public, as well as adaptation by existing water users to new pressures on our water supply. One opportunity is to begin a transition to less water-intensive, more economically productive crops. He offered several other options as well, such as cities providing irrigation improvements that can free up water for lease by agriculture to meet urban needs, which protecting rural community economies; urban purchase of dry year options as a relatively painless way of dealing with drought years; and increased conjunctive use of surface and ground water.

MEETING BRIEFS

National Institutes for Water Resources Convenes in Washington DC in March

The National Institutes for Water Resources (NIWR) held its annual meeting in Washington, D.C., March 6-8, 2005. NIWR is an association of the nation's 54 water resources research institutes created and operated under the Federal Water Resources Research Act. The water institutes connect the water expertise in higher education with the research and education needs of local, state, and regional water managers and users as well as help educate the next generation of water managers. The Colorado Water Resources Research Institute (CWRRI) is Colorado's water institute under the federal legislation.

The main topics discussed at the annual NIWR meeting addressed restoring the water institute program's $6.5 million federal funding, eliminated in the President's FY 06 budget. The national institute program must also be reauthorized during 2005. The water institute program is administered through the USGS and each federal dollar must be matched by two non-federal dollars.

During the meeting, the water institute directors met with Congressional staff to update them on current water research projects and request support for restoring federal funding for the national water institute program.

Another major topic of discussion was formulating a NIWR response to the 2004 National Research Council's report on the role of federally funded water research – a report that addressed the need to better coordinate the nation's water resources research enterprise and examined alternative institutional options for providing improved coordination, prioritization and implement of research on water resources.

NIWR is responding to the NRC report by developing a strategic plan that includes three key elements:

1. Periodic, systematic, state-based formulations of the nation's water research needs and priorities;
2. Periodic inventories of the nation's water research portfolio which can be compared to the nation's needs in order to identify gaps in water knowledge; and,
3. Expand NIWR's annual national water research competition to address the knowledge gaps identified above.

NIWR proposes to adapt its current internet-based water research administration software system to accomplish the above tasks in an efficient and effective manner. The goal is to create an enhanced federal-state partnership that recognizes the lead role states play in managing water resources while, at the same time, acknowledging and addressing the impact federal mandates have on the need for new water information.

A panel during the meeting presented several new water initiatives on campuses across the country. Several examples are:

- The University of Arizona is implementing a new $3.5 million Water Sustainability Program, utilizing funds from a new state tax, to strengthen water research, outreach, and education efforts at the University of Arizona. The goal of the program is to ensure a sustainable, high-quality water supply for economic development and enhanced quality of life for all of Arizona. For more information on this water initiative, see: http://www.uawater.arizona.edu/about/desc.html
- The Idaho Water Center has moved from Moscow, Idaho, (University of Idaho) to Boise State University as part of a state initiative to house the Idaho Water Center, the Idaho State Engineer's Office, a new geospatial center, a US Forest Service research station, the Ecohydraulics Research Center, and CH2MHill in the same building. The goal is to provide a state focus on water via development of new partnerships that are greatly facilitated by co-location.
- The University of Nebraska, has a $1.4 million initiative underway that involves hiring seven new faculty and improving the Water Sciences Laboratory on campus. For more information, see http://wrri.unl.edu/story.htm

Will Focht (OK) outlines the research prioritization process that is a part of the new NIWR strategic plan.

Above: Six directors describe features of their institutes that merited "exemplary" rating in latest national review of institute programs. From left: Henry Smith (Virgin Islands), Mike Barber (WA), Alan Jones (TX), Deborah Swackhamer (MN), Leroy Heitz (Guam), and Greg Jennings (NC).

Right: Senator Conrad Burns (R-MT) indicates his support for the national water institute program.

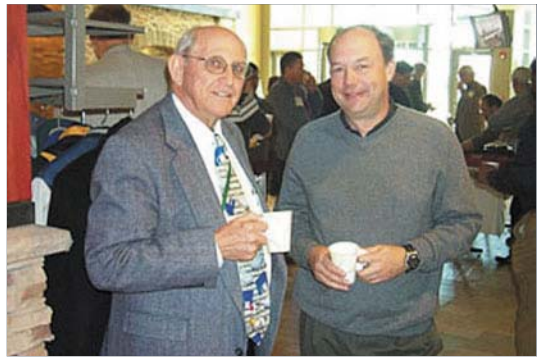
Below left: Gene Whitney, (U.S. President's Office of Science and Technology Policy) address director's of nation's water institutes.

Sharon Megdol (AZ director) discusses 2005 NIWR Executive Summary with Gretchen Rupp (MT director).

MEETING BRIEFS

USDA-ARS Hosts ET Remote Sensing Workshop

A Bureau of Reclamation ET (evapotranspiration) Workshop was held February 8-11, 2005, in the new USDA–Agricultural Research Service (ARS) facilities on the south campus of Colorado State University. A total of 102 professionals representing the U.S. Bureau of Reclamation, USDA-ARS, NASA, USGS, EROS-Data Center, NRCS, water districts in the West, universities, Ohio View institutions and private companies participated in the workshop. A pre-workshop session on SEBAL/METRIC was conducted by Dr. Richard Allen of University of Idaho on the afternoon of February 7th and morning of February 8th.



Dale Heermann (USDA-ARS) and Chris Neale (Utah State University) catch up.

The purpose of the workshop was to review the state-of-the-art in ET remote sensing science and technology, examine how remote sensed ET estimates can improve water management in the West, and finalize a work plan for joint ET remote sensing research involving Ohio View, Colorado State University, and the Bureau of Reclamation. Ohio View is a consortium of Ohio universities that employ remote sensing science and technology to study changes on the earth's surface due to natural and man-made forces. Professor Subramania Sritharan, Director of the International Center for Water Resources Management at Central State University, is leading the project.

Rick Allen (U. of Idaho) and Sritharan Subramania (Central State U., Ohio) take advantage of the break room.

Panel presenting information on technology transfer of ET research findings included: (left to right) Gerald Buchleiter (USDA-ARS), Luis Garcia (Colorado State U.), Josh Rice (Central Colorado Water Conservancy district), Steve Hansen (USBR-Albuquerque), and Dale Heermann (USDA-ARS).

Workshop participants were welcomed by Mr. Chuck Hennig, Research Coordinator, and Ms. Avra Morgan, Program Manager, WATER 2025, both with the Bureau of Reclamation. Dennis Montgomery, in a keynote address, provided insight into the value and need for accurate ET estimates and noted the criteria courts use to admit new scientific data and information (Montgomery's remarks are included in this issue of Colorado Water).

Sessions described current Reclamation ET research, emerging remote sensing ET science and technology, validation planning, use of ET technology by water managers, Reclamation's long-term ET strategy, and lessons learned in managing applied ET research.

The Workshop's proceedings will be published in the near future.

Right: Tom Trout (USDA-ARS) and Tom Ley (Colorado State Engineers Office) discuss the presentation.

Legal Consequences of Evapotranspiration Measurement

Dennis M. Montgomery
Hill & Robbins, P.C.

I am excited about the potential for using remote-sensing technology to measure evapotranspiration – for reasons I will discuss – but I also want to issue a warning that expert testimony based on remote-sensing technology is subject to the rules of evidence governing the admissibility of scientific and technical expert testimony and that careful consideration should be given to those rules before implementing studies in which this technology is used. If consideration is given to those rules at the beginning, it should increase the possibility that remote-sensing technology will become an accepted method to measure evapotranspiration.

Dennis Montgomery (Hill and Robbins) visits with Paula Sunde (USBR-Loveland) during the ET conference.

Consumptive use estimates are used for a variety of purposes:

1. planning for irrigation projects – estimating diversion requirements, sizing irrigation canals and laterals, determining needs for storage or supplemental water supplies;
2. irrigation scheduling;
3. negotiating interstate compacts and determining compliance with compacts;
4. river basin adjudications in some states;
5. quantifying federal reserved water rights for Indian reservations based on practicably irrigable acreage;
6. international negotiations to settle disputes over international rivers;
7. changing water rights – historical consumptive use is used as a limitation on the amount that can be changed to prevent injury to other water users;
8. sale and purchase of water rights – the value of a water right is often determined based on the historical consumptive use associated with the right, particularly a water right that will be changed from irrigation to municipal use; and
9. estimating consumption of ground water in plans for augmentation.

I want to discuss two of these uses of consumptive use data.

Determining compact compliance

First, consumptive use has been one method to equitably apportion the waters of interstate rivers between states. Colorado, for example, has entered into nine interstate water compacts to apportion waters of interstate rivers. Three of those compacts – the Colorado River Compact, the Upper Colorado River Compact, and the Republican River Compact – explicitly apportion water on the basis of consumptive use. However, even though a compact does not apportion the use of water directly on the basis of consumptive use, measuring or estimating consumptive use may still be necessary to determine if a state is in compliance with an interstate compact.

Arkansas River Compact

For example, the Arkansas River Compact of 1948 apportioned the waters of the Arkansas River between Colorado and Kansas primarily on the basis of releases of water from John Martin Reservoir, a large on-channel reservoir in Colorado about 60 mile upstream from the Colorado-Kansas Stateline. The reservoir was authorized by Congress in 1936 for construction by the U.S. Army Corps of Engineers for flood control and conservation storage. The reservoir was so situated that it could store unused flood flows and regulate existing flows for better use in both states, and the states entered into the Compact in part to apportion the benefits of the reservoir. However, even with John Martin Reservoir, it was recognized that there would be some flood flows and winter flows that would be unused.

Article IV-D of the Compact provided that the Compact was not intended to impede or prevent future beneficial development of the Arkansas River Basin in Colorado and Kansas by federal or state agencies, or by private enterprise, "[p]rovided, that the waters of the Arkansas River . . . shall not be materially depleted in usable quantity or availability for use to the water users in Colorado and Kansas . . . by such future development or construction."

In 1985, Kansas filed a complaint with the U.S. Supreme Court alleging that certain post-Compact developments in Colorado had depleted usable Stateline flows in violation of the Compact: the Trinidad Project, the Winter Water Storage Program, and post-Compact well development in Colorado, including increased pumping by pre-Compact wells. To determine whether the Winter Water Storage Program and post-Compact well development had depleted Stateline flows in violation of the Compact, Kansas constructed a model of the Arkansas River Basin in Colorado between Pueblo, Colorado, and the Colorado-Kansas Stateline, which the U.S. Supreme Court recently described as a "highly complex set of computer programs" that tries to "account for almost every Arkansas-River-connected drop of water that arrives in, or leaves Colorado, whether by way of rain, snow, high streams, well pumping of underground water, evaporation, canal seepage, transmountain imports, reservoir storage, or otherwise." Kansas v. Colorado, ___ U.S. ____ (Dec. 7, 2004). The "or otherwise" includes consumptive use by crops and phreatophytes along the river. The model also includes a calibration factor that is intended to account for other consumption that is not directly represented in the model, such as consumption of canal seepage and tail water before they return to the river.

Thus, one reason that measurements of evapotranspiration are important is because estimates of consumptive use derived from such measurements are used to determine directly or indirectly whether a state is in compliance with the terms of interstate compacts. There have been disputes in Kansas v. Colorado about the consumptive use by phreatophytes and crops. It turned out that the depletions to Stateline flows calculated by the model were not sensitive to the estimates of consumptive use by phreatophytes, but the depletions to Stateline flows from well pumping are quite sensitive to the estimates of potential consumptive use by crops used in the model.

Determining historical consumptive use

Another use of consumptive use data is as a limit to prevent injury in changes of water rights. In Colorado, water rights are considered to be property rights and the point of diversion and the type of use can be changed. Because of urban population growth, particularly along the Front Range, there has been an active market in the conversion of agricultural rights to municipal uses over the past 30 years.

In earlier cases, the Colorado Supreme Court had established a rule that junior appropriators are entitled to the maintenance of stream conditions at the time they made their appropriations and that if necessary to prevent injury, a change of a water right would be limited in quantity and time by historical use. Another way of implementing this rule is to require the party changing the water right to maintain the historical return flows. In a recent case, the Colorado Supreme Court said:

> Over an extended period of time, a pattern of historic diversions and use under the decreed right for its decreed use at its place of use will mature and become the measure of the water right for change purposes, typically quantified in acre-feet of water consumed. Essential functions of change of water right proceedings are to: (1) identify the original appropriation's historic beneficial use; (2) fix the historic beneficial consumptive use attributable to the appropriation by employing a suitable parcel-by-parcel or ditch-wide methodology; (3) determine the amount of beneficial consumptive use attributable to the applicant's ownership interest; and (4) affix protective conditions for preventing injury to other water rights in operation of the judgment and decree.
>
> Farmers Reservoir and Irrigation Company v. Consolidated Mutual Water Co., 33 P.3d 799, 807 (Colo. 2001) (emphasis added; citations omitted).

The Court also said:

> For an agricultural appropriation, this analysis focuses on the lands historically irrigated and utilizes diversion records, water application practices, soil and crop types, diversion and delivery efficiency, precipitation, temperature, growing season, aerial records, and testimony of irrigators, along with other reliable and relevant evidence of the appropriation's historic beneficial consumptive use over a representative time period.
>
> Id. n.5 (citation omitted).

Thus, another reason measurements of evapotranspiration are important is that determinations of historical consumptive use – using methods derived from such measurements – are often a limitation imposed when a water right is changed, a limitation that is intended to prevent injury to other water users after the water right has been changed. Moreover, once the Water Court has adopted a methodology for determining an appropriation's historical consumptive use and has made allocations of consumptive use based on a ditch-wide methodology, that methodology and those allocations are normally expected to govern future change proceedings involving the same water rights. Id. at 807.

Methods to estimate consumptive use

In the last 30 years, there have been hundreds of cases in Colorado approving changes of water rights and determining the historical consumptive use under the water right or rights being changed. In Colorado, there has been wide-spread acceptance of the modified Blaney-Criddle method to determine consumptive use in Water Court proceedings. This is despite the fact that in the past two decades there has been considerable research on new methods to determine evapotranspiration. One of the advantages of the Blaney-Criddle method is that it is relatively simple to use and temperature data required for the method are readily available in most areas; but, scientists and engineers have long wanted a more physically-based method to determine evapotranspiration, particularly for use in irrigation scheduling, where hourly or daily estimates of evapotranspiration are important.

Kansas v. *Colorado*

In Kansas v. Colorado, both states used the modified Blaney-Criddle method to determine potential crop evapotranspiration in their respective analyses, and that was the method used in the Kansas model to determine depletions to Stateline flows. Four years ago, however, Kansas proposed to use the Penman-Monteith equation with crop coefficients primarily developed by Dr. James Wright of the U.S.D.A. Agricultural Research Service in Kimberly, Idaho. Colorado's experts agreed that there are better methods to determine evapotranspiration than the modified Blaney-Criddle method, but preferred the 1982 Kimberly-Penman equation developed by Dr. Wright with a wind limit, and concluded that adjustments to evapotranspiration estimates were necessary for aridity, management, and salinity in the Arkansas River Valley in Colorado.

The Special Master in the case in his Fourth Report (October 2003) concluded based on the Kansas' experts testimony that the Penman-Monteith equation with the crop coefficients used by Kansas was the best method to determine potential evapotranspiration in the model and that there was insufficient evidence to support the adjustments made by the Colorado experts, although he left open the possibility that adjustments may be appropriate in the future based on "recognized professional procedures."

The scientific and engineering communities have widely accepted the Penman-Monteith equation and crop coefficients to estimate evapotranspiration; however, the issue in my mind is not the use of the Penman-Monteith equation to calculate reference evapotranspiration, but the use of the crop coefficients developed by Dr. Wright to determine potential evapotranspiration for use in the Arkansas River Valley in Colorado, where many farms are water-short, where management practices may not be the same as the conditions under which the crop coefficients were developed, and where there are relatively high salinity levels. Manual 70 published by the American Society of Civil Engineers (Jensen et. al.)1 described the crop coefficient values developed by Dr. Wright for alfalfa as being for "disease-free, insect-free crops of well-watered Ranger alfalfa harvested without windrow effects or other damage to regrowth. If regrowth of alfalfa is delayed due to irrigation system, disease, insect, fertility, compaction, and windrow effects, then the [crop coefficient] values should be reduced proportionately." (p. 126) The Special Master concluded that there was insufficient evidence to reduce the crop coefficient values.

Daubert and *Kumho Tire*

Now you can understand why I'm excited about the prospect of using remote-sensing technology to determine evapotranspiration. Currently, in the model used to determine Compact compliance in Kansas v. Colorado, research data from lysimeter studies has been used to develop crop coefficients that are applied to determine consumptive use over large areas. A method using remote-sensing technology that could determine actual evapotranspiration over large areas would eliminate an issue that has divided Colorado and Kansas' experts.

However, as I said at the beginning, I want to issue a caveat before suggesting that anyone rush out to use remote-sensing technology to measure evapotranspiration. Expert testimony based on such evidence is subject to the rules governing the admissibility of scientific and technical evidence. Those of you who have testified as expert witnesses in the last 10 years are probably familiar with the U.S. Supreme Court's decision in Daubert v. Merrell Dow Pharmaceuticals, 509 U.S. 579 (1993), which addressed the standard for admissibility of expert scientific testimony in federal cases and which has been adopted by many state courts. I would strongly suggest that anyone who is contemplating using remote-sensing technology to measure evapotranspiration read the Daubert case carefully to understand the factors that many courts apply to determine the admissibility of expert scientific and technical testimony.

Before Daubert, there were several theories of admissibility of scientific expert testimony. The most widely used test was first formulated in Frye v. United States, 293 F. 1013 (D.C. Cir. 1923), and commonly known as Frye test. Courts would inquire only into whether a scientific principle or technique had "gained general acceptance in the particular field in which it belongs." If so, testimony based on the scientific principle or technique was admissible.

In Daubert, the Supreme Court unanimously held that the Frye test had been supplanted by the Federal Rules of Evidence, which were enacted by Congress in 1975, specifically by Federal Rule of Evidence 702. Daubert, 509 U.S. at 589. The Court went on to express some "general observations" on the application of Rule 702's requirement of reliability to scientific expert testimony. The Court provided four nonexclusive factors to test the reliability of such testimony. Id. at 593-95. Those factors are:

1. Whether the theory or technique underlying the testimony can be or has been empirically tested. The Court quoted one author as saying that "[s]cientific methodology today is based on generating hypotheses and testing them to see if they can be falsified; indeed, this is what distinguishes science from other fields of human endeavor."
2. Whether the theory or technique has been subjected to peer review and publication. While the Court acknowledged that in some instances innovative

theories will not have been published, it said that submission to the scrutiny of the scientific community is a component of "good science," in part because it increases the likelihood that substantive flaws in methodology will be detected.

3. Whether there is the known or potential rate of error, and the existence and maintenance of standards controlling the technique's operation. The Court, as an example of a standard controlling a technique's operation, noted a professional organization's standards governing spectrographic analysis.
4. Finally, the Court said that general acceptance of the technique in the relevant scientific community can still have a bearing on the inquiry. This is simply the Frye test restated as a factor rather than the sole inquiry. But the Court said that widespread acceptance can be an important factor in ruling particular evidence admissible.

Several years later, in Kumho Tire Co. v. Carmichael, 526 U.S. 137 (1999), the Court held that Daubert's general holding also applies to testimony of engineers and other experts who are not scientists and that the factors set out in Daubert are not a definitive checklist and do not necessarily apply to every case, but that a trial court should consider one or more of the factors mentioned in Daubert when doing so will help determine the reliability of the testimony, although other factors may be relevant to determine the reliability of the testimony in light of the particular facts and circumstances of the particular case.

There are significant legal consequences to the measurement of evapotranspiration. Certain methods are widely accepted to measure and estimate evapotranspiration; but that doesn't mean that remote-sensing technology cannot supplement or replace those methods. But to be admissible in a court proceeding, expert testimony based on remote-sensing technology will have to satisfy the standard for the admissibility of expert testimony. Careful attention to the Daubert factors will increase the likelihood that remote-sensing technology studies will produce good science and reliable evidence that would be admissible as the basis for expert testimony.

References

M.E. Jensen, R.D. Burman, and R.G. Allen, eds., Evapotranspiration and Irrigation Water Requirements, American Society of Civil Engineers ASCE Manual No. 70 (1990)

International Decade of "Water for Life" Declared

International Decade "Water for Life", 2005 - 2015

As the International Decade for Action "Water for Life" begins, the United Nations and Governments are seeking to galvanize efforts to meet the internationally agreed targets of halving the number of people without access to safe drinking water and basic sanitation by 2015. Ministers and government delegates will meet in April 2005 in New York to take policy decisions on practical measures and options to accelerate progress toward these and other water-related goals at the Commission for Sustainable Development's 13th session.

The 'Water for Life' Decade, launched on World Water Day (22 March 2005), calls upon the international community to strengthen efforts to increase access to water and sanitation for all. The decision to establish this Decade was made by the General Assembly during its 58th annual session (A/RES/58/217). This is the second international decade on water-related issues under the auspices of the United Nations. The first, the International Decade on Drinking Water Supply and Sanitation, was held from 1981 to 1990. For more information, visit the website at www.un.org/waterforlifedecade .

Colorado Water Congress Workshops for 2005

The seminar and workshops will all be held in the Colorado Water Congress Conference Room, 1580 Logan Street, Suite 400, Denver, Colorado. The program and registration form will be posted as soon as available. CLE credits will be shown on the forms for the workshops when awarded.

September 26 – 27, 2005 – Colorado Water Law Seminar
October 12, 2005 – Water Quality Workshop
October 13, 2005 – Endangered Species Conference
October 20, 2005 – The Initiative Process: What You Need To Know
November 8, 2005 – Legal Ethics In Water & Environmental Law

For more information go to : http://www.cowatercongress.org/meeting_notices.htm

Beyond a Shadow of a Drought
Coping with a Changing World

Bill Heddles Center, Delta, CO
Tuesday, April 26, 2005

Agriculture in Colorado has faced some explosive problems recently, such as drought, low commodity prices, fears of ”Mad Cow” disease and impacts from ever-changing federal regulations. While these issues have exploded onto the scene, another area of concern is slowly sneaking up on agriculture: the land around them and how it is used is changing. More and more farms, ranchland and agricultural water will continue to be converted to residential uses. **Beyond a Shadow of a Drought: Coping With a Changing World** is a free seminar that will address what changes we will confront as more and more people move into agricultural areas looking for their own piece of heaven.

Schedule of Presentations

8am – Registration Opens

8:30am - **Our slice of the Pie –** How Much Water are We Fighting Over? Dan Crabtree, USBR

8:45am - **The More Things Change, the Less They Stay the Same**: Growth, Water Use Changes and Water Efficiency in Your Region. John Wilkins-Wells, Colorado State University.

9:20am - **Who Invited Them?** -Growth Issues & Other New Problems for Ag Water Providers. Marc Catlin, UVWUA; Dick Proctor, GVWUA.

10:00 – Break

10:15am - **City Confidential**: A Municipality’s Take on Subdivisions, Water Tap Sales and Growing Pains. Greg Trainer, City of Grand Junction, Dick Margetts.

11am - **The Effects of Local Land Use Changes on Water Quality**: The USGS Study of the Effects of Ag-Urban Water Transfers, Ken Leib, USGS.

11:15am - Question & Answer period for all presenters

11:30am - Luncheon speaker: **What the Big Picture of the Colorado River Means to You?** Dave Merritt, Colorado River Water Conservation District.

12:45pm - **Will We Wind Up Like Them?** The Front Range Speaks about Their Land Use Change Experiences, Todd Williams, City of Aurora

1:45pm - **Can We All Get Along?** The Success of Spy Glass Ridge, Kathy Portner. City of Grand Junction.

2:45pm – Break

3pm - **Now it’s Your Turn** Advice from DARCA on Deciding Your District’s Future. Karen Rademacher, Ditch and Reservoir Company Alliance.

This event is **free** and **open to the public** and a complimentary lunch will be provided.
Seating is limited, so reserve your seat today by calling Darlene Wilkinson at (970) 244-1555 or via e-mail at darlenew@gjcity.org.

See the latest in agricultural water efficiency products at the product expo to get the most productivity out of your scarce water resources. The expo will go on throughout the event.

The **Statewide Water Supply Index** for March is available on line at:
http://www.water.state.co.us/pubs/swsi.asp

For current **news** items concerning water, visit:
http://www.npscolorado.com/news.html

MEETING BRIEFS

Hydrology Days 2005 at Colorado State University

Hydrology Days 2005, organized by Dr. Jorge Ramirez, was conducted March 7-9th on the Colorado State University Campus. More than 120 contributed and invited papers made up 18 sessions on a variety of topics including: forest fires as forcing of hydrologic processes, landscape evolution and fluvial geomorphology, soil moisture dynamics and water balance, snow hydrology, groundwater remediation, and others. We had more than 120 contributed and invited papers.

C.A. Troendle of the U.S. Forest Service was the 2005 Hydrology Days award recipient in honor of his contributions to forest hydrology. The Borland Lecturer in Hydrology was Professor Renzo Rosso of the Polytechnic of Milan, Italy who presented a keynote lecture on forest fires and hydrology. The Borland Lecturer in Hydraulics was Professor Gary Parker of the University of Minnesota, who presented a keynote lecture on landscape evolution. Both Borland lecturers are internationally recognized leaders in their respective fields.

Clockwise from top right:

Gary Parker (U. of Minnesota) congratulates Renzo Rosso (Polytechnic of Milan) after Rosso accepts his plaque for the Borland Lecture in Hydrology.

Chester Watson (CSU) and Pierre Julien (CSU) discuss presentations.

Gary Parker (U of Minnesota) and BJ Gupta (CSU) visit at Hydrology Days.

CSU students enjoy the luncheon at Hydrology Days.

Renzo Rosso (Polytechnic of Milan) visits with Pepe Salas (CSU) about forest fires and floods.

MEETING BRIEFS

A Leadership Insight presentation at the AWRA Second National Water Resources Policy Dialogue
Tucson, Arizona, February 15, 2005

Science, Policy, And Water Availability

By Robert M. Hirsch, Ph.D.
Associate Director for Water, U.S. Geological Survey
Co-Chair, Subcommittee on Water Availability and Quality
Committee on Environment and Natural Resources

and Glenn G. Patterson
Coordinator, USGS Cooperative Water Program

When people think about water policy, they tend to think in terms of laws and regulations, economics and investments, and environmental issues and politics. To be effective, however, water policy must be informed by, and include, science and technology. To maximize the economic benefit from our water resources while respecting environmental values, we need science that defines the available supply, and technologies to enhance our water supply and advance strategies that use water more efficiently. Scientific knowledge plays a supportive role in the development of tools in leading to informed public and private decision-making.

In this talk we will discuss four science and technology issues that are critical to the issues of water availability and water policy:

- Water for ecosystem services
- Ground-water-storage depletion
- Climate change and water storage
- Supply enhancing technologies.

Trends in water use and allocation

Overall, from 1985 to 2000, total off-stream water withdrawals have been constant at about 400 billion gallons per day, while the population has increased by about 17 percent (Hutson and others, 2004). The two categories with the largest off-stream water use are cooling water for thermoelectric power generation (48 percent) and irrigation (34 percent). Most of the cooling water is returned to the stream, although most of the irrigation water is lost to evapotranspiration. Water use in these two large categories has been very stable or slightly decreasing for the last 20 years. Irrigation water use has decreased for several reasons. Some irrigated land has been converted to other uses such as dry-land farming or suburban development. On the land that remains under irrigation, the use of water-saving technology has increased, driven by both the scarcity of water, increased pumping lifts and the increasing energy costs. Public supply water use accounts for 11 percent of off-stream water use and is increasing, but at a slower rate than population growth. Industrial water use, accounting for 5 percent of off-stream use, has been decreasing as a result of efficiencies driven by the Clean Water Act.

When we look at in-stream water use, there is an increasing interest in ensuring adequate flows in streams and rivers to meet ecological needs. The demand for water to sustain ecosystems results in part from the Endangered Species Act, and has become a major driver of water-allocation decisions involving habitat for listed species. Uncertainty in determining the water needs for proper ecosystem function complicates the reallocation process. Recent efforts to reduce this uncertainty are shifting the paradigm of instream-flow determinations in ways that add complexity to the task, as outlined in the box below.

Paradigm Shift for Instream Flow

Old paradigm		New paradigm
Determine minimum flow	to	Optimize entire hydrograph
Assume a static channel	to	Predict future channel dynamics
Consider surface water only	to	Consider both surface and ground water (for example, the effect of ground-water on stream flow and temperature)
Consider effects of flow on a single species	to	Consider effects of flow on an entire aquatic ecosystem

Our shrinking water supply
In addition to questions related to ecological water needs, the issue of water availability is also complicated by depletion of ground water in storage. Current levels of water use in many parts of the country are dependent on withdrawing ground water at rates that exceed average recharge. As the amount of water in storage in aquifers decreases, and the vertical distance water must be pumped to the land surface increases, the overall availability of ground water decreases.

Ground-water depletion can have negative consequences for streamflow, riparian vegetation, land-surface subsidence, water quality, water temperature, flow to wells, and the quality of life for future generations. Some excellent examples of these effects are chronicled in Robert Glennon's book, Water Follies (Glennon, 2002). The underlying principles governing the effects are described in Ground Water and Surface Water A Single Resource (Winter and others, 1998). To understand and manage for sustainable ground-water use, it is crucial to understand ground-water/surface-water interactions and subsequent effects on biota. This requires well-designed monitoring programs and computer models that can accurately simulate both ground-water and surface-water flow systems, with some additional paradigm shifts, as outlined below.

Sustainable water supplies and effective market-driven mechanisms for the temporary transfer of water rights need to be guided by laws and regulations that are based on the proper representation of ground-water/surface-water interactions.

Paradigm Shift for Ground-Water-Surface-Water Interaction models

Old paradigm		New paradigm
Effects tens of meters away	to	Effects tens of kilometers away
Effects over hours to weeks	to	Effects over months to centuries
How much can be withdrawn and at what rate?	to	How much does the ecosystem need?

Effects of climate variability on water availability
The effects of changing climate bring an additional level of complexity and uncertainty to decisions of water allocation. Leaving aside the question of whether future global warming will result in changes in total precipitation over certain regions in the future, there are important documented observations that indicate that changes have been occurring during the past few decades in the timing of snowmelt and runoff.

In the Northeastern and North-Central States, and especially in the mountain West, the winter snowpack is a major natural reservoir of seasonal water storage, along with man-made reservoirs, soil water, and aquifers. Recent studies by the USGS and others have demonstrated that the center of mass of snowmelt runoff is occurring earlier now than 50 years ago in large parts of those regions—as much as 35 days earlier in parts of the northern Rockies, Sierras, and Cascades (Stewart and others, 2004). In parts of New England, median February streamflow has increased by more than 50 percent over the last 100 years due to earlier snowmelt, while median May streamflow has decreased by more than 50 percent for the same reason (Dudley and Hodgkins, 2002, 2005).

Even though the total annual precipitation and runoff have remained almost constant over the same period, these changes in the timing of runoff have serious implications for water availability and water management for humans and ecosystems. This makes understanding of snowpack dynamics crucial to water-supply planning in these areas. Unfortunately, due to the operational expenses, the number of streamgages is decreasing in high, remote areas where snowmelt processes dominate the streamflow hydrograph.

Enhancement of water availability by new technologies
New technologies are enhancing water availability by providing for enhanced supply or more efficient use of existing supplies. Such technologies include aquifer storage and recovery (storage of excess surface water underground for a season or longer, for later withdrawal), conjunctive use of both ground water and surface water, water conservation and reuse, control of phreatophytes (plants that draw water from alluvial aquifers), and desalination of seawater or brackish surface or ground water. Successful application of these emerging technologies needs to be informed by science, including research in the fields of geochemistry, hydraulics, botany, biophysics, microbiology, and contaminant chemistry.

Summary
Science and technology provide the basis for effective management of water resources in the face competing demands and significant uncertainty. Science provides the context of resource status and trends, technology can enhance supplies and efficiency of use, and together they can provide the basis for more informed decision-making through the predictions of outcomes on time scales from hours to centuries.

Next Steps
What is being done to advance the science related to water availability and use? Many of the issues cited above are active areas of research for government, academic, and

private-sector hydrologists. One new example from the U.S. Geological Survey is a pilot effort at the request of Congress to test concepts for a consistent National Assessment of Water Availability and Use. This effort is underway this Fiscal Year (FY 2005) with a concentrated study in the Great Lakes watershed. We will extend this effort to other water-resource regions as funding permits.

At a higher level in the Federal government, the National Science and Technology Council's Committee on Environment and Natural Resources (CENR) in 2003 established a Subcommittee on Water Availability and Quality, comprising water-research directors from over a dozen Federal agencies. The Subcommittee's first report, which defines the dimensions of the problem, was released on February 14, 2005, and was announced at the American Water Resources Association Second National Policy Dialogue in Tucson, Arizona. The title of this report is "Science and Technology to Support Fresh Water Availability in the United States," and it is available on-line at:
http://www.ostp.gov/NSTC/html/swaqreport_2-1-05.pdf (accessed March 22, 2005).

The report addresses the question, "Does the United States have enough water?" with a qualified response: "We do not know." As the General Accounting Office pointed out in 2003, "national water availability and use have not been comprehensively assessed in 25 years." The report points to the following needs for several advances in science and technology related to water availability and use:

- Data that define the available resource
- Understanding surface-water/ground water interactions
- Defining ecosystem water needs
- Defining water use, and the factors that influence water use
- Technology for conservation, use of impaired waters, and extending the life of infrastructure
- Understanding the variability and improving predictions of our water resources

The next step for the Subcommittee, at the request of the Office of Science and Technology Policy and the Office of Management and Budget, is to develop a strategic plan for Federal research and development on science and technology related to water availability and use. This plan is to be completed by the summer of 2005.

In conclusion, we are at a point where policy advisors within the White House have clearly recognized the need for science and technology to improve our understanding of water availability and use:

The ability to measure, monitor, and forecast the U.S. and global supplies of fresh water is another high-priority concern. Agencies, through the NTSC, should develop a coordinated, multi-year plan to improve research to understand the processes that control water availability and quality, and to collect and make available the data needed to ensure an adequate water supply for the Nation's future. – (John H. Marburger, Director, OSTP, and Joshua B. Bolten, Director, OMB, August 12, 2004, annual memo to heads of Federal agencies on science and technology needs in the Federal government).

The Subcommittee looks forward to developing this plan, making use of public input and the abundant existing literature on water research needs. Examples include the National Research Council's two reports on water resources research, National Research Council (2001, 2004) an American Geophysical Union monograph on water science, policy, and management (Lane and others, 2003), and the work of other groups such as the Second National Water Resources Policy Dialogue.

References

Dudley, R.W., and Hodgkins, G. A., 2002, Trends in streamflow, river ice, and snowpack for coastal river basins in Maine during the 20th century, USGS Water-Resources Investigations Report 2002-4245, 26 p., http://me.water.usgs.gov/wrir02-4245.pdf (accessed March 22, 2005).

Dudley, R.W., and Hodgkins, G. A., 2005, Trends in streamflow, river ice, and snowpack for coastal river basins in Maine during the 20th century, USGS Fact Sheet 2005-3001, http://water.usgs.gov/pubs/fs/2005/3001/ (accessed March 22, 2005).

General Accounting Office, 2003, Freshwater Supply: States' Views of How Federal Agencies Could Help Them Meet the Challenges of Expected Shortages, GAO-03-514, 110 p. http://www.gao.gov/new.items/d03514.pdf (accessed March 28, 2005)

Glennon, Robert, 2002, Water Follies, Island Press, Washington, DC, 314 p.

Hutson, S.S., Barber, N.L., Kenny, J.F., Linsey, K.S., Lumia, D.S., and Maupin, M.A., 2004, Estimated use of water in the United States in 2000, USGS Circular 1268, 46 p., http://water.usgs.gov/pubs/circ/2004/circ1268/ (accessed March 22, 2005).

Lane, N. F., Bierbaum, R. B., and Anderson, M. T., 2003. Science and Water Policy for the United States, Chapter 10 in Lawford, R., Fort, D., Hartmann, H., and Eden, S., 2003, Water, Science, Policy and Management, American Geophysical Union, Water Resources Monograph 16, p. 207-222.

National Research Council, 2001, Envisioning the Agenda for Water Resources Research in the Twenty-first Century, National Academy Press, Washington, DC, 61 p.

National Research Council, 2004, Confronting the Nation's Water Problems – The Role of Research, National Academy Press, Washington, DC, 310 p.

Stewart, I.T., Cayan, D.R., and Dettinger, M.D., 2004, Changes in snowmelt runoff timing in western North America under a "business as usual" climate change scenario, Climate Change, vol. 62, p. 217-232, http://meteora.ucsd.edu/cap/pdffiles/stewart_clch.pdf (accessed March 25, 2005).

Winter, T.C., Harvey, J.W., Franke, O.L., and Alley, W.M., 1998, Ground Water and Surface Water A Single Resource, USGS Circular 1139, 79p. http://water.usgs.gov/pubs/circ/circ1139/ (accessed March 28, 2005).

RESEARCH AWARDS

COLORADO STATE UNIVERSITY, FORT COLLINS, COLORADO
Awards for January 28, 2005 to March 30, 2005
Bold indicates new award. All others are revised awards.)

Primary PI	Department Number and Name	Sponsor/ Title
Bledsoe,Brian	**1372 Civil Engineering**	**DOI-Bureau of Reclamation / IPA Assignment: Brian Bledsoe, DoI, BoR**
Bledsoe,Brian	1372 Civil Engineering	Three Forks Ranch Corporation / Monitoring of the Little Snake River & Tributaries
Cooper,David Jonathan	1472 Forest Rangeland Watershed Stewardship	DOI-Bureau of Reclamation / Riparian Vegetation Studies on the Colorado River & its Tributaries
Garcia,Luis	**1372 Civil Engineering**	**Central State University / Alliance Universities Application of Remote Sensin Technologies to Water Supply Problems in the Western United States.**
Gates,Timothy K	1372 Civil Engineering	DOI-Bureau of Reclamation / Identification, Public Awareness, & Solution of Waterlogging & Salinity in the Arkansas River Valley
Julien,Pierre Y	1372 Civil Engineering	DOD-ARMY-Corps of Engineers / Numerical Model Development for Watershed Contaminant Transport and Fate
Ramirez,Jorge A	**1372 Civil Engineering**	**DOI-Bureau of Reclamation / IPA Assignment US Bureau of Reclamation**
Shaw,Robert B	**1490 CEMML**	**USDA-USFS-Rocky Mtn. Rsrch Station – CO / Support for Threatened & Endangered Species, Wildlife, Land & Ecosystems Programs for USACERL**
Smith,Freeman M	1472 Forest Rangeland Watershed Stewardship	USDA-USFS-Rocky Mtn. Rsrch Station – CO / Mapping Snow Properties: A Multi-Scale Approach
Stack,Mark W	**3050 Southwestern Colorado Research Center**	**DOI-Bureau of Reclamation / Irrigation Scheduling Education to Enhance Water Management/Conservation in Southwestern Colorado**
Steltzer,Heidi	1499 Natural Resource Ecology Laboratory	University of Alaska at Anchorage / Collaborative Research: Coupling of Carbon and Water Cycles in a Cold, Dry Ecosystem: Integrative Physical, Chemical
Stephens,Graeme L	1371 Atmospheric Science	NASA-Goddard / CloudSat
Stephens,Graeme L	1371 Atmospheric Science	NASA-Goddard / CloudSat
Stephens,Graeme L	1375 (CIRA)	NASA-Goddard / CloudSat
Thornton,Christopher I	1372 Civil Engineering	DOI-Bureau of Reclamation / Hydraulic Investigation of the American River
Vonderhaar,Thomas H	1375 (CIRA)	DOD - US Department of Defense / Multi-Year Cooperative Agreement with Colorado State University for Center for Geosciences/Atmospheric Research
Vonderhaar,Thomas H	1375 (CIRA)	DOD - US Department of Defense / Multi-Year Cooperative Agreement with Colorado State University for Center for Geosciences/Atmospheric Research
Ward,Robert C	2033 CWRRI	DOI-USGS-Geological Survey / Technology Transfer/Information Dissemination
Ward,Robert C	2033 CWRRI	DOI-USGS-Geological Survey / Administration

Ward,Robert C	2033 CWRRI	Various "Non-Profit" Sponsors / Developing a Decision Support System for the South Platte Basin
Ward,Robert C	**2033 CWRRI**	**Colorado River Water Conservation Dist. / Hydrologic Analysis and Stimulation of the Upper Colorado River System**
Wohl,Ellen E	1482 Geosciences	USDA-USFS-Rocky Mtn. Rsrch Station – CO / Assessing Snow-Making Impacts to Stream Channels

2005 New Mexico Water Research Symposium
Advances in Hydrology: Methods and Instruments
August 15th, 2005
Macey Center, New Mexico Tech, Socorro, NM

July 15th: Abstract Deadline
250 words or a single page and must address water research relevant to New Mexico. Submit online at http://wrii.nmsu.edu .

August 5th: Registration Deadline

Topics include: surface water, groundwater, surface and groundwater interactions, atmospheric investigations, hydrologic investigations, geomorphology, computer systems, ecosystems, GIS and remote sensing, water security, water quality, water management and quality.

To register go to http://wrri.nmsu.edu
For more information, contact Catherine Ortega Klett at (505) 646-1195 or coklett@wrri.nmsu.edu.

CALENDAR

Apr. 7-8	**Arkansas River Basin Water forum (ARBWF)** For more information check the website at http://arbwf.info/ .
Apr. 7-8	**Water Management and Policy in the Great Plains: Implications of Drought and Climate Change, Second Annual Water Law, Policy, and Science Conference.** University of Nebraska-Lincoln. Lincoln, NE. For more information go http://snr.unl.edu/waterconference/ .
Apr. 15	**Annual Symposium of American Water Resources Association Colorado State Section: Colorado Water Supply Status and Sustainability.** For more information go to: http://www.awra.org/state/colorado/ .
May 19-20	**Urban Flood Channel Design and Culvert Hydraulics.** University of Colorado at Denver Continuing Engineering Education Program. For more information go to: www.cudenver.edu./engineering/cont .
May 23-25	**Rocky Mountain Section, Geological Society of America, 57th Annual Meeting,** Mesa State College, Grand Junction, CO. For more information go to www.geosociety.org. See also Selenium-Sodium-Salinity-Sediment in the Upper Colorado River Basin below.
May 23-25	**Selenium-Sodium-Salinity-Sediment in the Upper Colorado River Basin: Origins and Impacts**, Mesa State College, Grand Junction, CO. For more information go to http://www.geosociety.org/ and select "meetings and excursions, then select 2005 section meetings. see also RMS,GSA, above.
May 24	**Scholarship recipient presentations of American Water Resources Association Colorado State Section.** Denver, CO**.** For more information go to: http://www.awra.org/state/colorado/ .

Jun. 6-8	**Environmental Statistics Short Course.** Fort Collins, CO. For more information contact: ocsreg@lamar.colostate.edu
Jun. 6-10	**Design of Water Quality Monitoring Networks.** Fort Collins, CO. For more information contact: ocsreg@lamar.colostate.edu
Jun. 8-10	**Hard Times on the Colorado River: Drought, Growth, and the Future of the Compact,** Natural Resources Law Center, University of Colorado School of Law, Boulder, CO. For more information go to www.colorado.edu/law/summerconference .
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, 2005	**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.** 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. 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. 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.