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Dear Mr. Godbout:

Routt County Conservation District has completed the tasks to the PO# POGG1 PDAA 20160000000000000244, for WSRA Grant - POGG1 206-244 "YWG Basin Roundtable Phase II Agricultural Needs/Return Flow Preliminary Assessment Project" and we are seeking reimbursement. Below is a brief overview of the tasks completed. I have also included the project findings.

- *Reconnaissance Field Trips.* Prof. Gates was hosted by members of the Agricultural Subcommittee of the YWB Roundtable for a visit to the Yampa River Valley on 21 - 22 September 2015. During the visit, he viewed the irrigated regions of the valley south of Steamboat Springs, near Craig, near Hayden, and near Maybell. He also toured areas along Fortification Creek and the Elk River tributaries. On September 28 - 29 2015 Prof. Gates was hosted for a visit to the White River Valley where he toured irrigated regions of the valley near Meeker and between Meeker and Rangeley.

- *Literature Review.* CSU personnel conducted extensive searches for information on data, models and analytical tools addressing irrigation practices, groundwater conditions, return flows, and related properties in the Yampa and White Rivers and major tributaries A number of pertinent reports, maps, and data sets were reviewed and evaluated.

- *Interaction with Knowledgeable People.* Prof Gates had discussions in person or by telephone conference with several irrigators; members of the Agricultural Subcommittee others within the YWB Roundtable; the Division 6 Engineer, water commissioners, and other personnel in the Division 6 office of the Colorado Division of Water Resources regarding opinions and concerns about the nature and impact of irrigation return flows and groundwater conditions.

- *Preparation of Draft Final Report.* A final report of activities, findings, and recommendations was prepared and was submitted to the YWB Roundtable on 8 February 2016.

Please let me know if you have any additional questions about this project.

Regards,

Selina Heintz

RCCD Treasurer

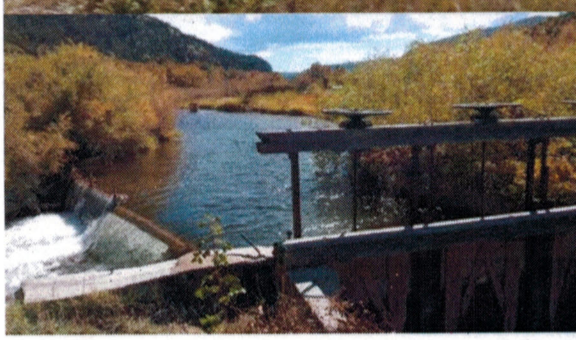
Reconnaissance and Scoping for

Assessing the Impact of Current and Altered Irrigation Practices on Groundwater Conditions and Return Flows to the Yampa and White Rivers, Colorado

Final Report

Timothy K. Gates
Department of Civil and Environmental Engineering
Colorado State University

February 2016



Colorado State University

Introduction

Irrigation brings the benefits of expanded and sustained crop productivity, while creating expansive green vistas and enhancing rural economies and lifestyles. It also can markedly alter the landscape and the hydrologic environment in which it is practiced. In alluvial valleys, irrigation water often is diverted from streams to meet the consumptive use demand of crops. Seepage from canals that convey diverted water to croplands and excess application of water often results in substantial quantities that drain off the surface of fields and percolate downward to cause groundwater levels to rise. A portion of these waters eventually make their way back to the stream system as "return flows". There are several potential impacts of these irrigation return flows:

(1) They alter the magnitude and the variability of flows along the streams and over time, often contributing relatively little to streamflows during the peak runoff season when diversions are large, and swelling flows during the drier season.
(2) They diminish groundwater quality due to evaporative concentration; reactive transport of salts, nutrients, pesticides through the root zone; and dissolution and transport of solutes in the underlying aquifer.
(3) They alter hydraulic gradients and drive solute loads to streams, thereby increasing instream solute loads and concentrations.
(4) They contribute to shallow groundwater tables, affecting crop productivity and water use under irrigated lands, and increasing non-beneficial consumptive use under fallow and naturally-vegetated lands.
(5) They create and sustain wetlands and expand riparian areas.

In the alluvial valleys of theYampa and the White River Basins of Colorado, where irrigation has been practiced for well over a century, irrigation return flows have become an integral part of the annual hydrologic cycle. Water diverted to alluvial farmland during late spring and summer that is in excess of crop consumptive makes its way back through surface and subsurface pathways to replenish the stream system in the drier months of late summer and fall. Not only are seasonal flow patterns altered, but the impacts outlined in (2) through (5) above are also displayed.

The Agricultural Subcommittee of the Yampa/White Basin (YWB) Roundtable has expressed interest in better understanding the current magnitude and patterns of return flows from irrigation to Colorado's Yampa and White River Basins and in predicting changes in return flows that are likely to occur under altered irrigation practices. Such alterations might include:

- Increased application efficiency on existing irrigated lands (through adoption of sprinklers or improved surface irrigation techniques),
- Reduced canal seepage through sealing and/or lining,

- Retirement of irrigated land,
- Rotational fallowing of irrigated land, and
- Expansion of irrigated land.

Concerns include the consequences that such changes will likely bring about.

Objectives and Tasks

Members of the Agricultural Subcommittee of the YWB Roundtable contacted Professor Timothy K. Gates at Colorado State University in March 2015 to discuss a prospective project aimed at addressing concerns about irrigation return flows in the Yampa and White River Basins. In August 2015 the YWB contracted with CSU through the Routt County Conservation District for a Colorado Water Supply Reserve Account (WSRA) project (WSRA Grant POGG1 206-244) to conduct a reconnaissance and scoping effort. The objectives were (1) to evaluate the need for and (2) to define the nature of a project aimed at assessing the impact of current and altered irrigation practices on irrigation return flows and related groundwater conditions in Colorado's Yampa and White River Basins.

In interaction with YWB Roundtable members and other stakeholders, CSU personnel conducted the following project tasks:

- *Reconnaissance Field Trips.* Prof. Gates was hosted by members of the Agricultural Subcommittee of the YWB Roundtable for a visit to the Yampa River Valley on 22 September 2015. During the visit, he viewed the irrigated regions of the valley south of Steamboat Springs, near Craig, near Hayden, and near Maybell. He also toured areas along Fortification Creek and the Elk River tributaries. On September 29 2015 Prof. Gates was hosted for a visit to the White River Valley where he toured irrigated regions of the valley near Meeker and between Meeker and Rangeley.
- *Literature Review.* CSU personnel conducted extensive searches for information on data, models and analytical tools addressing irrigation practices, groundwater conditions, return flows, and related properties in the Yampa and White Rivers and major tributaries A number of pertinent reports, maps, and data sets were reviewed and evaluated.
- *Interaction with Knowledgeable People.* Prof Gates had discussions in person or by telephone conference with several irrigators; members of the Agricultural Subcommittee others within the YWB Roundtable; the Division 6 Engineer, water commissioners, and other personnel in the Division 6 office of the Colorado Division of Water Resources regarding opinions and concerns about the nature and impact of irrigation return flows and groundwater conditions.

This report summarizes the outcome of these tasks in assessment of the need for a project to describe and predict return flows and groundwater conditions under current and altered irrigation practices.

Findings from the Reconnaissance Study

Nature of Irrigation Return Flows Under Current and Altered Practices

The vast majority of irrigation in the Yampa and White River Valleys is conducted using traditional surface irrigation methods on fields planted mainly to pasture, hay, and alfalfa. Water is diverted and distributed to a total of about 90,000 acres through dozens of earthen canals distributed among the tributary and main stem valleys of the Yampa River (AECOM 2009a). In the White River Basin, diversion of irrigation flows to roughly 29,000 acres is carried out mostly by individual landowners, there being only a small number of mutual ditch companies compared with other river basins in the Colorado (AECOM 2009b). Essentially no groundwater is pumped from alluvial aquifers in either basin for irrigation. Conditions in both basins are "water-long", and water rights calls rarely occur. This has contributed to irrigation efficiencies that are quite low, resulting in substantial surface and subsurface return flows back to the stream systems, including spills at the tail end of canals. Evidence of these conditions was apparent in surface flows at some sites (Figure 1) and was confirmed in discussions during reconnaissance field visits of September 2015.

Anecdotal evidence of irrigation return flows is ample; however, only two studies could be found that address quantitative estimates of the magnitude and variability of irrigation efficiency and return flows in the Yampa and White Basins. In their companion reports of the Yampa and White River planning models, developed as part of the Colorado's Decision Support Systems (CDSS), AECOM (2009c, 2009d) describe rough approximations of the return flow processes. Irrigation return flows are represented in these models as follows:

- Volume of return flow is computed in the models on a monthly time step as the difference between the historical volume of irrigation diversion and the estimated crop evapotranspiration, reduced by a percentage of ancillary losses (evaporation, non-beneficial consumptive use). Half of the computed return flow volume is assumed to return to the stream as surface flow within one month. The other half is routed back (lagged) to the stream as groundwater flow using a temporal pattern computed by the Glover-Balmer method.
- Two different patterns of ancillary losses are used. The first assumes that a total of 3% is lost within the first return month. The second assumes that 7% is lost during the first month and 3% during the second month, making up a total of 10% ancillary loss. Both patterns are used in the Yampa River model. Only the first is used in the White River model.
- Both the Yampa and White River models use the same rough estimates of average transmissivity (48,250 gpd/day), specific yield (0.13), and distance from the stream to the alluvial boundary (3,500 ft) that are based upon data from "ten representative sites throughout the west slope." Neither model directly accounts for groundwater storage change or upflux from shallow groundwater.

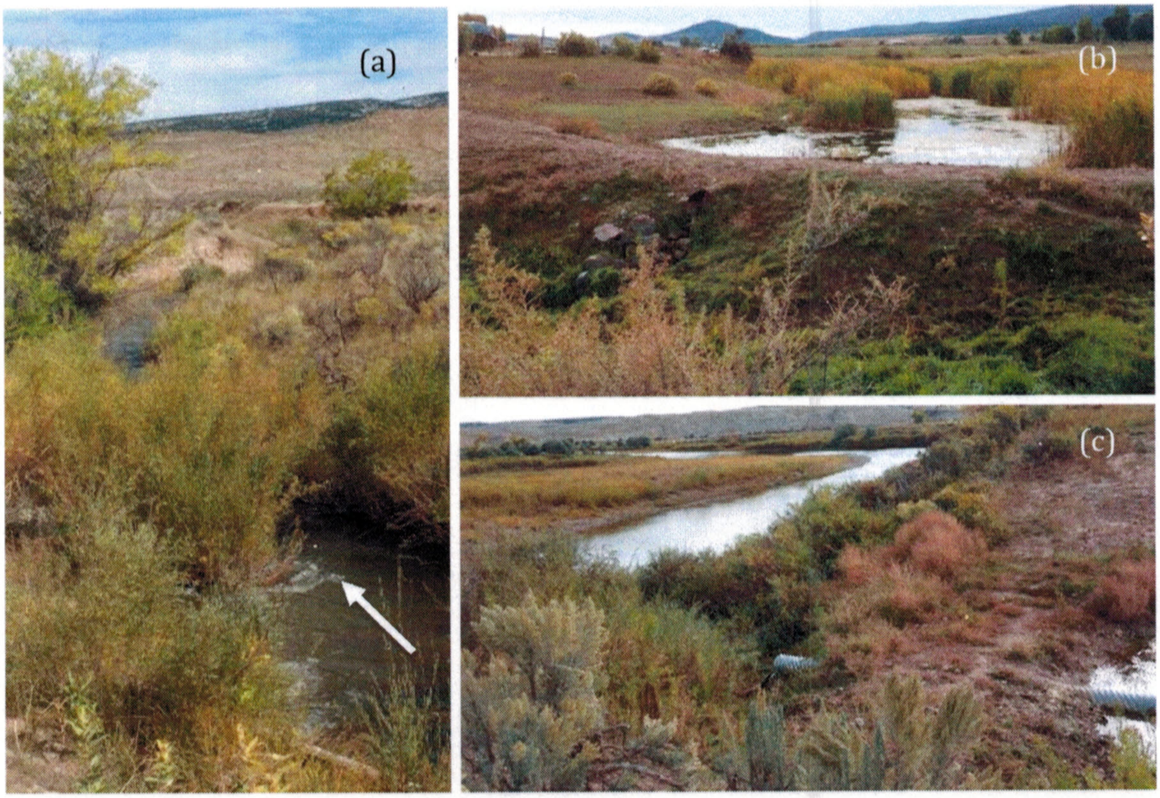


Figure 1. Return flows to the Yampa River at the tail end of the Maybell Canal (with flow direction indicated), as shown in (a), and from a wetland fed by irrigation drainage, as shown in (b) and (c) [September 2015].

- Historical irrigation efficiency (used in the baseline data set) is defined as the smaller of (a) average historical diversion for the given month divided by average irrigation water requirement, and (b) maximum irrigation efficiency.
- Maximum irrigation efficiency is set to 54% (assumed to be a reasonable maximum achievable for surface irrigation) for both models.
- Soil water storage is accounted for using StateCU data.
- "Return flow locations were determined during the original data gathering, by examining irrigated lands mapping and USGS topographical maps, and confirming locations with Division 6 personnel. Some return flow locations were modified during calibration." (AECOM 2009c, p. 4-16). Return flow locations varied among diversions.
- Calibration of the models was conducted by manually adjusting parameters to cause model simulations of gate flows and reservoir levels to reasonably reproduce historical observations (AECOM 2009c, AECOM 2009d).
- An independent test (validation) run of the model was not conducted after calibration.

The spatial and temporal variability in aquifer properties, stream properties, and irrigation patterns throughout the river valleys are not considered in the CDSS models described by AECOM (2009c, 2009d). Also, the models do not account for hydraulic impacts; groundwater storage change; and losses due to upflux from shallow groundwater tables.

CDM (2010) employed the CDSS models described by AECOM (2009c, 2009d) to "assess the effects on return flows of various irrigation practices or changes in those practices" in the Yampa and White basins. The models were run using streamflow and crop consumptive use data for the historic period 1955 – 2005 to describe a baseline condition of irrigation efficiency in each of the river basins as well as a scenario corresponding to a prospective adoption of sprinkler irrigation and limited canal lining. The average irrigation water requirement over the period was estimated as 183,000 ac-ft per year in the Yampa River Basin and 46,000 ac-ft per year in the White River Basin. The estimated average naturalized flow (i.e. basin supply) for the Yampa River Basin was estimated as 1,732,000 ac-ft per year and as 516,000 ac-ft per year for the White River Basin. Irrigation efficiency for surface irrigation was assumed by CDM (2010) to range from 30 – 50%. Using these values, the author of the present report estimates that surface and subsurface return flows from irrigation would contribute 11 to 25 % of total annual streamflow in the Yampa River Basin and 9 to 21 % in the White River Basin. Hence, return flows likely make up a sizable portion of the waters that make their way through the Yampa and White River Basins on an annual basis, with a greater portion occurring during fall and winter months.

The scenario corresponding to a prospective adoption of sprinkler irrigation and limited canal lining was assumed to result in an increased overall irrigation efficiency of 75%. Model predictions of monthly changes to instream flows, as affected by changes in irrigation diversions and return flows under the high efficiency scenario, were compared to baseline conditions at various locations in the Yampa and White Rivers. Consideration also was given to the possibility of storing reduced irrigation diversion volumes in upstream reservoirs and releasing them later in the season to offset the impact of reduced return flows from irrigation. The following general conclusions were drawn from this analysis (CDM 2010, p. 6-17):

- "Increasing irrigation efficiency to 75 percent causes a reduction in return flows and streamflows beginning generally in August and lasting throughout the year in many locations in the study area.
- Increasing irrigation efficiency to 75 percent results in higher streamflows during the peak runoff due to lower headgate diversions.
- The volume of increased streamflows (relative to the baseline model) during the peak runoff is comparable to the reduction in late season flows, but taken as a percent of streamflow, the late season reductions are generally much larger since streamflows are much lower in the late season.
- The reduction in late season flows when irrigation efficiencies are increased is more pronounced in basins that are water-short (i.e. irrigation water requirement is a larger portion of the total basin supply).
- Application of reservoir water can increase late season flows by providing another source of water in the late season."

The reported percent reduction in monthly average flow in the Yampa and White Rivers from late summer and extending through the winter was estimated to be as great at 31% on the Yampa River upstream of Stagecoach Reservoir. However, values typically ranged from 1 – 10%.

Impact of Irrigation Return Flows on Water Quality and Wetlands Under Current and Altered Practices

Water Quality Impacts. A portion of irrigation water that is applied to fields runs off the tail end of the fields and into surface drains. As this water flows over the land surface and through the drains it picks up a variety of dissolved solutes. The remaining applied water infiltrates into the soil to replenish the moisture deficit in the crop root zone for use by crops. That portion of infiltrated water that exceeds the storage capacity of the soil percolates downward out of the crop root zone. This deep percolation, along with canal seepage, passes down through the root zone and recharges the alluvial aquifer. Over time, the water table often rises to levels near the ground surface. The alluvial aquifers of the Yampa and White River systems are underlain in many locations by Upper Cretaceous marine and Tertiary sedimentary rocks, including shales, which serve as a source of salts and trace elements, like selenium (Se) (Topper et al 2003, Van Liew and Gesink 1985). These salts and trace elements are dissolved, mobilized, and transported by through the subsurface by excess irrigation flows which make their way back toward the river. In addition, irrigation of crops increases the consumptive use of water in the watersheds, leading to evaporative concentration of solutes already present. Consequently, concentrations in ground water and surface water can rise to levels that threaten agricultural production on the land, aquatic life in the streams, and human health.

Concentrations of total dissolved solids (TDS), major ions, nutrients, and trace elements in the waters of the Yampa and White River Basins have been summarized in several reports. Bauch et al (2012) reported values of TDS at some locations along the Yampa River that may threaten crop productivity. Phosphorus, a common element in agricultural fertilizer, also was found in concentrations exceeding federal recommendations at a number of sites. Both Bauch et al (2012) and Chafin et al (2001) report measured Se concentrations along the Yampa River downstream of Craig that indicate exceedance of the Colorado Department of Public Health and Environment (CDPHE) chronic standard for protection of aquatic life. Limited data from groundwater sampling indicate that TDS is higher at locations in contact with sedimentary rocks of marine origin, including shales (Bauch 2012). Topper et al (2003) report representative TDS concentrations from alluvial wells near Craig of about 2,800 mg/L, which exceeds the threshold to prevent yield reduction for alfalfa and some hay grasses. Dissolved manganese also was high at a number of surface water and groundwater sampling sites within the Yampa River network. According to Van Liew and Gesink (1985), 115 groundwater samples from White River alluvial aquifer had specific conductance (an indirect measure of TDS) ranging from 0.40 to 14.0 dS/m, generally increasing from east to west along the river valley and with distance from the river. Data indicate calcium bicarbonate groundwater salinity in the eastern part of the White River study region and sodium sulfate salinity in the western part.

The high solute concentrations that have been measured in some regions of the Yampa and White River stream-aquifer systems are indicative of the dissolution and evaporative concentration processes that are associated with irrigation return flows. However, no studies are known to have addressed the causative linkages of these high concentrations to irrigation practices and return flows in the Yampa and White River Valleys. No calibrated surface and subsurface solute transport models of the regions are known to exist. In other words, it remains unclear the degree to which irrigation return flows are responsible for high solute concentrations and how potential alterations to irrigation practices and associated return flows might lessen or worsen them.

Wetlands Impacts. The spatial patterns and temporal cycles of instream flows, with attendant ecological conditions, can be markedly affected by irrigation return flows (Fernald and Guldan 2006, Richter et al 2003, Poff et al 1997). Moreover, on their path back to the river, a portion of surface and subsurface return flows may be detained in low-lying areas to create wetlands. Also, they often contribute to very shallow water tables that develop along the flanks of rivers and tributary streams, creating and sustaining riparian vegetation. Wetlands, including riparian areas, caused by irrigation return flows, provide numerous ecological benefits, including wildlife habitat and chemical reduction of solutes before flows enter the river system (Sueltenfuss et al 2013). A downside of wetlands is increased evapotranspiration from the basins. Irrigation-influenced wetlands are apparent in field visits to the Yampa and White River Valleys. A more expansive perspective of wetlands distributed throughout the Yampa and White River Basins, many of which are affected by irrigation return flows, is provided in the Colorado Wetlands Inventory (2016).

Groundwater Conditions Under Current and Altered Practices

Deep percolation from excess irrigation along with canal seepage causes groundwater tables in alluvial aquifers to rise to levels which often are quite shallow below the ground surface. These higher water tables in turn create hydraulic gradients that drive subsurface flows back toward the stream network. They also contribute upflux to the overlying unsaturated zone. Under cropped fields, this upflux contributes to salt accumulation and reduced aeration (or waterlogging) that can lessen crop yields. Under some noncropped areas, upflux from shallow groundwater contributes to greater non-beneficial consumption of water by weeds and bare-soil evaporation.

Little data have been found on the flow and storage properties of the alluvial aquifers of the Yampa and White Rivers. General descriptions of aquifer thickness, composition, and hydraulic conductivity within the Yampa River alluvium are described by Topper et al (2003). Similar general information for the White River alluvial aquifer is presented by Van Liew and Gesink (1985).

Studies of groundwater levels in the Yampa and White alluvium also appear to be sparse. Topper et al (2003) report published water levels in wells in the Yampa River alluvial valley that range from 0 – 41 ft below ground surface, averaging about 10 ft below ground surface. They also report water levels in wells in the White River valley that range from 3 to 90 ft, but do not provide an average value. Shallow water table conditions are corroborated by discussions that the author had with landowners in both the Yampa and White River Valleys. However, details about the locations and nature of groundwater monitoring wells, the resulting spatial and temporal patterns of water table levels, and the relationship to irrigation return flows were not found in the literature.

Though not directly addressing irrigation return flows, recent studies have reported estimates of groundwater baseflow to the Yampa and White Rivers. Groundwater baseflow, or discharge, includes subsurface return flows from precipitation as well as from irrigation recharge. Garcia et al (2014) describe a USGS database of estimated groundwater discharge to streams in the Upper Colorado River Basin, including the Yampa and White Rivers. Rumsey et al (2015) present estimated values of groundwater baseflow for several sites along the Yampa and White Rivers within Colorado. They report that the baseflow index (ratio of mean annual baseflow to mean annual total streamflow) is about 30 to 40% along the Yampa River and about 50 to 70% for the White River. In a related study, Miller et al (2014) describe baseflow for the Yampa River in more detail, presenting mean daily values for the period 2007 - 2012, and indicating an average baseflow contribution equivalent to 30% of total streamflow over that same period. Water table elevation contours (very coarse) estimated by Van Liew and Gesink (1985) indicate groundwater accretion to the White River along most of their study region over most of the year.

No distributed parameter groundwater models of the alluvial aquifers within the Yampa and White River Basins are known to currently exist. The Glover-Balmer analytical method, which employs numerous simplifying assumptions, was used by AECOM (2009c, 2009d) to estimate accretion of groundwater to streams from irrigated command areas in both basins. The same gross average estimates of aquifer transmissivity, specific yield, and flow distance were incorporated into the Glover-Balmer method for application to both the Yampa and White aquifers. The bulk of seepage and deep percolation were estimated to return to the stream within one to two months. Values of overall irrigation efficiency, but not aquifer parameters, under each canal command area were adjusted to calibrate the CDSS models of flow in the Yampa and White River Basins.

Summary and Recommendations for the Scope of Future Studies

The availability of abundant water supply in the Yampa and White Rivers in Colorado allows for large diversions to irrigated agriculture, typically exceeding crop consumptive use and resulting in excess waters that return to the river systems. Information gathered from limited available investigations and from anecdotal evidence reveals conditions in the Yampa and White River Valleys that are typical of stream-aquifer systems heavily influenced by irrigation return flows:

(1) Surface and subsurface return flows from irrigated lands to the river networks make up a significant portion of instream flows;
(2) Total dissolved solids and trace element concentrations, though generally low, are high in some locations within the streams and alluvial aquifers, seemingly increasing downstream;
(3) Numerous and widespread wetlands have been created and are sustained;
(4) Water tables are relatively shallow under extensive land areas.

Existing information is adequate for making these general observations, but is insufficient to provide a refined understanding. The influence that irrigation return flows wield upon the stream-aquifer systems is dependent not only upon their magnitude but also upon their spatial and temporal distribution. In regard to spatial and temporal variation within the Yampa and White systems, available data are sparse and available models are rather coarse. Current data and models may be sufficient for rule-of-thumb assessments and for large-scale strategic planning. For example the CDM (2010) study, which employs the CDSS models described by AECOM (2009c, 2009d), likely provides a reasonable estimate of the gross monthly or seasonal impact on stream flow that would result from an extreme level of adoption of sprinkler irrigation over the basins. However, current data and models do not provide insight over refined spatial scales (mile by mile) or over shorter time steps (week to week or day to day). They do not address how varying stream and aquifer properties and how alterations in irrigation diversions, irrigation application efficiency, canal seepage, and drainage networks might influence irrigation return flows and groundwater conditions at these scales. Current data and models do not provide adequate spatial and temporal detail, nor do they provide ease of use or reliability for making river system management decisions (as opposed to large-scale assessment or strategic planning) to mitigate the adverse impact of altered return flow patterns (e.g. through managing reservoir releases, augmenting through groundwater recharge, etc) and/or to achieve targets for improved environmental and agricultural conditions in the basins.

The YWB Roundtable is concerned to know how emerging changes in irrigation practices within the two basins will impact the nature and consequences of irrigation return flows. Specifically, the Roundtable may want to know how changes in irrigation return flows will (1) amend instream flows so as to impact water rights, aquatic life conditions, water quality, and obligations to interstate flow compacts; (2) diminish wetland and riparian areas; and (3) alter groundwater levels, groundwater quality, and soil conditions so as to affect crop productivity and non-beneficial water consumption. If it is important to understand these effects, not just at a gross scale but at specific locales and over short-time as well as long-term time frames, additional data and models will be needed.

If the YWB Roundtable decides that a more refined understanding is indeed needed, it is recommended that the Roundtable consider a phased approach to build the available database and to develop and apply the needed modeling tools. The phases and tasks are outlined below.

Phase 1

(1) Identify the important questions that need to be answered related to irrigation return flows and their impacts in the Yampa and White River systems.

(2) Select one or two of the key representative irrigated regions (each encompassing about 1,000 to 10,000 acres) within each of the Yampa and White Valleys (Figure 2) to measure and compile data for use in describing and predicting the impact of altered irrigation practices on return flows and groundwater conditions. Such data might include:
    a. Aquifer properties (hydraulic conductivity, specific yield, boundary conditions)
    b. Soil properties (texture, water holding capacity)
    c. Topography (land surface elevation, hydrography)
    d. Geology and lithology (thickness to bedrock, etc)
    e. Precipitation and evapotranspiration
    f. Instream flows in the tributaries and main stem
    g. Crop types and distributions
    h. Groundwater levels and potentiometric surface
    i. Soil salinity
    j. Groundwater salinity and other solutes
    k. Stream, canal, and drainage network (layout, hydraulic geometry, resistance characteristics)
    l. Irrigation practices (application efficiency, canal tail escape flows)
    m. Canal seepage

    It is recommended that this data collection effort extend for 3 to 5 years.

(3) Begin constructing the conceptual and computational models (e.g. MODFLOW-UZF, UZF-RT3D) of surface water and groundwater within the selected regions. Initially, flows should be the major focus, with solute transport being secondary. This task would include defining the level of resolution and the needed data to answer the questions identified in Task (1). Tasks (2) and (3) need to be conducted in concert so that data are obtained that fulfill model needs and so that model features are designed to match available data.

Phase 2

(1) Calibrate and test the regional groundwater-surface water models.
(2) Apply the models to explore the likely regional-scale impacts of altered irrigation practices on irrigation return flows, groundwater conditions, wetlands, and agricultural productivity.

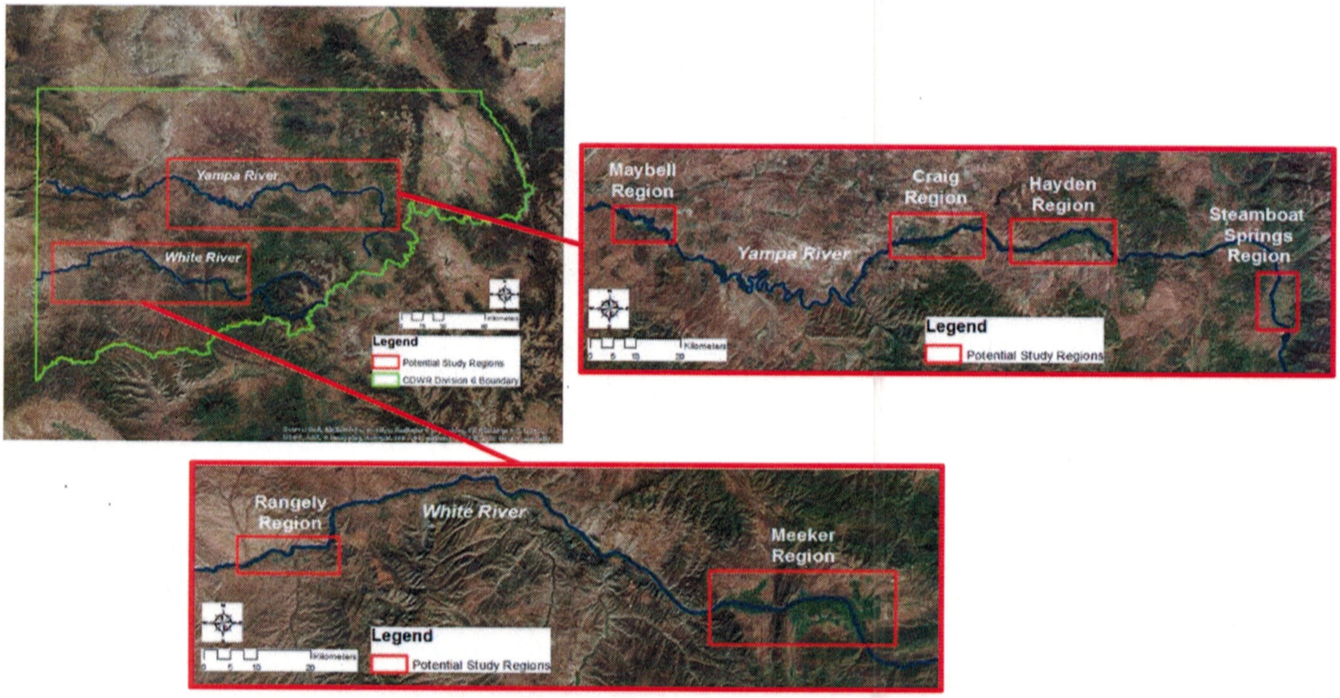


Figure 2. Key representative regions for potential data collection and modeling in the Yampa and White River Valleys.

Phase 3

Incorporate the regional model findings into a basin-scale administrative flow model that could be used to explore the effect of regional changes on flow, water quality, and water rights conditions over the entire river systems. This might involve a revision of current CDSS models or the use of other river basin administrative flow models like MODSIM. Additional data likely will need to be gathered and compiled during this phase.

The extent and level of detail involved in each of these phases will be constrained by the specific questions to be answered, the level of reliability required, and available time and budget, among other considerations. CSU has conducted and published monitoring and modeling studies to address similar problems in the irrigated stream-aquifer system of the Lower Arkansas River Basin over the last 16 years. CSU would be very interested in assisting with any effort the YWB Roundtable might decide to undertake in the Yampa and White River Basins.

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Invoice No. 2016_002
Date:4/26/16

Terms:
Due date: Upon Reciept

To:Craig Godbout
Program Manager
Colorado Water Conservation Board
Water Supply Planning Section
1313 Sherman Street, Suite 718
Denver CO 80203
(303) 866-3441, ext 3210 (office)
(303) 547-8061 (cell)
craig.godbout@state.co.us

Description	**Amount**
Completed WSRA Grant -POGG1 206-244 "YWG Basin Roundtable Phase II Agriculture Needs/Return Flow Preliminary Assessment Project"	$11,222.18
Administration	$950.00
Thank you!	**Total $12,172.18p**

WSRA GRANT - INVOICE TRACKING SUMMARY BY TASK

GRANTEE NAME: Routt County Conservation District
ADDRESS: 1475 Pine Grove Road, Steamboat Springs, CO 80487-8803
CONTACT: Selina Heintz, Treasurer

PHONE: 970-879-3225 x 107
EMAIL: esheintz@gmail.com

Project: YWG Phase II Agricultural Needs/ Return Flow Preliminary Assessment				TASK 1 BUDGET	TASK 2 BUDGET			
CONTRACT #: POGG1 2016-244		GRANTEE INVOICE#	WSRA GRANT BUDGET ONLY	Assessment	Admin			
DATE:	Description of Services:		$ 13,250.00	$ 12,300.00	$ 950.00			
2/16/2016	*Reconnaissance Field Trips.*	0088-001	$ 822.78	$ 822.78				
3/16/2016	*Literature Review.*	0088-002	$ 5,143.08	$ 5,143.08				
4/14/2016	*Interaction with Knowledgeable People. Preparation of Draft Final Report.*	0088-003	$ 6,206.32	$ 5,256.32	$ 950.00			
Total Billed			$ 12,172.18	$ 11,222.18	$ 950.00	$ -	$ -	$ -
Balance of Task Budget			**$ 1,077.82**	**$ 1,077.82**	$ -	$ -	$ -	$ -

PROVIDE A COVER INVOICE ON COMPANY LETTERHEAD WITH GRANTEE NAME & CONTACT, PROJECT NAME, CONTRACT #, INVOICE # AND TOTAL BILLED.
ATTACH INVOICE TRACKING SUMMARY ALONG WITH BACK UP DETAIL OF HIGHLIGHTED EXPENSES IN DATE ORDER FOR AUDIT PURPOSES.

INVOICE: 00088-001

Please Return a Copy of This Invoice with Check

Colorado State University
Sponsored Programs
Fort Collins, CO 80523-2002
FAX: (970) 491-6147

TO:
Jackie Brown
Routt County Conservation District
1475 Pine Grove Road, Suite 201
Steamboat Springs, CO 80487

REMIT TO:

COLORADO STATE UNIVERSITY
SPONSORED PROGRAMS
2002 CAMPUS DELIVERY
FORT COLLINS, COLORADO 80523-2002

Description of Articles or Services Provided:	CURRENT PERIOD 9/14/15 TO 10/31/15	CUMULATIVE SINCE INCEPTION 9/14/15 TO 10/31/15
PERSONNEL	$0.00	$0.00
DOMESTIC TRAVEL	$715.46	$715.46
INTERNATIONAL TRAVEL	$0.00	$0.00
MATERIALS AND SUPPLIES	$0.00	$0.00
OTHER DIRECT	$0.00	$0.00
SUBCONTRACTS	$0.00	$0.00
EQUIPMENT	$0.00	$0.00
INDIRECT COSTS @ 15 % - TDC	$107.32	$107.32
TOTAL AMOUNT DUE	**$822.78**	$822.78

I certify that to the best of my knowledge and belief this report is correct and complete and that all outlays reported are for the purposes set forth in the grant award documents.

Dawn Sharkey
Dawn Sharkey, Research Financial Project Administrator
Phone: (970) 491-2848

Contract Number:

Date:	11/9/15
CSU Tax ID:	84-6000545
Payment Terms:	NET
CSU Ref No:	5300088
CSU Lead Dept:	CO-1372
Project Title:	Reconnaissance and Scoping for Assessing the Impact of Current and Altered Irrigation

INVOICE: 00088-002

Please Return a Copy of This Invoice with Check

Colorado State University
Sponsored Programs
Fort Collins, CO 80523-2002
FAX: (970) 491-6147

TO:
Selina Heintz
Routt County Conservation District
1475 Pine Grove Road, Suite 201
Steamboat Springs, CO 80487

REMIT TO:

COLORADO STATE UNIVERSITY
SPONSORED PROGRAMS
2002 CAMPUS DELIVERY
FORT COLLINS, COLORADO 80523-2002

Description of Articles or Services Provided:	CURRENT PERIOD 11/1/15 TO 12/31/15	CUMULATIVE SINCE INCEPTION 9/14/15 TO 12/31/15
PERSONNEL	$4,472.24	$4,472.24
DOMESTIC TRAVEL	$0.00	$715.46
INTERNATIONAL TRAVEL	$0.00	$0.00
MATERIALS AND SUPPLIES	$0.00	$0.00
OTHER DIRECT	$0.00	$0.00
SUBCONTRACTS	$0.00	$0.00
EQUIPMENT	$0.00	$0.00
INDIRECT COSTS @ 15 % - TDC	$670.84	$778.16
TOTAL AMOUNT DUE	**$5,143.08**	$5,965.86

PAST DUE INVOICES:
00088-001, dated 11/9/15, $822.78

I certify that to the best of my knowledge and belief this report is correct and complete and that all outlays reported are for the purposes set forth in the grant award documents.

Dawn Sharkey
Dawn Sharkey, Research Financial Project Administrator
Phone: (970) 491-2848

Contract Number:

Date:	1/26/16
CSU Tax ID:	84-6000545
Payment Terms:	NET
CSU Ref No:	5300088
CSU Lead Dept:	CO-1372
Project Title:	Reconnaissance and Scoping for Assessing the Impact of Current and Altered Irrigation

INVOICE: 00088-003

Please Return a Copy of This Invoice with Check

Colorado State University
Sponsored Programs
Fort Collins, CO 80523-2002
FAX: (970) 491-6147

TO:
Selina Heintz
Routt County Conservation District
1475 Pine Grove Road, Suite 201
Steamboat Springs, CO 80487

REMIT TO:

COLORADO STATE UNIVERSITY
SPONSORED PROGRAMS
2002 CAMPUS DELIVERY
FORT COLLINS, COLORADO 80523-2002

Description of Articles or Services Provided:	CURRENT PERIOD 1/1/16 TO 2/29/16	CUMULATIVE SINCE INCEPTION 9/14/15 TO 2/29/16
PERSONNEL	$4,570.71	$9,042.95
DOMESTIC TRAVEL	$0.00	$715.46
INTERNATIONAL TRAVEL	$0.00	$0.00
MATERIALS AND SUPPLIES	$0.00	$0.00
OTHER DIRECT	$0.00	$0.00
SUBCONTRACTS	$0.00	$0.00
EQUIPMENT	$0.00	$0.00
INDIRECT COSTS @ 15 % - TDC	$685.61	$1,463.77
TOTAL AMOUNT DUE	**$5,256.32**	$11,222.18

PAST DUE INVOICES:
00088-001, dated 11/9/15, $822.78
00088-002, dated 1/26/16, $5,143.08

I certify that to the best of my knowledge and belief this report is correct and complete and that all outlays reported are for the purposes set forth in the grant award documents.

Dawn Sharkey
Dawn Sharkey, Research Financial Project Administrator
Phone: (970) 491-2848

Contract Number:

Date:	4/14/16
CSU Tax ID:	84-6000545
Payment Terms:	NET
CSU Ref No:	5300088
CSU Lead Dept:	CO-1372
Project Title:	Reconnaissance and Scoping for Assessing the Impact of Current and Altered Irrigation

Amendment #01 to Research Agreement

This Amendment (Amendment) is entered into by and between The Board of Governors of the Colorado State University System, acting by and through Colorado State University, an institution of higher education of the State of Colorado, located at Fort Collins, Colorado, 80523-2002 ("University" or "CSU") and the Sponsor whose name and address appear below ("Sponsor").

WHEREAS, University and Routt County Conservation District (Sponsor) have mutually entered into a research agreement dated August 25, 2015 (Agreement); and

WHEREAS, the both parties have expressed a desire to extend said Agreement with certain modifications; and

WHEREAS, Sponsor desires CSU to continue research under the modified agreement based on the Scope of Work shown in Exhibit A of the original Research Agreement;

NOW, THEREFORE, in consideration of the foregoing Recitals and the mutual promises herein contained, the parties agree as follows:

1. Scope of Work. The University agrees to perform the research for the Sponsor described in the previously negotiated Scope of Work for the original Agreement.

2. Term. This Amendment shall terminate on **March 31, 2016** unless sooner terminated as provided herein or extended by mutual written agreement of the Parties.

3. Except as expressly amended by this Amendment, all other terms and conditions of the Agreement shall remain in full force and effect.

IN WITNESS WHEREOF, the parties have executed this Agreement the day and year shown.

THE BOARD OF GOVERNORS OF THE COLORADO STATE UNIVERSITY SYSTEM, ACTING BY AND THROUGH COLORADO STATE UNIVERSITY:

By: [signature]

Printed Name: David B. Doty

Title: Interim Director, Sponsored Programs

Date: 3/30/16

ROUTT COUNTY CONSERVATION DISTRICT
1475 PINE GROVE ROAD, SUITE 201
STEAMBOAT SPRINGS, CO 80487

By: S Hertz

Printed Name: Selina Heintz

Title: RCCD Treasurer

Date: 2/25/16