COLORADO
Colorado Water Conservation Board
Department of Natural Resources

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John Hickenlooper, Governor

Mike King, DNR Executive Director

James Eklund, CWCB Director

**TO:** Colorado Water Conservation Board Members

**FROM:** Tim Feehan, Deputy Director
Steve Biondo, Finance Manager

**DATE:** March 18-19, 2015, Board Meeting

**AGENDA ITEM:** Agenda Item 25 – Severance Tax Operational Fund Grants

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**Introduction**

CWCB is entitled to an amount up to a 5% share of the Severance Tax Operational Fund. In January 2015, CWCB received internal requests and outside applications for funding that becomes available from the Operational Fund in July 2015 via the Long Bill enacted by the General Assembly. CWCB Staff reviews the applications and then recommends to the Board the projects that should receive funding. We expect to receive $1,275,500 in funding; however, should that amount be changed, the project funding will also need to be revised. Table 1 on pages 2 through 4 provides a summary of the recommended and non-recommended projects by CWCB Staff. These projects are described in more detail following Table 1 (see each write-up by the corresponding Project Number).

**Recommendation**

Staff recommends that the Board approve the proposed funding for each of the projects from the Severance Tax Operational Fund as summarized as Table 1 to this memo. Recommended projects are numbered 1 – 25 and projects not recommended are numbered 26 - 35.

Table 1
**SEVERANCE TAX OPERATONAL FUND PROJECTS**
**FOR FUNDING FROM JULY 1, 2015 TO JUNE 30, 2016**

| No. | Sponsor | Project Name | Funding Recommended |
|---|---|---|---|
| 1 | CWCB | Work related to Recreational Projects | $ 50,000 |
| 2 | CWCB | DWR Measuring Equipment | $ 46,000 |
| 3 | CWCB | CSU Water Resources Archive | $ 25,000 |
| 4 | Lower Arkansas Valley WCD | Fort Lyon Recharge Pond Demonstration Project | $ 39,725 |
| 5 | Colorado Geological Survey | County Groundwater Resources Series, Year 4 | $ 50,000 |
| 6 | Town of Norwood | Raw Water System Feasibility Study | $ 47,000 |
| 7 | DWR | Dam Safety Inundation Mapping Grant Program | $ 50,000 |
| 8 | CWCB | Case Management and Litigation Support | $ 65,000 |
| 9 | CWCB | Stream and Lake Protection Section Outreach and Education | $ 10,000 |
| 10 | CWCB | ISF Database Update | $ 150,000 |
| 11 | CWCB | Flood Mitigation and Project Compliance | $ 100,000 |
| 12 | CWCB | Community Assistance Program | $ 47,650 |
| 13 | CWCB | Enhanced Snowpack Monitoring above Taylor Reservoir | $ 73,000 |
| 14 | Center for Snow and Avalanche Studies | Colorado Dust on Snow Program | $ 25,000 |
| 15 | Dept of Agriculture - State Conservation Board | Kiowa Creek Watershed Flood Control Dam Maintenance Program | $ 25,000 |
| 16 | CWCB | Lean Program Support | $ 10,000 |
| 17 | CWCB | Water Planning and Operational Needs | $ 115,420 |
| | | Total | **$ 928,795** |

| No. | Sponsor | Project Name | Funding Recommended |
|---|---|---|---|
| **HIGHER EDUCATION PROJECT REQUESTS:** | | | |
| 18 | MSU | 2016 Watershed Summit sponsorship and K-12 education on water use, conservation, and existing program effectiveness | $ 25,000 |
| 19 | CWI/CSU | Determination of Consumptive Water Use of Winter Wheat in Arkansas Valley | $ 49,632 |
| 20 | CWI/CSU | River Change and Flood Hazards on the Colorado's Front Range | $ 49,853 |
| 21 | CWI/CSU | Using Remote sensing Assessments to Document Historical and Current Saved Consumptive Use (CU) on Alfalfa and Grass Hayfields Managed | $ 50,000 |
| 22 | CWI/CSU | Evaluating the Time Series Discontinuity of the NRCS Snow Telemetry (SNOTEL) Temperature Data across Colorado | $ 40,000 |
| 23 | CWI/CSU | Data Collection and Analysis in Support of Improved Water Management in the Arkansas River Basin, Phase 2 | $ 50,000 |
| 24 | CWI/CSU | Modeling the Influence of Conjunctive Water Use on Flow Regimes in the South Platte River Basin using the SPDSS Groundwater Flow Model | $ 50,000 |
| 25 | CWI/CSU | The ecological benefits of irrigated agriculture and potential risks under changing water allocation and supply | $ 31,720 |
| | | Total | **$ 346,205** |
| | | Grand Total | **$ 1,275,500** |

PROJECTS NOT RECOMMENDED:

| | | | |
|---|---|---|---|
| 26 | USGS | Lost Creek Specific Yield Study | $ 86,800 |
| 27 | Lost Creek Ground Water Mgmt District | Lost Creek Alluvial Monitoring and Management Study | $ 50,000 |
| 28 | Open Water Foundation | Enhance CDSS TSTool Software for CDSN and EPA Water Quality Data Web Services | $ 50,000 |
| 29 | Colorado Watershed Assembly | Colorado Data Sharing Network (CDSN) | $ 90,971 |
| 30 | Open Water Foundation | South Platte Point Flow Modeling and Visualization Tools | $ 50,000 |
| 31 | CWCB | Invasive Phreatophyte Control | $ 100,000 |
| 32 | Metro State University | Various research, registration, travel and staffing support for water education | $ $64,600 |

| No. | Sponsor | Project Name | Funding Recommended |
|---|---|---|---|
| 33 | CWI/CSU | Impact of Floodplain Restoration on Dynamics of Stream-Aquifer Interaction | $ 47,725 |
| 34 | CWI/CSU | Integrate CDSS and CSIP as Research Platform | $ 50,000 |
| 35 | CWI/CSU | Development of Water Rights Education Materials | $ 25,000 |

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**Severance Tax Operational Fund**

**Proposed Project for Fiscal Year 2015 – 2016**

**Project No. 1**

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Applicant: Ted Kowalski, Interstate & Federal Chief

Project Title: Work related to Recreational Water Projects

Recommended Amount: $50,000
Requested Amount: $50,000

Description of Project: The Staff has typically requested funds each year to either: 1) fund work associated with the litigation of RICDs; or 2) fund projects that have benefits to water based recreational interests. In the next fiscal year, the CWCB is anticipating that it may receive requests to assist local governments (i.e. Town of Lyons, Grand Junction, Fort Collins, etc.) in the design, construction or repair of their whitewater courses. Products may include: 1) finalization of design drawings and permitting for these communities to move toward building and/or repairing their Recreational In-Channel Diversions structures (RICD) and/or, 2) construction or repair of RICD structures. Staff may also use these funds for expert testimony in the upcoming Glenwood Springs RICD application. The funds may also be used to obtain data or information related to stream-related recreation that could be used to assure Colorado could fully use its compact entitlements and support Colorado's tourist recreation-based economy.

Project Manager(s): Suzanne Sellers

Program: Recreational Projects

Purpose: These funds will help assure that Colorado can fully use its compact entitlements while allowing mountain communities to develop water based recreational infrastructure. Wild and scenic rivers and RICD water rights, and the structures themselves, affect water planning in many important ways. The statutes and CWCB's policies on recreational use of water and on RICD's demonstrate a need to ensure compliance by local communities and to help protect Colorado's compact entitlements and to assure maximum utilization of Colorado's water resources. To the extent that recreational uses of water and RICD structures are designed and constructed in a manner that promotes maximum utilization of Colorado's water resources and that allows Colorado to fully use its compact entitlements, then CWCB's missions are being fulfilled.

Funding Available: July 1, 2015 – June 30, 2016

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**Severance Tax Operational Fund**

**Proposed Project for Fiscal Year 2015 – 2016**

**Project No. 2**

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Applicant: Ted Kowalski, Interstate & Federal Chief

Project Title: DWR Measuring Equipment

Recommended Amount: $46,000
Requested Amount: $46,000

Description of Project: To procure water and weather measuring equipment for use by Divisions 1, 2, and 3 to provide enhanced administration of water rights.

Project Manager(s): Steve Miller / Bill Tyner

Program: Interstate, Federal, and Water Information

Purpose: Water Divisions 1, 2 and 3 have experienced an increasing demand to monitor the quality of ground water measurements by performing quality control well tests across a range of highly diverse installations. DWR Surface Water and Ground Water Commissioners have had good success in this endeavor to the extent quality well testing equipment is available. DWR can stretch the resource of existing Commissioners with the purchase additional portable Ultrasonic flow meters to be used for both surface and ground water measurement verification in virtually all pipeflow situations. These portable flow meters are approximately $6000 each and the purchase of four units will help achieve the desired outcome. Total cost for these four meters is estimated to be $24,000.

Additionally, in Division 2, there is an increasing demand to verify measuring devices on ditches, augmentation station installations, and flumes measuring inflows to recharge ponds. This demand is due in part to implementation of complex terms and conditions in proposed lease-fallow project approvals, and the unique Arkansas Basin rules necessary to achieve Compact compliance. The demand has been partially met by Division 2 Hydrographers, but in many circumstances smaller flumes and measuring points could be more effectively checked for accuracy by Water Commissioners. Division 2 Hydrographers would provide the necessary training on measurement techniques to support this effort, but additional equipment is needed. The unit cost for a basic equipment setup is estimated to be approximately $4000 and four sets of equipment would allow optimal distribution to critical areas. Total cost for the four sets is estimated to be $16,000.

Division 2, in cooperation with Colorado State University and DWR Denver staff, will purchase one mobile weather station that will first be used at the Rocky Ford Research Station to enable crop rotations on the lysimeters and alleviate limitations at the existing station. The mobile station could also be used for data verification or emergency backup of other CoAgMet weather stations or be temporarily placed at a new research site as needed. Estimated cost is $6,000.

Funding Available: July 1, 2015 – June 30, 2016

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**Severance Tax Operational Fund**

**Proposed Project for Fiscal Year 2015 – 2016**

**Project No. 3**

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| | |
|---|---|
| Applicant: | Ted Kowalski, Interstate & Federal Chief |
| Project Title: | CSU Water Resources Archive - Digitization of Water Resources Archive Materials |
| Recommended Amount: | $25,000 |
| Requested Amount: | $25,000 |

Description of Project: To digitize materials in CSU's Water Resources Archive. Of highest priority are documents related to groundwater research and administration in Colorado , especially in the South Platte, Rio Grande, and Arkansas river basins.

| | |
|---|---|
| Project Manager(s): | Carolyn Fritz |
| Program: | Interstate & Federal Program |

Purpose: To provide online, public access to historical water resource related documents within CSU's Water Resources Archive.

Funding Available: July 1, 2015 – June 30, 2016

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**Severance Tax Operational Fund**

**Proposed Project for Fiscal Year 2015 – 2016**

**Project No. 4**

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Applicant: Lower Arkansas Valley Water Conservancy District

Project Title: Fort Lyon Recharge Pond Demonstration Project

Recommended Amount: $39,725
Requested Amount: $39,725

Description of Project: This phase of a multi-year demonstration project will involve the identification of three or four potential recharge sites in consultation with the participants in the Lower Ark District's Fort Lyon Rule 10 Plan. Considerations in the identification process will include relation to John Martin Reservoir, land ownership, ability of the Fort Lyon Canal and a lateral to deliver water to the site, topography, and geology of the site and the land lying between the site and the Arkansas River/tributary drain.

Project Manager(s): Steve Miller / Andy Moore

Program: Interstate, Federal, and Water Information Program

Purpose: The objective of this project is to demonstrate the physical and legal viability of locating and constructing recharge within the Arkansas River Basin to provide an additional source of augmentation and replacement water to support several essential water management programs carried out by the District.

Funding Available: July 1, 2015 – June 30, 2016

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**Severance Tax Operational Fund**

**Proposed Project for Fiscal Year 2015 – 2016**

**Project No. 5**

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Applicant: Peter Barkmann, Colorado Geological Survey (CGS)

Project Title: County Groundwater Resources Series – Chaffee County

Recommended Amount: $50,000
Requested Amount: $50,000

Description of Project: This project is a web-based publication for geology and groundwater resources in Chaffee County. It is patterned after the county-wide groundwater resource series produced in the 1960s through mid-1970s. CGS has previously received severance tax grants for this updated series for Douglas and Park Counties. The total cost of the project is $110,000, with CGS providing matching funds.

Project Manager(s): Andy Moore

Program: Water Information and Water Supply Planning Programs

Purpose: To provide the public, planners and policy-makers data and information on local geology and groundwater resources. The publication will include mapping applications and will address all aquifers utilized in the county, including alluvial, sedimentary, and crystalline bedrock formations.

Funding Available: July 1, 2015 – June 30, 2016

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**Severance Tax Operational Fund**

**Proposed Project for Fiscal Year 2015 – 2016**

**Project No. 6**

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Applicant: Town of Norwood – Chad Reed, Mayor

Project Title: Raw Water System Feasibility Study

Recommended Amount: $47,000
Requested Amount: $47,000

Description of Project: Feasibility study to construct a raw water irrigtaion system in the Town of Norwood, separate from the Town's treated water system.

Project Manager(s): Tim Feehan

Program: Finance Section

Purpose: A separate raw water irrigation system for the Town of Norwood would provide a more economical way for the Town to conserve its water resources, while also taking pressure off its water treatment facility during peak summer demand months. The raw water irrigation system would provide customers with an efficient cost effective way to promote and develop long term landscaping, which would benefit individual home owners and the community as a whole.

Funding Available: July 1, 2015 – June 30, 2016

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**Severance Tax Operational Fund**

**Proposed Project for Fiscal Year 2015 – 2016**

**Project No. 7**

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Applicant: Colorado Division of Water Resources, Dam Safety Branch

Project Title: CO Dam Safety Inundation Mapping Grant Program

Recommended Amount: $50,000
Requested Amount: $50,000

Description of Project: Colorado's Dam Safety Rules require owners of high and significant hazard dams to prepare and maintain an Emergency Action Plan (EAP). A key component of the EAP is an inundation map which shows the calculated extends of the flood wave that would occur in the event the dam were to fail. Beginning in 2010, Colorado established the Inundation Mapping Grant Program with a significant portion of its FEMA National Dam Safety Program grant money to assist owners of high and significant hazard dams in updating inadequate inundation mapping. A typical grant provides a 50% cost share with the dam owner. To ensure the mapping products are consistent, a guideline and sample scope of work is provided to the dam owner which outlines the minimum requirements of the Rules for use in selecting a qualified engineer to complete the project.

Project Manager(s): Jonathan Hernandez

Program: Water Project Loan Program

Purpose: Provide additional funding to continue the current Dam Safety Branch inundation mapping grant program that has been in place since 2010.

Funding Available: July 1, 2015 – June 30, 2016

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**Severance Tax Operational Fund**

**Proposed Project for Fiscal Year 2015 – 2016**

**Project No. 8**

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Applicant: Linda Bassi, Stream & Lake Protection Chief

Project Title: Case Management and Litigation Support

Recommended Amount: $65,000
Requested Amount: $65,000

Description of Project: Hire temporary paralegal staff (two positions, each limited to 9 months) to assist the Section with instream flow water rights case management, including organizing and imaging case files, tracking court deadlines, prioritizing case review, and drafting pleadings, memos, correspondence and other documents as appropriate.

Project Manager(s): Linda Bassi/Jeff Baessler/Kaylea White

Program: Instream Flow and Natural Lake Level Program

Purpose: Provide adequate staffing for legal protection of the State's ISF water rights until such time that a decision item can be obtained to fulfill this ongoing need.

Funding Available: July 1, 2015 – June 30, 2016

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**Severance Tax Operational Fund**

**Proposed Project for Fiscal Year 2015 – 2016**

**Project No. 9**

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| | |
|---|---|
| Applicant: | Linda Bassi, Stream & Lake Protection Chief |
| Project Title: | Stream and Lake Protection Section Outreach and Education |
| Recommended Amount: | $10,000 |
| Requested Amount: | $10,000 |

Description of Project: In most years, the Stream and Lake Protection section has budgeted between $12,000 and $16,000 to fund operating expenses such as travel, telecomm, printing, equipment, official functions, and conference registrations. However, those funds have been supplemented in most years by the section's severance tax operational account outreach and education project, which has been historically funded at $15,000.

The section's operating costs can vary significantly from year to year depending on the amount of outreach activities that are required to address issues associated with new appropriations, acquisitions, legal protection and involvement in the basin roundtable process regarding non-consumptive uses. It is estimated that $10,000 of supplemental funding will be required to address travel costs for outreach activities associated with basin roundtable meetings and with multiple new appropriation recommendations, some of which will be located in the southwest corner of the state, necessitating longer trips and associated expenses.

| | |
|---|---|
| Project Manager(s): | Linda Bassi/Jeff Baessler |
| Program: | Instream Flow and Natural Lake Level Program |
| Purpose: | Supplemental funding for the Stream and Lake Protection Section's annual operating budget to address extended outreach and education needs. |
| Funding Available: | July 1, 2015 – June 30, 2016 |

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**Severance Tax Operational Fund**

**Proposed Project for Fiscal Year 2015 – 2016**

**Project No. 10**

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Applicant: Linda Bassi, Stream & Lake Protection Chief

Project Title: ISF Database Update

Recommended Amount: $150,000
Requested Amount: $150,000

Description of Project: To update and revise the CWCB's Instream Flow Database.

Project Manager(s): Rob Viehl / Carolyn Fritz

Program: Instream Flow Program and Decision Support Systems

Purpose: To update the Instream Flow Database to be compatible with current DNR software, and to repair and refine the database to make it more user friendly and compatible with other CWCB systems, such as the ISFDSS — a GIS based decision support system.

Funding Available: July 1, 2015 – June 30, 2016

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**Severance Tax Operational Fund**

**Proposed Project for Fiscal Year 2015 – 2016**

**Project No. 11**

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Applicant: Kevin Houck, Watershed & Flood Protection Chief

Project Title: Flood Mitigation and Project Compliance

Recommended Amount: $100,000
Requested Amount: $150,000

Description of Project: The CWCB has identified a substantial need for identification of deficiencies to flood mitigation projects throughout Colorado, a point vastly reinforced by the devastating floods of September 2013. Funds from this program will be used to develop solutions to bring these projects back into technical or regulatory compliance. In some cases, some financial assistance may be provided to smaller communities to perform required one-time maintenance activities for regulatory purposes provided that the local governments and other entities benefiting from the project expend as many local resources as available to perform the work. The focus of this work will be to address local requests as well as identification and design of projects that can be implemented or upgraded to reduce the flood risk. The best example of the use of these funds are the current nationwide focus on the condition of levees, which has already impacted some Colorado communities and is expected to impact many more in the coming years. Many of these levees and other flood control/mitigation projects are located in small or impoverished communities throughout the state that are in need of both technical and, in some cases, financial assistance. Other projects being considered include ongoing post-wildfire analysis and mitigation as well as a long overdue update to the Statewide Floodplain and Stormwater Criteria Manual, last updated in 2006. The CWCB staff is requesting this Severance Tax non-reimbursable investment to provide a means of cost-sharing with local entities and other agencies to accomplish the much needed work. Cost-sharing will be emphasized when practicable to leverage the severance tax dollars.

Project Manager(s): Kevin Houck

Program: Watershed and Flood Protection Program

Purpose: Mitigate flood hazards throughout the state by partnering with local governments in plans, studies, and minor flood projects.

Funding Available: July 1, 2015 – June 30, 2016

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**Severance Tax Operational Fund**

**Proposed Project for Fiscal Year 2015 – 2016**

**Project No. 12**

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Applicant: Kevin Houck, Watershed & Flood Protection Chief

Project Title: Community Assistance Program

Recommended Amount: $47,650
Requested Amount: $47,650

Description of Project: To administer the Community Assistance Program, a 75/25 partnership with FEMA for administration of the National Flood Insurance Program in Colorado.

Project Manager(s): Jamie Prochno

Program: Watershed and Flood Protection Program

Purpose: To provide technical and administrative assistance for communities in the state for administering floodplain regulations and other related issues. To assist communities in adopting updated floodplain management regulations, including the requirements promulgated in the Rules and Regulations for Floodplains in Colorado.

Funding Available: July 1, 2015 – June 30, 2016

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**Severance Tax Operational Fund**

**Proposed Project for Fiscal Year 2015 – 2016**

**Project No. 13**

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Applicant: Kevin Houck, Watershed & Flood Protection Chief

Project Title: Ehanced Snowpack Monitoring above Taylor Reservoir

Recommended Amount: $73,000
Requested Amount: $73,000

Description of Project: This is a collaboration between the NRCS Snow Survey Program, National Center for Atmospheric Reseaarch, locals, and the CWCB. This is a demonstration project where we will moderninze and upgrade the snow data collection network in the Taylor River basin to improve the data used for water supply forecasts. We will add sensors to the Upper Taylor and Park Cone SNOTELs, (solar radiation, soil moisture, and relative humidity) which affect snowpack accumulation and ablation and therefore streamflow runoff. The budget is attached and we are only requesting half of the total project cost of $146,000. The rest must come from other sources. A similar project was completed in the Conejos Basin by the CWCB and NCAR. There, a remote drainage was outfitted to have information where there was none. The project upgrades two SNOTEL and adds five new "SNOTEL lites." NCAR will help loan additional eqiupoment for one season help with installs and maintenance and analyze new data with SNODAS and WRF-Hydro.

Project Manager(s): Joe Busto – CWCB / Brian Demonkos – NRCS / Dave Gochis - NCAR

Program: Watershed and Flood Protection Program

Purpose: Since 80% of our water is snowpack that is under represented and makes it difficult to forecast water supplies. Errors in water forecasts impact reservoir fill spill, equitable apportionment, recreation releases, instream flows, endagered species, and interstate compact programs. It is beneficial to upgrade exisitng federal snow data networks. Older conceptualized operational models are on the way out in favor of detailed physics based modeling. This is being settled at a national level now. More quality data is needed to feed these new modeling frameworks and out perform traditional methods. Given shrinking federal budgets partnerships are needed for more spatially distributed snow data to result in a more accurate water supply forecast. The NRCS will provide about $34,000 inkind through staff time in this demonstration project.

Funding Available: July 1, 2015 – June 30, 2016

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**Severance Tax Operational Fund**

**Proposed Project for Fiscal Year 2015 – 2016**

**Project No. 14**

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Applicant: Center for Snow and Avalanche Studies

Project Title: Colorado Dust on Snow Program

Recommended Amount: $25,000
Requested Amount: $40,000

Description of Project: The Center for Snow and Avalanche Studies serves the mountain system science community and regional land and water managers by conducting comprehensive weather, snowpack, hydrology, soils, and plant community monitoring at multiple study plots within the Senator Beck Basin Study Area at Red Mountain Pass, by monitoring and reporting on dust-on-snow conditions there and at ten additional locations throughout the Colorado mountains, and by hosting and conducting interdisciplinary research investigating processes affecting the ecological services provided by mountain systems, most notably water supplies.

Project Manager(s): Joe Busto

Program: Watershed and Flood Protection Program

Purpose: CODOS is designed to monitor hydrologic and ecologic conditions, including dust-on-snow. The program provides operationally useful snowmelt behavior information to stakeholders and supports snow hydrology and climate change research. Recent years have highlighted the vulnerability of Colorado's snow-based water supplies to extreme variability in precipitation and drought, and to the increasingly 'constant' influence of dust-on-snow. Forest health and other watershed-scale, climate driven changes in hydrology are creating additional uncertainty in current and future water supplies.

Funding Available: July 1, 2015 – June 30, 2016

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**Severance Tax Operational Fund**

**Proposed Project for Fiscal Year 2015 – 2016**

**Project No. 15**

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Applicant: Department of Agriculture – State Conservation Board

Project Title: Kiowa Creek Watershed Flood Control Dam Maintenance Program

Recommended Amount: $25,000
Requested Amount: $75,000

Description of Project: A comprehensive needs assessment has been completed and 31 of the 65 dams in this project are identified as needing maintenance or rehabilitation in the near future. The average cost per dam has been estimated to be about $10,000. The sponsor, Kiowa Conservation District (KCD), has encountered numerous financial challenges as they have attempted to meet their maintenance responsibility over the last 20 years. The total project cost estimate is $762,100, but this demonstration program will utilize the amount requested to establish project protocols and processes by performing 3-7 of these identified projects in the funding period. If successful, the applicant proposes to phase the remainder of the project over a ten year period. The Dept. of Agriculture will contract with the KCD to implement the project using the pass-through grant funding model established by the DWR Dam Safety Branch for their highly successful inundation mapping grant program.. Their attached grant application guidance document will be modified to be applicable to KCD and their potential maintenance and repair contractors. The NRCS will contribute engineering planning/design and project oversight. KCD will administer the procurement process.

Project Manager(s): Chris Sturm

Program: Watershed and Flood Protection Program

Purpose: To fund annual maintenance and repairs on existing watershed protection and flood control dams in the Kiowa Conservation District area of responsibility.

Funding Available: July 1, 2015 – June 30, 2016

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**Severance Tax Operational Fund**

**Proposed Project for Fiscal Year 2015 – 2016**

**Project No. 16**

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Applicant: Tom Browning, Deputy Director, Integrated Water Resources

Project Title: Lean Program Support

Recommended Amount: $10,000
Requested Amount: $20,000

Description of Project: To administer CWCB's efforts related to the DNR Lean Program that is geared towards streamlined operations for the benefit of the agency and its customers.

Project Manager(s): Tom Browning

Program: CWCB Lean Program

Purpose: To provide training and support services related to Lean initatives and events. This would have agency-wide and statewide benefits for improved operations, and would help to support the goals and metrics of the Department.

Funding Available: July 1, 2015 – June 30, 2016

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John Hickenlooper, Governor

Mike King, DNR Executive Director

James Eklund, CWCB Director

**Severance Tax Operational Fund**

**Proposed Project for Fiscal Year 2015 – 2016**

**Project No. 17**

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Applicant: James Eklund, CWCB Director

Project Title: Water Planning and Operational Needs

Recommended Amount: $115,420
Requested Amount: $125,000

Description of Project: CWCB needs funding to meet immediate needs for water planning. CWCB is implementing a number of water planning efforts since the inception of the Statewide Water Supply Initiative and has the responsibility to address other water planning needs that emerge during the fiscal year, but for which no other funding source is available. These funds will also be used to supplement any operational needs of the Water Supply Planning Section.

Project Manager(s): James Eklund / Tim Feehan / Tom Browning

Program: Water Supply Planning Program

Purpose: To provide funding for water planning efforts and associated operational expenses not covered by any other funding. Without these funds, immediate cooperative efforts needed may be delayed or postponed.

Funding Available: July 1, 2015 – June 30, 2016

One World One Water Center
MSU Denver
CWCB Severance Tax - Potential Funding
January 26, 2015

1) Organize and host a Watershed Summit in Denver in January, February or March 2016 (this is a continuation of the Water Stewardship Conference held in Longmont, Colorado, on January 21, 2015, and sponsored by the City & County of Boulder). Sponsors would be the One World One Water Center at MSU Denver, City of Boulder Water Conservation Department, and Denver Water. Aurora Water, Colorado Springs Utilities and other groups would also be invited to be sponsors. A $10,000 grant has been verbally approved by the City of Boulder, and a similar amount is anticipated from Denver Water. Conservation groups would also be invited to participate. Approximately 250-400 attendees – *please see attachment for additional details.*

   CWCB funding request - $10,000
   Funding Approved - $10,000

2) Provide release time for MSU Denver faculty to work with the Englewood Public Schools STEM project K-12 teachers utilizing the South Platte River as a teaching tool. Focus would be on in-school and in-home water use, potential for conservation, and assessment of program effectiveness as it relates to water conservation and the value of water in the schools. The project would also include a Project WET (Water Education for Teachers) curriculum planning workshop for 20 teachers. MSU Denver Teacher Education faculty and Pre-Service teachers would help Englewood Public Schools teachers implement hands-on activities of the STEM project related to the South Platte River. *Please see attachment for more details regarding the project.*

   CWCB funding request- $15,000
   Funding Approved - $15,000

**Project No. 19**

**Andales: Lysimeter**

**PROJECT TITLE: Determination of Consumptive Water Use of Winter Wheat in the Arkansas Valley**

**PRINCIPAL INVESTIGATORS:**

Dr. Allan A. Andales, Associate Professor of Irrigation and Water Science; Department of Soil and Crop Sciences, Colorado State University; Tel. (970) 491-6516;
Email: Allan.Andales@colostate.edu

Dr. Michael E. Bartolo, Research Scientist; CSU-Arkansas Valley Research Center, Rocky Ford, CO;
Tel. (719) 254-6312; Email: Michael.Bartolo@colostate.edu

Mr. Lane Simmons, Research Associate; CSU-Arkansas Valley Research Center; Rocky Ford, CO;
Tel. (719) 254-6312; Email: Lane.Simmons@colostate.edu

**LOCATION WHERE THE WORK IS TO BE CONDUCTED:** This project will be conducted at the Colorado State University (CSU) – Arkansas Valley Research Center (AVRC), Rocky Ford, CO.

**PURPOSE OF THE RESEARCH**

This proposal addresses priority research topic #5: "Develop new crop water use information for Colorado". One of the recommendations that came out of the Kansas v. Colorado Arkansas River Compact litigation is for Colorado to use the American Society of Civil Engineers (ASCE) Standardized Penman-Monteith equation (PME) to estimate crop evapotranspiration (ET) in the Arkansas River Basin. This equation requires accurate measurements of hourly weather data (solar radiation, air temperature, humidity, and wind speed) to calculate a reference crop ET ($ET_r$), which is a measure of local atmospheric demand for water. Crop ET ($ET_c$) is then calculated by multiplying $ET_r$ by a crop coefficient ($K_c$) that varies with crop growth and development. This project will continue the long-term research to date, to more accurately calculate the $ET_c$ of major irrigated crops in the basin, by defining the crop coefficients ($K_c$) used to convert $ET_r$ to $ET_c$ values and by validating (ground-truthing) the $ET_r$ values calculated by the ASCE-PME for local conditions in the Arkansas River Basin. After alfalfa hay and corn, winter wheat is the next dominant irrigated crop in the basin and a localized $K_c$ curve for it has not been developed. Therefore, a full growing season (2015-2016) of winter wheat $ET_c$ data will be collected using the large (crop) lysimeter. The more accurate calculations of $ET_c$ will ultimately improve the estimates of river flow that are used to determine compliance with the Arkansas River Compact. Related to this, accurate hourly weather data from 12 automatic weather stations in the basin are continuously needed to calculate $ET_r$ and $ET_c$ for the entire basin. These weather stations are part of the Colorado Agricultural Meteorological Network (CoAgMet). This

work will also capitalize on the progress to date in validating calculated $ET_r$ from ASCE-PME with measured alfalfa $ET_r$ from the reference (small) lysimeter.

## OBJECTIVES and METHODS

1. Develop a seasonal crop coefficient curve for winter wheat that accounts for local environmental conditions in the Arkansas basin.
2. Assess the impact of local weather and soil conditions on the $ET_c$ of winter wheat at various growth phases of the crop.

The objectives will be achieved in close collaboration with engineers in the Colorado Division of Water Resources (CDWR). Oats will be planted on the large lysimeter in spring 2015 as a transition crop, after which winter wheat will be planted in fall 2015. Winter wheat $ET_c$ from the large lysimeter and alfalfa $ET_c$ from the reference lysimeter will be calculated by mass balance (from automated weighing scale readings) and aggregated to 5-minute, 15-minute, and hourly totals. Lane Simmons (Research Associate) will manage the daily operations, crop management, maintenance, and data quality control of the 2 lysimeters. The following will be the major deliverables of the project: (1) Seasonal crop coefficient curve that characterizes winter wheat $ET_c$ (2015-2016 growing season) at different developmental phases; and is appropriate for local conditions in the Arkansas Basin; (2) Observed seasonal consumptive water use ($ET_c$) of winter wheat (2015-2016); (3) Accurate hourly weather data from 12 CoAgMet stations in the basin, made available through the CoAgMet online database; (4) One technical report published by the Colorado Water Institute detailing the methods and findings of the CSU research team. A draft of the report shall be provided to CDWR and CWCB by October 15, 2016.

This project will be conducted from July 1, 2015 to June 30, 2016.

## BUDGET AND JUSTIFICATION

This agreement is for a maximum of $49,632 budgeted as follows.

| | |
|---|---|
| Salary (one research associate; $5367/mo x 6.4 mo) | $34,347 |
| Fringe benefits (@ 25.65%) | $ 8,811 |
| Subtotal | $43,158 |
| Indirect cost (@ 15%) | $ 6,474 |
| Total | $49,632 |

These funds will pay for 6.4 months of work by one full-time research associate (Lane Simmons), who will manage the day-to-day operation of the lysimeters, take all measurements, and process the data.

## *River Change and Flood Hazards on the Colorado Front Range*

Brian Bledsoe, Professor (brian.bledsoe@colostate.edu) & Joel Sholtes, PhD Candidate
Department of Civil and Environmental Engineering, Colorado State University

**Location:** Big Thompson & St. Vrain Basins. Tools, methodology applicable statewide.

**Research Purpose:** Nationally, nearly 25% of flood insurance claims come from areas outside of the 100 yr floodplain[1]. Flood-related impacts outside of the 100 yr floodplain were observed throughout the Colorado Front Range in spite of many September 2013 peak discharge estimates having magnitudes less than or equal to the 100 yr flood[1,2]. Observations of river change and the extent of flooding along the St. Vrain River near Lyons and Longmont, for example, demonstrate that dynamic river processes (river change) played an important role. River avulsion (channel acquiring a new route), erosion, and deposition processes during a flood all change the boundaries of the river and the floodplain leading to unexpected and unmitigated flood impacts. As recognized by Congress and FEMA in the 1994 National Flood Insurance Reform Act, ignoring river change during floods may in some cases underestimate hazards in the floodplain[3]. Existing methods for determining risk of river change are labor intensive and rely on historical aerial photograph coverage[4], largely lacking in Colorado, or are based on simplifications of geomorphic processes[5]. We propose to develop new methods to characterize the magnitude and frequency of river change within a river and floodplain corridor using information on flood hydraulics coupled with channel and floodplain geomorphic setting. Using available data in a GIS environment, this study will identify zones within a watershed that are more susceptible to change, and ultimately lead to planning tools and guidance tailored to the floodplain planning and management needs of state and local governments. It will compliment the “Channel Migration Zone” (CMZ) mapping effort underway for the 2013 flood response and watershed master plans.

**Objectives & Methods:** We hypothesize that two mechanisms working at different scales drive river change during floods: (1) excess stream power interacting with river bed and banks at the local scale, and (2) changes in down valley stream power due to breaks in slope and geomorphic context (valley width) at the river segment or watershed scale (e.g., canyon to prairie transition). The physical processes leading to river change at a given point are complex and chaotic; however, statistical models informed by physical measurements of flood impacts (bank retreat), hydraulic metrics (stream power), and geomorphic channel and valley classification have proven useful in identifying areas susceptible to river change[6,7,8]. Our objectives and methods are as follows: (1) Characterize the relationship between the magnitude of river change and the magnitude and frequency of the September 2013 flood event that caused it within each geomorphic class (valley width, slope, and river type). (2) Create multivariate logistic regression models that relate flood peak, stream power, and geomorphic class to the probability, type (e.g., lateral erosion, deposition, or avulsion), and severity of river change throughout a watershed. To our knowledge, a probabilistic approach to river change in the context of flood hazards has not previously been proposed. This objective will also provide an understanding of the qualitative relationships between the geomorphic setting of the river and floodplain to the risk and type of river change as

guidance for river corridor planning. (3) Map reach-scale probability of river change based on our findings as case studies of the method. We propose the following tasks:

*Task 1:* *Stakeholder Meetings* (Month 1): Insight and feedback from local and state floodplain managers is essential to inform the format and scale of the results from this study and ensure their usefulness for planning needs. We will conduct stakeholder meetings up front to understand managers' experience with river change and its impacts on flooding within their districts. We will explore their level of interest, needs, and capabilities regarding the use of proposed guidance and maps to aid in floodplain management. Outcomes: Better informed framework and deliverables.

*Task 2:* *Data acquisition* (Month 1): This study will incorporate pre- and post- September 2013 flood aerial photography, river surveys, and digital elevation models (DEMs) to characterize pre- and post- flood river form; occurrence, type, and extent of river change; classify river and valley geomorphic type; and, calculate stream power throughout selected watersheds. An attempt will be made to obtain historic flood extent and river change data as well. These spatial data will be used in conjunction with flood peak and duration data from USGS gages and state sources of peak discharges.

*Task 3:* *Data Analysis & Field Verification* (Months 2-8): Three main types of analyses are to be conducted along selected river segments within the study watersheds: 1) river and valley geomorphic classification, 2) river network stream power estimation using GIS models, and 3) magnitude and associated frequency of river change. These data will be used in qualitative and multivariate statistical models to aid in predicting the type and severity of river change. The location and degree of river change will be mapped and then related to estimates and return intervals of flood peaks. Some limited fieldwork will be needed to verify GIS assessments of river change, geomorphic classification, and determine extent of engineered limitations to river change. We will calibrate this model with data collected from headwaters to main stem reaches in the Big Thompson and St. Vrain watersheds, and validate it on reaches not used for calibration to test its robustness and transferability. Outcomes: River change driving and response variable GIS database, statistical and qualitative models.

*Task 4:* *Report Results & Guidance Development* (Months 9-12): We will tailor our technical report and guidance document to state and local end users. This guidance document will focus on the qualitative relationship between river change and river and valley geomorphic type, and provide case study maps of river change risk. We will coordinate developing this document with the ongoing state-level CMZ delineation effort so that it complements the methods and guidance developed therein. We will pursue peer-reviewed publication of findings and regional presentation opportunities. Outcomes: Guidance Document for River Change Hazard Assessment in the Floodplain

**Budget Justification**

| Category | Quantity | Budget |
|---|---|---|
| Principal Investigator, Faculty | 0.5 mos. | $ 8,750 |
| Graduate Researcher | 6.5 mos. | $ 34,000 |
| Travel (Stakeholder Mtgs, Field Validation) | ~ 1,000 miles | $ 600 |
| Facilities and Administrative @ 15% | | $ 6,503 |
| **Total** | | $ 49,853 |

## References

[1] Gease, M. FEMA natural hazards specialist, quoted in Walker, R. (2014). Coming Home, a Calculation of Risk, Reward and Restitution in Flood Zones. Headwaters. Colorado Foundation for Water Education. p 23-27.

[2] Houck, K (2014). CDOT/CWCB Hydrology Investigation, Phase One – 2013 Flood Peak Flow Determinations. CWCB Watershed and Flood Protection Section, 8p.

[3] National Flood Insurance Reform Act (1994). 42 U.S.C. § 577

[4] State of Washington, Department of Ecology. Channel Migration Assessment Program. http://www.ecy.wa.gov/programs/sea/sma/cma/index.html. Accessed October 8, 2014.

[5] Kline, M. and K. Dolan (2008).Vermont Agency of Natural Resources River Corridor Protection Guide. Fluvial Geomorphic-Based Methodology to Reduce Flood Hazards and Protect Water Quality. Vermont Agency of Natural Resources River Management Program. 25p.

[6] Bledsoe, B. P., & Watson, C. C. (2001). Logistic analysis of channel pattern thresholds: meandering, braiding, and incising. Geomorphology, 38(3), 281-300.

[7] Bizzi, S., & Lerner, D. N. (2013). The use of stream power as an indicator of channel sensitivity to erosion and deposition processes. *River Research and Applications*.

[8] Buraas, E. M., Renshaw, C. E., Magilligan, F. J., & Dade, W. B. (2014). Impact of reach geometry on stream channel sensitivity to extreme floods. *Earth Surface Processes and Landforms*.

**Title:** Using remote sensing assessments to document historical and current saved consumptive use (CU) on alfalfa and grass hayfields managed under reduced and full irrigation regimes: A new CU documentation system

**Principal Investigator:** Perry E. Cabot, Research Scientist, Colorado Water Institute and CSU Extension, Colorado State University,
**Email:** perry.cabot@colostate.edu

**Location of research:** Mesa, Delta, Montrose and Gunnison Counties

## Purpose of the research

This project will address the research priority focused on developing new crop water use information for Colorado, by using remote sensing (RS) assessments of evapotranspiration (ET) rates in the Grand Valley and Uncompaghre River watershed. The proposed research will integrate with current field studies funded through the Colorado Water Conservation Board (CWCB) aimed at evaluating the water bank concept, which would work with agricultural water users to implement voluntary, compensated, interruptible supply agreements, thereby making water available on a temporary basis to address either Lake Powell or Colorado River Compact issues. Research ongoing on the Western Slope is aimed at measuring water balances on alfalfa and grass hayfields, for the purpose of calculating the saved consumptive use (CU) water achievable through reduced irrigation. Partial-season irrigation (also referred to as “split-season” irrigation) is the primary practice under evaluation. Funding has already been sought and is likely to be secured for the field instrumentation systems that will locally measure water balances. A water bank will require broad administration, however, in order to monitor the amount of saved CU from irrigation reductions on within a geographically diffuse array of individual fields. The proposed research is also congruent with numerous recommendations set forth in the URS (2013) report entitled *Assessing Agricultural Consumptive Use in the Upper Colorado River Basin*, pertaining to investigating “alternate methods for estimating actual CU where diversion records do not exist, specifically remote sensing data methods.”

## Objectives, methods, timeline, completion date

*Objectives*. Towards the goal of developing a broad administrative approach for assessing water conservation, the proposed project will: 1) compare RS estimates of crop consumptive use against crop water budgets measured on alfalfa and grass hay/pasture managed by partial-season irrigation; 2) apply ET estimation models to archived imagery (estimated to exist for the past 20-25 years) to estimate historic CU on alfalfa and grass hay/pasture, in particular for fields at higher elevations, and; 3) compare modeled RS estimates of crop ET against CU estimates derived from measured diversion records, akin to methodology currently used in Colorado.

*Methods*. Partial-season irrigation regimes for grass pasture and alfalfa fields are being established at several Western Slope research sites to monitor multiple seasons of actual crop water use (ETa). The sites consist of plots ranging from 10-30 acres and are comprised of reference fields and additional fields where irrigation reductions will be imposed under the assistance of farmer-cooperators. Digital satellite imagery and RS (ERDAS Imagine Version 2014; 16-day frequency LANDSAT 8 and/or ASTER) will be used to estimate CU and ETa rates from reference versus treatment fields. Spatial and temporal calculation of ETa will couple peer-reviewed ET models (RESET; METRIC)

ground-based soil water budgets. Additional CU comparisons will be made against baseline information from predicted values, historical assessments, and past records. Thermal band data will be "sharpened" to a higher spatial resolution by applying appropriate algorithms to correlate physical relationships between surface temperature and vegetative cover, using the higher resolution visible and near-infrared band data. Because temporal resolution of multispectral satellite images is too coarse (e.g., every 16 days for LANDSAT 8, or less if clouds are present in the scene) to estimate daily crop ET, this project will integrate the small unmanned aircraft system (sUAS) research currently funded through CWI to further intensify the spatial resolution of the ET model.

A graduate research assistant (GRA) will be employed to conduct the operational aspects of the research. The GRA will be supervised jointly by Dr. Cabot (PI) and Prof. Chávez. Dr. Cabot will take the lead on supervising research activities on the project sites and Prof. Chávez will direct the GRA in remote sensing, ET modeling methods and sUAS techniques. The GRA will be expected to relocate to Grand Junction during the summer 2015, where is provided at the CSU Agricultural Experiment Station. The different research locations are: a) furrow-irrigated alfalfa fields managed by a producer in the Grand Valley Water Users Association near Loma, CO; b) furrow-irrigated alfalfa fields managed by a producer in the Uncompaghre Valley Water Users Association near Delta, CO; c) flood-irrigated irrigated pasture fields managed by the Western Rivers Conservancy near Cimarron, CO. On each of these fields, it is expected that CWCB funding for in-field monitoring will be available under the CWCB water bank research. Additional assistance will be procured through AMEC consultants (funded by the Water Bank Workgroup) to gather historic data on diversion records for the study areas.

*Timeline and Completion Date.* It is proposed to start the project on 07/1/2015 and be completed by 06/30/2015. May/June: recruitment of GRA; July/August/September: data acquisition and analysis of field water budget data; October, November: ET model development, evaluation, comparison with historic records; December, January, February: research article production; March/April/May/June 2015: additional monitoring; June 2015: reporting to CWI.

**Budget**

| *Description* | *Salary* | *Fringe* | *Total* |
|---|---|---|---|
| GRA | $21,600 | $1,073 | $22,673 |
| Academic Faculty | $2,650 | $613 | $3,263 |
| In-State Tuition for GRA: | | | $9,075 |
| Travel Costs: | | | $2,517 |
| Equipment (UAV battery pack, software license, computing hardware): | | | $5,950 |
| TOTAL DIRECT COSTS: | | | $43,478 |
| Facilities & Administrative: 15% TDC: | | | $6,522 |
| **TOTAL Project Request:** | | | **$50,000** |

**Budget Justification.** Funds are requested to: a) cover the salary/fringe ($22,673) of a graduate research assistant for 12 months; b) pay for in-state tuition credits ($9,075); c) cover salary/fringe for collaborator Chávez ¼-summer salary/fringe ($3,323); d) funding to support UAV flights, software/hardware to develop crop CU/ET ($6,600); e) travel ($2,517), and; IDC ($6,522). Total amount requested is $50,000 for one year.

**1. Title**: Evaluating the Time Series Discontinuity of the NRCS Snow Telemetry (SNOTEL) Temperature Data across Colorado

**2. Principal Investigator**: Steven R. Fassnacht, Professor of Watershed Science, Department of Ecosystem Science and Sustainability, Colorado State University, Fort Collins, <Steven.Fassnacht@colostate.edu>

**3. Location**: Fort Collins and some mountain areas in Colorado (NRCS SNOTEL stations)

**4. Purpose of the research**: Several recent studies (e.g., Clow, 2010; Harpold *et al*., 2012) have illustrated a very strong rate of warming in the mountains of Colorado based on trends from SNOTEL stations. For example, Clow (2010) found warming in January and July of 10 to 20 degrees per century at these sites since the 1990s. However, the temperature sensors have been moved at all the sites in the mid-2000s. Preliminary results show that there is a discontinuity in the temperature time series (e.g., Figure 1). As many water resources managers are beginning to use climate change information in their future planning, it is crucial to have a homogeneous time series of temperature data for higher elevation locations across Colorado. Such a dataset would also be useful for research, including hydrologic and climate modeling.

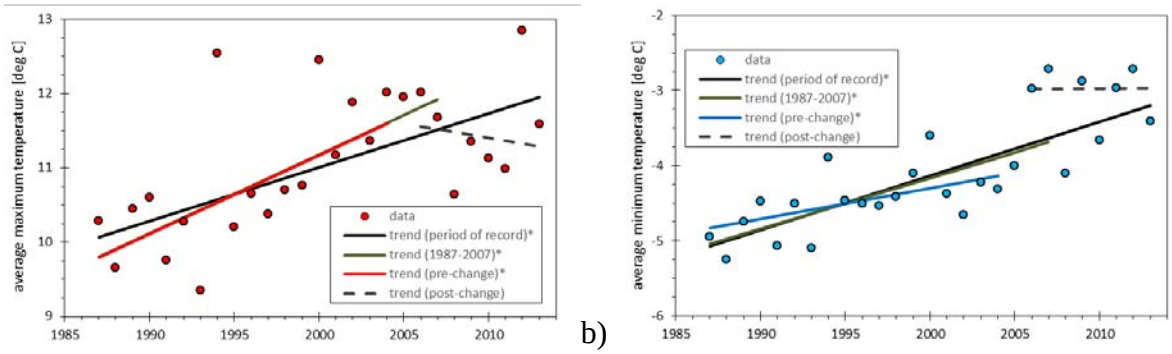


*Figure 1*. Trends in the mean annual a) maximum and b) minimum temperature time series for four time periods at the Stillwater Creek SNOTEL station in Northern Colorado. Significant trends at the 5% confidence level are shown with solid line, while non-significant trends are shown with a dashed line.

**5A. Objectives**: The objectives of the proposed work are as follows: 1) assess the continuity of the daily maximum, average and minimum temperature time series, 2) correct the heterogeneity of the time series, and 3) determine the temperatures trends from the corrected datasets.

**5B. Methods**:

Most of the investigation will focus on analyzing the daily time series of daily maximum, average and minimum temperature at each station. All the data will be quality controlled (QC) to identify and flag erroneous measurements and other anomalies. The metadata will be used for each station to identify the data of initial installation and any changes to the temperature sensor. Trend significance (Mann-Kendall test; Gilbert, 1987), rate of change (Sen's slope; Gilbert, 1987), and a change point analysis (Pettitt, 1979) will be performed.

The NRCS Lakewood Snow Survey field office is taking hemispherical photographs above each snow pillow, and we have requested that photographs also be taken above each

instrumentation hut. We will evaluate difference among these photographs to assess station (sensor) exposure (Fall *et al*., 2011). In consultation with the NRCS Lakewood office, stand-alone temperature sensors will be installed around several SNOTEL stations.

Where necessary and possible, the SNOTEL temperature time series will be adjusted; any adjustment will likely be performed to the pre-change time series as data will continued to be collected at the current, post-change position. Trend analysis will be performed on the new time series.

**5C. Timeline**:
*Time Series Analysis* – January 2015 through August 2015 (data and metadata retrieval and archiving, trend and change point analysis)
*Field Evaluation* – May 2015 through August 2016 (photograph analysis, stand-alone temperature sensor installation, data retrieval and processing)
*Time Series Evaluation* – May 2015 through October 2016 (time series adjustment, dataset archiving through CSU libraries and possibly NRCS, revised trend analysis)
*Final Reporting* – May 2016 through December 2016 (create revised time series metadata, write final report, write and submit journal manuscript)

**5D. Completion Date**: We anticipate this project being completed by the end of 2016.

**6-7. Budget and Justification**: TOTAL of $40,000
An undergraduate student (Amanda Weber) will perform most of the work, under the supervision of the principal investigator. Weber will be paid at a rate of $10 per hour for 20 hours per week for three semesters (spring 2015, fall 2015, spring 2016: $10,800), and for 40 hours per week for two summers (2015 and 2016: $9,600). The fringe at 1% is $204. PI Fassnacht will be paid for ½ month summer salary for each summer (2015 and 2016: $9,410) including fringe at 27.3% ($2,569). Travel expenses for additional sensor installation will be approximately 250 miles for 10 trips at $0.50 per mile. Twelve I-buttons and 24 funnels sensors will be purchased for $500. Various other miscellaneous supplies will also be purchased for $450, including batteries. The direct cost is $34,783, and an indirect cost of 15% is included on this proposal ($5,217).

Pre-Proposal to Colorado Water Institute FY2015 Water Research Program
**Title: Data Collection and Analysis in Support of Improved Water Management in the Arkansas River Basin, Phase 2**
**Principal Investigator:** T. K. Gates, Prof. (tkg@engr.colostate.edu), **Co-Principal Investigator**: Jeffrey D. Niemann, Assoc. Prof.; *Civil and Environ. Engrg. Dept., CSU*

**Location:** Arkansas River Basin, Colorado

**Purpose of the Research:** The Arkansas River, drawing from Colorado's largest watershed (more than 28,000 $mi^2$), serves as a vital part of the State's water resource system. In the years to come, important decisions, including long-term investments in infrastructure and amended management practices, will need to be made in Colorado's Arkansas River Basin to enhance overall beneficial water use, redress serious problems of water quality degradation (e.g., salinity, selenium, uranium, and nutrients), conserve water, and find innovative ways (e.g., the Super Ditch) to address mounting pressures for increased diversions out of the Basin.

A reliable database is needed to allow characterization of the Basin's stream-aquifer system and to undergird both existing and future modeling tools, including the proposed Arkansas Basin Decision Support System (Ark DSS). Data on both surface and subsurface waters are needed in both the mountainous Upper Arkansas River Basin (UARB), above Pueblo Reservoir, and in the agriculturally-intensive Lower Arkansas River Basin (LARB). For over 15 years in the LARB and 3.5 years in the UARB, Colorado State University (CSU) has conducted extensive field monitoring to build such a database. *The project proposed herein constitutes the second phase of an on-going CWI FY2014 project (Phase 1). The purpose is to collect and analyze key field data in representative regions of the Arkansas River Basin needed to maintain and enhance a database in support of improved water management. Thereby, the project will prevent interruption of long-term data collection efforts.*

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

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

**Methods:** The cooperation of about 150 landowners with CSU provides access to sampling sites for water and related characteristics in the UARB and LARB. *Availability of these sites provides valuable in-kind matching support for this proposed project.* Data on groundwater and surface water quantity and quality have been gathered at numerous locations in Phase 1 in the UARB in July 2014 and in the LARB in August 2014 with additional sampling events planned for November 2014, January 2015, March

2015, and May 2015. In Phase 2, field data on water table depth and in-situ water quality parameters (electrical conductivity, temperature, pH, dissolved oxygen, and oxidation reduction potential) will continue to be gathered at about 20 existing groundwater monitoring wells in a study region in Chaffee County in the UARB and about 120 groundwater monitoring wells in two study regions within Otero, Bent, and Prowers Counties in the LARB. Three to four sampling events will be conducted in each of the three study regions. During two of the sampling events in both regions of the LARB, water samples will be extracted from a subset of about 50 wells and analyzed for major dissolved ions, nutrients, selenium, and uranium. Depending on water quality results from Phase 1, similar water samples may be taken from UARB wells during one sampling event. Water quality samples will be analyzed by EPA-approved laboratories. In-situ water quality parameters will be measured during the sampling events at about 24 surface-water sites in the UARB and at about 120 to 140 sites in the LARB. Flow rates will be measured at about 18 of the surface-water sampling sites in the UARB. Also, pressure transducers will be installed in stilling wells to monitor water level changes (hourly intervals) near flow-measurement locations within two or three key tributaries that are not equipped with permanent stream gauges.

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

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

**Timeline, & Completion Date:** Data collection under Phase 2 is planned to commence in July 2015. Two irrigation season sampling trips and one to two off-season trips are planned for each of the study regions in the UARB and LARB. Data will be checked and entered into the database over the course of the one-year project. Final data analysis will commence on about 1 March 2016 and final report preparation will begin on about 15 June 2016. The project is scheduled for completion on 30 June 2016.

**Budget:** An estimated budget is summarized in Table 1.

Table 1. Estimated Budget ($) Project Budget (July 2015 – June 2016)

| | |
|---|---|
| **Salaries** | 17685 |
| **Travel** | 8893 |
| **Materials and Supplies** | 4000 |
| **Laboratory Analysis** | 12900 |
| **Indirect Costs (15%)** | 6522 |
| **TOTAL** | 50000 |

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

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

Dr. Ryan Bailey, Assistant Professor, Department of Civil and Environmental Engineering, Colorado State University

***Location of the Work***: South Platte River Basin, Colorado

***Background***: The surface watershed of the South Platte River Basin (SPRB) lies on alluvial deposits that form an unconfined aquifer system connected with the surface water, with a thickness that reaches 200 ft in the lower SPRB. The aquifer, which sustains the base flow in the river, is recharged by infiltrations from precipitation and irrigation canals, as well as seepage from surface water bodies and streams. The SPRB constitutes a major source of water for eastern Colorado and has allowed agricultural growth to approach 1 million acres of irrigated cropland. Conjunctive use of surface and groundwater resources in the SPRB is regulated accordingly with the 1969 Groundwater Administration Act (Senate Bill 81), which requires all non-exempt groundwater rights to come into priority. Prior to 2003, about 9,000 groundwater irrigation wells were active in the SPRB (Nettles, 2011) with augmentation requirements of 5-10% of their water consumptive use to protect surface water rights. Following legislative changes that occurred in 2003-2004, water resources have been administered following strict priority rules since 2006, with all non-exempt wells required to have a decreed augmentation plan that replaces 100% of their estimated stream depletion. As a consequence of the increased cost for acquiring augmentation water, about 4,000 wells have been totally or partially curtailed from pumping during the last 6 years (Nettles, 2011), potentially resulting in reduced aquifer drainage and rising water table levels in several areas of the SPRB.

***Purpose and Previous Results***: The overarching goal of this project is to provide the Colorado Water Conservation Board (CWCB) with an independent evaluation of the SPDSS groundwater flow model, highlighting model capabilities, strengths, and weaknesses. The original project was carried out over a three-year period, and focused on the following tasks:

- Analysis of model grid/time discretization to provide general guidelines regarding spatial and temporal scales for which the SPDSS model seems most suited as a water management tool;
- Analysis of hydrogeological parameter distributions used in the model (hydraulic conductivity, aquifer storage properties, streambed conductance);
- Analysis of representativeness of hydrological stress data used in the model with respect to the SPRB hydrogeology;
- Analysis of model robustness and stability with respect to applying realistic aquifer stresses;
- Analysis of the effects of increased stream augmentation by aquifer recharge, changes in aquifer pumping based upon realistic estimates of the reduction in groundwater withdrawal, and hypothetical drought conditions; and
- Using the SPDSS model to estimate effect of aquifer stresses on streamflow depletion, and comparing with results from analytical models (i.e. Glover model).

The latter task is the focus of the FY14 (Year 3) project. The SPDSS model and the Glover model are being used to simulate the effects of pumping and recharge on streamflow depletion/accretion, with the streamflow depletion factor (Jenkins, 1968) used as a comparison metric. Based on current results, more work is needed to explore the effects over a range of realistic pumping/recharge rates, the methods used to calculate aquifer parameter values for the Glover model, and the reasons for differences between the SPDSS model and the Glover model.

***Proposed Tasks for Year 4***: The proposed tasks of the project for fiscal year 2015 are:

1. Continue comparing model results with analytical models currently used to assess the impact of aquifer stresses (well pumping, stream augmentation) on stream behavior;
2. Compare model results with results from local, "daughter" models in 1-2 locations within the SPRB

For Task 1, methods used during Year 3 of the project will be continued to: (1) Use the SPDSS groundwater flow model to assess impacts of well pumping and recharge ponds on stream depletion for a range of pumping/recharge rates; (2) Compare results with the Glover analytical model; and (3) Investigate reasons for differences.

For Task 2, 1-2 local-scale "daughter" models will be created from the SPDSS model, with model results (i.e. water table elevation, groundwater discharge to the stream network) compared against results from the regional-scale model. This will provide an indication of the accuracy of the regional-scale model and how model results from the SPDSS groundwater flow model can be translated to local conditions. It is anticipated that two daughter models will be created, with possible areas including the Sterling and LaSalle/Gilcrest areas. However, only one daughter may be created and used depending on the time and effort required for grid refinement, model calibration, etc…

***Deliverables***: At the end of year (June 30, 2016), a final technical report describing project activities, analysis results, and findings will be submitted to CWCB. In addition, the PI will meet with CWCB representatives at least twice during the project duration, either at the CSU campus or at CWCB offices to best coordinate projects activities and discuss project progress and future direction.

***Completion Date***: This project will be completed by June 30, 2016. All deliverables will be provided to the CWCB on or before that date.

***Budget and Budget Justification***:

| | |
|---|---|
| 0.75 Month Faculty Salary[1] | $9,656 |
| 12 Month PhD half-time Salary[2] | $27,694 |
| 1 semester tuition and fees | $5,462 |
| Indirect Cost (15% rate) | $6,422 |
| Total Cost for Fiscal Year | $49,234 |

[1]Includes 25% fringe
[2]Inclues 5.5% fringe

In addition to the Project Principal Investigator, Dr. Ryan Bailey, one PhD student will be involved and financially supported in this study. PhD student salary includes $1,700/month during the semester and $3,500/month during the summer.

**TITLE: The ecological benefits of irrigated agriculture and potential risks under changing water allocation/supply**

**PRINCIPLE INVESTIGATORS:**
Dr. David Cooper – Senior Research Scientist/Professor – Department of Forest and Rangeland Stewardship – Colorado State University – David.Cooper@colostate.edu
Erick Carlson – PhD student – Department of Forest and Rangeland Stewardship – Colorado State University – Erick.Carlson@colostate.edu
**LOCATION**: Larimer and Weld County, CO
**PURPOSE OF THE RESEARCH:**
NEED: Diversion of water from streams has a major effect on that stream's flow regime including altering the magnitude and duration of flooding events. The water is typically not consumed at the point of diversion, but flows through a system of canals and ditches to its point of use. These constructed canals account for significantly more length of flowing water than the natural channels in regions with irrigated agriculture. The novel riparian and aquatic habitats that have developed in and along canals contribute significantly to regional biodiversity. While there have been numerous studies of how changing the hydrologic regime of streams alters the in-channel and riparian processes and biota, little is known about how the hydrologic regime of canal networks influences its processes and biota. Canals must be investigated using the same scientific approaches as have been used for natural streams. This will help us better understand how aquatic and riparian biota may respond to changes in the flow regime of canals.

In agricultural regions, canal water is used to irrigate crops, and irrigation tailwater and/or runoff have created many wetlands. The benefits provided by these wetlands should be included in all ecological analyses. Wetlands in agricultural landscapes are thought to function in nutrient removal, and the need to remove nitrate before it reaches aquifers is critical. Reducing irrigation could impact local groundwater levels, shrinking or eliminating wetland functions adjacent to crop fields. Thus, understanding the functioning of wetlands in agricultural landscapes for both canal biotic communities and their geochemical processes is important for land and water managers.
PURPOSE: Information on the characteristics of aquatic and riparian ecosystems, their similarity to natural channels and floodplains and their position on the landscape will help regional water planners and conservationists quantify the impacts of potential water transfers and shortages on these biota. Irrigation supported wetlands will also be investigated to identify the physical and biotic components of the agricultural field & wetland system that facilitate the transformation of nitrate into nontoxic nitrogen compounds.

**OBJECTIVES, METHODS, TIMELINE, AND COMPLETION DATE:**
Canal Network Analysis
*OBJECTIVES*: A GIS model will be created to assign ecological benefit measures to segments of the canal network of four irrigation canals companies based on previously collected field data. Riparian and aquatic habitats biodiversity would be impacted under altered canal flows.

*METHODS*: Mapping software (ArcGIS 10x) will be used to create a spatially explicit network of canals with riparian and aquatic characteristics and water right priority as independent attributes. A spatially explicit model will be used to produce risk maps under several scenarios of water transfers and drought.
*TIMELINE*:

| | |
|---|---|
| Fall 2014 | - Riparian and aquatic condition data analyzed |
| Spring 2015 | - Water transfer/shortage scenarios developed |
| Fall 2015 | - Final scenarios run including wetland nitrate data<br>- Final report compiled, findings presented to community |

Wetland Nitrate
*OBJECTIVES*: To identify site conditions that lead to the highest rates of nitrate transformation and nitrate uptake by plants. Three farmers agreed to participate in the research in 2014 which led to the development of 4 crop sites in Weld County with diverse physical characteristics, irrigation method, and wetland vegetation.
*METHODS*:
*Nitrate transformation*: Experiments at the sites will determine the rate of denitrification. This research will identify the limiting factors in denitrification in the wetland using field experiments and laboratory analyses.
*Plant uptake*: The annual above ground biomass will be sampled for nitrogen content at the end of the growing season to measure the amount of nitrogen stored in leaves and stems as a proxy for nitrate uptake.
*TIMELINE*:

| | |
|---|---|
| Fall 2014 | - Identify additional sites to sample |
| Spring 2015 | - Instrument sites, collect baseline data |
| Summer 2015 | - Conduct field and laboratory experiments |
| Fall 2015 | - Analyze results, present findings to community |

**Budget**

| **Estimated Cost Per Year ($)** | |
|---|---|
| Laboratory | 2,900 |
| Material and Supply | 500 |
| Equipment | 2,400 |
| PI Labor | 20,160 |
| Assistant Labor | 5,760 |
| **Total** | **31,720** |

**Budget Justification**
*Laboratory* costs include the processing of gas samples from field experiments measuring *in situ* denitrification. Other lab costs include analyzing soil samples for carbon and microbial biomass. *Materials and supplies* include piezometer and groundwater well items and soil incubation chambers. *Equipment* includes automatic groundwater sensors and a soil temperature/pH probe. *PI labor* supports the PhD student lead for 7 months full time (Apr.-Oct.). *Assistant labor* supports an upper level undergraduate for 4 months during the summer sampling season (May-Aug.).

COLORADO
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Department of Natural Resources

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John Hickenlooper, Governor

Mike King, DNR Executive Director

James Eklund, CWCB Director

**Severance Tax Operational Fund**

**Proposed Project for Fiscal Year 2015 – 2016**

**Project No. 26**

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Applicant: U.S. Geological Survey, Colorado Water Science Center

Project Title: Specific Yield Study of the Lost Creek Designated Ground Water Basin

Recommended Amount: $ 0
Requested Amount: $86,800

Description of Project: This is a specific yield study to estimate recharge and storage capacity in the Lost Creek Designated Ground Water Basin. The proposed study is planned as the first of several studies to address data gaps identified for the basin. This study would address basin-wide aquifer recharge and storage capacity by improving estimates of specific yield in the basin. Specific yield would be estimated at about 10 sites distributed across the basin by using a slim magnetic resonance imaging tool recently developed for use in small-diameter wells or boreholes. Because magnetic resonance imaging provides a water-content estimate of both bound and mobile water in saturated aquifer materials, specific yield can be estimated below the water table. As an added benefit, magnetic resonance imaging measurements also provide an estimation of hydraulic conductivity. Results of the study would provide useful information concerning the distribution of specific yield and hydraulic conductivity in the basin and complement plans by the Lost Creek Ground Water Management District to collect data that would improve understanding of the basin's water budget.

Project Manager(s): Andy Moore

Program: Water Information Program and Water Supply Planning Program

Purpose: The study contributes to understanding alluvial aquifers in a large geographic area with oil and gas development. Specifically, the study would provide data useful to groundwater management and the South Platte Decision Support System.

Funding Available: July 1, 2015 – June 30, 2016

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**Severance Tax Operational Fund**

**Proposed Project for Fiscal Year 2015 – 2016**

**Project No. 27**

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Applicant: Lost Creek Ground Water Management District

Project Title: Lost Creek Alluvial Aquifer Monitoring and Management Study

Recommended Amount: $ 0
Requested Amount: $50,000

Description of Project: A study to determine the feasibility of water storage in the Lost Creek Alluvial Aquifer.

Project Manager(s): Andy Moore

Program: Water Supply Planning Program

Purpose: The purpose is to better determine the historical water levels in the alluvial aquifer with the intention of developing a water budget, which is a necessary step to protect current users and allow for beneficial future uses of the aquifer.

Funding Available: July 1, 2015 – June 30, 2016

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**Severance Tax Operational Fund**

**Proposed Project for Fiscal Year 2015 – 2016**

**Project No. 28**

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Applicant: Open Water Foundation

Project Title: Enhance CDSS TSTool Software for CDSN and EPA Water Quality Data Web Services

Recommended Amount: $ 0
Requested Amount: $50,000

Description of Project: The project will enhance the CDSS TSTool software to include the ability to read water quality data from the Colorado Data Sharing Network (CDSN) and the EPA water quality web services, which will support engineering and planning studies performed by other organizations.

Project Manager(s): Steve Miller / Andy Moore

Program: Interstate, Federal, and Water Information Program

Purpose: The purpose is to leverage the available water quality web services, with proven TSTool software, in order to integrate water quality data access with other data types. Software would be developed for use by any organizations and have widespread impact in their work. The project will demonstrate application of the software in a variety of applications including flood areas, wildfire burn areas, urban areas, and agricultural areas.

Funding Available: July 1, 2015 – June 30, 2016

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**Severance Tax Operational Fund**

**Proposed Project for Fiscal Year 2015 – 2016**

**Project No. 29**

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| | |
|---|---|
| Applicant: | Colorado Watershed Assembly, on behalf of the Colorado Water Quality Monitoring Council |
| Project Title: | Colorado Data Sharing Network (CDSN) |
| Recommended Amount: | $ 0 |
| Requested Amount: | $90,971 |

Description of Project: The CDSN, which currently contains 11,104 monitoring locations, 127 projects, and over 3.3 million water quality results for 67 entities requested assistance to support their programs. CWCB funds would be used to educate users and to increase the amount of useful, managed and shared water quality data for the networks various users.

Project Manager(s): Andy Moore / Steve Miller

Program: Interstate, Federal, and Water Information Program

Purpose: To provide partial funding for the continuation of the operation, research, updates, enhancements and technical support to users of the CDSN.

Funding Available: July 1, 2015 – June 30, 2016

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**Severance Tax Operational Fund**

**Proposed Project for Fiscal Year 2015 – 2016**

**Project No. 30**

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Applicant: Open Water Foundation

Project Title: South Platte Point Flow Modeling and Visualization Tools

Recommended Amount: $ 0
Requested Amount: $50,000

Description of Project: The project would implement a "point flow model" where relatively simple water balance calculations are used to estimate river flow at locations along the river where water is diverted or returned. This project will review and consolidate understanding of multiple point flow tools including Visual South Platte and related free river analysis tools, Northern Water's point flow model, Wilson Water Group's point flow model used in the Basin Implementation Plan (BIP) analysis, SPDSS point flow analysis for groundwater modeling, and Water Information Sheets from the Colorado Water Right Administration Tool. The project will also consider how to integrate point flow analysis with StateMod modeling and the stream mile analysis framework that is being implemented for the environmental and recreational BIP in the South Platte. Data, analysis approach, and visualization techniques will be evaluated and recommendations will made to provide point flow tools as a standard offering for Colorado's Decision Support Systems. Documentation will be prepared describing fundamental data and analysis issues. Recommendations will be made for providing more accessible point flow tools and visualizations, with prototyping.

Project Manager(s): Andy Moore

Program: Water Information Program

Purpose: The purpose is to review and consolidate understanding of various point flow models that have been developed for the South Platte.

Funding Available: July 1, 2015 – June 30, 2016

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**Severance Tax Operational Fund**

**Proposed Project for Fiscal Year 2015 – 2016**

**Project No. 31**

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Applicant: Kevin Houck, Watershed & Flood Protection Chief

Project Title: Invasive Phreatophyte Control Program (IPCP)

Recommended Amount: $ 0
Requested Amount: $100,000

Description of Project: Restoration of riparian lands is an important activity that supports improvement of ecological function of rivers and streams. Many of these lands within Colorado are impacted by invasive plants such as tamarisk, an invasive woody shrub abundant along riversides in the western Unites States that, among other adverse ecological impacts, crowds out native vegetation, increases the severity of wildfire, and channelizes river banks. Based on a compilation of mapping and inventories, Colorado is infested with hundreds of thousands of acres of tamarisk and tens of thousands of acres of Russian olive. These funds would be used to administer the IPCP, a cost-sharing grant program to take measures to control or eradicate invasive phreatophytes in Colorado. These funds could potentially be matched by local partners and leverage Seven Basin States funds to share in costs. These funds would be used to partner with the Tamarisk Coalition, and other local or state partners, to plan projects, implement the projects, monitor the results, and maintain benefits with the riparian improvements.

Project Manager(s): Chris Sturm / Meg Dickey-Griffith

Program: Invasive Phreatophyte Control Program (IPCP)

Purpose: The IPCP grant program is intended to provide cost share assistance to eligible entities to control and/or eradicate tamarisk (also known as salt cedar), Russian olive, or other woody riparian invasive phreatophytes that have degraded the state's riparian areas, restricted channel capacity thereby increasing flood risk, and resulted in increased non-beneficial consumptive use of water. These funds can be used in conjunction with other funds to continue to improve ripraian corridors and reduce consumptive uses of water that occurs through evapo-transpiration by these invasive plants.

Funding Available: July 1, 2015 – June 30, 2016

One World One Water Center
MSU Denver
CWCB Severance Tax - Potential Funding
January 26, 2015

1) Provide registration scholarships and lodging for MSU Denver students to attend in-state water conservation conferences, such as WaterWise Colorado, AWRA, AWWA, etc.

   CWCB funding request- $5,175
   Funding Approved - $ 0

2) Create a Water Channel Digital Display in the Auraria Library at MSU Denver. Purchase, install and develop content for a digital flat screen display system devoted entirely to water stewardship, water conservation and the value of water.

   CWCB funding request - $4,900
   Funding Approved - $ 0

3) Work with MSU Denver School of Education/Speech/Journalism/Political Science Departments to find students who would research existing policy on water conservation in Colorado. Journalism students could write articles for the MSU Denver newspaper; promote state water plan and basin implementation plans on campus through digital media, Auraria Library Learning Wall, etc.

   CWCB funding request - $6,500
   Funding Approved - $ 0

4) Identify MSU Denver marketing/web design students to work with students in #5 above and create websites/marketing materials for CFWE and local water conservation departments/county governments.

   CWCB funding request - $4,600
   Funding Approved - $ 0

5) Earth Sciences professor, Dr. Randi Brazeau proposes to analyze how Auraria Campus current conservation techniques affect water health in premise plumbing – particularly in LEED designated buildings. This could be done in conjunction with the student-fee funded Sustainability Program on the Auraria campus (http://www.sustainableauraria.org/). Potentially, this data could help confirm the efficacy of our current water conservation strategies or help guide better decision making in that policy arena. This is a continuation of the work conducted in Virginia assessing "green" water heaters and best practices for hot water infrastructure. (See: http://www.collegepublishing.us/jgb/samples/JGB_V6N4_b02_Lieberman.pdf). *Please see Dr. Randi Brazeau attachment for additional project information.*

   CWCB funding request - $14,000
   Funding Approved - $ 0

6) Release time for faculty members who are faculty sponsors of paid internships for students in Denver Water and/or Aurora water (or Greeley or even on the western slope) to work side-by-side with the staff members that are responsible for implementing the policies around water conservation.

   CWCB funding request - $4,500
   Funding Approved - $ 0

7) Add low-flow fixtures to five of the 9th St. Houses on the Auraria Campus (last area to retrofit)

   CWCB funding request - $2,875
   Funding Approved - $ 0

8) Develop a winter term class where students would travel to key cities on the Colorado River- Phoenix, Las Vegas, Los Angeles, and meet with planners that are working on the water gaps in those places, then compare with the intent of utilizing in the Colorado State Water Plan. (We could promote this to some of the students in our September 2015 field conference in Denver.)

   CWCB funding request - $8,800 (faculty release time, transportation, lodging, meals for 9 students (3 to each city)
   Funding Approved - $ 0

9) Develop a new class in the MSU Denver Economics Department (cross-listed with the Environmental & Atmospheric Sciences Department) that studies the actual economics of the "value of water" and the interrelated nature of water efficiency and the value of water.

   CWCB funding request- $3,450 (faculty release time for course development)
   Funding Approved - $ 0

10) Develop a study abroad Winterim (January) or Maymester (late May) with Dr. Sara Beavis, Professor of Water Ethics and Water Studies at Australian National University, Melbourne, Australia, where students would compare and contrast water policy.

   CWCB funding request- $9,800 (travel & lodging for three MSU Denver faculty/administrators)
   Funding Approved - $ 0

# Impact of Floodplain Restoration on the Dynamics of Stream-Aquifer Interaction

**Dr. Ryan Bailey**, Assistant Professor, rtbailey@engr.colostate.edu
**Dr. Ayman Alzraiee**, Post-Doctoral Fellow, **Joel Sholtes**, Ph.D. Candidate
Department of Civil and Environmental Engineering, Colorado State University

**Location of the work.** Poudre River Floodplain Restoration Site, Fort Collins, CO.

**Purpose.** Stream-aquifer interaction has been intensively studied during the last 50 years due to the important role it plays in water rights management in alluvial aquifer systems. However, the impact and consequences of flood events on the dynamics of this interaction has not been studied extensively[1]. These events can provide a sudden expansion to riparian recharge zones, erode streambeds—thereby altering hydraulic connectivity to the aquifer— and impact the rate and spatial distribution of water exchange between surface and subsurface systems. Furthermore, these water exchange processes may be extensive in floodplain restoration areas, wherein levees have been removed to reconnect riparian hydrologic pathways. As stream restoration programs begin to focus on restoring hydrologic connectivity with the floodplain, a better understanding of the hydrologic implications is needed.

The hypothesis motivating this project is that flood events, though transient relative to the annual hydrograph, introduce persistent changes in the alluvial aquifer which in turn alter surface flows in the stream. Using a combination of field data collection and numerical model application, specific information to be gained from this project includes: (1) Quantifying the change in peak discharge over the study reach due to new flow of surface water into the alluvial aquifer; (2) Assessing impacts to post-flood flows by discharging groundwater; and (3) Determining changes in groundwater storage from pre- to post- floodplain restoration. We will coordinate fieldwork and study questions with the City of Fort Collins Stormwater and Natural Areas programs. This project provides training for new scientists in the area of water resources and hydrology, and directly addresses Research Priorities 4 and 1.

**Objectives and Method.** The overall objective of this project is to *identify the major hydrological processes dominating stream-aquifer interaction during and after flood events*. This will be accomplished using a combination of field data collection (streamflow, water table elevation) and numerical model application for a reach of the Cache La Poudre River where 1600 m of levees have been removed.

*Task 1: Field Data Collection:* Field data will assist in testing of the numerical simulation framework (see *Tasks 2-3*). Stream stage will be measured at upstream/downstream ends of the reach, and water table elevation will be measured within 6-8 2"-diameter observation wells installed in the riparian area. Wells will be installed at the beginning of the project using a Giddings rig. Data will be collected throughout the duration of the project using data loggers. *Timeline*: Months 1-12; *Deliverables*: Collected data sets.

*Task 2: Develop Numerical Simulation Framework*. The modeling framework will consist of a HEC-RAS[2] surface water model coupled with a MODFLOW groundwater model for transient simulations, with the latter developed from a localized section of the regional-scale SPDSS alluvial aquifer model. The Unstructured Grid (USG) version[3] of MODFLOW will be used, allowing for fine discretization along the river-riparian corridor and coarse discretization elsewhere. The framework will improve upon previous coupled HEC-RAS/MODFLOW models, which suffer from numerical instability, high computational burden, assumption of static stream parameters, and limitation to steady flow conditions [4]. *Timeline*: Months 1- 4*; Deliverables*: Source codes, code executable.

*Task 3: Calibration and Testing of Coupled Model*. Using the field data collected from the study reach and the observation wells, the coupled model will be calibrated and tested. The calibrated SPDSS alluvial aquifer model will be used as an initial guide, with hydraulic parameters, hydrological stresses, and simulated zonal budget of groundwater flow downscaled to the study reach by comparing model results with field data. *Timeline*: Months 4-6*; Deliverables*: Model input files for a number of scenarios.

*Task 4: Use calibrated model and collected data to answer research questions*. These include: (1) What is the change in peak discharge over the study reach due to net flow of surface water into the alluvial aquifer? (2) How are post-flood stream flows impacted as the alluvial aquifer drains the stored water into the channel over time? (3) How much transient storage is predicted, and how much change occurs, from pre- to post-floodplain restoration schemes? With the tested model, flood events of various magnitudes will be explored for each of these questions. *Timeline*: Months 5-10; *Deliverables*: Data sets, charts, tables, graphs quantifying water exchange processes.

*Task 5: Report Results*: Our final report will describe the methods, results of the research, and recommendations for expanding the work to larger scales. A CWI newsletter article will be written, and the results presented regionally. Peer-reviewed publication of this work will be pursued with support from Dr. Bailey. *Timeline*: Months 7-12*; Deliverables*: Final report, CWI newsletter article.

**Budget and Budget Justification.** The following table summarizes the proposed budget. Budget requested for the GRA is one semester month and one summer month. Fieldwork and equipment include Giddings rig rental, observation well pipe, water level loggers, and installation of wells and stream gauges. Fieldwork needs beyond $5,500 will be covered by Dr. Bailey's start-up funds.

| | |
|---|---|
| Faculty, 0.5 months | $5,000 |
| Post-Doctorate Fellow, 3.75 months | $25,000 |
| Graduate Research Assistant, 2 months | $6,000 |
| Fieldwork & Equipment | $5,500 |
| Facilities and Administrative @ 15% | $6,225 |
| **Total** | **$47,725** |

# Integrate CDSS and CSIP as Research Platform

**Principal Investigator**: Jack Carlson, Director OMSLab, Colorado State University (CSU)

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

**Purpose of the Research**: This project will result in a computation platform that allows CDSS software to access models and analysis tools hosted by CSU using internet communications. Colorado State University in conjunction with the United States Department of Agriculture has developed an open source modeling computing infrastructure CSIP (Cloud Services Innovation Platform) (http://www.javaforge.com/project/csip), which serves as a scalable platform for agro-environmental modeling. CSIP is used as a computational engine in support of web-based analysis tools, including the Environmental Risk Assessment and Management System (eRAMS, https://www.erams.com). CSIP-based web services for a number of modeling activities are publicly available (http://www.javaforge.com/tracker/191833), for example erosion estimate services, water flow analysis, land management database, etc. Whereas eRAMS provides an interactive website to provide input to CSIP web services and display results, it is possible to access the CSIP in an automated fashion to facilitate repetition and efficiency.

CDSS analysis processes are automated using data management interface (DMI) software StateDMI and TSTool. Automation allows large model datasets to be efficiently created and the software commands also allow flexibility in performing a variety of data processing tasks and analyses in support of State of Colorado staff and contractors. The TSTool software is able to access a number of data web services but cannot in its current form call CSIP web services.

The purpose of this research project is to integrate CDSS DMI software with the CSIP web services, in particular to demonstrate that relevant web services can be called and that standard data exchange protocols are in place. The results of this project will allow additional analysis services to be developed by CSU researchers for easy access by CDSS software users. Existing and new CSIP web services relevant to CDSS needs will be identified through coordination with CWCB staff and CDSS users, in particular focusing on agricultural and environmental water demand and use analysis. The result will be an operational and integrated research platform that can support future research and development, for example for future CWCB research grants.

**Objectives**:

1. Enhance CDSS DMI software to (i) prepare input for, and (ii) consume output of CSIP web services and access results:
    a. Enable creation of data formats needed by web services
    b. Enable packaging of web service data (e.g., automate handling lists of input files)
    c. Enable handling of returned results
2. Using available test data from CSU, demonstrate access to relevant CSIP web services.
3. Implement new web services in CSIP as identified and needed by CDSS.
4. Using HydroBase and CDSS data, call web services to demonstrate potential use within CDSS

5. Prepare documentation and training materials and educate the State about the potential of using CSIP and web services to implement new analytical tools and models.

**Method (Approach)**: If awarded, one or more students will be identified to work with CSU and OWF technical leadership. Tasks that are envisioned include:

1. Jack Carlson (CSU) and Steve Malers (OWF) will meet to coordinate to ensure that OWF is able to access CSIP web services.
2. CSU will improve documentation and provide web service test data.
3. CSU, OWF, and CWCB will meet to prioritize which web services will be the focus of the project. Documentation and test data will be used in the discussion.
4. OWF will enhance StateDMI and/or TSTool software to prepare input for web services, call the web services, and process output to provide access to users. OWF will utilize test data from CSU to demonstrate functionality.
5. CSU will work with OWF to ensure proper error-handling, etc.
6. OWF will create examples using HydroBase and other CDSS data to demonstrate functionality beyond test data.
7. OWF and CSU will prepare documentation and training materials explaining how to access CSIP web services with CDSS software and will provide training to CWCB staff.
8. CSU and OWF will meet with CWCB to determine recommendations for future research, for example tools that could be developed by CSU and which would be available in the CDSS software. As resources allow, additional CSIP web services will be developed consistent with previous tasks.

The result of this approach will be a platform that integrates CDSS tools with computational tools available from CSU. The existing analytical tools will be available to CDSS tool users. The platform also will be available to facilitate future research in a collaborative approach.

**Timeline and Completion Date**:

- Within 2 months of award, perform tasks 1-3
- Within 6 months of award, perform tasks 4-5
- Within 8 months of award, perform tasks 6-7
- Within 12 months of award, perform task 8

Updated CDSS software, CSIP web services, and documentation will be made available throughout the project.

**Budget**: $50,000 is being requested for this project, with distribution estimated as follows (final distribution will be based on available student intern resources at CSU and OWF):

- $20,000 – CSU
- $30,000 – OWF

**Budget Justification**: Budget will be used to pay for software developers and technical leadership at CSU and OWF, and CSU students. The resulting software platform can be leveraged in many ways on other projects.

# Development of Water Rights Education Materials

**Principal Investigator**: Madoline Wallace-Gross, Metropolitan State University of Denver (Metro)

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

**Purpose of the Research**: Anyone observing a group of diverse stakeholders discussing complex water issues will at some point hear the statement: "We need to educate the public so that they understand these issues." Although educational materials are available from organizations like the Colorado Foundation for Water Education (CFWE), there is a need for materials that serve the needs of university educators and the students that they are teaching, in particular to serve a diverse group of students who will become the next generation of water professionals. The purpose of this project is to develop educational materials focusing on water rights/water law and related topics, using data examples from Colorado's Decision Support Systems (CDSS) to provide real-world context and understanding. The materials will be developed for use in water law courses taught at Metro and will serve as a companion to "The Citizen's Guide to Colorado Water Law" (CFWE) and "Colorado Water Law for Non-Lawyers" (Tom Cech and P. Andrew Jones), which are used in the courses. Examples will focus on key topics including prior appropriation, historic consumptive use, water right transfers, return flows, instream flows, water reuse, and other topics. The materials will be made available to educators and the public free of charge and will allow a wide audience to better understand Colorado water law and its relationship to important water issues.

**Objectives**:

1. Develop examples using actual data that illustrate key concepts related to water rights and water law.
2. Leverage CDSS and HydroBase data and software to develop educational materials, thereby increasing knowledge of the data and tools for practitioners and the public.
3. Use the educational materials in water law courses at Metro as a companion to "The Citizen's Guide to Colorado Water Law" (CFWE) and "Colorado Water Law for Non-Lawyers" (Tom Cech and P. Andrew Jones) – this will demonstrate the potential for developing similar materials for other publications.
4. Provide public access to the created educational materials.

**Method (Approach)**: If awarded, one or more students will be identified to work with Metro and OWF technical leadership to develop educational materials:

1. Madoline Wallace-Gross, who teaches water law courses at Metro, will meet with OWF to identify key concepts that would benefit from real-world illustrative examples.
2. Identify Metro and/or CSU students that have technical skills and interest to develop materials. Existing interns at Metro and OWF will be utilized if available.
3. Identify one or more historical datasets for each concept, with input from practitioners, with emphasis on relevance, clarity, and availability of public data.
4. Use CDSS data and software to process the examples into forms that can be used in the course.
5. Metro and OWF will work together to create integrated curriculum materials.
6. Metro will use the materials in the course and request feedback from students as to the effectiveness of the approach.
7. OWF will facilitate making the materials available on the web, for use by other educators and the public.

The result of this approach will be education materials for use in water rights/water law courses as well as the public. This project will serve as a prototype that may be expanded in the future.

**Timeline and Completion Date**:

- Within 1 month of award, meet with Metro educators and identify a list of topics that will benefit from example data
- Within 2 months of award, identify students to work on project
- Within 3 months of award, determine specific examples as companions to existing printed materials
- Within 6 months of award, develop and integrate examples with curriculum
- Within 12 months of award, use materials in course(s) and make available to other educators and the public

**Budget**: $25,000 is being requested for this project, estimated as follows with final distribution depending on available student resources at Metro and OWF:

- $10,000 – Metro resources to define curriculum needs and integrate examples into the course (courses are already funded)
- $15,000 – Open Water Foundation technical resources to develop data examples

**Budget Justification**: Educating Colorado citizens about water issues is recognized as a worthy endeavor, as seen by CWCB investment in the CFWE, Basin Roundtable Public Education, Participation, and Outreach (PEPO) workgroups, and the outreach efforts of many water organizations. However, there is a need to provide water education at universities focusing on the context of complex core issues centered on water rights and water law. This project will result in improved educational materials that are relevant to today's complex water issues. The materials will be produced in a way that will allow for future enhancement and adaptation.