Colorado Water Institute

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Activities and Impact Report

November 1, 2012 through October 31, 2013

Colorado State University

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CWI Advisory Committee Agenda
Denver Water Board Room

November 15, 2013
9:30 AM – 1:00 PM

Denver Water
1600 West 12th Avenue
Denver, Colorado 80204
303-628-6000

9:30 AM	Welcome & Introductions
9:40 AM	Research Report – Brian Bledsoe, Colorado State University
10:00 AM	Research Report – Domenico Bau, Colorado State University
10:20 AM	Research Report – Joe Brummer, Colorado State University
10:40 AM	Research Report –Allan Andales, Colorado State University
11:00 AM	FY14 Project Ranking
12:00 PM	Working Lunch – Advisory Committee Input on CWI Activities and Programs
1:00 PM	Adjourn

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On the cover: The Platte River Basin between Platteville and Sterling, Colorado. Photo by Bill Cotton

Current Research (Active Projects During 11/1/2012 - 10/31/2013)

FY	Name	Type	Status	Title	Amount	Sponsor	End Date
FY14							
	Andales, Allan	Faculty	In Progress	Determination of Consumptive Water Use of Corn in the Arkansas Valley	$ 28,750	CWCB	06/30/14
	Bau, Domenico	Faculty	In Progress	Modeling the Influence of Conjunctive Water Use on Flow Regimes in the South Platte River Basin Using the Sc	$ 50,000	CWCB	06/30/14
	Bledsoe, Brian	Faculty	In Progress	Investigation of the Effects of Whitewater Parks on Aquatic Resources in Colorado - Year 3	$ 43,796	CWCB	06/30/14
	Brummer, Joe	Faculty	In Progress	Assessing the Agronomic Feasibility of Single-Season Irrigation Deficits on Hay as part of a Western Slope Wate	$ 49,996	CWCB	06/30/14
	Pritchett, James	Faculty	In Progress	Developing Metrics for Colorado Agriculture's Production and Efficiency with Water Resouces	$ 43,131	CWCB	06/30/14
	Malers, Steve	Faculty	In Progress	Bringing the Value of Colorado's Decision Support Systems (CDSS) to Universities and Establishing Protocols fc	$ 50,000	CWCB	06/30/14
	Waskom, Reagan	Faculty	In Progress	NPS Outreach Coordinator	$ 141,930	CWCB	09/30/14
	Waskom, Reagan	Faculty	In Progress	Poudre Basin Water Sharing Working Group Efforts Leading to Agreements, South Platte Basin	$ 86,940	CWCB	12/31/14
	Waskom, Reagan	Faculty	In Progress	MOWS - Modeling of Watershed Systems NIWR-USGS Student Internship Program	$ 10,000	USGS	07/31/14
	Waskom, Reagan	Faculty	In Progress	WEBB-Water, Energy, and Biogeochemical Budgets NIWR-USGS Student Internship Program	$ 40,219	USGS	08/19/17
	Waskom, Reagan	Faculty	In Progress	Moving Forward on Agricultural Water Conservation in the Colorado River Basin	$ 649,000	USDA-NIFA	09/30/16
				Total FY14 Research Projects	**$ 1,193,762**		
FY13							
	Andales, Allan	Faculty	In Progress	Determination of Consumptive Water Use by Alfalfa in the Arkansas Valley	$ 85,000	CWCB	12/31/13
	Bau, Domenico	Faculty	In Progress	Modeling the Influence of Conjunctive Water Use on Flow Regimes in the South Platte River Basin	$ 50,000	CWCB	06/30/13
	Bledsoe, Brian	Faculty	In Progress	Investigation of the Efects of Whitewater Parks on Aquatic Resources in Colorado: Year 3	$ 46,000	CWCB	06/30/13
	Johnson, Frank	Faculty	In Progress	Determination of Consumptive Water Use by Alfalfa in Arkansas Valley	$ 85,000	CWCB	12/31/13
	Waskom, Reagan	Faculty	In Progress	AG Economics & Water Resources: A Specialty Workshop	$ 9,746	CWCB	12/31/13
	Waskom, Reagan	Faculty	In Progress	Colorado House Bill 12-1278 South Platte River Alluvial Aquifer Study	$ 786,981	CWCB	12/31/13
	Brummer, Joe	Faculty	In Progress	Assessing the Agronomic Feasibility of Single-Season Irrigation Deficits on Hay as part of a Western Slope Wate	$ 20,000	NIWR 104B	02/28/14
	Brummer, Joe	Faculty	In Progress	Assessing the Agronomic Feasibility of Partial and Full Season Hay Fallowing as Part of a Western Slope Water	$ 20,000	NIWR 104B	02/28/14
	Labadie - Herzog	Student	In Progress	Social Network Analysis Technique for Water Resources Management Workshop	$ 4,500	NIWR 104B	02/28/14
	Waskom, Reagan	Faculty	In Progress	Program Administration Project Fiscal Year 2013	$ 10,000	NIWR 104B	02/28/14
	Waskom, Reagan	Faculty	In Progress	Technology Transfer & Information Dissemination Fiscal Year 2013	$ 37,835	NIWR 104B	02/28/14
	Pritchett, James	Faculty	In Progress	Value of Water in Agriculture: Gathering Baseline Information	$ 35,360	CDM	06/30/13
	Waskom, Reagan	Faculty	In Progress	Upper Gunnison Ranchers Self-Assessment Tools and Results Focused Dialogue of Agricultural and Environme	$ 36,000	Cattlemens	10/31/13
	Waskom, Reagan	Faculty	In Progress	NPS Outreach Coordinator	$ 88,508	CDPHE	09/30/13
	Waskom, Reagan	Faculty	In Progress	SRN: Routes to Sustainability for Natural Gas Development and Water and Air Resources in the Rocky Mountai	$ 249,308	CU-Boulder	09/30/17
	Waskom, Reagan	Faculty	In Progress	Future of Water and Preservation of Agriculture in the South Platte Basin	$ 50,000	GFF	03/31/14
	Waskom, Reagan	Faculty	In Progress	The Poudre Runs Through It Study/Action Work Group	$ 10,000	PHAROS	12/31/13
	Waskom, Reagan	Faculty	In Progress	Comprehensive Planning Studies for Salinity Control Measure in the Upper Colorado River Basin	$ 60,603	URS	12/31/13
	Waskom, Reagan	Faculty	In Progress	MOWS-Modeling of Watershed Systems NIWR-USGS Student Internship Program	$ 10,000	USGS	12/20/14
				Total FY13 Research Projects	**$ 1,694,841**		
FY12							
	Doesken, Nolan	Faculty	Complete	The Colorado Agricultural Meteorological Network (CoAgMet): Monitoring Evapotranspiration and Other Key Ele	$ 50,000	CWCB	06/30/13
	Goemans, Chris	Faculty	Complete	Colorado Household Preferences in Meeting Future Water Challenges	$ 50,000	CWCB	06/30/13
	Cheng - Huber-Sterns	Student	Complete	Assessing the Benefits and Drawbacks of Different Institutional Arrangements to Enhancing Forest and Water E	$ 5,000	NIWR 104B	02/28/13
	Cooper - Gage	Student	Complete	Structural and Functional Controls of Tree Transpiration in Front Range Urban Forests	$ 5,000	NIWR 104B	02/28/13
	Doesken - Muniz	Student	Complete	Winter Precipitation Variability in the Colorado Rocky Mountains	$ 5,000	NIWR 104B	02/28/13
	Fassnacht - Venable	Student	Complete	Reconstructing a Water Balance for the San Luis Valley: Streamflow Variability, Change, and Extremes in a Sno	$ 4,945	NIWR 104B	02/28/13
	Goemans/Pritchett - Nelson	Student	Complete	The Short and Long-Term Impacts of Drought on the Structure of Regional Economics: Investigating the Farm S	$ 5,000	NIWR 104B	02/28/13
	Goemans - Serbina	Student	Complete	Quantifying Risks Producers Face when Entering Agricultural Water Lease Contracts	$ 5,000	NIWR 104B	02/28/13
	Myrick - Herdrich	Student	Complete	Thermal preference of age-0 stonecats (Noturus flavus): Are thermal water quality standards protective for this s	$ 4,858	NIWR 104B	02/28/13
	Omur-Ozbek - Venkatapathi	Student	Complete	Biowin Simulation to Assess Alternative Treatment Units for a Local Wastewater Treatment Plant to Meet the Ne	$ 5,000	NIWR 104B	02/28/13

Stednick - Roudebush	Student	Complete	Using Water Chemistry to Characterize the Connection Between Alluvial Groundwater and Streamflow Water Ur	$	5,000	NIWR 104B	02/28/13
Waskom, Reagan	Faculty	Complete	Program Administration Project Fiscal Year 2012	$	10,000	NIWR 104B	02/28/13
Waskom, Reagan	Faculty	Complete	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	08/31/14
Bledsoe - Kolden	Student	Complete	3D Modeling of Fish Passage in Colorado Whitewater Parks	$	5,000	CWI	02/28/13
Bledsoe - Fox	Student	Complete	3D Modeling of Fish Passage in Colorado Whitewater Parks	$	5,000	CWI	02/28/13
Nissen, Scott	Faculty	Complete	New Methods for Sago Pondweed Management	$	10,000	CWI	06/30/12
Waskom, Reagan	Faculty	Complete	Addressing Agricultural Water Security in the Colorado River Basin: Planning for Water Research	$	149,000	USDA-NIFA	08/31/14
Waskom, Reagan	Faculty	In Progress	MOWS-Modeling of Watershed Systems NIWR-USGS Student Internship Program	$	60,000	USGS	12/20/14
Waskom, Reagan	Faculty	Complete	The Year of the River 2012	$	10,000	PHAROS	12/30/12
Waskom, Reagan	Faculty	Complete	Exploratory Water Sharing Fields Trips and Corollary Work	$	159,799	WFF	12/31/12
			Total FY12 Research Projects	**$**	**731,296**		
Pre-FY12 Projects Still Active							
Waskom, Reagan	Faculty	In Progress	CWCB/CWI Cooperative Intern Program	$	100,000	CWCB	09/01/14
McCray, John	Faculty	In Progress	Water Quality Impacts of the Mountain Pine Beetle Infestation in the Rocky Mountain West: Heavy Metals and D	$	140,162	NIWR 104G	02/29/14
Neupauer, Roseanna	Faculty	Complete	Adjoint Modeling to Quantify Stream Flow Changes Due to Aquifer Pumping	$	117,847	NIWR 104G	08/31/13
			Total Pre-FY12 Research Projects	**$**	**358,009**		

Current Faculty Projects

Determination of Consumptive Water Use of Corn in the Arkansas Valley

Dr. Allan A. Andales, Assistant Professor of Irrigation and Water Science;
Department of Soil and Crop Sciences, Colorado State University
Dr. Michael E. Bartolo, Research Scientist; CSU-Arkansas Valley Research Center, Rocky Ford, CO
Lane Simmons, Research Associate; CSU-Arkansas Valley Research Center; Rocky Ford, CO

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. This project is being conducted at the Colorado State University (CSU) – Arkansas Valley Research Center (AVRC), Rocky Ford, CO.

Need: 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 (ET_r), which is a measure of local atmospheric demand for water. Crop ET (ET_c) is then calculated by multiplying ET_r by a crop coefficient (K_c) that varies with crop growth and development.

This proposed project will continue the long-term research to date, to more accurately calculate the ET_c of major irrigated crops in the basin, by defining the crop coefficients (K_c) used to convert ET_r to ET_c values and by validating (ground-truthing) the ET_r 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 ET_c 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 ET_r and ET_c 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.

Seasonal crop coefficient curve that characterizes corn ET_c (2013 growing season) at different developmental phases; and is appropriate for local conditions in the Arkansas Basin.

Observed seasonal consumptive water use (ET_c) of corn (2013).

3. Accurate hourly weather data from 12 CoAgMet stations in the basin, made available through the CoAgMet online database.

Comparison of calculated alfalfa ET_r 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.

4. One technical report published by the Colorado Water Institute detailing the methods and findings of the CSU research team.

Timeline: This project began on July 1, 2013 and will be completed on June 30, 2014.

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

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.

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.

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.

Timeline: 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.

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

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

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.

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.

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.

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.

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

Assessing the Agronomic Feasibility of Partial and Full Season Hay Fallowing as Part of a Western Slope Water Bank

Joe Brummer, Associate Professor/Extension Forage Specialist, Department of Soil and Crop Sciences, Colorado State University
Calvin Pearson, Professor/Research Agronomist, Colorado State University, Western Colorado Research Center - Fruita

Colorado River Compact compliance in partnership with the other three Upper Basin States is a topic of growing concern within Colorado. 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 Colorado River Compact administration[1]. The populated Front Range diverts about a half-million acre feet of CRB water of which the majority are junior rights to 1922[3]. 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 States[2] are restored. A water bank approach might facilitate this arrangement by brokering short-term leases of pre-1922 agricultural rights for temporary use by post-1922 municipal and industrial - mostly Front Range - water right holders.

Six irrigated alfalfa or grass hayfield sites will be established in Western Colorado to test fallowing practices likely to be used for generating conserved water for a future water bank. Testing of practices will be side-by-side with a control treatment (i.e. limited or deficit irrigation treatments next to "fully irrigated" or "business-as-usual" irrigation treatments). The test sites will be located throughout the Yampa, Colorado, and Gunnison River basins, an area that includes about 360,000[3] acres of irrigated grass and/or alfalfa hay.

A master's level graduate student will be recruited in the Soil and Crop Sciences Department at CSU and charged with answering three basic questions about single season hay fallowing in the Upper Colorado River Basin: 1) What is the impact on hay stand life, productivity, and quality due to a single-season fallowing? 2) What is the potential range of marketable, saved (otherwise consumed) water per acre of single-season fully and partially fallowed hayfields in Western Colorado? 3) Are there any environmental benefits or concerns to fallowing hay in Western Colorado? For example, what are the implications for reducing in-stream salt and selenium concentrations in Mancos shale areas? Does fallowing make hayfields prone to weed invasion?

Agronomic responses will be determined by measuring yield, species composition, ground cover, and forage quality. Soils will also be sampled and analyzed to assess changes in soil moisture, impacts to soil health, and shifts in salt and selenium on affected sites. Atmometers will be installed at each site to help estimate a range of water savings that might be eligible for leasing through a future water bank.

By answering the above three questions, hay producers as well as proponents of water banking will have enough information available to confirm if this approach is worth pursing as a method to free up water to meet compact obligations and/or other uses. There are other questions that must be answered, but if the impacts to yield, forage quality, etc. are too severe or long lasting, then hay producers will be reluctant to participate in a water banking program.

Many Colorado CRB water bank discussions focus on legal framework, administration logistics, and return flow effects. This study will not focus on these aspects, only the agronomic implications.

Objectives And Timeline: This study will use a multiple site approach in achieving the following objectives:

1. Determine the impacts to forage yield and quality and associated recovery period for fallowed and partially-fallowed alfalfa and grass hayfields in different regions of Western Colorado.
2. Refine our understanding of the amount of water that might be available for leasing through fallowing of hayfields in Western Colorado.
3. Improve our understanding of potential environmental implications for fallowing hayfields, especially in salt and selenium affected areas.

[1] Huggins, L. Colorado River Water Bank: Making Water Conservation Profitable. *Property and Environment Research Center.*
[2] It's assumed the United States would be honoring its 1.5 million acre-feet per year treaty deliveries to Mexico.
[3] 2007 USDA Census of Agriculture acreages for the four West Slope basins hosting the six study sites.

The project is designed as a two year project with potential to extend it to a third year should funding be available and warranted. This full project proposal is for March 2013 to February 2014 funding only. Preliminary reporting of the 2013 project would be submitted in time to support a second proposal for 2014.

Methods and Procedures: Six sites in the Upper Colorado River basin of Western Colorado will be selected to test the agronomic responses associated with fallowing perennial alfalfa and grass hayfields.

Three sites will be chosen in the lower parts of the basin to study the effects on alfalfa and three will be chosen in the upper parts of the basin to study the effects on grass hay. Four of the sites have already been selected with two yet to be determined.

In the spring of 2013, the project team will visit each site prior to irrigation commencing to establish plots for the control (i.e. "business-as-usual") and fallowing treatments. Hay type and age will be identical between the two treatments. Ideally, treatment plots will be side-by-side using the same irrigation technology and source water, with similar acreage and soil type. At this time, each site will be fitted with an atmometer for tracking evapotranspiration which will be used as part of the equation to estimate conserved, otherwise consumed water. A rain gauge and data logging temperature sensor will also be installed at each site to track these important weather variables. Baseline soil samples will also be taken at this time from each treatment (i.e. control and fallowed) at each site. A minimum of 15 soil cores will be taken per treatment to a depth of 15 cm, composited, and air dried before sending to the lab for a routine soil analysis.

Table 1: Proposed Study Sites

Site Name	Hay Type	Approximate Hectares	Nearest Town	Basin
Kehmeier Farm	Alfalfa	16	Eckert	(Lower) Gunnison
Western Colorado Research Center	Alfalfa	1-3	Fruita	(Lower) Colorado
TBD	Alfalfa	(Lower)		
Peterson Ranch	Grass	12	Gunnison	(Upper) Gunnison
Carpenter Ranch	Grass	12	Hayden	(Upper) Yampa
TBD	Grass			(Upper)

To implement the treatments, fields or sections of fields will be flagged where side-by-side testing should be easiest to manage and stand health and soil type are reasonably consistent across both treatments. The actual size and shape of treated areas will vary by site depending on the size and shape of each individual producer's field. Ideally, each treated area will be a minimum of 2 ha in size. For the higher elevation (above 6500 ft) "mountain meadow" sites where only one cutting of grass hay is usually taken, irrigation will be withheld for the entire growing season on the fallow treated ground. On the lower elevation sites where alfalfa is being grown, the fallow treated ground will be irrigated up until the first cutting after which it will receive no additional irrigation water for the rest of the season (i.e. partial deficit or limited irrigation). At all sites, the control treatment will be irrigated based on each producer's normal schedule. The amount of water applied at each site will be estimated based on each producer's irrigation records.

In 2014, full irrigation will be restored to ground fallowed in 2013, and continued on the "business-as-usual" control treatments. The objective being to determine how well hay responds after water is withheld for part or all of the previous growing season.

Prior to each cutting (1 for higher elevation and 3 to 4 for lower elevation sites), forage samples will be taken within each treatment by hand clipping 8, 0.5 m^2 quadrats to an 8 cm height (approximate cutter-bar height). In addition, forage samples will be taken at the end of the growing season to account for any regrowth that occurs following the last cutting of hay. Samples will be bagged and dried in a forced-air oven for 72 hours, then weighed and converted to yield per hectare. The samples will then be ground through a 2 mm screen using a Wiley mill in preparation for forage quality analyses. Samples will be analyzed for crude protein, neutral detergent fiber, acid detergent fiber, and neutral detergent fiber digestibility.

In addition to the baseline soil samples taken in the spring, each treatment will be sampled again at the end of the growing season at each site using the same protocol as outlined above. Samples will be analyzed for pH, electrical conductivity, organic matter content, and nitrogen, phosphorus, and potassium concentrations. Samples from the lower basin sites will also be tested for selenium concentration.

The impact on selenium and salinity in the lower basin will be estimated by first assuming a nominal system efficiency (e.g. 50 percent for gated pipe surface irrigation) and deep percolation fraction (e.g. 20 percent of the unconsumed portion). With these assumptions, the amount of percolated irrigation water per unit area prevented through fallowing can be calculated. With access to local United State Geological Survey (USGS) and Bureau of Reclamation (USBR) salt and selenium loading rate estimates, tons of salt and pounds of selenium prevented from groundwater transport to local waterways can also be estimated. Soil electrical conductivity on soil samples in 2013 and 2014 will also reveal any salt encroachment problems into hay root zones due to fallowing.

Model A[4] atmometers will be installed at each site to account for reference evapotranspiration (ET_O). The values recorded during the fallowing period will be compared to full season ET_O to determine a likely range of marketable water and the proportion of full season ET_O that is potentially accounted for by fallowing. ET_O values for the fallowing period will be grouped and averaged by upper basin and lower basin sites. The seasonal ET_O for 2013 for each of the two elevation groups will then be compared to seasonal averages for ET_O from previous years to develop a range of conserved water yields based on climatic conditions.

All of the above measurements will be continued in 2014 to establish soil and crop responses and account for water use when full irrigation is restored. Analysis of variance (ANOVA) will be used to compare soil parameters from the spring samples with the fall samples to determine any short-term impacts to the soil due to fallowing. Forage yield and quality will be compared between the control and fallowed plots using ANOVA to determine the impact on these parameters. The most meaningful comparisons will be able to be made after the 2014 growing season when soil, forage, and water use parameters can be compared between the 2 years.

Project Benefits: One of the biggest questions for the irrigation community and water bank proponents is how to account for (i.e. quantify) the incidental effects of withholding irrigation water from a hayfield. Establishing agreeable terms for the water to be leased is academic in comparison to accounting for incidental costs to the landowner due to fallowing hayfields. For example, is there a recovery period when full irrigation is restored the following year or do yields bounce back immediately? Will weed control be required? Also, many other agronomic factors such as elevation, soils, and water availability vary regionally throughout the Western Slope; how might they be accounted for when pooling irrigation water from different locations in Western Colorado?

Consequently, the primary benefit this study will provide is a baseline of agronomic knowledge for hayfield fallowing to complement the current and expanding examination of the legal, engineering, and administrative hurdles of water banking.

Reporting: A preliminary report of initial findings will be submitted in time to support a pre-proposal for a second year's worth of funding. This report will be completed and submitted immediately prior to the deadline for 2014 pre-proposals (i.e. mid-September to mid-October).

A final and full report of 2013's findings will be completed and submitted after the irrigation season, prior to the completion of the full proposal (i.e. January to February 2014). The PI will also lead an article on the project for the Colorado Water magazine during the 2013 project period.

[4] Model E atmometers do have data logging capability, but also have a track record of being unreliable. Considering the additional expense of Model E versus Model A, this project went with Model A atmometers.

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

James Pritchett, Associate Department Head, Agriculture and Resource Economics, Colorado State University
Christopher Goemans, Assistant Professor, Department of Agriculutral and Resource Economics, Colorado State University

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.

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.

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 Bulletin: 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: This project began on March 1, 2013 and will conclude on or before February 28, 2014.

Bringing the Value of Colorado's Decision Support Systems (CDSS) to Universities and Establishing Protocols for Integrating University Research with CDSS

Steve Malers, Cheif Technology Officer, Open Water Foundation

There is a need to improve university access to and use of CDSS for research and education. There is also a need to incorporate research and innovation into CDSS. The purpose of this project is to formalize relationships and protocols to address these needs and build a foundation for future interactions. Such effort can result in greater leveraging of CDSS and help educate a new generation of water resources scientists, engineers, and policy-makers. This project also will enhance research by leveraging CDSS beyond this project.

Background: CDSS has been under development for twenty years and has resulted in a significant body of work related to understanding, planning for, and managing water resources in Colorado. CDSS components include the HydroBase database and spatial data layers, model data sets, software, documentation, and processes. However, the learning curve for understanding and using CDSS offerings is intimidating and to date CDSS has primarily been utilized by a few consultants with long-term involvement in State projects. Although universities have access to CDSS, the evolving nature of research and a student workforce presents challenges to utilizing CDSS to its fullest in research and education. Additionally, the CDSS development team is not well-positioned to incorporate university research in software enhancements and procedures. These limitations result in barriers to innovation and efficiency in using CDSS at a time when water resources problems are becoming increasingly urgent.

The constraints on State budgets limit CDSS maintenance and innovation. The State of Colorado will have difficulty maintaining CDSS software with internal resources and specific projects will not holistically address maintenance and enhancement of the CDSS core software tools. CWCB staff has recommended moving CDSS software to an open source software approach and in September of 2012 the CWCB Board directed staff to develop a plan to do so. The nonprofit Open Water Foundation (OWF) has being established as an option to fill the role of CDSS software maintenance, enhancement, and support. The OWF is involved with multiple projects in Colorado, including the HB 1278 South Platte Groundwater Study, South Platte Decision Support System (SPDSS) modeling, Alluvial Aquifer Accretion and Depletion Analysis Tool (AAADAT), and others and is well-positioned to facilitate increased collaboration with universities.

Approach: The OWF will coordinate with the CWI to execute the project, with the OWF providing CDSS perspective and the CWI providing university perspective. Both organizations reside in Fort Collins and personnel have been collaborating on other efforts, such as the HB 1278 South Platte groundwater study.

The following tasks will be accomplished under this project. The result of this approach will be an enhanced network of university researchers and educators that can benefit from CDSS and can help to improve CDSS. It is envisioned that this project will illustrate a CDSS outreach effort for universities that can be adapted for other sectors, such as the consulting community, government agencies, and nonprofits. This outreach will benefit CDSS and the State of Colorado by enhancing understanding of water resource issues, elevating the discussion of issues to use additional science and data, and expanding opportunities for dialogue, collaboration, and funding.

Task 1 – Determine points of contact at universities and identify university needs

1. Determine points of contact at universities to participate in the project, including program leaders and faculty that can benefit from CDSS.
2. Determine from points of contact the university needs relevant to CDSS, for example:

- Larger programs such as the CWI may serve as a point of focus for CDSS interactions
- Water resources courses may benefit from data and tools
- Research projects may benefit from data and tools
- Grant proposals may benefit from CDSS collaboration
- Universities that house facilities for advanced visualization and discourse (such as the OWOW Decision Theatre and Google Liquid Galaxy installation at CSU) may benefit from data and tools

Determining university needs will be accomplished with face-to-face meetings, webinars, and email exchanges. On-campus workshops will be utilized if necessary to engage larger groups.

Task 2 – Enhance CDSS to facilitate use by universities

Take action on tangible efforts that will bring CDSS benefits to universities, for example:

- Create/improve CDSS documentation and training materials to be suitable for universities
- Help install CDSS tools in university systems, for access by students and researchers
- Help utilize CDSS tools and data in classes

Task 3 – Implement protocols to facilitate university contributions to CDSS

- Implement protocols for universities to contribute to CDSS, for example:
- Define how CDSS software and processes are structured so that researchers can collaborate with CDSS developers
- Work with universities to contribute to the open source software effort
- Improve CDSS feedback mechanisms so that university questions and comments can be used to improve CDSS offerings

Task 4 – Specific university implementations and final report

Scale the effort up within CSU and expand to other universities, depending on interest and specific needs and benefits, for example:

- Implement CDSS tools in courses, research projects, and laboratory projects
- Evaluate ease of use of CDSS tools in practice in a university setting and implement improvements
- Evaluate ease of contributing to CDSS tools and implement improvements

Deliverables: The deliverables have been discussed in the approach and are summarized as follows:

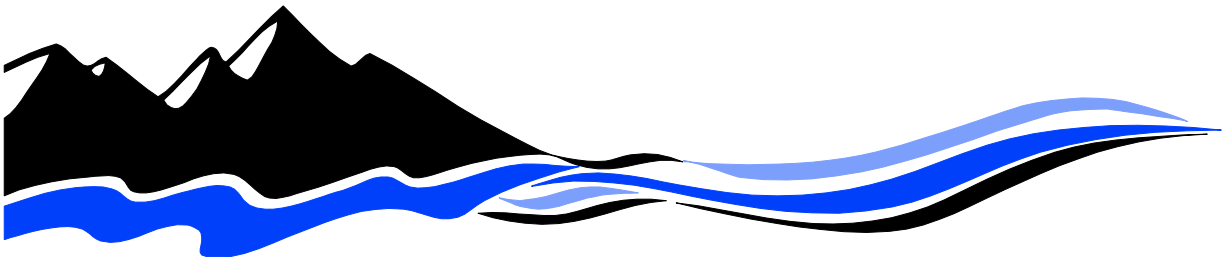
- Improved CDSS documentation and training materials, suitable for universities
- Documented protocols for university/CDSS interaction, including lines of communication and technical guidelines
- CDSS data and tool installations at universities, with supporting documentation

Additionally, a summary memorandum will be provided to the CWCB at the end of Task 4 to describe the results and benefits of the project.

Timeline:

Task Number	Task Name	Delivery Dates
1	Determine points of contact at universities and identify university needs	August 15, 2012
2	Enhance CDSS to facilitate use by universities	September 30, 2012
3	Implement protocols to facilitate university contributions to CDSS	October 31, 2012
4	Specific university implementations and final report	December 31, 2012

Current Student Projects



FY13 Student Water Research Grant Program

Request for Proposals

The Colorado Water Institute announces a request for proposals for the FY13 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, 2013 and be completed by February 28, 2014. 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 01/07/2013. Please visit http://cwi.colostate.edu for submission site and proposal preparation guidelines.

Announcement of Awards

The student applicant and faculty sponsor will be notified as to the status of their application by February 1, 2013 via 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 and 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 or faculty advisors may be asked to present an oral report on their work to the CWI Advisory Board.

Projects must be completed by February 28, 2014. The final project report will be due no later than March 31, 2014.

Proposal Deadline

Monday, January 7, 2013 at 5:00 PM (MT)

Expected Award/Start Date

Start Date: March 1, 2013
End Date: February 28, 2014

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.

Social Network Analysis Techniques for Water Resources Management Workshop

Margaret T. Herzog, PhD Student, Department of Civil and Environmental Engineering, Colorado State University

John Labadie, Professor, Department of Civil and Environmental Engineering, Colorado State University

Abstract: Social network analysis (SNA) is a system for studying relationships between people, groups, organizations, and other entities, as well as, network flows of information and resources. The purpose of this CWI project will be to test SNA techniques, then develop materials to provide a Fall 2013 half-day workshop in *Social Network Analysis Techniques for Water Resources Management.* The SNA workshop will introduce interested Colorado State University (CSU) students and faculty in engineering, natural resources, agriculture, and other scientific disciplines to complimentary analysis for social aspects of their work and research through SNA principles and techniques.

As part of the researcher's dissertation entitled Decision Support System (DSS) for Adaptive Co-Management of Water and Environmental Resources, the author is developing semi-structured interviewing techniques and social network analysis (SNA) routines to define organizational ties, information and resource flows, and regulatory frameworks to better characterize the human dimensions of current conditions watershed-wide and to better plan diverse options to improve integrated water resources management (IWRM). In addition to social systems analysis, SNA will also serve as part of the DSS module for monitoring and assessment to analyze how management options that increase social network bridging ties, reduce network fragmentation, improve leadership measures of centrality, and increase in number and strength flows of resources and information work to improve sustainability and resilience of water resources management frameworks.

In the student's dissertation research, SNA techniques are embedded in a process of adaptive co-management (ACM), which combines the experiential knowledge-building process of adaptive management with the flexible, shared governance approach of co-management. An introduction to ACM will also be include as a components of the workshop, as would others SNA findings from select CSU faculty and student research, as well as, worldwide research in SNA applied to natural resources problems.

The Social Networking Analysis Techniques for Water Resources Management workshop could be provided as part of the CWI Fall 2013 water resources seminar series or as a separate half-day workshop. CSU faculty in sociology and other departments with SNA expertise would be involved in workshop review prior to presentation. If a lab at the CSU campus could be found with UCINET software installed, for additional preparation costs, the workshop could also be expanded to a full-day to include practical UCINET lab practice in the latter portion.

Budget Breakdown: Provide a brief preliminary budget using the format provided.

Cost Category	Total
1. Student Hourly/Total Salaries and Wages	$ 4,075
2. Fringe Benefits	$ 0
3. Supplies	$ 40
5. Services	$ 0
6. Travel	$ 0
7. Other direct costs	$ 0
8. Total direct costs	$ 4,115
9. Indirect costs (10%)	$ 408
10. Total Project Costs	$ 4,523

Budget Justification: Breakdown and justify expenses.

Salaries and Wages. **Provide estimated hours and the rate of compensation proposed for each individual.**	
The student will be paid **$25 / hour** with NO tuition reimburse or other fringe benefits	$25/hr
Additional testing of SNA methods specifically for workshop purposes SNA Workshop material preparation and workshop-specific SNA research SNA Workshop material review and refinement SNA Workshop preparation / followup SNA Workshop presentation Final CWI Report with Final Workshop Materials Packet, Newsletter article, etc. | Total Hours	12 hr 70 hr 20 hr 8 hr 8 hr 45 hr 163 hr
Total Direct Labor Costs	**$4,075**
Fringe Benefits. Provide the rate (%) and amount for fringe benefits applicable to each category of employee proposed in the project.	
The student is only charging an hourly rate with no fringe benefits, since she is not a university employee. The faculty support is only rated as a portion of the student rate to 10% indirect support costs, so their fringe benefits are not included either.	
Supplies. Indicate separately the amounts proposed for office, laboratory, computing, and field supplies.	
Workshop materials will be provided through a website prior to the workshop for download, and all reports/ photos will also be provided electronically. UCINET software: $40, one student copy. Workshop will need to be recorded, so may require additional fee, if CSU cannot cover charge.	
Services. Identify the specific tasks for which these services would be used.	
It is assumed that services related to workshop setup would be provided by CSU free of charge.	
Travel. Provide purpose and estimated costs for all travel.	
No travel costs associated with workshop will be charged.	
Other Direct Costs. Itemize costs not included elsewhere, including publication costs. Costs for services should be included and justified under "Services".	
No other direct costs will be charged the CWI project.	
Indirect Costs. Provide indirect (Facilities & Administration) cost rate. Will keep to 10%.	
Expert faculty will need to review workshop materials and other related consultation, $408.	

Statement of Regional or State Water problem: I have spoken with several CSU graduate students in several science and engineering departments who would like to use SNA in interdisciplinary research to better understand the human dimensions of water resources, natural resources, and environmental management, however, there are only a few CSU semester long courses in sociology, communications, and anthropology that only briefly address SNA as part of the curriculum. The *Social Networking Analysis Techniques for Water Resources Management* workshop would specifically provide a jump start in natural systems-focused SNA for under-served graduate students, as well as, interested faculty and senior undergraduate students in other CSU science and engineering departments. Not only can SNA help researchers describe social, organizational, political, legal, and regulatory issues better, but it may also be used to compare successful and unsuccessful applications of IWRM, ACM, and other resource management methods. SNA also serves to more fully analyze how well alternative options improve relationships for long term sustainability and resilience, rather than focusing only on an option's technical merits. SNA is also an effective monitoring and assessment tool to gauge how well an implemented solution improves social network structure and resource and information exchange.

Statement of the results or benefits: Increasing awareness of SNA techniques among faculty and student workshop attendees in agriculture, engineering, and natural resources disciplines will meet several objectives:

- encourage students to strive to build more sustainable, resilient socio-ecological systems,
- more analytically consider the human dimensions of apparently technical problems,
- increase interdisciplinary research activity,
- increase the flow of scientific research into practical applications, and
- better assess project outcomes to include improvements in social network structure.

Nature, scope, and objectives of the project, including a timeline of activities:

The objectives of the project are to test SNA methods, develop materials, present the SNA workshop, follow up with attendees, and compile results and lessons learned for CWI benefit.

Month	Activities
March 2013	Determine faculty reviewers, Finalize data collection techniques for workshop inclusion, Conduct SNA research integration from list in part 17. below.
April 2013	Outline course content, Develop graphics to describe each SNA principle
May 2013	Develop water, natural resources, and environmental application examples
June 2013	Complete SNA principles and data collection techniques section of workshop
July 2013	Develop SNA techniques portion of the workshop, UCINET based examples
August 2013	Have draft workshop materials reviewed by experts, Make revisions, Set workshop date and venue, Develop workshop marketing materials and campaign
September 2013	Make preparations for video recording of workshop and schedule any onsite example demos to include, Launch marketing campaign and adjust if needed to achieve minimum 20 attendees, Develop exit surveys and follow-up activities
October 2013	Present Workshop: Social Networking Analysis Techniques for Water Resources Management, Obtain survey feedback, Plan next steps with attendees
Nov. 2013	Write CWI report, Compile results of workshop exits surveys, Complete followup
Dec. 2013	Project closeout

Methods, procedures, and facilities: SNA determines how entities are organized in relation to one another. The focus of the workshop will be to explain how SNA can be used to better evaluate organizational ties, knowledge and resource exchange, and regulatory frameworks to improve analysis, implementation, and ongoing assessment of water resources, natural resources, and environmental management practices at the watershed scale and beyond. The workshop will present SNA as part of an systematic approach to IWRM through ACM.

The SNA resources listed in part 17. below will serve as the theoretical SNA basis of the workshop. Ongoing SNA research being conducted as part of the principal investigator's dissertation case study of Bear Creek Watershed in integrated, watershed scale nutrient management will serve as the basis for more practical aspects of the workshop, which will be supplemented by research being conducted by other CSU teams in sociology, anthropology, education, communications, and human dimensions of natural resources and a review of other examples from the part 17. resource list. UCINET software main features and examples will also be briefly covered based on research experience and related tips and caveats from its several dedicated online communities.

Since CWI has been able to secure CSU classrooms and labs and support services for other projects, it is assumed that these resources can be obtained at no direct cost to the project.

Related research: Several key resources will be used in developing workshop materials:

Banathy, B. 1996. Designing social systems in a changing world. Springer-Verlag, Berlin.

Bodin, O. and B. Crona. 2009. The role of social networks in natural resource governance: What relational patterns make a difference? Global Environmental Change 19 (2009): 366–374.

Bodin O. and C. Prell. eds. 2011. Social Networks and Natural Resource management: Uncovering the Social Fabric of Environmental Governance. Cambridge University Press, Cambridge, UK.

Checkland, P. 1999. Systems Thinking, Systems Practice. In Soft Systems Methodology: a 30-year Retrospective. John Wiley & Sons, Ltd. NY.

Knoke, D. and S. Yang. 2007. Social Network Analysis, Series: Quantitative Applications in the Social Sciences. Sage Publications, NY.

Ostrom, E. 2005. Understanding Institutional Diversity. Princeton University Press, Princeton, NJ.

Plummer, R., B. Crona, D. Armitage, P. Olsson, M. Tengo, and O. Yundina. 2012. Adaptive Comanagement: A Systematic Review and Analysis. Ecology and Society 17(2): 11.

Prell, C. 2012. Social Network Analysis: History, Theory, and Methodology. Sage Publications, NY.

Rodela, R. 2012. The social learning discourse: Trends, themes and interdisciplinary influences in current research. Environmental Science & Policy, 25 (January 2013): 157-166.

Walker, B., and D. Salt. 2012. Resilience Practice: Building capacity to absorb disturbance and maintain function. Island Press, Washington, D.C.
Wasserman, S. and K. Faust. 1994. Social Network Analysis: Methods and Applications. Cambridge University Press, Cambridge, UK.

Training potential: Since the *Social Networking Analysis Techniques for Water Resources Management* workshop could be repeated at different interested universities and other settings throughout Fall 2013 and beyond, training potential could be quite large, but as a minimum, a single workshop would seek a minimum of twenty students in engineering, natural resources, natural sciences, and agriculture colleges in a variety of disciplines through effective marketing.

Student Attendance Goals	Classification	Area of Study (Discipline)
Workshop attendees #1-5	Masters and PhD	CSU College of Agricultural Sciences
Workshop attendees #6-10	Masters and PhD	CSU College of Engineering
Workshop attendees #11-15	Masters and PhD	CSU College of Natural Sciences
Workshop attendees #16-20	Masters and PhD	CSU College of Natural Resources
Undergraduate attendees	Sr. Undergrads	CSU Science and Engineering Depts.
Faculty attendees	Interested Faculty	CSU Science and Engineering Depts.

Investigator's qualifications: Margaret Herzog has been a trainer, researcher, and integrator for more than fifteen years. She provided workshops to Natural Resources Damage Assessment and Restoration Program (NRDAR) managers from more than six different federal agencies in the Dept. of Interior annually from 2004 through 2008. She was also an ESRI authorized GIS instructor, for which she trained federal, military, and private clients in GIS software and techniques, and for which she also developed an ArcGIS lab as an adjunct professor for the University of Colorado at Denver, and ArcView programming workshops for Colorado State University GIS course presentations. In 2010 and 2011, she trained statewide staff from the Colorado Division of Water Resources, including all seven division offices, to implement more collaborative intranet and internet systems, which she designed.

Last year, Ms. Herzog also self-completed the ExCEEd Model Instruction Strategy course developed by the University of Texas, which is used by Colorado State University for new faculty and graduate teaching assistants in the College of Engineering. This course is designed to improve instructional techniques through more appropriate student orientation, learning objectives development, incorporating ways to stimulate critical thinking, providing models, assessing learners performance and feedback, and utilizing better communication skills, including expanded media techniques, speaking, and exceptional nonverbal bonding methods.

Ms. Herzog has also presented her research in a variety of settings. In March 2012, out of over 1000 solutions, her Water Action Network concept was selected for presentation in the small *Village of Solutions* at the 6th World Water Forum in Marseille, France. In June 2012, she presented a statewide *Measurable Results* restoration monitoring system she had developed at the AWRA Summer Riparian Symposium, and in June 2011, she presented the Water Action Network at the AWRA Summer IWRM Symposium. In 2000, she presented new GIS techniques at the Alaska Surveying and Mapping Conference and both a landfill siting application and a stormwater runoff management application at the ESRI User Conference. For each presentation, she also wrote related papers that were peer reviewed for inclusion in conference proceedings.

Ms. Herzog has developed instructional manuals, standard operating procedures, best management practices, project reports, business charters and plans, and other technical documents for federal, state, private, non-profit, and academic clients. In 2000, she also wrote two chapters for *ASCE Urban Planning and Development Applications of GIS* (Said Easa and Yupo Chan, eds.) - Chapter 2: GIS Technology & Implementation and Chapter C9: Stormwater and Waste Management Applications. As a Project Management Institute, Project Management Professional (PMP) and a Professional Engineer (PE), project professionalism is her passion.

Ms. Herzog wishes to use this CWI project opportunity to develop the *Social Network Analysis Techniques for Water Resources Management Workshop* as a first step in making SNA to implement ACM for IWRM more widely understood and practiced. If the SNA workshop is successful, she hopes to build it into a semester-long graduate course, a full-day workshop with UCINET software training, and , eventually, into related books and research publications.

FREE! Social Network Analysis Workshop for Water and Resource Management

When: Wednesday, October 23rd **OR** Tuesday, October 29th
Time: 4PM – 8PM **(includes free dinner!)** Choose preferred day.
Where: Engineering Bldg-E, Rm. 126, Physics Conference Room
Cost: Absolutely FREE! + earn certificate and points for prizes!!
How: REGISTER and more details at ***sna.wateractionnetwork.org***

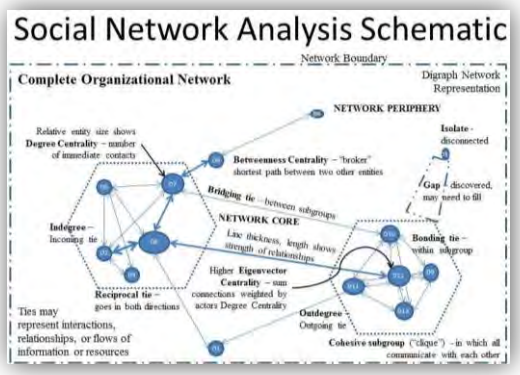
- ✓ **Review** what you know *and don't know yet* about social networks and human dimensions of technical problems
- ✓ **Learn** systematic, structured approach to analyze groups
- ✓ **Explore** how to apply SNA to resource problems and more

Physics Conference Room 126

SE entrance = E-Wing
Engineering Bldg. is NE of Lory SC

Workshop Schedule

4:00-4:30 Introductions, Roundtable, Scenarios
4:30-5:00 Challenges of Integrated Management
5:00-5:30 SNA theory and FUNdamentals
5:30-6:00 BREAK! for pizza, subs, drinks, snacks
6:00-6:30 Social Network Analysis methods
6:30-7:00 Adaptive Co-Management concepts
7:00-7:30 Applications to Water & Resource Mgmt
7:30-7:50 Improving your own networks, Tips
7:50-8:00 Wrap-up, Next steps, Join collaborative!



sna.wateractionnetwork.org

More questions??? Call (303) 238-0419 or complete *Contact tab* on the website or contact: margaret.herzog@colostate.edu

For more details, visit the website or scan QR code>

INTERNSHIPS

CWCB - INTERNSHIP IN WATER RESOURCES RESEARCH

Intern for Basin Needs Decision Support System (BNDSS)

Craig Godbout

Intern for Open Water Foundation

Elizabeth Sellos-Moura Mahon*

USGS - INTERNSHIP IN WATER RESOURCES RESEARCH

MOWS - Modeling of Watershed Systems

Michael Sanders*

Andrew Reimanis

Sydney Wilson

*Photo unavailable.

FY14 Research Proposals

FY 2014 Request for Pre-Proposals

Closing Date: October 28, 2013 at 5:00 p.m. (Mountain Time)

Full proposal: http://cwi.colostate.edu/other_files/Faculty_RFP_2014.pdf

Pre-Proposals are invited for the Colorado Water Institute FY 2014 water research program. Full proposals may not be submitted until a pre-proposal is approved by the Colorado Water Institute director.

Priority Research Topics:
For the FY 2014 competition, the CWI Advisory Committee for Water Research Policy has identified needs for new water knowledge that will assist in addressing the following issues for Colorado:

- Use of the Arkansas Valley Lysimeter for developing crop coefficients
- Deficit irrigation of hay as a source for potential water banking
- Colorado Decision Support System evaluation and use
- Developing and maintaining a climate data system for Colorado
- Developing techniques for remote sensing of ET
- Quantifying irrigation water requirement associated with the Arkansas DSS

Interested applicants are encouraged to contact Reagan Waskom at reagan.waskom@colostate.edu for additional details.

Funds Available:
The FY 2014 CWI Request for Proposals is supported by the Colorado Water Conservation Board and the U.S. Geological Survey, pending state and federal budget allocations. CWI research funds are awarded through a competitive process guided by the CWI Advisory Committee. Proposals that contain matching funds from Colorado water-related organizations are strongly encouraged. Project budgets must not exceed $50,000 of total CWI funds requested. Non-federal matching funds are encouraged.

Proposal Review Process:
All pre-proposals are due in the CWI office by October 28, 2013 at 5:00 p.m. (MT). Pre-proposals will be reviewed before ranking by the CWI Advisory Committee. The general criteria used for proposal evaluation include: (1) scientific merit, (2) responsiveness to RFP, (3) qualifications of investigators, (4) originality of approach, (5) budget, and (6) extent to which Colorado water managers and users are collaborating.

Eligibility:
The competition is open to faculty and researchers at Colorado's public research universities.

Applications Not Eligible For Funding:
Applications submitted by an investigator who has not met reporting requirements on a previous award administered or awarded by CWI are not eligible.

Pre-Proposal Submission:
Pre-Proposals are to be submitted electronically as a Microsoft Word document no later than 5:00 p.m. (MT) on October 28, 2013. Submit via email to: nancy.grice@colostate.edu. Full Proposal Submission: Pre-proposals selected for funding will be developed into full proposals by December 22, 2013 in consultation with CWI staff.

CWI Pre-Proposals

FY 14

PI's	Title	Budget
Andales Bartolo Simmons	Determination of Consumptive Water Use of Corn in the Arkansas Valley (Year 2)	$ 46,137
Bau	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	$ 50,000
Brummer	Assessing the Agronomic Feasibility of Single-season Irrigation Deficits on Hay as Part of a Western Slope Water Bank	$ 49,512
Chavez	Developing an Unmanned Aerial Remote Sensing of ET System	$ 50,000
Doesken Ryan	Improving data quality for an enhanced climate data delivery system for CoAgMet (Colorado Agricultural Meteorological) network	$ 50,000
Elhaddad Arabi	Remote Sensing Based Irrigation Water Management Tools for Assessing the Impacts of Deficit Irrigation and Quantifying Irrigation water	$ 44,000
Gates Niemann	Data Collection and Analysis in Support of Improved Water Management in the Arkansas River Basin	$ 50,000
Malers	Development of Visualization Tools for the South Platte	$ 50,000
	Total Requested Funding	**$ 389,649**

Determination of Consumptive Water Use of Corn in the Arkansas Valley (Year 2)

**Dr. Allan A. Andales, Associate Professor of Irrigation and Water Science,
Department of Soil and Crop Sciences, Colorado State University
Dr. Michael E. Bartolo, Research Scientist, CSU-Arkansas Valley Research Center, Rocky Ford, CO
Mr. Lane Simmons, Research Associate, CSU-Arkansas Valley Research Center, Rocky Ford, CO**

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

Purpose: 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, and wind speed) to calculate a reference crop ET (ET_r), which is a measure of local atmospheric demand for water. Crop ET (ET_c) is then calculated by multiplying ET_r by a crop coefficient (K_c) that varies with crop growth and development. This 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 ET_r to ET_c values and by validating (ground-truthing) the ET_r values calculated by the ASCE-PME for local conditions in the Arkansas River Basin. Corn is a dominant irrigated crop in the basin and has been the focus of this project in 2013. At least 2 growing seasons of data are required to develop a seasonal crop coefficient curve that is representative for the area. Therefore, a second growing season (2014) of corn data will be collected using the large (crop) lysimeter. The more accurate calculations of ET_c 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 ET_r from ASCE-PME with measured alfalfa ET_r from the reference (small) lysimeter.

Objectives and Methods:

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.

The objectives will be achieved in close collaboration with engineers in the Colorado Division of Water Resources (CDWR). Corn ET_c from the large lysimeter and alfalfa ET_c from the reference lysimeter will be calculated by mass balance (from automated weighing scale readings) and aggregated to 5-minute, 15-minute, and hourly totals. A full time research associate will manage the daily operations, crop management, maintenance, and data quality control of the 2 lysimeters. The following will be the major deliverables of the project: (1) Seasonal crop coefficient curve that characterizes corn ET_c (2014 growing season combined with 2013) at different developmental phases; and is appropriate for local conditions in the Arkansas Basin; (2) Observed seasonal consumptive water use (ET_c) of corn (2014); (3) Accurate hourly weather data from 12 CoAgMet stations in the basin, made available through the CoAgMet online database; (4) Comparison of calculated alfalfa ET_r 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 ET_r 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. A draft of the report shall be provided to CDWR and CWCB by June 30, 2015.

This project will be conducted from July 1, 2014 to June 30, 2015.

Budget and Justification

This agreement is for a maximum of $46,137 budgeted as follows.

Salary (one research associate; $5445/mo x 6.0 mo)	$32,670
Fringe benefits (@ 22.8%)	$ 7,449
Subtotal	$40,119
Indirect cost (@ 15%)	$ 6,018
Total	$46,137

These funds will pay for 6.0 months of work by one full-time research associate, who will manage the day-to-day operation of the lysimeters, take all measurements, and process the data. The CSU Agricultural Experiment Station will provide matching funds for 6 additional months of salary and fringe, 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 CDM-Smith [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 mi^2) 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 overarching 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 is carried out over a three-year period. In the first two years, CSU has focused on the following tasks:

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.

e) Sensitivity study on:

- Effects of hypothetical increased stream augmentation by aquifer recharge that reproduces quantitatively the changes in water administration practices enacted in 2006.

- Changes in aquifer pumping based upon realistic estimates of the reduction in groundwater withdrawal and its spatial distribution across the SPRB that have occurred since 2006.

- Effects on groundwater and surface water flow regimes of hypothetical drought conditions producing reduced snowmelt upstream inflows and increased evapo-transpiration in relation to modified atmospheric conditions and rising water table levels, respectively.

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 third year of the project.

Proposed Tasks for Year 3: It is anticipated, in the fiscal year 2013, the SPDSS groundwater flow model will be applied to verify the adequacy of analytical, semi-analytical and numerical models currently used to assess:

a) The impact of well pumping from alluvial formations on the flow in hydraulically connected to streams and irrigation canals.

b) The plans for stream augmentation that permitted wells are currently required to meet for consumptive use of groundwater.

In both tasks, the SPDSS groundwater model will be applied to simulate the effects on stream flows of hydrological stresses (well pumping and artificial recharge) applied to the alluvial aquifer system. The results of the model will be compared to corresponding stream-aquifer interaction laws used for water administration. Since the SPDSS groundwater model simulates realistic conditions of unconfined subsurface flow and, given its considerable spatial extent, uses an upscaled griblock size (1000×1000 ft2) this study will also focus on the influence that effects that local heterogeneity and unconfined-flow related non linearity may have on the calculation and the adopted constitutive laws for stream depletion and recharge. It is worth mentioning that this proposed application of the SPDSS groundwater flow model is one of the goals originally specified by the CWCB in their original SPDSS feasibility study (CWCB, 2001).

Deliverables: At the end of the third year, a final technical report describing project activities and findings will be submitted to CWCB. In particular, this report will include all 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: The following table shows a detailed budget for the fiscal year 2014:

0.75 Month Faculty Salary[1]	$9,292
6.5 Month Post-Doc Salary[1]	$34,186
Indirect Cost (15% rate)	$6,522
Total Cost for Fiscal Year 2013	$50,000

[1]Includes 25% fringe.

In addition to the Project Principal Investigator, Dr. Domenico Baù, one Post-doctoral fellow will be involved and financially supported in this study. The Post-doctoral fellow will work part-time on the project (6.5 months).

Assessing the Agronomic Feasibility of Single-season Irrigation Deficits on Hay as Part of a Western Slope Water Bank: Continuation of Project Funded in 2013

Joe Brummer, Associate Professor/Extension Forage Specialist, Soil and Crop Sciences, Colorado State University
Calvin Pearson, Professor/Research Agronomist, Colorado State University, Western Colorado Research Center – Fruita
Abdel Berrada, Research Scientist, Colorado State University, Southwestern Colorado Research Center

Location: Seven irrigated, established hay fields (4 grass and 3 alfalfa) located in six Western Colorado counties: Delta, Montezuma, Gunnison, Mesa, Grand, and Routt.

Purpose and Need: To determine potential water savings, crop responses, and environmental impacts from strategic deficit irrigation of hay fields in Western Colorado.

Under the 1922 Colorado River Compact, the four Upper Division States may not allow the flow at Lee's 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 curtailment. 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 administration. The populated Front Range diverts about a half-million acre feet of CRB water of which the majority is junior to 1922. 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 average delivery requirements to the Lower Basin States 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.

Western Colorado includes the headwaters of the Colorado and numerous tributaries, such as the Yampa, White, and Gunnison. Together, these four basins include about 350,000 acres of irrigated grass and alfalfa hay. Many water bank discussions focus on the legal framework, administration logistics, and return flow implications of a possible water bank. Still to be determined is the agronomic feasibility for individual irrigators.

Objectives: "Deficit irrigation" refers to withholding water during non-critical crop growth stages. In mid to lower elevation environments, deficit irrigation is typically carried out by seasonally irrigating alfalfa and/or grass hay 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 treatments, 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), 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?

Timeline and completion date: This proposal is a request to fund the second year of a two-year project that was initiated in the spring of 2013. Completion of data collection and reporting of final results will occur in the fall of 2014. A graduate student was recruited in the spring of 2013 and she has completed the first year of data collection and is now in the process of analyzing and summarizing the data. We plan to collect data at the seven sites established in 2013 and hope to add several additional sites if possible to make the data set more robust.

Budget:

Item	Request	Indirect 15%	Request Total
Graduate Student	$21,204	$3,180	$24,384
Fringe (4.9%)	$1,039	$156	$1,195
In-State Tuition	$8,811	$1,322	$10,133
Travel	$8,500	$1,275	$9,775
Sample Analysis	$3,500	$525	$4,025
Totals	$43,054	$6,458	**$49,512**

Budget justification:

Graduate Student ($31,054): Covers salary, fringe benefits, and tuition.

Travel, Motel, and Per Diem ($8,500): Mileage to cover student travel to collect data at West Slope sites (mileage for pickup truck at $0.62/mile for estimated 12,000 miles); approximately six overnight stays ($85 incl. tax); and twelve days of per diem ($45/day).

Sample Analysis ($3,500): Approximately 20 soil samples (2 to 3 samples per site) will be analyzed each year for basic soil properties and nutrients at $25/sample ($500 total). Forage quality analyses will be run on 10 samples per treatment per cutting (3 to 4 cuttings per alfalfa site and 1 to 2 cuttings per grass site) for an estimated total of 400 samples ($7.50/sample for lab supplies or $3,000 total)

Matching ($5,000 or 10%): Cash provided via CSU Soil and Soil Crop Sciences donated by the Environmental Defense Fund specifically to support research in the area of water banking. Matching funds will be used to compensate cooperating landowners for lost hay production.

Developing an Unmanned Aerial Remote Sensing of ET System

José L. Chávez, Assistant Professor, Civil and Environmental Engineering Department, Colorado State University

Location: Greeley, La Salle, Fort Collins, and Rocky Ford, CO

Purpose: The proposed research will integrate proven remote sensing (RS) sensors into a small unmanned aerial system (sUAS). Data derived from the aerial RS platform will be used to develop a suitable RS of crop evapotranspiration (ET) method for Colorado.

The grant will make possible the development of a sUAS and in addition it will allow collaborative and will make future proposals more competitive (state, federal).

The type of information to be gained include: a) suitable (accurate) RS of crop ET algorithm for CO; b) ability to map (monitor) ET at high spatial resolution on demand; and c) documentation of spatial crop water stress and ET not used, for water rights, court, transfer purposes.

Considering an increase competition for water, the development of a sUAS for RS of ET purposes will be highly beneficial for irrigation ditch companies, water conservation districts, crop growers assoc., cities (landscape ET), and state and federal agencies.

Objectives, methods, timeline, completion date:

Remote sensing ET models are being used in agricultural irrigation water management. These models either rely on distributed information on surface vegetation indices (visible and near infra-red bands) or on surface temperature images. RS of ET models perform better on certain regions, environments and surface conditions. Therefore, there is a need to develop a reliable RS of ET model for Colorado. Furthermore, a main challenge regarding RS imagery, is that the temporal resolution of multispectral satellite images is not adequate (e.g., every 16 days in the case of Landsat 8) to estimate daily crop ET. If there is cloud cover during a satellite overpasses then estimates of ET for a month will not be possible. Using airborne RS platforms may be cost-prohibited (~$5,000 per campaign/farm) and may not be available on demand (due to the nature of their commercial applications and commitments). Therefore, it is believed that with the integration of multispectral sensors in a small unmanned aircraft system (sUAS), a robust and dependable high spatial resolution ET model can be developed.

The sensors (multispectral scanner and infra-red thermometer) that will be mounted on the new sUAS have been used at ground level. The collected data have proved to be useful in promoting a more efficient and sustainable management of agricultural water. However, a major critique is the time difference between data points collection. Mounting sensors on a sUAS will enable the collection of needed high resolution (~30 m) crop water use data on a spatial fashion on demand. Hence, with the development of the sUAS larger areas will be able to be covered and the evaluation and development of a suitable RS of ET method will be more efficient since a wider range of surfaces/conditions will be covered on demand (i.e., not depending on the limitation of ground-based sensors, satellite overpass, or costly aircraft imagery).

Objectives: The objectives of the proposed research include: a) integrating multispectral remote sensing sensors in a sUAS, b) development of a suitable remote sensing of crop evapotranspiration (ET) method for Colorado, and c) evaluation of items (a) and (b).

Methods: A small Unmanned Aerial Vehicle (sUAV) will be acquired from UASUSA and multispectral RS sensors will be mounted on the aerial platform. The PI has secured funds from a Borland Grant (CEE Dept.); thus requesting $15,000 from CWI to complete funds to purchase the aerial system.

A graduate research assistant (GRA) will help operate the system to acquire high spatial resolution data (~30 m footprint diameter by flying ~50 m from the ground) over research fields. The GRA will be trained in remote sensing of ET methods. The different research locations include: a) corn and alfalfa fields, managed under center pivot (CP) full and deficit irrigation, near La Salle, CO (Collaborator: Randy Ray, CCWCD); Randy has funded an in-field soil moisture sensor network to estimate crop ET; b) corn and alfalfa fields, fully furrow irrigated, near Rocky Ford, CO (Collaborators: Mike Bartolo/Lane Simmons/Allan Andales, CSU AES AVRC); where two weighing lysimeters are

located; c) limited drip irrigated corn fields near Greeley, CO (Collaborators: Jon Altenhofen, Northern Water; and Tom Trout, USDA ARS); and potentially d) limited CP irrigated corn near Fort Collins, CO (R. Khosla, A. Andales).

RS data will be used in three ET algorithms: a) a two-source energy balance (EB) model, b) a surface aerodynamic temperature EB model, and c) a crop water stress index (CWSI) model. Resulting ET values will be evaluated with ET derived from soil TDR, neutron probe, and lysimetric ET data. The model that better performs will be enhanced for the conditions found in CO. For instance, the CWSI approach could be enhanced by modeling the canopy temperature based on the sUAS data. Similarly, the aerodynamic temperature could be modeled based on the accurate characterization of percent vegetation cover, etc.

Timeline and Completion Date: It is proposed to start the project on March 1st of 2014 and end it by February 28th of 2015. March/April: acquisition of sUAV and recruitment of GRA; May/June/July/August: sUAS development, field tests and data acquisition and analysis; September, October, November: ET model development, evaluation; December, January, February: research article production; and March/April 2015: Report due to CWI.

Budget

Graduate Research Assistant:	$22,281
Fringe:	$1,107
In-State Tuition for GRA:	$5,090
Equipment:	$15,000
Total Direct Costs:	$43,478
Facilities & Administrative: 15% TDC	$6,522
Total:	$50,000

Budget Justification: Funds are requested to: a) cover the salary and fringe benefits ($23,388) of a graduate research assistant for 12 months; b) pay for partial in-state tuition credits ($5,090); c) complete funds to purchase a sUAV ($15,000); and d) cover CSU indirect costs ($6,522). The total amount requested is $50,000 for a period of one year.

Improving Data Quality for an Enhanced Climate Data Delivery System for CoAgMet (Colorado Agricultural Meteorological) Network

Nolan J. Doesken, State Climatologist, Colorado State University
Wendy A. Ryan, Assistant State Climatologist, Colorado State University

Location: Work will be conducted throughout Colorado.

Purpose: CoAgMet is a statewide weather network that was mainly designed to support Colorado's agricultural industry. With this funding request, the Colorado Climate Center will continue to develop, improve and maintain a climate data system for Colorado. Use of CoAgMet data to schedule irrigation is the most prominent use of this network, but without quality data as inputs to evapotranspiration (ET) equations, questions arise about the validity of ET estimates. The new eRAMS irrigation scheduling tool and the Arkansas Valley lysimeter projects rely heavily on ET estimates from CoAgMet stations and improved quality control is essential for these efforts. These funds will be used to build more robust data quality control into the CoAgMet database so that users are aware of potential problems with data inputs. This is a large undertaking but a worthy effort to increase reliability of the data being distributed.

Objectives, Methods, Timeline and Completion Date: The objectives of this work are to create a more reliable climate data delivery system for CoAgMet by improving upon both quality control of data and updating equipment to be used throughout the network. Researchers at the Colorado Climate Center will build automated quality control standards following the standards set by the FAO in Irrigation and Drainage Paper 56 for both weather data integrity and statistical analysis for filling in missing/suspect data. This will result in complete time series with flags for the data that is deemed questionable. The data flags will alert users to raw data that has been changed and for what purpose.

New sensors will be purchased and installed where it is deemed necessary during routine maintenance. Equipment will mainly include wind sensors, rain gages, pyranometers, and temperature/humidity probes.

Timeline:

July, 2014: Procure equipment and begin database investigations for programming quality control and data completeness algorithms once funds become available.

July - September 2014: Annual maintenance is performed on all stations; equipment will be installed at locations where sensors are found to be failing. Begin testing and implementation of data QC/completeness algorithms.

October 2014 - June 2015: Once testing of the data QC is completed internally, users will be solicited to test the algorithms. After the work is completed, the new database will be rolled out on the website and through web services. Final report writing begins.

June 30, 2015: Project completed and final report submitted to Colorado Water Institute.

Budget & Budget Justification:

Salary - $23,704:
Nolan Doesken, (0.1 of a person month (pm)) Senior Research Associate, will serve as Principal Investigator and oversee project tasks.
Wendy Ryan, (2 pm) Research Associate III, will procure equipment and perform annual maintenance on CoAgMet stations. She will also assist in the quality control upgrades.
TBD, (3 pm) Technical Support, will mainly focus on database upgrades with quality control and completeness routines.
Fringe - $5,405: Fringe benefits for administrative professional staff cover Medicare, unemployment insurance, worker's compensation, DCP, and BenPay, excluding sick leave. Fringe is estimated to be 22.8% of salary in all years of the project.
Domestic Travel - $3,000: Travel costs are requested for annual maintenance visits to sites across Colorado
Materials and Supplies - $11,185: Supplies are requested to replace aging sensors throughout the network including: pyranometers, temperature/humidity probes, anemometers and rain gages.

Other Direct Costs - $184:
ATS computer charges are for department Ethernet connections. This charge is $36/PM and 3.1PM are budgeted. The computer service charge is a rate developed using Section J-47 (Specialized Service Facility) of OMB Circular A-21 and Colorado State University's internal policy for computing, charging and auditing such Service Facilities.
Facilities and Administrative Costs (Indirect Costs) - $6,522:
The indirect cost rate will be 15% TDC in all project years.

CWI Total - $50,000

Matching Funds - $14,652
Unrecovered indirect costs (UIC) are proposed as matching funds. UIC is the difference between the CWI mandated F&A rate of 15% TDC and CSU's federally negotiated F&A rate of 48.7% MTDC.

Total - $64,652

Remote Sensing Based Irrigation Water Management Tools for Assessing the Impacts of Deficit Irrigation and Quantifying Irrigation Water

Aymn Elhaddad, Research Scientist, Department of Civil and Environmental Engineering, Colorado State University
Mazdak Arabi, Associate Professor, Department of Civil and Environmental Engineering, Colorado State University

Proposal Summary: Climate variability and droughts exacerbate the vulnerability to water scarcity in already over-allocated basins such as the South Platte River Basin in Colorado. Therefore improved tools for optimizing water use among competing interests are essential in order to reduce their impact. This proposal will develop a set of web-based water resource management tools that provide data and analytics to better understand the allocation of limited water supplies amongst competing sectors. In particular, the water saving and economic benefits of using remote sensing satellite based approaches to quantify the amount of actual crops evapotranspiration (ETa) at large scales will be demonstrated. To increase the impact of the project and the accessibility of the proposed tools, the remote sensing tools for ETa estimation will be deployed on a state-of-the-art cloud computing infrastructure developed at CSU called eRAMS. An added value of the proposed approach is accessibility of the tools via mobile devices. The two main objectives of this proposal are:

1. To develop a suite of automated fresh water management tools based on remote sensing of ETa.
2. To apply these tools to facilitate:

   A) Deficit irrigating monitoring for hay as a source for potential water banking.

   B) Quantification of irrigation water requirement associated with the Arkansas DSS.

The tools will consist of an automated surface energy balance model (Colorado-ReSET) and a semi automated seasonal evapotranspiration estimation tool (ReSET-Sea). The(Colorado-ReSET) model will be a variant of the previously developed ReSET-Raster model which uses the same surface energy balance approach as the SEBAL model [Surface Energy Balance Algorithm for Land, (Bastiaanssen et al. 1998a, b)] and METRIC model [Mapping EvapoTranspiration at high Resolution with Internalized Calibration, (Allen et al. 2007a,b)] .The ReSET-Raster model has a grid based implementation which allows it to explicitly take into account the spatial variation in evapotranspiration (ET) which if ignored can result in substantial errors (Elhaddad and Garcia 2011). The model will be automated and customized to use NASA satellites imagery data in different spatial and temporal formats (Landsat 7, 8 and MODIS).

The ReSET model has been used extensively in the South Platte River Basin in Colorado, the Arkansas River Basins in Colorado, the Palo Verde Irrigation District in California, Spain, as well as in the Nile Delta in Egypt to calculate ETa and develop crop coefficients. The ReSET model will be validated using field measurements of Arkansas Valley Lysimeter. The proposed methodology will be applied initially in Colorado, USA; however, the methodology is transferable to other locations throughout the world.

The complementary seasonal ET tool (ReSET-Sea) will act as a water management decision support tool that will have High spatiotemporal resolution to take into account spatially explicit ETa information. The proposed seasonal tool will use daily Landsat MODIS products to ETa interpolation. The model and the seasonal tool will be applied to the South Platte River basin in Colorado in corporation with NCWCD (Northern Colorado Water Conservation District). The developed tools can also be used to investigate long term management plans, which might include the feasibility of deficit irrigation schemes, crop rotation schemes, and operation under severe drought conditions. The model is data driven and therefore can be applied in other locations throughout the world were adequate data is available.

Project Timeline:

Milestone	3/2014 - 2/2015	
	0-6 M	7-12 M
1) Develop a suite of automated fresh water management tools that is based on remote sensing of Evapotranspiration	X	
2a) Deficit irrigating monitoring of hay as a source for potential water banking		X
2b) Quantifying irrigation water requirement associated with the Arkansas DSS		X

Budget:

Personnel Salaries:	Year 1
Administrative Professional:	$44,000
Total:	$44,000

Budget justifications:

PI: Aymn Elhaddad: 5 months
Computer programmer: 1 month

Data Collection and Analysis in Support of Improved Water Management in the Arkansas River Basin

Timothy K. Gates, Professor, Department of Civil and Environmental Engineering, Colorado State University
Jeffrey D. Niemann, Associate Professor, Department of Civil and Environmental Engineering, Colorado State University

Location: Arkansas River Basin, Colorado

Purpose: Colorado's Arkansas River Basin, the largest in the state, comprises a varied and complex water system. Emerging as a snowmelt-fed alpine stream, it extends about 165 miles and drops more than 4900 ft before gathering into Pueblo Reservoir to be released again onto the southeastern plains. Along the remaining 195 miles of its course before it flows into Kansas, the river winds through a broad and varied alluvial valley that supports extensive irrigated agriculture. In the Upper Arkansas River Basin (UARB), above Pueblo Reservoir, the water resources of the stream-aquifer system supply the demands of mountain communities and Front Range cities, recreation and fisheries, and some irrigated agriculture. In the Lower Arkansas River Basin (LARB), irrigated agriculture is the predominant water consumer with a growing municipal and industrial demand. In addition to natural snowmelt and rainfall, the Colorado River Basin provides inflow to the Arkansas River Basin via the Fryingpan-Arkansas and Twin Lakes trans-mountain diversions.

Water managers and users in the Arkansas River Basin need information to help them enhance overall beneficial water use, redress serious problems of water quality degradation (e.g., salinity, selenium, and uranium), conserve water, and find innovative ways (e.g., the Super Ditch) to address mounting pressures for increased diversions out of the Basin. Sound water management requires a good database to characterize the stream-aquifer system and to undergird existing and future modeling tools. For over fourteen years in the LARB and three years in the UARB, Colorado State University (CSU) has conducted extensive field monitoring to build such a database. *The purpose of the project proposed herein is to collect and analyze key field data in representative regions of the Arkansas River Basin needed to maintain and enhance the Arkansas River Basin database in support of improved water management. Thereby, the project will provide funds needed to prevent interruption of long-term data collection efforts.*

Objectives: The data-focused objectives of this one-year project are:

1. Gather data on water table levels and water quality in existing groundwater monitoring wells distributed over representative study regions in the UARB and LARB, for characterization of the aquifer system and to support flow and transport models developed by CSU, the Lease-Fallowing Accounting Tool currently under development, and the proposed Arkansas Basin Decision Support System to be developed over the coming years by the Colorado Water Conservation Board;
2. Gather data on water quality and flows at selected sites along canals, tributaries, and the main stem of the Arkansas River in the UARB and LARB to characterize the stream system and to support current and future models;
3. Conduct quality-control tests of the gathered data and enter them into the SQL database for the Arkansas River Basin developed and maintained by CSU; and
4. Conduct a preliminary analysis of the data gathered under this project and summarize in a final report for use in system characterization and model support.

Methods: About 150 landowners have cooperated with CSU to provide access to sampling sites for water and related characteristics in the UARB and LARB. *Availability of these sites provides valuable in-kind matching support for this proposed project.* Field data on water table depth and in-situ water quality parameters (electrical conductivity, temperature, pH, dissolved oxygen, and oxidation reduction potential) will be gathered at about 22 existing groundwater monitoring wells in a study region in Chaffee County in the UARB and about 140 groundwater monitoring wells in two study regions within Otero, Bent, and Prowers Counties in the LARB. Four to five sampling events will be conducted in each of the three study regions. Water samples will be extracted from the wells in the UARB during one of the sampling events for analysis of major dissolved ions, nutrients, and selected metals. During two of the sampling events in both regions of the LARB, water samples will be extracted from a subset of about 50 wells and analyzed for major dissolved ions, nutrients, selenium, and uranium. In-situ water

quality parameters will be measured during the sampling events at about 24 surface-water sites in the UARB and at about 145 sites in the LARB. Flow rates will be measured at about 18 of the surface-water sampling sites in the UARB. Water quality samples will be analyzed by EPA-approved laboratories.

Standard procedures and protocol will be followed in maintaining, cleaning, and calibrating probes and pumping equipment for field measurements and sample collection. Field data will be checked to insure that values are physically reasonable and will be subjected to statistical outlier tests in comparison with data previously collected at the same locations.

Data will be added to CSU's SQL database (compatible with Colorado Division of Water Resources HYDROBASE). Preliminary data analysis will describe spatiotemporal variability of measured values and basic statistical characteristics in relation to previous data gathered in the study regions. Field measurement methods, along with procedures and results of preliminary analysis, will be documented in a final project report.

Timeline & Completion Date: Data collection will commence shortly after the proposed start date of 1 Mar 2014. Three irrigation season sampling trips and one to two off-season trips are planned for each of the study regions in the UARB and LARB. Data will be checked and entered into the database over the course of the one-year project. Final data analysis will commence on about 1 Oct 2014 and final report preparation will begin on about 15 Jan 2015. The project is scheduled for completion on 28 Feb 2015.

Budget: An estimated budget is summarized in Table 1.

Table 1. Estimated Budget ($) Project Budget (Mar 2014 – Feb 2015)	
Salaries	$15,392
Travel	$8,539
Materials and Supplies	$7,417
Laboratory Analysis	$12,130
Indirect Costs (15%)	$6,522
TOTAL	$50,000

Budget Justification: Included are about 750 person-hours of undergraduate student effort and 0.5 person-months of faculty effort; mileage, per diem, and accommodations; parts/maintenance for multi-probes, sampling pumps, acoustic Doppler velocimeters; monitoring well maintenance; water sample filters; sample bottles and preservatives; calibration solution; field books; and other miscellaneous supplies. Costs of laboratory analysis are based upon recent quotes from respective laboratories.

Development of Visualization Tools for the South Platte

Steve Malers, Cheif Technology Officer, Open Water Foundation

Location of the work and project team: The work will be performed in Fort Collins utilizing CSU faculty, students, and in collaboration with the Open Water Foundation (OWF), a nonprofit that focuses on open source software for water resources and specifically Colorado's Decision Support System (CDSS) software.

Purpose: The South Platte River Basin system is complex, involving aspects of natural and engineered physical systems, water law and administration, operations, and many other factors. A water manager in the South Platte Basin recently stated "People need to understand systems and the space/time/water quality continuum." It is challenging to present complex water resource data in a way that can be understood by a variety of interests. This project will build on South Platte Decision Support System (SPDSS) data and tools to create reusable and operational data visualization tools that can be used to educate the public, public servants, and professionals about water resource issues in the basin.

Objectives:

1. Leverage SPDSS data and software to develop enhanced data visualization tools applicable to SPDSS and other State data
2. Demonstrate use of visualization software tools that are accessible to the public, for example Google Earth, Tableau Public (Tableau was used in Colorado River Study), Mapstory, Gapminder, and open source web visualization tools
3. Apply tools to system-wide data visualizations in ways that increase understanding of interactions in the system, for example:

   a.) Online integrated map of current South Platte River conditions, such as calls, free river conditions, reservoir levels, suitable for State website

   b.) System-wide summary of historical trends focusing on identifying sustainable systems

   c.) Visualization of water rights transfers and diversion coding "water color" over time

   d.) Interactive line diagrams and "snake diagram" that can be efficiently updated
4. Demonstrate collaboration that leverages the technical capabilities and funding potential of multiple organizations, for example students and staff from:

   a.) Integrated Decision Support Group – The IDS Group combines advanced techniques with software engineering to create Decision Support Systems for water and natural resources management.

   b.) Geospatial Centroid - The Centroid is a resource and research center at Colorado State University established to provide students, faculty, and the Colorado community with information about GIS at CSU and how these activities link to broader statewide, regional and global initiatives

   c.) CitSci - CitSci.org is a website that allows citizen science organizations and their volunteers to streamline data collection, management, mapping, and analysis

Method (Approach): If awarded, one or more students will be identified to work with CSU and OWF technical leadership to develop visualization tools and techniques:

1. Meet with key CWCB staff to identify needs for data analysis and visualization. For example, requirements from the Colorado Water River Availability Study (CRWAS), SPDSS modeling, and Colorado Water Plan may provide guidance.
2. Evaluate the needs identified in the previous task and determine tools that can be leveraged, such as Google Earth, Tableau, CDSS software, and open source visualization tools.
3. Identify CSU student(s) that have technical skills and interest to develop tools.
4. Develop/configure visualization tools and apply to the identified visualization needs.
5. Make tools available to the State and public for SPDSS data.

The result of this approach will be working data visualization tools appropriate for the South Platte and other basins. The results will be suitable for use by a variety of organizations that need to visualize and understand complex water resource data.

Timeline and Completion Date:

- Within 1 month of award, meet with CWCB to determine visualization needs
- Within 2 months of award, determine technologies and identify student(s)
- Within 10 months of award, develop visualization tools and demonstrate implementation to meet needs that have been identified
- Within 12 months of award, integrate tools with SPDSS software and make available to State and public for general use, provide project overview to State

Budget: $50,000 is being requested for this project due to many visualization options. Actual costs and distribution will be adjusted based on feedback from the proposal evaluation and availability of student hires:

- $5,000 – project management
- $20,000 – CSU student(s) cost
- $25,000 – Open Water Foundation technical resources for DSS software development, testing, integration, and student oversight

Budget Justification: Implementing effective data visualization tools and processes can be a labor-intensive effort and consequently hiring students at low rates is a cost-effective solution. Additionally, there is an opportunity for CSU faculty and students to work with OWF staff to move research into production. Demonstrating success on this project will facilitate future tool development efforts that benefit CSU and the State. Various projects are ongoing that can utilize improved visualization and could potentially be leveraged to supplement funding.

CWI 2013 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: Twelve students


Reagan Waskom


Nancy Grice


Amanda Barngrover


Karie Boone


Perry Cabot


Roy Cook


Derek Drummond


Craig Godbout


Pia Gerstle


Kim Hudson


Julie Kallenberger


Lindsey Middleton


Joy Labadie


Loretta Lohman


Panagiotis Oikonomou


Elizabeth Plombon


Denis Reich


Joel Schneekloth


Alicia Shogbon

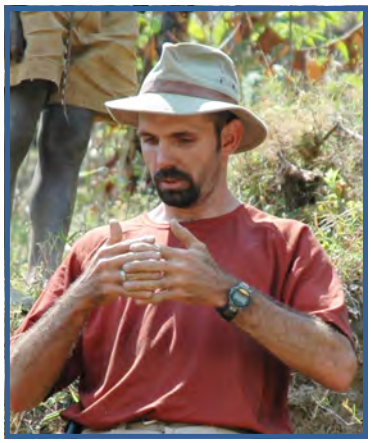

Blake Skipper


MaryLou Smith


Faith Sternlieb


Lloyd Walker


Shannon Wittstock



Perry Cabot
Water Resources Specialist/Assistant Professor / Research Scientists II
2013 Accomplishments

Updates:

- Completed Project (4 years) – $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 (4 years) – $24,306: NRCS- Conservation Innovation Grant, *Strategies for Permanent Fallowing of Previously Irrigated Cropland Under Groundwater Pumping Restrictions in the San Luis Valley.*
- Completed Project (3 years) – $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 2 of 4 - $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.
- Completed Project (2 years) - $31,457 (Sub-Contract HSI Funding to CSU-Pueblo), Integrating Research, Extension, and Education in the Northern Plains and Mountains Region. Huerfano County Well-Testing Program for private/household drinking water wells throughout the Huerfano County area. Sampling conducted as part of a "baseline" sampling program for local well-owners out of concern for hydraulic fracturing in the county.

New Projects:

- $427,700 – with Gates (PI), Arabi, Hoag : CDPHE – Colorado Nonpoint Source Watershed Plan and Assessment Proposal, *Identifying Arkansas River Selenium and Nitrogen Best Management*
- $365,000 – with Andales (PI), Bauder: USDA-NIFA – Integrated Research, Education, and Extension Comp. Grants Program, *Mobile irrigation water management system using eRAMS cloud computing infrastructure*

Publications:

- Hall, C.D, P.E. Cabot and M.F. Quigley. *In Review.* The Effect of Planting Date and Irrigation on the Establishment of an Herbaceous Community. *Restoration Ecology.*
- Lakshminarayanan, A. D.B. Olsen and P.E. Cabot. *In Review.* Performance and Emissions Evaluation of Straight Vegetable Oil and Gasoline Blends in Agricultural Compression Ignition Engines. *Transactions of the American Society of Agricultural and Biological Engineers.*

Teaching/Advising:

- Committee Member – Master's Degree 2014 (Candace Walking, CSU-Pueblo, Department of Biology), *Thesis Name TBD*
- Committee Member – Doctoral Candidate (Aaron Drenth, Colorado State University, Department of Mechanical Engineering), *Dissertation Name Name TBD*

Conferences:

- "Tributaries to Change." Arkansas River Basin Water Forum │ Walsenburg, CO │ April 24-25, 2013.
- "Valuing Colorado's Agriculture: Workshop for Water Policy Makers." Cheyenne Mountain Resort │ Colorado Springs, CO │ October 7, 2013.

Service:

- Chair and Treasurer of Arkansas River Basin Water Forum (*Ongoing*) ; coordinated $17,950 in sponsorships.
- Public Education, Participation and Outreach liaison for Arkansas Basin Roundtable.
- Education Program Committee Member, Colorado Foundation for Water Education

Joel P. Schneekloth

Northern Regional Water Resources Specialist, Colorado State University

2013 Accomplishments

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.

Impact of Growth Regulators and Fungicides on Irrigated Wheat Water Use – Research in Europe has shown potential for reducing water use in winter wheat with the use of growth regulators. Syngenta wanted to further research the use of growth regulators in combination with fungicide applications on the impact of grain yield and water use of winter wheat under full and limited irrigation management of winter wheat in the High Plains.

Demonstration and validation of an online irrigation scheduling tool for use in sugarbeet production in Northern Colorado – Sugarbeet growers in Colorado are interested in utilizing an online irrigation scheduler developed by CSU. Concerns over the accuracy of the model where voiced. In response, growers funded a research/demonstration project looking at comparing the model water use versus field observations of sugarbeets grown in various locations in Northern Colorado.

Meetings:

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.

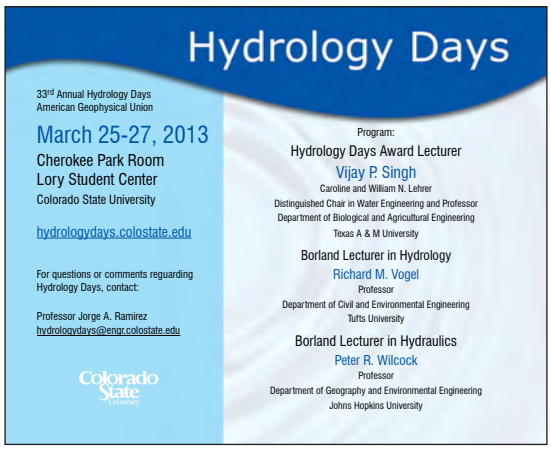
Technology Transfer

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. SR23 — **Agricultural Chemicals & Groundwater Protection in Colorado** Authors: Troy Bauder, Reagan Waskom, Rob Wawrzynski, Karl Mauch, Eric Wardle, Andrew Ross

2. IS115 — **The Ins and Outs of the South Platte Basin** Editor: Jennifer Brown



Meetings

Actively sponsored or supported water meetings in Colorado:

24th Annual South Platte Forum
October 23-24, 2013

UCOWR/NIWR Annual Conference 2013
June 11-13, 2013

Arkansas River Basin Water Forum
April 24-25, 2013

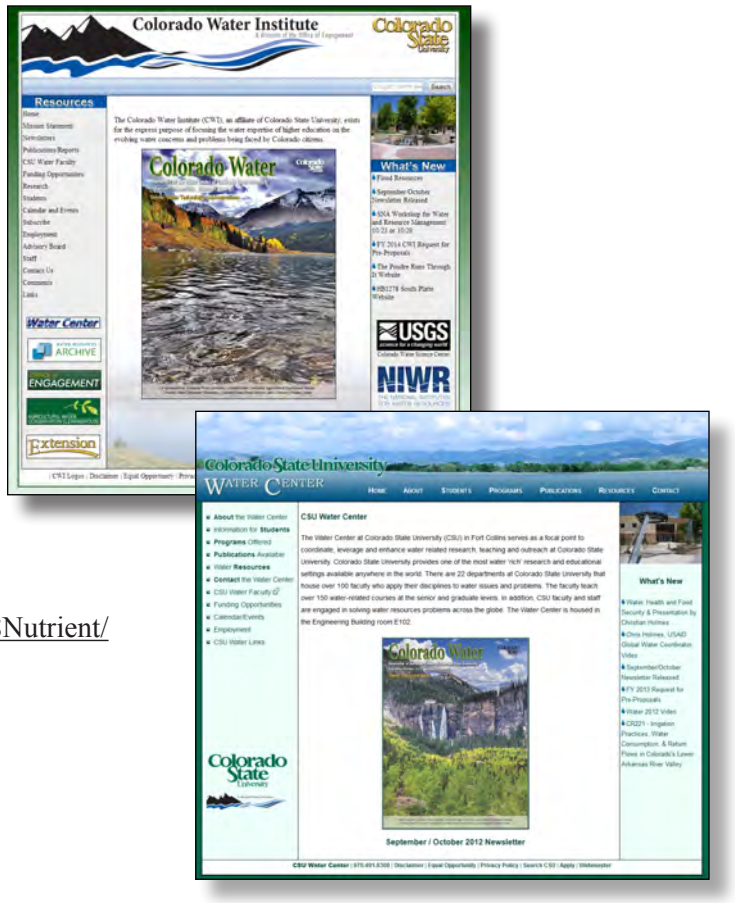
33rd Annual Hydrology Days
March 25-27, 2013

Water Tables
March 2, 2013

NIWR Annual Conference 2013
February 11-13, 2013

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 recipients, Marina Meneakis, Jonathon Roberts, Zach Dufault, and Amanda Snyder.

Marina Meneakis is an undergraduate student at Wester State College who majors in Environmental Studies with a Water Emphasis. She is interested in stormwater, water sampling, and efficient use.

"Currently, I am a student Intern at Los Alamos National Laboratories (LANL) through their student program and have been since 2009. My plans are to stay with LANL's student program until I graduate, because the program I am in applies greatly to my major and I enjoy the variety of tasks that our unit performs. Then, I hope to obtain a permanent position at LANL in the Environmental Program or apply with other similar organizations and businesses such as the Forest Service."

Jonathon Roberts is an undergraduate at Mesa State College who majors in Environmental Science and minors in Watershed Science.

"My goals are very basic but not easy. I wish to make where I live a better place and am not afraid to work hard to do it. I volunteer with my local fire department as a firefighter and EMT and also with our community center. After starting my environmental education everything about water has interested me, from the science to the politics. Living in an area with a growing population and dwindling water supply, thinking outside the box is essential. I feel that there is a need to use the resource but at the same time preserve resources for things like biological reasons. I wish to live on the western slope of Colorado. I enjoy the atmosphere, the people and the land. With water being the foundation of the lives of everybody and everything in my valley and all the land of the state we need more scientists to be able to provide good data so water managers can make informed decisions. Resource extraction, tamarisk infestation, selenium contamination, endangered species needs, and many others are issues that have a need to be addressed and resolved. I want to start my career in the field to be able to get the experience needed to be a great leader. These issues were not created in a day and will not be resolved quickly. They may not be fixed during my time, but I do want to move it in the right direction."

Zach Dufault is an undergraduate who recently transferred to Colorado State University, interested in environmental science and watershed science.

"After graduation, I would like to stay in western Colorado and work for an environmental agency/firm or work for a government agency such as Colorado Department of Parks and Wildlife, Bureau of Land Management, or U.S. Forest Service. Being an avid hunter and fisherman, I would love to work in either of those areas of the environment. If graduate school becomes more of a focus, attending school after working a few years in the work force would be preferred. Changing the way people look at and treat the environment in their daily lives is of interest to me. With the environment (water especially) becoming more threatened and resources becoming more scarce, the general public needs to be educated on how their daily lives harm certain aspects of the environment. Being as involved as possible in the environment and helping to protect and conserve what we have is my ultimate goal."

Amanda Snyder is an undergraduate at Colorado State University studying watershed science and interested in water quality and restoration work.

“I truly enjoy being in the Watershed Science program. Within my degree, I am especially interested in water quality. I would like to start out in the Glenwood and/or Rifle, Colorado area. A company that appeals to me as a possible place to start a career would be the Sonoran Institute. They work to make sure the environment is protected in the west. Specifically, I would like to work in the area of clean water. Other jobs along the western slope that would be of interest to me are city and government jobs that allow me to work in the department of water. I could be doing anything from switching out sprinkler heads to make them more efficient to being a watershed planner to assist in maintaining the health and appearance of the watershed. As I grow in my career, I would eventually like to get into restoration. I would also like to expand my career outside of Colorado and even out of the United States eventually. Moving to Alaska is one of my main goals after I get my feet wet in the real world. I would mostly consider a government job there as well working in water quality or restoration. I think it would be extremely rewarding to work in third world countries, as well, and possibly come up with a system to better their water.”

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

Spring 2013
Interdisciplinary Water Resources Seminar

Sponsored by CSU Water Center, USDA-ARS, Civil and Enviormental Engineering, Forest and Rangeland Stewardship, and the School for Global Enviormental Sustainability

Theme: Advances in Water Research

Wednesdays From 12:00 to 1:00 PM

February 6 LSC Room 208	Joe Ryan & Mark Williams - University of Colorado Economic and Environmental Trade-Offs of Unconventional Oil and Gas Extraction
February 13 LSC Room 226	Holly Barnard - University of Colorado Ecohydrology of Forested Catchments: Investigations of Transpiration and Subsurface Hydrology
February 20 LSC Room 208	Suzanne Pashke - U.S. Geological Survey Simulation of Groundwater Movement in the Denver Basin Aquifer System
February 27 LSC Room 208	Thijs Kelleners - University of Wyoming Measurement and Modeling of Soil-Plant-Atmosphere Water, Heat, and Carbon Fluxes in Cold Regions
March 6 LSC Room 208	Dave Williams & Scott Miller - University of Wyoming Hydrological Consequences of Woody Plant Encroachment into Floodplain Grasslands
March 13 LSC Room 208	Levi Brekke - U.S. Bureau of Reclamation Evaluating the Relevance, Reliability, and Applicability of CMIP5 Climate Projections for Water Resources and Environmental Planning
March 20	No Seminar Spring Break
March 27	No Seminar Hydrology Days Mar. 25-27; www.hydrologydays.colostate.edu
April 3 LSC Room 208	Stephen Burges - University of Washington Hydrological Variability, Reservoir Storage, and Water Supply Reliability
April 10 LSC Room 208	Michael Ronayne - Colorado State University Modeling Coupled Conduit and Matrix Flow in Karst Aquifers
April 17 LSC Room 211E	Mark Eiswerth - University of Northern Colorado The Joint Impact of Drought Conditions and Media Coverage on the Colorado Rafting Industry
April 24 LSC Room 228	Lee Sommers - CSU Agriculture Experiment Station Reflections on Water Research
May 1 LSC Room 208	Reed Maxwell - Colorado School of Mines Towards a Complete Description of the Hydrologic Cycle: Large Scale Simulations with Parallel Integrated Models

* Room may be changed if needed. Check weekly announcements.

All interested faculty, students, and guests are encouraged to attend.
For more information, contact Reagan Waskom at reagan.waskom@colostate.edu or visit the CWI web site at www.cwi.colostate.edu.

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 researchers, scientists, and private industry to develop sound science that assists and informs Colorado water managers and users. CWI accomplishes this by facilitating the transfer of new water knowledge and assisting in educating the next generation of Colorado water professionals 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. 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 Faculty and Student Research Projects").

Outreach/Information Transfer

CWI collaborates with CSU Extension to house four water outreach specialists around the state. CWI operates several websites with up-to-date water information that have become a consistent source of knowledge for water professionals and community members alike. Publications available on these sites include research reports and *Colorado Water*, a bimonthly newsletter containing information on research, faculty, outreach programs, water history, conferences, and other events with a water focus.

CWI outreach activities are conducted in conjunction with CSU Extension, the Colorado Agricultural Experiment Station, the Colorado State Forest Service and the Colorado Climate Center. Our primary partners include water managers, water providers, and water agencies.

Training

One of CWI's primary missions is to facilitate the training and education of university students. To this end, the institute works with the U.S. Geological Survey and the Colorado Water Conservation Board to place student interns in positions and also funds student research grants and manages scholarships on behalf of students. Student researchers funded by CWI work with faculty members and gain valuable water expertise as well as knowledge of the research process.

CWI Staff

Reagan M. Waskom, Director
Nancy Grice, Assistant to the Director
Perry Cabot, Water Resources Specialist
Joel Schneekloth, Water Resources Specialist
Faith Sternlieb, Research Associate
Julie Kallenberger, Research Associate
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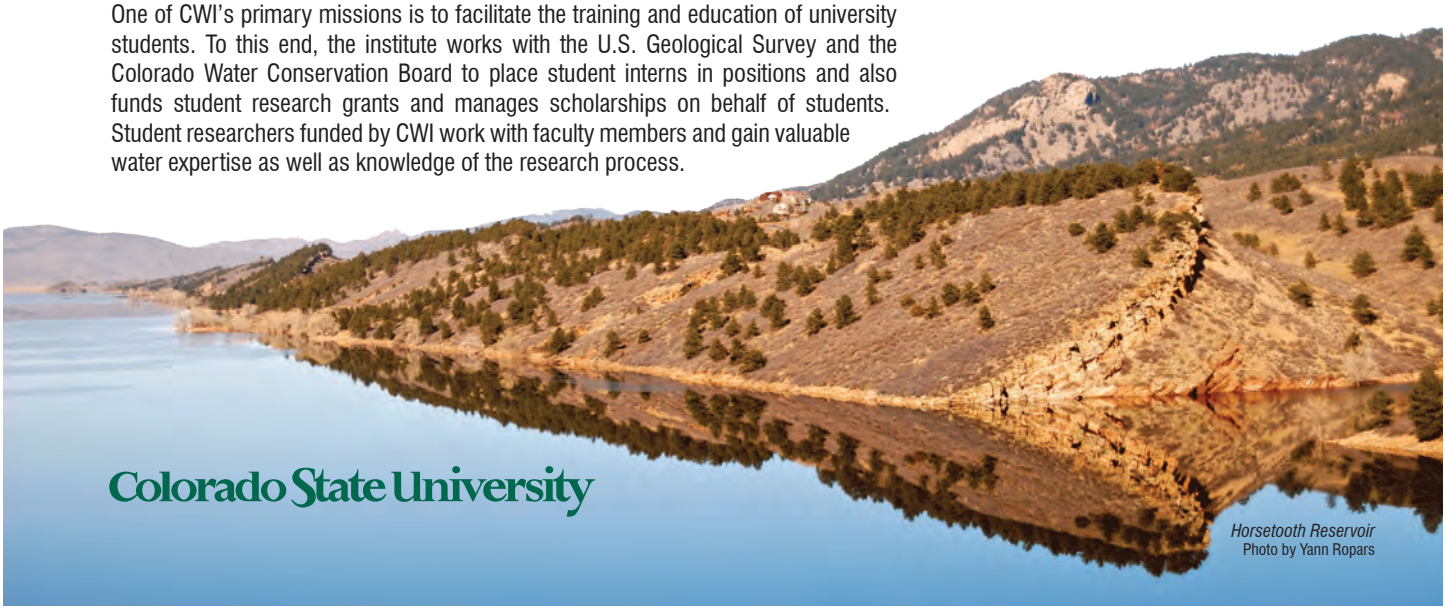

Horsetooth Reservoir
Photo by Yann Ropars

CWI Highlights Response to State Needs

Drought Support for Colorado Water Users

CWI provided support to the state, Extension field staff, and Colorado's Drought Task Force during the 2012 drought by serving as the Co-Chair of the Agriculture Drought Task Force and serving on the Colorado Governor's Water Availability Task Force. In addition to regular communication across the Extension Regions, we provided online and printed factsheets and information resources, held local drought meetings for stakeholders, helped producers with crop insurance claims, staffed the Colorado Water Availability Task Force, chaired the Ag Impact Task Force, held drought information tours for state officials and the Governor, helped organize the state 2012 Drought conference, and handled media and stakeholder requests.

South Platte Groundwater

Groundwater users in the South Platte River Basin are required to fully augment their pumping to prevent injury to surface irrigators with senior water rights. The state legislature has commissioned CWI to explore whether high water tables causing crop damage and flooded basements are caused by over-augmentation. In addition to analyzing data, CWI is working to bring well users and surface users into productive dialogue to find solutions to benefit both.

Agricultural Water Conservation

The Agricultural Water Conservation Clearinghouse Project is a joint collaboration between CWI, USDA-NIFA Northern Plains and Mountains 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 water agencies, provide technical expertise regarding agricultural water, and offer detailed information on the management, policies, and laws surrounding agricultural water conservation.
www.agwaterconservation.colostate.edu

Addressing Agricultural Water in the Colorado River Basin

Forecast shortages of water supply to meet demand caused by urban growth, environmental needs, and climate change has put the bull's-eye on agricultural water in the Colorado River Basin. CWI is teamed with the water institutes in the other Colorado River Basin states to find out how Ag producers and water managers are responding to the pressure and how land grant universities can help.

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.

Recent Publications

Paleohydrology of the Lower Colorado River Basin and Implications for Water Supply Availability by Jeffrey J. Lukas, Lisa Wade, and Balaji Rajagopalan

Irrigation Practices, Water Consumption, & Return Flows in Colorado's Lower Arkansas River Valley by Timothy K. Gates, Luis A. Garcia, Ryan A. Hemphill, Eric D. Morway, and Aymn Elhaddad

Direct Determination of Crop Evapotranspiration in the Arkansas Valley With a Weighing Lysimeter by Abdel Berrada

Agricultural/ Urban/ Environmental Water Sharing: Innovative Strategies for the Colorado River Basin and the West by MaryLou Smith and James Pritchett

Federal Bureaucracy and Locality: A Case Study of the Uncompahgre Valley Water Users' Association's Management of its Water Commons by April Pratt

Occurrence of Steroid Sex Hormones in the Cache la Poudre River, and Pathways for their Removal in the Environment by Thomas Borch, Jessica Davis, Yun-Ya Yang, and Robert Young

Examining the Impact of Shallow Groundwater on Evapotranspiration from Uncultivated Land in Colorado's Lower Arkansas River Valley by Brandon M. Lehman, Niklas U. Hallberg, Jeffrey D. Niemann, and Timothy K. Gates

Development of Characterization Approaches and a Management Tool for the Ground Water-Surface Water System in the Vicinity of Sutherland Reservoir and Gerald Gentlemen Station Lincoln County, Nebraska by Clint P. Carney and Eileen P. Poeter

Publications can be found at: http://www.cwi.colostate.edu/publications.asp

Photos above (left to right): Copeland Falls, Kim Hudson. Gunnison River, Bill Cotton. Clinton Reservoir, Bill Cotton. Crystal Mill, John Fowler. Lower Arkansas River Basin, Bill Cotton.

Current Faculty and Student Research Projects

Faculty Projects

Modeling the Influence of Conjunctive Water Use on Flow Regimes in the South Platte River Basin
Domenico Bau, Colorado State University

Investigation of the Effects of Whitewater Parks on Aquatic Resources in Colorado: Year 2
Brian Bledsoe, Colorado State University

CoAgMet: Monitoring Evapotranspiration and Other Key Elements of Colorado's Climate
Nolan Doesken, Colorado State University

Colorado Household Preferences in Meeting Future Water Challenges
Chris Goemans, Colorado State University

Determination of Consumptive Water Use by Alfalfa in Arkansas Valley
Allan Andales, Colorado State University

Water Quality Impacts of the Mountain Pine Beetle Infestation in the Rocky Mountain West: Heavy Metals and Disinfection Byproducts
John McCray, University of Colorado

Impacts of Aquatic Weeds on Water Flow and Canal Efficiency
Scott Nissen, Colorado State University

Value of Water in Agriculture: Gathering Baseline Information
James Pritchett, Colorado State University

Addressing Agricultural Water Security in the Colorado River Basin
Reagan Waskom, Colorado State University

Alt Ag Grant - Lake Canal Alternative Agricultural Practices and In-stream Flow Demonstration Project
Reagan Waskom, Colorado State University

Colorado House Bill 12-1278 South Platte River Alluvial Aquifer Study
Reagan Waskom, Colorado State University

Comprehensive Planning Studies for Salinity Control Measure in the Upper Colorado River Basin
Reagan Waskom, Colorado State University

Student Projects

3D Modeling of Fish Passage in Colorado Whitewater Parks
Brian Fox, Colorado State University

Structural and Functional Controls of Tree Transpiration in Front Range Urban Forests
Edward Gage, Colorado State University

Thermal preference of age-0 stonecats (Noturus flavus): Are thermal water quality standards protective for this species?
Adam Herdrich, Colorado State University

Assessing the Benefits and Drawbacks of Different Institutional Arrangements to Enhancing Forest and Water Ecosystem Services and Ecosystem Services Markets in Colorado
Heidi Huber-Sterns, Colorado State University

3D Modeling of Fish Passage in Colorado Whitewater Parks
Nell Kolden, Colorado State University

Winter Precipitation Variability in the Colorado Rocky Mountains
Andrew Muniz, University of Northern Colorado

The Short and Long-Term Impacts of Drought on the Structure of Regional Economics: Investigating the Farm Supply Chain
Ron Nelson, Colorado State University

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, Colorado State University

Quantifying Risks Producers Face when Entering Agricultural Water Lease Contracts
Larisa Serbina, Colorado State University

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

Biowin Simulation to Assess Alternative Treatment Units for a Local Wastewater Treatment Plant to Meet the New Effluent Nutrient Regulations
Keerthivasan Venkatapathi, Colorado State University

Arkansas River
Photo by Bill Cotton

What are the Water Resources Research Institutes?

The Water Resources Research Institutes represent cooperative agreements between public universities and federal and state government that engender lasting partnerships among state universities; federal, state, and local governments; businesses and industries; and non-governmental organizations aimed at solving problems of water supply and water quality at local, state, regional, and national levels.

At the land grant university of each state, a small federal grant provides base support for a program that identifies water resources research needs, discovers university researchers capable of conducting useful research, and leverages federal funds with state and other resources to sponsor the needed investigations. More importantly, the modest federal grant creates an environment that encourages the other partners to incorporate science into their efforts and fund additional research in ways that might not occur without the protection of the federal grant. Some of these programs are free-standing university institutes; others are subunits within university departments or cross-discipline research entities. NIWR networks these separate institutes into a coordinated unit represented by eight regional groupings that function through NIWR.

NIWR
THE NATIONAL INSTITUTES FOR WATER RESOURCES

The State Water Resources Research Institute Program is administered by the U.S. Department of the Interior through the U.S. Geological Survey. Program contact:

Office of External Research
U.S. Geological Survey
12201 Sunrise Valley Drive, MS 424
Reston, VA 20192-0002
Phone: (703) 648-6800
Fax: (702) 648-5070
Email: eagreene@usgs.gov
http://water.usgs.gov/wrri/

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Colorado Water Conservation Board

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Colorado State Senate

Rep. Randy Fischer
Colorado State House of Representatives

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Ex Officio Members:

Joseph Duda
Director, Colorado State Forest Service

Lee Sommers
Director, Colorado Agricultural Experiment Station

Louis Swanson
Vice President for Engagement, Director of Extension

On the web: http://cwi.colostate.edu

The Arkansas River south of Buena Vista, Colorado.
Photo by Bill Cotton

Revised 2/5/2013

Honor

Ralph Curtis

Water VIP Ralph Curtis is retiring after many years on the CWI Advisory Committee.

Ralph got his early start in water issues growing up on an irrigated livestock ranch in the Saguache region of the San Luis Valley. He earned a degree in business administration from the University of Colorado at Boulder (where he played varsity football for four years), and served two years in the Army before returning to his family ranch, where Ralph continued working until it was sold in 1975.

Ralph has served since then as President of the Colorado Water Congress, President of the Colorado Association of Soil Conservation Districts, and general manager and Executive Director of the Rio Grande Water Conservation District (RGWCD). He has also served on the Board of Directors of Rio Grande Headwaters Land Trust since 2001.

A large part of Ralph's career was spent in with the Rio Grande watershed, located in his home region of Colorado, the San Luis Valley. He was there when the district took on American Water Development Inc., a group that intended to export water from the valley. Farmers fought this group, fearing that exporting water would effectively shut down agriculture in the valley, and they won their case in the Colorado Supreme Court in 1994. The Rio Grande Water Conservation District led legal battles in the courtroom.

In 2004, Ralph was awarded with the Wayne N. Aspinall "Water Leader of the Year" Award, presented annually to an individual who demonstrates "courage, dedication, knowledge, and strong leadership in the development, protection, and preservation of Colorado water," according to the Colorado Water Congress, who presents the prestigious award. He was also awarded with the University of Colorado Lifetime Achievement Award for his work as "a unifying force in the often fractious debate over water in the San Luis Valley." Ralph is also an honorary life member of the Colorado Water Congress.

In his career dealing with Colorado water, Ralph has seen many changes. During those 25 years, there have been drought years, years of high and low snowpack, changes in irrigation techniques, policy changes, water quality issues, and many other variations to the complex systems that interact with water. He has navigated these changes with a strong ethic that has made him a go-to figure for water knowledge in the San Luis Valley.

Ralph's expertise in Colorado's water issues and his ability to coordinate and unite diverse groups have been an asset to the water community, and he will be missed on the CWI Advisory Board.

CWI Advisory Board

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