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Groundwater
Feature Article:
An Overview of Colorado Groundwater Law, Justice Hobbs

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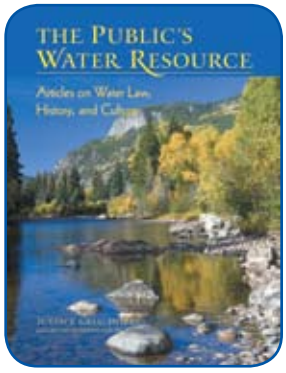

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Cover Photo: Observation well equipment at M. Winslow farm, Peckham, CO. November 1942. From the Groundwater Data Collection, CSU Water Resources Archive.

Are We Thinking Big Enough?

by Reagan Waskom, Director, Colorado Water Resources Research Institute

EDITORIAL

This summer in Colorado, we again witnessed the "heritage of conflict" John Wesley Powell predicted in 1893 would accompany the over-allocation of western water resources. In this year's installment, the conflict was played out between surface and ground water interests as the South Platte Task Force sought to find compromises that would achieve the goals established by the 1969 Water Right Determination and Administration Act; namely, maximum beneficial use while preventing injury to senior users.

Reagan Waskom

The crafters of the 1969 Act were wrestling with the problem of ground water use impinging upon surface rights, similar to the contemporary situation in the South Platte. No doubt, the situation they faced seemed every bit as difficult as our current struggle. In 1969, a brilliant solution was proposed - if you have a court approved augmentation plan to replace your depletions in timing and amount, you can withdraw groundwater out of priority. This concept of a "plan for augmentation" worked particularly well when water was relatively cheap, the river was not under administrative call for much of the year, and there was adequate water in the river due to upstream return flows and favorable climactic conditions. The 2007 South Platte Task Force was unable to find a similarly creative solution, perhaps because duel goals (in this case maximum utilization while preventing injury) can create cognitive dissonance. It takes intellectual discipline to simultaneously hold two apparently contradictory ideas as both being valid and worthy of attainment.

The outlook for immediate help for South Platte well owners without court approved augmentation plans does not appear hopeful, unless the state legislature can craft a political mechanism to provide some relief. Interestingly, the need for additional surface water storage was discussed throughout the Task Force proceedings as a primary solution to the Basin's problems. The irony of this is the South Platte alluvial aquifer can hold more than twice as much water as the combined capacity of all of the current reservoirs in Colorado, without requiring a dam to be built, surface lands inundated, or federal permits be obtained. Yet we stay stuck in the paradigm that the only way to expand our water supply is to build more surface reservoirs. Given the difficulty and expense of constructing reservoirs, more creative thinking may allow us to maximize our water supply through sustainable ground water use.

Whatever creative solutions we arrive upon, we will ultimately be limited by the aridity of Colorado's environment. The current ground water troubles we are experiencing in Colorado force recognition of this aridity and the interconnection of surface and ground water. It has been observed that the major function of our current water administrative system is to effectively allocate water in times of shortage. If there was an abundance of water in our system, there would be little debate as to the appropriateness of current law. There is however a difference between the position that the doctrine of prior appropriation is not working, versus just not liking the way it works.

The question I pose in the title of this editorial was inspired by the late director of the Sierra Club, David Brower. When asked about the apparent futility of some of his efforts, he made the statement, "If you are working on a problem that can be solved within your lifetime, you are not thinking big enough." In the case of the South Platte, Republican, San Luis Valley and Denver Basin aquifers, how do we think bigger and what is the role of scientific research in this process? In this issue of Colorado Water, Drs. Durnford, Garcia, and Howe outline some of their ideas. Their research points to the need for more complete characterization of individual ground water basins and for accurate models and decision tools to estimate ground water withdrawal and recharge.

The human tendency when it comes to the development of natural resources is often to think too big. Thus, there is a need for quantification of sustainable ground water yields, coupled with tools and technology to manage this water to its fullest extent. Understanding our ground water history, law, and the social side of this equation is also critical, as highlighted in the articles by Justice Hobbs and CSU history student Nick Kryloff. The challenge before us is to bring past accomplishments and the present situation into context, as we strive to see beyond our own narrow interests and find solutions that will sustain Colorado's water future.

An Overview of Colorado Groundwater Law

by Justice Greg Hobbs, Colorado Supreme Court

All water within Colorado is a public resource, subject to the creation of use rights according to the applicable constitutional and statutory provisions. There are four classifications of water in Colorado: (1) waters of natural streams, which include surface water and groundwater that is tributary to a natural steam, (2) designated groundwater, (3) nontributary groundwater outside of designated groundwater basins, and (4) nontributary and not-nontributary Denver Basin groundwater of the Dawson, Denver, Arapahoe, and Laramie-Fox Hills aquifers.

Before any well may be drilled for use of any classification of groundwater anywhere in Colorado, the State Engineer must issue a construction permit. Often, people think that issuance of a state engineer well construction permit is the same as the state of Colorado granting a water use right. As the statutes of the General Assembly and cases of the Colorado Supreme Court demonstrate, however, a well construction permit does not amount to establishment of a water right. Like a ditch, a well is a diversion device. To be administered, the water right must be obtained and recognized as the applicable law provides.

Tributary Groundwater

The first classification of water includes groundwater that is tributary to a natural stream. This groundwater is subject to allocation and administration according to Colorado's constitutional prior appropriation doctrine, as implemented by the 1969 Water Right Determination and Administration Act.

Water courts for the seven water divisions in Colorado adjudicate conditional and absolute use rights, changes of water rights, and augmentation plans for tributary groundwater, as with surface water. Appeals from decisions of the seven water courts proceed directly to the Colorado Supreme Court.

Colorado water law contains a presumption that groundwater is tributary unless shown to be otherwise. Under Colorado Supreme Court case law, groundwater is tributary if, in its natural state, it could reach a surface stream within one hundred years.

State administration differs depending on the classification of the groundwater. In 1965, the Colorado General Assembly enacted two separate statutes delineating the fundamental differences between the administration of tributary groundwater and groundwater that has little or no effect on surface streams.

For water of the natural stream and tributary groundwater, actual beneficial use of the water creates the water right. However, to be administered, the water right for a ditch or a well must have a water court decree that sets forth its priority date, location of diversion, rate of diversion, and type of beneficial use. The State Engineer, Division Engineers for the seven water divisions, and local Water Commissioners enforce the water rights for the diversion ditches and wells in order of the adjudicated priority dates of the various water rights in the water division.

Colorado Justice Greg Hobbs

In times of short supply, water rights are curtailed in reverse order of priority, junior to senior, in accordance with the decrees of the water court. Out-of-priority diversions are allowed only if a water-court adjudicated augmentation plan, or a State Engineer approved substitute supply plan, is in effect in compliance with statutory requirements to replace depletions to the water supply that would injure decreed water rights. Injury occurs when water that would otherwise be available to fill a water right operating in priority has been intercepted by someone whose decreed appropriation is junior in priority or someone who is diverting without a decree.

Three out of four major river basins of Colorado are over-appropriated, the Platte, the Arkansas, and the Rio Grande. This means that there is essentially no un-appropriated water remaining for appropriation by ditches or wells. Regulation of surface and tributary groundwater diversions in these over-appropriated basins is necessary to protect vested water rights according to their decreed priorities.

Three Other Classifications of Groundwater

The General Assembly has created three other classifications of groundwater under the 1965 Ground Water Management Act: designated groundwater, nontributary groundwater, and Denver Basin bedrock groundwater. These classifications are for groundwater the legislature has presumed has little or no connection to a natural stream.

Designated Groundwater

The Colorado Ground Water Commission allocates and administers the use of designated groundwater utilizing a modified prior appropriation permit system for the beneficial use of groundwater that has little or no connection to a surface stream (except for designated groundwater in the four Denver Basin aquifers, which is subject to allocation by the Ground Water Commission by permit for beneficial use to overlying landowners at a 1/100ths percent per year pumping rate, as with the rest of the Denver Basin, see below). The purpose of this management program is to permit economic development while maintaining reasonable pumping levels, so that the designated basin groundwater will not be mined excessively over the rate of recharge.

The Ground Water Commission has designated eight groundwater basins in Colorado, all of which are located on the high plains of Colorado east of the Continental Divide: Northern High Plains, Southern High Plains, Camp Creek, Upper Crow Creek, Lost Creek, Kiowa Bijou, Upper Black Squirrel Creek, and Upper Big Sandy designated basins. The latter four of these include portions of the Denver Basin.

Under the modified prior appropriation regime for designated groundwater, curtailment based upon an injury allegation is subject to the discretion of the Ground Water Commission and the local Ground Water Management Districts.

Appeals from actions of the Ground Water Commission and Ground Water Management Districts go to local Colorado district court groundwater judges, not to the water court judges whose jurisdiction is under the 1969 Act. Appeals from the decisions of the groundwater judges go directly to the Colorado Supreme Court.

The Ground Water Commission has promulgated rules applicable to the use of designated groundwater.

Nontributary and Denver Basin Groundwater

The General Assembly has provided that the use of nontributary groundwater outside of the designated basins, and the use of groundwater in the four Denver Basin bedrock aquifers, may be made by overlying landowners or those who have the consent of the overlying landowners. This groundwater may be extracted at the rate of 1/100ths percent per year. In contrast to designated groundwater, nontributary water outside of the designated basins and Denver Basin groundwater may be mined regardless of any consideration of recharge.

The overlying landowner, or person acting with the consent of the overlying landowner, may obtain such a use right by drilling a well or obtaining water court adjudication for the amount of water underlying the land (an amendment to the 1969 Act provided water court judges with this jurisdiction for nontributary and Denver Basin groundwater that is outside of a designated groundwater basin).

> "The four Denver Basin bedrock aquifers are the Dawson, Denver, Arapahe, and Laramie-Fox Hills aquifers."

Use of nontributary and Denver Basin groundwater is not subject to curtailment on an injury basis. The State Engineer has promulgated rules for the use of nontributary and Denver Basin groundwater.

Colorado Justice: Celebrating 41 years of fair and impartial courts through merit selection

Timeline of Colorado Ground Water Law

1876 2004

The following timeline sets forth, in summary form, major events in the establishment of Colorado groundwater law.

1876

Article XVI, Sections 5 and 6 of the Colorado Constitution declare that the un-appropriated water of every "natural stream" is the property of the public dedicated to the beneficial use of the people of the state by priority of appropriation.

1903

Colorado General Assembly provides that any water right derived from any "natural stream" is subject to court adjudication, 1903 Colo. Sess. Laws, Ch. 130, 297-98.

1914

Colorado Supreme Court confirms that the constitutional term "natural stream" subjects to the rule of prior appropriation all sources of stream supply, including percolating ground water, that is tributary to a surface stream, German Ditch & Reservoir Co., 56 Colo. 252, 270-71 (1914).

1919

Colorado General Assembly provides that all claims to prior appropriation water rights shall be filed within two years; if not, their priorities shall be postponed to those water rights that are adjudicated by the courts, 1919 Colo. Sess. Laws, Ch. 147, 487-96.

1951

Colorado Supreme Court holds that Colorado law includes a presumption that all groundwater is tributary to and subject to appropriation and administration as part of the waters of a surface stream, unless a person proves by clear and satisfactory evidence that the ground water is not tributary, Safranek v. Town of Limon, 123 Colo. 330, 333 (1951).

1957

Colorado General Assembly provides that: (1) all users of ground water must file a statement of use with the state engineer, (2) new wells shall not be drilled without a permit from the state engineer, (3) a well permit "shall not have the effect of granting or conferring a ground water right upon the user," (4) the priority date of a "ground water appropriation shall not be postponed to a time later than its true date of appropriation by failure to adjudicate the right in a surface water adjudication," and (5) the newly-established Ground Water Commission shall identify critical ground water areas that "have approached, reached or exceeded the normal annual rate of replenishment," 1957 Colo. Sess. Laws, Ch. 289, 863-73.

1965

Colorado General Assembly adopts the Ground Water Management Act that: (1) authorizes the Colorado Ground Water Commission to create designated basins for groundwater that has little or no connection to a surface stream, (2) provides for the Ground Water Commission to allocate and regulate designated groundwater through a permit system on a modified prior appropriation basis for economic development through the maintenance of reasonable pumping levels, (3) authorizes the creation of local groundwater management districts for regulation of designated groundwater, (4) requires all new wells, wherever they may be located in the state, to obtain a construction permit from the state engineer, and (5) provides that a state engineer well construction permit "shall not have the effect of granting nor conferring a ground water right upon the user," 1965 Colo. Sess. Laws, Ch. 319, 1246-68.

1965

Colorado General Assembly, by a separate act from the Ground Water Management Act, requires State Engineer to administer tributary groundwater in accordance with the doctrine of prior appropriation that is applicable to the distribution of surface water, and adopt rules and issue orders necessary to enforce this responsibility, 1965 Colo. Sess. Laws, Ch. 318, 1244-45.

1968

Colorado Supreme Court states that "implicit" in the Colorado Constitution's prior appropriation provisions are the propositions that: (1) "along with vested rights, there shall be maximum utilization of the water of this state" and (2) administration of water in the second century of prior appropriation law involves how maximum utilization of surface water and tributary groundwater can be integrated into the law of vested rights, Fellhauer v. People, 447 P.2d 989, 995 (Colo. 1968).

1969

Colorado General Assembly adopts the Water Right Determination and Administration Act of 1969 which, among other provisions, states that (1) tributary groundwater and surface water shall be administered according to the doctrine of prior appropriation, in order to maximize beneficial use, (2) vested surface water and tributary groundwater rights shall be protected in order of their decreed priorities, (3) wells that have not obtained adjudication of their priorities have a period of two years in which to file for their original appropriation date and, if not, their priorities shall be postponed to other priorities that have been adjudicated by the courts, and (4) augmentation plans may be decreed to allow out-of-priority diversions that are not subject to state engineer curtailment, if sufficient replacement water is provided to alleviate material injury to adjudicated water rights, 1969 Colo. Sess. Laws, Ch. 373, 1200-1224.

1973

Colorado General Assembly provides that non-tributary ground water outside of designated ground water basins shall be subject to state engineer well construction permits and rules that provide for overlying landowners, or those acting with the consent of overlying landowners, to use this type of groundwater which underlies their lands on the basis of a "minimum useful life of one hundred years," 1973 Colo. Sess. Laws, Ch. 441, 1520.

1974

Colorado Supreme Court holds that the "tributary character" of water that "takes over a century to reach the stream" is "de minimus" and is "not part of a surface stream" as contemplated by the Colorado Constitution's prior appropriation provisions, Kuiper v. Lundvall, 187 Colo. 40, 44 (1974).

1977

Colorado General Assembly repeals legislation it had enacted in 1974, 1974 Colo. Sess. Laws, Ch. 111, 440-42. that had allowed the State Engineer to approve temporary augmentation plans while the water court was adjudicating applications for augmentation plans, 1977 Colo. Sess. Laws, Ch. 483, 1702-04.

1983

Colorado Supreme Court holds that: (1) designated groundwater and nontributary ground water are not subject to the prior appropriation provisions of the Colorado Constitution, and the General Assembly may use its plenary authority to decide how these public waters shall be allocated and administered, and (2) the 1969 Act applies only to surface water and tributary groundwater, State v. Southwestern Colorado Water Conservation District, 671 P.2d 1294 (1983). The General Assembly responds promptly with legislation that (1) recognizes and enforces prior water court decrees adjudicating nontributary groundwater outside of designated basins and (2) allows the water courts to adjudicate to overlying landowners the right to extract nontributary groundwater outside of designated basins under their lands, 1983 Colo. Sess. Laws, Ch. 516, 2079-80.

1985

Colorado General Assembly provides that nontributary and not-nontributary groundwater in the Denver Basin bedrock aquifers of the Dawson, Denver, Arapahoe, and Laramie-Fox Hills formations shall be allocated to overlying landowners, or those acting with the consent of the overlying landowners, to be extracted at a rate of no more than 1/100ths percent per year, 1985 Colo. Sess. Laws, Ch. 285, 1160-69.

1988

General Assembly clarifies that the Ground Water Commission, when issuing permits for the beneficial use of designated groundwater in the four Denver Basin aquifers, shall allocate this water on the same basis as provided in the 1985 act for non-designated portions of the Denver Basin, namely "upon the basis of ownership of overlying land" and "an aquifer life of one hundred years," 1988 Colo. Sess. Laws, Ch. 258, 1238.

2000

Colorado Supreme Court holds that all water within Colorado constitute a public resource consisting of: (1) waters of the natural stream, which includes surface water and groundwater that is tributary to the natural steam, (2) designated groundwater, (3) nontributary groundwater outside of designated groundwater basins, and (4) nontributary and not-nontributary Denver Basin groundwater of the Dawson, Denver, Arapahoe, and Laramie-Fox Hills aquifers, Upper Black Squirrel Creek Ground Water Mgmt. Dist. v. Goss, 993 P.2d 1177, 1182 (Colo. 2000).

2001

Colorado Supreme Court holds that through the 1969 Act (1) the General Assembly created a new statutory authorization for water uses that, when decreed, are not subject to curtailment by priority administration, (2) this statutory authorization is for out-of-priority diversions for beneficial use that operate under the terms of decreed augmentation plans, (3) plans for augmentation allow diversions of water out-of-priority while ensuring the protection of senior water rights through a replacement water supply that offsets injurious out-of-priority depletions, and (4) injurious depletions not adequately replaced shall result in curtailment of the out-of-priority diversions. Empire Lodge Homeowners' Association v. Moyer, 39 P.3d 1139, 1150 (Colo. 2001).

2002

Colorado General Assembly (1) authorizes State Engineer to approve substitute supply plans for out-of-priority tributary groundwater diversions under limited circumstances while augmentation plan applications are pending in the water court, and (2) approves the Arkansas river basin amended rules governing the diversion and use of tributary groundwater in that basin, 2002 Colo. Sess. Laws, Ch. 151, 459-64.

2003

Colorado Supreme Court holds that proposed State Engineer 2002 South Platte Basin rules allowing out of priority diversions under replacement plans, in the absence of an augmentation plan application pending in water court, were contrary to statute and in excess of his authority, Simpson v. Bijou Irrigation Co., 69 P.3d 50, 67 (Colo. 2003).

2004

Colorado General Assembly allows South Platte tributary groundwater wells to operate out-of-priority under State Engineer approved substitute supply plans, with provisos that (1) augmentation plan applications must be filed in Division No. 1 Water Court by December 31, 2005, and (2) wells not included in an adjudicated augmentation plan or State Engineer approved substitute supply plan shall be "continuously curtailed" from operating out of priority, 2004 Colo. Sess. Laws, Ch. 316, 1205.

Some Suggestions for Reducing Surface Water/Groundwater Conflicts in the South Platte: Water Law and Economics

by Charles W. (Chuck) Howe, University of Colorado

Colorado newspapers have been full of stories about the shutdown of a large number of irrigation wells in 2006 and 2007 in the South Platte Valley and the subsequent distress as farms and related businesses have had to shut down. While these shutdowns were in keeping with Colorado water law and court decisions of the past several years, it is legitimate to ask if the shutdowns make economic sense and, if not, why there should be such a conflict between water law and the economics of how we use our water resources. Are such conflicts likely to increase as pressure on our rivers increases? The following background and suggested strategies may be useful to the Governor's South Platte River Task Force.

Charles Howe

Background on the South Platte conflicts

Under our Colorado system of water law, the "priority doctrine" imbedded in our constitution, each water right in the State has a priority attached to it, the rights with earlier priority dates (senior rights) having preference in the use of surface or groundwater. In the South Platte Basin, surface diversions for irrigation date back to the mid-19th century and are thus quite senior. If low flows prevent senior rights from getting water to which they are entitled, the seniors can "put a call" on the river, requiring all rights junior to them to stop taking water.

Following WWII, there was an explosion of water well drilling and ground water use in the South Platte Valley because of innovations in pump technology, cheap energy and the absence of a regulatory framework for wells. In the 1950's, South Platte irrigators tapped into the huge aquifer tributary to the river with thousands of wells as a reliable and handy source of water. During that era, developments in hydrology were making it clear that river flows and tributary aquifers were closely connected, e.g. that the aquifer provides water to the river in the late season but draws water from the river as pumping expands.

With this new knowledge, the 1969 Colorado Legislature decided that wells tapping the tributary aquifer should be incorporated into the "priority system" along with surface rights. This made the wells very junior in the ranking of rights. It thus appeared that the use of many wells during periods of water shortage, e.g. during prolonged droughts, was likely to be prohibited just when the store of groundwater might be the most valuable.

To avoid this uneconomic result, the Legislature in 2003 allowed the State Engineer to approve temporary "substitute water supply plans" (plans for augmentation) that would allow the junior wells to continue pumping during periods of shortage (i.e. when there was a "call" on the river) as long as they could supplement surface flows to make up any shortage attributable to their pumping. The State Engineer could approve substitute supply plans only if an application had been filed with the water court. Under these arrangements, about 1800 South Platte wells continued to operate under court approved augmentation plans and about 1000 continued to operate with cases pending before the court.

Several groups of well owners had been formed to develop collective plans for augmentation, among them the Groundwater Appropriators of the South Platte (GASP, 1972) representing about 3000 wells and the 1973 Central Colorado Water Conservancy District's (CCWCS, 1973) Groundwater Management Subdistrict initially representing some 1000 wells.

As the drought of the early 2000's became increasingly severe, surface water shortages generated increasingly frequent "calls" on the river. There were almost continuous calls on the river from 2003 into 2006. This meant that junior wells operating under temporary augmentation plans had to provide augmentation water with increasing frequency if they were to continue pumping. GASP decided to go out of business because of lack of finances to obtain sufficient water. The CCWCD's Water Augmentation Sub-District was formed in 2004 to provide augmentation for 445 wells but was unable to obtain sufficient augmentation water in 2006 even after offering $200 per acre-foot for leased water. Those wells were shut down in 2006 and 2007.

In 2001, the Colorado Supreme Court had ruled that the State Engineer did not have the authority to approve substitute water supply plans (SWSP's) (plans for augmentation) for out-of-priority users, that all such plans must go through the water court before out-of-priority uses could

continue (Empire Lodge case of 2000). While the Legislature gave non-conforming wells additional time to acquire augmentation water to satisfy the water court, many could not because of the sharply rising prices of water rights and leased water. Shares in the Northern Colorado Water Conservancy District had risen to more than $10,000 by 2004. Finally in May of 2006, the Water Court required the State Engineer to shutdown CCWCD's 445 wells, drying up 30,000 acres.

Key questions about the well shutdown

A number of key questions arise from the scenario above, but before listing those questions, one must differentiate between the issue of the well losses versus resultant surface water gains and the system wide effects of placing the call on the river. These are different assessments, the first comparing direct losses and gains from the shutdown of the wells, the second tracing the total impacts of the call on all parties, many of whom were not physically impacted by the pumping.

The following questions about the shutdown need to be asked:

- How much of the surface shortage that led to the calls was attributable to the wells' current and past pumping?
- What would be the time profile of enhanced surface flows resulting from the shutdown?
- How do the income losses incurred by the farms and associated businesses in 2006 compare with any downstream benefits that may be generated by the shutdown?

Until these questions can be answered, no one can assess the economic consequences of the shutdown nor the seriousness of the conflict between economic values and water administration.

> "The direct farm income losses from the shutdown have been estimated at $390 per acre while the total direct and indirect income losses have been estimated to be $690 per acre."

Regarding pumping as the cause of the surface shortages, the lingering effects of drought must also have played a significant role. Changing patterns of water use in the higher reaches of the river, including increasing water reuse, may also have played a role. In a very similar situation in the East Snake Plain Aquifer in Idaho, a major study commissioned by the State Engineer found that surface shortages were 1/3 due to pumping, 1/3 due to drought and 1/3 due to changes in irrigation techniques.(Snyder and Coupal, Feb. 2005)). The City of Boulder's analysis has indicated that 15,000 acre-feet of the 2006 shortage may have been due to past pumping of the CCWCD WAS wells that led to a new, lower water table equilibrium that reduced replenishment of the river. In sum, pumping by the WAS wells clearly played a role in shortages over several years up to 2006 but was not the only cause of those shortages.

Once pumping has stopped, time is required for the water table to reach a new higher equilibrium that will further supplement surface flows. In the Idaho study noted above, the cessation of pumping was estimated to result in a new, higher equilibrium water table in approximately 10 years (Snyder & Coupal, Appendix A). Whatever the time pattern, the futurity of the benefits reduces their present value.

The costs incurred by the well owners & affected business activities appear to have substantially exceeded any benefits to downstream users, including the calling seniors for the following reasons:

As noted above, benefits from enhanced streamflows will occur only slowly over time while the losses to the shutdown farms and associated business activities were immediate in 2006

The direct farm income losses from the shutdown have been estimated at $390 per acre while the total direct and indirect income losses have been estimated to be $690 per acre (Thorvaldson and Pritchett, Completion Report No. 207, CWRRI, December, 2006).

Even if downstream positive income impacts per acre were the same as the losses in CCWCD, those income increases must be discounted for their futurity. Thus the shutdown by itself led to substantial overall economic losses. In the Idaho study referenced above, the present value of losses to well owners resulting from a call was vastly greater than the present value of gains to the surface and spring water users even though the latter included the largest trout farms in the country.

Key questions regarding the economics of the call

It is clear that many parties were injured by the call and not by reductions in river flows. As noted above, these parties included Boulder, Highlands Ranch, Greeley and numerous irrigation ditches. Their involvement has been an artifact of the priority system of water administration. Their being called out, rather than physically affected, was what rallied them to the anti-well campaign. Thus an overall economic assessment of the consequences of the call must include losses to the surface juniors who were called out. It is clear that the call resulted in large net economic losses. How can the occurrence of uneconomic calls be avoided?

The losses to called-out junior rights owners occasioned by the call were substantial in 2006 and accounted for much of the active opposition to the wells. As noted earlier, Boulder estimates its 2006 losses to be at least $100,000.

If one were to apply Boulder's range of water values of $25/af (had the water been leased to farmers) to $100/af (if Windy Gap water had to be called over) (correspondence with Carol Ellinghouse, Boulder Water Utility) to the volumes of foregone withdrawals for Boulder, Highlands Ranch and Greeley alone, the total value lost would be quite large. The main point is that the call overall was a big loser, generating more costs than benefits in the short term.

In fact, there are reasons to believe that the placing of any river call is likely to generate short term economic losses. The most obvious reason is that those placing calls have no motivation to consider the losses to affected juniors. The underlying problem is the low correlation between water right priorities and incomes generated by those rights, i.e. many senior rights are owned and used by low income generating users while many higher value water rights, by virtue of more recent economic and population growth, are junior in priority. If this correspondence were closer, there would be few conflicts, indeed, few calls.

This is not to deny that the use of priority calls is an integral part of priority doctrine that affirms property rights embodied in water, property rights that are vital to protection of the owners' wealth and the ability to transfer title to that water as desired. The real issue is what steps can be taken within our current water law to increase the priority-value correspondence value while protecting property rights?

Reducing legal-economic conflicts: suggestions for the South Platte

Facilitating the water transfer process would reduce these conflicts. This is exactly the function of "water markets" that have been operative for 125 years in moving increasingly scarce water from less economic to more economic uses. Market transfers are willing seller-willing buyer arrangements: no one need sell. A key is to make our water markets as easy to use as possible while avoiding injury to non-transacting water users.

In Colorado, a majority of transfers go through water court reviews and hearings where various dimensions of the right (e.g. the consumptive use) are clarified. These procedures are costly to the participants (see MacDonnell et al, "Water Banks in the West", Natural Resources Law Center, August, 1994). In Idaho, Wyoming and New Mexico, these evaluations and subsequent approvals are carried out by the State Engineer or appropriate technical agency where technical expertise is available. In Idaho, the Supreme Court recently ruled that their State Engineer has the authority to approve plans for augmentation for well owners as well as flexibility in designing those arrangements with an eye to general public welfare:

"Somewhere between the absolute right to use a decreed water right and an obligation not to waste it and to protect the public's interest in this valuable commodity, lies an area for the exercise of discretion by the director" (Idaho Supreme Court, 2007 Opinion No. 40).

The Idaho Department of Water Resources also has a hydrologic model that has been accepted by nearly all stakeholders for use in analyzing the consequences of alternative plans. General agreement on standard models and greater authority for the State Engineer Office would be desirable in Colorado.

The organization of "water banks" through which buyers, sellers, and leasers can quickly communicate greatly facilitates short term and permanent water transfers. There is a long history of water banks in Idaho, California and Arizona. Water banks have been authorized by the Legislature for all major basins in Colorado, although none is currently operational. The pilot water bank authorized in 2002 for the Arkansas River failed partly because of the long delays involved in getting required reviews by the Division Engineer, thus ruling out short term transfers, especially those that would have been beneficial to agriculture. Idaho utilizes a variety of types of water banks and rental pools that facilitate quick water transfers and acquisition of water for plans for augmentation. The activation of water banks in each basin should be pursued.

"Facilitating the water transfer process would reduce these conflicts. This is exactly the function of "water markets" that have been operative for 125 years in moving increasingly scarce water from less economic to more economic uses."

Market transfers would be facilitated by better administrative bookkeeping on the ownership of water rights and on prices at which transfers occur so that potential market participants can know whom to contact and what "the going price" is in a particular area. The Arkansas water bank experience indicated that persons offering to buy or sell had little idea of a reasonable price.

The South Platte Task Force recently appointed by Governor Ritter has a great opportunity to consider these alternatives among others, taking into account the experience of other States, especially Idaho, in recommending solutions to the conflicts in the South Platte.

Hole in the River: A Brief History of Groundwater in the South Platte Valley

by Nick Kryloff, Colorado State University, Department of History

Water moves beneath the South Platte valley floor. Not gushing in an underground river or swirling in some subterranean lake, but rather seeping through the loose sediment and rock that make up the South Platte alluvial aquifer. This ice-age formation, according the *Colorado Groundwater Atlas*, contains some 25 million acre-feet of water, more than the current volume of Lake Powell. Yet its use has created strange difficulties, which rank among Colorado's most pressing water problems today.

But these problems are hardly new. In fact, they have vexed lawmakers, scientists, and water users for more than three-quarters of a century. Using archival documents made available by the CSU Water Resources Archive and the Colorado Historical Society, scholars can now reconstruct the history of this resource and its use.

Too often, water history focuses exclusively on law, engineering, and administration. Although these elements are vital to our understanding, they do not tell the whole story. In the South Platte valley, human ideas and institutions became entangled with natural circumstances largely beyond their control. The movement of water underground challenged longstanding notions about water management in the West and created intractable problems we are still trying to untangle.

The South Platte valley is home to some of Colorado's richest agricultural land, with fields of corn and alfalfa spreading across the mostly flat terrain. But this uniform landscape also conceals the contours of an earlier age. Below the ground, the South Platte valley aquifer is more than 200 feet deep in places. A mixture of sand, clay, and gravel, it sprawls beneath the flowing stream and its tributaries like a shadow, filling lost subterranean channels once carved by Pleistocene rivers. Most importantly, the water it holds is freely exchanged with the South Platte River flowing above it.

Though the South Platte aquifer was formed thousands of years ago, its water is not ancient. In fact, this vast subterranean reservoir is more the product of nineteenth-century farming than of continental uplifts and glaciations. When American settlers came to the valley in the decades following the Colorado gold rush of 1858, the river's flow was often intermittent.

But the South Platter River was gradually altered by decades of extensive irrigation in the valley. Every season, irrigation water not consumed by crops seeped into the porous subsoil, filling the permeable aquifer beneath the river. This seepage water later emerged downstream, making the river's flow consistent where once it had been intermittent. By the 1920s, surface-water irrigators had legally claimed these increased flows. Unwittingly, people filled the aquifer and altered the river above.

Irrigators were also utilizing the valley's groundwater. The first recorded irrigation wells in the region were those owned by E.F. Hurdle, who powered his pumps with steam engines. In 1893, a neighbor filed suit against Hurdle for allegedly diminishing the flow of the nearby river. But the court, despite finding a probable connection between groundwater and creek water, ruled that allegations of the wells' detrimental impacts were "vague, conflicting, and indefinite." The case established a legal precedent that some groundwater was connected to surface flows, but it also exposed the difficulty of demonstrating specific injuries in court based on that relationship.

Nick Kryloff

Groundwater use offered certain advantages over ditch irrigation. It was available instantly, at precisely the location and in the quantity an irrigator desired. Additionally, underground supplies remained relatively unaffected by droughts, at least in the short-term. When the century's most notorious drought seared the region during the 1930s, groundwater use seemed more appealing than ever.

At the same time, technological advances allowed better access to underground water. Centrifugal pumps underwent a series of revisions to increase their efficiency, and improved rotary drills soon followed, allowing the wider bore necessary to install improved pumps. Oil, gasoline, and diesel engines gradually replaced steam power, and by the 1930s, rebuilt automobile engines were driving high-speed pumping equipment. But soon there were even cheaper fuel alternatives.

Electric power came to the region in the late 1930s. This energy, produced largely by Reclamation developments such as the Colorado-Big Thompson project, required consumers of electricity to make these projects economically viable. In the South Platte valley, pump irrigators were targeted as prime candidates. By 1940, there were nearly 3,000 irrigation wells statewide, most running on electricity, with nearly two-thirds of those located in the South Platte valley.

"If groundwater was strictly private property, depletion was an imminent possibility. But if groundwater was deemed a public resource, it would be governed by the prevailing doctrine of prior appropriation..."

But this use did not come without problems. Among the first to notice was researcher William E. Code, an engineer at the State Agricultural College (later renamed Colorado State University) in Fort Collins. In the 1930s and 1940s, Code compiled thousands of well data logs from eastern Colorado, and he was disturbed by the patterns he saw. Although South Platte groundwater levels rose and fell with irrigation demands, snowmelt, and precipitation, many areas exhibited an alarming downward trend. Groundwater was being depleted more rapidly than it was recharged.

Code and others called for groundwater's legislative regulation, which until the 1950s was subject to no oversight in Colorado. Researchers such as Code feared that unregulated pumping would lead to depletion. "To delay would only cause a bad situation to grow worse," he wrote for the *Denver Post*. Like other conservation-minded scientists of his era, Code conceived of groundwater in terms of resource depletion.

But farmers, whose livelihoods often depended on irrigation water, saw things differently. One area suffering from depletion was the Bijou Basin, located along a normally dry tributary of the South Platte. Although the opinions of farmers in this area differed on many issues, certain refrains rang clear. "The land is worthless without the water," one said. "We have paid so much for what's on top," echoed another, "we need what's underneath to make a decent living." For many farmers, loss of groundwater would mean insurmountable debt and financial ruin. While researchers focused mainly on resource depletion, most farmers saw underground water as part of an economic investment.

Lawmakers faced a different set of concerns. Colorado was one of the last states in the West to pass meaningful groundwater legislation. With more than 5000 unregulated wells in operation by the mid-1950s, the state's legal code was falling behind. Former State Engineer M.C. Hinderlider suggested the delay involved overlapping use of groundwater and surface water, with water users often having "interests on both sides of the question." But by 1957, calls for legislation grew to a fever pitch.

The 1957 Ground Water Act was a legislative Frankenstein. After undergoing more than two dozen revisions, it accomplished little more than cataloguing the wells already in existence by requiring permits. The act also created an eight-member Ground Water Commission, which could restrict groundwater use in any area it designated as critical. But local residents were allowed to overturn such a measure. When the Bijou Basin received the commission's first designation, residents overwhelmingly voted against it. The 1957 Act was unable to stop depletion.

But during the political debates leading to the Act's passage, the prevailing terms of discussion shifted. Groundwater management, at first primarily focused on resource conservation, became a firestorm debate about property rights. As early as 1954, Sen. Ranger Rogers accused well users of "robbing" the South Platte River. Groundwater users fired back with property claims of their own: "Taking cubs away from a wild lioness would be a pleasure compared to trying to take water away from the farmers," boasted one representative. The discussion about resource management was being reframed as a water war.

At the root of this debate was a question of ownership. Did a landholder own the water beneath his property, or did a vaguely defined "public" own the resource? The question was more than academic. If groundwater was strictly private property, depletion was an imminent possibility. But if groundwater was deemed a public resource, it would be governed by the prevailing doctrine of prior appropriation, which would enjoin almost all wells because of their junior status relative to most surface rights.

Lawmakers finally resolved this question with the 1965 Ground Water Management Act. Under this law, groundwater was considered public property under prior appropriation principles, but with certain modifications. The law sought to regulate groundwater conjunctively with surface

rights, while simultaneously allowing for its "full economic development."

Recognizing that not all basins shared equal characteristics, lawmakers separated groundwater into several categories: non-tributary, which was not meaningfully connected to surface water; designated, which despite its connection to surface supplies was exempt from the overall priority system; and tributary, which was connected to surface supplies and therefore subject to prior appropriation. Most groundwater in the South Platte valley was deemed tributary.

> "The curtain is opening upon the new drama of maximum utilization and how constitutionally that doctrine can be integrated into law of vested rights."
>
> --Justice James Groves

The first test of this law came from the Arkansas River. Although groundwater development in the South Platte basin was more extensive than along the Arkansas, both areas shared similar problems. In 1966, senior surface-rights holders placed a call on the Arkansas, and the State Engineer accordingly shut down several dozen wells. But because only 39 of the region's 1600 or more irrigation wells were enjoined, the Colorado Supreme Court ruled that the State Engineer's office had acted "arbitrarily and capriciously." The case, *Fellhauer v. People* (167 Colo. 320, 1968), highlighted the difficulties of applying strict prior appropriation principles to groundwater.

Justice James Groves' majority opinion in the *Fellhauer* case was even more telling: "As administration of water approaches its second century," he commented, "the curtain is opening upon the new drama of maximum utilization and how constitutionally that doctrine can be integrated into the law of vested rights." In a single sentence, Groves crystallized the problem which would continue to vex Colorado into the next century.

A year later, the 1969 Water Rights Determination and Adjudication Act was passed in an attempt to reconcile vested rights and maximum use. The new law required tributary wells to obtain legal priority dates, but it also allowed them to pump out-of-priority under certain conditions.

Retaining the previously established categories for groundwater, the law also introduced "augmentation," a provision allowing tributary wells to offset river depletions by finding replacement surface water to compensate senior rights. The law was an effort to integrate groundwater fully into the prior appropriation system while allowing enough flexibility for its continued use.

Although the 1969 Act was drafted in conjunction with several scientific studies, difficulties persisted. A report by the engineering firm Bittinger-Wright emphasized the aquifer's enormous storage capacity. Bittinger, a prominent groundwater expert, envisioned an underground reservoir that scientists could "manipulate" to achieve full use. To accomplish this goal, the aquifer would be drafted heavily during dry cycles, then artificially recharged during wet periods by transferring surface supplies underground. Because any drawdown of the aquifer would affect the river, surface rights would at times need to be served from underground.

But aligning property rights with the conception of the aquifer and river as a technologically correlated whole was not easy. Despite Bittinger's suggestion that 10 to 15 percent of the aquifer could be utilized, surface claims made this vision difficult to realize. Water's independent movement complicated the issue. Former State Engineer Clarence Kuiper recalled that administration of the South Platte was "one of the biggest headaches of my job. It was like the river had a great big hole in it."

> Former State Engineer Clarence Kuiper recalled that administration of the South Platte was "one of the biggest headaches of my job. It was like the river had a great big hole in it."

This "hole" beneath the South Platte River was made by nature, consisting of thousands of years' worth of loosely composed sands and gravel. Early irrigators unintentionally filled it with water, and by the start of the twentieth century it fed the river's flow, which had grown stronger on top of it. Irrigators claimed these added volumes, expanding the accommodation between water use and availability.

When prolonged drought disrupted this situation in the 1930s, farmers tapped the aquifer with new technologies – drills, pumps, new fuels, and electricity. As the drought lifted, groundwater use continued. The amount of irrigated acreage in northeastern Colorado increased, stretching the accommodation even further.

Then, when declining water tables threatened to upset this tentative balance, scientists began to see groundwater as a vulnerable resource, requiring preservation and careful management. But to farmers, it was a form of economic investment, and its use continued and even accelerated. This activity threatened property rights built on the river's increased flow, and new droughts inflamed the conflict.

Ultimately, groundwater legislation in the 1960s struggled to preserve not a natural state, but rather a half-natural accommodation between water use and availability – a full river and the continuing use of underground water. But when severe drought returned in 2002, these twin goals again became difficult to reconcile. Today's problems along the South Platte are rooted in this history.

Deborah Young

Colorado State University, Extension

FACULTY PROFILE

Deborah Young
Extension Director

New Director of Colorado State University Extension Takes Office

Colorado State University Extension welcomes Deborah Young as its next director. Her appointment began August 1st.

Young comes to CSU from University of Arizona

Young comes to Colorado State Extension from the University of Arizona Cooperative Extension, where she served as associate director since 1997. She has also served from 1990 to 1997 as the county extension director for Yavapai County, Arizona. She earned doctoral and masters degrees in plant pathology from UA in 1979 and 1982, respectively.

"I believe Colorado State University has the potential to reach the people of the state in not only Extension's traditional strengths, but through new and innovative outreach programs," Young said. "Colorado State Extension can reach through its county offices to provide educational opportunities at all levels, and Coloradans can reach back to the university through those same offices."

Extensive experience supporting and promoting sustainable agriculture

Lou Swanson, Vice Provost for Outreach and Strategic Partnerships at Colorado State, praised Young's extensive experience in supporting and promoting sustainable agriculture. Young has also authored numerous articles and made several presentations on sustainable agriculture while working in Arizona.

"Dr. Young has been a county agent, a strong advocate for Arizona Extension, and an associate director," Swanson said "Her strong administrative experience will serve us well. I feel she will communicate well with all of us associated with Colorado State Extension, our county and state stakeholders and supporters, and with a broad spectrum of on campus faculty and administrators."

Extension connects Coloradans to CSU's research and expertise

Colorado State University Extension is a local community connection for university research, information, education, expertise and youth programs. Colorado State Extension delivers the latest research and local education designed to contribute to the pressing issues facing Coloradans living in both urban and rural communities. These topics include natural resource management; living well through raising kids, eating right and spending smart; gardening and commercial horticulture; the latest agricultural production technologies and community development.

CSU has 59 Extension offices throughout the state

Extension 4-H and youth development programs reach more than 100,000 young Coloradans annually, over half in urban communities. Colorado State University's 59 Extension offices provide a Front Door to university expertise for all Colorado citizens on the job, at home and in their communities.

For more information, visit http://www.ext.colostate.edu.

Extension

Chris Goemans

Colorado State University, Deptartment of Ag and Resources Economics

Chris Goemans

Dr. Chris Goemans is a new faculty member in the Department of Agricultural and Resource Economics. He received his bachelor's degree in Economics from the University of Maine and attended the University of Colorado at Boulder where he received his master's and doctoral degrees in economics.

Dr. Goemans has long been interested in the economics behind the allocation of water. Growing up in California's San Joaquin Valley he learned firsthand about both the economic and social importance of water. These experiences motivated him to attend CU where his advisor, Dr. Charles Howe, brought him onboard to help conduct a comparative analysis of water markets and their impacts across three Colorado water markets. Economists have long promoted water markets as an efficient means of transferring water from old, lower valued uses to new, higher valued ones. Results from this study suggested that the extent to which any particular market successfully reallocated water was highly dependent on the regional economic conditions and how property rights were defined in that market. Markets for water were less effective in reallocating water and resulted in greater economic and social impacts in specialized, marginal regions like the Arkansas River Basin.

The publication of "Water Transfers and Their Impacts: Lessons from Three Colorado Water Markets" in 2003 was timely. Rapid population growth over the previous several decades together with the onset of one of the worst droughts on record left most water managers along the Front Range scrambling to augment dwindling supplies. Most quickly realized it was no longer possible to rely solely on strategies based only on expanding supply. Planners were forced to address the long ignored other half of the equation: demand. This change in philosophy has opened up numerous opportunities for research as cities have expressed a need to better understand and predict how demands are likely to respond both to particular demand management programs and other exogenous factors (e.g., weather). In short, the drought has been good for business!

One example of this is his recent work with the city of Aurora. Like many water utilities along the Front Range, the city's water department, Aurora Water, implemented a long list of short- and long-term demand management programs. The list included changes to the type of rate structure used to price water, severe price increases, outdoor water use restrictions, and a variety of rebate programs designed to motivate residential customers to install various, new water saving technologies. Despite the collective success of these programs (reducing demand by roughly twenty-five percent in 2003), enthusiasm was tempered by the inability to identify which of the simultaneously employed tools were responsible for the savings and which reductions could, or could not, be relied upon in the future. Together with others from CU, Goemans began working with Aurora in the fall of 2005 to investigate these issues.

Although this research is ongoing, several important findings have already emerged. These include identifying important differences in how price and restrictions influence demand among different classes of customers. For example, our study is the first to account for the interaction of price and outdoor water restrictions. Consistent with economic theory, our estimates of price elasticity reflect the fact that households with large outdoor water demands do not respond to price increases when facing outdoor watering restrictions.

While a significant amount of effort has been dedicated to studying the demand for water, we still have a long way to go in terms of understanding how individuals and households make water use decisions. Few know the price they pay for water, how much water they use in any given month, how much water their lawns "need", or the quantity of water various appliances consume. Despite this, most demand studies begin by assuming that households know all of this information or behave as if they do.

Moving forward Dr. Goemans hopes to further investigate how continued population growth and climate change will affect the management of resources such as water. Much like in 2002, adapting to these challenges will require water managers to introduce new ways to both expand supply and control demand. Developing a better understanding of how consumers make water use decisions will be an important part of this.

Dr. Goemans is extremely excited to have the opportunity to continue to explore these issues at CSU. This excitement exists despite the fact that he was booed on his first day of class (he mistakenly announced that he graduated from CU).

Agricultural and Water Management Alternatives to Sustain a Vulnerable Aquatic Ecosystem on the Eastern High Plains of Colorado

by Deanna Durnford[1], Angela Squires[1], Jeff Falke[2], Kurt Fausch[2], Ramchand Oad[1], and Linda Riley[1]

Introduction

Among the largest and most persistent environmental and economic problems in the western U.S. is the decline of the High Plains Aquifer. The High Plains Aquifer underlies 174,000 square miles extending from South Dakota to Texas and New Mexico (Fig. 1). The Ogallala formation makes up 134,000 square miles of the High Plains Aquifer and is the principal aquifer used for groundwater pumping for agricultural irrigation. The Ogallala formation of the High Plains Aquifer sustains the regional agricultural economy by providing a predictable water supply for crop growth in an arid and unpredictable climate.

After World War II, high-capacity center-pivot irrigation wells started pumping from the Ogallala aquifer. The total number of acres irrigated with groundwater increased rapidly, from 2.1 million acres in 1949 to 13.7 million acres in 1980 (Gutentag et al., 1984). These high-capacity wells could pump up to 2000 gallons per minute and the thousands of wells that were installed began to mine the aquifer. In eastern Colorado alone, 17 million acre-feet had been mined from the aquifer by 1990 (VanSlyke and Joliet, 1990) and by 2002, the average rate of decline in the water table exceeded one foot per year (CDNR, 2002). Moreover, the recent drought has exacerbated the effects of groundwater pumping. Fardal (2003) reported that during summer 2002, farmers in Yuma County of eastern Colorado pumped continuously throughout the irrigation season and still met only about 70% of crop water needs.

Small streams and springs sustained by the Ogallala Aquifer provide aquatic and riparian habitats. These groundwater-fed habitats provide oases in the arid landscape and, in turn, support a unique and diverse aquatic and riparian fauna. Riparian areas along plains streams support the highest diversity of birds and mammals in the region (Samson and Knopf, 1996), and the aquatic habitats support a variety of amphibians and small fishes specially adapted to cope with harsh conditions (Fausch and Bestgen, 1997). Partly because of their dependence on scarce water resources, both the agricultural economies and aquatic ecosystems are in trouble in regions supplied by the Ogallala Aquifer. Farmers on the Great Plains in eastern Colorado subsist on very low profit margins. Meanwhile, fishes of the Great Plains are declining. The brassy minnow (Hybognathus hankinsoni), once widely distributed in northeastern Colorado, is now almost entirely restricted to six miles of the Arikaree River.

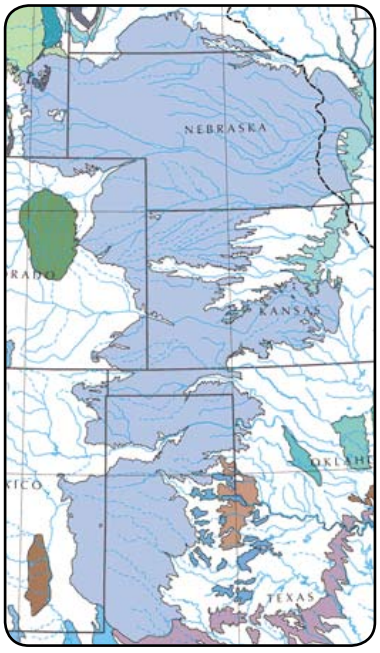

Fig. 1: Map of the High Plains Aquifer (from capp.water.usgs.gov).

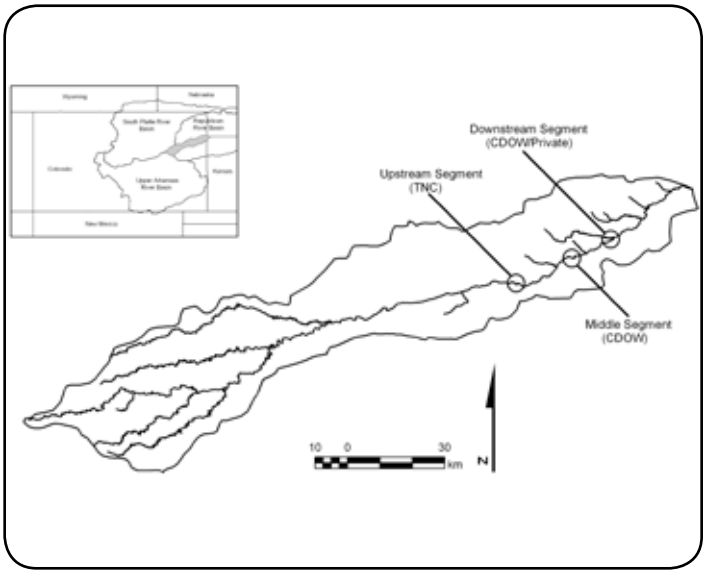

Fig. 2: The Arikaree River basin, showing (circled, left to right) wet, intermediate, and dry study river segments.

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[2] Fish, Wildlife and Conservation Biology, Colorado State University, Fort Collins, CO.

The study site

The study site is the Arikaree River (Figs. 2 and 3) on the eastern high plains of Colorado. The Arikaree River is in Yuma County and part of the Republican River Basin. Farmers in Yuma County extract almost 300,000 acre-feet of groundwater annually, one of the largest regional groundwater withdrawals in Colorado. However, the High Plains Aquifer also provides base flow to the Arikaree River. Regional declines in groundwater caused by agricultural pumping threaten to reduce groundwater discharges to the streams and dry up riparian and aquatic habitats. Figure 4 shows stream gage measurements on the Arikaree at Haigler, Nebraska, just downstream from the study site. The introduction of high capacity pumping in the early-1960s is clear in this graph. For the first time in recorded history, the year 2002 showed an annual stream flow less than 500 acre-feet/year (2 million m^3) at Haigler, where flows over 15,000 acre-feet/yr regularly occurred in the early half of the 20th century.

Our Project

To sustain both a precarious regional agricultural economy dependent on groundwater for irrigation, and an aquatic ecosystem likewise dependent on groundwater for existence, we must be able to predict tradeoffs in the use of this scarce resource. A group of researchers at Colorado State University, including groundwater hydrologists, irrigation engineers and fisheries biologists, are cooperating in an investigation of the effects of water and agricultural management options for conserving aquatic habitats. The project is about at its midpoint. Field data collected includes water-table levels, fish population surveys, aquatic-habitat measurements and information on agricultural practices. Groundwater modeling provides the connections between agricultural practices (e.g. pumping, crop mixes) and aquatic habitat. The first phase of the project collected data and developed "tools". The next phase of the project will apply these to evaluate the effects of agricultural and water management decisions on both the local agricultural economy and the river ecosystem. Questions to be answered will be in the form of "what if" scenarios. For example, if current climate and pumping conditions continue, how long will it be until the last fish refuge pools in the Arikaree River go dry? What if a percent of the large irrigation wells pumping from the Ogallala Aquifer or the alluvium are taken out of production? What about climate change? What if cropping mixes in the basin change, either due to conservation measures or due to corn acreage increases for ethanol production? What if there is an extended drought? Finally, which wells, if taken out of production, would have the most benefit to the aquatic ecosystem?

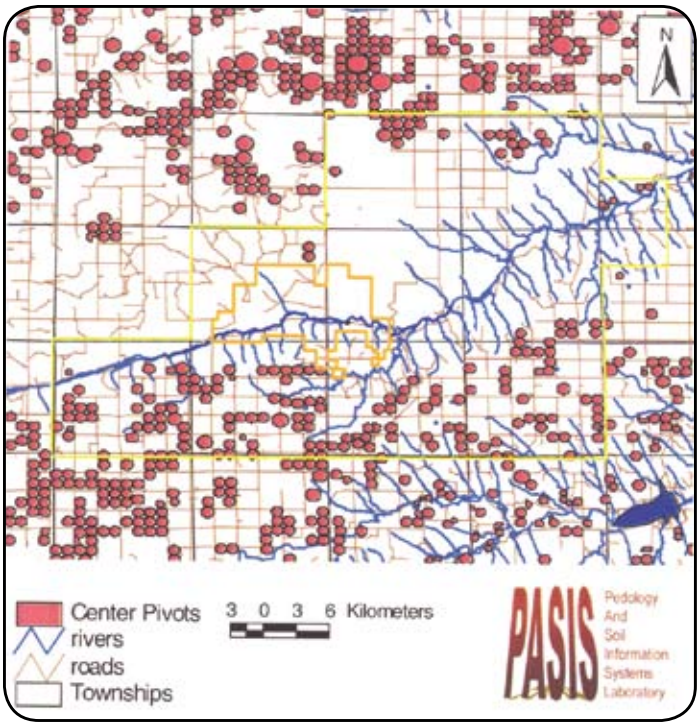

Fig. 3: Arikaree River and adjacent center pivots near The Nature Conservancy Fox Ranch (outlined in yellow).

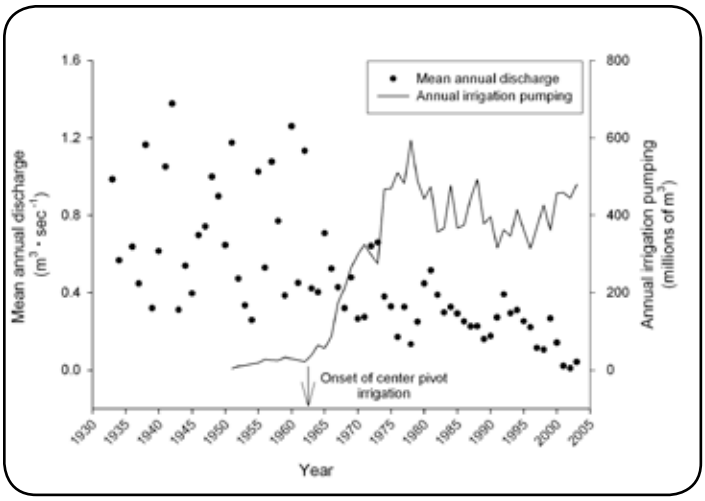

Fig. 4: Arikaree River flow measured at Haigler, Nebraska, showing introduction of high capacity wells in the early-60s.

Aquatic habitat monitoring

Habitat units (e.g., refuge pools and spawning backwaters) were sampled for physical habitat characteristics related to groundwater (e.g., water chemistry, maximum depth, area, and volume), and presence or absence of brassy minnow for five years. (Scheurer et al., 2003; Fardal, 2003; Griffin, 2004; Falke and Fausch, 2006; Falke and Fausch 2007).

The study focused on three four-mile river segments: upstream, middle, and downstream segments (Fig. 5). Figures 6, 7 and 8 show typical seasonal drying patterns. The upstream segment is typically wet with some intermittent flows and dry areas in August. The middle segment is flowing at the beginning of the summer season but experiences widespread drying by August. The downstream segment is dry throughout most of the summer, except at the confluence of a semi-perennial tributary, Black Wolf Creek, and the river.

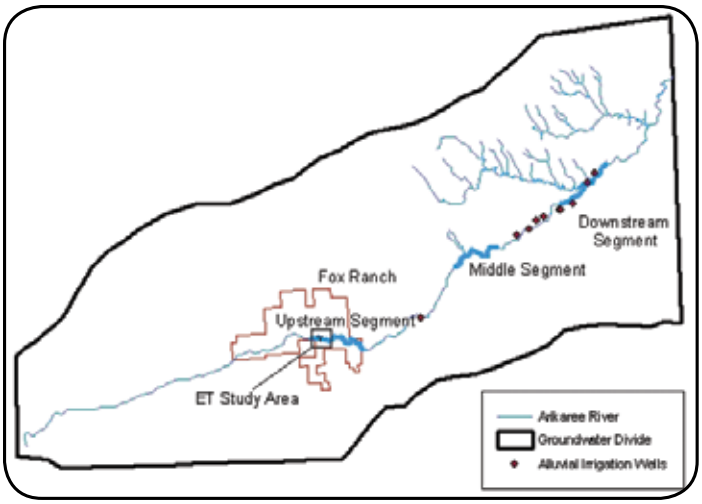

Fig. 5: Arikaree River basin showing the river, ET study area, the Fox Ranch and the upstream, middle and downstream stream habitat areas.

Groundwater modeling

The initial groundwater modeling challenge was to predict the depths of individual river pools in the three study segments where habitat was monitored. To accomplish this, two numerical models were developed, calibrated and linked. One is a regional model; the second is a model of only the alluvial aquifer and stream, which is on a smaller time and space scale. Both finite difference models use MODFLOW (McDonald and Harbaugh, 1988), which is the industry standard for groundwater modeling.

Groundwater modeling is an iterative process. Physical and hydrologic data are sparse in the Arikaree River basin so

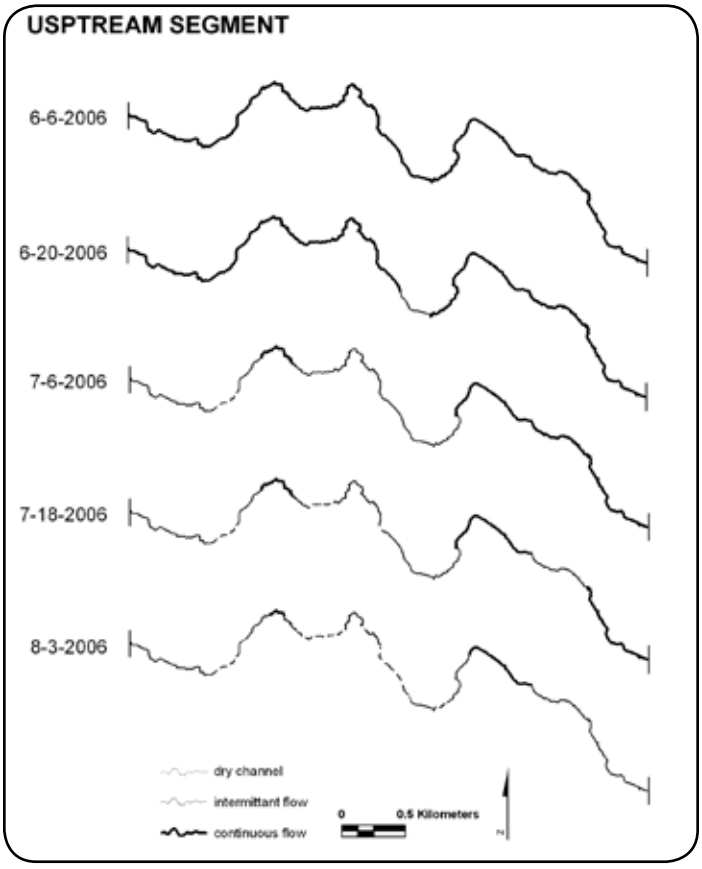

Fig. 6: Connectivity data for the upstream segment. The upstream segment is typically wet with some intermittent flows and dry areas in August.

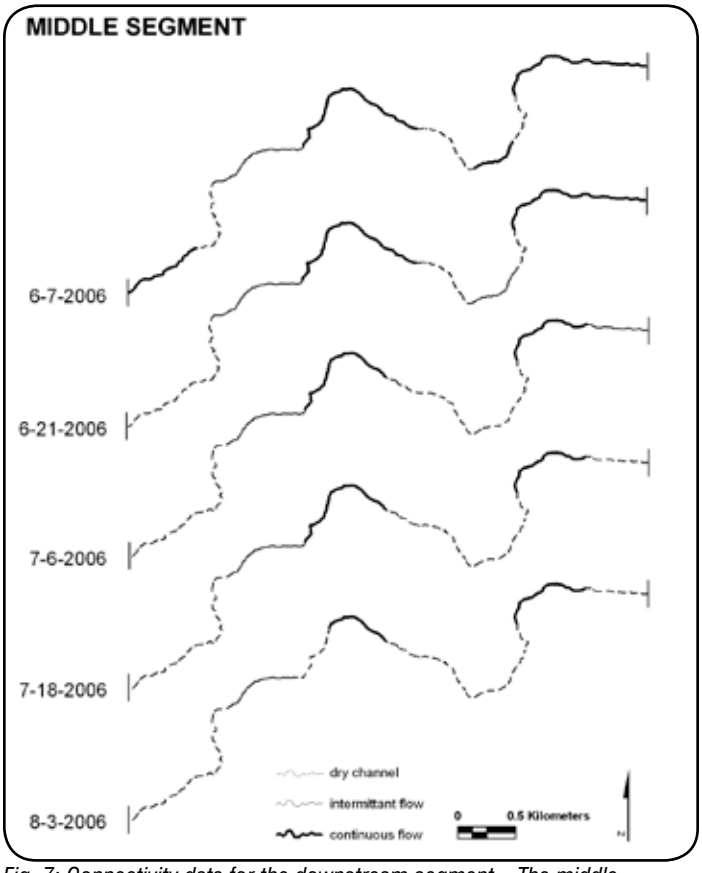

Fig. 7: Connectivity data for the downstream segment.. The middle segment is typically flowing at the beginning of the summer but experiences widespread drying by August.

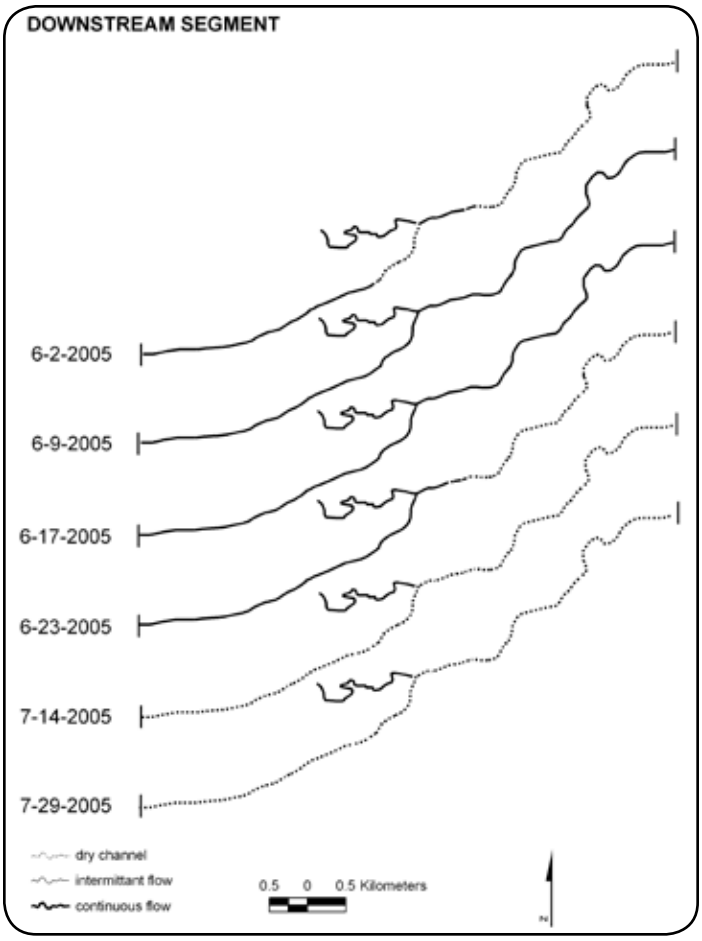

Fig. 8: Connectivity data for the downstream river segment. The downstream segment is typically dry except for local wet areas near Black Wolf Creek.

determining input parameter values is a significant effort in this project. Conceptualization of the system is also a focus. Data and modeling show that pool depths are a function of long-term trends impacted primarily by the center-pivots pumping from the Ogallala with short-term fluctuations around that trend caused by alluvial stresses (pumping, riparian evapotranspiration, precipitation). Cottonwood evapotranspiration (ET) rates, recharge rates to the groundwater and apparent specific yield are important, but uncertain parameters. This resulted in a number of secondary studies. Cottonwood ET, as described in the next section, is one example of these.

Cottonwood evapotranspiration

Many methods exist to estimate ET, but most have uncertainties when applied to phreatophytes in riparian corridors. One of the oldest methods uses water-table fluctuations to estimate the component of ET resulting from groundwater consumption by phreatophytes (White, 1932). We used a combination of a modified White method, calibration of response functions generated by the numerical groundwater model, and water balances. The next section discusses only the response function calibration method. All three methods, however, resulted in similar average seasonal evapotranspiration rates.

In the response function calibration method, we calibrated weekly ET rates to match 2006 water-table levels measured in seven monitoring wells installed in a cottonwood area along the Arikaree River (Fig. 9). The monitored area is located significantly outside the radii of influence of any pumping wells, so short-term water table fluctuations were assumed to be in response to precipitation events and cottonwood evapotranspiration. An iterative process was used to calculate weekly ET rates that minimized the sum of the squares of the differences between predicted and measured drawdowns at the end of each week in the 2006 season.

The calibration process resulted in an ET estimate that generated a best fit to all the measured drawdown data (Fig. 10). It is clear from this figure that ET is highly dependent on the density of the cottonwood stands. The calibration process was repeated using only data from the observations wells in a low density cottonwood area and only the data from observations wells in a high density cottonwood area. We found that evapotranspiration in the cottonwood areas ranged from 51 to 120 cm/season, depending on stand density and assuming an apparent specific yield of 0.12, with trend lines equal to 1.0 and R2 values greater than 0.96 for each case. To verify that the ET coefficients calculated from 2006 data could be used in other years, drawdown data measured in 2000 were predicted using 2006 coefficients and a reference ET based on climate data for 2000. Figure 11 shows good agreement between predicted and measured depths.

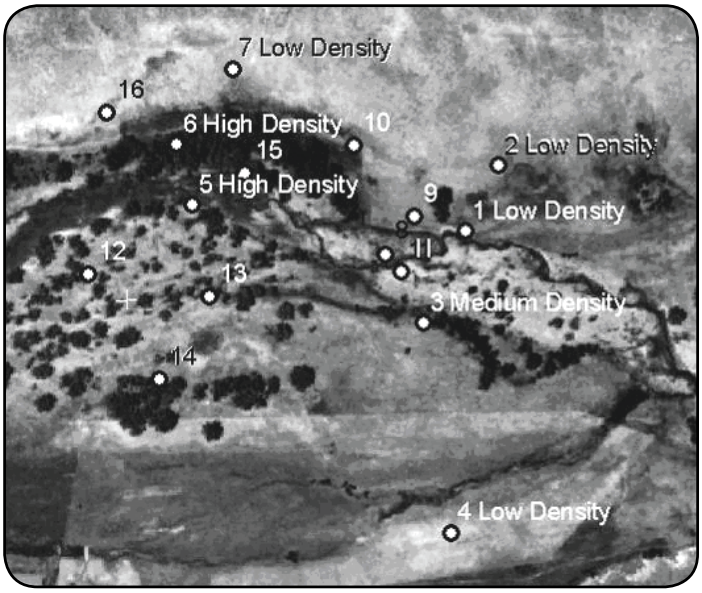

Fig. 9: Riparian vegetation along the Arikaree River and monitoring wells in cottonwood areas used for ET study

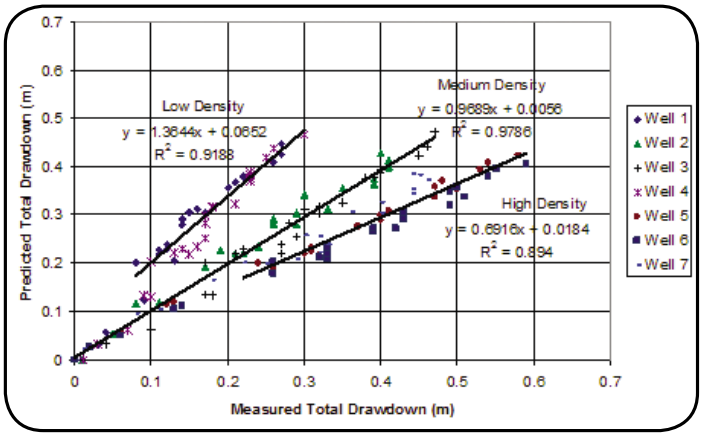

Fig. 10: Measured vs. modeled drawdown from the ET analysis assuming a uniform cottonwood density. This graph shows the effects of different cottonwood stand densities.

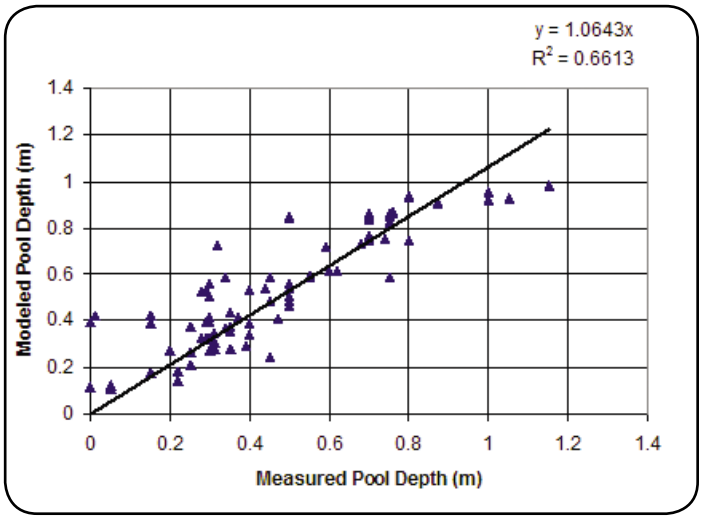

Fig. 11: Modeled vs. measured pool depths in 2000 predicted using ET coefficients developed from 2006 water table measurements. This comparison was used to verify the ET computations

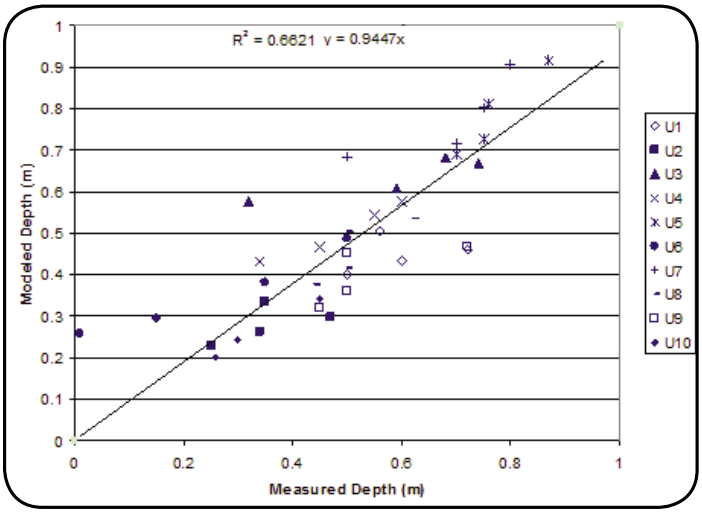

Fig. 12: Modeled vs. measured pool depths in the upstream segment

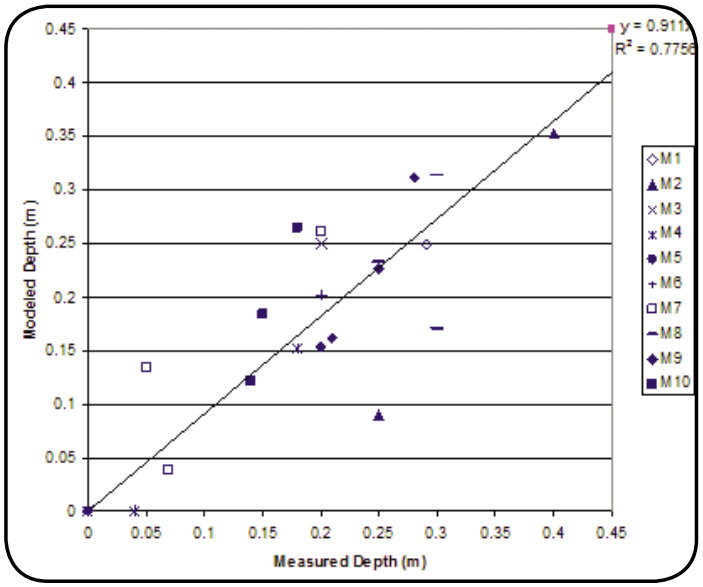

Fig. 13: Modeled versus measured pool depths in the middle segment

Aquatic habitat modeling

The goal of the project is to predict depths of fish refuge pools over time so that, as inputs such as pumping rates or climate data are changed, pool depths (aquatic habitat) can be predicted. To test our ability to do this, ten fish refuge pools were identified in each of the upstream and middle river segments. These twenty pools were identified as being among the deepest pools in each segment. Pool depths were recorded five times throughout the 2000 season (Scheurer, 2002). Response functions were generated in the numerical model for each of the twenty pools at each monitored time. Figure 12 shows modeled vs. measured pool depths in the upstream segment and Figure 13 shows modeled vs. measured pool depths for the middle segment.

The path forward

We believe that our study site, the Arikaree River, is at a "critical threshold", as are other groundwater-sustained streams on the high plains. A high concentration of center-pivot irrigation systems, a declining water table, a strong link between groundwater pumping and stream baseflow, the presence of a state-threatened fish, a precarious local agricultural economy, an exploding urban population willing to pay high prices for water rights and finally, state and local agencies and local farmers primed by a recent drought make this an important study. The project is especially timely because the State of Colorado expects to spend tens of millions of dollars over the next 15 years to take center-pivot irrigated acres out of production in the Republican River basin to meet an interstate water compact. Our research will identify center-pivot systems that will not only meet compact requirements, but also are important for core aquatic habitat. The project will identify strategies that will protect a precarious agricultural economy and a vulnerable aquatic ecosystem, both dependent on the same scarce and declining resource - groundwater.

Acknowledgments

We gratefully acknowledge the support of the Colorado Division of Wildlife and Colorado Agricultural Experiment Station and the cooperation of The Nature Conservancy.

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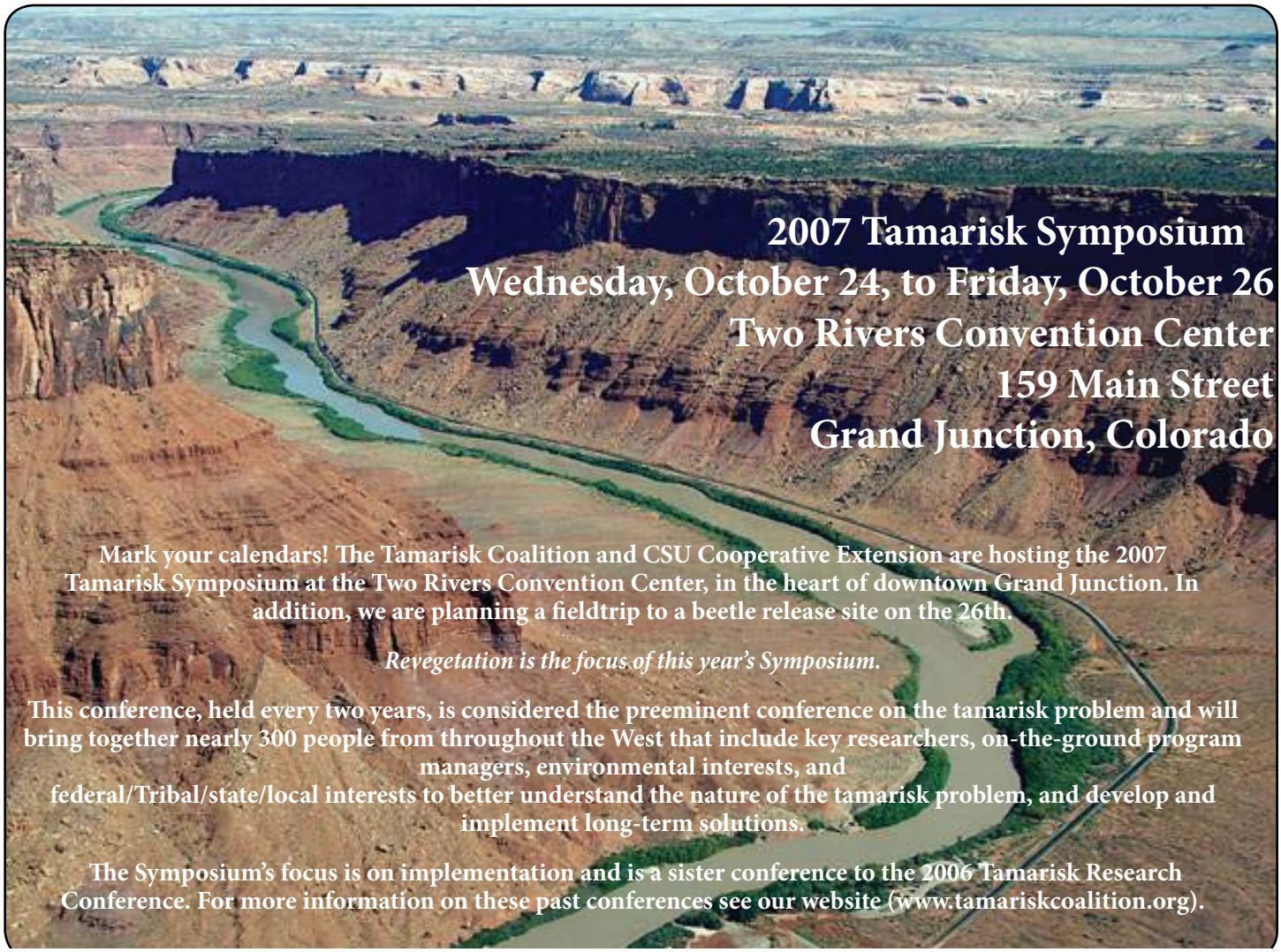


Consensus Development For Augmentation Accounting

by Luis A. Garcia, Colorado State University, Department of Civil and Environmental Engineering

Luis A. Garcia

The severe drought of 2002 and rapidly growing urban populations have exacerbated conflicts between ground and surface water users. These conflicts have caused the amount of groundwater depletions from well pumping in alluvial aquifers to be scrutinized more closely. Water managers are attempting to reconcile the desire to make use of the large amount of storage in the alluvial aquifer with the need to protect Colorado's Doctrine of Prior Appropriation and more senior surface water rights. To accomplish this, the development and understanding of a common framework of information is essential. Such a framework is especially needed in areas like the Lower South Platte River where conjunctive use of surface and groundwater is fairly common. One way to develop this framework is with a common set of computer tools and data that can be used to accurately estimate augmentation requirements.

For the past twelve years, as director of the Integrated Decision Support (IDS) Group at Colorado State University and CSU Extension Water Resources Engineer, I have had the opportunity to study the data and modeling needs of water users in the Lower South Platte River in Colorado. With the active participation of water users, IDS has prioritized their data and modeling needs and collected or generated the data and modeling tools to meet their needs. Our work in the South Platte is one framework for the development and implementation of decision support tools to assist water managers in addressing the complex issues surrounding conjunctive management of Colorado's ground and surface waters. As the modeling tools are employed in the 'real world' of water management in Colorado, we have developed a framework that allows us to enhance the capabilities of the software to continue to provide upgrade the tools for the fair and equitable management of Colorado's limited water resources.

The tools that IDS has developed for the Lower South Platte Basin are collectively called the "South Platted Mapping and Analysis Program" (SPMAP). These tools and data are designed to help build consensus concerning water accounting when dealing with conjunctive use and augmentation requirements. This effort was initiated in 1995 with funding from the Colorado Water Resources Research Institute (CWRRI). As a result of this process, a number of data and modeling needs have been identified, and with funds from a number of organizations most recently: CWRRI, Colorado Agricultural Experiment Station, CSU Extension, and Northern Colorado Water Conservancy District we have developed a framework that is dynamic and is based on a "user centered approach" for data and model development. This process is as open and transparent as possible with all the products being distributed via the web (www.ids.colostate.edu/projects/splatte).

Quantification of Augmentation Requirements

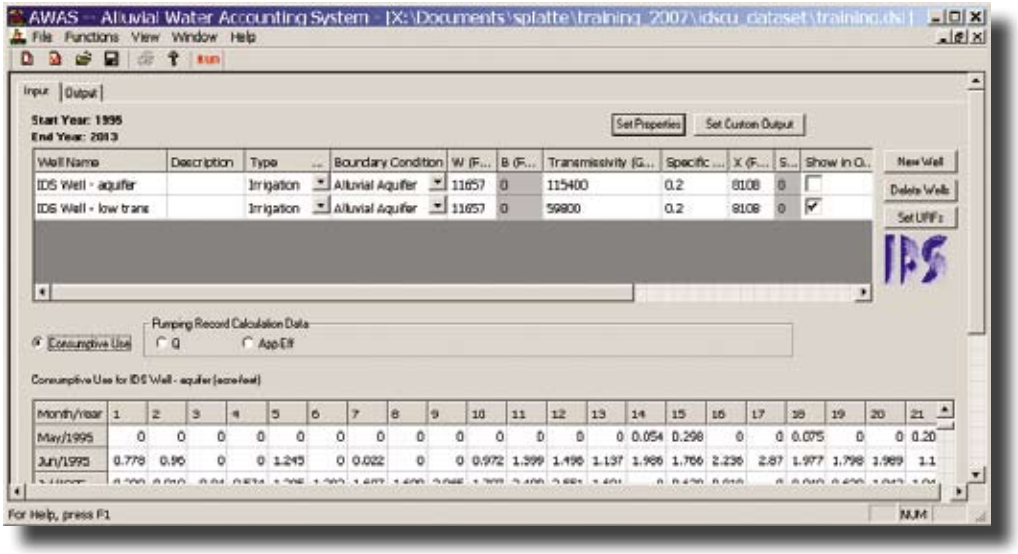
Colorado water managers need to determine the lag time from when a well is pumped or water is recharged to a recharge site and when a depletion or accretion happens in the river. Historically the Stream Depletion Factor (SDF) (Jenkins, 1968) methodology has been used in Colorado to determine the impact of the depletions of groundwater on a particular stream, and the IDS Group developed a model to calculate the monthly depletions or accretions (in the case of recharge sites) using the SDF methodology (SDF View). The SDF methodology is an analytical technique based on several boundary assumptions that are viewed by some as unrealistic. However, analytical techniques are convenient and, if properly calibrated, very valuable tools. Therefore the need for using other analytical techniques that support different boundary conditions (no flow boundaries, alluvial aquifers, etc.) was identified.

To meet the additional needs expressed by water users, a new model based on the State Engineer's Office system was implemented by IDS: the IDS Alluvial Water Accounting System (IDS AWAS). The model is based on The Analytical Stream Depletion method developed in 1987 by Dewayne R. Schroeder. This method 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 may evaluate a number of different boundary conditions (alluvial, infinite, no flow, unit return flow and effective SDF). IDS AWAS can create model input in two ways:

1. Each well can have a list of pumping records consisting of a pumping rate and duration (original mode).
2. Input records consisting of net consumptive use or recharge in a daily or monthly time step can be used.

Year type can be set to calendar, irrigation, or USGS. Data can be projected into the future or past based on

Figure 1: IDS AWAS GUI Input Screen



historical data, and the effect of turning off the well by specifying an end date beyond the period of record can be simulated. Figure 1 shows the IDS AWAS input screen and Figures 2 shows an example of the IDS AWAS output plot of depletions. This software can be downloaded from: http://www.ids.colostate.edu/projects/idsawas.

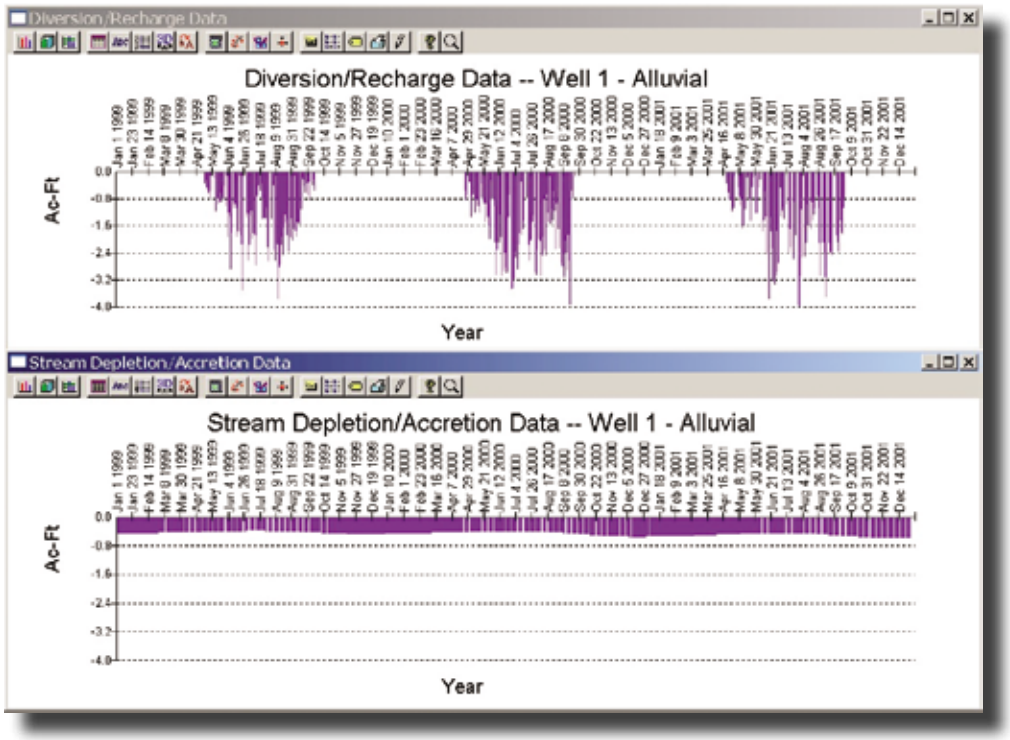
On May 6, 2006, Hal D. Simpson, the State Engineer at the time issued Procedures Memorandum 2006-1 to all Division of Water Resources Staff announcing "*In an effort to modernize the software used to model stream depletion caused by well pumping, the Division of Water Resources has selected the IDS AWAS software as the standard software to be used by all.*" Furthermore, the memorandum stated, "*Evaluators and Engineering staff must use the IDS AWAS Stream Depletion Model, and the Records staff must direct customers to use this software in conjunction with our data*"

The combination of using existing models, building graphical interfaces, following a modular approach and developing good documentation makes this software flexible, generalized, and easy to use. These tools have been developed with the active participation of area water managers and staff from the Division One State Engineer's Office. The result is a transparent and inclusive development process that has been coupled with quick responses to users' needs and feedback and has resulted in a set of tools that are helping to build consensus on water accounting in the Lower South Platte.

The IDS Group's work in the South Platte is one framework for the development and implementation of decision support tools to assist water managers. The tools and process used to develop them have confirmed their worth by their wide use and helping work through water disputes during Colorado's recent unprecedented drought. I have been very fortunate to be part of this collaborative process and look forward to the continue to work closely with water managers to develop tools and data to meet their needs.

There continues to be opportunities for updating the current methodology used for calculating augmentation requirements. Fertile areas for ongoing research include developing, maintaining, updating, and deploying DSS.

Figure 2: IDS AWAS Output Sample Plots



Supreme Court Justice Publishes New Book on Water

by Brian Werner, Northern Colorado Water Conservancy District

Brian Warner

In a publication that comprises poetry, pictures and numerous articles about water, Colorado Supreme Court Justice Greg Hobbs asserts that "water has always possessed a very practical and a very spiritual dimension."

"The Public's Water Resource: Articles on Water Law, History and Culture" is the latest book from Hobbs who previously wrote "In Praise of Fair Colorado," "The Practice of Poetry," and "Colorado Mother of Rivers, Water Poems."

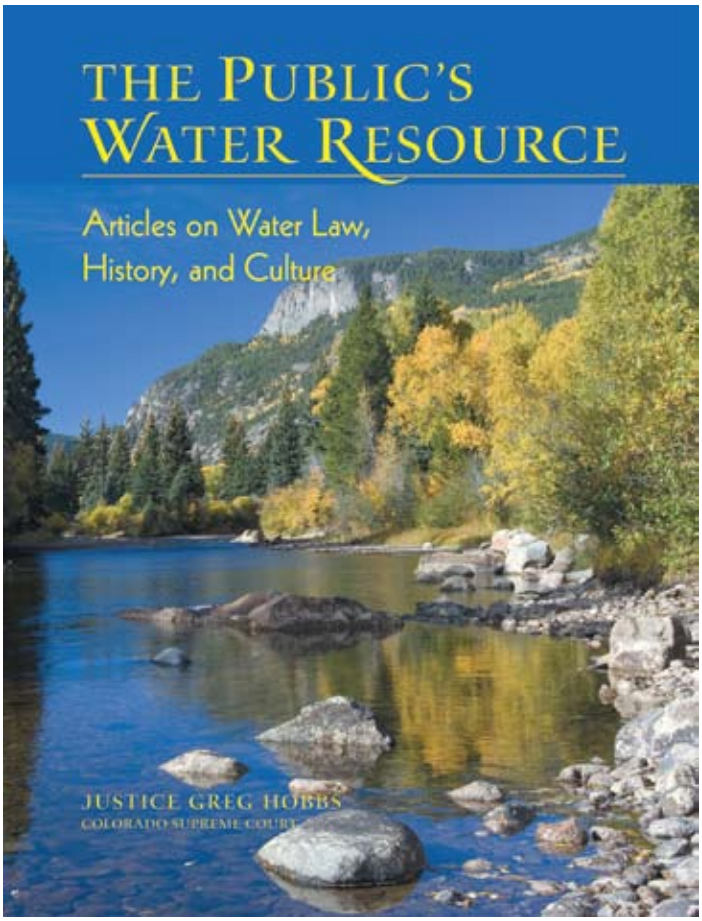
"Water will go where the people want it to go," writes Hobbs in the preface.

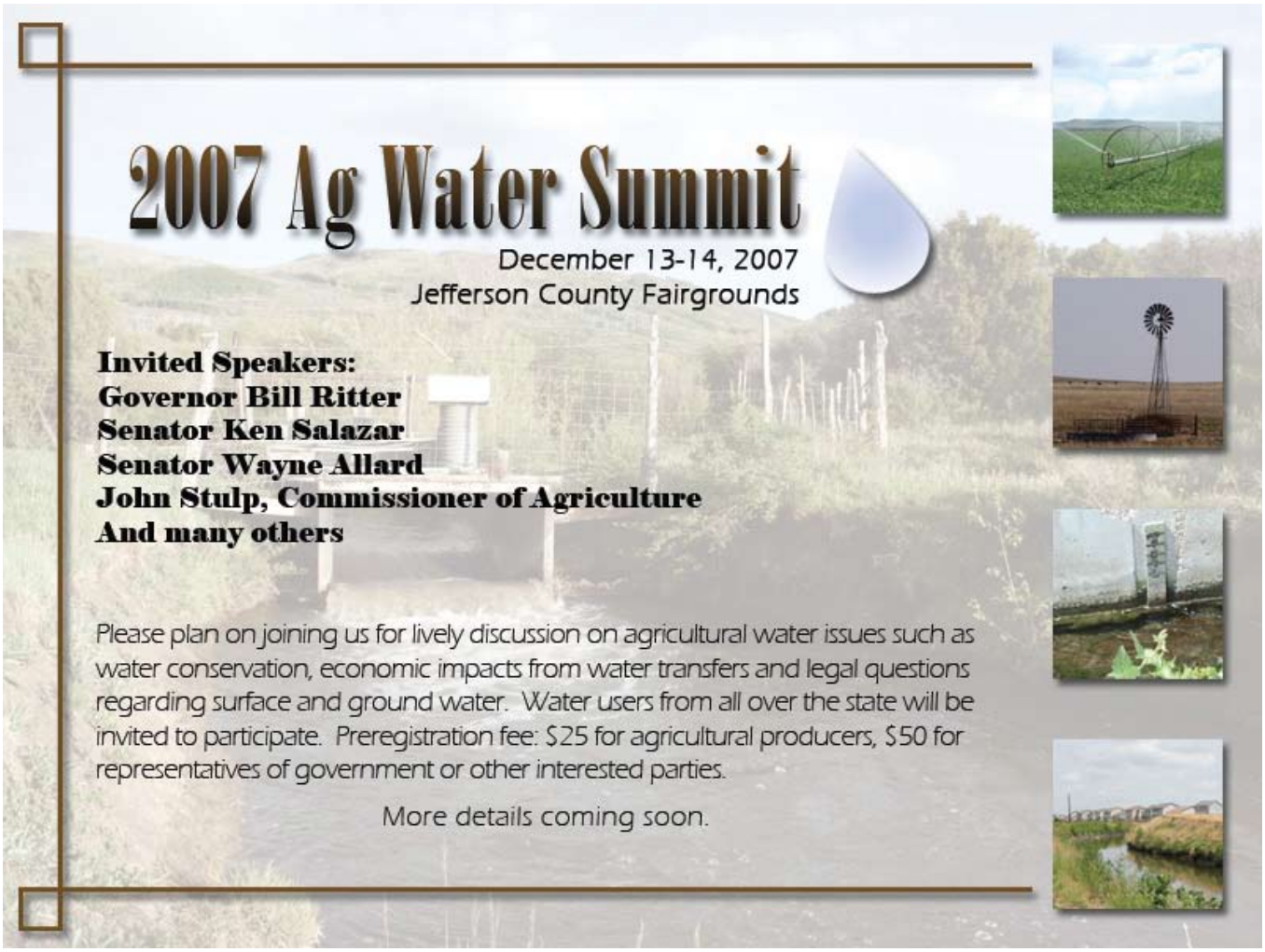
"Contemporary citizens value fish and wildlife, parks, recreation, walking paths along river corridors with live streams, and open space … Now it seems more than ever, we are not developing a water resource, we are learning how to share an already developed resource."

Hobbs, an accomplished poet, includes more than a dozen of his own poems about water in the publication. "The Public's Water Resource" also includes many of Hobbs' articles about such topics as the Colorado River, Colorado water law and water quality. A point/counterpoint section also includes a series of pieces by Hobbs and Professor Michael C. Blumm.

Hobbs is vice president of the Colorado Foundation for Water Education and co-convener of the western water judges' educational project, Dividing the Water. Before becoming a supreme court justice, he served as legal counsel for 17 years for the Northern Colorado Water Conservancy District.

The book is published by Continuing Legal Education in Colorado, Inc. cobar.org/cle





Colorado Water Resources and Power Development Authority Announces Open House

The Colorado Water Resources and Power Development Authority is holding an open house to celebrate the completion of our office renovation project. Please join us on Friday, December 7, 2007, from noon until 2:30 p.m. for a light lunch and a tour of the remodeled space.

The Authority is still located at:
1580 Logan Street, Suite 620
Denver, Colorado

The Authority Board of Directors will meet Friday morning at 9:00 a.m., and all are welcome to attend the meeting to learn more about the Authority and its programs. The Authority is a financing entity that was created in 1981 by the State of Colorado to assist communities in funding their water and wastewater infrastructure projects. To date the Authority has assisted communities in Colorado with over $1.5 billion in loans.

Mark the date on your calendars now and plan to visit with us for a light lunch and office tour.

If you are planning to attend please call us at:
303-830-1550, ext. 13

Ground Breaking Ground Water Conference Tackles Aquifer Recharge and Storage Policy Issues

by MaryLou Smith[1], Vice President, Aqua Engineering, Inc.

What do Maryland Blue Crabs in a bushel basket have in common with the Prior Appropriate Doctrine? 250 participants in a ground-breaking ground water conference in Colorado Springs got the answer to that riddle from Gary Barber. Barber is executive director of El Paso County Water Authority, recorder for the Arkansas Basin Roundtable, and the person who had the idea for the conference in the first place.

Aquifer Recharge and Storage Policy was the theme of the conference held September 27 and 28 at the Colorado Springs Doubletree Inn. Not the technology of aquifer recharge and storage, but the politics of it. The legal issues, the management issues. Issues about where to get the water to store in aquifers. How to be sure the entity taking it out is the one entitled to it, and how much they get to take out. What kind of water quality standards should be applied. Whether the state needs a regulatory framework to guide these and a thousand other decisions, or whether the law as it stands gives us plenty of guidance already.

Gary Barber visits with Peter Nichols

The Organizers

El Paso County Water Authority has a myriad of problems to solve regarding ground water. They received funds from the Arkansas Basin Roundtable to help them do two things:

1. Study the Upper Black Squirrel groundwater basin and its potential for aquifer recharge.

2. Put on a conference about aquifer recharge and storage policy to try to get some discussion going about what's holding up Colorado using aquifer storage and recharge as actively as some of our neighboring states.

Concurrently, Representative Amy Stephens introduced a successful house joint resolution calling for the findings of the conference to be sent to Harris Sherman, director of the Colorado Department of Natural Resources, for voluntary peer review by appropriate state level officials and the House/Senate joint water resources review committee.

The Arkansas Basin Roundtable is one of the nine roundtables formed as part of the legislature's Colorado Water for the 21st Century Act, commonly known as the HB1177 process or the IBCC/Roundtable Process. It is charged by the state legislature to convene a wide array of stakeholders in the basin to make decisions about how best to meet the water challenges faced by the basin. The legislature has made funds available for the roundtables to support processes and projects to help achieve that goal—subject to approval by the Colorado Water Conservation Board (CWCB.)

The Studies

Organizers staged this conference as a direct "next step" following two pertinent research studies:

- "Artificial Recharge of Ground Water in Colorado—A Statewide Assessment" conducted by Colorado Geological Survey as requested by Greg Walcher, then DNR director, 2004. This study assessed "the best aquifers in Colorado for their artificial recharge potential of ground water based primarily on their hydrogeological suitability."

- "SB06-193 Underground Water Storage Study—A Study of Potential Underground Water Storage Areas in the South Platte and Arkansas River Basins" conducted by Colorado Geological Survey for Colorado Water Conservation Board as directed by the state legislature. The study identifies sites hydrogeologically suited for aquifer recharge in those basins, but closes by saying "The lack of rules and regulations regarding withdrawal of stored water from alluvial aquifers has the potential to present a serious challenge to implementing underground water storage projects outside the Denver Basin, which has rules regarding underground water storage. It is recommended that the State Legislature, in conjunction with the Colorado Division of Water Resources and interested parties, enter a dialog on this issue with the hope of developing a regulatory framework that encourages underground water storage in all areas of the State.

[1]*MaryLou Smith was hired by El Paso County Water Authority to design and facilitate this conference in conjunction with the American Ground Water Trust.*

During his presentation, Ralf Topper, one of the authors of both these studies stated that he thinks the conference "will be looked upon in the future as a turning point for aquifer recharge and storage in Colorado."

The Participants

In order to achieve the high expectations for this conference, organizers sought to draw a wide range of participants not just to sit and listen to a slate of speakers, but to actively engage in dialogue. They gained endorsement, sponsorship and participation from members of more than 20 associations, organizations, agencies and businesses, the diversity of which spans from Colorado Water Congress to Trout Unlimited, University of Colorado's Natural Resources Law Center to Colorado Water Well Contractors Association, from Brown and Caldwell to Northern Colorado Water Conservancy District. (Financial sponsors include El Paso County Water Authority, Brown and Caldwell, Aqua Engineering, Colorado Springs Utilities, Western Resource Advocates, R.W. Beck, and Northern Colorado Water Conservancy District.)

So who came? Who participated in the dialogue? Here's a sampling that shows the diversity:

Robert Sakata, Brighton farmer
Sara Duncan, Denver Water Board
Manuel Montoya, Farmers' Reservoir and Irrigation Company
Jim Miller, Colorado Department of Agriculture
SeEtta Moss, Arkansas Valley Audubon Society
Bob Longenbaugh, Consulting engineer
Peter Nichols, water attorney with Trout, Raley, Montano, Witwer & Freeman
Mike Stiehl, Fremont County Commissioner
Chris Treese, Colorado River Water Conservation District
Mark Sponsler, Colorado Corn Growers
Steve Witte, State Engineer's Office
Chris Woodka, Pueblo Chieftain
Bea Crandal, Protect Our Wells

The Presenters

Providing legal history, scientific fact, and experiential accounts was a critical requirement for this conference. Once again, organizers drew broadly and deeply. In addition to Greg Hobbs, Colorado Supreme Court Justice and Harris Sherman, director of the Colorado Department of Natural Resources, presenters included Fred Anderson, who served as president of the Colorado Senate during the years formative ground water legislation was passed. Other presenters:

- Policy makers and practioners from California, Idaho and Arizona and a representative from the EPA.
- Academicians Deanna Durnford from Colorado State University and Denise Fort from University of New Mexico.
- Water attorneys Michael Shimmin, Steve Simms, Melinda Kassen, David Robbins, and Sandy MacDougall.
- On the ground water managers and decision makers in Colorado such as Joe Frank, Lower South Platte Water Conservancy District; Steven Vandiver, Rio Grande Water Conservancy District; John Hendrick, Centennial Water and Sanitation; Gary Thompson, Widefield Channel Recharge Project, Kathy Hare, Upper Black Squirrel Ground Water Management District and Don Shawcroft, Colorado Farm Bureau and Colorado Ag Water Alliance.
- Researchers such as Ralf Topper from Colorado Geological Survey and Tim Gates from Colorado State University.
- Engineering consultants from CDM, Leonard Rice, R.W. Beck, and Stewart Environmental

The Presentations

Harris Sherman kicked things off by relating a conversation he had with then state engineer Hal Simpson on Sherman's first week back at the job as DNR director.

Sherman: "Hal, what keeps you awake at night?"
Simpson: "Groundwater, groundwater, groundwater"

Senator Fred Anderson discusses the history of the 1969 Act

Colorado Water Congress Executive Director Doug Kemper and his panel of water attorneys

"Now, I have inherited that insomnia," Sherman told the audience. He went further to say that how to broaden utilization of groundwater uses without harming senior appropriators "is a chapter yet unwritten." A tangible possibility Sherman raised is that of the state helping communities fund opportunities for recharge, through both CWCB construction funds and the IBCC Water Supply Reserve Account.

Orange County (California) Water District's groundwater replenishment system provides water to 2.5 million people, according to Craig Miller, and they do it while leaving plenty of water in the ground. He pointed to a $1.5 billion savings provided by the system's natural filtration over traditional filtration.

Fred Anderson ruminated on what the atmosphere was like in the state capital 50 years ago when major groundwater bills were passed there in 1965 and 1969. He said there was more cross-pollination between the three branches of government then, which allowed for more flexibility to solve problems. He said when the justices asked the legislature to recodify water law to allow for conjunctive use of groundwater with surface water, they were clear in saying "but don't kill the well users—the state can't afford the economy we would lose." Anderson stated that we store 10.5 MAF of water under the South Platte and then asked, "Why can't we take out 1 MAF of that each year and put it to good use?"

Colorado Supreme Court Justice Greg Hobbs gave his traditional rundown on Colorado Water Law, pausing heavy on the ground water chapters, and reminding participants that Colorado water is owned by the people of Colorado. Only the right to appropriate the water for beneficial use is a private property right.

Alexander Davis, DNR assistant director for Water gave a brief summary of the work of Governor Ritter's South Platte Wells Task Force. She cited two bills that are likely to come out of the work of the task force, and an effort to streamline water court which is being headed up by Rebecca Love Kourlis. Was the task force successful? From the point of view of opening dialogue and educating, it can be seen as a success, she said.

Karl Dreher, now with Brown and Caldwell, earlier director of Idaho's Department of Water Resources, talked about the Idaho high tech manufacturer Micron Technology and how they recharged very junior unappropriated water from spring runoff on the Boise River into injection wells to provide exceptionally high quality water to manufacture memory devices.

Melinda Kassen of Trout Unlimited reminded participants that "big dams create barriers to fish. Storing water underground does not." She discussed further the potential for environmental enhancement through groundwater recharge, but cautioned that water quality issues must be carefully monitored.

"Who owns an aquifer?" asked Sandy MacDougal. I may own the beds and the banks of a stream on my land, he

said, but the state owns the water in that stream. If the state owns the water that fills the space under my land, do I own the space itself?

Gary Thompson introduced participants to the successful Widefield Channel Recharge Project beneath Fountain Creek in the Arkansas Basin. The project provides a sustainable and renewable supply of groundwater for municipal and irrigation use. Thompson relayed the history of the project going back to 1975 when well users were embroiled in conflict over shortages related to location and timing. He said that a combination of good modeling and an attitude of "enlightened self interest" lead to a successful resolution of the conflicts and a smoothly functioning project today.

Challenges overcome and remaining were addressed by managers of two different water districts in two different areas of the state. Joe Frank from Lower South Platte Water Conservancy District presented "The Good, the Bad, and the Ugly of Managed Recharge—Lower South Platte Alluvium." From the other end of the state, Steve Vandiver from Rio Grande Water Conservation District showed a dramatic slide of the San Luis Valley in which the wells in a relatively small area are so dense that all the dots representing the wells blurred together in a solid mass.

Kathy Hare, president of the Upper Black Squirrel Ground Water Management District had a stark set of slides to present as well. She started off by asserting that her district is in dire need of recharge but hasn't the financial or technical resources required. She cited a 1999 state engineer's report that said, "Based on the current decline in alluvial saturated thickness, the useful life of the aquifer is estimated to be 41.71 years. However if the proposed municipal use of 7300 acre-feet annually is realized, this useful life will decrease dramatically."

Assistant state engineer Dick Wolfe cautioned participants that "as more surface water is used, there will be less available for recharge opportunities."

Asked to speak about aquifer recharge and implications for Colorado's interstate compacts, David Robbins asserted that not one of the nine compacts Colorado has with neighboring states mentions ground water. However, he said, all those compacts definitely affect what we can do in terms of using our ground water. He brought up the problem of putting water away when you don't need it yet, when people who do need it now are being turned away.

Mike Shimmin reminded participants that aquifers do not just store water, they conduct water, too. And most aquifers do both continuously. He said "unconfined aquifers are plentiful, but the water is not going to stay put. Alluvial aquifers do not provide secure storage." Therefore, he said, it is best to recharge only in aquifers where not much movement is happening—unless you can impound the water somehow.

Steve Sims agreed with Shimmins assessment, and followed up by pointing out that Aurora is planning to do just that in its Prairie Waters Project.. They propose to build a liner for containment of the groundwater and at the same time deal with the question "how do you maintain dominion and control?" Water quality is a primary goal of the project, which will include 200 acres of sand infiltration basins.

Colorado State University professor Tim Gates discussed "Too Much of a Good Thing—Possible Perils of Excess Recharge in Alluvial Aquifers" and demonstrated that in some areas of the lower Arkansas basin, rising water tables are contributing to actual loss of water as it comes to the surface and evaporates. Salinity is, of course, a significant problem in these areas.

The Dialogue

Participants asked a number of highly targeted questions of presenters, which lead to rich dialogue on a number of points. However, one subject of dialogue of particular note is that of whether we need new legislation.

- Do we need new legislation regarding aquifer recharge or are the statutes we currently have doing the job?

Denise Fort, from University of New Mexico's School of Law and currently serving as a member of the National Academy of Sciences Committee on "Sustainable Underground Storage of Recoverable Water" had this to say: "States need to enact statutory systems for aquifer recharge and recovery so that we don't have such high transaction (legal) costs." She said that states need to provide a "path through the process."

Colorado Geological Survey researcher Ralf Topper called for the "preparation and promulgation of a legal framework for aquifer recharge and storage statewide." He said that rules currently exist only for the non-designated portions of the Denver Basin and for augmentation plans, and that there is uncertainty regarding legal status and disposition of recharged water. Furthermore, he stated that "existing water laws are inapplicable or biased with respect to recharging groundwater."

On the other hand, water attorney Mike Shimmin said that we don't need any new law for aquifer recharge. He said the law is not the source of the problem, the facts are. "How do you implement legal concepts in the real world?" he asked. He answered the question by asserting that the water court system is our mechanism for implementing those concepts. Shimmin contends that the water court provides all the assistance needed, and that the eight "elements of proof to acquire an underground right" handed down by Colorado's Supreme Count in the Park County Sportsmen's Ranch case gives us plenty of direction.

Eight "elements of proof to acquire an underground right" handed down by Colorado's Supreme Count in the Park County Sportsmen's Ranch case:

1. Must capture, possess, and control the water it intends to put into the aquifer;
2. Must not injure other water use rights, either surface or underground, by appropriating the water for recharge;
3. Must not injure water use rights, either surface or underground, as a result of recharging the aquifer and storing water in it;
4. Must show that the aquifer is capable of accommodating the stored water without injuring other water use rights;
5. Must show that the storage will not tortiously interfere with overlying landowners' use and enjoyment of their property;
6. Must not physically invade the property of another by activities such as directional drilling, or occupancy by recharge structures or extraction wells, without proceeding under the procedures for eminent domain;
7. Must have the intent and ability to recapture and use the stored water; and
8. Must have an accurate means for measuring and accounting for the water stored and extracted from storage in the aquifer.

The Legislative Panel

In keeping with the intent of raising issues and promoting potential solutions regarding aquifer recharge and storage policy, organizers invited a number of legislators to participate in a panel moderated by Jim Broderick from Southeastern Colorado Water Conservancy District. As Representative Kathleen Curry pointed out, all panel members were from the House and all are members of the House Ag Committee which she chairs. In his typical "Phil Donahue style" Broderick warmed up the panel by asking their views on education about groundwater. "This conference has been an excellent example of that!" responded Representative Mary Hodge, the only legislator to attend the entire conference from start to end.

The discussion moved to the question of how legislators could become more collaborative, to come up with better solutions. Representative Curry stated that "legislators need to be given authority to be more collaborative." Committees are a good place to start, she said. She promised to do even more as chairman of the House Ag Committee to create an environment where legislators come to the table ready to work instead of coming with their positions already formed and hoping for a rubber stamp. Representative Marsha Looper praised Curry for her leadership in that direction.

When asked if they could support funding for a statewide aquifer recharge project, most of the legislators answered yes. However, Representative Curry cautioned against the strings that could be attached for a given basin if such a project came about through state funding.

A Panel of Colorado House Representatives discusses compromise and collaboration

When asked by former Colorado secretary of agriculture Don Ament whether they would be willing to give the state engineer more authority/flexibility to put water to beneficial use (but with a number of carefully calculated restrictions in place such as reliance on DSS—decision support systems) Representatives Cory Gardner and Frank McNulty gave a cautiously qualified yes—"if private property rights are respected."

Not having been present for the first day's dialogue in regard to the need for more legislation, Representative Curry asked if the conference had resulted in consensus that we need new law regarding aquifer recharge. The answer is "No." said Eric Hecox, who closed the conference by summarizing the two days. He pointed out that though the conference fostered a healthy dialogue on the subject, some believe that the law is working just fine—"it all comes out in water court"—while some believe transaction costs are too high—"we are spending too much money on water attorneys." Some think we have a good system in place, and that we just have to look at each project on a case-by-case basis. Others think looking at things on a "case by case" basis is too expensive, and holds things up.

The Conclusion

Did the conference meet expectations? What will the draft report submitted to Harris Sherman say?

Hecox, who is the manager of the Interbasin Compact Process for the Department of Natural Resources cited the conference as a very successful example of what the Colorado Water for the 21st Century Act—the IBCC/Roundtables process—is trying to accomplish. He said the stage is set for the roundtables to move into actively tackling the difficult issues. He is hopeful the process will continue to foster dialogue, and reduce the historical tendency for lining up with our respective positions. He said the conference in its design and implementation was effective in that it allowed for active dialogue, not just a series of presentations by experts.

Reminding participants that the next step is for conference organizers to work with the Arkansas Basin Roundtable to present a draft report to Harris Sherman, Hecox asked all participants to consider forwarding to him any comments they had for inclusion in the report.

So back to that bushel of Maryland Blue Crabs. What do they have in common with the Prior Appropriation Doctrine? Gary Barber had the crowd listening intently for that answer as he showed a graphic that asserted that perhaps we need to move beyond the concept of winners and losers. And that maybe we need to move, even, beyond the probably unreachable ideal of both sides coming out winners. (That, he said, requires that you make a bigger pie, something that he doesn't see happening with Colorado water.) Maybe, he said, we need to aim for a status which he called "not losing."

He told the story of catching a bushel of Maryland Blue Crabs and being puzzled, while he was waiting for the pot of water to boil in which they would be cooked, that they were not jumping out of the basket. "Don't we need to put a lid on the basket?" he asked his father-in-law. Turns out that the crabs have a habit of reaching out and grabbing hold of one another which prevents any of them from jumping out of the basket. They have a protective instinct to oppose everything that invades their domain. The result is that they all end up in hot water.

Barber warned that Coloradoans may be in a similar fix. While prior appropriation has worked brilliantly for more than a hundred years, it does rely on an adversarial process. Do we have the courage and the vision to change it to allow us to cooperate and save ourselves from the boiling water?

At the interactive lunch session, in which participants at each table were asked to discuss a series of questions and come up with observations of their own, one group came up with a simple but possibly very useful idea.

They suggested that a water court category be created for a "statement of interest" in new applications, that would allow interested parties to receive all information in the case without having to file as an "objector." Why automatically set up an adversarial atmosphere when many "objectors" are simple registering in order to be kept informed of the proceedings?

Perhaps this and the one or two hundred other suggestions written on the cards during this small group exercise will play an important part in moving Colorado forward in the arena of aquifer recharge and storage.

As Betty Konarski, president of El Paso County Water Authority said as she wished everyone a safe journey home, we must now act. The "highest and best use of the water resources of Colorado" depends on it.

MEETING BRIEFS

Colorado Water Congress Summer Convention

Members of the Colorado Legislature address the Colorado Water Congress

The Colorado Water Congress held its 2007 summer convention at the Sheraton Conference Center in Steamboat Springs, Colorado on August 22- 24 with the theme of "Climate Change and Water Policy." The conference was opened by Steamboat local, Senator Jack Taylor, who discussed the impact of extensive oil and gas drilling and population growth in Western Colorado, with the possibility of oil shale development and the concomitant water needs lurking in the near future.

Denver Water Manager, Chips Barry moderated first session on Western Water Policy in response to climate change. He stated that the Earth is warming, but posed two questions: what is happened to precipitation and how do we make our water system more robust so that we can adapt to these warming trends? Shaun McGrath of the Western Governors Association suggested that waiting for US Congress to decide what we do about climate change mitigation and adaptation may not be wise. Shawn called for relevant research that can help operations, water supply measurement and predictions. He noted the perception that much of the scientific research is not relevant to water managers' needs. David Behar of the San Francisco Public Utilities Commission outlined their expectation that the snowline will move upwards 500 feet per 25 years due to warming, resulting in 24% decrease in snowpack by 2050. He stated that as peak runoff moves up by a month or more it will reduce system resiliency in dry years. Interestingly, San Francisco's greatest concerns relative to climate change

Steve Fearn and Doug Kemper talk with University of Colorado Researchers Brad Udall and Kenneth Strzepek

is the prospect of stormwater and wastewater systems being inundated as sea levels rise. He stated that water managers are in many ways the "First Responders" to climate change. Water system will suffer first, and may suffer worst.

Paul Fleming of the Seattle Public Utilities made the point in his talk that the financial sector is actively studying issue of climate change and how they should invest in a carbon constrained economy. Paul stated that Seattle has decoupled population growth from water demand by conservation and other savings mechanisms—price, leakage, plumbing code, operational improvements. He also mentioned related research needs, including: water quality, forest management, species conservation, new system design standards.

Dick MacRavey and John Porter catch-up with Senator Salazar

Other speakers included Chris Landry, Center for Snow and Avalanche Studies, who spoke on the impact of dust on snowmelt. Heidi VanGenderen, from the Governor's Office of Policy and Initiatives, who discussed the recent outcomes of the Climate action Panel. Eric Kuhn, Colorado River Conservation District, addressed the need for leadership for addressing climate change and reflected on the recent failure of leadership on the issue of ground and surface water interaction. Eric noted his expectation that the SB122 Colorado River Availability Study will include climate change impacts. Others included Marc Waage, Denver Water, Joel Smith, Stratus Consulting, Mark Pifher, Aurora and a number of other informative speakers. Highlights of the conference were addresses by Senator Ken Salazar, and Representative Mark Udall, who provided their perspectives on Colorado water in the context of global and national issues.

The CWC annual winter meeting will be held in Denver on January 24 and 25, 2008. Colorado State University will host a one day water science symposium on January 24th in conjunction with the annual meeting.

John Fetcher and Jim Hokit share a laugh

State Engineer's Office Forum

Presented by the Applegate Group, Inc. and the Colorado Division of Water Resources

Staff from the Colorado Division of Water Resources, Colorado Water Conservation Board and the Colorado Attorney General's Office will provide an update on the administration of the Republican River Compact compliance and potential Colorado River Compact call compliance impacts to the East Slope, discuss changes in farming efficiencies and effects in Division 2, provide a summary of the South Platte River Task Force recommendations, discuss pending policies and written orders and instructions of the State Engineer, impacts of recent Supreme Court decisions, provide information concerning new dam safety rules and regulations, review tools used by the State Engineer's Office staff in water right evaluations, and an update on the status of the South Platte River Decision Support System. This forum will provide consultants, attorneys and other interested parties with an opportunity to become more informed regarding the issues mentioned above. There will also be an opportunity to ask questions and provide comments on each of these areas of discussion. Handouts will be available for the presentations and refreshments will be provided.

8:30am - 12:30pm on Wednesday, October 31, 2007

Hunter Education Building

6060 Broadway

Denver, Colorado

Please RSVP via email to **trishabbey@applegategroup.com** by noon October 24, 2007.

A RIVER OF CHANGE

The 18th Annual South Platte Forum

October 24-25, 2007—Radisson Conference Center—Longmont, Colorado

A Change of Pace—*projects*
Peter Binney, City of Aurora
Alan Berryman, Northern Colorado Water Conservancy District
Carl Brouwer, Northern Colorado Water Conservancy District
Lisa McVickers, P.C.

An Inconvenient Climate
Brad Udall, CU-NOAA Western Water Assessment
Greg McCabe, U.S. Geological Survey
Marc Waage **and** Bob Steger, Denver Water
David Clow, U.S. Geological Survey

Changing Faces
Harris Sherman, Department of Natural Resources
John Stulp, Department of Agriculture

Changing Hearts and Minds—*education*
Don Glaser, Colorado Foundation for Water Education
Curry Rosato, Keep It Clean Partnership
Brent Mecham, Northern Colorado Water Conservancy District

Fields of Change
James Pritchett , Colorado State University
Frank Jaeger, Parker Water and Sanitation District
Neil Hansen, Colorado State University

Change Your Ways—*regulations*
Patti Tyler, U.S. Environmental Protection Agency
Amy Woodis, Metro Wastewater Reclamation District
Gabe Racz, Trout, Raley, Montano, Witwer & Freeman P.C.

Modeling the Change
Suzanne Paschke, U.S. Geological Survey
Chris Goemans, Western Water Assessment
Ray Alvarado, Colorado Water Conservation Board

Call for Posters

You are invited to submit a one-page abstract to the organizing committee by Aug. 1, 2007. Selected posters will be displayed throughout the forum with a staffed poster session from 4:45–6:00 p.m., Wed., Oct. 24. Authors will be notified of acceptance by Sept. 1. Send your abstract to Jennifer Brown, Jennifer@jjbrown.com.

REGISTRATION FEES

Registration fees include meals, breaks and reception.

Early Registration - by Oct. 1.....$100
Registration after Oct. 1.....$115

Register at www.southplatteforum.org.

FOR MORE INFORMATION

Visit www.southplatteforum.org to see schedule updates, register and get more information.
Or contact Jennifer Brown, (402) 960-3670, Jennifer@jjbrown.com

Sponsored By

Northern Colorado Water Conservancy District
Colorado Water Resources Research Institute
Metro Wastewater Reclamation District
CSU Cooperative Extension
Parker Water and Sanitation District
U.S. Fish and Wildlife Service
City of Aurora
Colorado Division of Wildlife
Denver Water
U.S. Geological Survey
U.S. Bureau of Reclamation

WWW.SOUTHPLATTEFORUM.ORG

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Research Awards

Colorado State University, Fort Collins, Colorado
Awards for July 2007 to September 2007

Bestgen,Kevin R, Fish, Wildlife, and Conservation Biology-Bureau of Reclamation - Annual YOY Colorado Pikeminnow Fall Monitoring (Project No. 138), **$15,438**.

Bestgen,Kevin R, Fish, Wildlife, and Conservation Biology-Bureau of Reclamation - Interagency Standardized Monitoring Program Assessment of Endangered Fish Reproduction in Relation to Flaming, **$71,027**.

Bestgen,Kevin R, Fish, Wildlife, and Conservation Biology-Colorado Division of Wildlife - Eastern Plains Native Fish Investigations , **$18,100**.

Bledsoe,Brian S, Civil Engineering- CA Coastal Water Research Project - Development of Tools for Hydromodification Assessment and Management, **$449,100**.

Brozka,Robert J, Center for Environmental Management of Military Lands (CEMML)-USDA - USFS - Rocky Mtn. Rsrch Station - CO - Mitigation Wetland Monitoring and Clean Water Act Section 404 Support for Fort Drum, New York, **$30,370**.

Clements,William H, Fish, Wildlife, and Conservation Biology-National Park Service - Integration Water Quality, Habitat, & Benthic Macroinvertebrate Data Access Ecological Integrity of Streams Yellowst, **$21,362**.

Collett,Jeffrey L, Atmospheric Science-National Park Service - Airborne Nitrogen Concentrations and Deposition in Rocky Mountain National Park, **$449,644**.

Cooper,David Jonathan, Forest, Rangeland, and Watershed Stewardship-National Park Service - Assist Determine & Prioritize Wetland Restoration Projects in Kawunechee Valley, **$3,000**.

Cooper,David Jonathan, Forest, Rangeland, and Watershed Stewardship-National Park Service - Developing Concepts for Stream Channel & Floodplain Restoration at Canyon de Chelly Monument, Arizona, **$96,724**.

Cooper,David Jonathan, Forest, Rangeland,and Watershed Stewardship-National Park Service - Developing Wetland Restoration Plan , **$74,267**.

Cooper,David Jonathan, Forest, Rangeland, and Watershed Stewardship-National Park Service - Remove Artificial Levee & Connect Glorieta Creek to Recently Restored Floodplain, **$8,740**.

Cooper,David Jonathan, Forest, Rangeland, and Watershed Stewardship-National Park Service - The Role of Herbivory & Hydrologic Condition in Cottonwood Establishment: Determining Barriers Establishment & Persist, **$8,000**.

Cooper,David Jonathan, Forest, Rangeland, and Watershed Stewardship-USDA - USFS - Forest Research - Quantification of Water Needs of Riparian & Wetland Vegetation: US Forest Service General Technical Report, **$30,000**.

Deo,Shripad D, Cooperative Institute for Research in the Atmosphere-Natl Oceanic & Atmospheric Admn - Advanced Hydrologic Prediction Service , **$4,037**.

Doesken,Nolan J, Atmospheric Science-Bureau of Reclamation - Walking Through The Water Year , **$30,720**.

Doherty,Paul F, Fish, Wildlife, and Conservation Biology-Colorado Division of Wildlife - South Platte Duck Study , **$58,742**.

Douglas,Marlis R, Fish, Wildlife and Conservation Biology-New Mexico Department of Game and Fish - Introgression in Rio Grande Cutthroat Trout From New Mexico Hatchery Broodstocks, **$11,900**.

Egenhoff,Sven Olaf, Geosciences-Nance Petroleum Corporation - Fracture Occurence, Mechanical Stratigraphy & Reservoir Architecture in the Middle Bakken Member of the Willisto ?, **$23,000**.

Fausch,Kurt D, Fish, Wildlife, and Conservation Biology-Bureau of Land Management - A Field Test of Effects of Grazing Management Systems on Invertebrate Prey that Support Trout Populations in Central, **$10,000**.

Fausch,Kurt D, Fish, Wildlife, and Conservation Biology-Bureau of Land Management - A Field Test of Effects of Grazing Management Systems on Invertebrate Prey that Support Trout Populations in Central, **$5,000**.

Garcia,Luis, Civil Engineering-USDA - ARS - Agricultural Research Service - GeoLem Caching and Multithreading Development , **$50,000**.

Gates,Timothy K, Civil Engineering-Colorado Dept Public Health & Environ - Assessing Irrigation - Induced Selenium and Iron in the Stream - Aquifer System of the Lower Arkansas River Basin, CO, **$100,000**.

Hawkins,John A, Fish, Wildlife, and Conservation Biology-Bureau of Reclamation - Yampa Diversion Entrainment (Project No. 146) , **$14,000**.

Hawkins,John A, Fish, Wildlife, and Conservation Biology-Bureau of Reclamation - Yampa River Nonnative Fish Control: Translocation of Northern Pike from the Yampa River, **$22,065**.

Jacobi,William R, Bioagriculural Science & Pest Management-Denver Water Department - Water Usage by Cottonwood Trees , **$12,250**.

Johnson,Brett Michael, Fish, Wildlife, and Conservation Biology-Bureau of Reclamation - Chemically Fingerprinting Nonnative Fishes in Reservoirs (Project No. C18/19), **$42,821**.

Johnson,Brett Michael, Fish, Wildlife, and Conservation Biology-Colorado Division of Wildlife - Management of Mercury Bioaccumulation in Colorado Reservoirs, **$188,500**.

RESEARCH AWARDS

Julien,Pierre Y, Civil Engineering-USDA - USFS - Rocky Mtn. Rsrch Station - CO - Hydraulic Feometry and Sediment Transport of the Rio Grande, **$35,000**.

Liston,Glen E, Cooperative Institute for Research in the Atmosphere-Natl Oceanic & Atmospheric Admn - A High - Resolution Meteorological Distribution Model for Atmospheric, Hydrologic, and Ecologic Applications, **$21,000**.

Liston,Glen E, Cooperative Institute for Research in the Atmosphere-NSF-National Science Foundation - Collaborative Research: Norwegian - United States IPY Scientific Traverse: Climate Variability and Glaciology in East..., **$89,202**.

MacDonald,Lee H, Forest, Rangeland, and Watershed Stewardship-USDA - USFS - Rocky Mtn. Rsrch Station - CO - Evaluating & Predicting Postfire Logging Effects on Erosion, **$53,281**.

Myrick,Christopher A, Fish, Wildlife, and Conservation Biology-USFWS - Fish & Wildlife Service - A Pilot Project Testing the Use of Copper and Copper - Based Compounds to Prevent the Upstream Movement of New Zeal..., **$43,767**.

Ojima,Dennis, Natural Resource Ecology Lab-USGS-Geological Survey - Western Mountain Initiative: Response of Western Mountain Ecosystems to Climatic Variability and Change, **$4,522**.

Pruden - Bagchi,Amy, Civil Engineering-NSF-National Science Foundation - CAREER: Antibiotic Resistance Genes (ARG) as Emerging Pollutants in Our Water: Pathways, Mitigation, and Treatment, **$104,935**.

Qian,Yaling, Horticulture and Landscape Architecture-Bureau of Reclamation - Assessment of Inland Saltgrass Plant Performance , **$10,000**.

Ramirez,Jorge A, Civil Engineering-DOD - ARMY - ARO - Army Research Office - Quantifying the complex hydrologic response of an ephemeral desert wash, **$32,573**.

Ramirez,Jorge A, Civil Engineering-USDA - USFS - Rocky Mtn. Rsrch Station - CO - Vulnerability of the United States Water Supply System to Shortage, **$35,000**.

Rocchio,Joseph F, Fish, Wildlife, and Conservation Biology-Colorado Division of Wildlife - CDOW Cash Match for EPA Project: Ecological Integrity Scorecard Blue River Watershed, **$10,833**.

Roesner,Larry A, Civil Engineering-EPA -Environmental Protection Agency - SWMM Runoff Manual , **$25,000**.

Roesner,Larry A, Civil Engineering-Water Environment Research Foundation - Linking Stormwater BMP Systems Performance to Receiving Water Protection to Improve BMP Selection and Design, **$162,074**.

Salas,Jose D, Civil Engineering-Bureau of Reclamation - Generating Stochastic Flows for the Truckee River System, **$15,000**.

Sengupta,Manajit, Cooperative Institute for Research in the Atmosphre-Natl Oceanic & Atmospheric Admn - Analysis of Simulated Radiance Fields for GOES - R ABI Bands for Mesoscale Weather and Hazard Events., **$70,000**.

USGS science for a changing world — Recent Publications

Methods for Adjusting U.S. Geological Survey Rural Regression Peak Discharges in an Urban Setting, by G.E. Moglen, and D.E. Shivers, U.S. Geological Survey Scientific Investigations Report 2006-5270, http://pubs.usgs.gov/sir/2006/5270/

Characterization of Stormflows and Wastewater Treatment-Plant Effluent Discharges on Water Quality, Suspended Sediment, and Stream Morphology for Fountain and Monument Creek Watersheds, Colorado, 1981-2006, by D.P. Mau, R.W. Stogner, Sr., and P. Edelmann, U.S. Geological Survey Scientific Investigations Report 2007-5104, http://pubs.usgs.gov/sir/2007/5014/

Selenium and Other Elements in Water and Adjacent Rock and Sediment of Toll Gate Creek, Aurora, Arapahoe County, Colorado, December 2003 through March 2004, by J.R. Herring, and K. Walton-Day, U.S. Geological Survey Scientific Investigations Report 2007-5018, http://pubs.usgs.gov/sir/2007/5018/

Field Reconnaissance of Debris Flows Triggered by a July 21, 2007, Thunderstorm in Alpine, Colorado, and Vicinity, by J.A. Coe, J.W. Godt, T.C. Wait, and J.W. Kean, U.S. Geological Survey Open-File Report 2007-1237, http://pubs.usgs.gov/of/2007/1237/

From the River to You: USGS Real-Time Streamflow Information…from the National Streamflow Information Program, by J.P. Nielsen, J.M. Norris, U.S. Geological Survey Fact Sheet 2007-3043, http://pubs.usgs.gov/fs/2007/3043/

A simulation-based approach for estimating premining water quality: Red Mountain Creek, Colorado, by R.L. Runkel, B.A. Kimball, K. Walton-Day, and P.L. Verplank, 2007, Applied Geochemistry, 22(9):1899-1918, http://dx.doi.org/10.1016/j.apgeochem.2007.03.054

Selected Field Parameters from Streams and Analytical Data from Water and Macroinvertebrate Samples, Central Colorado Assessment Project, Environmental Assessment Task, 2004 and 2005, by D.L. Fey, S.E. Church, T.S. Schmidt, R.B. Wanty, P.L. Verplank, P.J. Lamothe, M. Adams, and M.W. Anthony, U.S. Geological Survey Open-File Report 2007-1044, pubs.usgs.gov/of/2007/1044/

U.S. Geological Survey Colorado Water Science Center: http://co.water.usgs.gov

Swift,David M, Natural Resource Ecology Lab-National Park Service - Investigation of National Nitrogen Deposition Loch Valley, **$15,069**.

Theobald,David M, Human Dimensions of Natural Resources-USDA - USFS - Rocky Mtn. Rsrch Station - CO - Fire & Water in Colorado: Resource Trends & Interactions in a Changing Landscape, **$108,000**.

Theobald,David M, Human Dimensions of Natural Resources-National Park Service - Assessment of Natural Resources and Watershed Conditions for Rocky Mountain National Park and Florrisant Fossil B..., **$130,000**.

Thornton,Christopher I, Civil Engineering-Ayres Associates - NCHRP Project 24 - 26: Effects of Debris on Bridge - Pier Scour, **$26,010**.

Thornton,Christopher I, Civil Engineering-USDA -USFS - Rocky Mtn. Rsrch Station - CO - Hydraulic Modeling of Stabilization Techniques 02 - JV11221602 - 145, **$65,000**.

Valliant,James C, Arkansas Valley Research Center-Lower AR Valley Water Conservancy Dist. - The Effect on Corn Yield, Nutrient Needs and Economics when Fallowing Land in the Arkansas River Valley, **$8,529**.

Waskom,Reagan M, Colorado Water Resources Research Institute-USGS - Geological Survey - OMS Internship - USGS - WRRI Student Internship , **$20,000**.

Waskom,Reagan M, Colorado Water Resources Research Institute-USDA - CSREES - Coop State Rsrch Edu & Ext - Coordinated Agricultural Water Quality Programming for the Northern Plains and Mountains Region, **$587,000**.

Wickramasinghe,Sumith Ranil, NSF - National Science Foundation - REU SUPPLEMENT: New Generation Responsive Membranes for Water Treatment, **$12,000**.

Wickramasinghe,Sumith Ranil, Chemical Engineering-University of Colorado - Assessment of Membrane Adsorber for Removal of Residual Trace Impurities, **$32,500**.

Winkelman,Dana, Colorado Division of Wildlife - Aquatic Studies: Water Pollution & Native Plains Fishes, **$18,000**.

Winkelman,Dana, Colorado Division of Wildlife - Evaluation & Control of Whirling Disease in the White River, CO, **$90,000**.

Wohl,Ellen E, Geosciences-USDA -USFS-Rocky Mtn. Rsrch Station - CO - National Riparian Protocol Development , **$27,500**.

Young,Peter, Electrical and Computer Engineering-Solix Biofuels, Inc. - System Analysis and Controller Synthesis for Photobioreactor Algal Growth, **$81,687**.

Zeidler,James A, USDA - USFS - Rocky Mtn. Rsrch Station - CO - Aquatic/Fisheries Technical Support for Fort Leonard Wood, Missouri - **$105,709**.

GRAD 592

Interdisciplinary Water Resources Seminar

Mondays, 4:00 - 5:30 p.m.
A-206 Clark Building
Colorado State University, Fort Collins, Colorado

Fall 2007 Theme: Colorado Water Development in the 21st Century

The purpose of the 2007 Interdisciplinary Water Resources Seminar (GRAD 592), through a series of invited speakers, is to examine how new water supplies are being developed in Colorado during the current era and to study an array of projects that are in various stages of development. These projects include Animas La Plata, Elkhead Reservoir, Reuter Hess Reservoir, NISP, Barr Lake pipeline, the Prairie Water project, and others. More specifically, the seminar will:

1. Examine the steps and processes involved in water supply development.
2. Understand the legal and environmental aspects of water development.
3. Discuss the intra- and interstate issues that increase the complexity of water supply planning in the 21st century.
4. Examine current Colorado water projects to understand the issues of public water supply, drought protection, environmental mitigation, transfer of agricultural water, endangered species needs, interstate compacts, water quality protection, and other topics.

All interested faculty, students, and off-campus water professionals are encouraged to attend and participate.

Aug. 20	Dave Little, Denver Water	Life after Two Forks – What happened and how the Two Forks veto changed our approach to water resources planning
Aug. 27	Rick Brown, Colorado Water Conservation Board	Colorado's water development needs for the 21st Century
Sept. 10	Dave Merritt, Colorado River Water Conservation District	Intrabasin, interbasin, and transmountain water movement to meet growing water demands – Case studies: Wolford Mt. Reservoir, Union Park, and the Gunnison pumpback
Sept. 17	Mark Pifher, Aurora Water	The Prairie Waters Project – A sustainable approach to increasing water demands
Sept. 24	Dan Birch, Colorado River District	Elkhead Reservoir Enlargement – Partnerships and "multiple use" as a mechanism to build new projects
Oct. 1	Frank Jaeger, Parker Water	Permitting, water acquisition, and other legal aspects of developing water projects – Case study, Rueter Hess Reservoir
Oct. 8	Dave Kaunisto, East Cherry Creek Valley Water and Sanitation District	Urban partnership and competition for a limited water supply – Barr Lake pipeline project
Oct. 15	Carl Brouwer, Northern Colorado Water Conservancy District	Navigating the EIS process – Northern Integrated Supply Project
Oct. 22	Sean Cronin, Greeley Water	Integrated Water Resources Planning in Northern Colorado
Oct. 29	Wayne Vanderschuere, Colorado Springs Utility	Development of new water resources, Southern Delivery System, planning, process, and challenges
Nov. 5	Jay Winner, Lower Arkansas Water Conservancy District	The Super Ditch – Ag Transfer as a new source of M&I Water
Nov. 12	Kelly DiNatale, CDM	South Metro water needs and supply options
Nov. 26	John Hendrick, Centennial Water and Sanitation	Highlands Ranch: 0 to 100,000 in 30 years
Dec. 3	David Robbins, Council for the Southwest Colorado Water Conservation District	Animas La Plata Project – Last of the big federal projects in Colorado?

2007-2008

CALENDAR

2007

Sep. 30 to Oct. 5	**USCID Fourth International Conference on Irrigation and Drainage: Role of Irrigation and Drainage in a Sustainable Future.** Sacramento, CA. For more information go to www.uscid.org
Oct. 2-4	**Sustaining Colorado's Watersheds Conference: Making the Water Quality Connections.** Breckenridge, CO. For more information visit www.coloradowater.org/conference/
Oct. 23-26	**ASDSO Advanced Technical Seminar on Slope Stability for Embankment Dams**. Denver, CO. For more information please contact Susan Sorrell by phone at (859) 257-5146 or for on-line registration please visit www.damsafety.org
Oct. 24-25	**South Platte Forum 2007**. Longmont, CO. For more information visit www.southplatteforum.org
Oct. 24-25	**2007 Tamarisk Symposium**. Grand Junction, CO. For more information visit www.tamariskcoalition.org
Nov. 7-9	**NWRA Annual Conference**. Albuquerque, NM. For more information visit www.nwra.org
Nov. 8	**Records Management for Ditch Companies Workshop**. Fort Collins, CO. For more information and to register please visit www.darca.org
Nov. 9	**The Power of Microsoft Excel-Spreadsheet Techniques for Ditch Companies Workshop**. Fort Collins, CO. For more information visit www.darca.org
Nov. 12-15	**2007 AWRA Annual Water Resources Conference.** Albuquerque, NM. For more information and/or to register please visit www.awra.org
Nov. 28-30	**2007 Groundwater Foundation National Conference and Groundwater Guardian Designation**. Lakewood, CO. For more information please visit www.groundwater.org
Dec. 12-14	**CRWUA Annual Meeting: Global Changes, Local Impacts**. Las Vegas, NV. For conference information visit www.crwua.org

2008

Jan. 23	**Real Estate Law for Ditch Companies Workshop**. Denver, CO. For more information and to register visit www.darca.org
Feb. 9	**Water Tables: From Water Fights to Water Rights**. Fort Collins, CO. More information available at http://lib.colostate.edu/archives/water/
Feb. 20	**Flow Measurement for Ditch Companies Workshop**. Alamosa, CO. More information available at www.darca.org
March 5-6	**The 18th High Altitude Revegetation Workshop**. Fort Collins, CO. For more information please call (303) 422-2440 or (303) 279-8532.
March 10	**Directors & Officers Training for Ditch Companies Workshop**. Las Animas, CO. More information and registration available at www.darca.org
March 20	**GIS I for Ditch Companies Workshop.** Fort Collins, CO. More information and registration available at www.darca.org
March 21	**GIS II for Ditch Companies Workshop**. Fort Collins, CO. For more information visit www.darca.org
April 14	**Ditch Hazards Awareness & Safety Workshop**. Grand Junction, CO. More information available at www.darca.org
May 28-31	**USCID Water Management Conference: Urbanization of Irrigated Land & Water Transfers**. Scottsdale, AZ. For more information visit www.uscid.org

COLORADO WATER
Newsletter of the Water Center of Colorado State University

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