Colorado Water Institute

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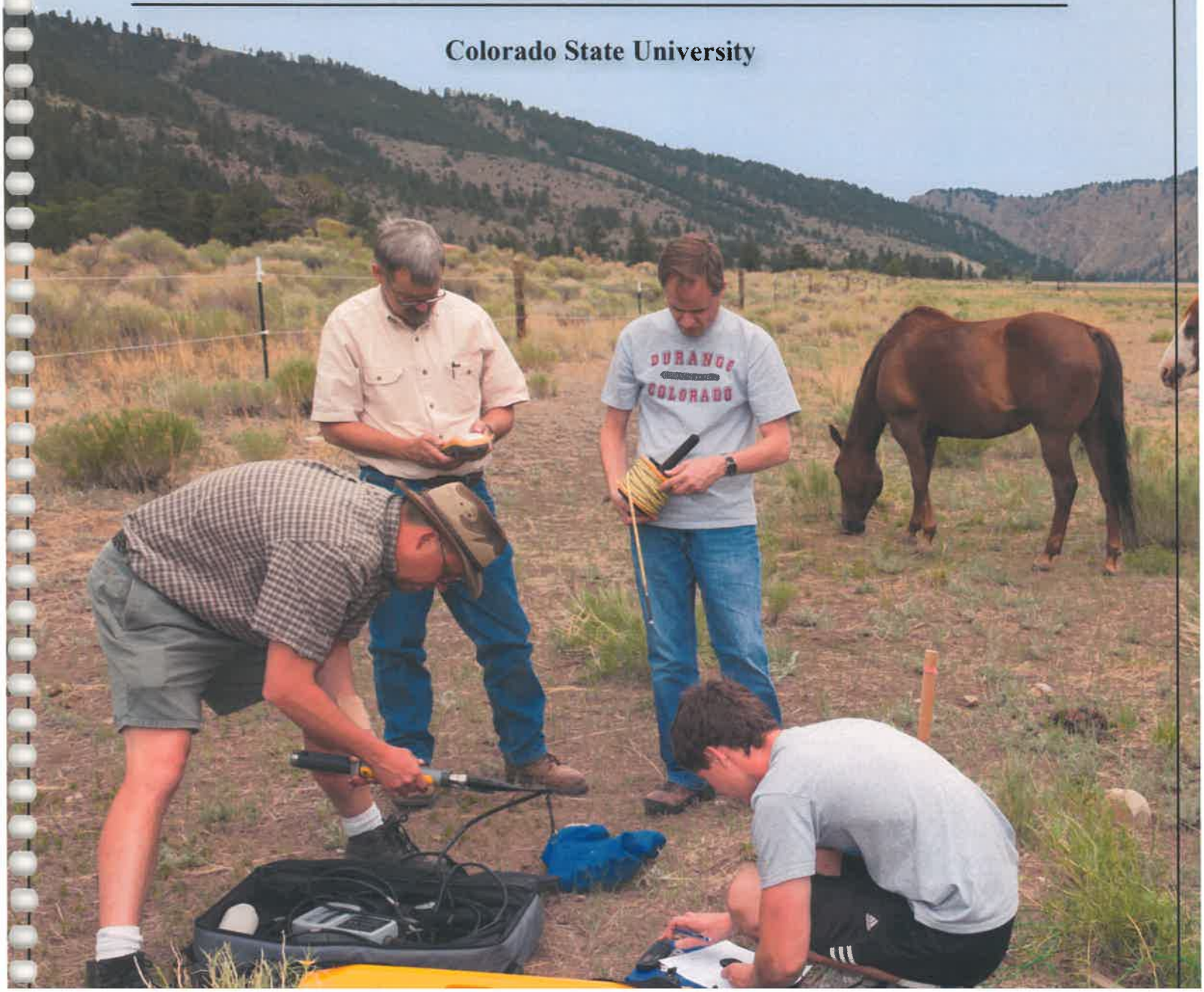
Activities and Impact Report

November 1, 2011 through October 31, 2012

Colorado State University



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On the cover: Colorado State University Civil and Environmental Engineering Professor Timothy Gates, graduate student Greg Steed, Professor Jeff Niemann and undergraduate student Justin Kattnig, collect data at a well on a ranch along the Arkansas River north of Buena Vista, Colorado, July 5, 2011 as a part of Civil and Environmental Engineering Professor Timothy Gates Arkansas River basin monitoring and modeling research project.

Photo By Bill Cotton

Current Research (Active Projects During 11/1/2011 - 10/31/2012)

FY	Name	Type	Status	Title	Amount	Sponsor	End Date
FY13							
	Johnson, Frank	Faculty	In Progress	Determination of Consumptive Water Use by Alfalfa in Arkansas Valley	$ 85,000	CWCB	12/31/13
	Goemans, Chris	Faculty	In Progress	Colorado Household Preferences in Meeting Future Water Challenges	$ 50,000	CWCB	6/30/13
	Doesken, Nolan	Faculty	In Progress	The Colorado Agricultural Meteorological Network (CoAgMet): Monitoring Evapotranspiration and Oth	$ 50,000	CWCB	6/30/13
	Bledsoe, Brian	Faculty	In Progress	Investigation of the Effects of Whitewater Parks on Aquatic Resources in Colorado: Year 2	$ 46,000	CWCB	6/30/13
	Bau, Domenico	Faculty	In Progress	Modeling the Influence of Conjunctive Water Use on Flow Regimes in the South Platte River Basin	$ 50,000	CWCB	6/30/13
	Nissen, Scott	Faculty	In Progress	Impacts of Sago Pondweed on Water Flow and Canal Efficiency	$ 37,224	CWCB	6/30/13
	Waskom, Reagan	Faculty	In Progress	Colorado House Bill 12-1278 South Platte River Alluvial Aquifer Study	$ 786,981	CWCB	12/31/13
				CWCB Funded Active Research Projects Total	**$ 1,105,205**		
	Waskom, Reagan	Faculty	Pending	Alt Ag Grant - Lake Canal Alternative Agricultural Practices and In-stream Flow Demonstration Projct	$ 13,725	CWIC	
	Waskom, Reagan	Faculty	Pending	Comprehensive Planning Studies for Salinity Control Measure in the Upper Colorado River Basin	$ 60,603	URS	12/31/13
	Pritchett, James	Faculty	Pending	Value of Water in Agriculture: Gathering Baseline Information	$ 35,360	CDM	6/30/13
				Other Sponsor Funded Active Research Total	**$ 109,688**		
FY12							
	Bledsoe, Brian	Faculty	In Progress	Investigation of the Effects of Whitewater Parks on Aquatic Resources in Colorado	$ 25,000	CWCB	4/30/12
	Goemans, Chris	Faculty	In Progress	Estimating the Short and Long-term Economic and Social Impacts Associated with the Current Drougl	$ 34,753	CWCB	6/30/12
				CWCB Funded Active Research Projects Total	**$ 59,753**		
	Knight-Sultenfuss	Student	In Progress	Ecosystem Services, Biodiversity, and Irrigation Inefficiencies Year 2	$ 12,500	CWI	6/30/12
	Bledsoe - Kolden	Student	In Progress	3D Modeling of Fish Passage in Colorado Whitewater Parks	$ 5,000	CWI	2/28/13
	Bledsoe - Fox	Student	In Progress	3D Modeling of Fish Passage in Colorado Whitewater Parks	$ 5,000	CWI	2/28/13
	Nissen, Scott	Faculty	In Progress	New Methods for Sago Pondweed Management	$ 10,000	CWI	6/30/12
				CWI Funded Active Research Projects Total	**$ 32,500**		
	Omur-Ozbek - Venkatapathi	Student	In Progress	Biowin Simulation to Assess Alternative Treatment Units for a Local Wastewater Treatment Plant to M	$ 5,000	NIWR 104B	02/28/13
	Fassnacht - Venable	Student	In Progress	Reconstructing a Water Balance for the San Luis Valley: Streamflow Variability, Change, and Extreme	$ 4,945	NIWR 104B	02/28/13
	Goemans/Pritchett - Serbina	Student	In Progress	Quantifying Risks Producers Face when Entering Agricultural Water Lease Contracts	$ 5,000	NIWR 104B	02/28/13
	Stednick - Roudebush	Student	In Progress	Using Water Chemistry to Characterize the Connection Between Alluvial Groundwater and Streamflov	$ 5,000	NIWR 104B	02/28/13
	Goemans - Nelson	Student	In Progress	The Short and Long-Term Impacts of Drought on the Structure of Regional Economics: Investigating t	$ 5,000	NIWR 104B	02/28/13
	Doesken - Muniz	Student	In Progress	Winter Precipitation Variability in the Colorado Rocky Mountains	$ 5,000	NIWR 104B	02/28/13
	Cheng - Huber-Sterns	Student	In Progress	Assessing the Benefits and Drawbacks of Different Institutional Arrangements to Enhancing Forest ar	$ 5,000	NIWR 104B	02/28/13
	Myrick - Herdrich	Student	In Progress	Thermal preference of age-0 stonecats (Noturus flavus): Are thermal water quality standards protectiv	$ 4,858	NIWR 104B	02/28/13
	Cooper - Gage	Student	In Progress	Structural and Functional Controls of Tree Transpiration in Front Range Urban Forests	$ 5,000	NIWR 104B	02/28/13
	Waskom, Reagan	Faculty	In Progress	Program Administration Project Fiscal Year 2012	$ 10,000	NIWR 104B	02/28/13
	Waskom, Reagan	Faculty	In Progress	Technology Transfer & Information Dissemination Fiscal Year 2012	$ 37,532	NIWR 104B	02/28/13
	Waskom - McCray	Faculty	In Progress	Water Quality Impacts of The Mountain Pine Beetle Infestation in the Rocky Mountain...Year 2	$ 140,162	NIWR 104G	8/31/14
				NIWR Funded Active Research Projects Total	**$ 232,497**		
	Waskom, Reagan	Faculty	In Progress	MOWS-Modeling of Watershed Systems NIWR-USGS Student Internship Program	$ 60,000	USGS	12/20/14
	Knight-Sultenfuss	Student	In Progress	Ecosystem Services, Biodiversity, and Irrigation Inefficiencies Year 2	$ 12,500	AES	6/30/12
	Waskom, Reagan	Faculty	In Progress	Addressing Agricultural Water Security in the Colorado River Basin: Planning for Water Research	$ 149,000	USDA-NIFA	8/31/13
	Waskom, Reagan	Faculty	In Progress	The Year of the River 2012	$ 10,000	PHAROS	12/31/12
	Waskom, Reagan	Faculty	In Progress	Exploratory Water Sharing Fields Trips and Corollary Work	$ 159,799	WFF	12/31/12
				Other Sponsor Funded Active Research Total	**$ 391,299**		

*Does not include completed projects Pre-FY11

FY11							
McKnight - Khan	Student	Complete	Novel Technique for Evaluation of Dissolved Organic Material (DOM); research methodology and lab	$	4,500	CWI	2/29/12
Chavez - Rambikur	Student	Complete	Large Aperture Scintillometers for Evapotranspiration (ET) evaluation	$	4,740	CWI	2/29/12
Omur-Ozbek - Sam	Student	Complete	The Efficacy of the Use of Moringa Oleifera Seeds to Remove Metabolites of Cyanobacteria from Drir	$	4,980	CWI	2/29/12
			CWI Funded Active Research Projects Total	**$**	**14,220**		
Waskom, Reagan	Faculty	Complete	Program Administration Project	$	10,000	NIWR 104B	2/29/12
Waskom, Reagan	Faculty	Complete	Technology Transfer & Information Dissemination	$	37,532	NIWR 104B	2/29/12
Sale - Mauer	Student	Complete	Aquifer Storage and Recovery Optimization	$	5,000	NIWR 104B	2/29/12
Arabi - Smith	Student	Complete	Environmental Impacts of Ag-to-Urban Water Rights Transfers in the South Platte River	$	5,000	NIWR 104B	2/29/12
Wohl - Duru	Student	Complete	Variables Controlling Reservoir Sedimentation in the Colorado Front Range	$	5,000	NIWR 104B	2/29/12
Balaji, Rajagopalan	Faculty	In Progress	Paleohydrology of the Lower Colorado River Basin Yr.2	$	29,964	NIWR 104B	2/29/12
McCray, John	Faculty	In Progress	Water Quality Impacts of the Mountain Pine Beetle Infestation in the Rocky Mountain West: Heavy Me	$	140,162	NIWR 104G	02/29/14
			NIWR Funded Active Research Projects Total	**$**	**232,658**		
Waskom, Reagan	Faculty	Complete	Regional Water Conservation Plan Southeastern Colorado Water Conservancy District for Colorado V	$	16,264	GWI	5/31/12
			Other Sponsor Funded Active Research Total	**$**	**16,264**		
Pre-FY11 Projects Still Active							
Waskom, Reagan	Faculty	In Progress	CWCB/CWI Cooperative Intern Program	$	75,275	CWCB	9/1/14
Sommers, Lee	Faculty	Complete	Determination of Consumptive Water Use by Alfalfa in Arkansas Valley	$	300,000	CWCB	12/31/11
			CWCB Funded Active Research Projects Total	**$**	**375,275**		
Neupauer, Roseanna	Faculty	In Progress	Adjoint Modeling to Quantify Stream Flow Changes Due to Aquifer Pumping	$	117,847	NIWR 104G	8/31/13
			NIWR Funded Active Research Projects Total	**$**	**117,847**		
Waskom, Reagan	Faculty	In Progress	Integrating Water Research, Extension, and Education in the Northern Plains and Mountains Region	$	1,825,000	USDA-CREES	8/31/12
Waskom, Reagan	Faculty	In Progress	NPS Outreach Coordinator	$	450,855	CDPHE	10/31/12
			Other Sponsor Funded Active Research Total	**$**	**2,275,855**		
			CWCB Funded Active Research Projects Total	**$**	**1,540,233**		
			CWI Funded Active Research Projects Total	**$**	**46,720**		
			NIWR Funded Active Research Projects Total	**$**	**583,002**		
			Other Sponsor Funded Active Research Total	**$**	**2,793,106**		
			ACTIVE RESEARCH PROJECTS GRAND TOTAL	**$**	**4,963,061**		

*Does not include completed projects Pre-FY11

Faculty Projects

Colorado Household Preferences in Meeting Future Water Challenges

Chris Goemans, Assistant Professor, Department of Agricultural and Resource Economics, Colorado State University
James Pritchett, Associate Professor, Department of Agricultural and Resource Economics, Colorado State University

Location of the work: This research will be conducted at Colorado State University and with collaborators among Colorado's water providers and academic institutions.

Purpose: Colorado faces a significant gap in meeting future water needs. A portfolio of solutions is being proposed to meet the gap including increased water conservation, water supply development, water reuse and reallocation among users.
This study builds off of a recent Colorado Water Institute survey of households in the West (Pritchett et al 2009), that benchmarked the public's view of many Western water issues, and particular attention was focused on households' perceptions of water scarcity, how municipal households view water in agriculture and tradeoffs among alternatives for meeting future water demands. While the previous report is very general in its approach, the current study will focus tightly on Colorado household preferences, specific water initiatives and the context of Colorado prior appropriations, headwaters state facing significant population growth. This proposal will result in several presentations to stakeholders and a completion report available at the Colorado Water Institute website.

Need: In the face of increasing water scarcity, decisions must be made about how future demands for water resources will be met. This includes identifying "acceptable" strategies for addressing scarcity during short term droughts and where public investment should be made in water development, infrastructure and mitigation. In particular, water providers seek customer preferences for water initiatives because of an implicit notion that policy decisions should also be consistent with public attitudes and preferences. After all, households are the likely source of funds for water development, firming and relocation. What are the preferences of Colorado households towards the various alternatives for closing the gap? Little has been researched or written on this question.

State-of-the-art survey methods will be employed to conduct a comprehensive investigation of residential Colorado households' water knowledge, preferences for meeting short term scarcity, addressing long term water development challenges and customer's willingness to pay for water initiatives to meet the municipal gap. This will include the use of an advisory committee of water stakeholders in survey and questionnaire design, pretests and an Internet questionnaire. Research results will include opportunities for enhancing water knowledge and education, a relative ranking of the value of water across uses, quantification of the public support and potential funding for water resource initiatives that might include investment in infrastructure, cost shares of water efficient appliances, temporary versus permanent transfers of water from agriculture, re-use of water in the home and for food production, etc.

Completion Date: This project will be completed by June 30, 2013.

Budget Justification: Budget is for two months of faculty time ($15,652), 11 months stipend of half-time, PhD graduate research assistant ($27,391), a small allocation for within state travel ($435). Total budget, including indirect costs calculated at %15, is $50,000.

The Colorado Agricultural Meteorological Network (CoAgMet): Monitoring evapotranspiration and other key elements of Colorado's climate

Nolan Doesken, Sr. Research Associate, Department of Atmospheric Science, Colorado State University
Wendy Ryan, Research Associate III, Department of Atmospheric Science, Colorado State University

Location of the Work: Throughout Colorado.

Purpose: CoAgMet is a network of 67 automated weather stations across the state that provides hourly and daily meteorological and consumptive use data. In order for the CoAgMet network to collect quality data for these purposes, annual site maintenance and sensor recalibrations as well as routine data quality assurance and control are all essential. In the past 3 years, quality assurance has become a top priority and this involves annual station maintenance visits. Its cost has been supplemented by support from the Water Supply Reserve Account grants from several of the Basin Roundtables across the state as they are more and more realizing the value of the CoAgMet network to their respective basins. A data rich basin has more opportunity to use physically based methods to calculate consumptive use than a basin with limited data. These stations fill monitoring gaps across the state in intensive agricultural areas that are quite susceptible to drought impacts. As evidenced during severe regional and/or statewide drought conditions in 2002, 2006, 2011 and 2012, real time reference evapotranspiration has become a key tool in drought monitoring and drought impact assessment.

Need: In order to ensure CoAgMet is providing quality data for these calculations and monitoring goals, sensors must be recalibrated, stations must be serviced and maintained and data must be thoroughly quality controlled. In addition, as has been keenly pointed out during the rapid onset of drought conditions in early summer 2012, soil moisture monitoring is a very desirable parameter to measure for drought monitoring statewide, the addition of these sensors will immediately add value to our statewide monitoring network beyond the agricultural scope that CoAgMet currently fills. These funds will ensure that CoAgMet is maintained to high standards for data collection and monitoring in Colorado to provide a high value collaborative climate data resource.

Completion Date: June 2013

Budget Justification: $50,000 is being requested to support these quality assurance and climate network observing enhancements including sensor calibrations, additional sensors, staff time for quality control and maintenance as well as travel to these locations.

Investigation of the Effects of Whitewater Parks on Aquatic Resources in Colorado

Dr. Brian Bledsoe, Associate Professor, Department of Civil Engineering, Colorado State University
Brian Fox, M.S. Candidate, River Mechanics/Stream Restoration, Colorado State University
Nell Kolden, M.S. Candidate, Hydraulic Engineering, Colorado State University

Location of the work: The research will be focused on several hydraulic structures along the St. Vrain River near Lyons, CO. In addition, hydraulic data will be collected and hydraulic modeling will be performed on the Arkansas River in Salida, CO to provide an additional test of the hydraulic model resolution necessary for design purposes.
Purpose: An improved understanding of the fundamental hydraulic processes and potential environmental effects of Whitewater Parks (WWPs) is needed to inform management decisions about Recreational In-Channel Diversions (RICDs). It is our understanding that this is the first in-depth study that will be conducted to assess how these structures may affect aquatic resources. Given the lack of data on the effects of WWP on fish movement, this analysis of the physical processes affecting passage at WWPs provided important information on patterns of hydraulic behavior, swimming ability of fish, physical characteristics of WWPs and the potential effects they may have on longitudinal connectivity.
Need: There is a pressing need for design recommendations for future parks and design modifications for in-place parks that can be used by WWP designers, reviewers, and decision makers. Some WWP designers have attempted to accommodate fish passage by incorporating roughness elements that, from a theoretical standpoint, could prove effective; however, no in-depth studies that detail the extent to which these roughness elements improve fish passage have been performed to date. This study intends to bridge this current gap in knowledge by quantifying the effects of roughness elements on velocity patterns in the context of WWPs.
Data collection in this study will focus on using Passive Integrated Transponder (PIT) antennas which will allow direct determination of fish movement and a continuation of detailed measurements of water velocity, depth and total hydraulic drop. These data will also allow us to test the efficacy of various hydraulic modeling tools for use in predicting passage at these structures. A literature review will be performed on boundary layer theory in rough beds to answer the questions, "how does relative submergence and spatial arrangement of large roughness elements affect near-bed velocities and fish passage?" and "can certain roughness conditions yield improved fish passage for future WWP designs?" The literature will be used in conjunction with field data to test the hypothesis that combinations of roughness element size, configurations that promote wake interference, and relative submergence can create hydraulic refugia with near-bed zones in which velocities are sufficiently reduced at scale suitable for promoting fish passage while maintaining hydraulic features desired by WWP users.
Completion Date: One year after notice to proceed for each task. (Exception: task 5 will commence 14 months after notice to proceed.)
Budget Justification:

Task 1: PIT Tag Antenna Maintenance: The use of PIT tag antennas allows for the collection of detailed fish movement data across specific structures with unique hydraulic characteristics. These systems require weekly maintenance to change batteries, download data and verification that the system is functioning properly. It is anticipated that approximately 52 maintenance trips will be required throughout the course of the PIT tag deployment. Deliverables: n/a

Task 2: Field Data Collection: Measurements of stream velocity, depth and total hydraulic drop will be continued over the course of the next year to characterize these variables over a range of discharges. It is anticipated that measurements of approximately 12-15 discharges will be required at each structure in the study site to fully characterize the variability of the hydraulic parameters affecting fish passage. Deliverables: n/a

Task 3: Data Analysis and Review: Data collected from the PIT tag antennas and hydraulic measurements will be reviewed to determine if any of these variables are causing an impediment to fish movement. Statistical analysis of the PIT tag data will relate measured probability of fish passage to spatial metrics that integrate the velocity field along potential swimming paths, as well as fish size. HEC-RAS, River2D, and FLUENT (3-D model) will then be used to reproduce observed hydraulic conditions to determine the resolution needed to sufficiently resolve the complex flow fields around WWP structures to enable prediction of WWP structures where fish passage can occur and where it cannot. Deliverables: n/a

Task 4: Develop Design Recommendations: The literature review, field survey data, hydraulic analysis, statistical analysis of passage data, and fundamental theory from fluid mechanics will be used to develop design recommendations that are both physically-based and practical. Deliverables: see Task 5 final report.

Task 5: Report Results: A report describing the results of the PIT tag study and hydraulic measurements will be provided to CWCB. This report will document the measured effects of WWPs on fish passage. The report will also provide practical design recommendations with respect to selection of hydraulic modeling tools, appropriate descriptors of flow characteristics, and configuration of roughness elements and wing walls to improve fish passage. Deliverables: Final synthesis report and two M.S. theses / technical reports on WWP/RCID effects on fish passage and design recommendations, respectively.

Modeling the Influence of Conjunctive Water Use on Flow Regimes in the South Platte River Basin Using the South Platte Decision Support System Groundwater Flow Model

Dr. Domenico Baú, Assistant Professor, Department of Civil and Environmental Engineering, Colorado State University

Location of the Work: South Platte Basin

Purpose: The research proposed by CSU will focus on the critical linkages between groundwater pumping for irrigation and the coupled groundwater/surface water regimes in the South Platte River Basin (SPRB). The study will rely on the use of the South Platte Decision Support System (SPDSS) alluvial groundwater flow model. The long-term goal of this project is to provide the Colorado Water Conservation Board (CWCB) with an independent evaluation of the SPDSS groundwater flow model, highlighting model capabilities, strengths and weaknesses. The proposed project will be carried out over three years. In the first year, the following Task 1 will be carried out.

Task 1: A review of the SPDSS groundwater flow model will be conducted, which will include:

(i) Analysis of model grid and time discretization.

(ii) Analysis of hydrogeological parameter distributions used in the model, such as hydraulic conductivity; storage properties, and streambed conductance.

(iii) Analysis of hydrological stress data used in the model, such a time series of surface boundary conditions, groundwater pumping, aquifer recharge, and lateral boundary flow conditions.

(iv) Preliminary model runs will be performed to test the numerical robustness and stability of the model with respect to hypothetical, yet realistic, changes in hydrologic stress conditions.

The objective of subtask (i) is to provide general considerations and directions regarding the spatial scale and the temporal scale for which the SPDSS model seems most adequate as water management simulation tool. The objective of subtasks (ii) and (iii) is to gain a general understanding of the extent to which the parameter distributions and the hydrological stress distributions assumed in the model are representative of the South Platte hydrogeological setting. The objective of subtask (iv) is to assess the ability of the model to provide reasonable water level distributions under hydrologic stress conditions different than the those utilized during model calibration.

Completion Date: The proposed project is conceived to be three-year long. Since funding is available only on a yearly basis, at the end of each year a new proposal will be submitted to the CWCB. The PI is aware that further funding is not guaranteed.

Deliverables: At the end of the first year, a technical report describing project activities and findings will be submitted to CWCB. In particular, this report will include the results of the analysis conducted in the substasks (i-iv) listed above. In addition, the PI will meet with CWCB representatives at least twice a year, either at the CSU campus, at CWCB offices or via teleconference, to best coordinate the project activities, discuss project progress and future direction.

Budget Justification: One PhD student will be involved and financially supported in this study. The student will take courses necessary to obtain the mandatory coursework credits required towards the completion of the PhD degree at CSU, and will work exclusively in this project.

Future tasks: It is anticipated that the following two tasks will be carried out in the following years.

Task 2: The SPDSS groundwater flow model will be applied to perform a sensitivity study on the effect of hypothetical water management scenarios on groundwater/surface water regimes in the SPRB. The SPDSS groundwater model will serve as the primary purpose of providing engineering-based evaluations of what-if scenarios, as a most crucial step in the decision- making process.

Task 3: The SPDSS groundwater flow model will be used to verify the adequacy of analytical, semianalytical and numerical models currently used to assess: (i) the impact of well pumping from alluvial formations on the flow in hydraulically connected streams and irrigation canals; (ii) the plans for stream augmentation that permitted wells are currently required to meet for consumptive use of groundwater. It is worth mentioning that this application of the groundwater flow model is one of the goals originally specified by the CWCB [2001] in their SPDSS feasibility study.

The modeling analyses conducted in the proposed project will achieve the two following objectives: (a) create faculty expertise and provide training opportunities for one graduate student to improve the human capital and skills required for using the SPDSS groundwater model; (b) serve as benchmark analyses to validate the capacity of the SPDSS groundwater flow model to assist water informed decision making in the SPRB. The application of the SPDSS groundwater flow model also has the potential to drive the implementation of additional data collection programs that may be used to corroborate model results and further refine the calibration of model parameters.

Impacts of Sago Pondweed Control on Water Flow and Canal Efficiency

Dr. Scott Nissen, Professor/Weed Science, Department of Bioagricultural Sciences and Pest Management, Colorado State University

Location of the work: This research will be conducted using an irrigation canal in Boulder County, while the information generated will be applicable across Colorado. This site has been used for previous sago pondweed research and it has a consistent sago pondweed infestation that is ideal for this project.

Purpose: Sago pondweed growth and its impact on flow rates and water depth will be evaluated. In addition to characterizing sago pondweed impacts, canals will also be monitored following herbicide applications to determine the rate at which sago pondweed is eliminated from the water column and the impacts of treatment on water flow. The long-term goal of this research is to improve the efficiency of water delivery systems in Colorado by providing irrigation districts with additional information on sago pondweed's growth rate and the effectiveness of herbicide treatments in returning canals to maximum efficiency.

Need: Sago pondweed (Stuckenia pectinata) is a submerged aquatic plant that is native to Colorado. It commonly occurs in irrigation canals along Colorado's Front Range, eastern plains, and west slope. Sago pondweed infested irrigation canals have slower flow rates, reduced canal efficiency, and greater losses to evaporation. While this has been observed for many years, little has been done to quantify water loss as a result of sago pondweed.
The most common methods for sago pondweed control have been dredging and Magnacide (acrolein) treatments. Magnacide provides effective in-season, top-growth control, but control is temporary and repeat applications are generally required. Even though both methods provide short-term control, they are expensive, and Magnacide is highly toxic to the applicator and requires specific licensing to transport and use the product. In 2010 a new herbicide, Cascade® (endothall, United Phosphorous International) was approved for use in irrigation canals. It is applied to flowing water and the manufacturer suggests that a single application may provide season-long control. While Cascade appears to be a promising management tool, additional field trials are needed determine the strengths and weaknesses of this new technology. In many cases, dense sago pondweed infestations often occur in combination with filamentous algae. This means that Cascade alone will not be sufficient to restore maximum canal efficiency. The more canals we survey the more apparent it is that what canal operators call "moss" can be any number of native and invasive aquatic plants and filamentous algae.
Endothall is available as two different formulations that can be used for aquatic weed control in irrigation canals. Cascade is the dipotassium salt, while Teton® is the dimethylalkyalamine salt. Teton is used at much lower concentrations and is more specifically designed for algae control. Teton and Cascade combinations could also improve control of species like elodea, horned pondweed and Eurasion watermilfoil.
The objective of this project is to determine the effect of sago pondweed on canal flow, water depth, and water loss due to evaporation. Five sampling sites will be selected for this canal. Water level will be determined during the irrigation season. Water level data will be combined with water flow data provided by the Colorado Department of Water Resources and measured using a Flowatch® handheld flow meter to determine the impact of sago pondweed on flow and depth. From these data, an estimate of increased evaporation loss as a result of sago pondweed will also be calculated. In addition to information on water flow, bi-weekly measurements of sago pondweed biomass and length will be taken until herbicide applications are made. Once sago pondweed is actively growing and has reached a length of 12-18 inches, an herbicide treatment containing Cascade will be made (Cascade concentration and time of exposure to be determined). Following herbicide applications, sago pondweed biomass and length will be determined weekly for 4 weeks.

Completion Date: Work will be initiated and completed Spring and Summer 2014 and data summarized late August 2014.

Budget Justification: Funds requested for this project will provide summer salary for the PI (Table 1). My main interest is to develop and test new management options in flowing water systems and transfer that information to irrigation companies across Colorado. There will be significant time dedicated to monitoring and data collection for this study so in addition to the PI salary, I am requesting additional funds to support a student hourly and travel. The student's duties will include assisting with data collection, plant sampling, monitoring water levels and assisting with the herbicide application. Supplies for this study will also need to be purchased including herbicides and analytical equipment.

Colorado House Bill 12-1278- South Platte River Alluvial Aquifer Study

Scope of Work: July 1, 2012- Dec 31, 2013

HB12-1278 states that the study's objectives are:

(i) to evaluate whether current laws and rules that guide water administration in the South Platte river basin achieve the dual goals of protecting senior water rights and maximizing the beneficial use of both surface water arid groundwater within the basin;

(ii) to identify and delineate areas within the basin adversely impacted by high groundwater levels and to conduct a feasibility-level evaluation of the causes of high groundwater levels in the affected areas;

(iii) to provide informatipn to use as a basis for implementation of measures to mitigate adverse impacts in areas experiencing high groundwater levels; and

(iv) to provide information to the general assembly, the board, and the state engineer to facilitate the long-term sustainable use of South Platte water supplies.

In addition, and without expending additional funds, the institute shall evaluate and report its findings and conclusions to the board and the general assembly regarding:

(i) to what extent augmentation plans are preventing injury to other water rights holders or potentially causing over-augmentation of well depletions;

(ii) whether additional usage of the alluvial aquifers could be permitted in a manner consistent with protecting senior surface water rights; and

(iii) whether, and to what extent, the use of water in the basin could be improved or maximized by affording the state engineer additional authority to administer water rights while ensuring protection of senior surface water rights.

Reporting

The institute shall prepare a final report, including its conclusions, and present it to the general assembly no later than December 31, 2013. The institute shall prepare a progress report and present it to a joint meeting of the House ofRepresentatives committee on agriculture, livestock, and natural resources and the senate committee on agriculture, natural resources, and energy, or their successor committees, during the first regular session of the sixty-ninth general assembly in 2013. The institute shall present the final report to a joint meeting of the House of Representatives committee on agriculture, livestock, and natural resources and the senate committee on agriculture, natural resources, and energy, or their successor committees, during the second regular session of the sixty-ninth general assembly in 2014.

Scope of Work

HB-1278 calls for an investigation of high groundwater levels in the South Platte, in particular in several identified areas. The bill calls for review, analysis, evaluation, and conclusions using existing data. The study objectives necessitate well-calibrated and functioning models and a comprehensive network of groundwater observation wells to achieve the stated goals. However, new modeling and data collection is not envisioned under the auspices ofHB1278; nonetheless, the study must be definitive enough to support future decisions, or at a minimum provide guidance on additional efforts that must be completed to support such decisions.

The need for good science and transparency cannot be understated, must remain fundamental goals throughout the study, and should be applied to the following:

- clear identification of data sources
- understanding of data quality and completeness (or incompleteness)
- data analysis processes
- presentation of results

Colorado's Decision Support Systems (CDSS) faced these and other challenges from inception and CDSS implementation has resulted in a data and analysis framework that can serve as the foundation for HB-1278. It is important to note that "CDSS" or "the DSS" does not automatically imply modeling. A significant part of the CDSS effort has been to establish the State of Colorado's HydroBase database as the center of the "CDSS data ... centered approach". Although a primary goal ofCDSS has been to establish baseline planning model data sets (and the science

that supports these modeling efforts), data and tools increasingly are being used to more efficiently perform various studies beyond the initial focus of CDSS, such as the Colorado River Water Availability Study (CRWAS). CWCB and DWR are currently performing a feasibility-level evaluation of the causes of high groundwater levels in two areas (Sterling and Gilchrest/LaSalle) with funding provided under the 2013 "Projects Bill." CWCB has developed a scope of the pilot project work envisioned for these areas, which will be invaluable to the Water Institute in its larger scale basin analysis. CWI will carefully coordinate with these pilot studies to ensure that no duplication occurs and that the two efforts derive maximum benefit from each other.

The following tasks summarize recommended activities necessary to successfully complete the project. It is recognized that there are significant personal interests in the outcomes of the project. Given the complexity of issues, data, and natural systems, there is risk that the outcome might be difficult to interpret and utilize. However, there is also the opportunity that the project can demonstrate the benefits of CDSS and objective knowledge of State of Colorado staff. Recognition of the past, current, and future SPDSS efforts (and limitations) will allow the HB-1278 project to dovetail with SPDSS efforts.

Task 1. Data Collection, Organization and Display

HB 1278 specifies under item (c) The institute shall conduct the study independently using relevant, available, current, and historical hydrologic data and documents. The study must examine water use in Water Districts 1, 2, and 64 within Water Division 1. In conducting the study, the Institute is directed by HB1278 to consider the impacts to all water rights and interstate obligations in Water Division 1 and shall investigate, compile, and evaluate hydrologic variables and factors, including the following items specifically outlined in HB1278:

(i) the number and location of alluvial wells that are currently withdrawing groundwater;
(ii) the number and location of alluvial wells that are currently curtailed from pumping, either fully or partially;
(iii) the number and location of existing artificial recharge facilities and the historical volume of water recharged;
(iv) historical volumes of water pumped for each high-capacity irrigation, municipal, industrial, or other well not exempted under section 37-92-602;
(v) historical amounts of water leaving the state in excess of the requirements of river compacts and of the "Platte River cooperative agreement" of 1997;
(vi) historical water deliveries to surface water rights;
(vii) groundwater level data available from existing observation wells and the historical fluctuations of groundwater levels based on the data;
(viii) the South Platte decision support system's existing phreatophyte groundwater evapotranspiration module and, using available data, the relationship between high groundwater levels and nonbeneficial consumptive use by phreatophytes from 2001 through 2011;
(ix) the number and size of augmentation plans in operation in the study area; and
(x) the impact of transbasin supplies, reuse of fully consumable supplies, conservation practices, and the installation of lined storage facilities in the alluvium.

The purpose of Task 1 is to assist with addressing the following elements of HB12-1278:

- Identify and delineate areas within the basin adversely impacted by high groundwater levels
- Conduct a feasibility-level evaluation of the causes ofhigh groundwater levels in the affected areas
- Provide information to use as a basis for implementation of measures to mitigate adverse impacts in areas experiencing high groundwater levels
- Provide information to the General Assembly, the Colorado Water Conservation Board, and the State Engineer to facilitate the long-term sustainable use of South Platte water supplies
- Examine water use in Water Districts 1, 2, and 64 within Water Division 1
- Use relevant, available, current, and historical hydrologic data and documents

1.1) Kickoff Meeting and Approach Confirmation

Task 1 will begin with a thorough review of all available water resource data housed in HydroBase. To insure all relevant data is reviewed, interviews will be conducted with personnel within DWR, CWCB, CGS, USGS and both surface and groundwater users within the basin. A one-day kickoff meeting will be held between the State technical advisory group and project team to discuss and determine project outcomes and initiate project activities. It is envisioned that the technical advisory group from the DNR, CWCB and the CWI Project Team will confirm an understanding of the desired project outcomes, data sources and limitations, and technical approach. It is

recognized that the focus of a kickoff meeting could vary depending on the attendees and intent. For the purpose of this document, it is assumed that the kickoff meeting will focus on technical issues and approach rather than overall stakeholder issues.

Most data that are relevant to the HB-1278 study effort are represented by the above individuals and the data representations for which they are responsible. A preliminary summary of important data include the following and will be discussed with the technical advisory group:

- Well levels, and depth- in HydroBase (1970's-1980's, gap, then 1990's and forward)
- Well pumping - in HydroBase diversion records; also in accounting workbooks, which DWR is trying to standardize so data can be imported into HydroBase
- Well locations - in HydroBase and associated spatial data layers
- Recharge - in HydroBase (via surface water diversions since 1970's and more specifically as recharge since 1970's)
- Streamflow data - in HydroBase and available from USGS and others using CDSS tools
- Climate data - in HydroBase and available from NCDC and others using CDSS tools
- Reservoir data - in HydroBase and available from others using CDSS tools

Members of the State technical advisory group noted above have in-depth knowledge about the data and can confirm data access, quality, and limitations. Ideally the required data will exist in HydroBase or are envisioned for inclusion in HydroBase (such as the augmentation plan workbook data); however, some external sources may need to be utilized (e.g., GASP, CCWCD, LSPWCD, USGS). Data sources and formats will need to be understood early in the project. The technical advisory group will provide feedback on the access, quality and limitation to using the data. The project team will coordinate with the State technical team on existing and ongoing state projects to insure duplication of effort is avoided and data and results are made available to the project team. We anticipate that during the project and following the kick-off meeting there will be a need for several short consultation meetings with specific DWR, CWCB and other staff to clarify aspects of the data.

At the kick-off meeting, the CWI project team will present an approach to using the data to analyze issues identified in HB-1278 and the technical advisory group will provide feedback on the approach. This approach will utilize CDSS, and as needed other, tools to automate data process, resulting in a repeatable, transparent process that can be utilized and enhanced in the future (for example to repeat the analysis with more years of historical data). Visual output products such as maps and graphs will be identified for outreach and to evaluate for presenting final results. Suitable milestones for State and peer review will be discussed in order to identify breakpoints in the project. The preliminary approach will serve as guidance for the following tasks and will be adapted as information is obtained.

1.2) HydroBase/CDSS Training for CWI Project Team

Outcome: Ensure that the project team has an understanding of CDSS tool features related to HydroBase data access and processing.

HydroBase and related data such as spatial data layers will serve as the primary source of data. Members of the CWI Project Team may not have extensive experience with HydroBase and CDSS data tools; consequently, hands-on training will be provided early in the project to demonstrate data access and processing using TSTool, StateDMI, CDSS and DWR website and web services, GIS, and other tools. Limitations may be identified in this exercise, leading to a list of possible enhancements for the tools and technical approach. The CWI project team will document identified limitations and potential enhancements for consideration by CWCB and DWR staff. A pragmatic result of the training will be identification of resources within the team and State staff that can answer technical questions. A one-half to one day workshop is likely appropriate, with follow-up as needed. Participation by State staff may be beneficial.

1.3) Data Inventory and Preliminary Data Analysis

Outcome: Produce a preliminary inventory of data necessary to perform the study and utilize the data to perform a preliminary analysis, in order to evaluate issues with data and the approach.

The project team will use CDSS tools to access data relevant to the project and produce inventory level data products. Suitable quality control checks will be established, such as period of record, outlier analysis, etc. Preliminary analysis

will occur and visual products will be created, such as maps showing well locations, trends, and metrics. Products will be provided to the USGS and appropriate State staff for review, with time for review meetings budgeted appropriately. Additional effort may be needed if existing CDSS tools are limited. For example, the CDSS TSTool software currently is able to read all diversion "DivTotal" records from HydroBase; however, TSTool is not yet able to read diversion record classes (source/from/use/type) from web services and DWR has changed the diversion coding design in the past year. It is likely that several weeks of effort may be required to deal with these changes. Work product: data layers of all HB 1278 required groundwater and related features to address HB1278 objectives (iii) and (iv).

Task 2. Groundwater mapping

Objective (ii) ofHB1278 requires CWI to identify and delineate areas within the basin adversely impacted by high groundwater levels and to conduct a feasibility-level evaluation of the causes of high groundwater levels in the affected areas. In order to understand spatial and temporal patterns of high water levels in the S. Platte basin, a GIS mapping component is needed to clarify the relationship between areas of high water levels, augmentation facilities, ditches and curtailed pumping. Fortunately, significant mapping of the S. Platte basin has already occurred in the process of developing the SPDSS, and these layers will be evaluated and used to develop maps of areas adversely impacted by high groundwater. Specifically, we anticipate using base layers defining areal extent of the alluvial aquifer, bedrock surfaces, surface water features and ditches, groundwater contours and others as appropriate. The CWI Project Team will review all existing SPDSS GIS data and incorporate into this effort as warranted. Additional GIS mapping generated under this effort will endeavor to meet the standards set under SPDSS.

It will be important to determine a working definition of "adverse impacts" and "high groundwater levels" as there is some subjectivity and judgment implied given this is site specific and has historically occurred due to natural hydrologic processes in various area of the basin. Working in conjunction with students and consultants under Task 1, a student GIS technician will be hired to work with CSU GIS faculty to develop map layers for the basin that include spatially referenced data related to groundwater levels and surface features. Work product: GIS maps of S. Platte groundwater and related features specifically needed for 1278 objective (ii).

Task 3. Evaluation of existing groundwater level analysis conducted by USGS

HB1278 requires CWI to conduct a feasibility-level evaluation of the causes of high groundwater levels in the affected areas and to provide information to use as a basis for implementation of measures to mitigate adverse impacts in areas experiencing high groundwater levels. These objectives will be addressed by compiling existing information regarding well and augmentation locations and water volumes from the South Platte Decision Support System. In order to fully utilize the expertise and capacity of US Geological Survey scientists, modeling frameworks and data management capabilities, the data acquired in Task 1 will be compiled into USGS ESRI ARC geographic information system (GIS) software using geodatabases that can be made publically accessible to other local, State, and Federal agencies. As this might appear duplicative of state funded efforts in Task 1, USGS matching funds will be used to resource this data transfer. Groundwater-level data available from existing USGS and other appropriate observation wells will be compiled from raw data sources into Microsoft Excel spreadsheets (if not already available), and the data will be uploaded to the U.S. Geological Survey National Water Information System (NWIS) database. The NWIS database is a web-based system that allows public access to the data, and it includes pre-programmed data-analysis tools that will provide summary statistics of the minimum, maximum, and mean water level for each well and by season. Once the data are entered into the NWIS database, they will be downloaded into ARC GIS files for temporal and spatial analysis. The analysis of when and where high groundwater levels have occurred will identify and delineate areas within the basin adversely affected by high groundwater levels to satisfy HB1278 and will provide information to use as a basis for implementation of measures to mitigate adverse effects in areas experiencing high groundwater levels.

Results from activities will be synthesized to (1) identify areas affected by high groundwater levels; (2) determine relations (or lack thereof) among the timing and locations of high groundwater levels and the timing and locations of pumping, well shut down, and augmentation; (3) develop hypotheses regarding the causes of high groundwater levels; and (4) develop a groundwater monitoring plan for the basin that accounts for the relations and tests the hypotheses. The resulting data sets also will support extending the SPDSS groundwater-flow model from year 2006 through water year 2011 and will be compatible with existing State tools and databases.

The USGS will provide quarterly written progress report to the Colorado Water Institute (CWI), and a draft USGS Scientific Investigations Report will be provided in November 2013 that documents the data compilation and

interpretations and presents a draft groundwater monitoring plan. The funds planned for the project total $304,230 with $152,115 coming from CWI and $152,115 coming from the U.S. Geological Survey Cooperative Water Program.

Task 4. Stakeholder involvement in data and groundwater problem area identification, mutual problem solving and public education

HB1278 requires CWI to collect and organize a comprehensive array of data that are not all easily assessable or necessarily widely known to be reliable and acceptable for this analysis. For this reason alone, CWI must implement a process that facilitates stakeholders combining their collective knowledge toward shared agreements about data and mutual fact finding for agreeable solutions required under the bill. We will do this by facilitating a robust dialogue and fact finding process in three distinct settings focused on finding information called for by HB1278. The activities envisioned under this Task may be conducted independent of CWCB and DWR but will include and coordinate with CWCB and DWR personnel as appropriate.

4.1) Independent Scientific Panel

In order to peer review the findings developed by the CWI Project Team under Tasks 1, 2 and 3 and to address the policy, institutional and administrative objectives specified in HB1278 an independent scientific panel of well-qualified and respected individuals will be convened to deliberate upon and address the questions outlined as the bill objectives. We expect the panel will be comprised of approximately 5 respected scientists/engineers with collective knowledge of groundwater, modeling and the S. Platte Basin to function similarly to a National Academies panel to provide peer review of data and develop hypotheses, conclusions and recommendations in a written report. The panel will specifically address these HB1278 objectives:

- to evaluate whether current laws and rules that guide water administration in the South Platte river basin achieve the dual goals of protecting senior water rights and maximizing the beneficial use of both surface water and groundwater within the basin;
- to what extent augmentation plans are preventing injury to other water rights holders or potentially causing over-augmentation of well depletions;
- whether additional usage of the alluvial aquifers could be permitted in a manner consistent with protecting senior surface water rights; and
- whether, and to what extent, the use of water in the basin could be improved or maximized by affording the state engineer additional authority to administer water rights while ensuring protection of senior surface water rights.

CWI will facilitate meetings in which this small panel of unbiased experts will discuss and carefully consider the data, maps and analyses conducted under Tasks 1, 2 and 3. We envision running this panel in the manner of a National Academies review panel that will ask for expert input and offer opportunity for public input as it reviews the available data and model output. The panel will also be afforded opportunity to conduct executive session if needed. Although CWCB, the Attorney General's Office and DWR personnel are not envisioned as members of the panel, it will be important to include selected state experts as staff to the panel as appropriate. CWI will be responsible for assisting the Independent Scientific Panel in coming to conclusions and recommendations, including agreement and lack of agreement. Panelists will be provided travel expenses and a modest honorarium for service. Work product: written interim and final reports.

4.2) South Platte Roundtable Groundwater Committee

CWI will work with the Roundtable groundwater committee to:

- Provide input to the CWI Director and CWI Project Team on study scope, research process, data suitability, maps, and specific questions from the CWI Project Team.
- Provide a forum for public input and discussion at the regular meetings of the Groundwater Committee.
- Advise the fullS. Platte Roundtable on progress and concerns related to the HB1278 study. Make recommendations to the Roundtable as to when presentations from the CWI Project Team to the Roundtable are appropriate.
- Hear presentation of the interim and final CWI reports to the legislature and provide input on the reports.
- Help CWI develop an educational strategy for the public, elected officials and the media regarding factual information on groundwater in the Basin.

We envision meeting with the Roundtable groundwater committee at least on a quarterly basis and providing reports and presentations as requested by the Roundtable Execution Committee.

4.3) Community Outreach and Education
Working with the South Platte Roundtable's Public Participation and Public Education Committee, CWI will develop and implement a strategy for convening the public in communities along the river for education and facilitated dialogue via a series of public meetings. Work product: we will develop a website to organize and serve data, documents and educational factsheets for dissemination to the press and the public, both in printed and electronic form.

MaryLou Smith, Colorado Water Institute Policy and Collaboration Specialist and Reagan Waskom, CWI director, will facilitate meetings of the Independent Scientific Panel, the South Platte Roundtable Groundwater Committee, community outreach meetings and hold educational briefings with the press.

Timeline for Work Completion
We expect that Tasks 1-4 will all take the entire 18 months for completion, thus the deliverables under this Scope of work will be completed and final reports will be delivered by December 31, 2013.

Estimating the Short and Long-term Economic and Social Impacts Associated with the Current Drought in Southern Colorado

Chris Goemans, Assistant Professor, Department of Agricultural and Resource Economics, Colorado State University

Location of the work and Project Team: The study will focus on drought impacted areas in southern Colorado. The project team will consist of researchers in the Department of Agricultural and Resource Economics (DARE) at Colorado State University.

Purpose and Need:
Agricultural producers throughout southern Colorado are currently suffering through drought conditions comparable to 2002; one of the worst droughts on record. The objective of this study is to develop a better understanding of the immediate and longer term economic and social impacts associated with the current drought.

Water is a critical input to most agricultural activities. As a result, water shortages lead to immediate reductions in output and lost revenues for agricultural producers. Given the critical role that agriculture plays in most rural communities, the initial revenue losses associated with decreased production represent only a portion of the true impact. Reduced spending by agricultural producers (via "backward linkages") negatively impacts households (lost income) and producers in other industries, both locally and throughout Colorado.

These additional production related impacts (commonly referred to as indirect and induced impacts) can amount to two times the direct impact associated with lost output; yet they still do not capture the full impact of drought on rural communities and the State as a whole. Evidence of this comes from Schuck et. al (2003 and 2005) who surveyed Colorado farmers and ranchers following the 2002 drought. The authors found that as a result of drought related reductions in household income, agricultural households experienced lower living standards, were forced to pursue additional, off-farm employment opportunities, and were more likely to seek federal assistance. Moreover, the findings suggested that the drought had a significant impact on the resiliency of farming operations, increasing the likelihood that producers would permanently decrease or cease agricultural operations.

The bottom line: impacts of drought extend far beyond the immediate losses in revenue associated with reduced output levels. Estimates of drought impacts which only consider the direct, indirect, and induced production losses provide an incomplete, and potentially understated, picture of the true impacts. Despite this, few studies exist which provide insight into the impacts of drought beyond those associated with the immediate production impacts. Our goal with this study is to close this gap; using a combination of existing regional economic models and survey work to develop a more complete view of the impacts associated with the current drought.

Methods and Project Outline:
The proposed analysis will be conducted in two phases: Phase One using regional economic models to develop estimates of the short-term economic impacts; Phase Two using surveys to collect data that will be used to generate a better understanding of the longer term impacts of the drought. A more detailed overview of each Phase is provided below:

Phase One: During this phase the research team will utilize the (already built) Colorado Equilibrium Displacement Programming (CEDMP) model to estimate the short-term economic impacts of the current drought to the agricultural sector. The CEDMP, developed at CSU, is a basin-level model of Colorado agriculture that offers several advantages over more traditional input-ouput models (e.g., Implan). Unlike input-ouput models, the CEDMP model reflects farmer risk profiles and price expectations, captures both forward and backward production linkages within the agricultural sector, and will also allow us to estimate consumer surplus losses resulting from price changes. In sum, the CEDMP provides a more accurate reflection of the production impacts associated with drought (see Davies et. al, 2010 for more information the model).

Output from the CEDMP model will be input into a traditional input-ouput model to generate estimates of the direct, indirect, and induced economic impacts to other, agriculture-related industries. Together, the two regional models will present a more accurate picture of the short-term economic impacts than approaches used in past studies.

Phase One Tasks/Timeline (assumed start date of 10/15/2011):

Phase One, Task One: October 15th-January; collect background production data, prepare CEDMP and IMPLAN for model runs

Phase One, Task Two: January-April; conduct impact analysis using CEDMP and IMPLAN models

Phase One, Task Three: April-June; Prepare Phase One report and preview results with relevant parties

Phase One, Task Four: June; Submit final report and fact sheets, present project findings

* All tasks and phases will be complete by June 30, 2012

Phase Two: The general objective of this phase is to describe the managerial response of farms and ranches during the ongoing drought, identifying the current financial standing of these farms and ranches and assessing their ability to respond to both financial challenges and opportunities during the next three to five years. This information will be collected via a survey and is useful in refining the estimates of the economic impact study because it suggests how the asset base and purchasing behavior of farms and ranches change with persistent drought. These changes have ripple effects that flow through the general economy. As an example, if ranchers choose to depopulate the cow herd in response to poor forage conditions, the reduction in the ranch's asset base decreases local feedlot placements, reduces demand for corn silage locally and impacts the ranch balance sheet. Likewise, this curtails the manager's ability to take advantage of favorable price conditions. Impacts of this type are not typically captured in standard regional economic models.

Surveys will be designed, delivered and results summarized by undergraduate students participating in the Farm Credit Services of Southern Colorado Student Board of Directors. These students are agriculture business majors who have completed upper division finance and agribusiness management classes. The students will work under the direction of Agriculture Economics faculty (James Pritchett , Dawn Thilmany and Norman Dalsted), together with a graduate research assistant. Survey results will be presented to the Farm Credit Services of Southern Colorado Board of Directors at their annual meeting. Farm Credit Services of Southern Colorado is interested in having the students complete the drought study, and are willing to assist with expenses and paying the students a small stipend.

The survey design will be based on the recommendations of an advisory committee and accepted methods. While details have not yet been established, the survey will build off of previous work by Schuck et. al (2003 and 2005) and likely have the following characteristics:

(a) Be internet based in order to improve response rates and decrease costs;
(b) Target farmers, ranchers, local lenders, local agribusiness and government officials;
(c) Include Likert-scale based behavioral questions
(d) Include categorical, quantitative questions
(e) Hold all responses as confidential.

Survey responses add to the breadth and depth of the knowledge that stakeholders have in assessing the impact of the recent drought on agricultural producers. This information is particularly useful in:

a) Targeting future technical and financial assistance to farmers, ranchers, communities and businesses in southern Colorado. This information is of particular importance to CSU Extension, USDA-NRCS, USDA-FSA, Colorado Department of Agriculture and commodity and ag advocacy organizations;
b) Communicating the effectiveness of crop and pasture, range and forage insurance programs to USDA-Risk Management Agency;
c) Assessing the outcomes of changes made to Colorado Drought Mitigation and Response plan that was substantially revised in 2010. Recommendations for future adaptation can be drawn from the survey responses, but would certainly need be part of a larger effort;
d) Identifying the perceived success of local drought management strategies to assist in future planning;

e) Informing policymakers who may be part of disaster assistance and commodity program hearings for Farm Bill 2012.

Fact sheets that combine the economic impact analysis and survey results will be written in the context of the issues noted above. As an example, a fact sheet can focus on the use and effectiveness of pasture, range and forage management insurance that was recently made available in Colorado.

Phase Two Tasks/Timeline (assumed start date of 10/15/2011:

Phase Two, Task One: October 15th-January; prepare survey

Phase Two, Task Two: January-February; administer survey and collect responses

Phase Two, Task Three: February-April; analyze survey data
Undergraduate students working on Phase Two of the project will present preliminary results to Farm Credit Services in late April.

Phase Two, Task Four: April-June; Prepare Phase Two report, including a series of fact sheets summarizing survey results

Phase Two Task Five: June; Submit final report and fact sheets, present project findings

* All tasks and phases will be complete by June 30, 2012

Deliverables:
The project team will prepare and deliver a detailed report and an executive summary for decision makers to the CWCB and CDA. The final report and summary will be available on the CWCB, CDA and Colorado Water Institute websites. A project summary will also be prepared for submission to an outlet similar to Colorado Water. In addition to the project summary, a series of fact sheets will be prepared (as discussed above). Fact sheets will be delivered to the CWCB, CDA and accessible via their website. Oral presentations of project findings will be given to the CWCB, CDA and other interested parties.

New Methods for Sago Pondweed Management

Dr. Scott Nissen, Professor/Weed Science, Department of Bioagricultural Sciences and Pest Management, Colorado State University

Sago pondweed (Stuckenia pectinata) is a submerged, perennial aquatic species that is native to Colorado. When present in standing water, sago pondweed is not usually problematic; however, irrigation canals across Colorado provide optimal growing conditions for sago pondweed. When sago pondweed is present the efficiency of water delivery can be severely impacted. Sago pondweed reaches maximum growth in July and August when water demand is highest.

Common control methods in Colorado include acrolein (Magnacide) applications and canal dredging. These methods are expensive and in the case of acrolein, very dangerous for applicators. Since current methods are limited, alternative control strategies are needed to provide water districts with additional tools for sago pondweed management in irrigation canals.

Previous studies have indicated that several aquatic herbicides have synergistic effects when applied to submerged aquatic plants. When copper sulfate pentahydrate (CSP) was combined with endothall or diquat there appeared to be a synergist interaction with respect to hydrilla (Hydrilla verticillata) control. Diquat and several copper formulations are currently registered for the sago pondweed control in irrigation canals, and endothall will be registered by spring 2010. While these compounds are registered for sago pondweed control, they provide only marginal control much of the time. The objective of this study will be to determine if combinations of diquat and endothall with copper formulations will provide better control compared to the herbicides applied individually.

Greenhouse studies will be conducted to evaluate control using combinations of endothall, diquat, copper sulfate pentahydrate, and four chelated copper formulations. Sago pondweed tubers will be planted in topsoil and allowed to produce approximately six inches of top growth. Plants will then be transferred to simulated irrigation canals (Shown in Figure 1) to simulate the forces of flowing water, and treated with these herbicides applied alone and combination. Plants will exposed to the herbicides for 2, 4, 6, and 8 hours. Following herbicide treatment plants will be rinsed in clean water and then place in clean water in the simulated canals. This will be followed by a 30 day grow-out period. After the grow-out period, plants will be harvested, dried, and biomass will be recorded. Data will then be analyzed and the effectiveness of herbicide combinations compared.

If any of the herbicide treatments appear synergistic they may provide a new alternative for the sago pondweed control in irrigation canals. In addition to providing better control, the combinations may reduce the required exposure time and may also provide lower cost alternatives compared to the current control methods.
Budget: $10,000

Water Quality Impacts of the Mountain Pine Beetle Infestation in the Rocky Mountain West: Heavy Metals and Disinfection Byproducts

John E. McCray, Professor, Hydrologic Science and Engineering Program, Colorado School of Mines

Abstract: The Mountain Pine Beetle (MPB) is the primary cause of insect-induced mortality in pine forests in western North America. The MPB's range encompasses most of western North America, from the Mexico to British Columbia, and from the Pacific Coast to South Dakota. The Rocky Mountains are the source-water region for more than 60 million people. The current epidemic is severe: lodgepole forests are expected to experience more than 90% tree mortality. Two important potential watershed impacts are changes in the hydrologic cycle and water quality. While impacts on the hydrologic cycle have received considerable attention; the impacts of this phenomenon on water quality are not well understood.

This proposal addresses two potential MPB impacts on water quality: increased metal concentrations with ecotoxicological and human health ramifications and the potential formation of disinfection byproducts (DBPs) in downstream drinking water supplies.

Dissolved organic carbon (DOC) increases in waters below impacted pines forests are expected based on fundamental biogeochemical mechanisms resulting from sources such as tree stress, litter fall, and decay. This increased DOC can result in enhanced metal transport to natural waters as well as increased potential for the formation of DBPs (e.g., trihalomethanes and nitrosamines) during disinfection of natural waters used for drinking water supplies. Municipal water suppliers are concerned about the impact of MPB infestation on drinking water quality and the potential need for costly treatment process modifications to meet public health mandates. These concerns persist over the entire Rocky Mountain West, but are currently based on anecdotal evidence that has not been sufficiently analyzed and documented using systematic and mechanistic studies.

The proposed research strongly addresses the NIWR research priority regarding vulnerability and resilience assessment of public water supplies. Specifically, results from this project will enable water managers to better understand the vulnerability of their water supplies to MPB outbreaks and implement a plan to ensure current and future resilience of the water supplies.

The proposed research aims to answer 3 primary questions with an integrated approach that includes synthesis and analysis of data collected by municipal water suppliers over the past fifteen years, a field investigation, and supporting laboratory experiments. These questions are as follows: (1) can DBP formation potential and metal loading be estimated based on forest, hydrologic, geographic or geologic factors that represent the watershed's vulnerability (or resiliency) to MPB impacts; (2) will surface waters associated with MPB impacted lodgepole pines will see an increase in TOC and DBP formation potential that corresponds with the degree of infestation and tree mortality; (3) do soils associated with MPB-impacted trees have an increased potential for metal leaching and release of DOC than will soils associated with healthy lodgepole pines?

This research proposal represents a strong collaboration with an existing USGS study in Rocky Mountain

National Park (RMNP) related to hydrologic and water quality impacts (primarily nutrients) associated with MPB infestation. If funded, the research will provide training for a PhD graduate student, an early-career professor, 6 non-thesis MS students, and approximately 60 undergraduates. A well-rounded plan is provided for transferring results to the science community, water managers, and the public, including K-12.

Budget: $140,162 from 104G Competitive Grants

Addressing Water for Agriculture in the Colorado River Basin: A Project Progress Report

Peter Leigh Taylor, Department of Sociology, Colorado State University
MaryLou Smith, Policy and Collaboration Specialist, Colorado Water Institute
Julie Kallenberger, Assistant Regional Water Coordinator, Colorado Water Institute
Faith Sternlieb, Research Associate, Colorado Water Institute
Reagan Waskom, Director, Colorado Water Institute

Colorado State University's Colorado Water Institute (CWI) is spearheading a U.S. Deartment of Agriculture-funded research project on water for agriculture in the Colorado River Basin (CRB). Carried out in partnership with the seven CRB land-grant universities—Colorado State University, University of Arizona, University of California, University of Nevada, New Mexico State University, Utah State University, and University of Wyoming (Figure 1)—we want to find out what farmers, ranchers, and water managers are thinking about the current and future status of their agricultural water. Through this project, we hope to identify ways in which land-grant universities can better assist agricultural water users and managers with the challenges they are facing.
Here, we briefly report on our progress with the research, which includes in-depth exploratory interviews and survey and mapping activities.

The Interviews
We have completed in-depth telephone interviews with more than sixty farmers, ranchers, and water managers in all seven CRB states. Our other university partners helped us identify areas of high significance for agricultural water within each state and assisted us in contacting potential interviewees. We asked interviewees open ended questions about what they felt were the main pressures, if any, on agricultural water, how farmers were responding, how they saw the future of agricultural water, and how land-grant universities might help. Although we are in the process of analyzing the rich information from these discussions, below we provide some preliminary thoughts on what we have learned.

The Survey
The project team will be administering an online survey of farmers and ranchers in selected counties of Colorado and Arizona who use Colorado River water. The survey will address similar topics as those covered in the interviews, but will gather information from a broader audience in order to help formulate collective solutions to keep irrigated agriculture viable in the Colorado River Basin. The survey seeks to:

(a) Identify what CRB agricultural water users think about the current and future state of their water supplies and production activities
(b) Identify and compare the attitudes, beliefs, and perceptions held by agricultural water users towards the changes and pressures they are/are not facing with their water supplies, changes in water law and policy, and how to meet future water demands
(c) Gather data on agricultural producers' interest and involvement in temporary and permanent agriculture water transfers and water banks
(d) Identify how agricultural producers work cooperatively with other agricultural and non-agricultural stakeholders
(e) Identify how land-grant universities can better assist farmers and ranchers with the challenges they are facing, or will be facing with regard to their agricultural water
(f) Gather ideas for projects, partnerships, and other initiatives to work with agricultural producers to help address the challenges they are facing with regard to their water and operations

The GIS Mapping Activities
The project team conducted a mapping exercise in December 2011 with approximately 40 agricultural representatives from the CRB. A geospatial database is being created to help us better understand how agricultural water is administrated and managed in the seven CRB states. Data collected includes:

- Political jurisdictions including counties, states, tribal lands, counties, and municipalities
- Hydrologic boundaries defined both by state and by hydrologic unit

- Agricultural water jurisdictions within the basin including Bureau of Reclamation projects, irrigation districts, water conservancy districts and conservation districts, water users associations, and private irrigation and ditch companies
- Environmentally sensitive areas such as salinity control areas, designated wild and scenic stretches of the Colorado River and tributaries, and areas where endangered species are identified as of concern or are actively being protected

Maps have also been an integral part of the interview process. With help from water leaders in each state, we created maps to help us locate areas where agricultural water is especially important and where we needed to interview individuals and key water organizations' representatives (see Figure 2 for interviewee locations). Though the interviewees' identities are confidential, during the interviews we referenced digital maps showing local political jurisdictions, waterways and other features to help us locate our discussion in the complex geographic space occupied by the interviewees.

All of the base maps were created from a comprehensive geospatial database of the CRB that is being developed under the direction of Melinda Laituri (see both articles on agricultural water governance and agricultural lands in this issue).

Preliminary Results from the Interviews

Agricultural water users across the CRB are of course, very diverse. They operate across geographical contexts that vary from Upper to Lower Basin, high-altitude to sea level areas, and from forested to semiarid regions. They engage in a wide range of agricultural activities, from cattle ranching and cropping of pasture, alfalfa, and small grains, to high value vegetables, fruits, nuts, and more. Agricultural water users and managers operate under the 1922 Colorado River Compact and the Law of the River, yet each state provides distinctive frameworks for agricultural water use, management, and transfer. Agricultural water users and managers operate in a complex set of organizational contexts, from individual surface water diverters and groundwater users to ditch companies, irrigation districts, and water conservancy districts. Nevertheless, agricultural water users and managers report a number of common challenges (though their experience of them is shaped by geographic location, the history and seniority of their water rights, the type of agriculture and ranching, the proximity of urban areas and other competing water users, etc.).

These common challenges include uncertain water supplies, extended drought and the threat of climate change, and competition and conflicts with other water users within agriculture and from energy, environmental, recreational, and municipal/industrial sectors. Many respondents have talked about the need for storage to manage effectively for multiple use and conservation but often express concern about the barriers posed by negative public views of storage and time-consuming and expensive permitting processes. Conjunctive management of surface and groundwater poses increasingly complex problems of water access and management. Many have commented on how government regulatory frameworks, especially the Endangered Species Act, the National Environmental Protection Act, the Clean Water Act, and health and safety regulations, have fundamentally changed not only how water is used, but agricultural production itself. Many farmers have expressed concern about the need to strengthen public understanding of the importance of agriculture for a secure and healthy food supply. Many also have observed that the key role irrigated agriculture plays in creating ecological and amenity values is not well understood by many in the environmental and recreation communities. Others have remarked on the increasingly litigious environments in which discussions of water are occurring and suggested that more real progress can be made when people can stay out of court. Our interviewees have also spoken, often with great poignancy, about uncertain futures for family farms and agribusinesses as younger generations choose not to continue in agriculture. Numerous interviewees have spoken of farming's future as one integrated with growing cities, with fewer traditional operations and many smaller "amenity" farms. Some farmers spoke of selling parts of their land and water rights to developers or even acting themselves as development investors, with returns reinvested in agriculture elsewhere or in helping secure their retirement.

It seems clear that agricultural water users are not affected the same way by the challenges facing them today. Many interviewees describe themselves as positioned to move ahead and either surmount these challenges or adapt to them in new and productive ways. These well-positioned users of agricultural water are found in all parts of the CRB represented by our interviews. Yet agriculture and agricultural water is described as strongest where geographic and climatic conditions allow highly productive agriculture with year-round, high-value commercial cropping. Water users with the most senior water rights are more cushioned from the uncertainties of an intensively used river and of supplies threatened by extended drought and predicted climate change. Though having urban areas nearby generally

results in significant pressures from non-agricultural water demands, transportation and communication infrastructure also mean lower costs of production and marketing. Significantly, it is in these areas that interviewees spoke more consistently of new generations entering farming, ranching and related agribusiness.

Agricultural water users working in geographical areas where climatic and soil conditions pose higher obstacles to productivity, shorter growing seasons, and greater isolation from markets face special challenges in adapting to new water pressures. More of these respondents spoke poignantly about their sense of the threats to a traditional farming way of life, as their children seek futures outside of agriculture. Yet these interviewees are clearly not giving up; on the contrary, they express deep commitments to what is in many cases, multi-generational investments in their land, water and agricultural way of life. They also express a strong commitment to providing food for our society, and their concern for national food security. Moreover, they are working hard to develop innovative ways to protect their water and their communities.

Indeed, interviewees throughout the CRB have talked about innovative strategies they are developing to overcome or adapt to pressures on agricultural water. In many areas, as in California, Arizona, and Colorado, agricultural water users and managers have embarked on new agreements with large urban water users to develop water supplies for multiple objectives, including urban, environmental, recreation, and agriculture. Several water managers have described their organizations' services to multiple user groups and their need to plan for more urban and municipal demands while maintaining support for agriculture. In several areas, such as Wyoming, Colorado, and New Mexico, multi-stakeholder forums and organizations have formed to try to manage conflicting claims and perspectives on water by bringing agriculture, environmental, recreation, and other groups to the negotiating table. These initiatives are not easy and have had mixed results, but participants in successful experiences have spoken of what can be achieved with key visionary leaders, a focus on common interests of all parties in healthy local economies and riparian ecologies, willingness of all user groups to compromise, and a commitment to generating concrete results quickly, even if on a small scale. Other innovative responses reported by interviewees include diverse groundwater recharge programs, formal and informal water banking, and a range of leasing mechanisms. Numerous interviewees have reported on innovative approaches to planning storage as a key to developing secure future supplies of water for multiple uses, including agriculture, environmental, and recreational uses.

What Needs to be Done?

Our interviewees have spoken of possible paths to a positive future for agricultural water. They suggest that the broader public might be helped to better understand the importance of irrigated agriculture, not just for securing high quality and safe food for our nation, but also for creating significant environmental and amenity values. As one Wyoming rancher put it, "This is an oasis in the high desert. But God didn't make the oasis. It's man-made. It takes lots of water, diverted regularly in almost impossible quantities to keep it that way." Interviewees remarked that regulatory frameworks could better recognize both the continuing need for a viable agriculture throughout the CRB as well as its obstacles. Competing water users/stakeholders could develop more effective ways to negotiate based on understanding if not agreement with other perspectives and the need for a strong agriculture in the future.

What is the Role of Land-grant Universities?

Most interviewees have expressed positive views of land-grant universities. They speak of the Extension agents who help them improve efficiency of irrigation technology and water management, introduce new seeds, and implement better soil practices. Interestingly, although most of our open-ended questions about the agricultural water community's challenges stimulated discussion of issues that are largely political, economic, social, and cultural in nature, relatively few respondents had experience with universities helping with these issues. This suggests to us that land-grant universities have an opportunity to bring to bear new kinds of social science research and outreach on the problems facing agricultural water users and managers, in addition to their traditional strengths in natural science and more technical disciplines.

Results from the Addressing Water for Agriculture in the Colorado River Basin project will be summarized and posted on the project website (www.CRBagwater.colostate.edu) in the spring of 2013.

Colorado and Arizona Water Institutes Plant Seeds for Agricultural/Environmental Collaboration

MaryLou Smith, Policy and Collaboration Specialist, Colorado Water Institute

Agriculture and the environment both stand to lose in the battle for water in the Colorado River Basin. Urban growth, climate change, and energy development are all poised to grab the water. Can agricultural producers and environmentalists join forces to protect their common interests?

Successful agriculturalists have always had to carefully steward the environment to make it produce for them. Environmentalists value the open space and wildlife habitat that agriculture provides. But ideological differences keep the two groups at odds:

- Do environmentalists value fish more than crops for people?
- Do farmers divert too much of the water away from the rivers?

Western water law gives priority for use of the water to those who first put it to beneficial use. But in the late 1800s, when most senior water rights were claimed for agriculture, no one envisioned a need for the environment to hold water rights. Today, we are trying a number of ways to find water for the environment, including "instream flow rights." But the highest bidder for these senior water rights is most often the urban sector. If both agricultural producers and environmentalists want to keep this water on the land and in the rivers and streams, how can they work together to accomplish this?

Among both groups are die-hard purists forming the polar ends of the continuum. But in between are pragmatic farmers, ranchers, and environmentalists who seek common ground. There are examples of this throughout the West. In order for agricultural and environmental stakeholders to recognize the great potential for common gain by working together, traditional barriers must be overcome. Trust building has been difficult in the settings the two groups typically find themselves, such as in endangered species conflicts or litigation—the groups usually fight instead of cooperate.

Partnering with the University of Arizona and funded by a Walton Family Foundation grant, the Colorado Water Institute at CSU staged field trips to show environmental and agricultural stakeholders in the Colorado River Basin how their counterparts in the Pacific Northwest are successfully working together to keep water in agriculture as well as in the streams.

Two separate trips were staged—one for 23 Arizona stakeholders in August and the second for 25 Colorado stakeholders in September. Both trips featured visits to agricultural sites in central Oregon. In both cases, the relationship building gained from agricultural and environmental stakeholders spending a full week together was as important a benefit as learning how Oregonians put together their creative multiple-gain agreements.

The goal: to set the stage for Ag producers and environmentalists in the Colorado River Basin to jointly identify and implement agricultural water conserving/water sharing strategies that result in freeing up water for the environment within the context of water scarcity and competition for water resources, while preserving agricultural productivity and rural economies.

Both trips took travelers to areas in Oregon, where irrigation efficiency improvements and other strategies have freed up water for the environment. Both trips included visits to the Upper Klamath Basin and the Deschutes Basin. In addition, the Arizona group toured projects on the Middle Fork of the John Day River.

The Colorado Trip

Colorado Water Institute's Reagan Waskom (director) and MaryLou Smith (policy and collaboration specialist) hosted the Colorado contingent. Participants included West Slope IBCC and Roundtable members, a student from the Yampa Valley studying water law, farmers from the Montezuma and Dolores Valleys, San Miguel and Mesa County ranchers, watershed groups, and those representing groups such as Colorado Water Trust, Trout Unlimited, The Nature Conservancy, and the Southern Ute and Ute Mountain Tribes.

Here are excerpts from their post-trip reflections:

- Both the Deschutes and Klamath Wood river basins face several drivers for flow restoration. These include the adjudication of tribal water claims, listed fish already within the basin or to be introduced, and state Wild and Scenic designations or other caps on new consumptive water development. Instead of continually resisting these drivers,

these basins have turned them into cash registers for concurrently improving irrigation systems and restoring river flows.

- The cooperative flow restoration projects we saw in Oregon were built from the ground up by breaking them into manageable steps and not attempting to develop and implement comprehensive plans from the outset. They first entered into temporary water deals, including forbearance and non-diversion agreements and full and split season instream leases, before making permanent transfers and allocations of conserved ditch losses or consumptive use to bolster instream flows.
- Oregon's leasing laws have created a dynamic and widely used system that allows for water to be leased on an annual basis. This short-term approach seems to allow farmers, ranchers, and irrigation companies the ability to move their water freely between irrigated lands and the market as they see fit. While concerns persist with leasing agricultural water in Colorado, it would be helpful to see Colorado follow Oregon's dynamic and progressive example of fully developing and conserving their water resources to achieve maximum public and environmental benefit while benefitting agricultural production.
- Oregon showed us the value and necessity of working within multi-stakeholder groups to achieve shared benefits. Whether it was the Upper Klamath Basin where ranchers were devising water conservation strategies in order to preserve adequate flows for fish and the tribes, or in the Upper Deschutes Basin where irrigation districts were working hand-in-hand with state and local conservation organizations on line and pipe ditches and developing hydropower, the collaborations involving a large number of partners were impressive.
- Area farmers and ranchers were losing water through their open ditches to evaporation and leakage. The cooperating agencies put a plan together to pipe the ditch and, in return for having the costs covered, the irrigation company gave a portion of the saved water for instream flow to improve the river ecosystem and fish habitat. This collaboration avoided costly and divisive litigation as well as created more water for agricultural production.
- We could better manage our water resources by allowing greater flexibility in rules specific to an individual river basin rather than just statewide rules.
- The Conserved Water statute in Oregon would not work in the same manner here, but I do think there is potential for some kind of rule that would encourage and reward water users for conserving water and decreasing historic consumptive use. Using agricultural water more efficiently often has the added benefit of improving water quality and can reduce labor requirements, so anyone who helps make infrastructure improvements needed for such conservation financially possible can incur significant benefits to both his operation and the river system.
- Building hydroelectric plants on irrigation canals in Oregon is something that could be done here in Colorado. Since many of our systems have greater elevation head than exists Oregon, the potential may be even greater. If interests in our state could work together to improve the regulatory environment to allow such projects, it could help provide financing for needed water infrastructure improvements while decreasing our dependence on non-renewable energy.
- I was struck by the point made by Marc Thalacker of Three Sisters Irrigation District. He said in all their negotiation sessions with the environmental community, they focused on things the parties could agree on instead of those things they could not agree on. That gave them a very strong start at collaboration.
- The trip had characteristics of a retreat; energizing with focused discussions. The diverse Colorado contingent brought up many discussions between those of different basins—points of view that might not have been expressed without the travel and time spent away from daily pursuits.
- The passionate testimonies from the cattle ranchers in the Klamath Basin were remarkably powerful. When water users see a noticeable improvement in stream health by making small changes to their water use, they become more likely to protect the resource because of a sense of ownership in the solution.

A Success?

Participants from both states have already begun strategizing ways in which they might apply what they learned. Here is a statement from one of the participants that sums up the trips' success: "I look forward to using the knowledge gained from this trip to help me recognize and think 'bigger' about the opportunities that exist in my own state."

Paleohydrology of the Lower Colorado River

Balaji Rajagopalan, Environmental and Architectural Engineering, University of Colorado

The State of Colorado draws a substantial portion of its water supply from the Colorado River. The reliability of this supply is a function of natural hydrologic variability, upon which anticipated changes in future climate will be superimposed. Thus, it is extremely important to understand the range of this natural variability in the basin streamflows so as to obtain a robust estimate of the water supply risk and consequently, devise effective management and planning strategies. Observed flow data that are limited in time (~100 years) cannot provide the full range of variability, even with stochastic models built on them. Paleohydrologic reconstructions of annual flow using tree rings, however, provide much longer (500-1000+ years) records of past natural variability, and thus a much richer sampling of potential flow sequences, including severe and sustained droughts of greatest concern to water resource managers. Such reconstructions are available for the combined Upper Colorado River basin flows, but there is no equivalent data set for the Lower Basin. In this research we propose to develop a paleohydrologic reconstruction of the total Lower Basin streamflow. We will use all the existing tree-ring data and naturalized streamflow records, with a suite of statistical methods. The reconstructions from the different methods will be combined to provide an ensemble of flows in each year, thus providing an effective characterization of the uncertainty. A rich variety of streamflow ensembles will be generated for the entire basin using this and existing reconstructions for the Upper Basin to explore the basin-wide water supply risk, focusing on implications for the water resources of the State of Colorado.

Statement of the results or benefits: The principal data set generated by this study will be time-series of annual flows, extending back at least 500 years before ~2002, for gage locations which in sum represent the runoff for the Colorado River between Lees Ferry and the Northern International Boundary. These annual flows can then be used, either alone or in combination with the equivalent data sets for the Upper Basin, in further analyses and as inputs to water system models (e.g., Reclamation's CRSS model), to assess water supply vulnerability and risk for the Colorado River Basin and the State of Colorado's share of basin water supply. In fact, the third objective of this project (see below) is to use the reconstructed flows in exploratory analyses for risk assessment. We anticipate that the new flow reconstructions would also be used by other investigators for further modeling and analyses, as with previous paleo-reconstructions for the Colorado River Basin.

Nature, scope and objectives of the project: The natural flow of the Colorado River at the NIB is effectively the sum of three components: (1)The Upper Basin natural flows: the Colorado River at Lees Ferry, AZ (2) Intervening natural flows on the mainstem between Lees Ferry and Imperial Dam (including tributary flows from the Little Colorado R., Bill Williams R., Virgin R., and others) (3) The natural flows of the Gila River at its confluence with the Colorado between Imperial Dam and the NIB.

Component (1) has already been reconstructed using paleohydrologic methods (Woodhouse et al. 2006, Meko et al. 2007). Components (2) and (3), which constitute the Lower Basin flows, have been partially addressed with previous paleohydrologic work (see Related Research, below), but have not reconstructed in their entireties so as to allow the summation of paleo-flows for the Lower Basin and the entire Basin. Thus, the scope of this project is the generation of paleohydrologic reconstructions of annual flows for the intervening flow between Lees Ferry and Imperial Dam (2) and the Gila at its mouth (3). The climatological and hydrologic characteristics of the basins that contribute to (2) and (3) are sufficiently different that they will be reconstructed separately. The main objectives of this proposal are (i) to develop paleo-reconstructed annual streamflows of the Lower Basin (2 and 3) using all available tree ring chronologies using a suite of statistical techniques, (ii) disaggregate these flows to other locations on the river in the lower basin and (iii) demonstrate the utility of the reconstructed flows in water resources management and system risk estimation in the entire basin.

Budget: $29,964

Student Projects

FY12 Student Water Research Grant Program

Request for Proposals

The Colorado Water Institute announces a request for proposals for the FY12 Student Water Research Program.

Program Description

This program is intended to encourage and support graduate and undergraduate student research in disciplines relevant to water resources issues and to assist Colorado institutions of higher education in developing student research expertise and capabilities. It is intended to help students initiate research projects or to supplement existing student projects in water resources research. Proposals must have a faculty sponsor and students must be enrolled fulltime in a degree program at one of Colorado's public 4-year Universities.

Funding

Budgets may include, but are not limited to, expenditures for student salaries, fringe benefits, supplies, services, travel, and other direct costs. Funds will **not** be approved for faculty salaries, student tuition, or equipment*. All awards are limited to a maximum of $5,000. Research projects should begin March 1, 2012 and be completed by February 28, 2013. Only direct costs are allowed for these research grants. Facilities & Administrative (F&A) costs may be shown as institutional cost share. Institutions are encouraged to participate in project costs although cost sharing is not required.

Eligibility

Students must be enrolled full-time in a degree program at one of the nine Colorado public universities. Proposals must have a faculty sponsor from the applicant's institution. The faculty sponsor is responsible for ensuring that the proposal has been processed according to their university's proposal submission policies and procedures.

Submission Process

All proposals must be submitted online by 10/17/2011. Please visit http://cwi.colostate.edu for submission site.

Announcement of Awards

The student applicant and faculty sponsor will be notified as to the status of their application by January 2012 vi a email, pending availability of federal funds.

Deliverables

Upon completion of the research project, recipients will be required to submit a final project report, which will include:
Narrative on research activities
Project results
High-quality photos of students and faculty advisor conducting research of the project
Financial accounting of all expenditures
Final project reports may be published in the *Colorado Water* newsletter
Students may be asked to present an oral report on their work to the CWI Advisory Board
Projects must be completed by February 28, 2013. The final project report will be due no later than March 31, 2013.

Proposal Deadline

Monday, October 17, 2011 at 5:00 PM (MST)
Expected Award/Start Date
Start Date: March 1, 2012
End Date: February 28, 2013

Program Contact Information

Dr. Reagan Waskom, Director
reagan.waskom@colostate.edu
Nancy Grice, Assistant to the Director
nancy.grice@colostate.edu
Phone: 970-491-6308
Web: http://cwi.colostate.edu

* Equipment: Non-expendable property having a useful life of more than one (1) year and an acquisition cost of more than $5,000 per unit.

Ecosystem Services, Biodiversity and Irrigation Inefficiencies

Jeremy Sueltenfuss, M.S. Candidate, Ecology, Colorado State University
Rick Knight, Professor, Human Dimensions of Natural Resources, Colorado State University

Abstract: In order for agriculture to be successful in northern Colorado's semi-arid environment, irrigation canals have been in place for over 100 years to deliver a limited supply of water to water deficit lands. Due to the high amount of water that is lost through seepage, canals are often blamed for being "inefficient." These seepages are the center of debate between economists, managers, regulators, irrigators and environmentalists who argue that leakage results in wasted water which could be put to better use. As cities along the Front Range continue to increase in population, water transfers from agriculture to urban areas are expected to rise dramatically, consequently drying up many irrigation canals. I set out to challenge the notion that canal seepage leads to water that is truly lost by looking at the role of these seepages in creating wetlands. Wetlands are a supply of many important ecosystem services and are a limiting factor for many species in the west. Over the 2011 irrigation season, I mapped all the wetlands and characterized their vegetation within the boundary of the North Poudre Irrigation Company (NPIC) located in Larimer County, Colorado. To look for possible hydrologic connections between wetlands and irrigation canals, I installed 72 groundwater monitoring wells and six further pressure transducers in 21 wetlands across the NPIC area to monitor fluctuations in groundwater. These fluctuations in wetland groundwater were compared to daily records of adjacent canal flow. To provide further evidence of a hydrologic connection between wetlands and adjacent irrigation canals, water samples from 40 wetlands and each associated canal were collected and analyzed for their stable oxygen isotope ratio of $\delta 18O/ \delta 16O$. Ten of these samples were further analyzed for total ion and cation makeup. A total of 182 wetlands with a total area of 1,300 acres were mapped across the NPIC area. Preliminary results from groundwater wells show that the groundwater in many of the study wetlands respond to fluctuations in canal flow. Wetland groundwater levels showed a dramatic rise once the canals started transporting water at the beginning of the irrigation season. If wetlands across the NPIC area are hydrologically connected to irrigation canals, it can be argued that many wetlands across the irrigated regions of Colorado may show a similar trend. If this is the case, future water transfer locations should be carefully thought out to mitigate wetland loss due to the drying of irrigation canals.

Budget: $25,000

3D Modeling of Fish Passage in Colorado Whitewater Parks

Nell Kolden, M.S. Candidate, Hydraulic Engineering, Colorado State University
Dr. Brian Bledsoe, Associate Professor, Department of Civil Engineering, Colorado State University

Purpose of Study: Whitewater parks have become a popular recreational amenity in cities across the United States with Colorado being the epicenter of whitewater park (WWP) design and construction. An improved understanding of the fundamental hydraulic processes and potential environmental effects of WWPs is needed to inform management decisions about Recreational In-Channel Diversions. The Colorado Department of Wildlife (CDOW) has partnered with Colorado State University M.S. candidate Brian Fox to track fish passage through whitewater parks and determine how the parks affect longitudinal connectivity in Colorado rivers. Data is currently being collected for this study in the St. Vrain River in Lyons, CO, where PIT antennas have been installed to monitor fish movement.

This existing study can benefit greatly from 3D modeling of the WWPs and fish passage. Currently the project includes 1D modeling with FishXing and HEC-RAS, but the features in these parks create flow that is highly three-dimensional. Eddies and drops cannot be accurately represented in one-dimensional models. Three-dimensional modeling can be completed using FLOW-3D and ELAM (Eularian-Lagrangian-Agent Method). ELAM is a new software developed by the Army Corps of Engineers and is not yet widely used in academic settings. The model uses a mathematical approach to predict movement behavior patterns of fish in a river environment.

Partnering proposals are being submitted to the CWI by Brian Fox and myself to fund the development of these multidimensional models. Brian Fox will be requesting funding for additional field surveys and an academic FLOW-3D license, while I am requesting funding for model development.

Research Objectives
This project proposes to add the following research objectives to those in the existing CDOW/CSU study being conducted Brian Fox:

- Development of a 3D model of the study site using FLOW-3D.
- Modeling of fish passage through the WWP using ELAM.
- Evaluation of the accuracy and efficiency of 3D modeling for WWPs in Colorado in comparison to 1D and 2D modeling approaches.

Methodology
Development of these models will require more detailed bathymetric data than currently exists for the area. Surveys will be completed in Spring 2011 using existing CDOW and CWI funding. Bathymetry data will be used in FLOW-3D to develop a hydraulic model of the WWP. This model will be validated against measured field conditions at various discharges and adjusted as needed. Output from FLOW-3D will be used to develop the ELAM model and predict passage and movement of multiple fish species and sizes. The results of this model will be compared to fish passage data collected throughout the year.

Expected Results

- 3D hydraulic models of study area at different flow conditions.
- Validation of model with actual fish passage data.
- An evaluation of the applicability of FLOW-3D and ELAM to fish passage in Colorado WWPs and recommendations for future studies.
- Comparison of 3D model results to those from 1D and 2D models.

Results will be presented at CSU hydrology days and included in Master's theses written by Brian Fox and Nell Kolden.

Budget: $5000

3D Modeling of Fish Passage in Colorado Whitewater Parks

Brian Fox, M.S. Candidate, River Mechanics/Stream Restoration, Colorado State University
Dr. Brian Bledsoe, Associate Professor, Department of Civil Engineering, Colorado State University

Purpose of Study: Whitewater Parks have become a popular recreational amenity in cities across the United States with Colorado being the epicenter of whitewater park (WWP) design and construction. An improved understanding of the fundamental hydraulic processes and potential environmental effects of WWPs is needed to inform management decisions about Recreational In-Channel Diversions. The Colorado Department of Wildlife (CDOW) has partnered with Colorado State University M.S. candidate Brian Fox to track fish passage through whitewater parks and determine how the parks affect longitudinal connectivity in Colorado rivers. Data is currently being collected for this study in the St. Vrain River in Lyons, CO, where PIT antennas have been installed to monitor fish movement.

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Results will be presented at CSU hydrology days and included in Master's theses written by Brian Fox and Nell Kolden.

Budget: $5,000

Biowin Simulation to Assess Alternative Treatment Units for a Local Wastewater Treatment Plant to Meet the New Effluent Nutrient Regulations

Keerthivasan Venkatapathi, M.S. Candidate, Environmental Engineering, Colorado State University
Pinar Omur-Ozbek, Assistant Professor, Civil and Environmental Engineering, Colorado State University

Abstract: Colorado Department of Public Health and Environment is updating Regulation 31 and creating Regulation 85(3) (to be passed around early 2012) to reduce the nutrient loadings to lakes and streams by wastewater treatment plant (WWTP) effluents. Of the four effluent nutrient tiers, Tier 2 is expected to be the basis for the existing publicly owned treatment works (POTWs) (>1.0 MGD) as the limits can be achieved with conventional biological nutrient removal (BNR) technology. For Tier 2, effluents should not contain total phosphorus and total inorganic nitrogen above 1 and 10 mg/L, respectively. City of Loveland WWTP is selected as the model system for this research. It has a 10 MGD capacity and a conventional step-feed activated sludge process which operates effectively to meet the current regulatory effluent requirements. When the Regulation 85 goes into effect, Loveland WWTP, as well as many other CO WWTPs, will be required to meet the new effluent limitations by the next permit round. Hence it is essential for the WWTPs to proactively look for alternative options to update their treatment systems to meet the new regulations.
Budget: $5,000

Reconstructing a Water Balance for the San Luis Valley: Streamflow Variability, Change, and Extremes in a Snowmelt Dominated Internal Drainage Basin

Niah Venable, M.S. Candidate, Watershed Science, Colorado State University
Steven Fassnacht, Associate Professor, Ecosystem Science and Sustainability, Colorado State University

Abstract: The San Luis Valley in Colorado is an agriculturally productive region that relies on streamflow from the surrounding mountain ranges to recharge the important aquifer systems of the basin. The northern part of the valley is a closed system separated from the southern portion both topographically and hydrologically (Anderholm, 1996). Past hydrologic investigations focused primarily on subsurface characterization to manage irrigation production in the arid region (e.g. Anderholm, 1996). Surface streamflow however, is critical for sustaining natural systems and likely supported the historic local human population. The purpose of this study is to assess the natural variability, extremes, and changes in streamflow of the San Luis Valley basin over a longer period than the instrumented record. The objectives are to compare the modern water balance and streamflow of a catchment draining into the basin with that reconstructed from paleo-climatic data derived from tree-rings. This study will examine how natural systems in a closed basin function over longer periods which may define possible impacts of future change.
Budget: $4,945

Quantifying Risks Producers Face when Entering Agricultural Water Lease Contracts

Larisa Serbina, M.S. Candidate, Natural Resource Economics, Colorado State University
Chris Goemans, Assistant Professor, Department of Agricultural and Resource Economics, Colorado State University

Abstract: Agricultural producers throughout southern Colorado are currently suffering through drought conditions comparable to 2002. Water shortages have lead to reductions in output and lost revenues for the agricultural sector. Initial revenue losses associated with lost production represent only a portion of the full economic impact to these regions. Through linkages with other producers in the region, reductions in economic activity can be twice the direct impacts and therefore accurate estimates of their magnitude are critical to policy makers. Current approaches to estimating these impacts (e.g., Implan) assume that the relationships between industries remain constant through drought and non-drought periods. The objective of this study is to develop a better understanding of how the linkages within local economies evolve in response to prolonged drought. The proposed project is critical for developing an accurate and complete picture of the immediate and long-term economic impacts associated with drought.
Budget: $5,000

Using Water Chemistry to Characterize the Connection between Alluvial Groundwater and Streamflow Water Under Augmentation at the Tamarack Ranch State Wildlife Area, Colorado

Jason Roudebush, M.S. Candidate, Watershed Science, Colorado Water Institute
John Stednick, Professor, Forest Rangeland Watershed Stewardship, Colorado Water Institute

Abstract: This research is meant to better characterize the hydrologic connection between alluvial groundwater and streamflow water chemistries as affected by augmentation at TRSWA. The research will investigate alluvial groundwater chemistry in relation to the chemistry of streamflow water under augmentation - during periods of pumping and non-pumping. Previous research at the TRSWA project shows two distinctly different chemical identities for the water sources. The groundwater is a calcium bicarbonate type water and the streamflow is a sodium/calcium-sulfate type (Beckman, 2007). By using an 2 end member mixing analysis the groundwater can be characterized as a contribution to overall streamflow. Research objectives include: (1) Characterize the stream and groundwater chemistry during periods of pumping and non-pumping. (2) Use the chemical characteristics of these waters, compiled with the historical record in an end member mixing analysis of streamflow and groundwater.
Budget: $5,000

The Short and Long-Term Impacts of Drought on the Structure of Regional Economics: Investigating the Farm Supply Chain

Ron Nelson, M.S. Candidate, Environmental and Resource Economics, Colorado State University
Chris Goemans, Assistant Professor, Department of Agricultural and Resource Economics, Colorado State University
James Pritchett, Associate Professor, Department of Agricultural and Resource Economics, Colorado State University

Abstract: Agricultural producers throughout southern Colorado are currently suffering through drought conditions comparable to 2002. Water shortages have lead to reductions in output and lost revenues for the agricultural sector. Initial revenue losses associated with lost production represent only a portion of the full economic impact to these regions. Through linkages with other producers in the region, reductions in economic activity can be twice the direct impacts and therefore accurate estimates of their magnitude are critical to policy makers. Current approaches to estimating these impacts (e.g., Implan) assume that the relationships between industries remain constant through drought and non-drought periods. The objective of this study is to develop a better understanding of how the linkages within local economies evolve in response to prolonged drought. The proposed project is critical for developing an accurate and complete picture of the immediate and long-term economic impacts associated with drought.
Budget: $5,000

Winter Precipitation Variability in the Colorado Rocky Mountains

Andrew Muniz, M.S. Candidate, Meteorology, University of Northern Colorado
Nolan Doesken, Sr. Research Associate, Atmospheric Science, Colorado State University

Abstract: Varying winter precipitation influenced by seasonal or multi-seasonal weather events pose profound challenges for outdoor recreation, Colorado agriculture and water management. The purpose of this research project is to examine annual winter climate variability which will influence forecasting predictions in surface water supply to Colorado.
Budget: $5,000

Assessing the Benefits and Drawbacks of Different Institutional Arrangements to Enhancing Forest and Water Ecosystem Services and Ecosystem Services Markest in Colorado

Heidi Huber-Stearns, M.S. Candidate, Forest Sciences, Colorado State University
Tony S. Cheng PhD, Associate Professor, Department of Forest & Rangeland Stewardship, Colorado State University

Abstract: The purpose of my study is to contribute to a Colorado State University and Agricultural Experiment Station research project assessing the benefits, drawbacks and potential applicability of involving various institutional arrangements in the protection and enhancement of forest and water related ecosystem services in Colorado watersheds.
The overall project proposes to inform future Payment for Ecosystem Service (PES) capacity and institutional arrangement development in Colorado, as well as directly advise a water quality improvement pilot payment program in Northern Colorado. This project is focused on institutional actors such as federal land management agencies and collaborative decision making arrangements as potential ecosystem service "providers", and public and private sector entities such as water municipalities and brewing companies as "beneficiaries" of those ecosystem services. My study will contribute to this overall collaborative research project, informing project steps and results.
Budget: $5,000

Thermal preference of age-0 stonecats (Noturus flavus): Are thermal water quality standards protective for this species?

Adam Herdrich, M.S. Candidate, Fisheries Biology, Colorado State University
Dr. Christopher Myrick, Associate Professor, Fish, Wildlife, and Conservation Biology, Colorado State University

Abstract: Stonecats are only found in restricted sections of two river drainages, the St. Vrain River near Longmont, CO and the Republican River near Wray, CO (Figure 1). They are found in riffle and pool sections of warmer rivers and are intolerant of water pollution derived from agriculture (Gammon and Gammon 1993; Duehr et al. 2006) and increased suspended solids (Bergstedt and Bergersen 1997). In the St. Vrain River, stonecats overlap with common shiner populations, which currently have special protection from thermal pollution through a Tier-1 Warm Water thermal standard (Regulations #31 and #38, WQCD). My study is aimed at determining whether this standard is also protective for stonecats.
Budget: $4,858

Structural and Functional Controls of Tree Transpiration in Front Range Urban Forests

Edward Gage, M.S. Candidate, Ecology, Colorado State University
Dr. David Cooper, SR Research Sci/Scholar, Department of Forest & Rangeland Stewardship, Colorado State University

Abstract: Most Colorado cities and towns pride themselves on their trees, which provide many critical ecological and aesthetic benefits. Urban water use by turfgrass has been extensively studied, but we know very little about patterns and processes of water use for urban forests. Urban forests are structurally complex and compositionally diverse, supporting trees widely differing in age, size and basic functional characteristics. How these factors influence basic ecohydrological processes and urban water budgets remains poorly understood, particularly for Front Range urban forests.
Budget: $5,000

Novel Technique for Evaluation of Dissolved Organic Material (DOM); research methodology and lab protocol development using a FluidImages Flowcam on lake water samples across the state of Colorado

Alia Khan, M.S. Candidate, Water/Environmental, University of Colorado (Boulder)
Diane McKnight, Professor, Civil and Environmental Engineering, University of Colorado (Boulder)

Abstract: Previous research suggests that production of nonhumic DOM can be related to chlorophyll-a concentrations. In recent years, increases in dissolved organic carbon (DOC) concentrations in surface waters have been documented in many northern temperate regions and the underlying processes of the affects of increasing DOC on aquatic ecosystems and drinking water quality are not yet fully understood. Furthermore, DOC has been directly correlated to the formation of potentially carcinogenic, chlorinated disinfection by-products (DBP's). Characterization of the relationship between varying DOC qualities (such as terrestrial versus humic, or certain types of algal species) to DBP formation is not yet fully understood. Part of this reason is due to the complexity and time consumption for source identification of DOC quality.
Budget: $4,500

Large Aperture Scintillometers for Evapotranspiration (ET) Evaluation

Evan Rambikur, M.S. Candidate, Irrigation and Drainage Engineering, Colorado State University
Jose Chavez, Assistant Professor, Civil and Environmental Engineering, Colorado State University

Abstract: Irrigation water management can be more effective and accurate when the crop consumptive use (CU), or ET, is known. This allows for more intelligent application of water by irrigators in arid and semi-arid regions. This is one reason for much needed research on different methods of evaluating ET. Local estimates of ET can be made directly by precision-weighing lysimeters. In addition, through measurement of the structure parameter of the refractive index of air (turbulence), the sensible heat flux, and subsequently ET, can be determined using a Large Aperture Scintillometer (LAS, Kipp and Zonen, The Netherlands) and the land surface energy balance (EB) equation. This LAS-EB method allows for spatially averaged estimates of crop or vegetation ET over a range of approximately 100m to 4.5km. Therefore, the instrumentation can potentially be validated by point estimates of ET (e.g. Lysimeter) and used to validate regional estimates of ET (e.g. Remote Sensing (RS) based). Further validation of LASEB ET estimates could be conducted using a soil water budget, where moisture deficit (soil moisture) and precipitation parameters can both be sensor monitored.
Budget: $4,740

The Efficacy of the Use of Moringa Oleifera Seeds to Remove Metabolites of Cyanobacteria from Drinking Water

Victor Sam, M.S. Candidate, Civil & Environmental Engineering, Colorado State University
Pinar Omur-Ozbek, Assistant Professor, Civil and Environmental Engineering, Colorado State University

Abstract: The proposed work aims to study the occurrence and removal of the cyanobacterial metabolites microcystin-LR, geosmin and 2-MIB in source waters (1,2). Microcystins are potent hepatoxins which can cause severe cases of gastro-enteritis and hepato-enteritis (i.e. liver damage) (3,1). Geosmin (trans-1,10-dimethyl-trans-9-decalol) and 2-MIB (2-methylisoborneol) are odorous compounds that causes earthy and musty odors in drinking water, respectively (2). Recently it was shown that microcystins usually co-occur with such taste-and-odor compounds (4). Since geosmin and 2-MIB can be detected by the human nose at very low concentrations (2), the surveillance of harmful toxins may be easily performed due to the co-occurrences of the metabolites.

Currently, there is not a cost-effective and sustainable method to treat source water for these detrimental metabolites. That is why the moringa oleifera tree seed will be studied in this project for its ability to treat water. The moringa oleifera seed has already been used for many purposes in third world countries, serving as a source of food, medicine, and more recently an effective coagulant for water treatment. The seed, which is grown in most parts of the world, eliminates the addition of synthetic chemicals (5).
Budget: $4,980

Aquifer Storage and Recovery Optimization

Anne Maurer, M.S. Candidate, Groundwater Engineering, Colorado State University
Tom Sale, Civil and Environmental Engineering, Colorado State University

Abstract: Increasing demands for water and finite resources are driving a need for more efficient water storage systems. An emerging strategy is aquifer storage and recovery (ASR). With ASR seepage and evaporation loses can be minimized. Furthermore, peak capacities of key infrastructure elements such as surface water storage, water treatment plants, and pipelines can be reduced. Unfortunately, resolving necessary infrastructure, timing of aquifer storage and recovery is a complex process. Key factors governing infrastructure and operations include timing of water delivery, water quality, and timing of demands. The purpose of the study will be to develop an optimization model that can be used to: -Resolve appropriate infrastructure and operations for ASR. -Develop feasibility level cost estimates. Preliminary work has been completed in this effort with support from the Town of Castle Rock, Dr. Sale faculty startup funds, and a senior design project. Matching support for this project will be provided by the Town of Castle Rock.
Budget: $5,000

Environmental Impacts of Ag-to-Urban Water Rights Transfers in the South Platte River Basin

Meagan Smith, M.S. Candidate, Hydrologic Science and Engineering, Colorado State University
Dr. Mazdak Arabi, Assistant Professor, Civil and Enviormental Engineering, Colorado State University

Abstract: Colorado's population is projected to increase nearly 40% by the year 2030; resulting in an estimated increase in water demand between 300,000 and 600,000 acre-feet (CWCB, 2004). While conservation will be heavily relied upon, transfers of water out of irrigated agriculture are anticipated to meet the majority of new demands. The South Platte River Basin is projected to lose as many as 226,000 irrigated acres by 2030 (CWCB, 2005). In recent years, however, there has been a greater push to keep water in agriculture whenever possible. This stems from the growing awareness of the public benefits of agriculture beyond its economic output; including the values associated with access to locally produced foods, open space, and wildlife habitat.
Budget: $5,000

Variables Controlling Reservoir Sedimentation in the Colorado Front Range

Umit Duru, M.S. Candidate, Geomorphology, Colorado State University
Ellen Wohl, Professor, Department of Geosciences, Colorado State University

Abstract: Sediment deposition can alter the storage capacity and operation of a reservoir. Numerous studies have been done on reservoir sedimentation, but site- and region-specific characteristics of sediment yield limit extrapolation of results between sites. One challenge in understanding reservoir sedimentation is that sediment yield to a reservoir varies spatially and temporally as sediment supply, storage, and mobilization from the contributing watershed change. This variability partly reflects regional characteristics such as lithology, rate of sediment generation, and mechanisms of sediment movement. The objective of this research is to evaluate the relative importance of parameters influencing sedimentation rate within and between reservoirs in the Front Range. The null hypothesis is that reservoir sedimentation correlates most strongly with the magnitude (spatial extent, frequency) of disturbance that alters land cover (e.g., forest fire) because disturbance can mobilize large volumes of sediment from the watershed. Increased disturbance by forest fire results in enhanced sedimentation in numerous sites across the Front Range. The alternate hypothesis is that reservoir sedimentation correlates most strongly with drainage area, relief, or elevation. The research will develop a GIS-based statistical model to determine the factors most important for reservoir sedimentation in the Front Range.
Budget: $5,000

INTERNSHIPS

CWCB - INTERNSHIP IN WATER RESOURCES RESEARCH

Computer Information Systems in the Environmental Sciences Interns

Andrew Baessler

Intern for Basin Needs Decision Support System (BNDSS)

Matthew Baessler

Instream Flow and Natural Lake Level Program archiving Intern

Jessie Hickey

Computer Information Systems in the Enviormental Sciences Intern

Craig Godbout

Annie Sligh

Davis Miller

USGS - INTERNSHIP IN WATER RESOURCES RESEARCH

MOWS - Modeling of Watershed Systems

Michael Sanders*

Emily Kuhr*

*Photo unavailable.

FY13 Research Proposals

FY13 CWI Faculty Research Proposals List

Faculty Department University	Proposal Title
Andales, Allan Soil and Crop Sciences CSU	Determination of Consumptive Water Use of Corn in the Arkansas Valley
Bau, Domenico Civil and Environmental Engineering CSU	Modeling the Influence of Conjunctive Water Use on Flow Regime in the South Platte River Basin Using the South Platte Decision Support System Groundwater Flow Model
Bledsoe, Brian Civil and Environmental Engineering CSU	Investigation of the Effects of Whitewater Parks on Aquatic Resource in Colorado: Year 3
Brummer, Joe Soil and Crop Sciences CSU	Assessing the Agronomic Feasibility of Single-Season Irrigation Deficits on Hay as part of a Western Slope Water Bank
Goemans, Chris Agriculture and Resource Economics CSU	Developing Metrics for Colorado Agriculture's Production and Efficiency with Water Resources
Goldstein, Joshua Human Dimensions of Natural Resources CSU	Mapping and Prioritizing Watershed-Scale Ecosystem Services and Biodiversity in the Upper Poudre River and Big Thompson River Watersheds

Determination of Consumptive Water Use of Corn in the Arkansas Valley

Principal Investigators:
Dr. Allan A. Andales, Assistant Professor of Irrigation and Water Science; Department of Soil and Crop Sciences, Colorado State University; Tel. (970) 491-6516; Email: Allan.Andales@colostate.edu (21 years of research and teaching experience in soil and water engineering; 4 years experience with the lysimeter project)

Dr. Michael E. Bartolo, Research Scientist; CSU-Arkansas Valley Research Center, Rocky Ford, CO; Tel. (719) 254-6312; Email: Michael.Bartolo@colostate.edu (Research Center Manager with expertise in horticultural and agronomic crop production; 7 years experience with the lysimeter project)

Mr. Lane Simmons, Research Associate; CSU-Arkansas Valley Research Center; Rocky Ford, CO; Tel. (719) 254-6312; Email: Lane.Simmons@colostate.edu (B.S. Agricultural Business with 2 years experience in construction, 10 years experience with data management and statutes enforcement for Colorado Department of Agriculture, and 5 years experience with the lysimeter project and the CoAgMet weather network)

Location where the work is to be conducted: This project will be conducted at the Colorado State University (CSU) – Arkansas Valley Research Center (AVRC), Rocky Ford, CO.

Purpose of the Research
The main purpose of this research is to improve the accuracy of crop evapotranspiration (ET; also called consumptive water use) calculations for the Arkansas River Basin of Colorado.

Need for the Research
One of the recommendations that came out of the Kansas v. Colorado Arkansas River Compact litigation is for Colorado to use the American Society of Civil Engineers (ASCE) Standardized Penman-Monteith equation (PME) to estimate crop ET in the Arkansas River Basin. This equation requires accurate measurements of hourly weather data (solar radiation, air temperature, humidity, wind speed) to calculate a reference crop ET (ETr), which is a measure of local atmospheric demand for water. Crop ET (ETc) is then calculated by multiplying ETr by a crop coefficient (Kc) that varies with crop growth and development.
This proposed project will continue the long-term research to date, to more accurately calculate the ETc of major irrigated crops in the basin, by defining the crop coefficients (Kc) used to convert ETr to ETc values and by validating (ground-truthing) the ETr values calculated by the ASCE-PME for local conditions in the Arkansas River Basin. Corn is a dominant irrigated crop in the basin and will be the focus of this project for years 2013 to 2014. The more accurate calculations of ETc will ultimately improve the estimates of river flow that are used to determine compliance with the Arkansas River Compact. Related to this, accurate hourly weather data from 12 automatic weather stations in the basin are continuously needed to calculate ETr and ETc for the entire basin. These weather stations are part of the Colorado Agricultural Meteorological Network (CoAgMet).
This work will also capitalize on the progress to date in validating calculated ETr from ASCE-PME with measured alfalfa ETr from the lysimeters.

Objectives
1. Develop a seasonal crop coefficient curve for corn that accounts for local environmental conditions in the Arkansas basin.
2. Assess the agreement between calculated alfalfa reference ET values from the ASCE-PME and measured alfalfa ET values from the reference lysimeter.

Deliverables:
The objectives will be achieved in close collaboration with engineers in the Colorado Division of Water Resources (CDWR). Updates on the project will be given to local stake holders, including the Lower Arkansas Valley Water Conservancy District, Arkansas Basin Roundtable, and local growers. The following will be the major deliverables of the project.
1. Seasonal crop coefficient curve that characterizes corn ETc (2013 growing season) at different developmental phases; and is appropriate for local conditions in the Arkansas Basin.
2. Observed seasonal consumptive water use (ETc) of corn (2013).

3. Accurate hourly weather data from 12 CoAgMet stations in the basin, made available through the CoAgMet online database.
4. Comparison of calculated alfalfa ETr from ASCE-PME and measured alfalfa ET from the reference lysimeter. A comprehensive analysis will be done of the behavior of the ASCE-PME under varying weather conditions in the Arkansas Valley. The analysis will reveal differences between ASCE-PME ETr and lysimeter-measured alfalfa ET in standard conditions. The specific weather conditions that cause significant differences will be characterized.
5. One technical report published by the Colorado Water Institute detailing the methods and findings of the CSU research team.

Completion Date:
This project will be conducted from July 1, 2013 to June 30, 2014.

Budget and Justification:
We are requesting $28,750. This amount includes a 15% Indirect of $3,750. This budget will partially pay for one full-time research associate, who will manage the day-to-day operation of the lysimeters, take all measurements, and process the data. The budget will also cover travel of CSU investigators, software, field and lab supplies, publication, and other miscellaneous expenses. The CSU Agricultural Experiment Station will provide matching funds for management of land and facilities at the Arkansas Valley Research Center and salary of CSU investigators.

Modeling the Influence of Conjunctive Water Use on Flow Regimes in the South Platte River Basin Using the South Platte Decision Support System Groundwater Flow Model

Dr. Domenico Baú, Assistant Professor, Department of Civil and Environmental Engineering, Colorado State University

Location of the Work: South Platte River Basin, Colorado

Background: The surface watershed of the South Platte River Basin (SPRB) lies on alluvial deposits that form an unconfined aquifer system connected with the surface water, with a thickness that reaches 200 ft in the lower SPRB. The aquifer, which sustains the base flow in the river, is recharged by infiltrations from precipitation and irrigation canals, as well as seepage from surface water bodies and streams. The SPRB constitutes a major source of water for eastern Colorado and has allowed agricultural growth to approach 1 million acres of irrigated cropland. Conjunctive use of surface and groundwater resources in the SPRB is regulated accordingly with the 1969 Groundwater Administration Act [Senate Bill 81], which requires all non-exempt groundwater rights to come into priority. Prior to 2003, about 9,000 groundwater irrigation wells were active in the SPRB [Nettles, 2011] with augmentation requirements of 5-10% of their water consumptive use in order to protect surface water rights. Following legislative changes that occurred in 2003-2004, water resources have been administered following strict priority rules since 2006, with all non-exempt wells required to have a decreed augmentation plan that replaces 100% of their stream depletion. As a consequence of the increased cost for acquiring augmentation water, in the last six years, about 4,000 wells have been totally or partially curtailed from pumping [Nettles, 2011], potentially resulting in reduced aquifer drainage and rising water table levels in several areas of the SPRB.

Purpose: In 2012, CSU started a research project funded by the Colorado Water Conservation Board (CWCB) to study the critical linkages between groundwater pumping for irrigation and the coupled groundwater/surface water regimes in the SPRB. This study has relied on the use of the alluvial groundwater flow model developed as a fundamental component of the South Platte Decision Support System (SPDSS). The SPDSS was developed starting in 2001 by the Colorado Department of Natural Resources (DNR), the CWCB and the Division of Water Resources (DWR) in order to support State officials and water users in the optimal planning and management of water resources [Colorado Water Conservation Board, 2001]. The SPDSS groundwater flow model has been developed by Camp Dresser and McKee [2008, 2011] using the USGS finite-difference groundwater flow code MODFLOW [Harbaugh, 2005]. The model simulates, on a monthly step, flow regimes over the entire area of the SPRB in Colorado (~2,500 mi2) during the period 1950-2006 and constitutes a crucial tool to support and improve the planning and management of water resources in the SPRB.

The long-term goal of this project is to provide the Colorado Water Conservation Board (CWCB) with an independent evaluation of the SPDSS groundwater flow model, highlighting model capabilities, strengths and weaknesses. The proposed project will be carried out over three years. In the first year, CSU has focused on the review of the SPDSS groundwater flow model, which included:

a) Analysis of model grid and time discretization to provide general considerations and directions regarding the spatial and temporal scales for which the SPDSS model seems most adequate as water management simulation tool;

b) Analysis of hydrogeological parameter distributions used in the model (hydraulic conductivity; storage properties, streambed conductance) to gain a general understanding of the extent to which the parameter distributions are representative of the SPRB hydrogeological setting;

c) Analysis of representativeness of hydrological stress data used in the model (time series of surface boundary and lateral flow conditions, groundwater pumping, and aquifer recharge) with respect to the SPRB hydrogeology;

d) Preliminary runs performed to test the numerical robustness and stability of the model with respect to hypothetical, yet realistic, changes in hydrologic stress conditions, thus assessing its ability to provide reasonable water level distributions under hydrologic stress conditions different than those utilized during model development and calibration.

Completion Date: The proposed project is conceived to be three-year long. Since funding is available only on a yearly basis, a proposal for renewal of funding is submitted to the CWCB at the end of each year. This proposal concerns works envisioned for the second year of the project.

Proposed Tasks for Year 2: It is anticipated, in the fiscal year 2013, the SPDSS groundwater flow model will be applied to perform a sensitivity study on the effect of hypothetical water management scenarios on groundwater/ surface water regimes in the SPRB. The SPDSS groundwater model will serve to the primary purpose of providing engineering-based evaluations of what-if scenarios, as a most crucial step in the decision- making process. These scenarios will focus on the following realistic conditions:

(i) Increased stream augmentation by aquifer recharge that reproduces quantitatively the changes in water administration practices enacted in 2006.

(ii) Changes in aquifer pumping based upon realistic estimates of the reduction in groundwater withdrawal and its spatial distribution across the SPRB that have occurred in the last six years.

(iii) Effects on groundwater and surface water flow regimes of hypothetical drought conditions in which snowmelt upstream inflows are reduced and evapo-transpiration is increased in relation to modified atmospheric conditions and rising water table levels.

Deliverables: At the end of the second year, a technical report describing project activities and findings will be submitted to CWCB. In particular, this report will include the results of the analysis conducted in the Tasks listed above. In addition, the PI will meet with CWCB representatives at least twice a year, either at the CSU campus, at CWCB offices or via teleconference, to best coordinate the project activities, discuss project progress and future direction.

Budget Justification: One Post-doctoral fellow and one PhD student will be involved and financially supported in this study. The Post-doctoral fellow will work part-time on the project (2 months), while the PhD student will be full-time (12 months). In addition the student will take courses necessary to obtain the mandatory coursework credits required towards the completion of the PhD degree at CSU, and will work exclusively in this project.

Investigation of the Effects of Whitewater Parks on Aquatic Resources in Colorado: Year 3

Dr. Brian Bledsoe, P.E., Associate Professor, Department of Civil and Environmental Engineering, Colorado State University

Location of the work: The research will be focused on several hydraulic structures along the Arkansas River near Salida, CO to test hydraulic modeling approaches and data resolution necessary for designing whitewater parks that do not impede fish passage. In addition, innovative fish passage design concepts will be demonstrated in the collaborative design of an actual whitewater park in Fort Collins, CO.

Purpose: An improved understanding of the fundamental hydraulic processes and potential environmental effects of whitewater parks (WWPs) is needed to inform management decisions about Recreational In-Channel Diversions (RICDs). This is the first study of its kind that integrates actual fish passage data and computational fluid dynamic (CFD) modeling to assess how WWP structures may affect aquatic resources. Given the lack of data on the effects of WWP on fish movement, this analysis of the physical processes affecting passage at WWPs has provided important information on the effects of WWPs on longitudinal connectivity and how these effects can be mitigated through appropriate design.

Need: There is a pressing need for design recommendations for future parks and design modifications for in-place parks that can be used by WWP designers, reviewers, and decision makers.

Objectives: This study aims to address current knowledge gaps by extending direct measurements of fish passage and relating these data to detailed descriptions of hydraulic characteristics based on field measurements and CFD modeling at multiple sites. By testing controls on fish passage at two locations (Salida, CO and Lyons, CO), we can test the transferability of our findings to different river types and settings. In addition, innovative fish passage designs will be demonstrated in the collaborative design of an actual whitewater park. The objectives of this phase of the study are focused on demonstrating transferability of findings and demonstrating design techniques in an actual project.

Completion Date: One year after notice to proceed for each task. (Exception: task 5 will commence 14 months after notice to proceed.)

Budget Justification:

Task 1: PIT Tag Antenna Maintenance at the Salida, Colorado site: The use of PIT tag antennas allows for the collection of detailed fish movement data across specific structures with unique hydraulic characteristics. These systems require weekly maintenance to change batteries, download data and verification that the system is functioning properly. It is anticipated that approximately 16 maintenance trips will be required throughout the course of the PIT tag deployment. Deliverables: n/a

Task 2: Field Data Collection: Measurements of stream velocity, depth and total hydraulic drop will be continued over the course of the next year to characterize these variables over a range of discharges. It is anticipated that additional measurements of approximately 7-10 discharges will be required at each structure in the study site to fully characterize the hydraulic parameters affecting fish passage. Deliverables: n/a

Task 3: Data Analysis and Review: Statistical analysis of the PIT tag data will relate measured probability of fish passage to spatial metrics that integrate the velocity field along potential swimming paths, as well as fish size. HEC-RAS, River2D, and FLO-3d (3-d model) will then be used to reproduce observed hydraulic conditions to determine the resolution needed to sufficiently resolve the complex flow fields around WWP structures to enable prediction of fish passage. Deliverables: n/a

Task 4: Design Case Study: The PI and students will work with the designers of an actual WWP on the Cache La Poudre in Fort Collins, CO to demonstrate the implementation of features that increase probability of fish passage for multiple species and life stages without diminishing the quality of boating experiences. This will provide a real world example that permitting agencies can point to in which fish passage was rigorously addressed. Deliverables: see Task 5 final report.

Task 5: Report Results: A report describing the results of the PIT tag study, hydraulic measurements, and measured effects of WWPs on fish passage will be provided to CWCB. The report will also discuss practical design recommendations that were implemented in the case study in terms of the analysis performed and the effects on costs and boating. Deliverables: Final synthesis report and two M.S. theses / technical reports on WWP/RCID effects on fish passage and design case study, respectively.

Assessing the agronomic feasibility of single-season irrigation deficits on hay as part of a Western Slope Water Bank

Co-PI's: Denis Reich [Denis.Reich@Colostate.edu] – Research Associate III/Extension Water Specialist; Joe Brummer – Associate Professor/Extension Forage Specialist.

Location: Six established hay fields with a full season of irrigation water normally available in four Western Colorado drainages: Colorado, Gunnison, Yampa, and White.

Purpose of the research: To determine potential water savings, crop response, and salient environmental impacts from strategic deficit irrigation on hay fields in Western Colorado agricultural environments (Lower Valley, Mid Valley, and Mountain Meadow).

Need for the research: Under the 1922 Colorado River Compact, the four Upper Division States may not allow the flow at Lee Ferry to drop below a 10-year running average of 75 million acre-feet (MAF) or else be subject to curtailment. The current 10-year average is about 90 MAF, and while the threat of curtailment is not imminent, there is growing concern in Colorado that a combination of factors may conspire to hasten the onset of curtailment1. These factors include the possibility of a new trans-mountain project, full use of existing systems, new demands from energy development including oil shale, and growth in demands and water use stemming from climate change.
Western Slope water users account for about 1.3 million acre feet of Colorado River Basin (CRB) Water of which about 1 million are pre-1922 and exempt from compact administration2. The populated Front Range diverts about a half-million acre feet of CRB water of which the majority are junior to 19222. A possible curtailment scenario is Colorado's post-1922 water rights forgoing use (or a negotiated fraction) until all of the 75 million acre feet 10-year running average non-depletion requirements to the Lower Division States3 are restored. A water bank arrangement might consist of short term leases allowing pre-1922 agricultural rights to be used temporarily by post-1922 municipal and industrial – mostly Front Range - water right holders. Collectively the study area includes about 360,0004 acres of irrigated grass and/or alfalfa hay. Many Colorado CRB water bank discussions focus on legal framework, administration logistics, and return flow implications. Still to be determined is the agronomic feasibility for individual irrigators within this area. Without addressing these concerns water bank participation from private producers would be problematic.

Objectives: "Deficit irrigation" refers to withholding water during non-critical crop growth stages. For this study mid to lower elevation environments would deficit irrigate by seasonally irrigating alfalfa and/or grass hay as normal up to the first cutting only. For higher elevation mountain meadows, where only one cutting of hay is taken per season, a "deficit" treatment means no water is applied to the field for the entire growing season. Using side-by-side i.e. "deficit" versus "business as usual" irrigation treatments5 this project will answer three basic questions about these approaches: 1) What is the likely impact on hay stand life, productivity (measured as tons per acre per year), and quality due to a single-season deficit? 2) What is the potential range of marketable, saved (otherwise consumed) water per acre of single-season deficit irrigated hay in Western Colorado? And 3) are there any obvious environmental benefits or concerns to deficit irrigating hay? For example, what are the benefits of deficit irrigating perennials versus fallowing annually cropped ground? What are the implications for in-stream salt and selenium concentrations in Mancos shale areas?

Timeline and completion date: This proposal is a request to fund the first year (Mar-1-2013 to Feb-28-2014) of a two-year project. Preliminary reporting of the 2013 project would be submitted in time to support a second proposal with a similar budget for 2014.

Budget justification: Total Request = $49,996

Graduate Student ($30,677): Covers salary, fringe benefits, and tuition.

Travel and Accommodation ($9,348 + $1,500 cash match): Allows Co-PIs and student to travel to six West Slope sites (mileage at $0.50/mile); some overnights ($105 incl. tax); and per diem ($45/day). 4 months of $150/week accommodation stipend included for student's summer on West Slope.

Data Collection ($3,450 + $3,500 cash match): Provides instrumentation to monitor crop water use (atmometers and soil sensors for ground-truthing CoAgMet data collection). Also three soil samples per treatment, per site for

the season; includes complete fertility and soil characteristic analysis with salt and selenium tests where applicable. Also two forage quality tests per treatment, per site for the season.
Match ($5,000 or 10%): Cash match provided by Environmental Defense Fund specifically for water bank related work. $3,500 would pay for additional monitoring and instrumentation, $1,500 would pay for additional travel. Student supervision, extension support, and monitoring/data collection of hay yields also provided in-kind.
Accompanying Projects: In addition to related work and proposals (modeling by Colorado River District, drought resilient irrigation strategies by Trout Unlimited), an accompanying CWCB-Alternative Agricultural Water Transfer Methods proposal will be submitted by the Co-PIs this winter. The Colorado River District, Northern Water, The Nature Conservancy, and private landowners were consulted on this pre-proposal.

Developing Metrics for Colorado Agriculture's Production and Efficiency with Water Resources

Principal Investigators: James Pritchett, PhD and Chris Goemans, PhD

Contact: James Pritchett, Agriculture and Resource Economics, Colorado State University,
email: james.pritchett@colostate.edu, ph: 970-491-5496

Location of work and project team: This project's scope is focused on Colorado, but metrics will be developed for individual watersheds within the state. The project team will consist of researchers at the Colorado Water Institute located at Colorado State University, Fort Collins, CO.

Purpose and Need: Water is a scarce resource in Colorado whose rights are (nearly) fully allocated. Demand for water resources is expected to increase as population grows in Colorado. Moreover, climate change is increasing water requirements for the environment and the production of irrigated crops. While conservation, water pricing and infrastructure may play a role in meeting Colorado's increasing water demands, it is generally accepted that water rights will be transferred in ownership and use from agriculture to urban water suppliers.

Colorado agriculture blossomed with the development of water resources used for growing crops, which, in turn, spurred value-added production in the meat, sugar and dairy sectors. Agriculture is currently an important base industry in Colorado generating more than $6 billion dollars of farm gate receipts and contributing broadly to the state's economic activity – nearly 20% of Colorado's gross domestic product can be traced to agriculture or allied industries. It is also a sector in transition with new markets developing, technological innovations improving efficiency, laws and institutions evolving and, importantly, agriculture is seeing increasing competition for key resources such as land and water. New urban development is assumed to spur the reallocation of an additional six hundred thousand to one million acre feet of agricultural water to new municipal, industrial and energy demands by 2040 (SWSI 2010).

The reallocation of water from agricultural to other uses is a voluntary, market based transaction. Both the buyer and seller are suitably compensated in water transactions else they would not occur. In spite of compensation, the changes in water use and/or diversion are very contentious to the public because of third party effects. These effects include the disruption of the rural, regional economic base – irrigated agriculture contributes to a host of allied industries for farm inputs (fertilizer, chemical and seed) and value added industries with its outputs (feed, raw products for sugar, dairy, energy, etc.). The lost agricultural economic base may mean that future opportunities in crop production or value added enterprises are foregone. Lastly, the reallocation of water resource may impact the productivity of the agricultural sector – less water may reduce sector's overall value of goods produced, but the efficiency with which water is used to produce crops (or crop value) could potentially increase with management adaptation.

The purpose of this study is to create a simple metric(s) that proxies the level of production and efficiency with which agriculture uses its water resources.

Readily available data resources will be used to construct the metric so that agriculture's output and efficiency are easily benchmarked. The utility of the metric(s) will be demonstrated by describing the historical evolution of irrigated cropping and allied industries. The metric can also be used to gauge the impacts of potential water scenarios posed by stakeholders such as the IBCC.

Methods and Project Outline: Economists use metrics and indices to gauge changes in economic activity in industries, local economies and macroeconomics. Examples include measures such as the consumer price index, the Malmquist index and the Gini coefficient. This study's metric will focus on gauging irrigated cropping productivity and intensity with easily obtainable data. The index will be comprised of no more than 3 to 5 data series.

The methods begin with a review of the economic literature concerning productivity measures and indices used to measure agricultural activity. As an example, Griliches has written extensively regarding agriculture indices and productivity growth. Data sources used to construct the metric/index will be reviewed and obtained. Example data series sources include but are not limited to:

(a) USDA Census of Agriculture data series: a 5 year census of agriculture producers.
(b) USDA National Agriculture Statistic Series Annual Bul'etin: a single year survey sample
(c) USDA Farm and Ranch Irrigation Survey (FRIS): a 5 year sample of census respondees
(d) Colorado Department of Revenue Property Tax Assessment and Valuation Data

The data series will be collected into spreadsheets for ease of use and charting. Data series will extend for as long a period as appropriate given reporting conventions and availability. It is anticipated that data series will begin in and around 1970. Hyperlinks to online data sources will be embedded in the spreadsheet for updating.

Alternative metrics will be constructed for major Colorado watersheds across the time period, and then changes in the metrics will be interpreted. Results will be reviewed by an advisory group of professionals including scientists, CDM and CWCB staff. Adjustments will be made as appropriate.

Deliverables: The deliverables for this report will include the data series and metric construction within a spreadsheet, a technical fact sheet describing the construction of the metric, assumptions and potential limitations, a fact sheet using the metric to interpret historical data for Colorado agriculture.

Timeline: Work will begin March 1, 2013 and conclude on or before February 28, 2014.

Budget: We are requesting a total of $ to fund faculty time, a graduate research assistant, travel, survey materials and publications.

Mapping and prioritizing watershed-scale ecosystem services and biodiversity in the Upper Poudre River and Big Thompson River watersheds

Principal Investigator: Joshua H. Goldstein, Assistant Professor, Colorado State University, joshua.goldstein@colostate.edu

Location: Cache la Poudre River and Big Thompson River watersheds, focusing on the upper regions that relate to source water areas for downstream users.

Purpose: The purpose of this project is to (i) conduct a watershed-scale analysis to map multiple ecosystem services, and (ii) examine the overlap (or tradeoffs) in prioritizing conservation efforts to protect source water areas (and water-related ecosystem services) relative to other ecosystem services and different elements of biodiversity. These dimensions will be analyzed in relation to the impacts resulting from the High Park and Hewlett Gulch fires in the project region, as well as the larger context of the upper reaches of the Poudre and Big Thompson watersheds that provide source water for downstream users. This project will advance knowledge in Colorado of ecosystem services in a watershed context. The modeling results will be relevant to key regional water-related constituencies, such as conservation groups, water utilities, land management agencies, breweries, and others. The results will also be informative to wildfire restoration efforts through government agencies and the High Park Restoration Coalition. Finally, this project will support the Colorado Conservation Exchange, which is developing a payment for ecosystem services program in the Poudre and Big Thompson River watersheds. Through our leadership of the Exchange, we have established working relationships with the key stakeholders listed above.

Need: Communities along the Colorado Front Range are heavily dependent upon surface water resources to provide drinking water to municipalities, irrigation water to agricultural producers, and environmental flows to support aquatic and riparian ecosystems. The watersheds that provide water to Front Range users also provide diverse ecosystem services beyond water-related services (e.g., carbon sequestration, recreation), as well as provide habitat to support biodiversity. These watersheds face many threats, such as residential development, nutrient pollution, and wildfires. Indeed, this past summer, high intensity, large-scale wildfires occurred in two locations along the Colorado Front Range: High Park fire (northern Colorado) and Waldo Canyon fire (Colorado Springs). In light of all these threats, it is important to understand the ecological impacts that result from fires and other environmentally-degrading activities, as well as how actions taken to reduce these threats can advance source water protection alongside co-benefits for other ecosystem services and biodiversity.

Objectives, Timeline, and Completion Date: This project will address the following objectives: (Obj. 1) conduct a spatial analysis in the context of the High Park and Hewlett Gulch fires to (1a) evaluate ecosystem-service impacts to water-related services, carbon sequestration, and recreation, and (1b) project how proposed wildfire restoration projects will impact these same ecosystem services; (Obj. 2) conduct a spatial analysis in the broader context of the upper reaches of the focal watersheds related to source water areas to (2a) identify priority regions for protecting and enhancing water-related ecosystem services, (2b) map and identify priority regions for carbon sequestration, recreational services, and biodiversity, (2c) evaluate the degree of overlap between high priority areas for source water protection and other ecosystem services and biodiversity, and (2d) compile descriptive information about parcels found in priority regions (e.g., land use/land cover type, ownership, protected status).

The ecosystem services analysis will utilize two software tools from the Natural Capital Project: Integrated Valuation of Ecosystem Services and Tradeoffs (InVEST) and Resource Investment Optimization System (RIOS). InVEST is designed for spatial mapping of multiple ecosystem services and biodiversity, and RIOS is designed to identify priority regions and optimal portfolios for protecting multiple ecosystem services and biodiversity. Both tools use a variety of biophysical datasets (e.g., land use/land cover, soils, topography) and ecosystem-service specific inputs. Biodiversity datasets (e.g., vegetation maps, element occurrences, CNHP potential conservation areas) and wetlands mapping will be provided by CNHP.

Timeline and Completion Date

- July 1 – August 31, 2013: solicit input from key stakeholders to refine project objectives; compile datasets for InVEST and RIOS analyses; coordinate with CNHP to compile existing biodiversity and wetlands datasets, and identify any coverage gaps to be addressed.

- September 1 – December 31, 2013: first round of model runs for InVEST and RIOS; obtain feedback on results from stakeholders; CNHP conducts analyses to fill any identified coverage gaps.
- January 1 – March 31, 2014: second round of InVEST and RIOS model runs; additional feedback from stakeholders; overlap analysis; prioritization analysis
- April 1 – June 30, 2014: Present final results to regional stakeholders; write and submit peer-reviewed journal article.

Budget and Justification: The total requested budget is $48,539 for a 12-month project. Where applicable, each line item describes unit costs and quantities. The majority of funds are for salary, fringe, and tuition to support a GRA (who will coordinate the project and perform the InVEST and RIOS model runs), a Geospatial Centroid GIS analyst (to assist with GIS data preparation and analysis tasks), and a CNHP technician (to assist with compilation and analysis of biodiversity datasets and wetlands mapping).

CWI Activities

CWI Activities

Mission

CWI Mission Defined

Federal Water Resources Research Act (42 USC Sec. 10301 et. seq.) - last amended on January 11, 2007, President Bush signed this act into law (by PL 106-374) (114 STAT. 1434 and the Water Resources Research Act Amendments of 2007) (PL 109-471)

- Colorado Legislature
  - SB06-183
  - HB07-1096
  - HB08-1026
    - Bill changed name to Colorado Water Institute and expanded the mission.
  - HB08-1405

CWI Mission Statement

Connect all of Colorado's higher education expertise to the research and education needs of Colorado water managers and users.

Reporting

CWI Reports to

1. Vice President of Engagement, Lou Swanson
2. CWI's Advisory Committee on Water Research Policy (per SB06-183)
3. USGS External Research Officer (Per Federal Water Resources Research Act - annual proposal and report required)
4. National Institutes for Water Resources Annual Report

CWI Activities Required to Implement both Federal and State Legislation

1. Organized Interdisciplinary faculty to prepare proposals for national competitions
2. Organized an annual, graduate level, water resources seminar (GRAD592)
3. Administrated graduate and undergraduate 'water' scholarships funded by private donors and through federal competitions
4. Administered internships for USGS and CWCB
5. Provided a venue for education, discussion and exposure of regional and global water re source issues through Spring Interdisciplinary Water Resources Seminars on CSU campus
6. Promoted CSU's annual Hydrology Days symposium that brings national and international hydrological scientists to CSU
7. Prepared nominations of outstanding CSU 'water' faculty for state and national awards
8. Supported the CSU Water Archives via collection, identification, and promotion
9. Graduate students funded through grants
10. Conducted annual state-based water research competition
11. Organized water outreach efforts for CSU and CSU Extension

Personnel

Current Water Center and Colorado Water Institute Faculty

The CWI office is located in Room E-102 of the Engineering Building on the campus of Colorado State University. The CWI staff consists of:

- Director: Dr. Reagan Waskom
- Assistant to the Director: Nancy Grice
- Nonpoint Source Outreach Coordinator: Loretta Lohman
- Research Associates: Faith Sternlieb, Julie Kallenberger, Joy Labadie and Lloyd Walker
- Water Resources Specialists: Perry Cabot, Denis Reich and Joel Schneekloth
- Policy & Collaboration Specialist: MaryLou Smith
- Technical Writing: Lindsey Middleton
- Student Support: Eighteen students


Reagan Waskom


Nancy Grice


Amanda Barngrover


Perry Cabot


Roy Cook


Derek Drummond


Doug Davis


Gio DiDomenico


Craig Godbout


Pia Gerstle


Kevin Hackett


Kim Hudson


Julie Kallenberger


Lindsey Middleton


Joy Labadie


Loretta Lohman


Panagiotis Oikonomou


Elmahdi Omar


Elizabeth Plombon


Denis Reich


Joel Schneekloth


Alicia Shogbon

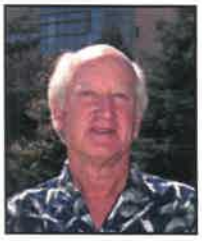

Blake Skipper


MaryLou Smith


Faith Sternlieb

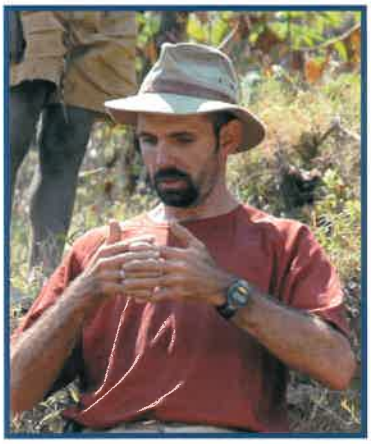

Annie Sligh


Jena Thompson


Lloyd Walker


Shannon Wittstock

Water Outreach Team



Perry Cabot – Assistant Professor / Water Resources Specialist (Southern Region).

2012 Accomplishments

Updates:

Finishing year 4 of 4 – $92.669: CWCB-Alternative Agricultural Water Transfer Methods, *The Effect of Land Fallowing and Water Rights Leasing on Corn Yield, Nutrient Needs and Economics in the Lower Arkansas River Valley of Colorado.*

Completed Project (2 years) $20,500: Colorado Department of Agriculture (Advancing Colorado Renewable Energy) – with Southeastern Colorado RC&D Council, *Oilseed Cropping as a Strategy for Sustained Farming in a Region Impacted by Agricultural Water Transfers.*

Finishing year 2 of 3 – $24,306: NRCS- Conservation Innovation Grant, *Strategies for Permanent Fallowing of Previously Irrigated Cropland Under Groundwater Pumping Restrictions in the San Luis Valley.*

Finishing year 2 of 3 – $48,952: Colorado Department of Agriculture (Advancing Colorado Renewable Energy), *Engine Performance Testing, Fuels Evaluation, and Enterprise Budgeting for a Simplified Approach to Diesel Biofuel.*

Finishing year 1 of 1 – $87,420: *Colorado Water 2012: A Yearlong Event Series to Educate and Engage the Public on the History and Future of Water Management in the Arkansas Basin.* (See Video at http://vimeo.com/37191829 with viewership at 3,000+ watchers.)

Finishing year 2 of 2 - $31,457 (Sub-Contract HSI Funding to CSU-Pueblo), *Integrating Research, Extension, and Education in the Northern Plains and Mountains Region.*

New Projects:

$46,204 – with Casey (Extension STEM): CWCB – Water Resource Conservation Public Education and Outreach, *Pilot Project to Develop Water Conservation Awareness through Inter-Curricular High School Programs (Water Resources Education Curriculum aka "The WRECing Crew Program").*

$46,971: CWCB – Water Supply Reserve Account request (Colorado RT), *A Multi-Media Program for Reporting Crop and Turf Water Use Estimates from the Colorado Agricultural Meteorological Network (CoAgMet).*

$27,501 – Sub-Contract with Sangre de Cristo RC&D Council.

$24,306: CWCB – Alternative Agricultural Water Transfer Methods, *Strategies for Rotational and Permanent Fallowing of Previously Irrigated Cropland Under Groundwater Pumping Restrictions in the San Luis Valley.*

$427,700 – with Gates (PI), Arabi, Hoag : CDPHE – Colorado Nonpoint Source Watershed Plan and Assessment Proposal, *Identifying Arkansas River Selenium and Nitrogen Best Management*

Pending:

$300,000 – with Kinney (CSU-Pueblo), Vanden Heuvel (CSU-Pueblo), and Chefetz (The Hebrew University of Jerusalem): USDA-National Institute For Food & Agriculture (NIFA), *Mechanisms and Factors Controlling the Uptake Of Organic Contaminants in Crop Plants: Tools to Mitigate Human Exposure to Contaminants Of Emerging Concern.*

$76,411 – with Valliant and Trujillo. Colorado Nonpoint Source Implementation Project, Implementing Drainage BMPs –Lower Arkansas River Valley-Colorado

Publications:

With Reich, Andales, Gates (CSU): Colorado Water Newsletter, *CSU Scientists part of Key State Agency Trio: answering some of Colorado's big water resource questions.*

With Taliga and Sparks (NRCS): *Colorado Plant Materials All Plants Considered, Zapata Seed Mini Pivot and Native Vegetation Trials*

Teaching/Advising:

BIO/CHEM 491/591: Introduction to Water Resources at CSU-Pueblo (1 credit)

Committee Member – Master's Thesis 2012 (Kim Schott, CSU-Pueblo), *The Effects of the Kerber Creek Restoration Project on Fisheries in Kerber Creek, Saguache County, Colorado.*

Committee Member – Master's Thesis 2012 (Scott Winter, CU – Colorado Springs), *Spatial Modeling of Residential Water Demand in Colorado Springs between 2000 and 2009.*

Committee Member – Master's Thesis 2013 (Courtney Hall, University of Denver), *Soil Stability and Resistance to Invasion of Restored Short-Grass Prairie.*

Committee Member – Master's Thesis 2014 (Candace Walking, CSU-Pueblo), *Thesis Name TBD*

Awards:

Shared with Extension Water Resources Team, *College of Ag Sciences Award in Research Activities* $5,000.

Service:

Chair and Treasurer of Arkansas River Basin Water Forum (*Ongoing*); coordinated $15,273 in sponsorships.

Chair, Regional Water 2012 Committee for the Arkansas Basin

Public Education, Participation and Outreach liaison for Arkansas Basin Roundtable.

Education Program Committee Member, Colorado Foundation for Water Education

Water Outreach Team

Denis Reich – Research Associate / Water Resources Specialist (Western Region).

2012 Accomplishments

New Contracts:

$112,347: CWCB-Water Supply Reserve Account request (Gunnison RT), *Agricultural Weather Data Delivery Improvements to Uncompahgre Valley Irrigators.*

$46,894: CWCB-Water Supply Reserve Account request (Colorado RT), *On-farm demonstration of water savings potential through using sub-surface drip irrigation on alfalfa.*

$8,841: CWCB-Alternative Agricultural Water Transfer Methods, *Quantification of Water Savings Benefits on Sub-Surface Drip Irrigated Alfalfa in the Grand Valley.*

Pending:

$31,782 Sub-Contract with Trout Unlimited – NRCS- Drought CIG 2013. *Use of Conservation Irrigation to Increase Drought Resiliency of High-Elevation Pastures.*

$17,928 Sub-Contract with Colorado Cattlemens Association – Walton Family Foundation. *Bridging The Gap.*

Updates:

Completed year 2 of 3 – $24,645: USBR-Water Conservation Field Services Program, *Quantifying and Promoting the Benefits of Deficit Irrigation in Commercial Peach Orchards of Western Colorado.*

Completed Project (2 years) $18,273: CWCB-Water Supply Reserve Account request (Colorado RT), *Small Acreage Irrigation Audit Program – Grand Valley.*

Publications:

With Cabot, Andales, Gates (CSU): Colorado Water Newsletter, *CSU Scientists part of Key State Agency Trio: answering some of Colorado's big water resource questions.*

Pending - With Dr. Calvin Pearson (CSU): Journal of Contemporary Water research and Education, *Irrigation Outreach in Afghanistan: Exposure to Afghan Water Security Challenges.*

Presentations:

With Dr. Calvin Pearson (CSU): week long train-the-trainer workshop (July) for Afghan Ministry of Agriculture, Irrigation, and Livestock in Kabul, Afghanistan.

"Natural Resources of the West" Seminar Series – taught by Dr. Gigi Richard (Colorado Mesa Univ): *How water access and scarcity challenges outside of North America inform planning for the Western US's water future*

Service:

Elected chair of Middle Colorado River Watershed Partnership Leadership Committee (April). Steered group through hiring its first coordinator and procuring NPS 319 funds for watershed plan.

Chair of Advisory Board for Water Center at Colorado Mesa University

Water Outreach Team

Joel P. Schneekloth - Northern Regional Water Resources Specialist

Colorado State University

Research Projects:

Water Stress Impacts Upon Genetically Modified Corn – Water stress can be an issue with corn production in the High Plains. Introduction of new drought genetics of corn has brought questions about their impact in irrigated corn production. For the past 4 years we have been working with Monsanto on the impact of their drought genetics and the impact of water stress and the response of drought genetics.

Nutrient Management of Irrigated Sunflowers - Irrigated sunflowers are a potential crop when water supplies are limited because of their drought tolerance. However, little was known about their response to nitrogen management in irrigated situations. Irrigation increases the options of nutrient management with fertigation. Research over the last 6 years has shown that in-season applications of nitrogen can reduce the amount of nitrogen needed by 25 to 50 lbs acre-1 applied without reducing yield potential.

Meetings:

Colorado Conservation Tillage Association – Responsible for developing irrigated agriculture programming dealing for a 2 day conference.

Central Plains Irrigation Association – I am the University representative for Colorado. The Central Plains Irrigation Association is a collaboration of Colorado, Nebraska and Kansas Land Grant Universities with the irrigation industry with an emphasis upon irrigated production issues in the High Plains region of these three States. This meeting rotates between each of the three States on a yearly basis.

National Sunflower Association – I am a member of the NSA Research Committee. Each year we review issues associated with sunflower production and make recommendations on relevant research topics. We also review submissions for recommendations to the Board of Directors.

Invited Meetings:

Producer group in Cody, Wyoming invited me to present irrigated research topics on sunflower production to their producer organization.

Sunflower industry in Alberta, Canada invited me to present irrigated research topics on sunflower production to their producers.

Awards:

Water Research Team has received the 2012 College of Agriculture Sciences Research Award.

Nonpoint Source Outreach Coordinator

Loretta Lohman - Colorado Nonpoint Source Coordinator

This project, funded by a grant from the Colorado Department of Public Health and Environment, is in its 12th year. It has evolved to become the clearinghouse for nonpoint source pollution information and activities in Colorado.

The primary outlet is a comprehensive web page, www.npscolorado.com, which incorporates information from a number of previous nonpoint source projects and maintains those resources for future users. The website provides daily news updates, a variety of educational resources, and current information on Colorado NPS activities. The site receives over 400,000 visits each year.

During the last fiscal year information from the site was used by the island of Bonaire in the Leeward Antilles, as well as in cities and towns nationwide and in Colorado. Most of these events make use of NPS-funder H2O Jo and Flo as a logo or as a balloon. That includes cooperation with Colorado Water 2012 to incorporate water quality into the year-long effort.

Lohman is a member of the Water 2012 task force and the follow-on Value of Water effort. She's provided research materials, particularly to the Value of Water committee with information on recent surveys about Colorado water issues and knowledge.

She provided information on Colorado River issues to CWI associates and to George Sibley for his recently published book on the Colorado River Water Conservation District. Additionally, she provides information to CWI upon request for particular efforts, like groundwater.

Additional Coordinator duties involve preparation for quarterly NPS Alliance meetings, including agendas and meeting notes, as well as coordination and presentation of all steps and information required for each NPS funding cycle.

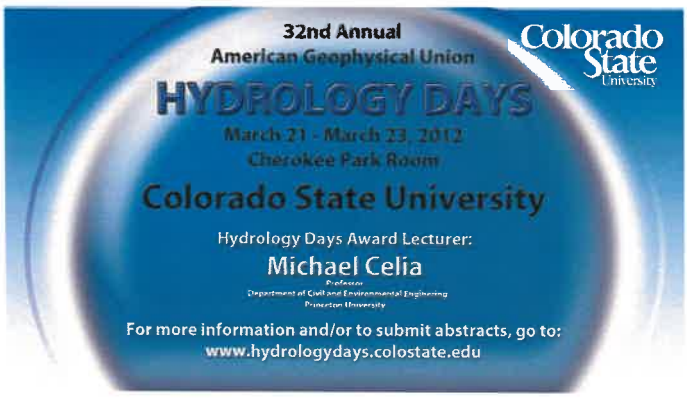
Technology Transfer

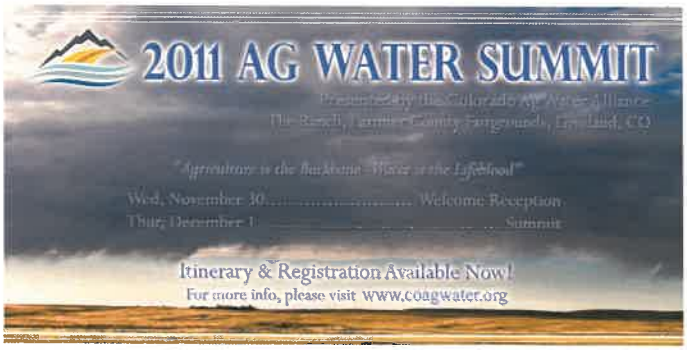
Research Reports and Publications

Research reports are prepared for each CWI water research project and for those with high public interest. Recent reports and publications include:

1. CR221 — **Irrigation Practices, Water Consumption & Return Flows in Colorado's Lower Arkansas River Valley** Author: Timothy Gates

2. IS113 — **Proceedings, South Platte Forum, 23rd Annual, "Water 2012: Celebrating Along the Way"** Author: Jennifer Brown, Ed





Meetings

Actively sponsored or supported water meetings in Colorado:

23nd Annual South Platte Forum
October 24-25, 2012

2012 CWCB Statewide Drought Conference
September 19-20, 2012

UCOWR/NIWR Annual Conference 2012
July 17-19, 2012

Arkansas River Basin Water Forum
April 25-26, 2012

32nd Annual Hydrology Days
March 21-23, 2012

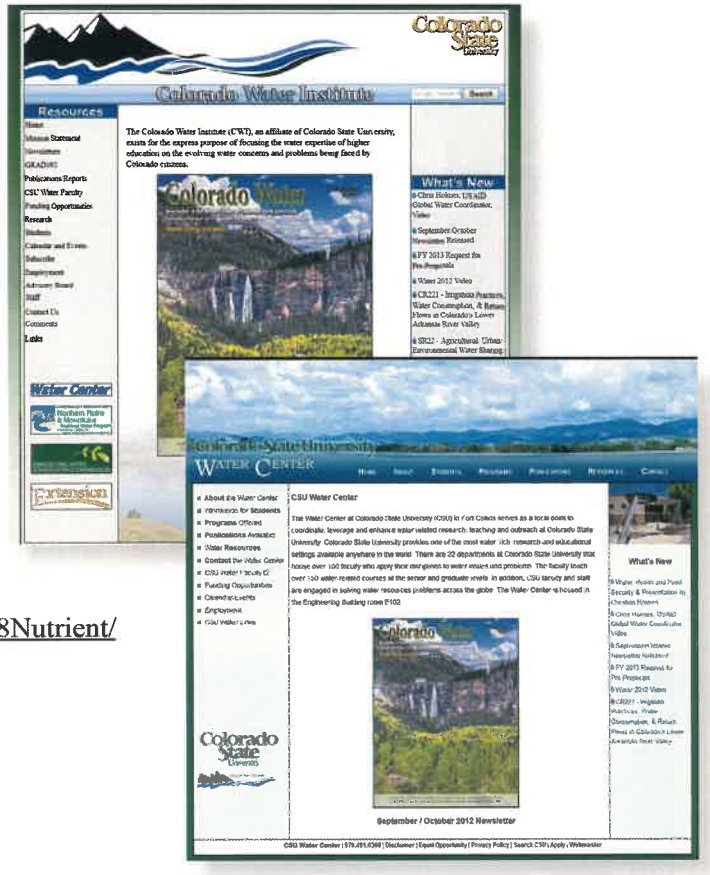
Water Tables
February 18, 2012

NIWR Annual Conference 2012
February 13-15, 2012

Ag Water Summit
December 1, 2011

Websites

- **Colorado Water Institute**
  http://www.cwi.colostate.edu
- **Colorado State University Water Center**
  http://www.watercenter.colostate.edu
- **Northern Plains & Mountain Region Water**
  http://www.region8water.org
- **Ag Water Conservation Clearinghouse**
  http://agwatconservation.colostate.edu
- **CSU Water Faculty Expertise**
  http://www.cwi.colostate.edu/CSUWaterFaculty/
- **Nutrients and Water Quality**
  http://www.cwi.colostate.edu/Workshops/Region8Nutrient/



Newsletter

Colorado Water newsletter, which was revamped in 2007, is sent to over 2000 Colorado water managers and users, including all members of the Colorado Legislature and Colorado Congressional delegation.

Scholarships

Upper Yampa Water Conservancy District

The Upper Yampa Water Conservancy District John Fetcher Scholarship provides financial assistance to a committed and talented student who is pursuing a water-related career in any major at a public university within the state of Colorado. Congratulations to this year's scholarship recipients, Tyra Monger and Benjamin Von Thaden.

Tyra Monger is an undergraduate student at Mesa State College who majors in Environmental Science and Technology with a Watershed Minor.

"Being raised on a cattle and hay ranch outside of Hayden, I understand the value of water. I also have understood and been schooled in the value of being a great steward of the land/water. Once I have graduated from Colorado Mesa University, I am hoping to find a career working in Colorado. Being an outdoors person and being able to maintain the environment have been my lifelong dreams. Currently I am an Environmental Science/ Technology major with a Watershed minor. I believe that these programs will become an ever more important field of study to our country and economy. One of the hopes for my future is to return to Routt County to volunteer to further nourish 4-H programs. 4-H provides skills to young adults that can be used throughout their lives as they fulfill their careers. I hope to also be able to help on my family ranch."

Benjamin Von Thaden is an undergraduate student at Colorado State University majoring in Watershed Science.

"I feel very privileged to have been raised in Routt County and I can definitely see myself living and working in the Yampa River Basin in the future. In 2009 I participated in a Tamarisk removal trip on the Yampa River through Dinosaur National Monument. The trip was very eye opening for me and I would like to do more work, and possibly research, in the fight against invasive species such as Tamarisk and Russian Olive in the Colorado River Basin. After I graduate I plan on joining Engineers Without Borders and traveling around South America to help create better access to safe drinking water and improve sanitation. When I was a sophomore at the Lowell Whiteman School I traveled with the school to Bolivia for my foreign trip. As a service project my group installed a water filter, utilizing rocks, gravel, sand, clay, and silt, to provide safe drinking water to a small village close to Rurrenbaque, Bolivia, in the Amazon Basin. It was an amazing experience to help these less-fortunate people by providing safe drinking water, and I feel I have an obligation to participate in similar projects in the future, hopefully on a larger scale. I have learned that water-related problems are often times very complex and do not have a simple solution, but require collaboration between many groups and industries. While I am not sure of the exact direction that my career will take, I am very excited about having a career in the water industry."

WATER CAFÉ
Colorado State University

WATER & ENERGY

February 9, 2012
1:00-3:30pm
LSC Senate Chambers

The Colorado State University Water Café is an interdisciplinary, interactive series designed to examine critical water issues and the University's roles in their solutions.

Upcoming topics include:

2/29/12: The Poudre River Watershed

3/22/12: Water & Sustainability

4/19/12: Water & Food

FEATURING PANELISTS

BILL RITTER, JR.
FORMER COLORADO GOVERNOR, DIRECTOR OF THE CENTER FOR THE NEW ENERGY ECONOMY

KEN CARLSON
DEPARTMENT OF CIVIL AND ENVIRONMENTAL ENGINEERING

JOHN LABADIE
DEPARTMENT OF CIVIL AND ENVIRONMENTAL ENGINEERING

SALLY SUTTON
DEPARTMENT OF GEOSCIENCES

JAMES PRITCHETT
DEPARTMENT OF AGRICULTURAL AND RESOURCE ECONOMICS

MARK PASCHKE
DEPARTMENT OF FOREST AND RANGELAND STEWARDSHIP

MODERATED BY NEIL GRIGG
DEPARTMENT OF CIVIL AND ENVIRONMENTAL ENGINEERING

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Colorado State University

www.soges.colostate.edu

EXPLORING SUSTAINABILITY IN OUR OWN BACKYARD

THE CACHE LA POUDRE WATERSHED

WATER CAFÉ
Colorado State University

February 29, 2012
1:00-5:00pm
LSC Senate Chambers

PANEL 1: LOCAL STAKEHOLDERS
1:00-2:30PM

JOHN STOKES
CITY OF FORT COLLINS

BRIAN ASHE
RIVERSIDE TECHNOLOGY FOR CWIC

JOHN SANDERSON
THE NATURE CONSERVANCY

GEORGE VARRA
POUDRE RIVER COMMISSIONER

MODERATED BY REAGAN WASKOM
COLORADO WATER INSTITUTE

PANEL 2: CSU FACULTY
3:00-5:00PM

MAZDAK ARABI
DEPARTMENT OF CIVIL AND ENVIRONMENTAL ENGINEERING

SARA RATHBURN
DEPARTMENT OF GEOSCIENCES

LEROY POFF
DEPARTMENT OF BIOLOGY

STEPHANIE KAMPF
DEPARTMENT OF ECOSYSTEM SCIENCE AND SUSTAINABILITY

MARK FIEGE
DEPARTMENT OF HISTORY

MODERATED BY MELINDA LAITURI
DEPARTMENT OF ECOSYSTEM SCIENCE AND SUSTAINABILITY

The Colorado State University Water Café is an interdisciplinary, interactive series designed to examine critical water issues and the University's roles in their solutions.

Upcoming topics include:

3/22/12: Water & Sustainability

4/19/12: Water & Food

sponsors

Colorado State University
WATER CENTER

SCHOOL OF GLOBAL ENVIRONMENTAL SUSTAINABILITY

Colorado State University

WWW.SUSTAINABILITY.COLOSTATE.EDU

PRESENTED IN CONJUCTION WITH HYDROLOGY DAYS AT CSU DETAILS AT http://hydrologydays.colostate.edu

WATER CAFÉ
Colorado State University

WATER & SUSTAINABILITY

MARCH 22-23, 2012

THURSDAY EVENT

MEETING THE GLOBAL CHALLENGES OF WATER SCARCITY

MARCH 22 - 5:00PM
NORTH BALLROOM, LORY STUDENT CENTER

KEYNOTE SPEAKER

BRIAN RICHTER
Global Freshwater Strategies
The Nature Conservancy

FRIDAY EVENT

WATER SUSTAINABILITY IN THE 21ST CENTURY

WHY THE WORLD NEEDS WHAT CSU HAS

MARCH 23 - 10:00-12:00PM
CHEROKEE PARK BALLROOM, LSC

BRIAN RICHTER
Global Freshwater Strategies
The Nature Conservancy

FACULTY PANELISTS

LEROY POFF
DEPARTMENT OF BIOLOGY

KURT FAUSCH
DEPARTMENT OF FISH, WILDLIFE, AND CONSERVATION BIOLOGY

BRIAN BLEDSOE
DEPARTMENT OF CIVIL AND ENVIRONMENTAL ENGINEERING

GENE KELLY
DEPARTMENT OF SOIL AND CROP SCIENCES

sponsors

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Colorado State University

www.sustainability.colostate.edu

GRAD592
Interdisciplinary Water Resources Seminar

Fall 2012 Theme: **Addressing Global Water Resource Challenges with Local Expertise**
Mondays at 4:00 PM, Building NATRS 109

Aug 20	John Stednick Erin Donnelly	Environmental Flows; Or Can Groundwater Pumping Grow More Sturgeon?
Aug 27	Susan De Long Jeremy Chignell	Energy Recovery From Wastewater: New Trends and Possibilities
Sept 10	Brian Bledsoe Joel Sholtes	River Management in a Changing Climate: Tools for Planning Under Uncertainty
Sept 17	Larry Roesner Sybil Sharvelle	Integrated Urban Water Management
Sept 24	Kurt Fausch James Roberts	Ecological Futures for Native Trout of the Interior West in a Changing Climate: Are We in Hot Water Yet?
Oct 1	Patty Rettig	Using the Water Resources Archive for Research, Teaching and Scholarship
Oct 8	Patrick Byrne Steve Becker	Improving Drought Tolerance in Great Plains Wheat Cultivars with Synthetic Hexaploid Wheat
Oct 15	Allan Andales Neil Hansen Kendall DeJonge	Addressing Water Scarcity Through Limited Irrigation Cropping: Field Experiments and Modeling
Oct 22	Susan De Long Maria Renno	Development of Sustainable Water Treatment Technologies
Oct 29	William Bauerle Grace Lloyd	Measurement and Modeling of Physiological Responses to Soil Moisture Deficits: Applications to Irrigation Scheduling, Plant Breeding, and Global Climate Models
Nov 5	Mark Fiege	Using Digital History for Education About Local Water Resources
Nov 12	Melinda Laituri Faith Sternlieb	Spanning Boundaries Across the Colorado River Basin: A Geospatial Analysis of Agricultural Water Governance
Nov 26	Jorge Ramirez	Vulnerability of US Water Supply to Hydroeconomic and Climate Variability
Dec 3	LeRoy Poff	Using Environmental Flows to Stem Species Invasion of Western Rivers in a Period of Rapid Climate Change

Students wishing to obtain 1 credit for the seminar may sign up for Water Resources Seminar (CRN 67067) GRAD 592 Section 001. The Fall 2012 seminar will be held Monday afternoons at 4-5pm in Natural Resources Room 109.

Faculty and guests are welcome to attend and participate.

For more information, contact Reagan Waskom at reagan.waskom@colostate.edu or visit the CWI website. Sponsored by CSU Water Center & School of Global Environmental Sustainability

COLORADO WATER INSTITUTE

About CWI

Colorado water managers and users must contend with the fickle nature of weather and climate, the allocation of limited water among competing sectors of Colorado's economy and environment, and the demands of thirsty downstream states. CWI works closely with Colorado water managers and users to develop sound science to assist water managers in reducing conflict among water users. CWI facilitates the transfer of new water knowledge to water managers and assists in educating the next generation of Colorado water managers by working with all Colorado institutions of higher education.

Research

CWI, an affiliate of Colorado State University (CSU), exists for the express purpose of focusing the water expertise of higher education on the evolving water concerns and problems being faced by Colorado citizens. We are housed on the campus of CSU but work closely with all institutions of higher education in Colorado. CWI coordinates research efforts with local, state, and national agencies and organizations. Recent state funding allowed CWI to fund research projects at CSU, the University of Colorado, and Colorado School of Mines. (See "Current Research Projects").

Training

One of CWI's primary missions is to facilitate the training and education of university students. To this end, CWI works with the U.S. Geological Survey to place student interns in positions, funds student research grants, and manages scholarships on behalf of students.

Outreach/Information Transfer

CWI publications include research reports and *Colorado Water*, a bimonthly newsletter containing information on research, faculty, conferences and other events with a water focus. Outreach activities are conducted in conjunction with CSU Extension, the U.S. Department of Agriculture, the Colorado Department of Agriculture, the Environmental Protection Agency, and The Colorado Department of Public Health and Environment.

CWI works with CSU Extension to coordinate outreach with three Water Resources Specialists: Perry Cabot, Denis Reich, and Joel Schneekloth. The specialists focus on water resource-related research and outreach, as well as statewide collaboration. Their research and outreach topics include meeting water demand, agriculture, and water quality assurance.

Highlights
Response to State Needs

Agricultural Water Conservation

The Agricultural Water Conservation Clearinghouse Project is a joint collaboration between CWI, CWCB, CSREES, Western Regional Water Program, and CSU Libraries. The project's goals are to increase access to information that will help build collaborative relationships between and among regional and national agencies, provide technical expertise regarding agricultural water conservation, and offer detailed information on the management, policies, and laws regarding ag water conservation. www.agwaterconservation.colostate.edu.

Lysimeter

State of Colorado, USDA/ARS, and Colorado State University are working together to install and instrument two scientifically sound large weighing lysimeters in the Arkansas Valley in support of the Arkansas River Compact settlement.

Colorado River

The Colorado River is subject to significant natural hydrologic variability, yet water managers have limited flow data that may not represent the full array of hydrologic futures and risk. This research employs paleohydrologic reconstructions of annual flow using tree rings to provide much longer (500-1000+ years) records of past natural variability, and thus a much richer sampling of potential flow sequences, including severe and sustained droughts of greatest concern to water resource managers.

Mussels in Colorado

Zebra and Quagga mussels are non-native freshwater bivalves which reproduce rapidly and have the ability to form thick mats that clog pipes and cause millions of dollars in damage to water-delivery systems. An adaptive management model is under development which estimates costs and benefits (in terms of economic, ecological, and wildlife impacts) associated with various treatments, along with other available mussel management and mitigation strategies that focus primarily on prevention or infestation control.

Colorado State University

Current Faculty Research Projects

Adaptive Management of Zebra and Quagga Mussels in Colorado
Craig Bond, Colorado State University

Adjoint Modeling to Quantify Stream Flow Changes Due to Aquifer Pumping
Roseanna Neupauer, University of Colorado

Assessing the Relative Costs/ Values of New Water Supply Options
Doug Kenney, University of Colorado

Data Analysis and Final Report of the Nature and Implications of Irrigation Practices in Colorado's Lower Arkansas River Valley
Tim Gates, Colorado State University

Determination of Consumptive Water Use by Alfalfa in Arkansas Valley
Lee Sommers, Colorado State University

Estimating the Cost Effectiveness of Water Conservation Programs
Chris Goemans, Colorado State University

New Methods for Sago Pondweed Management
Scott Nissen, Colorado State University

Paleohydrology of the Lower Colorado River Basin
Balaji Rajagopalan, University of Colorado

Current Student Research Projects

Aquifer Storage and Recovery Optimization
Anne Maurer, Colorado State University

The Efficacy of the Use of Moringa Oleifera Seeds to Remove Metabolites of Cyanobacteria from Drinking Water
Victor Sam, Colorado State University

Environmental Impacts of Ag-to-Urban Water Rights Transfers in the South Platte River Basin
Meagan Smith, Colorado State University

Large Aperture Scintillometers for Evapotranspiration (ET) Evaluation
Evan Rambikur, Colorado State University

Novel Technique for Evaluation of Dissolved Organic Material (DOM); Research Methodology and Lab Protocol Development Using a FluidImages FlowCam on Lake Water Samples Across the State of Colorado
Alia Khan, University of Colorado (Boulder)

Variables Controlling Reservoir Sedimentation in the Colorado Front Range
Umit Duru, Colorado State University

Ecosystem Services, Biodiversity, and Irrigation Inefficiences
Jeremy Sueltenfuss, Colorado State University

CWI Staff

Reagan M. Waskom, Director
Nancy Grice, Assistant to the Director
Lindsey Knebel, Editor
Loretta Lohman, Nonpoint Source Outreach Coordinator
MaryLou Smith, Policy & Collaboration Specialist
Faith Sternlieb and Julie Kallenberger, Research Associates
Perry Cabot, Denis Reich, and Joel Schneekloth, Water Resources Specialists

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06/27/20

Awards

CSU Student Joseph D. Vassios Receives Award

Colorado State University Ph.D. candidate Joe Vassios was recently honored with the annual Outstanding Graduate Student Award from Aquatic Plant Management Society. Vassios says the graduate work he was recognized for has focused on "examining the absorption and translocation of the aquatic herbicides triclopyr, fluridone, and penoxsulam in two aquatic plant species, hydrilla and Eurasian watermilfoil." In addition to this research, Vassios has been active in CSU Professor Scott Nissen's aquatic plant management research program. He's also been "evaluating current and new methods for control of sago pondweed in irrigation canals and new control methods for Eurasian watermilfoil in lakes, ponds, and irrigation canals."

Vassios plans to graduate in fall 2011, and says he hopes to pursue an industry career in the aquatic plant management field. He holds a Bachelor of Science in Soil and Crop Sciences and a Master of Science in Bioagricultural Sciences and Pest Management, both from CSU.

Tributes

Fred Anderson, 83, former state senator, helped change Colorado water laws

Former state senator Fred Anderson, who was well known for his legislative work on Colorado water, died on December 22, 2011 doing what he loved, moving water (shoveling snow). Fred, known to his friends as Freddie, was 83 and still engaged in water. In fact, three weeks prior to his passing he stood up at the Colorado Ag Water Summit and strongly admonished us to get on with the work of untangling the groundwater problems in the South Platte. Fred was a beloved member of the Colorado Water Institute's advisory board for many years, helping to guide water research and researchers through the maze and pitfalls of water politics.

Senator Anderson is widely credited as the legislative father of Colorado's pioneering Instream Flow Program. Anderson carried the bill in the state legislature that permitted the concept of beneficial use for the environment, also known as the Instream Flow law. In 1973, beneficial use for the environment was a new concept in Colorado water law that was eventually tested in Colorado Supreme Court, which ruled in favor of this new beneficial use. Fred made sure the Colorado Water Conservation Board would be the sole custodian of the program. After leaving the legislature, he worked closely with Senator Martha Ezzard on the 1986 legislation that provided for the CWCB to supplement its junior instream flow rights by allowing the Board to accept donations or leases of senior water rights for instream flow purposes. Today over 8,500 miles of Colorado streams are protected by instream flow water rights held by the CWCB.

Fred Anderson served sixteen years in the state Senate, eight of those as Senate President. Among his greatest achievements was helping to integrate ground and surface water management through the 1969 Water Rights Determination and Administration Act, which introduced the concept of augmentation plans to replace out of priority depletions caused by the pumping of tributary groundwater. The State Engineer was given the responsibility of jointly administering surface and tributary groundwater within the priority system. Prior to leaving the legislature Senator Anderson was the primary sponsor or co-sponsor of virtually every significant piece of water legislation. After leaving the Senate, Fred was very active in water legislation for the Northern District and the Colorado Water Congress from 1982 to 1996 when he retired. Fred was also instrumental in crafting Senate Bill 5, enacted in 1985, which resolved a number of questions concerning allocation of Denver Basin groundwater. Fred once indicated to me that the 1969 Act and Senate Bill 5 were the result of hard won compromises, but that he never thought at the time that the bills would be the final word on these complex management issues.

At CSU, we should also recognize that Senator Anderson was the driving force on the state legislature behind the building of present day veterinary hospital at Colorado State University. The previous Vet Hospital was in the Glover Building west of the Oval on main campus. A new facility was desperately needed, yet some of the powers in the legislature in the mid-1970s were not favorably disposed towards CSU and wanted to deny the requested funding for a new Vet medicine center. Joe Shoemaker crafted a compromise to remodel the existing building rather than build a new hospital. Fred engineered a field trip for some of the Joint Budget Committee members to visit campus where they saw students cutting through the Glover Hospital while animal surgery and recovery was underway, creating a chaotic and cramped atmosphere. It is not clear whether this was staged or not, but Fred was able to convince his fellow legislators of the need to fund the building of a separate facility on Drake Road south of the main campus in order to elevate CSU Vet Science programs to the next level.

Senator Anderson grew up as a fourth generation farmer near Loveland and served in the U.S. Army during the Korean War. Loveland was his home for all of his 83 years and he served the Loveland community in many capacities. He was a tough negotiator, a good man and a great friend to CSU. Thanks, Freddie!

CWI Advisory Board

Name	Organization	Telephone	Email
Jim Broderick	Southeastern Colorado Water Conservancy District	(719) 948-2400	jwb@secwcd.com
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