Water Supply Reserve Account – Grant and Loan Program
Water Activity Summary Sheet
March 22-23, 2017
Agenda Item 24(j)

Applicant & Grantee:	Colorado School of Mines
Water Activity Name:	Designing River Basin Storage Along the South Platte River
Water Activity Purpose:	Agricultural & M&I
County:	Sedgwick
Drainage Basin:	South Platte
Water Source:	South Platte River
Amount Requested/Source of Funds:	$38,089 South Platte Basin Account $11,841 Statewide Account* $50,930 Total Grant Request * The discrepancy between the Statewide Account request in the application, the Roundtable Chair Recommendation Letter ($15,000), and that stated herein, can be attributed to the applicant' voluntarily reducing their request to accommodate the Statewide Account shortfall.
Matching Funds:	Basin Account Match ($38,089) = 330% of Statewide Account request (meets 10% min); Applicant's In-kind Match ($46,442) = 392% of Statewide Account request (meets 10% min); Total Match (Basin & Applicant Match of $85,531 = 722% of Statewide Account request (meets 50% min). (refer to *Funding Summary/Matching Funds* section)

Staff Recommendation:

Staff recommends approval of up to $39,089 from the South Platte Basin Account; and $11,841 from the Statewide Account to help fund the project titled: Designing River Basin Storage Along the South Platte River.

Water Activity Summary: If approved, WSRF grant funds will assist the grantee to develop a quantitative method employed to assist in a decision making process to identify potential storage sites, or combinations of sites, of unappropriated waters along the Lower South Platte River. The proposed method will link StateMod to a mixed integer-linear optimization* program. This optimization model seeks the minimum costs solution of designing reservoir storage utilizing StateMod flow data. The objective of this work is to minimize the costs to meet all demands and shortages by assigning network flow from expanded capacity and pumping, while adhering to the constraints that force the physical and topographical structures of the river in a given time horizon. Additional storage methods considered in this research include: (1) expanding existing surface storage reservoir capacity by raising the height of dams, as well as dredging, (2) constructing new

surface storage reservoirs, (3) constructing new underground storage. WSRF Grant funds, if approved, will be expended to develop a Lower South Platte case study that uses a generalized methodology and structure that can be applied to other basins throughout the State of Colorado.

* In general, an optimization model can be employed to maximize desired outcomes, while minimizing undesirable outcomes. Applied optimization uses a mathematical process to choose the best option (objective) among various alternatives (variables), with regard to some criterion (constraints). Optimization models are useful when: (1) there are many unknown values to be determined (variables), (2) the relationships between unknowns are complex and inextricably linked, (3) the goal (objective) has many tradeoffs, and (4) a repeatable solution, which can be generated quickly, is desired.

Discussion: This project furthers multiple goals and objectives of the South Platte Basin Implementation Plan (SPBIP) in accordance with Section 1.9.4 Goals and Measurable Outcomes: South Platte Storage and Other Infrastructure.

With respect to Colorado's Water Plan, this project supports the Critical Goals and Actions as described in Section 10.3E: Storage, "Promote Additional Storage and Infrastructure".

Issues/Additional Needs: No issues or additional needs have been identified.

Eligibility Requirements:
The application meets requirements of the three subsections of the Eligibility Requirements: General Eligibility, Entity Eligibility, and Water Activity Eligibility.

Eligibility Based on Funding Match Requirements:
The application meets the Statewide Account Matching requirements.

Evaluation Criteria:
This activity has undergone review and evaluation and staff has determined that it satisfies the Evaluation Criteria. Please refer to WSRF Application and Exhibit A (Statement of Work) for applicant's detailed response.

Funding Summary/Matching Funds:

Funding Source	**Cash**	**In-kind**	**Total**
Colorado School of Mines	$46,442	$0	$46,442
WSRF South Platte Basin Account	$39,089	n/a	$39,089
WSRF Statewide Account	$11,841	n/a	$11,841
Total Project Costs	**$97,372**	**$0**	**$97,372**

CWCB Project Manager: Craig Godbout

All products, data and information developed as a result of this grant must be provided to the CWCB in hard copy and electronic format as part of the project documentation. This information will in turn be made widely available to Basin Roundtables and the general public and will help promote the development of a common technical platform. In accordance with the revised WSRA Criteria and Guidelines, staff would like to highlight additional reporting and final deliverable requirements. The specific requirements are provided below.

Reporting: The applicant shall provide the CWCB a progress report every 6 months, beginning from the date of the executed contract. The progress report shall describe the completion or partial completion of the tasks identified in the scope of work including a description of any major issues that have occurred and any corrective action taken to address these issues.

Final Deliverable: At completion of the project, the applicant shall provide the CWCB a final report that summarizes the project and documents how the project was completed. This report may contain photographs, summaries of meetings and engineering reports/designs.

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

February 3, 2017

Craig Godbout – WSRF Application
Colorado Water Conservation Board
1313 Sherman St., Room 721
Denver, CO 80203
Craig.godbout@state.co.us

Dear Mr. Godbout:

The South Platte Basin Roundtable has reviewed the WSRF application from Colorado School of Mines entitled *Designing river basin storage along the lower South Platte* and voted at its January 10th, 2017 meeting to approve the grant application for $39,089 from the SPBRT Basin account and $15,000 from the Statewide account. The SPBRT did request that the grant applicant coordinate with the South Platte Storage Study, where possible.

This letter is intended to fulfill Threshold Criteria B (Part III 1.b. in the WSRF Application). The full WSRF Application will be provided separately by the applicant. Please let me know if you need any additional information.

Sincerely,

Joe Frank

Joe Frank, Immediate Past Chair
South Platte Basin Roundtable

COLORADO WATER CONSERVATION BOARD

WATER SUPPLY RESERVE ACCOUNT APPLICATION FORM

Designing river basin storage along the Lower South Platte River

Name of Water Activity/Project

Colorado School of Mines

Name of Applicant

South Platte

Approving Basin Roundtable(s)
(If multiple basins specify amounts in parentheses.)

Amount from Statewide Account: $15,000

Amount from Basin Account(s): $39,089

Total WSRA Funds Requested: $54,089

Application Content

Required Exhibits

A. Statement of Work, Budget, and Schedule
B. Project Map
C. As Needed (i.e. letters of support, photos, maps, etc.)

Appendices – Reference Material

1. Program Information
2. Insurance Requirements
3. WSRA Standard Contract Information (Required for Projects Over $100,000)
4. W-9 Form (Required for All Projects Prior to Contracting)

Instructions

To receive funding from the Water Supply Reserve Account (WSRA), a proposed water activity must be approved by the local Basin Roundtable **AND** the Colorado Water Conservation Board (CWCB). The process for Basin Roundtable consideration and approval is outlined in materials in Appendix 1.

Once approved by the local Basin Roundtable, the applicant should submit this application **with a detailed statement of work including budget and schedule as Exhibit A** to CWCB staff by the application deadline.

WSRA applications are due with the roundtable letter of support 60 calendar days prior to the bi-monthly Board meeting at which it will be considered. Board meetings are held in January, March, May, July, September, and November. Meeting details, including scheduled dates, agendas, etc. are posted on the CWCB website at: http://cwcb.state.co.us Applications to the WSRA Basin Account are considered at every board meeting, while applications to the WSRA Statewide Account are only considered at the March and September board meetings.

When completing this application, the applicant should refer to the WSRA Criteria and Guidelines available at: http://cwcb.state.co.us/LoansGrants/water-supply-reserve-account-grants/Documents/WSRACriteriaGuidelines.pdf

The application, statement of work, budget, and schedule **must be submitted in electronic format** (Microsoft Word or text-enabled PDF are preferred) and can be emailed or mailed on a disk to:

Greg Johnson – WSRA Application
Colorado Water Conservation Board
1580 Logan Street, Suite 200
Denver, CO 80203
gregory.johnson@state.co.us

If you have questions or need additional assistance, please contact Greg Johnson at: 303-866-3441 x3249 or gregory.johnson@state.co.us.

Water Supply Reserve Account – Application Form
Revised December 2011

Part I. - Description of the Applicant (Project Sponsor or Owner);

1.	Applicant Name(s):	Colorado School of Mines		
	Mailing address:	Colorado School of Mines 1500 Illinois Street Golden, CO 80401		
	Taxpayer ID#:	84-6000551		
	Primary Contact:	Andy Burrow	Position/Title:	PhD Candidate
	Email:	aburrow@mymail.mines.edu		
	Phone Numbers:	Cell: (949) 697-0077	Office:	
	Alternate Contact:	Alexandra Newman	Position/Title:	Professor
	Email:	anewman@mines.edu		
	Phone Numbers:	Cell:	Office:	(303) 273-3688

2. Eligible entities for WSRA funds include the following. What type of entity is the Applicant?

	Public (Government) – municipalities, enterprises, counties, and State of Colorado agencies. Federal agencies are encouraged to work with local entities and the local entity should be the grant recipient. Federal agencies are eligible, but only if they can make a compelling case for why a local partner cannot be the grant recipient.
	Public (Districts) – authorities, Title 32/special districts, (conservancy, conservation, and irrigation districts), and water activity enterprises.
	Private Incorporated – mutual ditch companies, homeowners associations, corporations.
	Private individuals, partnerships, and sole proprietors are eligible for funding from the Basin Accounts but not for funding from the Statewide Account.
X	Non-governmental organizations – broadly defined as any organization that is not part of the government.

3. Provide a brief description of your organization

Colorado School of Mines is a public research university devoted to engineering and applied sciences.

4. If the Contracting Entity is different then the Applicant (Project Sponsor or Owner) please describe the Contracting Entity here.

5. Successful applicants will have to execute a contract with the CWCB prior to beginning work on the portion of the project funded by the WSRA grant. In order to expedite the contracting process the CWCB has established a standard contract with provisions the applicant must adhere to. A link to this standard contract is included in Appendix 3. Please review this contract and check the appropriate box.

[ ] The Applicant will be able to contract with the CWCB using the Standard Contract

[x] The Applicant has reviewed the standard contract and has some questions/issues/concerns. Please be aware that any deviation from the standard contract could result in a significant delay between grant approval and the funds being available.

6. The Tax Payer Bill of Rights (TABOR) may limit the amount of grant money an entity can receive. Please describe any relevant TABOR issues that may affect the applicant. N/A

Part II. - Description of the Water Activity/Project

1. What is the primary purpose of this grant application? (Please check only one)

	Nonconsumptive (Environmental or Recreational)
x	Agricultural
x	Municipal/Industrial
	Needs Assessment
	Education
	Other Explain:

2. If you feel this project addresses multiple purposes please explain.

This project seeks to identify new water storage locations and types on the lower South Platte river. Therefore, the project will affect both agricultural and municipal/industrial.

3. Is this project primarily a study or implementation of a water activity/project? (Please check only one)

X	Study		Implementation

4. To catalog measurable results achieved with WSRA funds can you provide any of the following numbers?

X	New Storage Created (acre-feet)
	New Annual Water Supplies Developed, Consumptive or Nonconsumptive (acre-feet)
X	Existing Storage Preserved or Enhanced (acre-feet)
	Length of Stream Restored or Protected (linear feet)
	Length of Pipe/Canal Built or Improved (linear feet)
	Efficiency Savings (acre-feet/year OR dollars/year – **circle one**)
	Area of Restored or Preserved Habitat (acres)
	Other -- Explain:

4. To help us map WSRA projects please include a map (Exhibit B) and provide the general coordinates below:

Latitude:	40.390342	Longitude:	-104.542465

5. Please provide an overview/summary of the proposed water activity (no more than one page). Include a description of the overall water activity and specifically what the WSRA funding will be used for. A full **Statement of Work** with a detailed budget and schedule is required as **Exhibit A** of this application.

The overall purpose of this research is to provide quantitative information to undergird a decision regarding the optimal location, type and size of additional unappropriated water storage along the Lower South Platte River. In order to identify a location for increased water storage, this research uses flow data produced by StateMod as input for a mixed integer-linear optimization* program. This program minimizes the cost to meet all demands and shortages by assigning network flow while adhering to the constraints that force the physical and topographical structures of the river. The program solution contains a location/s and amount of water storage that mitigates the shortages in a given time horizon. Additional storage methods considered in this research include: (1) expanding existing reservoir capacity by raising the height of dams, as well as dredging, (2) constructing new surface reservoirs and (3) constructing underground storage. Costs used in this study are obtained from estimates associated with like projects in Colorado and California. Feasible locations of underground storage are obtained from the CWCB Underground Water Storage Study. Program solutions are then inserted into StateMod for validation. This process is repeated using subsequent optimization model results until a feasible StateMod outcome is reached. We seek WSRA funds in order to develop a Lower South Platte case study that uses a generalized methodology and structure that can be applied to other basins throughout the State of Colorado.

*Applied optimization uses a mathematical process to choose the best option, from among many available alternatives, with regard some criterion. Optimization models are especially useful when: (1) there are many unknown values to be determined, (2) the relationships between the unknowns are complex and inextricably linked, (3) the goal has many tradeoffs and (4) a repeatable solution, which can be obtained quickly, is desired. Our optimization model seeks the minimum cost solution of designing additional reservoir storage while using flow data produced by StateMod.

Part III. – Threshold and Evaluation Criteria

1. Describe how the water activity meets these **Threshold Criteria.** (Detailed in Part 3 of the Water Supply Reserve Account Criteria and Guidelines.)

   a) The water activity is consistent with Section 37-75-102 Colorado Revised Statutes.[1]

   This project involves the completion of a study for the purposes of identifying the optimal location/s of new water storage. It is consistent with the statues contained in Section 37-75-102 in that the model solution does not change existing policy or laws.

   b) The water activity underwent an evaluation and approval process and was approved by the Basin Roundtable (BRT) and the application includes a description of the results of the BRTs evaluation and approval of the activity. At a minimum, the description must include the level of agreement reached by the roundtable, including any minority opinion(s) if there was not general agreement for the activity. The description must also include reasons why general agreement was not reached (if it was not), including who opposed the activity and why they opposed it. Note- If this information is included in the letter from the roundtable chair simply reference that letter.

[1] 37-75-102. Water rights - protections. (1) It is the policy of the General Assembly that the current system of allocating water within Colorado shall not be superseded, abrogated, or otherwise impaired by this article. Nothing in this article shall be interpreted to repeal or in any manner amend the existing water rights adjudication system. The General Assembly affirms the state constitution's recognition of water rights as a private usufructuary property right, and this article is not intended to restrict the ability of the holder of a water right to use or to dispose of that water right in any manner permitted under Colorado law. (2) The General Assembly affirms the protections for contractual and property rights recognized by the contract and takings protections under the state constitution and related statutes. This article shall not be implemented in any way that would diminish, impair, or cause injury to any property or contractual right created by intergovernmental agreements, contracts, stipulations among parties to water cases, terms and conditions in water decrees, or any other similar document related to the allocation or use of water. This article shall not be construed to supersede, abrogate, or cause injury to vested water rights or decreed conditional water rights. The General Assembly affirms that this article does not impair, limit, or otherwise affect the rights of persons or entities to enter into agreements, contracts, or memoranda of understanding with other persons or entities relating to the appropriation, movement, or use of water under other provisions of law.

c) The water activity meets the provisions of Section 37-75-104(2), Colorado Revised Statutes.[2] The Basin Roundtable Chairs shall include in their approval letters for particular WSRA grant applications a description of how the water activity will assist in meeting the water supply needs identified in the basin roundtable's consumptive and/or non-consumptive needs assessments.

This project uses existing tools and data (StateMod) for the purpose of evaluating the basin water supply along the lower South Platte. It specifically seeks a location for new water storage related to demands and shortages as well as the optimal storage location for unappropriated waters within the basin, thus meeting the stipulations in Section 37-75-104(2).

d) Matching Requirement: For requests from the **Statewide Fund**, the applicants are required to demonstrate a **20 percent** (or greater) match of the request from the Statewide Account. Statewide requests must also include a minimum match of **5 percent** of the total grant amount from Basin Funds. Sources of matching funds include but are not limited to Basin Funds, in-kind services, funding from other sources, and/or direct cash match. Past expenditures directly related to the project may be considered as matching funds if the expenditures occurred within 9 months of the date the application was submitted to the CWCB. Please describe the source(s) of matching funds. (NOTE: These matching funds should also be reflected in your Detailed Budget in **Exhibit A** of this application)

The overall project budget is $97,372. Of this total, matching funds from the G.I. Bill amount to $43,283. Thus, the remaining $54,089 is requested via WSRA grant. Our matching funds represent an 80% match. Of this total WSRA request of $54,089, we are requesting $15,000 from the state fund and $39,089 from the basin fund. Our matching funds exceed the requirement percentage in both cases.

[2] 37-75-104 (2)(c). Using data and information from the Statewide Water Supply Initiative and other appropriate sources and in cooperation with the on-going Statewide Water Supply Initiative, develop a basin-wide consumptive and nonconsumptive water supply needs assessment, conduct an analysis of available unappropriated waters within the basin, and propose projects or methods, both structural and nonstructural, for meeting those needs and utilizing those unappropriated waters where appropriate. Basin Roundtables shall actively seek the input and advice of affected local governments, water providers, and other interested stakeholders and persons in establishing its needs assessment, and shall propose projects or methods for meeting those needs. Recommendations from this assessment shall be forwarded to the Interbasin Compact Committee and other basin roundtables for analysis and consideration after the General Assembly has approved the Interbasin Compact Charter.

2. For Applications that include a request for funds from the **Statewide Account**, describe how the water activity/project meets all applicable **Evaluation Criteria.** (Detailed in Part 3 of the Water Supply Reserve Account Criteria and Guidelines and repeated below.) Projects will be assessed on how well they meet the Evaluation Criteria. **Please attach additional pages as necessary.**

Evaluation Criteria – the following criteria will be utilized to further evaluate the merits of the water activity proposed for funding from the Statewide Account. In evaluation of proposed water activities, preference will be given to projects that meet one or more criteria from each of the three "tiers" or categories. Each "tier" is grouped in level of importance. For instance, projects that meet Tier 1 criteria will outweigh projects that only meet Tier 3 criteria. WSRA grant requests for projects that may qualify for loans through the CWCB loan program will receive preference in the Statewide Evaluation Criteria if the grant request is part of a CWCB loan/WSRA grant package. For these CWCB loan/WSRA grant packages, the applicant must have a CWCB loan/WSRA grant ratio of 1:1 or higher. Preference will be given to those with a higher loan/grant ratio.

Tier 1: Promoting Collaboration/Cooperation and Meeting Water Management Goals and Identified Water Needs

a. The water activity addresses multiple needs or issues, including consumptive and/or non-consumptive needs, or the needs and issues of multiple interests or multiple basins. This can be demonstrated by obtaining letters of support from other basin roundtables (in addition to an approval letter from the sponsoring basin).
b. The number and types of entities represented in the application and the degree to which the activity will promote cooperation and collaboration among traditional consumptive water interests and/or non-consumptive interests, and if applicable, the degree to which the water activity is effective in addressing intrabasin or interbasin needs or issues.
c. The water activity helps implement projects and processes identified as helping meet Colorado's future water needs, and/or addresses the gap areas between available water supply and future need as identified in SWSI or a roundtable's basin-wide water needs assessment.

Tier 2: Facilitating Water Activity Implementation

d. Funding from this Account will reduce the uncertainty that the water activity will be implemented. For this criterion the applicant should discuss how receiving funding from the Account will make a significant difference in the implementation of the water activity (i.e., how will receiving funding enable the water activity to move forward or the inability obtaining funding elsewhere).
e. The amount of matching funds provided by the applicant via direct contributions, demonstrable in-kind contributions, and/or other sources demonstrates a significant & appropriate commitment to the project.

Tier 3: The Water Activity Addresses Other Issues of Statewide Value and Maximizes Benefits

f. The water activity helps sustain agriculture & open space, or meets environmental or recreational needs.
g. The water activity assists in the administration of compact-entitled waters or addresses problems related to compact entitled waters and compact compliance and the degree to which the activity promotes maximum utilization of state waters.
h. The water activity assists in the recovery of threatened and endangered wildlife species or Colorado State species of concern.
i. The water activity provides a high level of benefit to Colorado in relationship to the amount of funds requested.
j. The water activity is complimentary to or assists in the implementation of other CWCB programs.

Continued: Explanation of how the water activity/project meets all applicable **Evaluation Criteria**.
Please attach additional pages as necessary.

Tier 1a: This activity addresses multiple interests. By providing a location for new water storage that would meet all demands, multiple interests are being served.

Tier 1b: This activity represents the cooperation and coordination of more than one agency. Reagan Waskom (Director, Colorado Water Institute), Steve Malers (CTO, Open Water Foundation) and the Colorado Water Conservation Board were consulted regarding the scope and direction of this research.

Tier 1c: This activity addresses both (1) above ground storage to meet demands and shortages in the form of: (i) current reservoir expansion and/or (ii) new reservoir construction and (2) underground storage of unappropirated water.

Tier 2d/e: The matching funds associated with this activity are currently paying for StateMod training and primary model development. Without funding from this account, this activity will not reach a full state of maturity in time for the results to impact decisions that need to be made in the near future.

Tier 3f: The activity helps sustain agriculture by providing the optimal location of additional water storage.

Tier 3i: A large porition of the budget for this activity was provided through matching funds. Thus, the benefit obtained from WSRA funds is the completion of the study at less than half of the total cost.

Tier 3j: This activity uses StateMod, a current CWCB tool.

Part IV. – Required Supporting Material

1. **Water Rights, Availability, and Sustainability** – This information is needed to assess the viability of the water project or activity. Please provide a description of the water supply source to be utilized, or the water body to be affected by, the water activity. This should include a description of applicable water rights, and water rights issues, and the name/location of water bodies affected by the water activity.

This activity uses StateMod as applied to the lower South Platte from the Kersey Gauge to the Nebraska border. Since it uses StateMod, all of the water rights, diversions, and return flows are included, as well as the following primary reservoirs: Latham, Empire, Riverside, Bijou #2, Jackson Lake, Snyder, North Sterling, Prewitt and Julesburg.

2. Statement of Work, Detailed Budget, and Project Schedule

The statement of work will form the basis for the contract between the Applicant and the State of Colorado. In short, the Applicant is agreeing to undertake the work for the compensation outlined in the statement of work and budget, and in return, the State of Colorado is receiving the deliverables/products specified. **Please note that costs incurred prior to execution of a contract or purchase order are not subject to reimbursement**. All WSRA funds are disbursed on a reimbursement basis after review invoices and appropriate backup material.

Please provide a detailed statement of work using the template in Exhibit A. Additional sections or modifications may be included as necessary. Please define all acronyms and include page numbers.

REPORTING AND FINAL DELIVERABLE

Reporting: The applicant shall provide the CWCB a progress report every 6 months, beginning from the date of the executed contract. The progress report shall describe the completion or partial completion of the tasks identified in the statement of work including a description of any major issues that have occurred and any corrective action taken to address these issues.

Final Deliverable: At completion of the project, the applicant shall provide the CWCB a final report that summarizes the project and documents how the project was completed. This report may contain photographs, summaries of meetings and engineering reports/designs.

PAYMENT

Payment will be made based on actual expenditures and invoicing by the applicant. Invoices from any other entity (i.e. subcontractors) cannot be processed by the State. The request for payment must include a description of the work accomplished by major task, and estimate of the percent completion for individual tasks and the entire water activity in relation to the percentage of budget spent, identification of any major issues and proposed or implemented corrective actions. The last 5 percent of the entire water activity budget will be withheld until final project/water activity documentation is completed. All products, data and information developed as a result of this grant must be provided to the CWCB in hard copy and electronic format as part of the project documentation. This information will in turn be made widely available to Basin Roundtables and the general public and help promote the development of a common technical platform.

The above statements are true to the best of my knowledge:

Signature of Applicant: Ralph L. Brown 10/31/16

Ralph L. Brown
Director
Office of Research Administration

Print Applicant's Name:

Project Title: Designing river basin storage along the Lower South Platte River

Return an electronic version (hardcopy may also be submitted) of this application to:

Greg Johnson – WSRA Application
Colorado Water Conservation Board
1580 Logan Street, Suite 200
Denver, CO 80203
gregory.johnson@state.co.us

Exhibit A

Statement of Work
Date: 31 October 2016

WATER ACTIVITY NAME - Designing river basin storage along the lower South Platte using StateMod and optimization

GRANT RECIPIENT – Colorado School of Mines

FUNDING SOURCE – G.I. Bill

INTRODUCTION AND BACKGROUND

Provide a brief description of the project. (Please limit to **no more than 200 words**; this will be used to inform reviewers and the public about your proposal)

The overall purpose of this research is to provide quantitative information to undergird a decision regarding the optimal location, type and size of additional unappropriated water storage along the lower South Platte. In order to identify a location for increased water storage, this research uses flow data produced by StateMod as input for a mixed integer-linear optimization program. This program minimizes the cost to meet all demands and shortages by assigning network flow while adhering to the constraints that force the physical and topographical structures of the river. The program solution contains a location/s and amount of water storage that mitigate the shortages in a given time horizon. Storage methods considered in this research include: (1) expanding existing reservoir capacity by raising the height of dams, as well as dredging, (2) constructing new surface reservoirs and (3) constructing underground storage. Costs used in this study are obtained from estimates associated with like projects in Colorado and California. Feasible locations of underground storage are obtained from the CWCB Underground Water Storage Study. Program solutions are then inserted into StateMod for validation. This process is repeated using subsequent optimization model results until a feasible StateMod outcome is reached.

OBJECTIVES

Overall, we seek to develop a lower South Platte case study that uses a generalized methodology and structure that can be applied to other basins throughout the State of Colorado. The primary objective is to provide quantitative information to undergird a decision regarding the optimal location, type and size of additional unappropriated water storage along the Lower South Platte River. This objective shall be accomplished by producing an optimization model that uses simulated flow, produced by StateMod, as input data. This model shall represent mathematically, and include all necessary information, to correctly constrain the problem based on the physical topography of the basin and the structures contained therein. This objective shall be accomplished using the following tasks:

Executive Summary

Introduction

This executive summary describes a research endeavor by the Colorado School of Mines to use existing tools and applied optimization to identify additional unappropriated water storage along the lower South Platte River between the Kersey Gage and the Nebraska border.

Applied optimization uses a mathematical process to choose the best option, from among many available alternatives, with regard some criterion. Optimization models are especially useful when: (1) there are many unknown values to be determined, (2) the relationships between the unknowns are complex and inextricably linked, (3) the goal has many tradeoffs and (4) a repeatable solution, which can be obtained quickly, is desired. Our optimization model seeks the minimum cost solution of designing additional reservoir storage while using flow data produced by StateMod. We seek to develop a Lower South Platte case study that uses a generalized methodology and structure that can be applied to other basins throughout the State of Colorado.

Section 1: Promotes South Platte Basin Implementation Plan

The main focus of this project is determining additional water storage locations, using existing data and tools, thus advancing the South Platte Basin Implementation Plan (SPBIP) Section 1.9.4. To do so, the Colorado School of Mines (CSM) is developing an optimization model that uses StateMod simulated flow as a data source and finds the minimum cost option to meet both demand and shortages using unappropriated water. Additional storage methods considered in this research include: (1) expanding existing reservoir capacity by raising the height of dams, as well as dredging, (2) constructing new surface reservoirs and (3) constructing underground storage. Costs used in this study are obtained from estimates associated with like projects in Colorado and California. Feasible locations of underground storage are obtained from the CWCB Underground Water Storage Study. Model solutions are inserted into StateMod for validation. This process is repeated using subsequent optimization model results until a feasible StateMod outcome is reached.

By developing quantitative information to undergird a decision regarding the optimal location, type and size of additional unappropriated water storage along the lower South Platte River, this project contributes to funding category 1: develop or advance multi-purpose water supply projects.

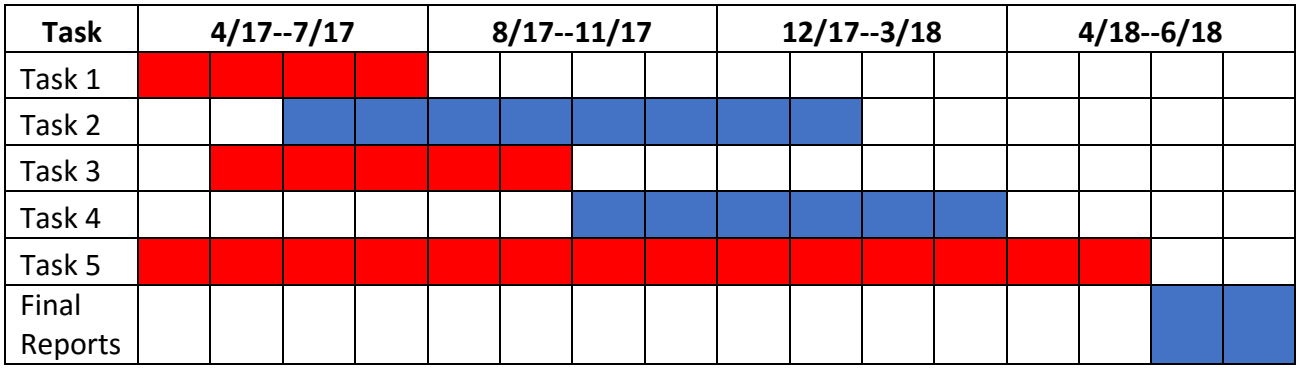
This project also contributes to funding category 2: promoting education and outreach that emphasizes the South Platte BIP priorities. Throughout the course of this project, the work will be mentioned publicly in the following ways: (1) Three separate presentations to Colorado School of Mines (CSM) faculty, (2) technical papers describing the work will be submitted for publication to peer reviewed journals and (3) We will request to present our work at The Institute for Operations Research and the Management Sciences (INFORMS) annual meeting in Houston during October of 2017. INFORMS is the largest society in the world for professionals in the field of operations research, management science and analytics.

Section 2: Project Urgency and Readiness

The matched funding for this project will be exhausted in March of 2017. At that point, if this project receives no further funding, the model will simply exist in an academic environment and will provide only a single solution, not a robust capability to be used in the future for planning purposes in the South Platte Basin. Therefore, it is imperative this project be funded now.

The project's schedule is tied to five different tasks:

1. Cost estimate collection
2. StateMod flow data preparation
3. Feasible underground storage site data collection
4. StateMod—Optimization model interface development
5. Mixed integer-linear optimization model development



Section 3: Matching Funds

The overall project budget is $97,372. Of this total, matching funds from the G.I. Bill amount to $43,283. Thus, the remaining $54,089 is requested via the WSRA grant. Our matching funds represent an 80% match of the total. Of this total WSRA request of $54,089, we are requesting $15,000 from the state fund and $39,089 from the basin fund. Our matching funds exceed the requirement percentage in both cases.

Section 4: Measurable Outcomes

Project success will be measured by a committee consisting of:

(1) Alexandra Newman, PhD, Operations Research at the School of Mines
(2) Tissa Illangasekare, PhD, Civil Engineering at the School of Mines
(3) Andres Guerra, PhD, Civil Engineering at the School of Mines
(4) Dinesh Mehta, PhD, Computer Science at the School of Mines
(5) Reagan Waskom, PhD, Colorado Water Institute

PROPOSED BUDGET CSM Proposal No. 17-0185

April 1, 2017 - June 30, 2018 (15 months)

		Year 1	Year 2	Total
A.	SALARIES AND WAGES		(3 months)	
1.	Alexandra Newman, PI - 3 summer days	$1,933	$0	$1,933
2.	Graduate Research Asst. (Andrew Burrow) @ $1,760/month (no summer)	15,840	5,491	21,331
	Subtotal	$17,773	$5,491	$23,264
B.	FRINGE BENEFITS			
1.	38.8% of A1	$750	$0	$750
2.	GRA tuition and fees (reduced)* Fall 2017 and Spring 2018 and summer 2018 session 1 only	10,810	3,402	14,212
	Subtotal	$11,560	$3,402	$14,962
C.	OTHER DIRECT COSTS			
1.	Travel - domestic	$2,500	$0	$2,500
	Subtotal	$2,500	$0	$2,500
D.	TOTAL DIRECT COSTS	$31,833	$8,893	$40,726
E.	MODIFIED TOTAL DIRECT COSTS @ 50% IDC**	$5,256	$0	$5,256
	MODIFIED TOTAL DIRECT COSTS @ 50.5% IDC	$15,767	$5,491	$21,258
F.	INDIRECT COSTS - 50% of E***	2,628	0	2,628
	INDIRECT COSTS - 50.5% of E	7,962	2,773	10,735
G.	**TOTAL AMOUNT REQUESTED (Lines D + F)**	**$42,423**	**$11,666**	**$54,089**

*student has own health insurance
**Line D not including B2
***Effective July 1, 2017 the IDC rate becomes 50.5%

H.	*COST SHARE - THIRD PARTY (GI BILL)*			
1.	*Tuition*	*$21,670*	*0*	*$21,670*
2.	*Stipend*	*20,488*	*0*	*20,488*
3.	*Supplies*	*1,125*	*0*	*1,125*
	Subtotal	*$43,283*	*$0*	*$43,283*

TASK 1 – Cost estimate collection

Description of Task

The optimization model uses costs associated with reservoir expansion and new reservoir construction. However, site-specific information is not known a priori. For example, our model considers all available locations for new reservoir construction. However, each location may be quite different to consider; one location may have higher permitting fees versus another location that may require more infrastructure. In order to obtain a cost estimate that incorporates this unknown disparity, several cost estimates shall be obtained in order to produce a median value for use in the optimization model.

Method/Procedure

All cost estimates shall come from like projects in Colorado or other similar environments and be gleaned from Environmental Impact Studies produced by the Army Corps of Engineers, Bureau of Reclamation or other like entity.

Deliverable

These costs shall be incorporated into the model mentioned in task 5.

TASK 2 – StateMod flow data preparation

Description of Task

Flow data shall be produced using all available time periods in StateMod.

Method/Procedure

StateMod will be used on all available time periods to simulate flow data. This data will be converted from standard StateMod .xdd file output, into a format compatible with the optimization model.

Deliverable

A correctly formatted data file for use in task 5.

TASK 3 – Feasible underground storage site collection

Description of Task

Underground storage is not possible in all locations because of the underlying geology. So, all possible locations must be determined.

Method/Procedure

All locations for underground storage will be extracted from the CWCB Underground Water Storage Study.

Deliverable

These locations shall be incorporated into the model mentioned in task 5.

TASK 4 – StateMod—Optimization model interface development

Description of Task

In order to ensure the optimal solutions produced by the model mentioned in task 5 are feasible, the solution/s needs to be plugged back in to StateMod for verification.

Method/Procedure

The iterative process of collecting data produced by simulation, running the optimization model, evaluating the solution and plugging the solution back in to StateMod shall be evaluated.

TASK 5 – Mixed integer-linear optimization model development

Description of Task

Develop a mixed integer-linear optimization model that uses flow produced by StateMod to determine the optimal location for additional water storage along the Lower South Platte River, between the Kersey Gage and the Nebraska border. This model shall include as options: (1) expanding existing reservoirs by dredging and dam raising, (2) constructing new surface reservoirs and (3) constructing underground storage. A minimum cost solution may include filling the reservoir naturally or pumping from a downstream location. This model shall be constrained based on physical, topographical and geological information which describes the lower South Platte region.

Method/Procedure

The optimization model will be developed in accordance with accepted standards of practice within the Applied Mathematics, Industrial Engineering and Operations Research communities.

Deliverable

Functional optimization model that produces an optimal solution using flow data produced by StateMod.

REPORTING AND FINAL DELIVERABLE

Reporting: The applicant shall provide the CWCB a progress report every 6 months, beginning from the date of the executed contract. The progress report shall describe the completion or partial completion of the tasks identified in the statement of work including a description of any major issues that have occurred and any corrective action taken to address these issues.

Final Deliverable: At completion of the project, the applicant shall provide the CWCB a final report that summarizes the project and documents how the project was completed. This report may contain photographs, summaries of meetings and engineering reports/designs.

BUDGET

Provide a detailed budget by task including number of hours and rates for labor and unit costs for other direct costs (i.e. mileage, $/unit of material for construction, etc.). A detailed and perfectly balanced budget that shows all costs is required for the State's contracting and purchase order processes. Sample budget tables are provided below. Please note that these budget tables are examples and will need to be adapted to fit each individual application. Tasks should correspond to the tasks described above.

Total Costs				
	Labor	Other Direct/Indirect Costs	Matching Funds	Total Project Costs
Task 1 - Cost estimate collection	$2,401.40	$6,015.00	$8,656.60	$17,073.00
Task 2 - StateMod flow data preparation	$2,401.40	$6,015.00	$8,656.60	$17,073.00
Task 3 - Feasible underground storage site collection	$2,401.40	$6,015.00	$8,656.60	$17,073.00
Task 4 - Optimization model interface development	$2,401.40	$6,015.00	$8,656.60	$17,073.00
Task 5 - Mixed integer-linear optimization model development	$14,408.40	$6,015.00	$8,656.60	$29,080.00
Total Costs:	$24,014.00	$30,075.00	$43,283.00	$97,372.00

Project Personnel: Hourly Rate:	PhD Student $16.985	Faculty Advisor $80.54	Total Costs $97.525
All Tasks	1300	24	
Total Hours:	1300	24	
Cost:	$22,081.00	$1,933.00	$24,014.00

* Hourly rates are shown per the sponsor's request. Please be aware that CSM employees are not generally paid on an hourly basis, and invoices for work performed will not show hourly rates.

SCHEDULE

1. Task 5 milestones:
   i. Cost estimate completion, 7/17
   ii. Underground storage site collection completion, 9/17
   iii. StateMod flow data preparation completion, 1/18
   iv. Model completion 5/18

2. Task 4 milestone:
   i. Interface development completion, 3/18

Task	4/17--7/17				8/17--11/17				12/17--3/18				4/18--6/18			
Task 1																
Task 2																
Task 3																
Task 4																
Task 5																
Final Reports																

Exhibit B

As a ***proof of concept***, a basic optimization model was developed which used StateMod as a data source for the purposes of designing new water storage along the Lower South Platte River. Our basic model only considered existing reservoir expansion (dam raising only, no dredging) and new reservoir construction as the means for this additional storage.

The flow used in our model was simulated by StateMod at multiple points only the 150-mile reach between Greeley and the Nebraska border (Figure 1).

Figure 1: Points at which StateMod simulates flow

Data was used for August and September of 2011, which produced shortages of 4684 AF and 1854 AF, respectively. Costs used for new reservoir construction and existing reservoir expansion were $3,128/AF and $2,226/AF, respectively. In this case study, it was assumed that all unappropriated water could be used to meet any shortages. The final solution suggests that expanded capacity at either Empire Reservoir or Riverside Reservoir (Figure 2) by 632 AF mitigates shortages during this time period.

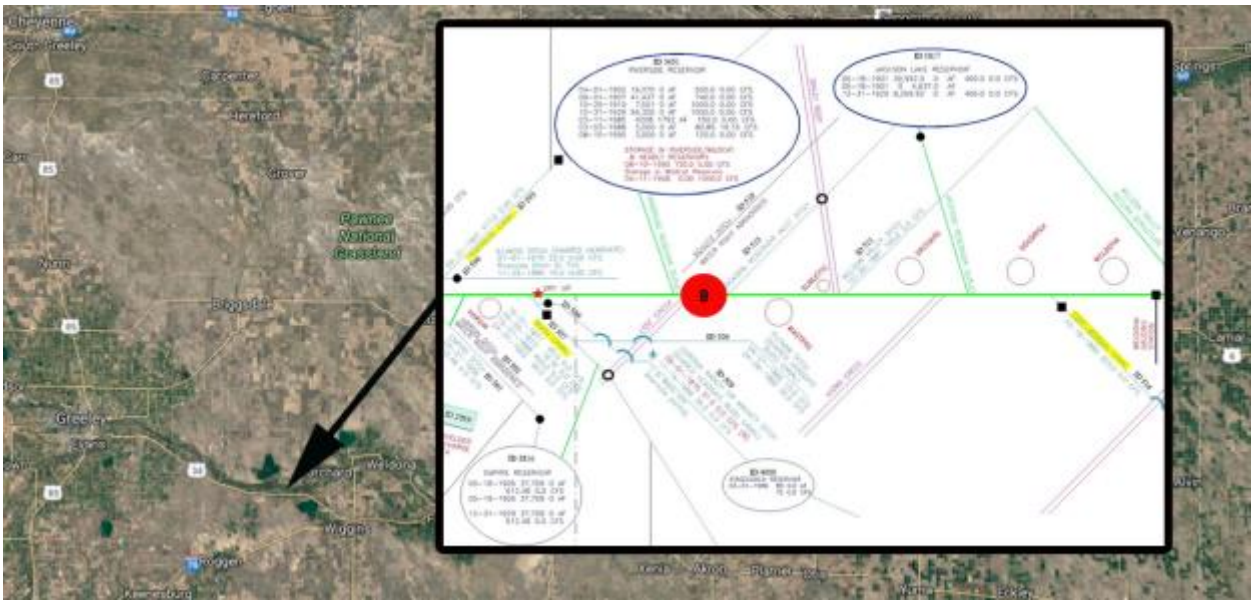


Figure 2: Expanded capacity location along the Lower South Platte

STATE OF COLORADO

Godbout - DNR, Craig <craig.godbout@state.co.us>

Budget Cut

1 message

Andrew David Burrow <aburrow@mymail.mines.edu> Wed, Feb 15, 2017 at 3:48 PM
To: craig.godbout@state.co.us

Craig,

As per our conversation, the $3159.00 that will be cut from our requested budget will be replaced using student loans.

Andy