UPPER ARKANSAS
WATER CONSERVANCY
DISTRICT

PH: (719) 539- 5425 ~ P.O. BOX 1090, SALIDA, COLORADO 81201

December 7, 2009

Via email only

Mr. Todd Doherty
Intrastate Water Management and Development Section
COLORADO WATER CONSERVATION BOARD (CWCB)
1580 Logan Street, Suite 200
Denver, CO 80203

Re: WATER SUPPLY RESERVE ACCOUNT CONTRACTING
Applicant: Upper Arkansas Water Conservancy District
Water Activity Name: Hydrologic Water Balance Study

Dear Todd,

The Upper Arkansas Water Conservancy District (UAWCD) has reviewed your Water Activity Summary Sheet and correspondence related to our proposed hydrological water balance study. In the attached *Revised Scope of Work / Contract, Water Supply Reserve Account, December 2009*, we have addressed all your conditions / issues / additional needs. Also attached is our fully executed W-9 form (Request for Tax Payer Identification Number and Certification).

This project can only be successful, on time, and within budget, with cooperative and responsive sharing of information between UAWCD, the U.S. Geological Survey, Colorado State University (CSU), and Colorado Division of Water Resources, CWCB, and its Decision Support System in the Arkansas Basin. The *Revised Scope of Work / Contract* on a task-by-task basis denotes the responsible entity whether USGS or UAWCD, plus explicates the CWCB / CSU coordination / data contribution. Completion and submittal of the new CWCB invoice tracking spreadsheet to streamline project management is included in Task 4A project management. Up-to-date figures include a new field logistics map and an updated schedule. Figure 4 scheduled dates are approximate and will be adjusted as necessary during the project.

I look forward to this project and know that when completed it will provide information needed to better understand and manage water resources in the Upper Arkansas River Basin. Please do not hesitate to contact me if you have any questions.

Sincerely,

Ralph "Terry" L. Scanga, Jr.
General Manager

Cc: Pat Edelman, Southeast Colorado Chief, USGS Pueblo (w/enc.) VIA EMAIL ONLY
Ken Watts, Ground Water Specialist, USGS Pueblo (w/enc.) VIA EMAIL ONLY
Timothy K. Gates, Professor, Civil and Environmental Engineering, CSU (w/enc.) VIA EMAIL ONLY
Andy Moore, P.E., Colorado Water Conservation Board (w/enc.) VIA EMAIL ONLY

Form **W-9**
(Rev. October 2007)
Department of the Treasury
Internal Revenue Service

Request for Taxpayer Identification Number and Certification

Give form to the requester. Do not send to the IRS.

Print or type
See Specific Instructions on page 2.

Name (as shown on your income tax return)
Upper Arkansas Water Activity Enterprise

Business name, if different from above

Check appropriate box: ☐ Individual/Sole proprietor ☐ Corporation ☐ Partnership
☐ Limited liability company. Enter the tax classification (D=disregarded entity, C=corporation, P=partnership) ▶ .....
☑ Other (see instructions) ▶ Governmental

☑ Exempt payee

Address (number, street, and apt. or suite no.)
339 E. Hwy 50

Requester's name and address (optional)

City, state, and ZIP code
Salida, CO 81201

List account number(s) here (optional)

Part I Taxpayer Identification Number (TIN)

Enter your TIN in the appropriate box. The TIN provided must match the name given on Line 1 to avoid backup withholding. For individuals, this is your social security number (SSN). However, for a resident alien, sole proprietor, or disregarded entity, see the Part I instructions on page 3. For other entities, it is your employer identification number (EIN). If you do not have a number, see *How to get a TIN* on page 3.

Note. If the account is in more than one name, see the chart on page 4 for guidelines on whose number to enter.

Social security number
___ ___ ___

or

Employer identification number
84 1279548

Part II Certification

Under penalties of perjury, I certify that:

1. The number shown on this form is my correct taxpayer identification number (or I am waiting for a number to be issued to me), and
2. I am not subject to backup withholding because: (a) I am exempt from backup withholding, or (b) I have not been notified by the Internal Revenue Service (IRS) that I am subject to backup withholding as a result of a failure to report all interest or dividends, or (c) the IRS has notified me that I am no longer subject to backup withholding, and
3. I am a U.S. citizen or other U.S. person (defined below).

Certification instructions. You must cross out item 2 above if you have been notified by the IRS that you are currently subject to backup withholding because you have failed to report all interest and dividends on your tax return. For real estate transactions, item 2 does not apply. For mortgage interest paid, acquisition or abandonment of secured property, cancellation of debt, contributions to an individual retirement arrangement (IRA), and generally, payments other than interest and dividends, you are not required to sign the Certification, but you must provide your correct TIN. See the instructions on page 4.

Sign Here — Signature of U.S. person ▶ [signature] Date ▶ 12-05-2009

General Instructions

Section references are to the Internal Revenue Code unless otherwise noted.

Purpose of Form

A person who is required to file an information return with the IRS must obtain your correct taxpayer identification number (TIN) to report, for example, income paid to you, real estate transactions, mortgage interest you paid, acquisition or abandonment of secured property, cancellation of debt, or contributions you made to an IRA.

Use Form W-9 only if you are a U.S. person (including a resident alien), to provide your correct TIN to the person requesting it (the requester) and, when applicable, to:

1. Certify that the TIN you are giving is correct (or you are waiting for a number to be issued),

2. Certify that you are not subject to backup withholding, or

3. Claim exemption from backup withholding if you are a U.S. exempt payee. If applicable, you are also certifying that as a U.S. person, your allocable share of any partnership income from a U.S. trade or business is not subject to the withholding tax on foreign partners' share of effectively connected income.

Note. If a requester gives you a form other than Form W-9 to request your TIN, you must use the requester's form if it is substantially similar to this Form W-9.

Definition of a U.S. person. For federal tax purposes, you are considered a U.S. person if you are:

- An individual who is a U.S. citizen or U.S. resident alien,
- A partnership, corporation, company, or association created or organized in the United States or under the laws of the United States,
- An estate (other than a foreign estate), or
- A domestic trust (as defined in Regulations section 301.7701-7).

Special rules for partnerships. Partnerships that conduct a trade or business in the United States are generally required to pay a withholding tax on any foreign partners' share of income from such business. Further, in certain cases where a Form W-9 has not been received, a partnership is required to presume that a partner is a foreign person, and pay the withholding tax. Therefore, if you are a U.S. person that is a partner in a partnership conducting a trade or business in the United States, provide Form W-9 to the partnership to establish your U.S. status and avoid withholding on your share of partnership income.

The person who gives Form W-9 to the partnership for purposes of establishing its U.S. status and avoiding withholding on its allocable share of net income from the partnership conducting a trade or business in the United States is in the following cases:

- The U.S. owner of a disregarded entity and not the entity,

Revised Scope of Work / Contract
Water Supply Reserve Account
December 2009

Applicant: Upper Arkansas Water Conservancy District (UAWCD)
Water Activity Name: Hydrologic Water Balance Study (or Water Budget)
Water Activity Purpose: Consumptive and Nonconsumptive Study or Analysis
Counties: Chaffee, Lake, and Saguache
Drainage Basin: Arkansas River (see Figure 1)
Water Source: Arkansas River
Amount Requested: $180,000 (Statewide Account)
Matching Funds: Approximately $220,000

Water Activity Summary: The study goal is to quantify the surface water and groundwater components of the water budget — especially groundwater recharge — and includes characterizing the interactions between surface and groundwater. The Arkansas River Basin (Figure 1) study area is primarily in Chaffee County (Figure 2). Growth pressures in the upper basin require a better understanding of the connection between ground and surface water hydrology to allow better management of basin water. Study results can be used to estimate the effects in changes in water use on the availability and sustainability of groundwater resources. The study fits within the conclusions of the *Arkansas Basin Consumptive Use Water Needs Assessment: 2030* (2008) which identified a 31,500 acre feet municipal and industrial gap by 2030 and recommended conjunctive surface water and groundwater management solutions to deal with the gap. This study will help implement conjunctive use strategies.

Funding Overview: The total project cost is ~$406,000. The Upper Arkansas Water Conservancy District (UAWCD) is requesting 44% or $180,000 from the Colorado Water Conservation Board (CWCB) Statewide Account. The U.S. Geological Survey (USGS) is contributing ~$134,550. Local water providers, municipalities, and counties are contributing ~$93,000.

Project Leadership: Project leadership is shared between U.S. Geological Survey Colorado Water Science Center in Pueblo, Colorado, and UAWCD in Salida, Colorado. USGS will take the lead and provide labor for the majority of the tasks. UAWCD will provide labor specific to tasks 2F, 2G, 2H, and 2I. These tasks involve UAWCD labor for providing data from its 15 new data collection platforms as they are constructed and come on-line. UAWCD data includes precipitation and other meteorological data, stream stage measurements for Arkansas River mountain front tributaries, irrigation canal measurements, and surface water inflow and outflow data. The UAWCD data collection platform project is funded in part by a Bureau of Reclamation Water 2025 Challenge grant. UAWCD will take the lead and provide labor for Task 4A project management. UAWCD project management includes grant financial and performance reporting. This Scope of Work explicates project responsibility for each subtask.

Project Coordination: UAWCD will continue to work cooperatively to ensure the water budget study will be complementary to three CWCB-funded projects:

1. The Colorado State University study *Data Collection and Assessment in Support of Improved Water Management in the Arkansas River Basin* (CSU study), a ~$800,000 project funded in full by CWCB Water Supply Reserve Account grant contract no. C150441, with a project period from 2009-2012;
2. The CWCB *Feasibility Study for an Arkansas River Decision Support System*, being conducted by Brown and Caldwell with a 12-month project period from 2009-2010; and
3. The UAWCD *Telemetry Data Collection Platforms at Six Reservoirs plus Flow Control/Gauging at Six Reservoirs and Nine Streams* (UAWCD project), a ~$800,000 structural water activity funded in part by CWCB Water Supply Reserve Account grant contract no. C150439, with a project period from 2008-2010.

Project coordination is tangible. This Scope of Work explicates coordination with Colorado State University (CSU) and Colorado Water Conservation Board (CWCB). The study will specifically coordinate with CWCB to utilize its comprehensive water resources database, HydroBase, and to ensure that the water balance study serves implementation of the CWCB Decision Support System in the Arkansas Basin. For each subtask, the CSU or CWCB data contribution to the water budget study is highlighted. Details of data gathering (locations, final numbers) and data sharing will be refined in dialogue with CSU and, where feasible, local cost-share partners. Unlike the CSU study, the water budget does not have a water quality component. Substantial project coordination began in January 2009, when UAWCD, USGS, and CSU met in Salida to make joint decisions about data collection locations. In October 2009, UAWCD, CSU, and USGS again met in Salida to share details of field logistics. The October 2009 Upper Arkansas River Basin Field Logistics Map (Figure 3) demonstrates that collaboration with CSU provides more than 30 new data collection points for the water budget. In the upper basin study area, CSU has or will:

- Installed 17 alluvial wells to estimate hydraulic conductivity of the alluvial aquifer;
- Measured flow at nine tributary locations; and
- Conducted canal seepage tests in three canals.

Project History: USGS began work in 2009, in accordance with the attached schedule (Figure 4). USGS spent two weeks in the field in 2009 conducting aquifer tests on ~30 wells. To obtain access agreements for domestic wells, USGS support staff donated one week on phone calls contacting well owners. USGS tested 13 wells in residential areas to characterize hydraulic connectivity between surface water and domestic groundwater pumping (Task 2B). USGS tested 17 new CSU alluvial wells in irrigated areas to characterize the hydraulic connectivity between surface water and irrigation pumping. USGS will contribute its 35% match relative to the 2009 portion of the local water providers, municipalities, and counties matching funds. See Figure 5, budget. Local matching fund payments are staggered over three years to minimize the burden on small governmental organizations.

Task Structure

- Overview main task
- Sub-task described
- Location of sub-task
- Responsible entity (USGS or UAWCD)
- Explanation of sub-task procedure
- CSU / CWCB coordination / contribution

Task 1 Overview: Compile Existing Data (FY2010)

Task 1 compiles existing data. A broad trans-disciplinary search of available geologic, geophysical, hydrologic, and meteorological data will be compiled into a common geospatial database. This task will be facilitated by local knowledge USGS acquired during field work for its *2000-2003 Hydrogeology and Quality of Ground Water in the Upper Arkansas River Basin from Buena Vista to Salida, Colorado* (Watts, Kenneth R., 2005, USGS Water Resources Investigation Report 2005-5179). Data compilation in all disciplines will be initiated concurrently, and Task 1 will be conducted in tandem with Task 2 Data Collection.

The geospatial database will include well data from the Colorado Division of Water Resources; test-hole and well data from the Colorado Oil and Gas Conservation Commission (COGCC); published interpretations of surface and airborne geophysical surveys (such as the USGS October 2008 helicopter survey of Poncha Springs geology and hydrology); results from aquifer tests (Tasks 2A and 2B); groundwater levels (Task 2C); plus a bibliography of published water resources reports, maps, and electronic data.

Historical streamflow data sets, meteorological data sets, and surface water diversion data sets are available from HydroBase, the State of Colorado's comprehensive water resources database. HydroBase was developed as part of the Colorado Decision Support Systems (CDSS), a joint effort of CWCB and Colorado Division of Water Resources (CDWR). All data is available at cdss.state.co.us.

Task 1A Described: Review available geologic, geophysical, hydrologic, and meteorological data. Review climate data (CWCB 2008). Review well and water use data from local, state, and federal agencies, educational institutions, UAWCD, counties, municipalities, and water providers.

Location for Task 1A is U.S. Geological Survey Colorado Water Science Center in Pueblo, CO.

Responsible entity for Task 1A is U.S. Geological Survey Colorado Water Science Center.

USGS reviewed the CDWR electronic database of water well logs in 2009. The CDWR GIS specialist provided a spreadsheet of all ~6500 wells in the study area. USGS refined it to ~3600 study area wells (domestic, commercial, industrial, irrigation, municipal, fishery, and geothermal) by eliminating wells never built or abandoned. The study requires wells completed in sedimentary rocks, yet older CDWR well logs merely state "ground water" for the aquifer in which the wells were completed. The CDWR well log review was conducted to focus Task 2B Aquifer Tests Domestic Wells.

To further support the aquifer tests of municipal and domestic wells as part of Tasks 2A and 2B, available aquifer test data will be compiled from state and federal agencies. Data from drillers' logs and pump-installation reports associated with existing municipal and domestic wells chosen for the study will be compiled from documents (paper and scanned images), summarized, and entered into the geospatial database. Wells and test holes with available geophysical logs will be identified in the database and, at a minimum, the source, types, and depth intervals of geophysical logs, and media (format) of the logs will be identified in the database.

CSU coordination / contribution: CSU data compilation under its Task 1 will likely include: flow rates at existing gauging stations; trans-basin diversions; precipitation and snowpack records; pumping well records; water quality samples; topography and hydrography; reservoir features, storages and releases; crop surveys and yields; natural vegetation inventories; geologic, lithologic, and soils characteristics; climate data; satellite imagery; and evapotranspiration estimates. USGS Groundwater Specialist Kenneth R. Watts will communicate directly with CSU study leader Professor Timothy K. Gates to coordinate data sharing.

Task 1B Described: Compile available data in a public-access geospatial database and the USGS National Water Information System (NWIS) database.

Location for Task 1B is U.S. Geological Survey Colorado Water Science Center in Pueblo, CO.

Responsible entity for Task 1B is U.S. Geological Survey Colorado Water Science Center.

CSU coordination / contribution: CSU will prepare documents, maps, and electronic data files as its Task 1 product. Relevant CSU data will be converted into an appropriate format and incorporated into the USGS NWIS database. USGS Groundwater Specialist Kenneth R. Watts will communicate directly with CSU study leader Professor Timothy K. Gates to coordinate data sharing.

Task 1C Described: Update the geospatial database and NWIS as additional data are collected and as interpretations are completed and approved during Task 2 Data Collection.

Location for Task 1C is U.S. Geological Survey Colorado Water Science Center in Pueblo, CO.

Responsible entity for Task 1C is U.S. Geological Survey Colorado Water Science Center.

CSU coordination / contribution: CSU will create a database (see CSU SOW task 6, page 10) based on the Microsoft version of the Structured Query Language, the most common database language. Relevant CSU data will be converted into an appropriate format and incorporated into the USGS NWIS database. USGS Groundwater Specialist Kenneth R. Watts will communicate directly with CSU study leader Professor Timothy K. Gates to coordinate data sharing.

Task 2 Overview: Collect New Data (FY2009-2011)

Data collection will occur over a two-year period. Data collection will be prioritized in consultation with the local water providers, municipalities, and counties who are contributing ~$93,000. Data collected will be the basic data needed for a first iteration steady-state system conditions water budget: aquifer tests at large capacity municipal and irrigation wells; aquifer tests in domestic and alluvial wells; water levels in a well network spatially distributed to include both shallow and deep wells in residential and irrigated areas; water levels plus temperature at selected wells to characterize stream-aquifer interaction; evapotransporation/consumptive use from irrigated land and native vegetation; precipitation and other meteorological data; mountain front stream data to estimate stream-aquifer interaction on tributaries; irrigation canal conveyance loss; and surface water inflow and outflow data. The data collected will be used to:

1) Refine conceptual models of the hydrogeologic framework;
2) Define hydraulic and storage properties of aquifers; and
3) Support preparation of the water budget.

Task 2A Described: Conduct aquifer tests (pumped-well tests) in three large capacity wells using constant-discharge methods to define hydraulic and storage properties of aquifers, estimate aquifer transmissivity, and determine specific yield of the aquifers.

The location of the large capacity wells is based on spatial distribution across the study area near the three major tributary streams to the mainstem Arkansas River: Cottonwood Creek, South Arkansas River, and Poncha Creek. Figure 2 depicts the location of the tributaries and their affiliated municipalities. Buena Vista is in the northern part of the study area at the confluence of Cottonwood Creek and the Arkansas River. Poncha Springs is at the confluence of Poncha Creek and the South Arkansas River. Salida is in the southern region of the study area at the confluence of the South Arkansas and the Arkansas Rivers.

Responsible entity for Task 2A is U.S. Geological Survey Colorado Water Science Center.

Pumped-well tests are conducted using constant-discharge methods. Large-capacity wells will either be municipal or irrigation. There are ~50 large capacity irrigation wells in the study area that pump ~100s gpm so they serve as alternate points of main stem surface-water diversion. Duration of discharge for constant-discharge tests will likely be 24 to 72 hours, with an equivalent duration of monitoring prior to pumping and during recovery (after pumping ceases). A control well or wells will be pumped at a constant rate(s) and water levels in nearby wells will be measured to determine aquifer response to pumping. Analytical methods or numerical modelss will be used to determine hydraulic and storage properties of the aquifers.

CSU coordination / contribution; Not applicable; this water balance study tasks involves deeper large capacity wells while CSU focuses on the shallower alluvial aquifer.

Task 2B Described: Conduct aquifer tests in a network of ~50 domestic or monitoring wells to quantify hydraulic properties (hydraulic conductivity and transmissivity) of the alluvial and basin-fill (Dry Union Formation) aquifers. This new 50 well network is referred to as the *water balance study well network*.

The location of the ~50 domestic or monitoring wells will be designed to ensure a representative spatial distribution across the study area and will include both shallow and deep wells in residential and irrigated areas. No new wells will be drilled. To save money, alluvial wells in the CSU monitoring network will be used. To further save money, where possible wells with pre-existing access agreements from the USGS *2000-2003 study* will be used. Since the population has grown since 2003, more wells have been drilled, so new wells will be added to expand the areal extent of the study area from that of 2000-2003, particularly west of the Arkansas River. To save time during the two to three week period required to negotiate new access agreements, USGS interns will make the first overture to well owners.

Responsible entity for Task 2B is U.S. Geological Survey Colorado Water Science Center.

USGS conducted aquifer (slug) tests in 13 domestic wells in residential areas and 17 alluvial wells in the CSU monitoring network in 2009 to characterize hydraulic properties of the alluvial and basin-fill aquifers. Analyses of this initial 2009 test data will facilitate the selection of additional wells for the *water balance study well network*. The goal is to get enough information (water levels and hydraulic properties) for the alluvial aquifer and the basin-fill aquifer to characterize the interflow between the two aquifers.

USGS will review its well test data to finalize the selection of additional wells for the *water balance study well network*. Instantaneous change-in-head (slug) tests will be used to estimate the transmissivity of the aquifer. Slug tests are conducted by instantaneously injecting or displacing a known volume of water from the well and measuring the subsequent rate of rise or decline of the water level in the well (and the associated time-varying hydraulic gradient) with a pressure transducer. Analytical methods are used to interpret the data and estimate the approximate transmissivity (the product of hydraulic conductivity and saturated interval) of the aquifer near the well.

CSU coordination / contribution: CSU installed 17 monitoring wells in the alluvial deposits within the study region in 2009 (see Figure 3). Wells were sited in conjunction with USGS and UAWCD within the alluvium of the main stem, plus along Chalk Creek, Browns Creek, and the South Arkansas River. CSU monitoring wells were also sited in consideration of the Upper Arkansas domestic well network the USGS monitors water levels in. That network is referred to as the *USGS historical well network* to distinguish it from the *water balance study well network*. The *USGS historical well network* includes one deep well with semi-annual data going back to the 1970s. Because it is simpler to analyze slug tests of well that do not have pumps installed, 17 monitoring wells from the CSU network were substituted for domestic wells of the *water balance study well network.*. CSU monitoring wells are simpler to slug test, the well construction and completion data are more reliable, and the test analyses is less complicated. In addition,: domestic-well owners are not inconvenienced. Where relevant, USGS will utilize CSU data. USGS Groundwater Specialist Kenneth R. Watts will communicate directly with CSU study leader Professor Timothy K. Gates to coordinate data sharing.

Task 2C Described: Measure water levels periodically in existing domestic wells selected to be a part of the *water balance study well network* to define regional water-level surfaces and to monitor seasonal fluctuations of water levels.

Location rational for selecting pre-existing domestic wells (and CSU alluvial wells) to make up the *water balance study well network* is discussed under Task 2B. To save money, no laboratory analytical work will be conducted.

Responsible entity for Task 2C is U.S. Geological Survey Colorado Water Science Center.

Water levels will be measured four to six times per year in the *water balance study well network* for two consecutive years. Measurements frequencies over the two-year data collection period will be determined based on evaluation of hydrographs from the CSU monitoring wells. In

addition, water levels will be measured in 12 wells that are part of its *USGS historical well network* (there are 12 in the study area). USGS historic well network water levels are measured twice a year: once in mid-summer (when groundwater levels are near annual maximum levels) and once in late fall (when groundwater levels are near annual minimum levels).

CSU coordination / contribution: CSU installed 17 monitoring wells in the alluvial deposits within the study region in summer 2009 (see Figure 3). Wells were sited in conjunction with USGS and UAWCD within the alluvium of the main stem plus along Chalk Creek, Browns Creek, and the South Arkansas River. Wells were also sited in consideration of the USGS historical well network. CSU is manually measuring with multiprobes on a bi-weekly or monthly basis water levels and temperature in its 17 alluvial monitoring wells. CSU measuring frequency is based on hydrologic conditions (e.g., seasonal response to snowmelt-induced recharge) and observed levels of irrigation and pumping activities. CSU also installed pressure transducers equipped with thermistors and data loggers in its observation wells for continuous monitoring of water levels. Where relevant, USGS will utilize CSU data. USGS Groundwater Specialist Kenneth R. Watts will communicate directly with CSU study leader Professor Timothy K. Gates to coordinate data sharing.

Task 2D Described: Use pressure transducers/data loggers to monitor water levels and water temperature at selected wells to evaluate short-term changes in water levels and temperature, primarily to evaluate seasonal changes in water levels.

Location rationale for data loggers is not based on spatial distribution across the study area, but rather the data loggers will be rotated throughout the *water balance study well network* where it is anticipated that they will be most useful due to expected variation in water temperature or expected fluctuation in pressure that result from seasonal variation in recharge within two study focus areas: (1) gaining and losing stream reaches, and (2) along the mountain front. Data loggers will be used on wells at, near, or along streams (or irrigation canals) to establish which reaches tend to be losing and which tend to be gaining. Data loggers will be used evaluate subsurface mountain front inflow.

Responsible entity for Task 2D is U.S. Geological Survey Colorado Water Science Center.

Continuous data loggers will be utilized in a subset of the *water balance study well network* to define a temporal response within the aquifer to snowmelt runoff or agricultural recharge. Results can be used to evaluate aquifer response to short-term and seasonal changes in recharge and discharge processes, and estimate stream-aquifer interchange.

CSU coordination / contribution: CSU has continuous data loggers equipped with pressure transducers with thermistors in its 17 alluvial monitoring wells. Where relevant, USGS will utilize CSU data. USGS Groundwater Specialist Kenneth R. Watts will communicate directly with CSU study leader Professor Timothy K. Gates to coordinate data sharing.

Task 2E Described: Measure evapotranspiration (ET) from irrigated land and native vegetation. This will be done using a radiation-energy balance (REB) system (Bowen Ratio method). ET represents consumptive use.

Location of the REB system (equipment owned by the USGS) will be statically placed during the two-year study period. The location will be selected based upon irrigated land with relatively uniform characteristics — for instance, between Chalk Creek and Brown's Creek west of the Arkansas River. Portable hemispherical chambers will be used to measure instantaneous ET for irrigated crops and pasture, and native grasses, at selected sites across the study area. Instantaneous ET rates from the chambers will be calibrated with measurements from the static REB station to develop ET curves for the selected sites. Estimated ET from the REB method also will be correlated to ET measurements from the weighing lysimeter at the CSU Agricultural Experiment Station near Rocky Ford, Colorado.

Responsible entity for Task 2E is U.S. Geological Survey Colorado Water Science Center.

The emphasis will be to gather instantaneous rates of ET monthly at four irrigated fields during the growing season, using the affiliated hemispherical chambers (Stannard, 1988). Instantaneous measurements for specific sites will be correlated with the data from the static site to estimate ET for major crops in the study area. The major crop tends to be alfalfa or pasture hay.

In addition to the focus on four irrigated fields in the study area, ET rates from native vegetation will be measured three times during the growing season at multiple (10 to 20) sites using the hemispherical chambers. Those ET sites will be selected to evaluate possible differences or effects of elevation, location, vegetative cover, and depth to groundwater on ET of native vegetation.

CWCB coordination / contribution: The CDSS Consumptive Use model provides historic crop and non-crop demand data from 1950-2006. A FORTRAN program with a graphical user interface, it relies on a modified Blaney-Criddle consumptive use method, with monthly calculations. Other crop consumptive use methods available when the FORTRAN program is operated independently of the interface include the Penman-Monteith and Modified Hargreaves methods, both operated on a daily time step. CoAgMet network uses a Penman-Kimberly or Penman-Monteith equation.

Task 2F Described: Measure precipitation (P), and other meteorological data, for use in estimating recharge and discharge from the basin.

Locations will be determined based upon the distribution of existing precipitation gauges, and the distribution of other meteorological data collection points. Meteorological data within the study area typically includes maximum and minimum temperature, precipitation, and snowfall frost dates, wind, vapor pressure, snow-course snow water equivalent, and snow depth. Data is limited to several National Ocean and Atmospheric Administration (NOAA) weather stations. The U.S. Department of Agriculture, Natural Resources Conservation Service, Water and Climate Center operates several Snotel sites that measure snow pack, precipitation, and air temperature. Volunteers throughout the basin collect meteorological data through a network known as CoCoRaHs. Data from CoCoRaHs will be included in the study.

Responsible entity for Task 2F is both U.S. Geological Survey Colorado Water Science Center and UAWCD. UAWCD will share data from its weather data collection platforms at six high-elevation

reservoirs: North Fork Reservoir, Cottonwood Lake Reservoir, Rainbow Lake Reservoir, Boss Lake Reservoir, Grays Creek O'Haver Lake Reservoir, and DeWeese Reservoir.

Orographic variation in the study area can substantially affect the distribution and quantity of precipitation, solar radiation, relative humidity, wind, and air temperature. For instance, in the arid high mountain study area, ~50-70% of snowpack tends to be sublimated.

CWCB coordination / contribution: NOAA and Snotel meteorological data sets are available in *HydroBase*. Data sets incorporated into *HydroBase* include elevation, snow water equivalent, and total precipitation at Apishapa (since 1993), Brumley (since 1993), Fremont Pass, Porphyry Creek, and Saint Elmo. NOAA sites are listed.

ID	STATION NAME	START	END	COUNTY
7345	ST ELMO	1950	1953	CHAFFEE
7370	SALIDA	1948	2009	CHAFFEE
7371	SALIDA 3 W	1970	1984	CHAFFEE
8064	SUGARLOAF RESERVOIR	1948	2009	LAKE
8212	TENNESSEE PASS	1948	1953	LAKE
8496	TWIN LAKES EVAPORATI	1965	1967	LAKE
8501	TWIN LAKES RES	1949	2009	LAKE
1071	BUENA VISTA	1948	2009	CHAFFEE
1660	CLIMAX	1949	2009	LAKE
4884	LEADVILLE	1948	1982	LAKE
4885	LEADVILLE LAKE CO AP	1976	2008	LAKE

Task 2G Described: Measure stream stage, groundwater levels, plus surface (stream) and subsurface temperatures to estimate seepage losses from four mountain front streams and to estimate stream-aquifer interchange of the Arkansas River and its major tributaries.

Locations of the four mountain front streams is based on spatial distribution across the study area and the relative proportion of tributary flow that they contribute to the main stem river. Possible choices include Cottonwood and Chalk Creeks west of the mainstem river; Trout Creek Ditch east of the mainstem river; Poncha Creek south of the South Arkansas; and the South Fork Arkansas River. Location decisions were jointly made with CSU during field reconnaissance in January 2009.

Responsible entity for Task 2G is both U.S. Geological Survey Colorado Water Science Center and UAWCD. UAWCD will provide its stream stage data from:

- North Fork of the South Arkansas below North Fork Reservoir
- South Arkansas below Boss Lake Reservoir and above its confluence with the North Fork
- Cottonwood Creek below Cottonwood Lake Reservoir
- South Arkansas River Tenassee Gauge near Salida
- Poncha Creek below O'Haver Lake Reservoir
- Texas Creek by DeWeese Reservoir
- Trout Creek Ditch east of the Arkansas River

Mountain front infiltration represents groundwater recharge via infiltration of surface water. It occurs where streams flow across alluvial, basin-fill, and glacial deposits adjacent to the mountain front. Groundwater recharge from infiltration along the mountain front will be estimated using mass transport of heat in the subsurface. Data loggers with both temperature and pressure sensors placed at several intervals in the shallow subsurface (15-20 feet bgs) and in four tributary streams along the mountain front to measure the transport of heat with infiltration of stream flow. Stream-aquifer interaction will be measured via subsurface temperature and water

level measurements near four key tributary streams to estimate streambed seepage (gains and losses) (Skinner, 2005).

Temporary shallow piezometers will be used to identify gaining and losing reaches on four key tributaries. Shallow piezometers nests will be utilized to a depth of ~15 feet bgs; then data loggers for temperature and pressure can be used to identify mountain front water / pulses. USGS has the equipment so that two geologists can install one piezometer nest per day. Two such piezometer nests will be installed on each of four key tributaries to generate data about groundwater recharge zones. It is anticipated that these tributaries will be chosen from among Cottonwood and Chalk Creeks west of the Arkansas; Trout Creek east of the Arkansas; the North Fork and Middle Fork of the South Arkansas; and Poncha Creek, where it traverses the outcrop of the Dry Union Formation.

CSU coordination / contribution: not applicable.

Task 2H Described: Measure irrigation canal (ditch) stage, groundwater levels, and surface (canal) and subsurface temperatures to estimate conveyance losses of major irrigation canals and ditches.

Locations are based on decisions jointly made with CSU during field reconnaissance in January 2009. Location of irrigation canals will be based on local knowledge. For instance, UAWCD possesses on its board local knowledge of key irrigation canals such as The New Salida (30 c.f.s), Sunnyside (18 c.f.s.), and Williams and Hamm (18 c.f.s.)

Responsible entity for Task 2H is U.S. Geological Survey Colorado Water Science Center. UAWCD will provide irrigation canal data from its Lester Atterbury gauge.

The sum of conveyance loss of irrigation diversions and return flows to the water table (from irrigation) will be estimated as the difference between diversions and estimated consumptive use. As a check on this water budget component, conveyance losses from irrigation canals will be estimated at selected sites, using either current-meter measurements, in-situ seepage measurements, or subsurface temperature and potentiometric measurements. Return flows (infiltration) of irrigation water will be estimated as the difference between reported or estimated applied water and estimated consumptive use for individual canals or irrigated areas. Irrigated areas will be determined by analysis of the most recent aerial photography available. A GIS layer will be developed that shows locations of diversion points and ditches or canals and irrigated areas.

CSU coordination / contribution: CSU is conducting 1 or 2 seepage tests in 5 to 10 reaches within three ditches (see Figure 3). The ditches are Riverside Allen north of Buena Vista, Cottonwood Maxwell southwest of Buena Vista, and The New Salida north of Salida. The three ditches were selected to represent variable field conditions, to comply with the interests and constraints of the ditch companies, and in conjunction with USGS and UAWCD.

CSU will conduct ditch seepage tests by making simultaneous measurements of flow velocity and stage at ditch cross sections bounding the upstream and downstream ends of each selected

canal reach, using acoustic Doppler velocimeters or acoustic Doppler velocity profilers to estimate channel inflow and outflow within each reach. Simultaneous flow rates in the canals will be obtained from CDWR diversion records. CSU will use pressure transducers to measure water stage at selected locations along the reach, and ditch cross-section geometry will be surveyed at appropriate intervals between the upstream and downstream ends to evaluate storage changes along the reach. CSU will estimate evaporation from the water surface and minor inflows and outflows along the reach, allowing canal seepage to be calculated from the mass balance equation. Where relevant, USGS will utilize CSU data. USGS Groundwater Specialist Kenneth R. Watts will communicate directly with CSU study leader Professor Timothy K. Gates to coordinate data sharing.

Task 2I Described: Measure study area surface-water inflow and outflow by compiling data available Hydrobase. Streamflow data sets and surface-water diversion data sets are available from HydroBase, the State of Colorado's comprehensive water resources database, and includes data for streamgages operated by the USGS. HydroBase was developed as part of the Colorado Decision Support Systems (CDSS), a joint effort of CWCB and Colorado Division of Water Resources (CDWR). All data is available at cdss.state.co.us.

Locations of surface water flow data points are available from:

1. Streamflow datasets compiled from Hydrobase CDWR, USGS, and BOR gauges such as those listed in the box. Study area streamflow gauging is limited. Surface-water inflow at the northern border of the study area is available at the Arkansas River below Granite gauge near Clear Creek. Surface-water outflow at the southern border of the study area is available at the Arkansas River near Wellsville gauge. Other existing gauges are available at the confluence of the Arkansas with Clear Creek, Cottonwood Creek near Buena Vista, Arkansas River near Nathrop (a seasonal gauge at Chalk Creek), and the CDWR South Arkansas River near Salida gauge;
2. New streamflow data from nine CSU surface-water monitoring points; and
3. New streamflow data from UAWCD data collection platforms.

NAME	SOURCE	LOCATION	TIMEFRAME	PARAMETER
DISTRICT 11	ARKANSAS RIVER: HEADWATERS TO SALIDA			
ARKBGNCO	USGS	ARKANSAS RIVER BELOW GRANITE	1999 - PRESENT	DISCHRG
ARKEFOCO	USGS	EF ARKANSAS R AT US HIWAY 24, NR LEADVILLE	1967 – PRESENT	DISCHRG
ARKEMPCO	USGS	ARKANSAS RIVER BELOW EMPIRE GULCH NEAR MALTA	1990 – PRESENT	DISCHRG
ARKGRNCO	CDWR	ARKANSAS RIVER AT GRANITE	1910 – PRESENT	DISCHRG
ARKLEACO	USGS	ARKANSAS RIVER NEAR LEADVILLE, CO.	1967 – PRESENT	DISCHRG
ARKNATCO	USGS	ARKANSAS RIVER NEAR NATHROP (SEASONAL)	1965 – PRESENT	DISCHRG
ARKSALCO	CDWR	ARKANSAS RIVER AT SALIDA	1909 – PRESENT	DISCHRG
ARKWELCO	CDWR	ARKANSAS RIVER NEAR WELLSVILLE	1961 – PRESENT	DISCHRG
BOUTUNCO	CDWR	CHARLES H. BOUSTEAD TUNNEL	1971 – PRESENT	DISCHRG
BUSTUNCO	CDWR	BUSK-IVANHOE TUNNEL	1947 – PRESENT	DISCHRG
CCACCRCO	CDWR	CLEAR CREEK ABOVE CLEAR CREEK RESERVOIR	1946 – PRESENT	DISCHRG
CCBCCRCO	CDWR	CLEAR CREEK BELOW CLEAR CREEK RESERVOIR	1953 – PRESENT	DISCHRG
CHCRNACO	CDWR	CHALK CREEK AT NATHROP	1949 – PRESENT	DISCHRG
CLRRESCO	CDWR	CLEAR CREEK RESERVOIR	NA	ELEV, STOR
COCRBVCO	CDWR	COTTONWOOD CREEK NEAR BUENA VISTA	1970 – PRESENT	DISCHRG
COLDITCO	CDWR	COLUMBINE DITCH NEAR FREMONT PASS	1947 – PRESENT	DISCHRG
DINTUNCO	USGS	DINERO MINE DRAINAGE TUNNEL BLW TURQUOISE LK NR	2003 – PRESENT	DISCHRG
EWIDITCO	CDWR	EWING DITCH AT TENNESSEE PASS	1947 – PRESENT	DISCHRG
HALMALCO	USGS	HALFMOON CREEK NEAR MALTA, CO.	1946 – PRESENT	DISCHRG
HOMTUNCO	CDWR	HOMESTAKE TUNNEL	1966 – PRESENT	DISCHRG
LAKATLCO	CDWR	LAKE CREEK ABOVE TWIN LAKES RESERVOIR	1953 – PRESENT	DISCHRG
LAKBTLCO	CDWR	LAKE CREEK BELOW TWIN LAKES RESERVOIR	1946 – PRESENT	DISCHRG
LARDITCO	CDWR	LARKSPUR DITCH AT MARSHALL PASS	1948 – PRESENT	DISCHRG
LFCBSLCO	CDWR	LAKE FORK CREEK BELOW SUGAR LOAF DAM NEAR LEA...	1969 – PRESENT	DISCHRG
LKCTURCO	CDWR	LAKE FORK CREEK ABOVE TURQUOISE	1984 – PRESENT	DISCHRG
MTELFBCO	BOR	MOUNT ELBERT FOREBAY, CO	NA	ELEV
MTELFBCO	BOR	MOUNT ELBERT FOREBAY, CO	NA	STORAGE
SOARSACO	CDWR	SOUTH ARKANSAS RIVER NEAR SALIDA	1922 – PRESENT	DISCHRG
TURQLACO	BOR	TURQUOISE LAKE AT SUGARLOAF DAM NEAR LEADVILLE CO	NA	ELEV, STOR
TWIRESCO	BOR	TWIN LAKES RESERVOIR, CO	NA	ELEV, STOR
TWITUNCO	CDWR	TWIN LAKES TUNNEL	1934 – PRESENT	DISCHRG
WURDITCO	CDWR	WURTZ DITCH NEAR TENNESSEE PASS	1947 – PRESENT	DISCHRG
WUREXTCO	CDWR	WURTZ EXTENSION	1991 – PRESENT	DISCHRG

Responsible entity for Task 2I is both U.S. Geological Survey Colorado Water Science Center and UAWCD. With the implementation of UAWCD's ~$815,000 structural water project, the areal extent of gauges, especially high mountain gauges, will be substantially increased. UAWCD will provide streamflow data form its new data collection platforms at the following locations:

- North Fork of the South Arkansas below North Fork Reservoir
- South Arkansas below Boss Lake Reservoir and above its confluence with the North Fork
- Cottonwood Creek below Cottonwood Lake Reservoir
- South Arkansas River Tenassee Gauge near Salida
- Poncha Creek below O'Haver Lake Reservoir
- Texas Creek by DeWeese Reservoir

CWCB / CSU coordination / contribution: Streamflow data sets and surface water diversion data sets are available from HydroBase, the State of Colorado's comprehensive water resources database. CSU will measure flow and temperature at nine tributary locations on bi-weekly or monthly intervals (see Figure 3):

- Clear Creek
- Four Mile Creek
- North Cottonwood Creek
- Cottonwood Creek above Rainbow Lake Reservoir
- South Cottonwood Creek below Cottonwood Lake Reservoir
- Chalk Creek above Cascades
- Browns Creek at two locations
- South Arkansas above its confluence with the North Fork

The nine locations were selected in coordination with UAWCD and USGS, so that flow will be measured near anticipated new UAWCD gauges and exiting USGS / CDWR gauges. At sampling locations distant from existing gauge sites or when gauges are not operational during the winter (yet ice cover does not prohibit measurement), CSU will make simultaneous streamflow measurements using acoustic Doppler velocimeters or acoustic Doppler velocity profilers. CSU will make simultaneous stream flow measurements three to six times per year at sampling sites near existing stream gauges to check the accuracy of flow rating equations at the existing USGS Arkansas River Below Granite gauge (near confluence with Clear Creek), the USGS Arkansas River Near Nathrop gauge (near confluence with Chalk Creek), and the CDWR South Arkansas River near Salida gauge. Where relevant, USGS will utilize CSU data. USGS Groundwater Specialist Kenneth R. Watts will communicate directly with CSU study leader Professor Timothy K. Gates to coordinate data sharing.

Task 3 Overview: Data Analyses (FY2010-2011)

Overview. Data analysis will be conducted currently with Task 2 Data Collection, and continue to support Task 4 Reporting. USGS will analyze data for descriptive statistics, patterns, and inter-relationships. Spatial and temporal averages, measures of variability, and correlations will be estimated. Plots and contour maps will be prepared to explore spatial and temporal trends. Interrelationships among variables will be examined using multivariate regression and other

techniques. The final written report will include results displayed in color maps, graphics, bar charts, cross sections, tables, water level hydrographs, charts of hypothetical drawdown relative to distance, among others.

So that a steady-state systems condition water budget can be prepared from data compiled for and collected by the study, the groundwater recharge rate will be estimated by focusing on:

- infiltration of surface water from streams that flow from high mountains into the basin (aka mountain front stream seepage),
- subsurface flow into the basin along the mountain front (aka mountain front subsurface inflow), and
- infiltration of surface water diverted for irrigation along canals.

Task 3A Described: Subsurface inflow along the mountain front will be estimated using geospatial, meteorological, and streamflow data with a coupled precipitation-runoff-groundwater-flow model (GSFLOW; *Markstrom and others, 2008*) for selected drainage basins that contribute surface and groundwater to the Buena Vista–Salida Basin. For instance, the basins might include Cottonwood and Chalk Creeks on the west of the Arkansas; South Arkansas major tributaries North Fork and Middle Fork; and Poncha Creek above Poncha Springs; and, possibly, Trout Creek to the east of the Arkansas River.

Location for Task 3A is U.S. Geological Survey Colorado Water Science Center in Pueblo, CO.

Responsible entity for Task 3A is U.S. Geological Survey Colorado Water Science Center.

CSU coordination / contribution: not applicable.

Task 3B Described: Recharge from precipitation on non-irrigated land and from precipitation and applied water on irrigated land will be estimated using the Farm Package (FMP; *Schmid and others, 2006)* or variably Saturated Flow (VSF; *Thoms and others, 2006*) packages for MODFLOW.

Location for Task 3B is U.S. Geological Survey Colorado Water Science Center in Pueblo, CO.

Responsible entity for Task 3B is U.S. Geological Survey Colorado Water Science Center.

CSU coordination / contribution: not applicable.

Task 3C Described: Estimate changes in groundwater storage.

Location for Task 3C is U.S. Geological Survey Colorado Water Science Center in Pueblo, CO.

Responsible entity for Task 3C is U.S. Geological Survey Colorado Water Science Center.

The procedure will involve estimated groundwater-storage changes using water-level data, aquifer storage properties, and GIS.

CSU coordination / contribution: not applicable.

Task 3D Described: The simplified equation for steady-state system conditions is basic water budget equation will be:

$$\mathbf{P - ET + SWin - SWout - GWout + GWin = 0.}$$

where: P = precipitation; ET = consumptive use; SWin = surface-water inflow; SWout = surface-water outflow; GWout = groundwater outflow; and GWin = groundwater inflow.

Location for Task 3D is U.S. Geological Survey Colorado Water Science Center in Pueblo, CO.

Responsible entity for Task 3D is U.S. Geological Survey Colorado Water Science Center.

The procedure will involve a mass balance approach.

CSU coordination / contribution: not applicable.

Task 4 Overview: Reporting (FY2010-2011)

The key final document will be a U.S. Geological Survey Scientific Investigation Report tentatively titled, *Groundwater and surface water resources in the Upper Arkansas River Basin between Granite and Wellsville, in Chaffee and parts Lake and Saguache Counties, Colorado, 2009-2011.* It will document methods used to collect data, describe data analyses, and present a water budget for the basin between the Granite and Wellsville gauges. Deliverables will include non-proprietary data compiled for and collected by the study stored in a relational database. All data collected by the USGS will be stored in a public-access database, the USGS National Water Information System (NWIS) database. Geospatial data will be available from the USGS Water Resources National Spatial Data Infrastructure Node. Considering the use of State funds for this project, all provisional data compiled for and collected by the study shall also be available upon request.

Task 4A Described: Project management includes time for the UAWCD District Manager and Grant Manager to provide principal-in-charge oversight of the water balance study, including coordinating among all cost share participants and other stakeholders in the basin. This may include making progress report presentations to stakeholder groups including the Arkansas Basin Round Table. Project management also includes grant financial reporting and performance reporting, specifically requirements contained within the Amended WSRA Criteria and Guidelines for bi-annual progress report. Oral progress reports will be presented quarterly to CWCB staff, and at least annually to the Arkansas Basin Roundtable,

Location for Task 4A is UAWCD in Salida, Colorado.

Responsible entity for Task 4A is UAWCD.

This will involve producing for CWCB a progress report every six months, beginning from the date of the executed contract. Progress reports shall include the CWCB invoice tracking spreadsheet to streamline project management, and describe the completion or partial completion of the tasks identified in the scope of work including a description of any major issues that have occurred and any corrective action taken to address these issues. At project completion, UAWCD will provide the CWCB a final report that summarizes the project to document how the project was completed. This report may contain photographs, summaries of meetings, and engineering reports/designs.

All engineering work (as defined in the Engineers Practice Act (§12-25-102(10) C.R.S.)) performed under this grant shall be performed by or under the responsible charge of professional engineer licensed by the State of Colorado to practice Engineering.

CSU coordination / contribution: not applicable (?)

Task 4B Described: The GIS Geospatial Database will be publicly accessible and include all non-proprietary data collected for this study. The geospatial database will include but is not limited to the following types of data:

- Locations of wells, test holes, and other groundwater data collection sites
- Locations of stream gauges and other surface water features and data collection sites
- Locations of meteorological data collection sites
- Hydraulic and storage properties from aquifer tests
- Groundwater levels
- Bibliography of published water resources reports, maps, and publicly accessible data.

Location for Task 4B is U.S. Geological Survey Colorado Water Science Center in Pueblo, CO.

Responsible entity for Task 4B is U.S. Geological Survey Colorado Water Science Center.

CWCB / CSU coordination / contribution: To avoid duplication of data stored in both data bases, USGS will cooperate with DWR's HYDROBASE database manager, since HYDROBASE is developed under the SQL Server platform. If appropriate, USGS will utilize CSU scripts that allow interchange of data between databases. Where relevant, USGS will utilize CSU data. USGS Groundwater Specialist Kenneth R. Watts will communicate directly with CSU study leader Professor Timothy K. Gates to coordinate data sharing.

Task 4C Described: The interpretive maps and GIS, Potentiometric Surfaces task will include:

- Potentiometric and depth-to-water surfaces in the Buena Vista–Salida Basin, Chaffee County, Colorado
- Estimated spatial distribution of hydraulic and storage properties within alluvial, basin-fill, and glacial deposits in the Buena Vista–Salida Basin, Chaffee County, Colorado
- Aquifer storage potential.

Location for Task 4C is U.S. Geological Survey Colorado Water Science Center in Pueblo, CO.

Responsible entity for Task 4C is U.S. Geological Survey Colorado Water Science Center.

CSU coordination / contribution: CSU intends to develop its database into a GIS-based Internet Information System using ArcIMS (ESRI, Inc.) internet mapping server, which is similar to the Colorado Decision Support System's (CDSS) online map view. USGS will work with CSU share GIS metadata using ArcSDE. Where relevant, USGS will utilize CSU data. USGS Groundwater Specialist Kenneth R. Watts will communicate directly with CSU study leader Professor Timothy K. Gates to coordinate data sharing.

Task 4D Described: The final report *Groundwater and surface water resources in the Upper Arkansas River Basin between Granite and Wellsville, in Chaffee and parts of Lake and Saguache Counties, Colorado, 2009-2011* will document methods used to collect data, describe data analyses, and present a water budget for the basin between the Granite and Wellsville gauges. Other reports anticipated include:

- A USGS Fact Sheet summarizing results from aquifer, slug , and specific-capacity tests,
- A USGS Scientific Investigations Report to document data collection and analyses and present results from Task 2 (stream-aquifer interaction),
- A USGS Scientific Investigations Report to document data collection and analyses and present results from Task 3 (the water budget), and
- A USGS Scientific Investigations Report to document data collection and analyses and present results from Task 4 (potential for aquifer storage and recovery).

Location for Task 4D is U.S. Geological Survey Colorado Water Science Center in Pueblo, CO.

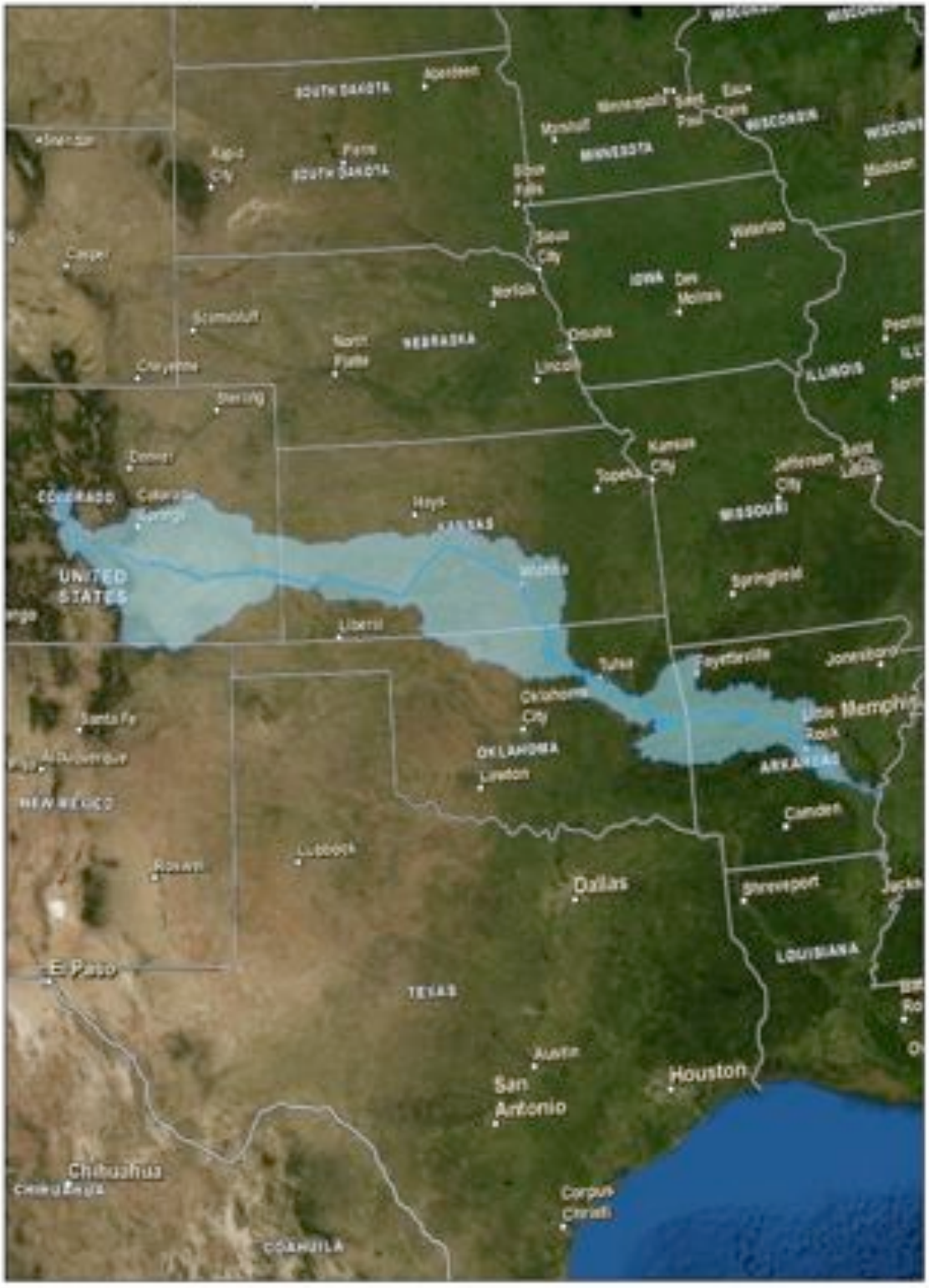
Responsible entity for Task 4D is U.S. Geological Survey Colorado Water Science Center.

All products, data and non-proprietary information developed as a result of this grant must be provided to the CWCB in hard copy and electronic format as part of the project documentation. This information will in turn be made widely available to Basin Roundtables and the general public to help promote the development of a common technical platform.

CWCB coordination / contribution: USGS published documents (reports) must undergo supervisory, editorial, two peer, and cooperator reviews. Typically, this includes one USGS reviewer from within Colorado and one from outside Colorado. In addition, after the report has been reviewed and revised, it is submitted to USGS Regional Specialists for review and approval. UAWCD as primary cooperator may designate, if deemed appropriate, one technical reviewer which might include the CWCB or an engineering consultant.

Attachments:
Figure 1. Arkansas River Basin
Figure 2. Location of the Study Area in Parts of Chaffee, Lake, and Saguache Counties, CO
Figure 3. Upper Arkansas River Basin Field Logistics Map October 2009
Figure 4. Schedule
Figure 5. Budget

Figure 1 - Arkansas River Basin



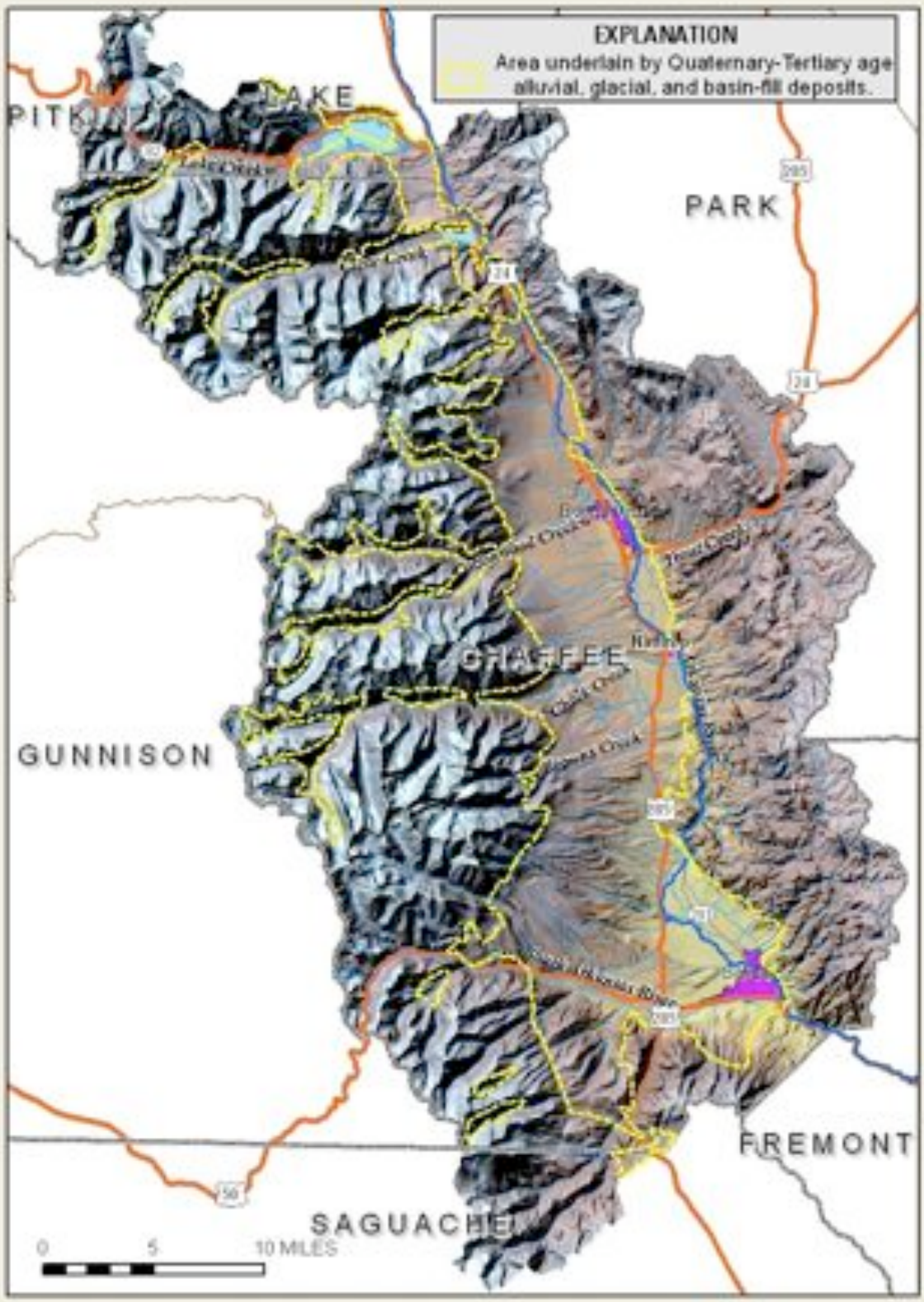


Figure 2. Location of the study area in parts of Chaffee, Lake, and Saguache Counties, Colorado.

Upper Arkansas River Basin Field Logistics Map -October 2009

- CSU Monitoring Wells - Drilled June 09
- USGS Existing/Historical Monitoring Wells
- Existing Wells for Possible Supplemental Monitoring
- Irrigation Ditch and Canals
- CSU Surface Water Sampling Point at Existing Gauge
- CSU Surface Water Monitoring Point
- Ditches for Seepage Testing

Buena Vista

Poncha Springs

Salida

0 0.2 0.4 Miles

4,900 2,450 0 4,900 Meters

CWCB WSRA 12/09

Hydrologic Water Balance Study at the Headwaters of the Arkansas River in all of Chaffee and parts of Lake and Saguache Counties, CO

STEPS and Task Elements	FY-2010				FY-2011				FY-2012			
Step 1: Aquifer Tests												
Aquifer tests												
Slug tests												
Documentation of aquifer tests												
Aquifer test archival												
Report – Fact Sheet												
Step 2: Stream-aquifer interaction												
Evaluate streamflow records												
Gain-loss measurements												
Heat-transport methods												
Data analyses												
Report – SIR[1]		O							D			A
Model and data archival												
Step 3 – Water Budget												
Data compilation												
Water-level measurements												
Water-level maps												
Evapotranspiration studies, including MF2K–FMP models												
Conveyance losses												
Mountain-front stream loss, Heat-transport models												
Mountain-front subsurface inflow, including GSFLOW models												
Report – SIR[1]		O							D			A
Geospatial data												
Model and data archival												
Step 4 – Potential Aquifer Storage & Recovery												
Data Analysis, Geospatial Models												
Data Analysis, Analytical models												
Data analysis, Numerical Models												
Report – SIR[1]							O		D			A
Model and data archival												

[1]Approximate dates (end of quarter) for reports: O – outline; D – draft to review; and A – approved for release.

CWCB WSRA 12/09

Hydrologic Water Balance Study at the Headwaters of the Arkansas River in all of Chaffee and parts of Lake and Saguache Counties, CO

FIGURE 5. BUDGET						
	Total Labor	Direct Costs	TOTAL	USGS Match	Local Match	CWCB Cost
Task 1 — Data Compilation						
Task 1A: Review Available Data	$2,624	$500	$3,124	$1,031	$719	$1,375
Task 1B: Compile Available Data	$6,848	$500	$7,348	$2,425	$1,690	$3,233
Task 1C: Update Available Data	$4,224	$500	$4,724	$1,559	$1,087	$2,079
Task 2 — Data Collection						
Task 2A: Aquifer Tests Muni Wells	$15,520	$5,033	$20,553	$6,782	$4,727	$9,043
Task 2B: Aquifer Tests Domestic Wells	$25,348	$3,814	$29,162	$9,623	$6,707	$12,831
Task 2C: Water Level Measurements	$15,680	$3,534	$19,214	$6,341	$4,419	$8,454
Task 2D: Transducer Measurements	$4,032	$6,134	$10,166	$3,355	$2,338	$4,473
Task 2E: ET Irrigated Land	$14,848	$8,886	$23,734	$7,832	$5,459	$10,443
Task 2F: P / Meterorological Data	$17,440	$3,000	$20,440	$6,745	$4,701	$8,994
Task 2G: Stream-Aquifer Temperatures	$28,192	$35,119	$63,311	$20,893	$14,562	$27,857
Task2H: Irrigation Conveyance Loss	$27,480	$11,814	$39,294	$12,967	$9,038	$17,289
Task 2I: Surface Water Inflow / Outflow	$24,460	$3,033	$27,493	$9,073	$6,323	$12,097
Task 3 — Data Analysis						
Task 3A: Subsurface Inflow Model	$29,810	$500	$30,310	$10,002	$6,971	$13,336
Task 3B: Recharge Estimating	$16,272	$250	$16,522	$5,452	$3,800	$7,270
Task 3C: Changes in Storage	$7,780	$500	$8,280	$2,732	$1,904	$3,643
Task 3D: Water Budget	$26,320	$1,000	$27,320	$9,016	$6,284	$12,021
Task 4 — Reporting						
Task 4A: Project Management	$6,900	$2,000	$8,900	$2,937	$2,047	$3,916
Task 4B: GIS, Geospatial Database	$4,220	$250	$4,470	$1,475	$1,028	$1,967
Task 4C: GIS, Potentiometric Surfaces	$2,400	$218	$2,618	$864	$602	$1,152
Task 4D: Final Report	$36,250	$3,700	$39,950	$13,184	$9,189	$17,578
TOTAL BUDGET	$316,648	$90,285	$406,933	$134,288	$93,595	$179,051
In-Kind Contributions	$24,220	$0	$24,220	$0	$0	$0
TOTAL COSTS	$340,868	$90,285	$431,153	$134,288	$93,595	$179,051

* amounts are affected by rounding

PAYMENT

Payment will be made based on actual expenditures and invoicing by the water activity sponsor. The request for payment must include a description of the work accomplished by major task, and estimate of the percent completion for individual tasks and the entire water activity in relation to the percentage of budget spent, identification of any major issues and proposed or implemented corrective actions. The last 5 percent of the entire water activity budget will be withheld until final project/water activity documentation is completed.

All products, data and information developed as a result of this grant must be provided to CWCB in hard copy and electronic format as part of the project documentation.