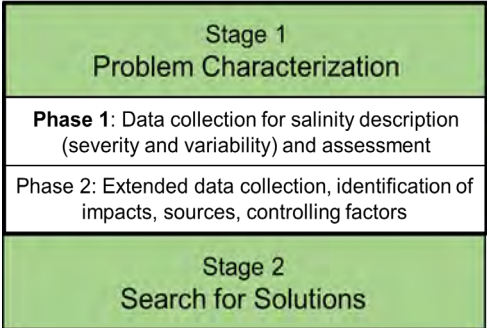


STATE OF COLORADO INTERAGENCY AGREEMENT SHORT FORM

| | |
|---|---|
| Paying State Agency Department of Natural Resources Colorado Water Conservation Board, ("CWCB") | Contract Number CMS Number: 190937 Encumbrance Number: CTGG1 PDAA 2024*4008 |
| Performing State Agency The Board of Governors of the Colorado State University System acting by and through the Colorado State University | Agreement Performance Beginning Date The Effective Date |
| Contract Maximum Amount Entire Contract term for all applicable fiscal years: \$464,361.49 | Agreement Effective Date Upon approval by the State Controller or an authorized delegate |
| | Agreement Expiration Date April 29, 2029 |
| | Terms Payment is due 30 days upon receipt of a valid invoice. Disputes are governed by Fiscal Rule 3-5, Section 4.2. Agencies shall report any outstanding balance on Exhibit AR_AP at Fiscal Year end. |
| Agreement Purpose and Obligations of the Parties The Grantee will study and characterize the salinization of water and land resources across seven regions in the South Platte River Basin. Water Plan Grant funding will support collecting field data, analysis, and integrating results. | |
| Exhibits and Attachments The following Exhibit(s) and/or Attachment(s) are included with this Agreement: 1. Exhibit A – Statement of Work and Budget | |
| Principal Representatives <div style="display: flex; justify-content: space-between;"> <div> For the Paying State Agency: Jackie Daoust Colorado Water Conservation Board 1313 Sherman St., #718 Denver, CO 80203 jacqueline.daoust@state.co.us </div> <div> For the Performing State Agency: Tiffany Roller Colorado State University 2002 Campus Delivery Fort Collins, CO 80523 tiffany.roller@colostate.edu </div> </div> | |

Exhibit A

| Statement Of Work | |
|---|---|
| Date: | March 25, 2024 |
| Name of Grantee: | Colorado State University – The Board of Governors of the Colorado State University System acting by and through the Colorado State University |
| Name of Water Project: | South Platte River Basin Salinity Study |
| Water Project Overview: | |
| <p>The Grantee will address the following research questions: (1) Just how severe and variable is salinization of water and land resources across the South Platte River Basin (SPRB)? and (2) Where and how should further investigation be focused to refine understanding of the problem and to support a search for solutions?</p> <p>There is presently a lack of peer-reviewed salinity studies in the SPRB. Information and local expertise are nevertheless suitable to guide the study of actual field conditions. The Grantee will complete a systematic field investigation, based upon an understanding of the existing data adequacy and gaps. This study will enhance the current state of knowledge of the salinity issue, illuminate the urgency of the problem, and clarify the need for additional data collection.</p> <p>The Grantee will complete Phase 1 of Stage 1 of a multi-year research effort (Figure 1). Phase 1 of the problem characterization stage will build off previously existing information in the SPRB to design and embark on a coordinated field data collection effort to better describe and define the salinity problem in relation to issues identified in collaboration with stakeholders. The Grantee will collect and analyze groundwater depths and salinity, salt concentrations and loads in streams and canals, and soil salinity. The Grantee will apply analytical and statistical methods to the gathered data to (a) gain a preliminary sense of the nature of salinity and its severity in relation to beneficial water uses within representative regions across the basin, and (b) to determine the need for additional and refined field data to adequately characterize the salinity problem.</p> | |
|  <pre> graph TD subgraph Stage1 [Stage 1 Problem Characterization] direction TB P1[Phase 1: Data collection for salinity description (severity and variability) and assessment] P2[Phase 2: Extended data collection, identification of impacts, sources, controlling factors] end Stage1 --> Stage2[Stage 2 Search for Solutions] </pre> | |
| <p>Figure 1. Components of the research effort needed to understand and solve salinization in the SPRB, with this project being Phase 1 of Stage 1.</p> <p>If evidence from Phase 1 indicates the salinity levels are high, data collection will be expanded to better define the pattern of the problem over the entirety of the basin in a later Phase 2 of the problem characterization stage. The Grantee will collect additional proximal (ground-level) data and remotely-sensed data to permit cost-effective routine large-scale tracking of salinity levels across the SPRB. The Grantee will clarify the major impacts and to identify major sources and controlling factors of salinity. The resulting description of salinity conditions will form a baseline reference point and a platform for a systematic search for solutions.</p> <p>The degree of success of this study will depend upon collaboration with many agencies and partners. Concerns about the apparent salinity problem in the water and land of the SPRB led to the formation in 2020</p> | |

of the South Platte Salinity Stakeholder Group (SPSSG) (> 35 members), which is being coordinated by the Colorado Water Center (CoWC). The Grantee has interacted with this group over the last 2.5 years and this study incorporates many of their interests. An integral part of this project will be close interaction with the SPSSG who will provide regular input, guidance and support.

Project Background Information:

Existing and emerging evidence suggests that portions of SPRB, like many other intensively irrigated stream-aquifer systems worldwide (Hopmans et al 2021; Wallender and Tanji 2012), suffer from salinization of water and land resources. Salt buildup poses a serious problem to agro-environmental systems, threatening the long-term productivity and sustainability of irrigated agriculture as well as municipal water supplies and other uses. Beyond the concentrating of solutes in applied waters that occurs by evaporation and transpiration, intensive irrigation and fertilization of alluvial soils can accelerate the rate at which geogenic salts and other mineral pollutants (e.g., selenium and uranium) are dissolved into alluvial aquifers that interact with rivers. This results in elevated salt concentrations that lower the quality of river flows that are diverted for irrigation and for other uses further downstream and threatens the ecological health of the riverine environment. Moreover, excess irrigation and canal seepage can lead to shallow saline water tables under cropped lands where evaporative up-flux accelerates soil salinization and depresses crop yields.

Many water users and managers agree that the nature, degree, and effects of salinity in the SPRB need to be better understood within the agricultural, environmental, and water-supply contexts. There are several related issues of concern to such stakeholders that have been identified:

- the spatial and temporal patterns in salinity and its chemical composition in streams, groundwater, and soils across the whole basin;
- the relative contribution to river salt loading and concentrations from treated municipal effluent point sources compared to that from agricultural return flow nonpoint sources;
- the severity of the salinity impact on soils and productivity from the 700,000 acres of valuable crop land in the SPRB;
- the effects of expanding sprinkler irrigation and the partial curtailment of well pumping by the Colorado Division of Water Resources (CDWR) on shallow groundwater and soil salinity;
- the long-term impact of recharge ponds for well augmentation situated throughout portions of the basin on subsurface and surface water salinity;
- the influence of salinity on municipal water supply and on water/wastewater treatment;
- the implications of dissolved salts to aquatic life in the stream network;
- the potential of alternative land and water management strategies to lower salt loads and concentrations; and
- the economic costs and benefits of salinity management.

The Grantee's study will fill in the data needed to allow the above issues to be better understood and adequately addressed. Previously existing information suggests that high concentrations of salts in streams and groundwater, along with salt damage to land and crops, are indeed significant in the basin, increasing downstream. The Grantee will conduct further problem characterization using well-designed and coherent data collection and analysis.

Project Objectives:

The objectives of this project are:

- (1) To gather new field data to better characterize groundwater, stream, and soil salinity for the purpose of addressing identified issues of concern in representative regions of the SPRB, and
- (2) To process and synthesize the field data to (a) describe the severity and variability of salinity across the SPRB and (b) design additional data collection for further salinity characterization and assessment.

Task 1

Task 1- Collect Phase 1 Field Data on Salinity

Description of Task:

The Grantee will design and implement a first-stage data collection effort. The Grantee will gather data on water and land salinity at field sites in seven study regions of the SPRB (Figure 2). These study regions were designated based upon similarities in location along the stream network, soils, subsurface geology, and other factors. The Grantee will use a coherent methodology within and among the regions to obtain information that sheds light on the extent and severity of salinization.

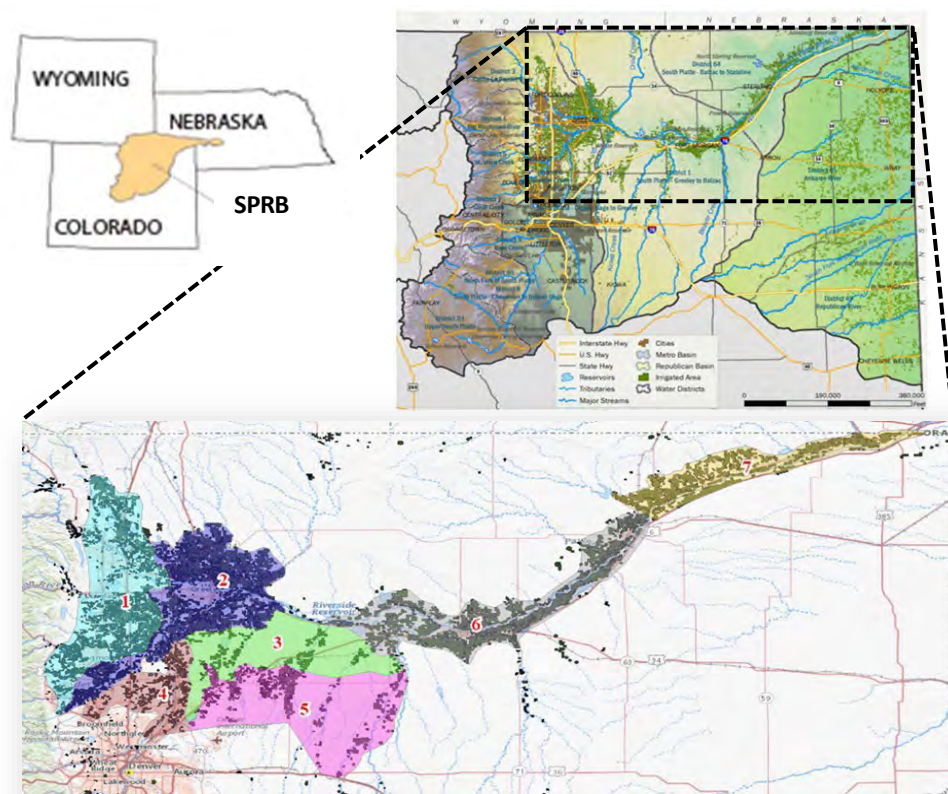


Figure 2. Map of the SPRB (above), and map of the proposed seven study regions in the Colorado SPRB (below). Sources: USGS Colorado Water Resources Center (left) and Colorado Water Plan, CWCB (right).

Method/Procedure:

The Grantee will complete an extensive compilation of previously existing documents, databases, and models addressing SPRB salinity issues carried out by an ongoing companion project funded by the Colorado Agricultural Experiment Station (CAES). Information compiled by these projects will be analyzed and interpreted in view of the salinity-related issues highlighted by the SPSSG and other experts. Based on this information, the Grantee will complete reconnaissance field visits to verify, further assess, and document (e.g., via photos, GPS tagging, notes) salinity-affected areas identified in past studies and to locate new monitoring sites. Sites will be selected within each of the seven study regions of the basin. Site selection will be guided by statistical considerations and by Geographic Information System (GIS) database queries and surveys for areas with similar soil textures, irrigation methods, water sources, cropping patterns, remote sensing (RS) spectral response (e.g., using multispectral images from Landsat and Sentinel satellites and algorithms based on vegetation indices), etc. The Grantee will conduct interviews with farmers, stakeholders, and experts to guide site selection.

The Grantee will complete a field data collection effort at the selected field sites to obtain water and land data. This work will be coordinated with the companion CAES project and with projects funded by Colorado Corn (CC) which have initiated similar tasks related to Phase 1 data collection. The Grantee will apply consistent methodology at multiple representative sites to provide coherent information to adequately answer the research questions. Results are intended to either affirm or deny the value of investigating the issue further in a Phase 2 and in a subsequent search for solutions stage. In designing Phase 1, as well as the later Phase 2, of salinity characterization, The Grantee will consider landowner interest and permission, stakeholder input, cost, personnel constraints, and statistical guidelines in light of uncertainty (Sanders et al 1983; Smith, Schwartz, Alexander 1997; Strobl, Robillard et al 2006). The Grantee will address methods for storing, managing, and accessing data.

Describing the nature of saline shallow water tables, caused in part by irrigation deep percolation and canal seepage, is important to understanding waterlogging and capillary upflux of salt into the crop root zone. A total of 15 groundwater monitoring wells have already been installed in study regions 2, 6, and 7 by the CAES and CC projects and another 5 to 10 are planned.

Groundwater monitoring wells will be installed by the proposed project at an additional 15 sites across regions 1 – 7. The wells will be drilled at a distance below the water table and equipped with PVC pipe (5-cm ID), bentonite sealant, and concrete pad. Each well will be permitted by the State of Colorado, will be equipped with a water level logger to monitor water table depth, and will provide access for periodic reading of water quality parameters (Electrical Conductivity (EC), pH, temperature, oxidation reduction potential) using roaming In-Situ Aqua Troll multiprobe devices and for collecting water samples. About half of these new monitoring wells also will be equipped with calibrated EC data loggers. To validate water level loggers, routine manual readings of water table depth and water quality parameters will be taken three times during the irrigation season (May – October) and twice during the non-irrigation season (November – April). Ground water samples will be collected from each well three times during the irrigation seasons and twice during the non-irrigation seasons using a filtered low-flow sampling technique. Samples will be analyzed in the laboratory to determine major cations and anions and total dissolved solids (TDS). This will permit calibration relationships between EC and TDS to be developed. Data on water table depth also will be obtained from dozens of wells routinely monitored by Colorado Department of Water Resources (CDWR) and Colorado Department of Agriculture (CDA) through an agreement with these agencies. EC measurements with data loggers, periodic measurements of other water quality parameters, and periodic sampling for TDS and salt ion concentrations will be made in about 10 of these CDWR and CDA wells, rendering a total of about 25 new groundwater monitoring wells in which salinity data will be gathered.

The Grantee will use multiprobe instruments for measuring water quality parameters at about 30 locations in streams, irrigation canals, and drains across the representative regions. At a representative subset of these

locations, filtered water samples for salt ion analysis also will be gathered three times during the irrigation seasons and twice during the non-irrigation seasons using a peristaltic pump. At 5 to 10 sites that are in proximity to key stream gaging locations in the South Platte River and tributaries, operated by CDWR and USGS, EC dataloggers will be placed in stilling wells to gather data for use in computing salt mass loading. Sites will be included near selected points of urban wastewater effluent discharge as well as near key diversion stems for urban water supply.

Agricultural fields, within the area of influence of the groundwater monitoring stations, will be surveyed during the irrigation season of the first and second year of the project with electro-magnetic induction (EMI) instruments (e.g., EM38-MK2) for field-based and regional mapping of the electrical conductivity of the saturated soil extract (EC_e) (Morway and Gates 2012). Within each sampled field area, dozens of GPS-positioned readings of bulk soil EC (EC_a) will be taken. The calibration of the EC_a data will be carried out in comparison with EC_e data obtained from laboratory analysis of soil samples. Soil samples for this calibration will be gathered at multiple depths at an average of about 8 to 10 sites within each 20 to 30-acre sampled field area, guided by the Electromagnetic Sampling Analysis and Prediction (ESAP) and t-ANOCOVA procedures (Lesch et al 2002). Samples obtained from the fields also will be analyzed in the laboratory for soil water content, texture, bulk density, and major ion composition.

The Grantee will keep records of irrigation methods and water sources for the studied field sites. Crop yield estimates will be gathered from farmers and may also be measured at selected sites within fields using crop cuttings if time and budget permit. This information will shed light on the severity of measured salinity levels (EC_e) in relationship to impact on crop yields.

Deliverable:

The Grantee will provide CWCB Staff with a summary of field data elements on groundwater salinity, surface water salinity, and soil salinity at locations across the SPRB. The Grantee will present on this task to the SPSSG and provide the slides to CWCB.

Task 2

Task 2- Analyze and Interpret Data to Describe the Severity and Variability of Salinity

Description of Task:

The Grantee will apply analytical and statistical methods to the data collected in Task 1 to initially map and assess the extent of water and land salinization in the SPRB. Information from the literature and stakeholders and experts will be used to gauge the severity of the measured salinity levels, namely the degree to which beneficial water uses are damaged.

Method/Procedure:

The data gathered in Task 1, along with the data compiled and collected by the companion CAES and CC projects, will be used to gain preliminary insight into the salinity status of water and land within the selected representative regions of the SPRB.

The Grantee will use the GIS database platform to analyze and represent previously available data on factors that influence salinization spatially over the basin. This will include soil properties (i.e., soil texture, depths, soil layering, soil slopes and infiltration capacity/rates), water supply sources, stream networks and flows, groundwater aquifer characteristics, cropping patterns, irrigation methods, geology, long term weather variables (on air and soil temperature, rainfall, relative humidity, solar radiation, wind speed), and selected satellite-based multispectral remotely sensed images from Landsat satellites. Data quality and reliability will be assessed, and information gaps will be identified. Levels of uncertainty in the data will be estimated based on considerations of measurement error and system variability.

The GIS database also will be queried to visualize the data compiled and gathered by this project in Task 1 on groundwater salinity, stream salinity, and soil salinity. The Grantee will compare information on acceptable levels of salinity for different beneficial uses in the watershed (crop production, water supply, aquatic life) to measured levels of salinity to assess severity. GIS will display the varying magnitude of salinity from location to location and GIS analytical tools will be used to explore trends, patterns, degree of variability, and relationships among basin properties and these salinity variables.

Deliverable:

The Grantee will provide CWCB Staff with a summary of the analysis of preliminary field data. The Grantee will present on this task to the SPSSG and provide the slides to CWCB.

Task 3

Task 3- Integrate Results and Design Phase 2 of Salinity Characterization

Description of Task:

The Grantee will use the data gathered and analyzed in Tasks 1 and 2, along with previously existing information, in preparing Phase 2 of salinity monitoring to further refine the characterization of the salinity problem within the representative regions of the SPRB to permit an adequate answer to the research questions posed about severity and variability.

Method/Procedure:

The Grantee will assess the data gathered and analyzed in Tasks 1 and 2, along with compiled previous information, to note gaps in records, identify potential salinity hot spots in the SPRB, extrapolate data to unmonitored areas with estimates of uncertainty, and determine priority sites and timing for additional data collection.

The Grantee will explore the results of the information gathered within the GIS database platform under Task 2. The Grantee will use these results to identify areas of the SPRB to schedule additional sampling at the existing sites of Task 1 and for locating extra monitoring sites for groundwater/stream/soil salinity sampling that will encompass a wider range of field conditions. Additional field sites will be selected within the seven representative regions designated in Task 1. To determine the number and location of additional monitoring sites, the Grantee will implement two approaches: (a) evaluation of preliminary distributed salinity levels estimated from both previously existing data sources and from measurements made in Task 1, and (2) GIS spatial interpolation and extrapolation using analytical and statistical tools, such as kriging, following methods like those outlined in Bradai et al. (2016) and Eldeiry and Garcia (2011, 2012). New data elements also may be deemed necessary for collection at existing and new locations.

Deliverable:

The Grantee will provide CWCB Staff with a summary of collected data and a preliminary assessment of the severity and variability of salinity in the SPRB. The Grantee will present on this task to the SPSSG and provide the slides to CWCB.

Budget and Schedule

This Budget and Schedule reflects the tasks identified in the Statement of Work.

| Task No. | Task Description | Estimated Task Start Date | Estimated Task End Date | Grant Funding | Match Funding | Total |
|--------------|---|---------------------------|-------------------------|---------------------|---------------------|---------------------|
| 1 | Collect Phase 1 field data on salinity | 5/1/2024 | 12/31/2026 | \$ 247,928.20 | \$ 97,294.64 | \$345,222.84 |
| 2 | Analyze and interpret data to describe the severity and variability of salinity | 10/1/2024 | 1/31/2027 | \$ 123,109.00 | \$ 42,568.00 | \$165,677.00 |
| 3 | Integrate results and design Phase 2 of first-stage salinity characterization | 10/1/2026 | 3/31/2027 | \$ 32,755.40 | \$ 14,927.00 | \$47,682.40 |
| | Indirect Rate (15%) | | | \$ 60,568.89 | | \$60,568.89 |
| Total | | | | \$464,361.49 | \$154,789.64 | \$619,151.13 |

Reporting Requirements

Progress Reports: The grantee shall provide the CWCB a progress report every six months, beginning from the date of issuance of the grant agreement. The progress report shall describe the status of the tasks identified in the statement of work, including a description of any major issues that have occurred and any corrective action taken to address these issues.

Final Report: At completion of the project, the applicant shall provide the CWCB a final report on the applicant's letterhead that:

- Summarizes the project and how the project was completed.
- Describes any obstacles encountered, and how these obstacles were overcome.
- Confirms that all matching commitments have been fulfilled.
- Includes photographs, summaries of meetings and engineering reports/designs.

The CWCB will pay out the last 10% of the budget when the final report is completed to the satisfaction of CWCB staff. Once the final report has been accepted, and final payment has been issued, the grant agreement will be closed without any further payment.

Payment

Payment will be made based on actual expenditures and must include invoices for all work completed. The request for payment must include a description of the work accomplished by task, an estimate of the percent completion for individual tasks and the entire project in relation to the percentage of budget spent, identification of any major issues, and proposed or implemented corrective actions.

Costs incurred prior to the effective date of this grant agreement are not reimbursable. The last 10% of the entire grant will be paid out when the final deliverable has been received. All products, data and information developed as a result of this grant agreement must be provided to the CWCB as part of the project documentation.

Performance Measures

Performance measures for this grant agreement shall include the following:

- (a) Performance standards and evaluation: Grantee will produce detailed deliverables for each task as specified. Grantee shall maintain receipts for all project expenses and documentation of the minimum in-kind contributions (if applicable) per the budget. Per grant guidelines, the CWCB will pay out the last 10% of the budget when the final report is completed to the satisfaction of CWCB staff. Once the final report has been accepted, and final payment has been issued, the grant agreement will be closed without any further payment.
- (b) Accountability: Per grant guidelines full documentation of project progress must be submitted with each invoice for reimbursement. Grantee must confirm that all grant conditions have been complied with on each invoice. In addition, per Grant Guidelines, progress reports must be submitted at least once every 6 months. A final report must be submitted and approved before final project payment.
- (c) Monitoring Requirements: Grantee is responsible for ongoing monitoring of project progress per Exhibit A. Progress shall be detailed in each invoice and in each progress report, as detailed above. Additional inspections or field consultations will be arranged as may be necessary.
- (d) Noncompliance Resolution: Payment will be withheld if grantee is not current on all grant conditions. Flagrant disregard for grant conditions will result in a stop work order and cancellation of the grant agreement.