Southeastern Colorado Water Conservancy District
Board of Directors Meeting

COLORADO RIVER ISSUES STATUS
Monthly/Quarterly Report

Date: August 19, 2021 **Agenda Item:** VI.D

STAFF RECOMMENDATIONS:
Information

BUDGET IMPLICATIONS:
Information

PREVIOUS BOARD ACTION AND/OR ACTIVITY:
Information

ISSUE SUMMARY DESCRIPTION:
Following nearly two years of stakeholder discussions and input from Coloradans across the state and from various sectors, the Colorado Water Conservation Board (CWCB) released a draft Demand Management Framework. The Framework captures threshold issues; implementation options; and proportionality, fairness, and equity considerations. A copy of the framework was attached to the May 20, 2021, Colorado River Issues Status Report.

During May and June 2021, the CWCB scheduled several virtual events to ask questions and provide input on the Framework, culminating in a Demand Management Public Listening Session on June 29, 2021. CWCB staff tracked the input received and presented findings to the Board during the July 21, 2021, CWCB meeting. CWCB Staff's memo and summary findings are attached. CWCB staff has scheduled a CWCB Member workshop for August 18, 2021, as follow up to this presentation.

Discussions in the Colorado Water Congress Colorado River Project Executive Committee have focused principally on funding for the recovery program in the post-2023 time frame. The 2000 original authorizing legislation included capital funding by the four states of $17 million and $17 million by the power customers. The states propose to re-examine their monetary capital contributions in 10 years. Reclamation has not commented on the states' proposal to date.

The states have proposed to deal with each proposed capital project to determine if sources of nonfederal funding can be identified for the project that would reduce the amount needed from congressional appropriations. This has occurred over the last 20 years, wherein the states of Colorado and Utah have contributed funds beyond their commitment in the authorizing legislation and nongovernmental organizations have also contributed funds to at least one project. Other contributions that will be considered and brought to the attention Congress are

the very substantial non-monetary contributions to the recovery programs by the nonfederal partners, including, for example, the substantial contributions water by water users to the 15-mile reach. There are many other non-monetary contributions by states, water users and NGOs.

Regarding annual funding, the recovery programs' staffs propose an increase in annual funding of $3.8 million per year over above current levels. The states have proposed all annual funding, except for continuing approximately $450,000 per year from Colorado, Utah, and Wyoming, be provided by congressional appropriations to Reclamation, given the unreliability of hydropower funding in the future. There has not been a federal response to the states' proposal. Given concerns regarding the success of this proposal, the Executive Committee has indicated an interest in further discussions of proposals to make voluntary contributions. Tom Pitts, who manages the CWC Colorado River Project, said that contributions by the Executive Committee or other water users could not make up the lost funding from hydropower revenues but believe that it would be looked upon very favorably by Congress and the federal participants as nonfederal cost sharing contributions. District staff is participating in these discussions, and at an appropriate time will provide information to the Finance Committee and the Colorado River and Water Supply Committee on these discussions.

The Colorado River and Water Supply Committee has set a schedule to meet following the Board meeting every three months. The next meeting is scheduled for October and appears on the District's master calendar.

SUGGESTED MOTION:

Information

ATTACHMENTS:

1. Memo to Colorado Water Conservation Board Members from Amy Ostdiek dated July 21, 2021, regarding Demand Management Feasibility Investigation Update

COLORADO
Colorado Water Conservation Board
Department of Natural Resources

1313 Sherman Street, Room 718
Denver, CO 80203

P (303) 866-3441
F (303) 866-4474

Jared Polis, Governor

Dan Gibbs, DNR Executive Director

Rebecca Mitchell, CWCB Director

TO: Colorado Water Conservation Board Members

FROM: Amy Ostdiek

DATE: July 21, 2021

SUBJECT: Agenda Item 14: Demand Management Feasibility Investigation Update

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Staff recommendation:

Staff recommends that the Board adopt the Demand Management decision-making roadmap attached hereto as Exhibit A.

Background

The Upper Basin States of the Colorado River Basin are currently investigating the feasibility of a potential Demand Management program. Demand Management is the concept of temporary, voluntary, and compensated reductions in consumptive use. The conserved water would be used to ensure ongoing compliance with the 1922 Colorado River Compact. The Demand Management Storage Agreement, one element of the 2019 Drought Contingency Plan (DCP), provides the authorization for the Upper Division States to store water created pursuant to a Demand Management program in Lake Powell. The water would only be used for Compact compliance purposes at the direction of the Upper Colorado River Commission. Whether a program is established and how such a program would operate are still open questions. Each Upper Division State must make an initial determination that Demand Management is feasible before moving forward with creating a potential program.

The mission of the Colorado Water Conservation Board is to conserve, develop, protect, and manage Colorado's water for present and future generations. In carrying out this mission, CWCB is the agency authorized to determine whether Demand Management is feasible for Colorado. Following adoption of the DCP in March 2019 and after significant discussion by the Board and key stakeholders, the CWCB Board adopted the 2019 Work Plan to help guide the initial stage of the feasibility investigation. This work was focused on identifying key threshold issues associated with a potential Demand Management program. Pursuant to the 2019 Work Plan, staff convened workgroups that met throughout the 2019-2020 Fiscal Year. Staff provided regular updates to the Board and received guidance and input throughout the implementation of the 2019 Work Plan. A summary of work completed pursuant to the 2019 Work Plan is available in the July 2020 update to the Board.

Following Board discussion through workshops and Board meetings, the Board adopted the Step II Work Plan in November 2020. In this Work Plan, the Board directed staff to develop a framework of a Demand Management program, to be used to generate discussion about potential Demand Management program design and a range of potential implementation options. Staff developed the draft framework in early 2021, then engaged a wide range of stakeholders to solicit feedback on the framework, including through workshops, updates, and other outreach as detailed in the Step II Work Plan. Staff has provided regular updates to the Board throughout implementation of the Step II Work Plan.

Additionally, during this time the literature review was completed pursuant to Board guidance both through the 2019 Work Plan and pursuant to the Step II Work Plan direction to "[a]nalyze and learn from existing, ongoing, and/or new programs and projects." The process was designed to collect as much information as possible to inform the Board's discussion and process for the Demand Management Feasibility Investigation in July 2021 and beyond.

Status Update on Implementation of Step II Work Plan

The framework was released in March 2021, and from March - June 2021, staff conducted public outreach regarding the framework, including:

- *Six workgroup meetings:* Staff conducting meetings with six of the workgroups previously convened pursuant to the 2019 Work Plan to receive input on whether workgroup members' input is adequately captured in the framework.
- *Nine Basin Roundtable meetings:* Staff presented to and requested input from the nine Basin Roundtables.
- *IBCC meetings and input:* Staff presented to the Interbasin Compact Committee on the framework and solicited specific input on the Framework. Staff plans to facilitate continued discussion at the October IBCC meeting.
- *Three public workshops:* Staff hosted three public workshops to receive input on the framework, each focused on specific subject matters.
- *Public listening session:* Staff hosted a public listening session to receive additional input on the framework.
- *EngageCWCB Survey:* Staff developed an informational website and a survey soliciting feedback on the framework.
- *Demand Management informational video (to be released):* Staff worked with a consultant to develop an informational video regarding Demand Management to reach those who may be interested but have been unable to attend previous meetings or may not otherwise be involved in the discussion at this time. This yet-to-be-released video directs viewers to CWCB's website for more information and to learn how to engage.
- *Additional presentations as requested*: In addition to the above-referenced items, staff also presented the framework and provided opportunities for discussion and input upon request.
- *Written input*: Staff also invited written comments relating to the framework.

All input received on the Framework to date is provided in Exhibit B to this memo. Note that input received through workshops and public meetings is captured in summaries, as well as directly in the attached framework through comment bubbles.

Additionally, throughout this process, staff has worked with a team of consultants to achieve the following public outreach and engagement tasks, pursuant to the Step II Work Plan:

- Developed a communications toolkit designed to assist Demand Management messaging, provided electronically to the Board members previously.
- Developed strategies to make better use of various communications networks, including but not limited to social media, improved graphics and informational documents, and use of informational videos.
- Developed a database of stakeholders who have provided input, attended meetings, or otherwise shown interest in the Demand Management Feasibility Investigation, which will be used going forward to distribute information and solicit feedback on the ongoing feasibility investigation.
- Ongoing and continued engagement with Tribal Nations regarding Demand Management and the Framework on a sovereign-to-sovereign basis.

Context for Decision Making

In the Step II Work Plan, the Board adopted a lens through which to make decisions relating to Demand Management feasibility. The Work Plan breaks the feasibility question into three sub-questions:

(1) *Achievability:* The focus of this inquiry is whether it is technically possible to achieve a functioning Demand Management program within Colorado, and contemplates questions such as whether it is possible to verify and track water conservation, whether there are mechanisms available to track environmental benefits and impacts, whether it is possible to develop an appropriately robust outreach plan for a potential Demand Management program, and whether a funding source may be available.

(2) *Worthwhile for Colorado:* The focus of this inquiry is whether - even if a program is technically achievable - it is worthwhile from Colorado's perspective. The scope of this question includes whether a Demand Management program may be established in a way that is proportional and equitable and avoids or mitigates unacceptable adverse impacts within the state.

(3) *Advisability:* The focus of this inquiry is whether it is advisable for Colorado to make a feasibility determination within the broader context of Colorado River issues and strategy. This is a determination that will likely incorporate input from other states and the Upper Colorado River Commission, and therefore will be an evolving analysis. Given the quickly changing circumstances and ongoing investigation by the Upper Colorado River Commission, this determination would likely be made at the point in time after the first two questions are considered.

Next Steps

Roadmap for decision making

Within this context, the purpose of this agenda item is to discuss a potential roadmap for Board decision making to assist the Board in progressing in the Demand Management feasibility investigation. Staff suggests that the Board adopt the decision-making roadmap

attached as Exhibit A. As shown in this roadmap, staff suggests the questions relating to achievability be considered first, followed by questions relating to whether a Demand Management program may be worthwhile from Colorado's perspective, noting that answers to the "achievability" questions may help to frame and inform the analysis of whether Demand Management may be advisable.

In considering the attached roadmap for decision making, the Board may consider the following questions:

(1) Does this roadmap adequately capture and organize the key milestones you envision in board decision making relating to Demand Management?

(2) In considering the categories of decisions to be made relating to achievability, what are some specific questions you believe need to be answered relating to each subject in order to determine whether Demand Management is achievable for Colorado?

(3) In considering the potential decisions to be made in the future, what are your thoughts on appropriate timing of decision-making?

Resources to support decision making

In addition to information and resources previously provided, the following items are attached hereto, designed to assist the Board in its decision-making process:

Input received to date on the Framework (Exhibit B)
Literature review completed by the consultant team (Exhibit C)

Colorado Water Conservation Board
Demand Management Feasibility Investigation
Exhibit A - DRAFT Roadmap for Decision Making
July 2021

Achievability
[*Tentatively to begin September 2021; subject to change]*

- □ *Monitoring & Verification*: is it technically possible to monitor and verify conserved consumptive use within Colorado as required for a potential Demand Management program? - *Tentatively September 2021*
- □ *Environmental Considerations*: is it technically possible to track and monitor potential environmental impacts and benefits? - *Tentatively September 2021*
- □ *Education & Outreach*: is it possible to develop an outreach plan for a Demand Management program that would increase general water education, motivate participation in the program, and help to inform program design? - *Tentatively September 2021*
- □ *Funding*: given the above determinations, is it possible to secure a funding source to pay for a Demand Management program? – *Pending*

Worthwhile for Colorado
[*Tentatively to begin November 2021; subject to change*]

- □ *Proportionality considerations*: Can Colorado establish a Demand Management program that prioritizes avoidance of disproportionate negative economic or environmental impacts to any single subbasin or region within Colorado while protecting the legal rights of water rights holders, consistent with the Board's November 2018 Support and Policy Statement? - *Pending IBCC input to be received in October 2021, informing Board discussion in November 2021 and beyond*
- □ *Analyses and findings of UCRC and other states*: Based on information gained from the UCRC feasibility investigation and those ongoing in the other Upper Division States, would a Demand Management program be worthwhile from Colorado's perspective? - *Investigation ongoing*

EXHIBIT B

Input Received, Spring – Summer 2021

This Exhibit includes various input received on the Framework and the Demand Management Feasibility Investigation generally in Spring-Summer 2021, including meeting summaries, survey responses, letters, and other feedback received. In addition, the final document is the draft Framework with comment bubbles that correspond with specific input heard at public meetings.

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Stakeholder Input

CWCB Demand Management Feasibility Investigation

Spring - Summer 2021

Contents:

Demand Management Workgroup Workshop Meeting Summaries
- Economics and Local Government Workgroup
- Funding Workgroup
- Agricultural Impacts Workgroup
- Environmental Considerations Workgroup
- Monitoring & Verification Workgroup
- Education & Outreach Workgroup

Public Workshop Meeting Summaries
- Demand Management Public Workshop #1
- Demand Management Public Workshop #2
- Demand Management Public Workshop #3

Public Listening Session Meeting Summary

EngageCWCB Survey Responses

Stakeholder Letters

Meeting summaries prepared for CWCB by Emily Zmak, CDR Associates. This document is intended to summarize stakeholder input and does not necessarily represent the views or opinions of CWCB staff or Board.

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Demand Management Workgroup Workshop Meeting Summaries

DEMAND MANAGEMENT FRAMEWORK MEETINGS

Spring 2021

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Colorado Water Conservation Board
Department of Natural Resources

Economics and Local Government Workgroup

DEMAND MANAGEMENT FRAMEWORK MEETING

April 20, 2021 | 12:00 - 1:30p

Version 1 of the draft demand management framework is available for review here.

Discussion Highlights

Following presentations on the demand management framework ("framework") by Amy Ostdiek, CWCB, and Mark Smith, Colorado College, the Economics and Local Government Workgroup ("workgroup") had a facilitated discussion on the content within the workgroup's focus area.

The overall discussion focused on:

- The framework and the elements, trade-offs, and considerations captured within it; and
- Informing the CWCB Board's decision-making process.

Framework Feedback

- It is difficult to present both details and an uncomplicated overview in the same framework.
- The right-hand column could be clarified with a title along the lines of "considerations" or "interconnected issues." Issues should be captured in a consistent and accurate way.
- The A-B-C columns should better illustrate the escalation in complexity.
- "Do no harm" is a guiding principle that should be captured as fundamental to all topics / sections.
- Additional clarity around municipal participation would be helpful.
- Impacts to local government are closely connected to agriculture. The consultation category should capture that agriculture is a key component in addressing community impacts.
- Water efficiency programs may be more disruptive than currently captured in the framework.
- Green spaces are an important consideration to capture.
- Mitigation funds should be directly linked to the sector impacted.
- Iterative mitigation would allow communities to incorporate lessons-learned and/or unexpected impacts into mitigation measures.

Open Questions

- Does surplus water count as consumptive use?
- What criteria should be used to judge whether or not demand management is a good idea?
- What does proportionality mean?
- How much would other agencies be involved in a demand management program?

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Funding Workgroup

DEMAND MANAGEMENT FRAMEWORK MEETING

April 21, 2021 | 10:30 - 12:00

Version 1 of the draft demand management framework is available for review here.

Discussion Highlights

Following presentations on the demand management framework ("framework") by Amy Ostdiek, CWCB, and Brett Bovee, Westwater Research, the Funding Workgroup ("workgroup") had a facilitated discussion on the content captured within the workgroup's focus area.

The overall discussion focused on:

- The framework and the elements, trade-offs, and considerations captured within it; and
- Informing the CWCB Board's decision-making process.

Framework Feedback

- Consider clarifying the budgets' inclusion of one-time costs and early investments.
- Both fees and taxes should be considered as funding sources.
- Federal investments could be captured in the commentary as a potential funding source.
- The current presentation of costs begs the question, "Why would you pay more for the same amount of water?" The framework could articulate that the B- and C-columns fund worthwhile secondary benefits, such as consistency and mitigation. Attractive program components may have additional costs.
- There should be an expansive consideration of financing and funding, such as looking towards supply chains to broaden the pool of fee-payers.
- Costs should be considered on a perpetual basis, not solely an annual or near-term basis.
- Municipal participants would need to consider revenues and possible rate pressures, which would have impacts on low income communities and raise issues like bill affordability and customer assistance.
- Cost equity could be captured. There are different impacts and benefits to different geographies, water consumers, and economies.
- The framework could capture opportunity costs. Understanding opportunity costs could help clarify whether an entity should participate or not.

Open Questions

- How expansive are the references to "water users"? Direct users, secondary users?
- What is the optimum program? Defining that would be helpful in considering financing.
- Can the demand management model be built in a way that it is transferable to other Basins?
- What is the benefit for the cost and effort of the program?

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Agricultural Impacts Workgroup

DEMAND MANAGEMENT FRAMEWORK MEETING

April 22, 2021 | 10:00 - 11:30a

MEETING PURPOSE: To ensure that the framework responds to workgroup members' initial feedback, and to solicit additional input on framework elements.

Version 1 of the draft demand management framework is available for review here.

Discussion Highlights

Following presentations on the demand management framework ("framework") by Amy Ostdiek, CWCB, and Brett Bovee, Westwater Research, the Agricultural Impacts Workgroup ("workgroup") had a facilitated discussion on the content captured within the workgroup's focus area.

The overall discussion focused on:

- The framework and the elements, trade-offs, and considerations captured within it; and
- Informing the CWCB Board's decision-making process.

Framework Feedback

- □ Communicate the range of options' pros and cons, as well as financial and opportunity costs
- □ Consider addressing holistic sustainability and resiliency to future impacts within the framework
- □ A demand management program should treat producers fairly
- □ Consider intra-system impacts to ensure that nonparticipants are unaffected
- □ Pre-existing procedures, operations, and governance requirements for irrigation providers are constraints that a program would work within; for example, not all systems have individual water rights
- □ System compensation is an important consideration, although is only represented in Column C
- □ Soil health is a potential secondary benefit. The state could provide optional techniques or technical services to producers for improving soil health during fallowing. This could be a participation incentive.
- □ While the framework recognizes legal damages, it does not mention inconveniences. Someone will always be inconvenienced; early engagement could mitigate non-damaging impacts.
- □ Local benefit will stem from farmer compensation. Development funds could build and support agricultural economies, although the majority of the money should go to the program participants.
- □ Not all potential participants will be appropriate participants.

Open Questions

- □ Will there be a mandatory crop type to prevent further landscape damage?
- □ How much will be paid to producers?
- □ Who pays for technical assistance offered to program participants?

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Environmental Considerations Workgroup

DEMAND MANAGEMENT FRAMEWORK MEETING

April 26, 2021 | 2:00 - 3:30p

MEETING PURPOSE: To ensure that the framework responds to workgroup members' initial feedback, and to solicit additional input on framework elements.

Version 1 of the draft demand management framework is available for review here.

Discussion Highlights

Following presentations on the demand management framework ("framework") by Amy Ostdiek, CWCB, and Jordan Dimick and Bailey Leppek, SGM Engineering, the Environmental Considerations Workgroup ("workgroup") had a facilitated discussion on the content captured within the workgroup's focus area.

The overall discussion focused on:

- The framework and the elements, trade-offs, and considerations captured within it; and
- Informing the CWCB Board's decision-making process.

Framework Feedback

- □ The framework is a useful tool for evaluating trade-offs
- □ A successful program would provide resilience for the environment and recognize holistic environmental benefits
- □ Proportionality and fairness should be linked to discussions about water and costs
- □ Assessing net benefit should work within existing local environmental rules and guidance
- □ A long-term program will evaluate environmental benefit / impact through a different lens than a short-term program; for example, the timing of flows matters more in a long-term program
- □ Review language for implications or assumptions of adverse risk caused by some participants
- □ The value of water will factor into the proportionality discussion, and the more complicated the program, the more financially difficult it will be to launch the program

Open Questions

- □ What long-term programmatic options exist outside of the drought contingency plan timeframe?
- □ How can a demand management program be linked to other state programs to achieve win-win outcomes for environmental benefit?

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Monitoring & Verification Workgroup

DEMAND MANAGEMENT FRAMEWORK MEETING

April 30, 2021 | 12:00 - 1:30p

MEETING PURPOSE: To ensure that the framework responds to workgroup members' initial feedback, and to solicit additional input on framework elements.

Version 1 of the draft demand management framework is available for review here.

Discussion Highlights

Following presentations on the demand management framework ("framework") by Amy Ostdiek, CWCB, and Jordan Dimick, SGM Engineering, the Monitoring and Verification Workgroup ("workgroup") had a facilitated discussion on the content captured within the workgroup's focus area.

The overall discussion focused on:

- The framework and the elements, trade-offs, and considerations captured within it; and
- Informing the CWCB Board's decision-making process.

Framework Feedback

- Interconnected issues include potential environmental benefits, transmountain diversion projects, and agricultural techniques like deficit irrigation.
- The purpose of monitoring and verification is to accurately quantify what wet water has been added to the system, so functionality, accuracy, and efficacy are key themes.
- The references to time are not as accurate when referring to historical diversion rates. Consider taking out the "or" in the cell discussing bypass diversions, because of the potential disconnect between CCU on the west slope and historical diversion rates.
- Terms benefit from careful definitions. For example, conserved consumptive use may mean different things when discussing CCU in the Colorado River system or on the East Slope.
- Monitoring and verification in multiple systems is complex, and considerations include historic canal losses, potential telemetry, and field return flows.
- There are a variety of tools and resources available to potential DM participants.
- Grounding the A-B-C columns in hypotheticals would help to build more detail and illustrate a program.
- Equity considerations are less applicable to monitoring and verification than other workgroup topics.
- Consider building options for future participation from other sectors, like industry or environmental.
- Column A approaches to monitoring and verification may be too simplistic for many DM programs.

Open Questions

- How will pilot programs inform the framework?

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Department of Natural Resources

Education & Outreach Workgroup

DEMAND MANAGEMENT FRAMEWORK MEETING

May 3, 2021 | 1:30 - 3:00p

MEETING PURPOSE: To ensure that the framework responds to workgroup members' initial feedback, and to solicit additional input on framework elements.

Version 1 of the draft demand management framework is available for review here.

Discussion Highlights

Following presentations on the demand management framework ("framework") by Amy Ostdiek, CWCB, and Emily Zmak, CDR Associates, the Education and Outreach Workgroup ("workgroup") had a facilitated discussion on the content captured within the workgroup's focus area.

The overall discussion focused on:

- The framework and the elements, trade-offs, and considerations captured within it; and
- Informing the CWCB Board's decision-making process.

Framework Feedback

- □ Clarify messaging around purpose, motivation, and objectives.
- □ Outreach should give a clearer sense of the options to illustrate what implementation would look like.
- □ With a statewide program, messaging outside of Column C would be difficult because of the scale.
- □ Consider adding additional detail to capture the increasing complexities for message development. The range could capture the basic process for message development; and at a higher level, message specificity for certain geographies or target demographics.
- □ Education and outreach should identify target audiences for different messages. This process could include co-developing messages with the target audiences.
- □ A feedback loop will build trust and develop a better program.
- □ While the general public could benefit from general water education about curtailment and drought, targeted audiences should be DM program participants and other impacted stakeholders.
- □ Simplifying the framework's presentation would assist with engagement and interpretability.
- □ The framework does not capture the "why" (advisability) nor climate change.
- □ Frame issues around shared values, such as individual agency and the program's facilitation of choice.

Open Questions

- □ How are impacts being communicated? To what level of detail?
- □ How do messages change by audience and geography?

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Department of Natural Resources

Public Workshop Meeting Summaries

DEMAND MANAGEMENT FEASIBILITY INVESTIGATION

June 2021

COLORADO
Colorado Water Conservation Board
Department of Natural Resources

Demand Management Public Workshop #1

PUBLIC WORKSHOP MEETING #1

June 1, 2021 | 1:00 - 2:30p

Discussion Highlights

Following presentations on the Demand Management Framework ("Framework") by Amy Ostdiek, CWCB; the Monitoring & Verification section by Jordan Dimick, SGM; and the Environmental Considerations category by Bailey Leppek, SMG; the Public Workshop #1 had a facilitated discussion on the Framework categories Monitoring & Verification ("M&V") and Environmental Considerations.

Framework Feedback

- Participants' priority considerations included: creating a truly voluntary program; ensuring effectiveness; balancing accuracy and implementability; and maximizing benefits to environment
- Concern that M&V is complicated enough without combining it with the issue of proportionality
- Consider clarifying the language regarding municipalities on the West and East Slopes
- Broad concern for understanding how this framework is going to inform the CWCB decision-making and implementation processes
- Shift to hypotheticals to illustrate what requirements might be for each category
- Broaden the lens to include West Slope municipalities and industrial water users
- Concern about the significant costs of issues-management
- Define what shepherding water from remote and/or rural locations to the state line looks like
- Consider other options for incentivizing environmental benefits
- The state could consider a minimum and more robust requirement for environment
- Considering equity and proportionality in M&V adds an additional, complicated layer
- Gaps in the framework include the state's process for shepherding water; clarity on state measurement rules or mechanisms; and pilots to address transmountain projects and environmental impacts
- Incorporate relative time, accuracy, and costs into the Framework's A-B-C options
- Concern that incentives are shifting away from compact compliance and toward environmental benefit

Open Questions

- How to connect the Framework to decision-making and implementation at the CWCB?
- How does the Demand Management program work in different locations and elevations?
- How will the Board make decisions about the A, B, and C columns? And how does the Framework inform feasibility?
- How could a program incentivize a C-column approach to the environment without or beyond money?
- What does the cost look like? Where does the funding come from?
- What is the process for shepherding water to the state line?

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Department of Natural Resources

Demand Management Public Workshop #2

PUBLIC WORKSHOP MEETING #2

June 14, 2021 | 11:30 - 1:00p

Discussion Highlights

Following presentations on the Demand Management Framework ("Framework") by Amy Ostdiek, CWCB; the Economic Impacts & Local Governments section by Brett Bovee, WestWater Research; and the Agricultural Impacts section by Angie Fowler, SGM; the Public Workshop #2 had a facilitated discussion on the Framework categories Economic Impacts & Local Governments and Agricultural Impacts.

Framework Feedback

- Provide technical details about what Demand Management would encompass and look like in application, specifically for farmers and ranchers in the Colorado River Basin
- Interest in exploring the legal details of Demand Management in the Framework
- Concern about how to address claims of injury and how to prevent injury
- Consider defining alternative or innovative incentives for Demand Management participants beyond money, especially for municipalities
- Define the long-term implications for rural communities and the impacts to the agricultural sector
- Consider storing water in reservoirs within the state, rather directly in Lake Powell, to provide more internal control
- Develop clear direction for next steps and approach
- If participants are going to give up water for a few years, they need assurance that the program will provide insurance from curtailment
- Desire for a program to align with growing season schedules and ranch operations
- Impacts will likely be very localized and specific, so the Framework should include a process to evaluate and resolve local impacts in a responsive manner
- Consider secondary impacts of a program, such as health care

Open Questions

- How to ensure that one sector or region doesn't bear all the burden?
- How best to prepare water users for the new normal of water scarcity?
- What are the considerations and agreements that must be reached with the other Upper Basin states that are not encompassed by the Framework?
- Would the Demand Management program work with other state agencies?
- How is Demand Management different from existing programs like the ATM program?
- How is CWCB considering abandonment or speculation issues of water rights?
- Can other people object to an applicant's Demand Management application?
- How will the pricing of water work?
- What does "temporary" entail (years, months)?

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Colorado Water Conservation Board
Department of Natural Resources

Demand Management Public Workshop #3

PUBLIC WORKSHOP MEETING #3

June 14, 2021 | 1:30 - 3:00p

Discussion Highlights

Following presentations on the Demand Management Framework ("Framework") by Amy Ostdiek, CWCB; and the Education & Outreach and Process Consideration sections by Emily Zmak, CDR Associates, the Public Workshop #3 had a facilitated discussion on the Framework categories Education & Outreach and Process Considerations.

Framework Feedback

- Foster broader understanding for water providers and users about Demand Management's purpose and goals
- Turn the Framework into action through clearly-defined next steps and process clarity, and push up the contingent decision
- Define and articulate the problem of compact curtailment as the alternative to Demand Management
- Engage actual water users to better understand problems and obstacles for potential participants, which may require making the process more clearly defined
- Be intentional in special engagement with the Ute Tribe
- Create Spanish-language newsletters and informational documents about Demand Management, and partner with Latino organizations to assist with translation and messaging
- Add specificity about the audiences that should be targeted for outreach to better define the goals
- Stakeholder education needs to be informed by a real process, data, and programmatic information
- Group consensus that Column C in Process Considerations is needed to mitigate user concerns and ensure program success
- Incorporate process transparency with the public, especially around lessons-learned and successes
- Include a technical state role or service to help water users apply and develop applications

Open Questions

- Where are the other Upper Basin States in their processes?
- What is the worst-case scenario without Demand Management?
- Who are the key audiences, and what are the messages those audiences need to hear?
- How to engage water users to inform the planning process?
- How to reach stakeholders who have not shown up to CWCB's engagement opportunities?
- How do we communicate water and water challenges with diverse and historically underserved populations?

COLORADO
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Department of Natural Resources

Public Listening Session Meeting Summary

DEMAND MANAGEMENT FEASIBILITY INVESTIGATION

June 29, 2021

Discussion Preface

Following brief presentations on the Demand Management process by Greg Johnson, CWCB, and Emily Zmak, CDR Associates, meeting participants provided comment about the Demand Management framework; the work done to date; organizational positions pertaining to the proposed Demand Management program; and/or personal thoughts and reactions to the concept of Demand Management. Comments were limited to five minutes per participant, and were otherwise unrestricted.

Participants were encouraged to submit written comment in addition to the statements summarized below.

Comment Summaries

Aaron Citron, The Nature Conservancy

- Recognizing the ongoing bad hydrology and need for cohesive Colorado River policy, he encourages CWCB to pursue Demand Management as a critical piece in a suite of tools to address Colorado River issues
- Encourages CWCB to capture trade-offs in the framework document and to include sideboards to benefit rivers, protect communities, and ensure proportionality
- Advocates for advancing policies that would build a Demand Management program, which could include pilots and demonstrations to illustrate how a program could function

Mark Harris, Grand Valley Water Users

- He believes that the process to-date and the Demand Management framework have adequately captured the concept of Demand Management
- Now that the initial work is done, it is time to answer questions like, “So what?” and “What now?” Encourages CWCB to try a compensated, voluntary, and temporary program.
- Believes that many farmers, ranchers, and their organizations are willing to find solutions
- Supports CWCB’s identification of practical solutions, and believes that trying something new is the best way to answer the important questions
- Urges CWCB to articulate the next steps in the Demand Management process and develop a timeline

Tom Gray, Yampa/White/Green Basin Roundtable

- Are there hard parameters or sideboards about what Demand Management would look like and, if not, when will the hard parameters begin to be established? Encourages the development of hard statements for people to grapple with and respond to.
- Will staff make a recommendation to the Board about next steps?

Don West, Colorado Water Exchange

- Regarding the Monitoring and Verification section of the Framework, he advocates for a combination of the A and B Columns
- Is comfortable with the state's Lease Fallow tool, probably in Column B
- Encourages transparency around crop coefficients; in particular, taking a statement like, "For this program, the state will use X crop coefficient with Y elevation adjustments."
- What is the role of municipalities in conserved consumptive use? The framework focuses on the agricultural aspect.

Alden Vanden Brink, White River

- He believes that Demand Management adds to the crisis, and that it adds a target on agriculture
- The White River has depended on flood irrigation and artificial recharge for more than 100 years
- Encourages developing more reservoir space to alleviate compounding pressures on the White
- Would like a no-injury clause to protect White River users

Jeff Meyers, Yampa/White/Green Basin Roundtable

- He believes that motivation to deal with the drought is strong
- The framework document is valuable; however, the detail, complexity, and presentation means it is not the most accessible document
- Encourages CWCB to include language in the framework that defines equity as a means of ensuring all Colorado basins participate on an equitable basis
- A key issue is return flow, namely the ecosystem benefits of flood irrigation
- Feels that there is not a lot of knowledge about what Demand Management might mean or how seriously the hydrology is, so sees education and outreach as critical in this process
- Would be helpful to know from the State Engineer what curtailment might look like

Abby Burk, Audubon

- Both birds and people dependent on the Colorado River have been impacted by water supplies
- Demand Management is an alternative to curtailment and provides flexibility for Colorado
- Audubon is supportive of a Demand Management program to protect Colorado and other water users, and to yield environmental benefits; encourages CWCB to move forward and avoid delays
- Believes the framework is a good start: the next step is to evaluate the trade offs and develop a program that can be one tool in the toolbox

Austin Vincent, Colorado Farm Bureau

- Agriculture is one of the state's largest economies, especially on the West Slope and in rural areas
- Wants to help find the solution to western water supplies and to avoid risk of curtailment
- Colorado Farm Bureau supports temporary, voluntary, and compensated programs that share the load with municipal, in-stream, environmental, and recreational flows
- Wants to have attainable goals that supports producers and creates a practical program
- Encourages CWCB to use existing programs and state agencies in a Demand Management program
- Encourages CWCB to expand education and outreach with farmers / producers on the West Slope

Orla Bannan, Western Resource Advocates

- Has submitted written comments to CWCB
- Sees the need for urgent action because of the bad hydrology
- Encourages CWCB to look for next steps and find win-win environmental benefits

Chris Treese, ret. Colorado River District, consulting with Southwest Colorado River District

- Has submitted written comments to CWCB from the Southwest Colorado River District Board
- Characterizes the Southwest guidelines as skeptical-but-constructive, and articulates a commitment by their Board to remain engaged in Demand Management discussions
- Principally concerned with protecting agriculture and ensuring that a Demand Management program not target agriculture, nor encourage speculation in Western Colorado's agricultural waters
- Remains mindful of the consequences of both a Demand Management program and compact administration, which is not equitable, compensated, nor voluntary

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EngageCWCB Survey Responses

DEMAND MANAGEMENT FEASIBILITY INVESTIGATION

Engage CWCB Survey Responses

Questions					
What river basins are you interested in?	Southwest River Basin	Southwest River Basin	Yampa-White-Green River Basin	Colorado River Basin	Arkansas River Basin Colorado River Basin Gunnison-Uncompahgre River Basin North Platte River Basin Rio Grande River Basin South Platte River Basin Southwest River Basin Yampa-White-Green River Basin
From your perspective, Demand Management (select all that apply):					
Would benefit agricultural water users overall.	X	X		X	
Would hurt agricultural water users overall.			X		
Would benefit urban water users overall.	X	X			
Would hurt urban water users overall.			X		
Is an opportunity for the entire state to collaborate for the benefit of the Colorado River.		X	X	X	X
Is an opportunity for Colorado to insure itself against mandatory curtailment in the Colorado River Basin.	X			X	X
Is an opportunity to build resilience in rural communities.			X		X
Is a program that individual producers should be able to choose to participate in.	X	X	X	X	X
Is a program that communities should be able to provide feedback on.	X	X	X		X
Is a program that municipalities should be able to choose to participate in.	X	X	X	X	X
How might a Demand Management program potentially benefit or impact you individually?	To avoid the potentially devastating economic impacts of a Colorado River water curtailment on the west slope.	Probably not much effect	Increased likelihood of low stream flows in the summer, fall, and winter months reducing ability for irrigation (rising food cost), recreation (angling, canoeing, waterfowl), community water restrictions, degrades drinking water quality (water aesthetics, increased water treatment cost passed to the consumer), increase of nuisance aquatic vegetative species, increased tax burden risk due to seasonal low impacts on threatened and endanger species that live in our rivers (successes and dollars expended, invested, from protecting these species), increase concentration of wildlife to lands for available food, forage, water, winter range security, private land owner wildlife impacts and conflicts, loss of productive ag lands, create great dependence upon purchasing outside livestock feed source to maintain herd, livestock herd reductions due to loss of feed, secondary economic impacts from loss of agriculture, recreation, community water conservation losses to personal income (car washes, lawn care, plumbers), increased utility rates, increased to NPDES water quality standards and community waste water treatment processes	Rationalizing the approach to dealing with threats to the Colorado Basin, including agriculture, from climate change, hydrologic volatility, and related pressures. Waiting for the train wreck, slow or fast is a poor choice.	1. I live in rural Colorado and open space is a very important component of my quality of life. Programs that open the door for development of agricultural lands and/or abandonment without weed control would affect my community. Impacts (positive or negative) to the community MUST be taken into account in selecting participation. 2. I'm an avid outdoors person and work hard personally and professionally to help protect rivers and watersheds. A program that results in negative impacts to rivers and watersheds would impact me directly. 3. Wildfires have devastating effects on people, communities, rivers, watersheds and the wildlife they support. The potential for participating fields to increase wildfire risk needs to be evaluated before projects are accepted.
How might a Demand Management program potentially benefit or impact your community?	Avoiding the economic impacts of a curtailment.	Perhaps excess water could be dinted from city supplies for compensation. Protection from a call.	[Ditto]	See #6	See response above.

What topics or concerns would you like addressed in the next phase of the feasibility investigation?	Piloting the use of auctions to determine who gets paid and how much.	Value of water under this scenario	How to maintain the Colorado River system when water reserves are depleted due to continued drought and or aridification. Impacts to alluvial storage and agriculture return flows. Impacts to basins and water users dependent upon alluvial storage and return flows from agriculture. Quantify the injury to water users when storage is depleted. Quantify how basins without storage are impacted. Why does Colorado not want to use the states full Colorado Compact allocation? Why is Colorado anti-water storage for compact protection purposes? What risk are there and growing while Colorado continues to vet DCP and DM? Is there valuable time being lost to get critical projects done to offset or lessen drought and aridification impacts while the water political world vets DCP and DM? What will happen to an area, community, region should water not be available? What is the States plan for areas that lack adequate drought resiliency? What legal risk is the state opening if a DM program is developed and people run out of water due to a Colorado Approved or Sponsor DM program? Does "no-jury" come into the DCP/DM equation?	We know how to create CCU, programmatic pilots investigating the administration of such CCU should be among the choices	How will flows be shepherded to Lake Powell (or any other storage bucket)? Is storage in Lake Powell the best alternative (in light of tremendous evaporation loss); should storage in Colorado reservoir be explored as a first alternative, with delivery to Powell on an as needed bases? These matters are not included in the Framework.

Do you have any additional thoughts or feedback on the Demand Management Framework and the way the potential program is being considered?					
	I have previously commented to the CWCB that it needs to pilot the use of auctions. Auctions are a fair and equitable means to determine who gets paid and by how much. It is also fair to who pays the bill. The attached concept paper outlines the use of auctions. Attached is a water auction design document recently co-authored by Dr. Bonnie Colby from the University of Arizona and the Colorado River Research Group. https://climas.arizona.edu/publication/report/water-auctions-design-implementation-and-evaluation Additionally, below are a couple of opinion pieces that I co-authored regarding the use of auctions to reduce Colorado River Water use. Fresh Water News, August 19, 2020 Opinion: Use auctions to set prices for Colorado River drought pool https://www.watereducationcolorado.org/fresh-water-news/opinion-use-auctions-to-set-prices-for-colorado-river-drought-pool/ The Colorado Sun, September 14, 2020 Opinion: Colorado needs a water market to reduce Colorado River water use https://coloradosun.com/2020/09/13/colorado-river-compact-denver-water-opinion/?utm_source=ActiveCampaign&utm_medium=email&utm_content=A+fragile+foundation+for+vaccines+%2F+Lauren+Boebert+s+rise+%2F+State+sues+USPS+over+voting+misinfo+%2F+After+Suncor+settlement&utm_campaign=Sunriser+-+9%2F14%2F2020&vgo_ee=NoyTwJ1V3BKXqMdyi2gTAw%3D%3D I will be happy to help the CWCB think through how to design water auctions and the market structures required to implement any Demand Management Program.				
		I think the market should determine price. Mostly excess storage will be the best source.			
			Very dangerous program that opens up unintended secondary impacts to other water users. Each basin is different and should be treated as such. "No-injury" should be implemented. Yampa/White/Green Basin Roundtable Recommended Draft Demand Management Statement Executive Summary Context In the face of persistent drought and anticipated long-term growth in demand for water, Colorado and the other 6 Colorado River Basin states have prepared a Drought Contingency Plan (DCP). One element of that plan is to investigate the feasibility of Demand Management (DM). If implemented, DM will become a future program which, on a voluntary, temporary, and compensated basis, will reduce water use by individual, public, and commercial water rights holders, to avoid administration of the Colorado River Compact on the Colorado River. Statement of Principles Given the context for DM in Colorado, the Yampa/White/Green River Basin Roundtable considers the following concepts to be important in the development of a DM program: 1. Preservation of Quality of Life in the Y/W/G River Basin: Any DM program must preserve and enhance agriculture, local communities, and economies in our basin, while protecting municipal delivery, addressing environmental needs as well as recreational water use, and offering locally accepted methods to reduce consumptive use without injury. 2. Equity of Responsibility and Opportunity: A DM program must be structured to ensure that no river basin nor single water user group (i.e, Ag, M&I) bears a disproportionate share of DM responsibility, and to provide DM opportunities to all water right holders on a reasonably equitable basis. To ensure equity, some form of inter-basin apportionment is required. 3. Guided Market: The State of Colorado should establish a marketplace for DM water transactions that is structured to ensure/mandate fairness and transparency. 4. Recreation and Environment: Any DM program must consider/analyze its impacts on environmental and recreational needs, including those resulting from changes in water supply and/or timing of flows, and must not adversely impact these water uses and their contributions to local economies. 5. Rural Communities: Any DM program must evaluate and address all impacts that could result to rural communities, including negative economic, cultural, or social impacts. 6. Compensation for Value of Water Conserved: Any DM program must fairly compensate a participant who foregoes use of a water right. Compensation must be based on all economic impacts to the participant and not solely on the loss of income from the crop or product not produced. 7. Trans-Mountain Diversions (TMDs): Basins which benefit from water diverted from the Upper Colorado River must be considered as part of the CRS, with applicable DM responsibilities and opportunities, and subject to equitable apportionment for DM purposes. Any DM program must prohibit trans		
				We need to consider lower case demand management, that being water conservation, learning what we can, as we wrestle with upper case DM as a part of DCP; dm is coming ready or not.	
					The Framework does a good job summarizing the threshold issues and alternatives discussed in each DM workgroup, but it is still too abstract and vague. I think it is time to put one or more strawmen out there so people can react. And by strawman, I mean an outline of a potential program with specific components.

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Stakeholder Letters Submitted to CWCB

DEMAND MANAGEMENT FEASIBILITY INVESTIGATION

Grand Valley Water Users Association

Comments to CWCB DM Framework Listening Session June 29, 2021

I am Mark Harris General Manager of GVWUA in the Grand Valley

Thanks to all of you inside and outside the CWCB that have worked diligently to get us to this DM Framework to this point.

I am not going to make specific comments on the contents of the Framework or discuss the process by which it has been developed, but we do believe the process and the resulting document provides an adequate exploration of the appropriate issues and provides a place from which to continue the search for real time and real world solutions to the use of DM as a part of DCP and perhaps on what we call lower case dm….productive approaches to water conservation that are a part of all our futures.

What I do want to share briefly is what I am being asked by the Board I serve and the farmers and other water users we deal with every day.

What folks want to know is the "so what" and "what now"….

We hear a pretty clear concern with the state of the River, compounded by weather concerns, and by extension the fate of the GVWUA and the Grand Valley in the face of these challenges. People are asking us what we managers, the CWCB, organizations like the River District, and other organizations are doing to effectively deal with the outcomes of worsening trends and increased volatility, not just for this year and the very near term, but for the longer term as well.

They wonder how these DM explorations address the very real problems they see coming?

Our organization knows that many farmers and ranchers know how to create CCU, and even perhaps how to deal with it within their own organization or on their ditch. But the larger question I am asked is SO HOW move on and WHERE is the vehicle by which we do something productive with that water potentially made available in a voluntary, temporary, and compensated basis in several geographies by various methods.

Who is working on that that they ask? And when? What's next after all this talk they ask? Can't we try something?

Well the GVWUA submits that the time to work on answering those challenges is upon us. We recognize, acknowledge, and respect the very real differences in opinion that many of our peers and partners have regarding these difficult issues. But we also believe that many farmers, ranchers, and the organizations that serve them remain willing to find a productive way forward for agriculture and the State of Colorado, if for no other reason than it is in our best interest to do so. ***Agriculture will be as heavily impacted by the solutions to the water problems we face as we are from the problems themselves.***

Finally, we support CWCB's identification and funding of appropriate, practical, PROGRAMMATIC PILOT PROJECTS that help understand how to administer the CCU that many people already know how to create.

I know I am not telling you anything new when I say that the only way to really raise the important questions and to identify the positive and negative consequences of our actions is to try something.

You have heard me use his analogy before, but here it is one more time.

You can sit in the coffee shop all winter and talk about, cuss and discuss, and second a new crop for next spring. **But sometime you just gotta take the planter to the field…..**and you may get a few blanks, and you may abandon the plan in favor of another one next year, but you know you have to be trying something every year. Embracing the past too tightly does not help us deal with the future.

There is no other way to advance the agenda without taking some well-considered risk. And all those involved in creating the FRAMEWORK have done that. We urge the CWCB to take aggressive action toward putting this time and effort to continued good use, clearly articulating the next steps in the DM process, and creating a projected schedule by which it can be accomplished.

It doesn't look like the water and the weather are not going to wait for us.

Thanks for time this afternoon and good luck**.**

RIO BLANCO WATER CONSERVANCY DISTRICT

July 6, 2021

Colorado Water Conservation Board of Directors
1313 Sherman Street, Room 718
Denver, Colorado 80203

RE: Colorado Drought Contingency Plan - Demand Management

Dear Honored Member of the Colorado Water Conservation Board of Directors

The Rio Blanco Water Conservancy District (RBWCD) would like to say it is a pleasure to provide comment on Demand Management however recognizing our present state of drought and continued aridification this is proving to push a level of conversation not many are fully prepared for nor comfortable with. There is more gratifying task we all would rather be doing in our water world but here we are today in our drought-stricken region formulating a plan for a better tomorrow. Evidently all of us were chosen in one fashion or another to be part of this crucial topic in preparation for our future generation's water security. Changing times for sure.

The winds of change are upon us, and we recognize the need for adaption to our changing environment. Being such, the RBWCD believes it is imperative for the CWCB to understand the function of the White River Basin with respect to Drought Contingency Planning (DCP) - Demand Management (DM). We believe no other Colorado water basin in our great state functions as we do nor has done so for such an extend period.

Our White River community is cultivated around areas of alluvial gravel deposits that have been washed out from the Flat Tops and high desert plains over the millennium recharged by snow, rains, and flood irrigation. The combination of these is what keeps the water available for our community needs. With the reduction in snowpack and seasonal rains not to forget increased temperatures, this has impacted our ability to put water to full beneficial use due to the lack of directly available supply from the stream or retiming of water while also reducing the alluvium storage.

2252 East Main Street – Rangely, Colorado 81648 Phone (970) 675-5055 Fax (970) 675-5531

RIO BLANCO WATER CONSERVANCY DISTRICT

Under normal years with average precipitation, flood irrigation plays an immense role "topping-off" our White River alluvial aquifers but with the loss of direct flows and seasonal precipitation less water is available to be applied shorting the alluvial aquifer storage not to forget the natural recharge occurrence which our White River basin is dependent upon. Once the alluvium is full water eventually migrates back to the stream as return flows for other later in the season beneficial water reuse. Typical return flow season is from late summer to late winter months.

For DM discussion purposes, the White River basin has: 2 municipalities, Meeker (ground water supply) and Rangely (direct diversion surface water supply) supporting a population of about 6,400 citizens; limited industry that continues to be sequestered; recreation; and agriculture. A DM program imposed upon the municipalities will have limited conserved consumptive use with the small population, industrial water use is an incredibly small quantity, recreation is non-consumptive, so that leaves agriculture to take care of the lion's share of water for a White River DM program. As the DM program is rolling out with uncertain side boards, we must presume any Conserved Consumptive Use will be primarily sacrificed by agriculture which is the life blood of our basin hydrology. Take away or restrict flood irrigation and we eat away at the primary drought insurance policy of our community and stream ecology shorting alluvial recharge and return flows, which has been encountered during previous drought-stricken years.

Unlike other Colorado basin's, the White River is void of any real storage for drought or contingency protections hence part of the purpose and need for RBWCD along Yellow Jacket Water Conservancy District, Town of Rangely, and Rio Blanco County to aggressively push for Wolf Creek Reservoir. Our community is progressing with our Drought Contingency Plan that includes physical storage because we understand the vulnerability to our present system and how storage provides water user flexibility. White River constituents currently face an imminent municipal, agricultural, environmental, and economic catastrophe without a resilient water supply then add DM on top of our already tasked and limited water resources? The picture is grim for our community to say the very least. What happens to our towns if there is over conservation as part of a DM program and our water supply is eliminated or injuriously reduced due to the dry up of agriculture or another DM alternative? Where do we turn to then to carry us through these water short times? Critical storage is not here yet and as DM is evolving there will become more need and reliance upon storage. We ask, what are the states

RIO BLANCO WATER CONSERVANCY DISTRICT

plans to carry our district water needs through when water is already past the state line as part of a state Drought Contingency Plan and basins lack critical components for drought resiliency?

By keeping water in the stream and out of our alluvium by reducing flood irrigation what affect will this have upon stream ecology or the threatened and endangers fishes that reside here later in the season with reduced alluvium storage and return flows? What happens to the considerable investments made for the protection and recovery of our threatened and endangered species or recreational fishery species? Modeling completed for the White River demonstrates low to no stream flow risk to be very real.

Proponents for a DM program express climate change as a purpose and need for such a program yet are they taking into consideration the impacts to drying areas up removing green belts from playing a roll in carbon sequestration and the associated atmospheric cooling these areas provide? Perhaps in place of drying areas up we should be wetting areas using the plants and soils for what they have to offer. How does a browned pasture or field aid or play into a warming climate? Are we treating a symptom as opposed to implementing part of a cure by not wetting and activating these carbon bioreactors?

Part of the DM discussion includes conserved water to be stored downstream in Lake Powell. The district finds this approach unique since once the water has exited Colorado the multiple beneficial uses of our precious resource are no longer possible to Colorado water users. Has the state completed a Cost/Benefit analysis quantifying the benefits to our state by keeping the conserved consumptive use within our boarders? Our analysis has shown the financial benefits keeping water within our basin with the short list detailing; increased economic diversity, healthier municipalities, greater agriculture security, more recreation, stronger healthier stream ecology, and increased carbon sequestration. The White River, while not having formal representation to the DM framework development, is unaware of any attempt by the state to quantify such an analysis. Seeing this, the RWBCD recommends the state quantify these benefits as part of the DM process in a truly representative, open, and transparent means without prejudice including entities or individuals having a truly vested stake in any DM program. This includes entities statutorily created for water conservation such as water conservancy and conservation districts who have additional concepts for DM yet not part of the conversation.

RIO BLANCO WATER CONSERVANCY DISTRICT

"The Colorado Water Conservation Board's mission is to conserve, develop, protect, and manage Colorado's water for present and future generations." We understand and agree with this complex mission also realizing the state has a legal obligation to meet the Colorado River Compact. Not a simple task. In the instance of DCP and DM is the state truly looking for the wellbeing of our White River community? We see DM evolving around continued or expanded trans-mountain diversions, restrict less-developed basins/regions, and benefit the lower Colorado River basin states all of which is elated to in the DM Framework.

Through a public process created by HOUSE BILL 05-1177 "COLORADO WATER FOR THE 21ST CENTURY ACT" the Yampa-White-Green Basin Round Table unanimously created seven (7) Principles specific to Demands Management. The RBWCD believes these principles are important and MUST be an essential part of any DM program. The principles are: https://drive.google.com/file/d/1YpIQhFCnzzK5FgZ5mQO0Eo8Y19kmDak6/view

1. *Preservation of Quality of Life in the Y/W/G River Basin: Any DM program must preserve and enhance all aspects of quality of life in our basin, including agriculture, local communities, and local economies, while protecting municipal delivery, addressing environmental needs as well as recreational water use, and offering locally-accepted methods to reduce consumptive use without injury.*
2. *Equity of Responsibility and Opportunity: A DM program must be structured to ensure that no river basin nor single water user group (i.e, Ag, M&I) bears a disproportionate share of DM responsibility, and to provide opportunities for all water right holders to participate on a reasonably-equitable basis. To ensure equity, some form of inter-basin apportionment is required.*
3. *Guided Market: The State of Colorado should establish a marketplace for DM water transactions that is equitable and transparent.*
4. *Rural Communities: Any DM program must evaluate and address all impacts that could result to rural communities, including negative economic, cultural, or social impacts.*
5. *Recreation and Environment: Any DM program must consider/analyze its impacts on environmental and recreational needs, including those resulting from changes in water supply and/or timing of flows. Any DM program should strive to benefit, and must not adversely impact, environmental and recreational water uses and their contributions to local economies.*
6. *Compensation for Value of Water Conserved: Any DM program must fairly compensate participants. Compensation should be based on all economic impacts to the participant and not solely on the loss of income from the crop or product not produced.*

RIO BLANCO WATER CONSERVANCY DISTRICT

7. *Trans-Mountain Diversions (TMDs): Basins which benefit from water diverted from the Upper Colorado River must be considered as part of the CRS, with applicable DM responsibilities and opportunities, and subject to equitable apportionment for DM purposes. Any DM program must prohibit trans-mountain diverters from purchasing Western Slope water to meet a DM responsibility.*

The Rio Blanco Water Conservancy District unequivocally believes in water conservation and the overlaying rationale for DM but we question the looming injury such a program will have to our basin water users. We continue progressing our locally driven drought planning efforts that includes considerable water conservation imploring upon the CWCB and other state water agencies part of the DM development framework to keep the intricacies and lack of drought resiliency of our White River community in mind as the states DCP evolves. We must reiterate, significant desire to participate in a DM type program is evident in our White River basin however, we lack critical tools necessary for drought and over conservation resiliency. Basin storage is a vital component of our drought planning and must be part of any successful DM program.

Thank you for the opportunity to provide comment.

Wade Cox
Board President
Rio Blanco Water Conservancy District

Wade K Cox

2252 East Main Street – Rangely, Colorado 81648 Phone (970) 675-5055 Fax (970) 675-5531

June 30, 2021

Ms. Amy Ostdiek
Colorado Water Conservation Board
1313 Sherman Street, Suite 718
Denver, Colorado 80203

Delivered via electronic mail to amy.ostdiek@state.co.us

Re: Comments on Demand Management Feasibility Investigation

Dear Ms. Ostdiek,

On behalf of Trout Unlimited ("TU"), I am pleased to offer these comments on the Demand Management Feasibility Investigation (the "Investigation") and the Demand Management Framework (the "Framework"). TU appreciates the hard work of the Colorado Water Conservation Board ("CWCB") and its staff in leading the Investigation and in developing the Framework, and we appreciate the opportunity to provide input on these important issues.

As you will recall, in August of 2020, TU sent you a letter commenting on a number of issues related to demand management and the CWCB's Demand Management Feasibility Investigation. A copy of TU's 2020 letter is attached for your reference. Many of the issues we discussed in our 2020 letter remain outstanding or unresolved. While we recognize that demand management is complex and while we appreciate that development of the Framework has been time-consuming for CWCB staff, as an overriding matter we would have liked to have seen more progress towards resolution of demand management issues over the past year. Going forward, as we discuss in more detail below, it is important that the CWCB increase the pace of the Investigation.

Declining Climatic Conditions Require Swift Action

As you know well, climatic conditions across the Colorado River basin are in decline. Another year of hot and dry conditions has dramatically reduced runoff into an already-low Lake Powell, which is now approaching the lowest level since its filling in the early 1960s. The U.S. Bureau of Reclamation ("Reclamation") recently declared a Stage 1 shortage on the Colorado River, and Reclamation is projecting a further decline in water availability by 2022, which would trigger harsh curtailment measures under the 1922 Colorado River Compact. The need for action is urgent, and the CWCB must act now to advance the development of a demand management program, even if there is not 100% consensus across the state regarding the parameters of a demand management program.

Failure to Act Could Have Devastating Consequences

Failure to take action to address the declining hydrological conditions in the Colorado River basin could lead to severe economic disruption, litigation, or federal intervention. In other words, delays make it more likely that Colorado will suffer negative consequences or lose local control over shaping how to respond to the worsening climatic conditions in the Colorado River basin. Such a loss of control is not in the state's best interest. While there may be some hard choices in structuring a voluntary demand management program, the consequences of not acting could be significantly more disruptive to Colorado.

Demand Management is Critical

Reducing Colorado's risks under the 1922 Colorado River Compact will require a multitude of responses, with demand management likely being the most important. The upper Colorado River basin states' plan to release water from several upper basin reservoirs to bolster Lake Powell levels is an important tool, but it is a temporary fix that will not on its own prevent declines in Lake Powell elevations. Other solutions, including expanded water conservation and reuse, land use planning, infrastructure improvements, and investments in healthy watersheds will also be required. Demand management may be the most powerful risk-reduction response available.

A Pilot Program Would Help Advance the Investigation

The 2019 Drought Contingency Plan ("DCP"), which provided the upper basin states a seven-year opportunity to test demand management and store the conserved water in Lake Powell, expires in 2026. If the upper basin states are going to learn how a demand management program can work, it is imperative to launch a pilot program as soon as possible. Otherwise, we would be missing the opportunity to learn as much as we can during the DCP window. The CWCB should commit to initiating a new, multi-year pilot program with projects across different water use sectors and geographies as soon as possible. Given our past involvement in the System Conservation Pilot Program and other on-the-ground demonstration projects in the years since then, TU looks forward to working actively with our partners in the agricultural community to develop projects under a pilot program.

Conclusion

Trout Unlimited urges the State of Colorado to act quickly and decisively towards the development of a demand management program, and we look forward to continuing to work with the Colorado Water Conservation Board towards this goal. Thank you for the opportunity to provide these comments.

Sincerely,

Drew Peternell

June 28, 2021

Colorado Water Conservation Board
1313 Sherman St., 7th Floor
Denver, CO 80203
Via: demandmanagement@state.co.us

RE: Response to Request for Input on Demand Management Feasibility Decision

Dear Members,

The Theodore Roosevelt Conservation Partnership is a coalition of 60 hunter, angler, science and outdoor recreation groups working to ensure all Americans have quality places to hunt and fish. The TRCP has worked for most of its 20 years primarily with federal agencies but also with state governments on water issues of importance, including trying to correct the water demand-supply imbalance in the Colorado River Basin because of the importance of the Basin's habitat for fish and wildlife. We have been following the Colorado Water Conservation Board's efforts to determine the feasibility of a Demand Management program closely, including by serving on the Environmental Values Work Group in 2020.

Because TRCP staff will not be able to attend the Demand Management Framework Public Listening Session June 29th from 5-7 pm, we ask the Board to consider our comments below as it determines Colorado's next steps.

Context:

As the Board is well aware, this year's extreme drought conditions come on top of a 20 year mega-drought. The hydrology for the Basin's rivers and reservoirs is simply dire. If the Bureau of Reclamation's most recent 24-month study projections are true, Lake Powell may decline to elevation 3525 during the 2022 water year, triggering reductions in hydropower production at Glen Canyon Dam and putting Upper Basin cities, ranches and recreational water users at real risk for compact curtailment.

As a result, time is of the essence for the Board to identify and implement tools to help Colorado's water users collectively, including those who value our rivers for recreational benefit. Absent state solutions, individual water users will take individual action that may not help the State, its fish and wildlife, or even downstream water users. And, while the TRCP is aware of the Upper Colorado River Commission is also evaluating the feasibility of demand

management, its process cannot answer state-specific questions, so Colorado must find answers to its own issues rather than waiting for that investigation to conclude.

Delay will make it more likely that Colorado loses control to shape the responses best for its community of water users. Without action, Colorado's water users are at ever greater risk of severe economic disruption and potentially even litigation or federal intervention. Compared to those risks, which only grow with each dry year, it is worth the Board taking a leadership role to structure a demand management program, along with other tools (like the one-time reservoir releases current under discussion) to address the Basin's water challenges.

Further delay of pilots and a full demand management program in Colorado will also add to the existing burdens for Latino communities in Colorado and the Colorado River Basin. One third of U.S. Latinos live within Colorado River Basin states, including ours. As a group, Latinos are more likely to face health impacts from climate change than others. And, one cannot imagine a demographic more supportive of building resilient water systems that serve people, fish and wildlife. An astonishing 96% of Latinos in the West support funding to modernize water infrastructure and restore natural areas in ways that improve drought resilience, while 93% agree that, notwithstanding state budget shortfalls, it is imperative to fund protection of states lands, water and wildlife. Without adequate responses to drought and climate change – which is primarily expressed in terms of drought and fire in the West, including Colorado – Latinos will continue to feel the disproportionate adverse health impacts and other effects of climate change and drought. It is therefore incumbent on the CWCB to act expeditiously to stand up programs like demand management and others, that can build climate and drought resiliency without delay.

The Board, with its staff of policy, technical and legal experts, and having conducted several years of public outreach regarding demand management and other tools, is best positioned to act in a way that will best serve Colorado's people and water resources, including the fish and wildlife that resource supports. The Board must lead on demand management but also work with other agencies, water users and communities of interest to expand water conservation and reuse, promote land use plans that fosters efficient water use, fund upgrades to aging less efficient water infrastructure and invest in healthy forests and watersheds.

Framework Comments and Next Steps

The draft framework does a good job of laying out the many factors, and thus decisions that the Board would have to make to set up and implement an equitable, voluntary and effective demand management program. But the framework does not provide a way to evaluate the tradeoffs – costs and benefits – amongst those decisions. For example, with knowing the financial cost of choosing a simple, more complex or robust alternative for any one factor, the CWCB cannot know how that choice may constrain what other choices would be available based solely on their cost. While a more sophisticated decision support tool, along with more complete data, e.g., on the cost of various choices, would help the Board, given the need for quick action, there is not the time available to optimize a program at inception.

If the Board is going to set up a demand management program, not only the hydrology, but the seven-year timeline of the 2019 Drought Contingency Plan, demands action within the year. The States, Reclamation, and others have begun renegotiating the 2007 Interim Shortage Guidelines, which must also be completed in 2026. If the Upper Basin states are going to learn anything from a demand management program, they must launch that program and implement associated projects as soon as possible. A demand management program cannot help in a practical matter, or provide lessons useful for the renegotiation unless it is in place before the crisis, not after the horse is out of the barn.

We encourage the CWCB to be practical and focus on moving quickly beyond the Framework to seek solutions and implement a pilot program that incorporates a diverse range of pilot projects. There are too many additional complex questions that will also take time to answer. We encourage the CWCB staff to focus on identifying and answering key questions and supporting additional pilot projects, including hypothetical exercises in certain circumstances, as a good approach. A range of pilots is needed, incorporating diverse geographies and project types, including not only agricultural projects, but also transmountain diversion, industrial, and other projects. The conceptual proposal for a programmatic pilot from the Agricultural Impacts Demand Management Workgroup can be a starting point.

Because of the State's interests in, and in some respects, responsibilities for maintaining fish and wildlife habitat, as well as the economic benefits of recreational water use, the Board's next steps should include an analysis of potential environmental co-benefits in pilot project design or a full demand management program. Such co-benefits only become more critical in the face of changing hydrology and increasing aridification, which affect native and important non-native game species alike. Pilots as well as a full program both have the potential to impact recreational and environmental flows, either positively or negatively. We urge the state to incorporate an analysis of environmental and recreation needs and potential benefits and impacts, as well as quantitative monitoring and verification of those, in pilots and any DM program.

Thank you in advance for your consideration,

Melinda Kassen, Sr. Counsel
Jared Romero, Director of Strategic Partnerships

Feedback on the CWCB Demand Management Framework

By the Y/W/G Basin Roundtable Big River Committee
June, 2021

The Framework and Review Process

The CWCB DM Framework document contains a great deal of detailed information about DM issues and solutions, primarily gleaned from and organized around the DM Work Group discussions. The conceptual framework, based on 3 levels of solutions to address issues, is a well-thought-out approach to presenting the issues that have surface and some proposed solutions for them.

Members of the Y/W/G BRC have reviewed the Framework document in detail, and summarized their comments, suggestions, and questions in the brief that follows. The BRC chose to review the Framework document by comparing it to the Y/W/G Executive Summary of DM Principles ("Principles") published in March of this year. For each Framework topic and subtopic, members of the BRC reviewed solutions to determine whether or not those solutions aligned with or were counter to the Principles. Note that several subtopics in the Framework document are not addressed, as they do not appear to intersect with the Principles.

Comments and questions are generally divided into 2 parts; an initial section that highlights high-level comments and suggestions, and a more detailed discussion of several important topics and sub-topics contained in the Framework.

High-Level Issue Discussion

Following is a summary of high-level comments and suggestions:

1. Purpose and Goal of DM. The DM Framework should state clearly that the overarching purpose of any DM program is to reduce consumptive water usage in order to avoid a Compact call (Y/W/G Context). Although the idea of yielding conserved consumptive use and the goal of placing 500KAF in a pool in Lake Powell are discussed in the Underlying Assumptions of the doc, these were both missed by several reviewers, and it would be helpful if they were more clearly stated at the outset.

2. Shared Responsibility/Opportunity and Apportionment. The DM Framework should also state clearly that all CRS basins and water rights holders will share in responsibility and opportunity of the DM program (Y/W/G Principles 2, 7.) Specifically, no discussion of projects from Industrial water users is provided, while Municipal subtopics emphasize 'support'; several reviewers commented that the document is focused on Ag. While TMD projects are discussed, nowhere does the Framework indicate the requirement that TMD diverters participate in DM. Finally, no discussion of inter-basin apportionment, or some other means of ensuring shared responsibility/opportunity between and among basins, is offered.

Detailed Issue Discussion

Each of the topics and subtopics that intersect with the Y/W/G DM Principles was discussed to determine whether and to what degree each was aligned. Following is a summary of that review:

Major Topic 1: Monitoring and Verification (Agricultural DM Project)

Subtopic: Maintain Return Flows

Option A – (Y/W/G Principles 1, 4, 5): Does not align. Failure to maintain return flows will be detrimental to ag, urban/suburban water users, and recreation in our basin during the late summer/fall season.

Option B – (Y/W/G Principles 1, 4, 5): Could align, provided that adequate storage was available.

Option C – (Y/W/G Principles 1, 4, 5): Would align by providing locally-sourced return flow. However, the solution seems impossibly complex and costly.

Major Topic 1: Monitoring and Verification (Transmountain DM Project)

Subtopic: Measure Water Returned to Stream

Option A – (Y/W/G Principle 7): Does not align. Absent some form of accounting validation (as provided for in the next subtopic), a simple estimate provided by the TMD operator would leave room for a range of harmful outcomes. For example, the TMD operator could simply overestimate the amount of water to be diverted at that diversion point, and take credit for a greater DM impact than was actually earned.

Option B – (Y/W/G Principle 7): Does align. This approach, to which an auditable provision should be added, would help to ensure that the conserved consumptive use claimed is not simply replaced by other Western Slope waters in a 'shell game'.

Option C – (Y/W/G Principle 7): Does align. This approach is the most thorough, but probably is impractical to implement.

Subtopic: Verify Conserved Consumptive Use Occurs on the East Slope

Option A – (Y/W/G Principle 7): Does align. An auditable provision should be added to this statement, but this approach would prevent the 'shell game' tactic that allows a TMD operator to simply switch one West Slope source for another while claiming a DM contribution.

Option B – (Y/W/G Principle 7): Does align, slightly better than Option A but an auditable provision should be added.

Option C – (Y/W/G Principle 7): Does align, but seems overly complicated and expensive.

** Note: This subtopic title could be considered misleading; perhaps a better name would be: 'Verify Accuracy of Accounting for Foregoing TM Diversion and that Conserved Consumptive Use Occurs on the East Slope'.

Subtopic: Coordinate Environment and Other Benefits

Option A – (Y/W/G Principles 1, 4, 5, 7): Does align. Option A does not provide any additional benefit, but it does not involve negative impact.

Option B – (Y/W/G Principles 1, 4, 5, 7): Does align. The provision for temporary storage in a Western Slope reservoir helps to mitigate environmental and other impacts.

Option C – (Y/W/G Principles 1, 4, 5, 7): Does align (see comments for Option B) but is too complex and costly for actual implementation.

Major Topic 3: Environmental Considerations

Subtopic: Assessing Net Benefit or Impact

Option A – (Y/W/G Principles 1, 2, 4, 5): Does align, provided that benefits to Y/W/G basin and communities are part of the consideration.

Option B – (Y/W/G Principles 1, 2, 4, 5): Does align, provided that benefits to Y/W/G basin and communities are part of the consideration.

Option C – (Y/W/G Principles 1, 2, 4, 5): Does align, provided that benefits to Y/W/G basin and communities are part of the consideration.

Subtopic: Strategies to Incentivize Benefits

Option A – (Y/W/G Principles 2, 4): Does align. Ensures that all DM contributors have equal opportunity to participate.

Option B – (Y/W/G Principles 2, 3, 4): Does not align. Given hydrology, this option prioritizes participation by main stem users over tributary users.

Option C – (Y/W/G Principles 2, 3, 4): Does not align. Given hydrology, this option prioritizes participation by main stem users over tributary users.

Subtopic: Strategies to Avoid, Offset or Mitigate any Potential Negative Impacts

Option A – (Y/W/G Principles 2, 4): Does not align. Provides no benefit to Y/W/G basin users or communities.

Option B – (Y/W/G Principles 2, 4): Does align. Solutions provided would help to mitigate return flow issues and community impacts.

Option C – (Y/W/G Principles 2, 4): Does align, but seems too complex and costly.

** Note: This subtopic is very broad; some reviewers needed more context.

Major Topic 4: Economic Impact and Local Government (All DM Projects)

Subtopic: Support for Municipal Participants

Option A – (Y/W/G Principle 2, 7): May align, depending on implementation. Accounting verification required; as many municipals have conservation plans, it will be necessary to distinguish between permanent programs and CCU for DM.

Option B – (Y/W/G Principle 2, 3, 7): Does not align. Comments under Option A apply. But beyond those accounting factors, support for municipal project development provided in addition to DM compensation would constitute a large advantage for municipal projects, resulting in inequitable solutions.

Option C – (Y/W/G Principle 2, 3, 7): Does not align. Comments under Options A and B apply. And in addition to those considerations, this Option would potentially require the state of CO to make subjective decisions regarding the applicability secondary and tertiary impacts to DM, then to fund those which are deemed applicable. Ultimately, this Option is unsustainable.

Subtopic: Municipal Sector Mitigation

Option A – (Y/W/G Principle 1, 2, 4, 7): May align, depending on implementation. While this Option does not provide DM-based funding mitigation, it does allow for locally-accepted methods and decision-making.

Option B – (Y/W/G Principle 1, 2, 3, 4, 7): Does align, but involves complexities and subjective, bureaucratic judgements that would render it non-operational.

Option C – (Y/W/G Principle 1, 2, 3, 4, 7): Does align. This Option improves on the previous one by asserting non-subjective protocols. However, it would be complex and costly to implement, and very likely would not be sustainable.

Major Topic 5: Agricultural Impacts

Subtopic: Agricultural Mitigation

Option A – (Y/W/G Principle 1, 6): Does align, provided that compensation for participation is equitable. The goals for Ag Impacts (equitability, mitigating non-farm impacts, guided market, alignment with growing seasons) can and should met through appropriate funding for participants.

Option B – (Y/W/G Principle 1, 3, 6): Does align, but involves complexities and bureaucracy that would be difficult to sustain, and are unnecessary if compensation for participants is equitable.

Option C – (Y/W/G Principle 1, 3, 6): Does align, but involves complexities and bureaucracy that would be difficult to sustain, and are unnecessary if compensation for participants is equitable. Would likely be too costly to implement.

Subtopic: Agricultural Participant Field Requirements

Option A – (Y/W/G Principle 6): Does align. The operating principle asserted here is that the individual landowner holds a property right about which he/she is entitled to make decisions.

He/she has incentive to protect the value of that property through appropriate weed and pest control.

Option B – (Y/W/G Principle 3, 6): May align, depending on implementation. Providing assistance or support at the request of the individual landowner is appropriate. Enforced regulations for private property should not be implemented.

Option C – (Y/W/G Principle 3, 6): May align, depending on implementation. Providing assistance or support at the request of the individual landowner is appropriate. Enforced regulations for private property should not be implemented. Additional staffing may add cost that is unsustainable.

Yampa/White/Green Basin Roundtable
Demand Management Statement

Executive Summary

Context

In the face of persistent drought and anticipated long-term growth in demand for water, Colorado and the other six Colorado River Basin states have prepared a Drought Contingency Plan (DCP). One element of that plan is to investigate the feasibility of Demand Management (DM). If implemented, DM will become a future program which, on a voluntary, temporary, and compensated basis, will reduce water use by individual, public, and commercial water rights holders, to avoid administration of the Colorado River Compact on the Colorado River.

Statement of Principles

Given the context for DM in Colorado, the Yampa/White/Green River Basin Roundtable considers the following concepts to be important in the development of a DM program:

1. Preservation of Quality of Life in the Y/W/G River Basin: Any DM program must preserve and enhance all aspects of quality of life in our basin, including agriculture, local communities, and local economies, while protecting municipal delivery, addressing environmental needs as well as recreational water use, and offering locally-accepted methods to reduce consumptive use without injury.
2. Equity of Responsibility and Opportunity: A DM program must be structured to ensure that no river basin nor single water user group (i.e, Ag, M&I) bears a disproportionate share of DM responsibility, and to provide opportunities for all water right holders to participate on a reasonably-equitable basis. To ensure equity, some form of inter-basin apportionment is required.
3. Guided Market: The State of Colorado should establish a marketplace for DM water transactions that is equitable and transparent.
4. Rural Communities: Any DM program must evaluate and address all impacts that could result to rural communities, including negative economic, cultural, or social impacts.
5. Recreation and Environment: Any DM program must consider/analyze its impacts on environmental and recreational needs, including those resulting from changes in water supply and/or timing of flows. Any DM program should strive to benefit, and must not adversely impact, environmental and recreational water uses and their contributions to local economies.
6. Compensation for Value of Water Conserved: Any DM program must fairly compensate participants. Compensation should be based on all economic impacts to the participant and not solely on the loss of income from the crop or product not produced.
7. Trans-Mountain Diversions (TMDs): Basins which benefit from water diverted from the Upper Colorado River must be considered as part of the CRS, with applicable DM responsibilities and opportunities, and subject to equitable apportionment for DM purposes. Any DM program must prohibit trans-mountain diverters from purchasing Western Slope water to meet a DM responsibility.

The Nature Conservancy in Colorado
2424 Spruce Street
Boulder, CO 80302

tel (303) 444-2950
fax (303) 444-2985

nature.org/colorado

June 28, 2021

Submitted by email

RE: Demand Management Framework Comments

Dear Colorado Water Conservation Board members and staff:

The Nature Conservancy (TNC) appreciates the Colorado Water Conservation Board (CWCB) request for feedback on the Demand Management (DM) framework. We opted to send a letter rather than fill out the survey due the complexity of the issue and desire to provide more information than the survey could provide.

TNC is a global environmental nonprofit working in Colorado for over 55 years to create a world where people and nature can thrive. Our mission is to conserve the lands and waters on which all life depends. TNC has over one million members and works in all 50 states and impacts conservation in 72 countries and territories across the world.

Reservoirs in the Colorado River Basin, filled to the brim at the end of the 20th century, are at historic lows. By 2060, demand for water from the Colorado River may exceed supply by more than 3.2 million acre-feet. Coming up short could put at risk the drinking water supplies of almost 40 million people in the Southwest, agricultural production, endangered species, the health of our rivers, and future economic growth, as well as the Colorado River's $26 billion outdoor recreation economy with its quarter-million jobs. With so much at stake, we have been following CWCB efforts to determine the feasibility of a Demand Management program closely, and four TNC staff members served on the CWCB's demand management work groups.

Now, another year of hot and dry conditions have dramatically reduced run-off into an already low Lake Powell, which is now approaching the lowest level since its filling in the early 1960s. The U.S. Bureau of Reclamation recently projected that by early 2022, Lake Powell is likely to decline to elevation 3,525 feet—a level that would result in reduced hydropower production at Glen Canyon Dam and would put the Upper Basin at risk of triggering harsh curtailment measures under the 1922 Colorado River Compact. These unprecedented conditions require that Colorado decision-makers act swiftly and decisively to develop and implement a plan and tools to protect and manage Colorado's water and rivers for present and future generations.

Existing conditions require a multitude of responses, and demand management is a vital tool to address the Upper Basin's water challenges. The Upper Basin states' plan to release water from

several Upper Basin reservoirs to bolster Lake Powell levels is one important tool, but it is a temporary fix that won't prevent risky declines in Lake Powell on its own. Other solutions, including expanded water conservation and reuse, land use planning, infrastructure improvements, and investments to improve the health of forests and watersheds will also be required. Demand management, based on the bedrock principles of "temporary, voluntary, and compensated," and with sideboards to avoid disproportionate impacts and ensure environmental protection, may be one of the most useful risk-reduction responses available.

With hydrology rapidly degrading, the longer we wait to develop effective tools to collectively mitigate risk the more likely we are to lose local control in shaping how Colorado will respond and what tools will be available to us.

The CWCB draft framework is a good start in laying out the many decisions needed to set up and implement an equitable, voluntary, and effective demand management program. The Framework is a good summary of the State of Colorado's demand management feasibility evaluation, but it does not provide a way to evaluate tradeoffs and benefits to aid in decision-making. The framework is very detailed, which can be useful in understanding the State's process to date; however, its complexity may also be confusing to many stakeholders. As is, it provides a concise high-level summary of key workgroup concepts and issues. However, it cannot be used as a decision-making tool because it lacks a way to evaluate or consider tradeoffs and benefits between the various components of one category and the implications of that component choice on other categories.

We believe that CWCB decision-makers must evaluate trade-offs, make the hard calls, and develop a demand management program that can be in place as one tool if the situation continues to decline. The state should not let the desire for the perfect be the enemy of the workable—the current and projected hydrology doesn't allow Colorado to wait for 100 % consensus. **Now is the time for the CWCB to move forward so it has a plan and a program in place *before* a crisis.**

Inaction or undue delay could lead to severe economic disruption, litigation, and even federal intervention. While there may be some hard choices in structuring a voluntary demand management program and no one wants to reduce their water use, the consequences of not having a plan to address the crisis will be severe and costly. The decision to proceed or delay needs to be made in the full context of what can happen if dry years continue. There won't be any do-overs and curtailment without any siderails seems like a risky path for Colorado. The CWCB, with its staff and legal experts and the benefit of extensive public outreach, is positioned to make good decisions that best serve Colorado's people and water resources.

Many states in the Upper Basin are deferring to the UCRC feasibility process. That process is important but will not answer state-specific questions. Colorado must find answers to its own issues and concerns rather than waiting for the UCRC investigation to conclude.

The 2019 Drought Contingency Plan, which provided the Upper Basin States with a seven-year opportunity to test demand management and store the water conserved in Lake Powell, expires in 2026. The States, Reclamation, and others have begun renegotiating the 2007 Interim Shortage

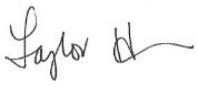
Guidelines, which must also be completed by 2026. If the Upper Basin states are going to learn how a demand management program can work, it seems that we are missing the opportunity to learn as much as we can during the DCP window to experiment with different approaches and pilot programs.

We encourage the CWCB to focus on moving quickly beyond the Framework to seek solutions and implement a program that incorporates a diverse range of pilot projects. We hope that the State will not linger on the process of finalizing or improving the Framework. We encourage the CWCB staff to focus on identifying and answering key questions and supporting additional pilot projects, including hypothetical exercises in certain circumstances, as a good approach. A range of pilots is needed, incorporating diverse geographies and project types, including not only agricultural projects, but also transmountain diversion, industrial, and other projects. The Agricultural Impacts Demand Management Workgroup shared a conceptual proposal for a programmatic pilot that offers opportunities for systematic exploration of the multiple objectives identified by the State and other interested parties.

The State has interests in and responsibilities for maintaining environmental, fish and wildlife, and recreational water uses and values. These only become more critical in the face of changing hydrology and increasing climate change driven drought. A demand management program has the potential to positively or negatively impact recreational and environmental flows, including target flows for endangered species. **We urge the state to create a demand management program that benefits rivers and that incorporates in program and project development and implementation an analysis of environmental and recreation needs and potential benefits and impacts, as well as quantitative monitoring and verification of project benefits and impacts**.

We thank the CWCB staff for their work in developing the framework and commend them on their efforts to ensure a robust and open conversation about demand management in Colorado.

Sincerely,



Carlos E. Fernandez
Colorado State Director

Taylor Hawes
Colorado River Program Director

CC:
Becky Mitchell
Lauren Ris
Dan Gibbs
Jonathan Asher
Kelly Romero-Heaney

DEMAND MANAGEMENT: Preliminary Guiding Principles

Adopted June 10, 2021

The principles outlined below are intended to guide Southwestern Water Conservation District (SWCD) in its evaluation of and input to any Demand Management (DM) program the state of Colorado, in cooperation with the other three Upper Basin states, may advance.

SWCD has not adopted a position of support, opposition or neutrality on the feasibility or development, let alone implementation, of a DM program within the Upper Basin. There are simply too many unknowns at this point. DM is an evolving concept; accordingly, this is a living policy document that will be reviewed periodically to reflect changing program elements, evaluations, and goals of DM in Colorado and the Upper Basin.

SWCD was created by the General Assembly in 1941 to lead in the conservation, use and development of the water resources of the San Juan and Dolores river basins, both of which are tributary to the Colorado River. SWCD's organic act also includes the charge "to safeguard for Colorado, all waters to which the state of Colorado is equitably entitled." Demand management is a novel concept that, if implemented, has the potential to alter water use and administration within the Upper Basin and, on a more local level, within SWCD's boundaries. Accordingly, SWCD will remain involved in the evaluation and potential formation and implementation of any DM program Colorado may pursue.

Colorado River Basin Drought Contingency Plans:

At least since the turn of this century, the security and sustainability of Colorado River water supply has been in question. The basin is currently experiencing one of the worst hydrologic cycles in recorded history. Continuing drought, resulting in worsening water supply and storage conditions, increases the risk of curtailment in the Upper Basin.

To reduce the risk of Lake Powell and Lake Mead declining to critically low levels, the United States Department of the Interior (Interior) and the seven Colorado River basin states agreed to develop and implement plans to overlay the 2007 Interim Guidelines addressing forecasted low reservoir elevations if the drought continued. The resulting Colorado River Drought Contingency Plans (DCP) were submitted to Congress on March 19, 2019. On April 16, 2019, then President Trump signed the Colorado River Drought Contingency Plan Authorization Act into law. This bill requires Interior to execute the Colorado River Drought Contingency Plans without delay and to operate applicable Colorado River System reservoirs accordingly.

For its part, the Upper Division states of Colorado, New Mexico, Utah and Wyoming committed to three primary strategies to address the impacts of continued drought in the basin. The first strategy, weather modification, was already being implemented across the basin and needed no federal legislation so was not included as part of the legislation passed in the Upper Basin's Drought Contingency Plan (DCP). The other two strategies focus directly on the goal to minimize the risk of water levels at Lake Powell falling below target elevations: an immediate response and a multi-year plan. The second strategy, articulated in the Drought Response Operations Agreement of the Upper Basin's DCP, is an immediate response measure designed to utilize operational adjustments or releases from the Colorado River Storage Project Act (CRSPA) Initial Units to bolster storage levels at Lake Powell when Lake Powell approaches a critical low elevation of 3,525' MSL. The Drought Response Operations Agreement also provides mechanisms for recovering storage at those same CRSPA Initial Units in subsequent years.

The Upper Basin's longer-term strategy is to explore the feasibility of developing and implementing a new demand management program that could generate water savings by either temporarily reducing existing water use within the Upper Basin or augmenting supplies with imported water. Under the Upper Basin's DCP, up to 500,000 acre-feet of DM water savings can be stored in the CRSPA Initial Units to help assure continued compliance with the Colorado River Compact under certain circumstances.

Most of the investigations and discussions pertaining to DM to date, have been focused on generating DM "water savings" through the voluntary, compensated and temporary reduction of historically consumptively used (HCU) water within the Upper Basin in order to assist with Colorado River Compact compliance. As a result, the guiding principles set forth below are based on the assumption that DM water will be generated in this manner.

Guiding Principles:

The foundational elements of any DM program must be voluntary, temporary, and compensated reductions in use of water that was being beneficially used under existing rights that otherwise would have depleted Colorado River basin flows within the Upper Basin.

SWCD believes DM is not a panacea. Additional options and alternatives (e.g., forest management, groundwater storage, weather modification, non-native phreatophyte removal, importing water from outside of the Colorado River basin) should be equally and fully explored as we work towards the goal of supply security and sustainability in the Colorado River basin.

Exploration of DM must be just one part of the comprehensive, basin-wide strategy for addressing short- and long-term water supply and demand imbalance that may be included in the next set of Interim Guidelines currently in negotiations regarding the operations of Lake Mead and Lake Powell for future Colorado Compact compliance.

SWCD pledges to evaluate DM as one of many possible strategies to provide flexibility and reduce the risk of curtailment in the Upper Basin.

SWCD will participate in the exploration and potential formation of any Colorado DM program to ensure any proposed program is capable of achieving its stated objectives and that adverse consequences are avoided, minimized, or fully mitigated.

Any DM program must operate within Colorado's Prior Appropriation Doctrine. The creation, storage, delivery and use of DM water must not injure any existing water right within Colorado.

Before deciding whether it would be feasible to adopt, let alone implement, a DM program within Colorado, the State must commit to developing the technical platform necessary to demonstrate that a program can be accomplished without injury to other users within Colorado, at a sufficient scale, and that any conserved water can be conserved, protected, and ultimately delivered for Compact compliance.

Any DM program must ensure equitable and proportional participation from all basins consuming Colorado River water as well as all regions and sectors of Colorado's economy. SWCD acknowledges that "equity" and "proportionality" are critical but undefined terms within the context of demand management. Both are currently the subject of statewide focus.

Transmountain diverters of Colorado River water must participate in DM using water that was historically diverted and beneficially used under decreed transmountain water rights. Transmountain diverters must not be allowed to purchase or otherwise rely upon other water supplies that originate in the Colorado River Basin in order to accomplish their proportional participation in DM.

A successful DM program can help ensure the safety and economic health of all Coloradans. Accordingly, the considerable funding required for DM must not target water right holders, water users, or other specific groups.

Colorado's DM program, if any, must be designed and implemented to support and aid sustaining Colorado's predominantly family- and locally-owned agriculture.

Storage of DM "savings" should be in CRSPA Initial Units that are located as high in the system as practicable.

Releases of DM water from storage should only be made by the Upper Colorado River Commission for the purpose of helping the Upper Division States assure continued compliance with Article III of the Colorado River Compact without impairing the right to exercise existing Upper Basin water rights in the future. Such releases should be timed, to the extent practicable, to provide the greatest economic, environmental, and recreational benefits.

Any DM program must not encourage or reward speculation in Colorado water resources.

Any DM program must recognize there will be impacts resulting from implementation of DM, and that impacts, both positive and negative, will be neither equally nor equitably distributed. Therefore, any DM program must include adequate mitigation for those individuals, water districts and ditch and reservoir companies, and communities impacted by implementation of a DM program. Additionally, DM mitigation should be designed to provide a net benefit to participating individuals, water projects, and their communities.

The evaluation of DM's feasibility, appropriateness, and whether DM is a timely and worthwhile pursuit must be approached without prejudice. In other words, a determination of infeasibility, inappropriateness or unworthiness must be honestly evaluated.

In order to 'test' DM and to allow for incremental implementation and accrual of meaningful DM savings, SWCD recognizes that initial implementation of DM may be required at a pilot or demonstration scale. However, any pilot or demonstration DM program must be conducted in conformance with Colorado water law, without injury to other water users and without prejudice regarding its conclusions or consequences.

As it continues to evaluate the appropriateness of DM, SWCD will remain mindful of the severe consequences of Compact Administration, which could force involuntary, and uncompensated water curtailments that could, in turn, result in disproportionate impacts to certain water users, economic sectors and geographic regions.

SWCD appreciates the CWCB's outreach and inclusivity in its evaluation process to date. SWCD pledges its continued, constructive participation with the state in its DM investigations.

Future Process:
SWCD will continue to explore demand management, including by proactively identifying and communicating its concerns regarding disproportionate and negative impacts potentially resulting from implementation of DM.

SWCD will continue to reach out to water districts, Tribes, and other interested parties in its on-going evaluation and assessment of DM.

SWCD will continue to evaluate water supply, water rights, and water uses and their respective relationships to Compact compliance.

SWCD will collaborate closely with the Colorado River District in order to maintain, to the greatest extent possible, harmony on DM between the two districts.

SWCD will continue to engage in all appropriate Colorado River Compact discussions.

COLORADO WATER CONSERVATION BOARD
Protecting Colorado Water
DEMAND MANAGEMENT FRAMEWORK

As part of Colorado's Demand Management Feasibility Investigation (see Work Plan) led by the Colorado Water Conservation Board (CWCB), this document includes a Demand Management Framework focusing on various issues associated with a potential Demand Management program.

While reviewing, note that the following Demand Management Framework draft is:

- For a potential Demand Management program that would involve temporary, voluntary, and compensated reductions in consumptive water use pursuant to the Demand Management Storage Agreement.
- Not a Demand Management program, but rather a tool for discussion regarding a potential program, which is not a foregone conclusion.
- Designed to be iterative, and there will likely be multiple updated versions released as the discussion progresses.
- Designed to show a broad range of implementation options, without showing preference for any given option.
- Set up using a range from A to C, designed to roughly correlate with level of complexity for the various implementation options. These designations do not correlate with any value judgments about which option may be best.
- Not intended to represent any commitments or guarantees regarding viability of a program design. For example, some options presented may have budgetary or other constraints.
- Intended to be used as a tool for discussion across Colorado about what may work and what may not work in a potential Demand Management program from varying perspectives, and any information gathered throughout this process is intended to assist CWCB in determining whether Demand Management may be achievable, worthwhile, and advisable from Colorado's perspective.
- Not intended to represent any position of the CWCB or the State of Colorado regarding the feasibility of Demand Management.

To provide feedback on this Framework document, please email demandmanagement@state.co.us or visit engagecwcb.org.

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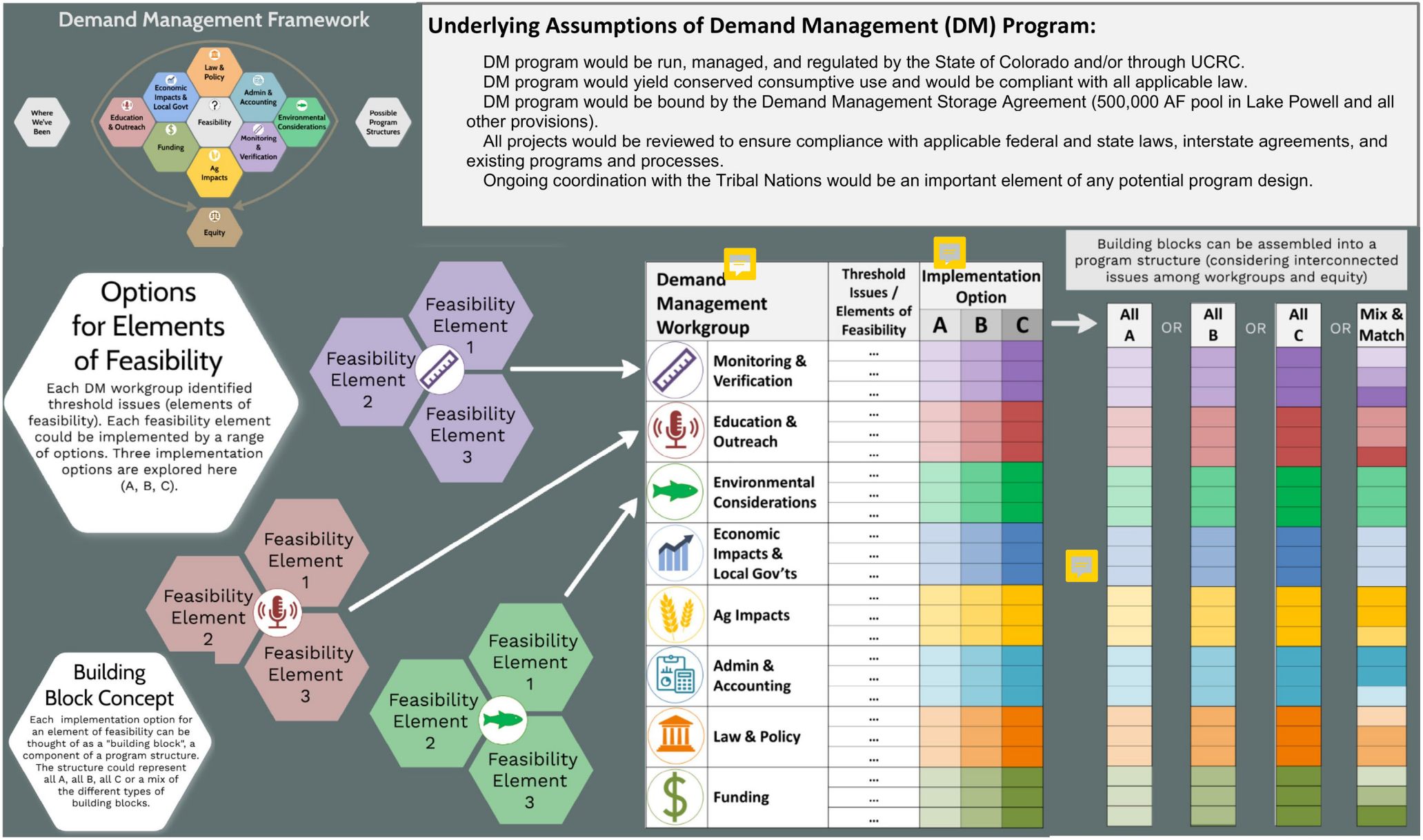
Department of Natural Resources



*Note that Law & Policy and Administration & Accounting elements are not included in this analysis.

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DM Program Structure Matrix of Building Blocks

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DM Workgroup • Guiding Principles	Threshold Issues / Elements of Feasibility	Implementation Options A	 B	 C	Interconnected Issues, Tradeoffs, and Equity Considerations
Timeframe and scale of DM Program		All potential options may impact or be impacted by the timeframe and scale of a DM Program.			
Monitoring & Verification (Agricultural DM Project) • Honest, accurate, transparent, and defensible • Protective of other water users • As simple, easy, and flexible as possible • Participation adds water to the Colorado River Basin – not solely a retiming of depletions	**Measure water returned to stream**	Bypass of diversions (streamflow and/or reservoir releases, if applicable) if the physical and legal availability can be easily determined; or estimate the amount of conserved consumptive use through moderate engineering estimates (such as reducing historical diversion rates) to protect downstream users.	Diversion of the irrigation supply (streamflow and/or reservoir releases, if applicable) into a ditch at a flume with a stage/discharge recorder, after which would be returned to the stream.	Diversion of the irrigation supply (streamflow and/or reservoir releases, if applicable) into a ditch with multiple real-time recording devices and a telemetry system to remotely monitor diversions and the measured returns of the irrigation supply to the stream.	Simplifying the measurement and verification requirements may underestimate the amount of credits generated for a DM project based on the need to use conservative assumptions and/or estimates. Increasing the measurement and verification requirements may result in increased instrumentation requirements, longer review and/or enrollment periods, and may increase program costs, but could result in greater amounts of credits/water generated for individual DM projects. Equity considerations include participation across diverse geographic areas, wide-spread locations within a stream system, wide-ranging ditch system complexities, and agricultural sectors/markets.
	Conduct a consumptive use analysis	Use the Division of Water Resources' Lease Fallow Tool to estimate historical consumptive use (conservatively underestimating to protect downstream users).	Complete a general site-specific potential consumptive use analysis, similar to a Substitute Water Supply Plan (SWSP), to estimate consumptive use, while considering the available diversion data and/or historical remote sensing data and/or aerial photographs.	Complete a detailed site-specific engineering analysis, similar to a water court change case, with parcel specific representative data to determine historical consumptive use and return flows.	
	Estimate the residual field consumptive use	Complete fallowing, removal of deep-rooted crops, and management practices to prevent inadvertent irrigation with visual inspections.	Full or split fallowing with ongoing measurement of groundwater levels and/or visual soil moisture inspections.	Split fallowing, irrigation of lower consumptive crops, or deficit irrigation with ongoing measurement of applied irrigation supplies, soil moisture, and remote sensing.	
	Maintain return flows	Bypass of diversions for the immediate delivery of both the consumptive use and return flow portions of the irrigation supply back to the stream after measurement.	Develop unit response functions (URFs) to determine the timing of delayed return flows to the stream and replace in time from legally available contracted supplies (reservoir releases or augmentation credits).	Determine the historical return flow patterns through a site-specific study and then construct and equip a recharge or infiltration pond with measurement devices near the fallowed field to maintain historical return flows in time, location, and amount.	Simplifying the monitoring and verification requirements for return flow maintenance may increase participation in a DM program, but could decrease streamflow absent a supply to replace lagged irrigation return flows. Increasing the monitoring and verification requirements for return flow maintenance may reduce participation in a DM program, but could be more protective of streamflow by identifying a supply to replace lagged irrigation return flows.
Monitoring & Verification (Transmountain DM Project)	**Measure water returned to stream**	Bypass of diversions if the physical and legal availability can be easily determined; or estimate the amount of conserved consumptive use using moderate engineering estimates (such as reducing historical diversion rates) to protect downstream users.	Diversion of the transmountain supply for measurement in a flume with a stage/discharge recorder, after which would be returned to the stream OR measurement of reservoir release.	Diversion of the transmountain supply with real-time recording devices and a telemetry system to remotely monitor measured returns/releases of the transmountain supply to the stream.	Simplifying the measurement and verification requirements may underestimate the amount of credits/water generated attributable for a DM project based on the need to use conservative assumptions and/or estimates. Increasing the measurement and verification requirements may result in increased instrumentation requirements, longer review and/or enrollment periods, and may increase program costs, but

*Note that implementation options A through C do not reflect the relative value or preference of any particular approach. They roughly align with varying levels of complexity, and are designed to encourage discussion about various tradeoffs relating to potential program designs.

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DM Program Structure Matrix of Building Blocks

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• Honest, accurate, transparent, and defensible • Protective of other water users • As simple, easy, and flexible as possible • Participation adds water to the Colorado River Basin – not a retiming of depletions	**Verify conserved consumptive use occurs on the East Slope**	Water user provides accounting demonstrating the reduction of West Slope deliveries for a DM activity did not result in additional West Slope diversions from another of its transmountain systems or contractual supply.	Water user provides accounting demonstrating the reduction of West Slope deliveries for a DM activity was offset by another East Slope supply or through a reduction in the overall demand of its customers.	Water user maintains double accounting records for several years to confirm that a DM activity in one year wasn't offset by retiming of future Colorado River depletions in subsequent years. This includes all reservoir accounting records and the reconciliation of carryover storage of West Slope supplies in East Slope reservoirs.	could result in greater amounts of credits/water generated for individual DM projects. Equity considerations include participation across diverse East Slope geographic areas, wide-spread locations of individual TMD projects, wide-ranging TMD system complexities, and ability to share conserved consumptive use impacts across all users within a DM participant's system.
Monitoring & Verification (Process considerations for all projects)	**Coordinate environmental and other benefits**	Qualitatively demonstrate an increase in streamflow after bypassing a transmountain diversion and/or divert, measure, and return flows to the stream. No additional measurement structures are required above what is deemed necessary to verify measurement of water returned to the stream.	Qualitatively demonstrate that temporary storage in a West Slope reservoir for a planned release bolsters non-consumptive, environmental and flow related benefits. Impacts and benefits evaluated qualitatively only. No additional measurement structures are required above what is deemed necessary to verify measurement of water returned to the stream and reservoir operations.	Quantitatively demonstrate that temporary storage in a West Slope reservoir for multi-benefit planned releases bolsters non-consumptive, environmental, and flow related benefits. Impacts and benefits evaluated quantitatively. Measurement needs could include flumes for measuring bypass of diversions and/or return flows; additional stream gages; measurements of water quality, etc. Accounting required to monitor a project's net effect (e.g. lagged return flow accretion timing, etc.).	Foregone agricultural and TMD diversions could provide additional benefits for non-consumptive uses and environmental flow needs both immediately after release and/or after temporary storage. Incorporating West Slope storage to manage releases of foregone agricultural and TMD diversions could maximize flexibility and bolster non-consumptive and environmental flow needs, but would result in additional evaporative losses and would reduce water generated by an individual DM project. Incorporating West Slope storage could also increase the requirements for measuring, verifying, and quantifying environmental benefits and/or impacts.

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DM Program Structure Matrix of Building Blocks

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Education & Outreach • Transparent and inclusive stakeholder engagement to shape the program • Address communication gaps with message consistency, partner networks, and virtual engagement • Water education at the state, regional, and local levels • Include an equity lens in all engagement and communication	**Water education (to engage broad audiences)**	State creates detailed website resources, issues press releases, conducts interviews, and delegates many education tasks to PEPO, WEco, and other partners.	State partners with groups such as WEco, PEPO, educators, cooperative extension or similar entity, and universities to implement a series of education activities; implements a targeted communications plan; offers webinars to partner organizations; some new audience engagement.	State brings on additional staff or funds education to travel statewide for strategic teaching efforts rooted in drought and water shortage knowledge; partners extensively; communicates broad-scale (i.e. radio, billboards, TV) to new water audiences.	"Change management" is an ongoing and resource-intensive effort to evolve both the program design and the state's attitudes towards water use.
	Stakeholder engagement (to inform the program)	State builds upon successes of preexisting programs. Utilizing Board and IBCC input, and updated website comment functionality, the state develops a DM program with assistance from consultants or others as needed and appropriate.	Leveraging the Board, Roundtables, IBCC, CWC, conservation districts, and public meetings, the State leads a public input process to inform a DM program and geography. As the program is developed, stakeholders are invited to address the CWCB Board to proactively identify and discuss how the program is working from varying perspectives and geographies.	The state engages a broad and diverse range of stakeholders over an extended period. As the program is developed and implemented, stakeholders are invited to address the CWCB Board to proactively identify and discuss how the program is working from varying perspectives and geographies. Based on this input, elements of the DM program are appropriately tailored to local needs across the state. An iterative process with evolving program options.	More localized programs may mean that some programs cost the state more, and other programs cost the State less. Stakeholders would need to determine whether it is fair for taxpayer dollars to be distributed inequitably for the sake of equity. While an evolving program structure may be desirable as a mechanism to proactively avoid or mitigate potential negative impacts, it may make it more difficult to ensure a clear, predictable process is in place. If a DM program is established, CWCB will coordinate with other state agencies relating to conflict resolution processes available.
	Program marketing (to ensure participation)	State remains active in water forums like CWC; implements marketing plan as needed to target audiences; maximizes pre-existing participants. No active solicitation. Assumes participants would approach state.	State partners with local actors to assist with program marketing; implements proactive marketing plan to target audiences using annual allocated funds.	State opens local offices to be liaisons between the state and program participants; extensive marketing; maximizes new program participants. State has a role in co-developing applications with new applicants.	The "bang for the buck" considerations would need to be weighed by decision makers and stakeholders regarding the extent to which additional efforts yield increased program participation. Lower levels of marketing would limit the State's ability to educate / market for increased participation in certain geographies / sectors. Smaller operations, non-English speakers, and nontraditional participants such as mining or food industry would benefit from higher levels of implementation. Proportionality of program adoption would require active marketing and education efforts in areas with lower levels of implementation.
Environmental Considerations • Achieve a net environmental benefit over time, and across hydrologic conditions and geographies	**How potential environmental benefits and impacts are considered**	Environmental benefits and impacts (flow needs, affected habitat, and/or species, alignment with other plans or efforts, etc.) considered through existing review processes and frameworks.	Identify potential environmental benefits and impacts and associated risks for potential projects. Evaluate possibility of realizing potential benefits and mitigating potential impacts. Coordinate with other agencies to identify and track potential benefits and impacts, including CPW and others as appropriate.	Consider each item in a comprehensive list of potential benefits and impacts. Public stakeholder engagement could be required for large projects. This may include consultation with local entities or with a committee of experts to assess local needs and impacts. Evaluate possibility of realizing potential benefits and mitigating potential impacts. Coordinate with other agencies and local entities to identify and track potential benefits and impacts, including CPW and others as appropriate.	

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DM Program Structure Matrix of Building Blocks

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• Provide opportunities for projects with net environmental benefits • Not harm the environment • Evaluate project environmental benefits/impacts without creating an unnecessarily burdensome process for applicants • Identify project impacts/benefits to environmental resources, including flow, water quality, affected habitats, etc.	**Assessing net benefit or impact**	Environmental benefit or impact of a given project is assessed through existing review processes and frameworks.	List of environmental considerations evaluated qualitatively for benefits or impacts. Net benefit or impact of a project is evaluated qualitatively based on evaluation of considerations.	List of environmental considerations evaluated quantitatively for benefits or impacts. Net benefit or impact of a project is evaluated quantitatively and qualitatively based on the evaluation of considerations. Evaluate risks and tradeoffs.	More comprehensive environmental assessments could be burdensome to potential applicants as well as the State. However, greater risk of adverse impacts or lost opportunities if these assessments are not conducted.
	Strategies to incentivize benefits	No incentives provided for projects with potential environmental benefits.	Preference and/or additional monetary or program incentive given to projects with net environmental benefits.	Preference and/or additional monetary or program incentive given to projects with greater net environmental benefits. Potential partnerships with NGOs and/or local organizations to support the assessment of potential benefits.	Coordinate efforts on incentivizing benefits with local governments to streamline approval. Opportunities for collaboration on a county/local level.
	Strategies to avoid, offset, or mitigate any negative impacts	No additional strategies implemented to avoid, offset, or mitigate any potential negative impacts.	Evaluate the program as a whole for opportunities for partnership(s) to add environmental value (enhance benefits or avoid, offset, and or mitigate negative impacts). Examples: potential storage and retiming of return flows in an upstream reservoir to increase benefits and/or mitigation measures.	Evaluate specific projects for opportunities for partnership(s) to add environmental value (enhance benefits or avoid, offset, and or mitigate negative impacts). Examples: Potential partnerships with NGOs and/or local organizations to help in realizing benefits and mitigating potential impacts and provide additional funding, programs, or opportunities. Potential projects could include watershed restoration work, diversion structure improvements, etc.	These are very similar to the options for monitoring and verification. Additional mitigation measures would require additional funding. Measurement and quantification of potential environmental benefits and/or impacts would have monitoring and verification components or requirements (see Monitoring & Verification).
Economic Impacts & Local Governments • Any program participation must be voluntary • Initial goal of program should be to do no harm • Program should seek to create net benefits for water users • Program operations should be transparent & collaborative	**Support for municipal participants**	Existing programs and funding sources are used to support municipal participants.	State consults with and provides support for municipal participants in developing projects.	State identifies other programs that may be coordinated to support municipal participation and assists in facilitating more significant conservation programs. State consults with local governmental entities to identify appropriate mitigation opportunities.	A water efficiency program is not temporary. However, it is likely to be the least disruptive option. Municipal participant may eliminate or minimize impact municipal water customers. However, mechanism of municipal participation and/or reliance on other water sources may impact water availability for other users.
	Municipal sector mitigation	Existing programs and funding sources are used relating to municipal sector mitigation. Municipalities may take steps to avoid secondary impacts to their customers.	State more actively works to identify and track potential secondary impacts to municipalities resulting from participation in the program. A portion of project compensation spent on mitigation efforts. Mitigation payments are made to municipalities or communities.	State sets specific protocol and mechanisms for identifying and tracking potential secondary impacts resulting from municipal participation. A larger portion of compensation spent on mitigation with a defined list of required mitigation actions dependent upon type of project activity. State partners with local governmental entities to identify appropriate mitigation opportunities.	Potential impacts to system reliability depending upon type of municipal participation. Mitigation measures taken by municipalities may have impacts outside their municipal boundaries. Municipalities with fewer resources may be less able to mitigate potential impacts on their own, resulting in areas of low socioeconomic status potentially having lower access to green spaces or other resources.

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DM Program Structure Matrix of Building Blocks

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	Consultation with local governments to track impacts and develop mitigation measures	General education and outreach to inform local governmental entities, water boards of DM program. State does not consult with municipal participants or local governments to identify, track, or mitigate potential impacts and identify potential benefits to local economies resulting from a DM Program.	State consults with program participant and/or local governmental agencies to identify potential impacts and mitigation strategies, for all types of project activity, and to identify potential benefits to local economies and communities relating to a DM Program, as well as strategies to increase benefits.	Inter-governmental Agreement (IGA) or similar framework developed to facilitate robust and iterative consultation process with local governments and other entities to address local concerns and mitigate local impacts, with specific strategy and focus on mitigating or avoiding potential adverse impacts and increasing potential benefits, for all types of project activity.	Less consultation with local governments may result in increased adverse impacts that are not adequately tracked and mitigated. There is a varying level of resources and capacity available for local governments to facilitate coordination and mitigation efforts. This variation may affect the extent to which impacts are tracked and mitigation measures implemented across the state. Consultation with the Colorado Municipal League and Regional Councils of Governments may be helpful in determining appropriate parties and mechanisms for engagement.
Ag Impacts • Equitable & proportional across state • Minimize & mitigate off-farm impacts • Program should be a structured & guided market • Program operations need to align with growing season schedules	**Agricultural sector mitigation**	Existing programs and funding sources are used to promote agricultural viability.	Fund is established to provide compensation to local entity for community economic development fund. Grant program established to assist with local agricultural and economic viability.	State and partners make efforts to identify potential secondary impacts. Fund established that potentially provides compensation for mitigation, some of which is distributed to water management entity servicing property, while a portion is distributed to local/rural economic development or other appropriate organization. Additional staff time targeted at mitigating agricultural sector impacts to non-participants. Dependent on funding availability and identification of appropriate funding source.	Limiting the community development fund to verifiable DM impacts would present additional complexity, but would perhaps lower costs or avoid reimbursement of economic impacts beyond the State's control; alternatively a community fund that supports projects regardless of verifiable impact would be easier to manage and generate positive community outcomes. State verification of potential impacts could be costly and difficult to accomplish. Assess impacts to tenant farmers and land rental prices through community outreach efforts, noting it may be challenging to distinguish DM-related impacts. Community impacts in sovereign Tribal Nations may require alternative structure. Determinations may need to be made regarding which sectors or workers receive preference in assistance.
	Agricultural participant field requirements	No field requirements	State works with cooperative extension, other local agencies to establish guidelines for cover crops (for annual crops) and weed and pest control measures (for perennial crops). State partners/contracts with cooperative extension or similar entity for technical assistance and limited monitoring of compliance.	State works with cooperative extension, other local agencies to establish guidelines for cover crops (for annual crops) and weed and pest control measures (for annual and perennial crops). State provides staffing for technical assistance and monitoring of compliance.	Cover cropping could add complexity to monitoring and verification of consumptive use; soil health practices such as conservation tillage could reduce Monitoring & Verification complexity; development of any mitigation guidelines would likely require input from the United States Department of Agriculture, Colorado Department of Agriculture, and cooperative extension. Cover cropping could provide additional environmental benefits; select cover crops could help offset impacts to livestock feed disruptions and provide additional revenue for the participant. Producers may lack knowledge of cover cropping techniques. Though cover crops may create additional costs, state may work with USDA NRCS to offset participant cost of any on-farm mitigation requirements. There may be federal crop insurance implications.

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DM Program Structure Matrix of Building Blocks

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	Agricultural participant assistance	Existing programs and resources in place are utilized to facilitate agricultural participant assistance to help fully realize potential benefits of participation or mitigate potential impacts.	State creates a grant or cooperative contracting program with the university cooperative extension service, conservation districts, or similar technical service providers, to offer technical assistance and help fully realize potential benefits of participation or mitigate agronomic impacts from the DM program to the participants.	State creates additional staff capacity responsible for assisting in fully realizing benefits of participation or mitigation of impacts from the DM program to the participants. Position manages a budget for technical assistance and mitigating impacts.	Participants would likely need technical assistance in both navigating any potential DM in-take process and in selecting/implementing mitigation measures (e.g. cover cropping); providing the ability to grant or contract with third parties would likely reduce programs costs and address state capacity concerns. Producer participants familiar with working with agricultural service providers may be more willing to work with a trusted [illegible]t versus state staff. In addition to direct technical assistance, online information regarding any DM sign-up process or agronomic impacts and best management practices would be helpful and more accessible
Process Considerations	**Soliciting projects**	No state solicitation	Annual grant funding for entities to identify & develop project applications	State staff support & grant funding for identifying & developing project applications	
	Application requirements	Participants are not required to submit information regarding mitigation, monitoring, or other elements with their application. No certification program due to open enrollment process.	Select mitigation & monitoring elements must have been completed or substantially planned for application.	Select mitigation & monitoring elements must have been completed or substantially planned for application. A certification process ensures that project applications meet minimum requirements.	
	Project selection process	Open enrollment (first come, first serve) for projects of any duration. No certification processes. Review is done on a project-specific basis.	Annual RFP process without any certification process. Coordination with local governments, entities, others to facilitate a "guided market" approach aimed at ensuring a program aligns with specific goals and does not create unacceptable adverse impacts (see Economic Impacts and Local Governments and Agricultural Impacts sections).	Annual RFP process with certification required. Clear protocol developed, incorporating coordination with local governments, entities, others, to establish a "guided market" approach designed to ensure the program aligns with specific goals and values and does not create unacceptable adverse impacts (see Economic Impacts and Local Governments and Agricultural Impacts sections).	Care should be taken to ensure that the timing of the application, review, and approval process align with when agricultural participants make operational decisions
	Localization and program evolution	No additional protocol put in place to localize and/or evolve a program to local needs.	Review of DM program put in place at specific milestone to consider successes, lessons learned, and stakeholder feedback. The review directly informs future program management across the state.	Regular review of the DM program to consider successes, lessons learned, and stakeholder feedback. The review directly informs program management at local level. The review is public, transparent, and available for comment.	Depending on the level and scale at which programs evolve, there may be program differences (perceived as inequity) over time at the Basin levels. Local agencies / entities have different statutes, capacity, jurisdictions, resources, knowledge, and mobilization. Different basins can engage at different levels.

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DM Program Structure Matrix of Building Blocks

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Funding • Portfolio of funding sources should be considered • Costs would be influenced by many factors including program design, scale, and participation	**Range of annual costs**	$3M - $16M Example Cost Breakdown: 10% Program Costs 90% Compensation Cost	$5M - $20M Example Cost Breakdown: 30% Program Costs 70% Compensation Cost	$12M - $30M Example Cost Breakdown: 65% Program Costs 35% Compensation Cost	Payment offered may impact who is interested and able to participate, which may affect proportionality in terms of sector and region. Compensation range reflects that some may be willing to participate at lower cost than others, and in some cases additional compensation may be available outside of state fund.
	Funding Sources	Compensation paid by State through budget reallocation	Compensation paid by State through [illegible]	Compensation paid by State through blend of multiple sources.	

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EXHIBIT C
Literature Review

Demand Management Feasibility Investigation
Literature Review
July 2021

COLORADO
Colorado Water Conservation Board
Department of Natural Resources

Consultant Team

CDR Associates

SGM

WestWater Research / Colorado College

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Introduction

In 2019, the consultant team was retained to conduct a literature review relating to topics that correlate with the workgroups convened pursuant to the 2019 Work Plan adopted by the Colorado Water Conservation Board. The consultant team was directed to conduct a literature review and to identify key data gaps in the literature to help inform Colorado's Demand Management Feasibility Investigation.

The consultant team conducted the literature review, as well as additional research and interviews in some cases to inform their findings. This report summarizes the consultant team's findings in the following topic areas:

- Agricultural Impacts
- Economic Impacts and Local Governments
- Education and Outreach
- Environmental Considerations
- Funding
- Monitoring and Verification

Each section of this report captures:

- A summary of the literature review
- A summary of work completed in addition to the literature review
- Key takeaways
- Data gaps

The Administration and Accounting and Law and Policy workgroups were not associated with the Consultant Team's scopes and therefore not included in this report.

SECTION 1 – FEASIBILITY INVESTIGATION BACKGROUND

Colorado is currently investigating the feasibility of a potential Demand Management (DM) program. Demand Management is the concept of temporary, voluntary, and compensated reductions in the consumptive use of water in the Upper Colorado River Basin. Each of the Upper Colorado River Basin States (also referred to as the Upper Division States) are conducting their own investigations to determine whether a potential program would be feasible from their states' perspectives.

It is beyond the scope of this document to provide an overview of the minimum requirements to establish a Demand Management Program. However, more information relating to the Drought Contingency Plan (DCP) and associated agreements can be found at the following website: https://www.usbr.gov/dcp/index.html.

Investigation Background

The DM Feasibility Investigation (Investigation) follows direction of the CWCB Board in the Support and Policy Statements adopted in November 2018, the 2019 Work Plan (Step I), and the most recent Step II Work Plan approved in November 2020.

2019 Work Plan

The 2019 Work Plan (Step I) had three primary components:

1. Establish **workgroups** comprised of subject-matter experts and key Colorado River stakeholders, which were directed to meet publicly at least four times in Fiscal Year 2019-20, and to identify key threshold issues for board consideration
2. **Regional workshops** designed to facilitate the public discussion around DM and provide opportunities for CWCB staff updates on the Investigation; and
3. Continued **education and outreach**.

In addition, the CWCB Board directed staff to facilitate a literature review, completed by the Consultant Team.

The July 2020 Board meeting included a presentation of the summary of workgroup discussions and other work found at the following website:

https://dnrweblink.state.co.us/cwcb/0/edoc/212695/8_Demand%20Management%20Update.pdf?searchid=a1d2b86a-6aab-4b53-b5dc-e3dd570b71fb

Step II Work Plan

Following the 2019 Work Plan, the Board adopted the Step II Work Plan, which contemplates exploration of potential program design options through development of a Framework. Figure 1 shows how information gained in the 2019 Work Plan has helped to inform the Framework, which shows a range of implementation options and program design options.

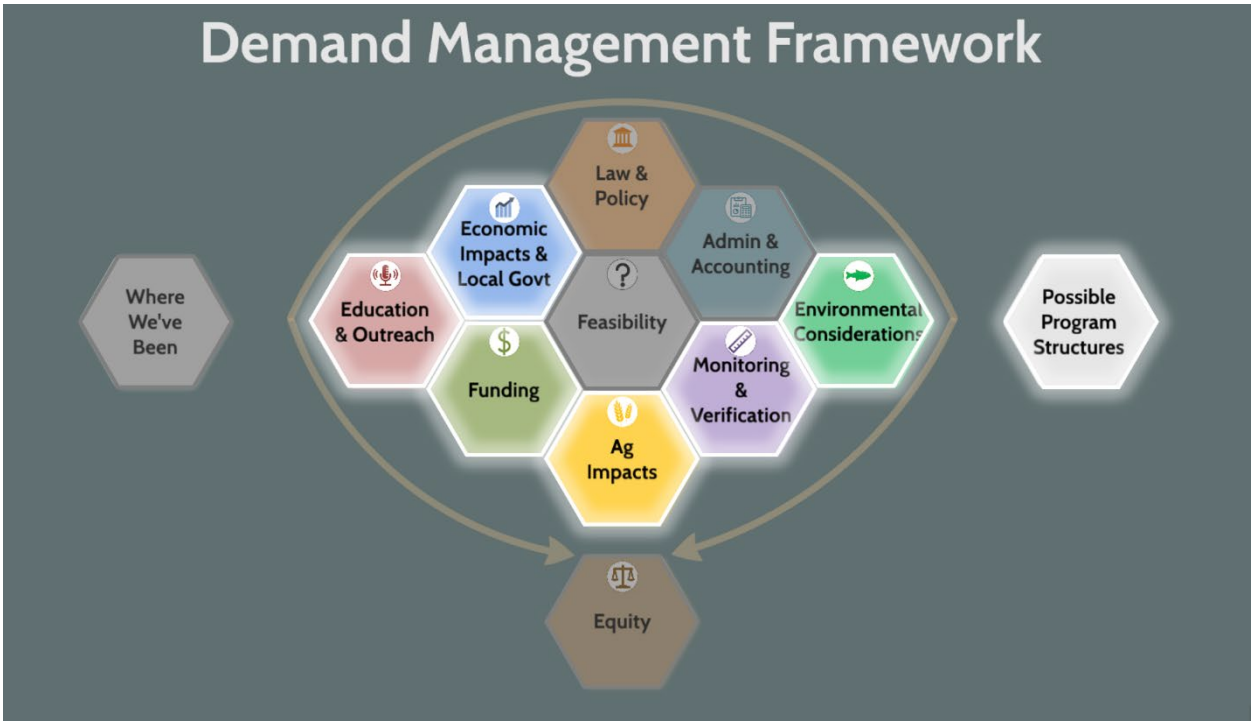

Figure 1. Demand Management Framework. The white highlighted tiles depict the Consultant Team's focus workgroups.

Consultant Team

The DM Consultant Team is comprised of three consultant firms that were responsible for different tasks. Each team member reviewed information from the workgroups, conducted a comprehensive literature review, and some conducted additional analyses and interviews. A list of each team member and their specific focus-area(s) are:

- CDR
  - Education and Outreach (E&O)
- WestWater Research & Colorado College
  - Agricultural impacts
  - Economics and Local Governments
  - Funding
- SGM
  - Monitoring and Verification
  - Environmental Considerations

SECTION 2 – LITERATURE REVIEW OVERVIEW

A comprehensive list of the documents reviewed by the Consultant Team is included in **Exhibit A**. The following sections summarize the literature reviews and analyses of the Consultant Team. While compiling the individual components of the literature review, the Consultant Team identified interconnected issues that were relevant across specific workgroup topics. Pertinent areas of overlap were included in each applicable section.

SECTION 3 – AGRICULTURAL IMPACTS - LITERATURE REVIEW & ANALYSES

WestWater Research led the Agricultural Impacts literature review. The tasks associated with their work specifically included:

- Participation in the final meeting of the Agricultural Impacts workgroup as a listener.
- Compilation and review of past studies and research regarding the agricultural impacts of water conservation and reduced irrigation projects in the Western U.S.
- Analysis of design elements of a DM program as they relate to agricultural impacts.
- Identification of knowledge or data gaps in the ability to understand and evaluate agricultural impacts of a DM program and individual DM project activities in the agricultural sector.

This report section provides a summary of the literature review research findings.

Literature Review

There is an extensive body of knowledge and library of past research studies on the impacts of reduced irrigation activities. This section summarizes some high-level summary points from the literature review.

What we know

Demand management is the reduction of consumptive water use. The types of activities that can be undertaken in the agricultural sector to reduce consumptive water use are focused on reduced irrigation, which can take on a variety of forms such as: full-season fallowing, split-season fallowing, rotational fallowing, deficit irrigation, and crop switching. Each demand management activity will have different economic effects which depend upon the existing water use and crop and livestock production on a farm or ranch property. It is also important to distinguish demand management activities as those resulting in water conservation or conserved consumptive use, and not activities that result in greater water use efficiency which do not generally result in a reduction in consumptive use. The following two sections (below) expand upon the on-farm and off-farm impacts of agricultural demand management activities.

On-Farm Impacts

All demand management activities that may be implemented in the agricultural sector will reduce the irrigation water supply to the crop. Various types of irrigation reduction are possible for a given operation, but the primary (expected) methods are listed in the above paragraph. On-farm impacts of demand management activities are described in the points below.

- **Crop Yield**. In the Colorado agricultural sector, a reduction in consumptive water use is expected to result in a reduction of crop yield. This is the most direct impact of reduced irrigation and will result in

reduced income for the producer. The extent of yield reduction depends on the crop type, extent of water stress, and timing of water stress.

- **Crop Quality**. The quality of the harvested crop or grazed pasture is often influenced by reduced irrigation, with both positive and negative quality changes documented. Particularly for alfalfa and grass hay cut for sale, quality influences price and therefore has an impact on producer income.
- **Management Impacts**. A variety of management impacts exist for reduced irrigation activities. For hay and pasture fields, there are expected to be significant and multi-year management impacts from large-scale reduced irrigation. Hay fields and pastures can take several years to establish and reduced stand density and quality changes from reduced irrigation can result in disruptions to operations. For cattle ranchers, reduced pasture production can impact herd sizes, health, and genetics, particularly if supplemental feed is not easily acquired. These impacts are expected to scale down with reduced demand management activity and forage crops are unique in their ability to scale with various irrigation inputs. For annual crops, full-season fallowing and crop switching are the most likely activities to be implemented and disruptions to operations are expected to be less than multi-year forage crops. Also, specialty annual crops are likely to see greater operational and management impacts compared to commodity crops. One aspect that is universal is the negative impact to business relationships that comes with not producing (or producing less of) a crop or agricultural product, which forces customers (buyers) to look elsewhere. The temporary reduction in agricultural production could impact the long-term business plans for producers.

Off-Farm Impacts

The off-farm impacts of reduced irrigation and agricultural production that come with demand management can touch upon multiple economic sectors in a community. Additional information on off-farm impacts is provided in the Economics & Local Government section of this report. For this report section, off-farm impacts will focus only on the agricultural sector. Off-farm impacts are organized into the following three categories: (1) hydrologic, (2) economic, and (3) agronomic.

Hydrologic Impacts

Irrigation activities change the natural hydrologic flow patterns in a watershed. These changes are often documented in the engineering studies that accompany water right change of use applications in water court. Cessation or reduction of irrigation results in a similar but reversed change to flow patterns. For many areas in Colorado, irrigation has been occurring for well over a century, such that both natural and human reliance on the irrigation flow patterns has occurred. Reduced irrigation due to demand management may result in the following hydrologic impacts:

- Increased annual streamflow volumes due to reduced crop consumptive use and reduced losses in the conveyance and application systems. Annual volume increases are the underlying reason for conducting demand management activities.
- A shift in the timing of streamflow with increases during the spring snowmelt period and reductions during the late summer and fall seasons. This shift results from not holding back spring runoff flows through irrigation diversion and land application.
- Reduction in canal flows serving multiple producers, such as irrigation districts and mutual ditch companies, which can negatively impact canal operations. Less carriage or “push” water can create hydraulic problems on ditch systems, particularly affecting neighboring producers needing elevation head in the canals and those located at the tail-end of ditches.
- A shift in the timing and volume of streamflow may result from changes in groundwater pumping for irrigation. Aquifer water levels may also increase with reduced pumping across a large area.

Economic Impacts

The off-farm economic impacts are tied to the flows of money into agricultural production and out of agricultural sales. In other words, off-farm economic impacts relate to an agricultural producer's typical spending habits and his/her modified spending habits under demand management. For production inputs, it is common to look at crop enterprise budgets developed by university extension offices to understand input types and values. The dollar value of operating costs (per acre) in the crop budget tables provide an indication of the relative economic impact resulting from reduced purchases by the producer because of demand management. For example, the 2018 budgets indicate that alfalfa hay has operating costs totaling $334 per acre or $86 per ton of hay production. Most of these operating costs will scale down with reduced production (yield) under demand management. Fixed costs identified in the crop budgets are not expected to change significantly under demand management activities.

The economic impact of modifications to spending that typically results from agricultural net income is more difficult to quantify and predict. Demand management activities will be compensated, and compensation amounts will need to be greater than the expected loss in agricultural net income to incentivize participation from agricultural producers. The off-farm economic impact from spending depends upon the source of compensation funds and whether the compensation income is spent locally or not. Limited data from two surveys indicate that approximately half to nearly all of the compensation payments will be spent locally.

The two money flows described above (inputs to and spending from agricultural production) are based on an owner-operator farm system. Many farms and ranches in Western Colorado have absentee landowners and are farmed by long-term lease tenants. An additional economic impact results to tenant farms if the landowner decides to participate in demand management activities without collaborating with the lease tenant. Demand management can disrupt the owner-tenant relationship because compensation payments to the owner may not be shared with the tenant, who will experience lost production and income. Landowners are incentivized to work with their lease tenants before participating in demand management activities to maintain a beneficial relationship with the tenant and to maintain market lease rates for the property.

Agronomic Impacts

The off-farm agronomic impacts relate to weeds, pests, and dust. A field that is participating in demand management can be a nuisance to neighboring fields due to these issues and therefore weed, pest, and dust management are often required as part of short-term and permanent fallowing plans. The extent of impact if such management actions are not taken is site dependent, based on field location, soil types, and localized infestation issues. Many of these agronomic impacts can be mitigated through cover crop establishment on fallowed fields and weed & pest controls on perennial forages.

The following illustration in **Figure 3** provides a conceptual model for thinking about the agricultural impacts of demand management and captures many of the themes identified in the literature review.

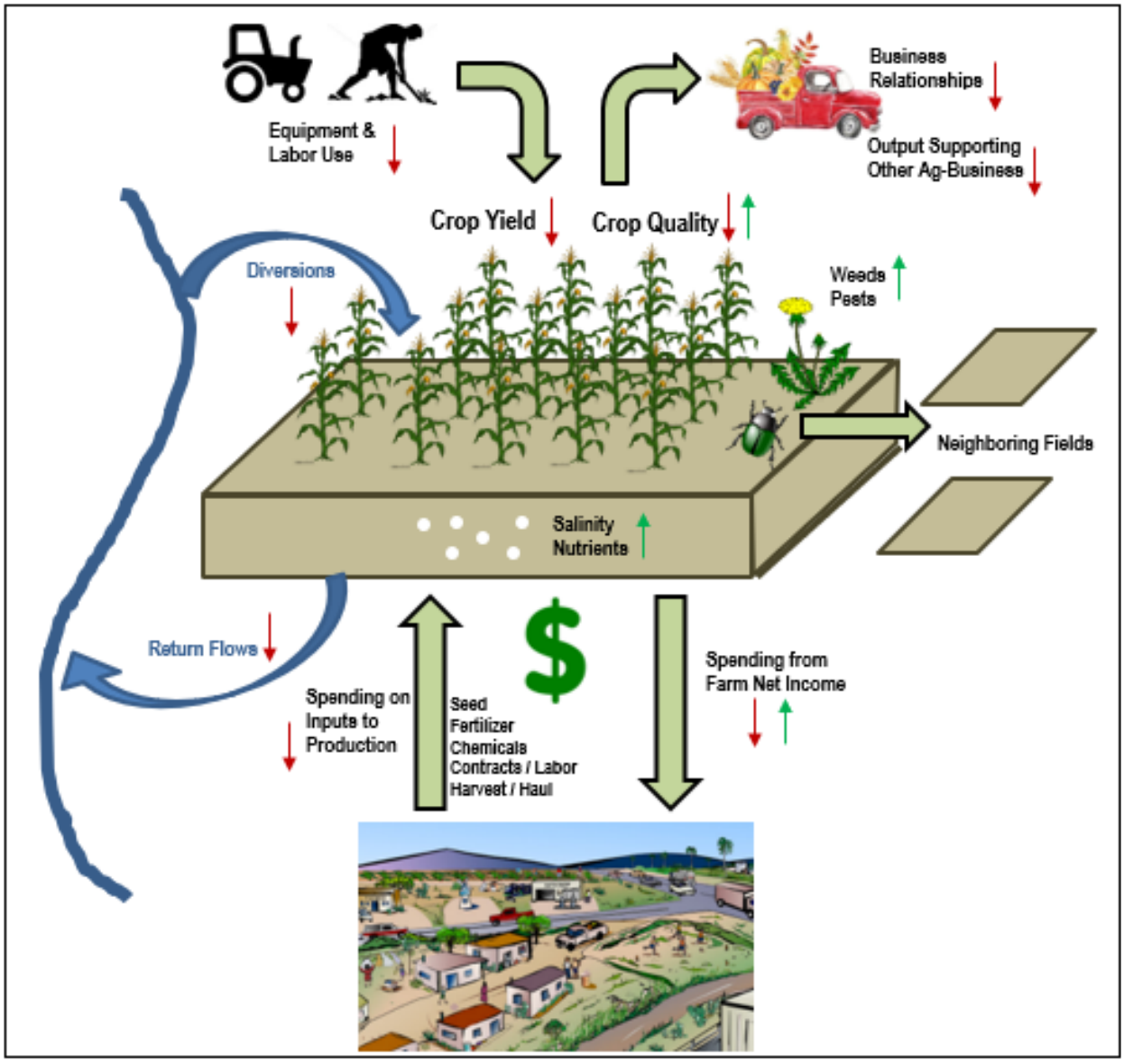

Figure 2. Conceptual Model of Agricultural Impacts from Demand Management Activities.

Key Takeaways

- **Develop Educational Resources for Producers**. The CWCB may work with the Colorado Department of Agriculture, Colorado State University Extension, Natural Resource Conservation Service, and other land management groups to develop a guide for agricultural producers on how to apply for and conduct demand management activities while minimizing on-farm and off-farm impacts. The guide may be organized by crop type and demand management activity and may present best management practices (BMPs) for reduced irrigation. In addition, technical staff support may be funded and supported to assist producers in designing their demand management programs.
- **Ensure Contracting Aligns with Seasonal Cycles**. The CWCB may ensure that the application, review, and approval process is timed to align with when producers make decisions and investments each growing season. For example, project contracts by October 1 of the preceding year would be best, by January 1 of the activity year would be good, and by approximately March 1 of the activity year is

necessary. If a rolling application process is used, then a demand management program may build in sufficient time to allow the producer to adjust investments and business commitments prior to activity implementation.

- **Limit Demand Management Activity Duration**. The available research suggests that partial-season reduction in irrigation on perennial forage crops, particularly alfalfa, can be achieved without significant and lasting damage to the forage stand. Full-season fallowing can be conducted on perennial forages but is best suited to the latter years of a stand when re-establishment is planned. For annual crops, multiple continuous years of demand management will require diligent management of weeds and pests. In general, agricultural impacts are less if specific fields do not participate in complete full-season fallow activities for multiple consecutive years.
- **Develop a Guide for Compensation Calculations.** This review identifies multiple on-farm and off-farm elements that compensation payments may consider. The CWCB may develop a simple guidance worksheet that helps producers understand the various costs that are likely to be incurred in demand management activities. Compensation payments are expected to be customized by each producer and operation, but general guidelines may be helpful to ensure that producers do not experience unforeseen costs as part of the program.
- **Limit Concentration of Activities**. An important tool in program design to minimize significant off-farm impacts of demand management activities is to limit the geographic concentration of projects. Demand management will be structured as a voluntary program and therefore the program may place maximum limits on the number of irrigated acres approved for participation in demand management by river basin or county.
- **Mitigate Off-Farm Impacts**. This review identifies hydrologic, economic, and agronomic impacts from demand management activities that the program may be designed to minimize and/or mitigate, and the following mitigation elements may be considered by CWCB. It is difficult to quantify the off-farm impacts for each specific project such that a program may look to implement standardized policies and payments that will apply to all projects.
- **Hydrologic Impacts**: Hydrologic impacts to off-site water users can be evaluated using standard engineering techniques such as those applied in Substitute Water Supply Plan (SWSP) applications. In addition, the CWCB may consider including mitigation payments to the managing ditch company, irrigation district, or other water user association as part of project costs (as applicable) to mitigate impacts to canal operations on larger systems.
- **Economic Impacts**: The on-farm economic impacts are expected to be fully addressed through compensation payments determined by the producer. Program design may be more concerned with off-farm economic impacts, which can partly be minimized through project selection. Mitigation payments to local governments may be a consideration of a demand management program, and these payments can be used for grant or loan programs for qualifying businesses or other economic development initiatives. The need for mitigation payments to local governments has not been definitively determined based on our research. It will be difficult to customize economic impact mitigation for each project due to uncertainty and privacy concerns with producer finances, such that a program may look to develop mitigation approaches applied uniformly to certain categories of demand management projects.
- **Agronomic Impacts**: Both on-farm and off-farm agronomic impacts can be minimized with a requirement that all farms and ranches participating in demand management conduct weed and pest control measures as part of the proposed projects. For perennial forages, this is likely to consist of various integrated approaches to maintaining a healthy forage stand. For annual crops, this is likely to require the establishment of a cover crop. A program may consider a requirement for field management techniques, such as cover cropping and weed & pest controls. CWCB may consider the compilation and

development of information resources to assist producers in determining the best cover crop and weed & pest control measures for their operation.

Data Gaps

There are two types of data gaps associated with the assessment of agricultural impacts: (1) those currently present in evaluating the feasibility of a demand management program, and (2) those that are likely to be present when evaluating the impacts of specific demand management projects.

Data Gaps in Evaluating the Feasibility of Demand Management

No major data gaps concerning agricultural impacts are identified that would significantly benefit an evaluation of demand management feasibility. Significant resources have been applied in studying demand management concepts for the past 8 years. Additional studies that are presently underway or near completion will also add to our understanding of agricultural impacts. Most of the data gaps identified during our analysis were focused on other subject areas, such as quantification of consumptive use savings and facilitation of program activities. The following data gaps related to agricultural impacts were identified:

- The costs, benefits, and impacts of crop switching and deficit irrigating as demand management activities. Most of the research we reviewed focused on partial and full-season cessation of irrigation on perennial forage stands. There are several outstanding questions about how (and if) crop-switching and deficit irrigation would work as demand management activities.
- The impact of demand management activities on the availability of hay for livestock operations. Demand management activities at a small scale will result in reduced hay production locally may require local purchase of supplemental hay. At a large scale, there are uncertainties about how the hay market would respond and how hay availability would be impacted. It is possible that demand management impacts would mirror past drought periods with a similar reduction in hay production.
- Additional information on specific best management practices for managing a field that is experiencing reduced irrigation, particularly a full-season fallowing. It is well-established that cover crop establishment for annual crops and various weed and pest control measures for perennial forage crops are critical to mitigating impacts, but specific information on practices relevant to different Western Slope agricultural zones would be beneficial. This information could form the basis for guides assisting producers in project implementation.

Further research and information on the above topics would be beneficial but is not likely to significantly change the existing knowledge base on agricultural impacts of demand management activities. Agricultural impacts will often be site-specific. The CWCB may consider additional pilot projects to expand the diversity of project examples. The pilots are not expected to provide definitive findings but rather improved perspective on likely impacts.

Data Gaps in Quantifying Impacts of Specific Demand Management Projects

The agricultural impacts associated with specific demand management projects will need to be addressed as part of compensation payments and program design. On-farm impacts will be site specific and standardized impact metrics are unlikely to be useful across operations. Each producer may evaluate the expected impacts, with available information resources and technical assistance, and incorporate impacts into proposed compensation terms. Off-farm impacts are a greater concern for program design, and program design is anticipated to mitigate off-farm impacts more than information gaps addressed during the application and review process.

SECTION 4 – ECONOMICS & LOCAL GOVERNMENTS – LITERATURE REVIEW & ANALYSES

WestWater Research worked with Dr. Mark Smith from the Colorado College Economics Department to lead the Economics & Local Governments processes for the Investigation. The tasks associated with these efforts specifically included:

- Participation in the final meeting of the Economic Impacts & Local Governments workgroup as a listener.
- Compilation and review of past studies and research regarding the economic impacts of water conservation projects in the agricultural and municipal water use sectors.
- Analysis of design elements of a DM program as they relate to economic impacts.
- Identification of knowledge or data gaps in the ability to understand and evaluate economic impacts of a DM program and individual DM project activities in the agricultural and municipal sectors.
- Implementation of a survey of 19 municipal water providers in Colorado to better understand the municipal perspective on a DM program and anticipated DM activities.

Literature Review

There is an extensive body of knowledge and library of past research studies on the impacts of reduced irrigation activities, or demand management types of projects in the agricultural sector. There is also an extensive knowledge base on municipal water conservation; however, there is a general lack of information on voluntary, compensated, and temporary reduction of water use in the municipal sector. This section summarizes key points from the literature review on economic impacts.

What we know

To evaluate the economic impacts of demand management, it is necessary to consider both the direct impacts of reducing water use through demand management activities, and the indirect effects of reduced water use. These are often referred to as the primary and secondary impacts of an action or decision. An expanded discussion on the primary and secondary impacts of agricultural and municipal demand management is provided in subsequent sections. In brief they are:

- **Agricultural Demand Management**. Irrigation water is one of many inputs to crop production. Reduced water use results in less production as the primary impact of demand management. Secondary impacts reflect the other economic sectors that are affected by both reduced water use and reduced production. Backward-linked impacts result from the producer spending less on production inputs, such as seed, fertilizer, labor, and other items. Forward-linked impacts result from less harvested crop feeding into agri-businesses and other industries.
- **Municipal Demand Management**. Municipal water providers provide a service which allows their customers to live and work, enjoy a good quality of life (health, safety, and happiness), and allows businesses to function. Direct water uses in a municipal system are varied and diverse. Reduced water use results in less service, which can be reflected in various ways in a community as the primary impact depending on how both the water utility and individual customers choose to implement demand reduction. Secondary impacts reflect the nature of conservation activities and can include impacts to urban vegetation, property values, and wildlife habitat, among others. It is important to acknowledge

that there remains significant uncertainty on how demand management will be achieved in the municipal sector and if demand management activities will impact municipal water use customers.

Economic Impacts of Reduced Agricultural Water Use

The economic impact of reducing water use in the agricultural sector has been studied in many locations and was previously reviewed for the Colorado Water Bank Working Group and for the Colorado River District. In addition, there are active studies occurring on the West Slope that will aid in the understanding of secondary economic impacts. The secondary or regional economic impacts of demand management activities primarily depends on the type of agricultural operation (crop type, farm size, location) and the type of activity to reduce water use. This section provides a high-level summary of economic impacts from reduced agricultural water use. Additional information on agricultural impacts is provided in a separate review for the Agricultural Impacts in the preceding section of this report.

Actions to Reduce Agricultural Water Use

Demand management is the reduction of consumptive water use. The types of activities that can be undertaken to reduce consumptive water use are focused on reduced irrigation, which can take on a variety of forms such as: full-season fallowing, split-season fallowing, rotational fallowing, deficit irrigation, and crop switching. Each demand management activity will have different economic effects which depend upon the existing water use and crop and livestock production on a farm or ranch property. It is also important to distinguish demand management activities as those resulting in water conservation or conserved consumptive use, and not activities that result in greater water use efficiency which do not generally result in a reduction in consumptive use.

Direct On-Farm Impacts

All demand management activities that may be implemented in the agricultural sector will reduce the irrigation water supply to the crop and will be compensated. The net income to the producer under demand management is expected to be positive to motivate participation, with compensation payments exceeding the on-farm costs associated with demand management activities. Compensation payments need to consider the following on-farm impacts of demand management activities:

- **Reduced Crop Yield**. In the Colorado agricultural sector, a reduction in consumptive water use is expected to result in a reduction of crop yield. This is the most direct impact of reduced irrigation and will result in reduced income for the producer. The extent of yield reduction depends on the crop type, extent of water stress, and timing of water stress.
- **Modified Crop Quality**. The quality of the harvested crop or grazed pasture is often influenced by reduced irrigation, with both positive and negative quality changes documented. Particularly for alfalfa and grass hay cut for sale, quality influences price and therefore has an impact on producer income. For annual crops, reduced irrigation may result in an unmarketable product.
- **Negative Farm Management Impacts**. A variety of management impacts result from reduced irrigation and reduced production. One universal impact is the negative impact to business relationships that comes with not producing (or producing less of) a crop or agricultural product, which forces customers (buyers) to look elsewhere. The temporary reduction in agricultural production could impact the long-term business plans for producers. For hay and pasture fields, there are expected to be significant and multi-year management impacts. For cattle ranchers, reduced pasture production can impact herd sizes, health, and genetics. The on-farm impacts on cattle ranches are a function of location and scale of reduced production. In remote areas where access to supplemental hay is limited and associated replacement costs are high, the on-farm impact of reduced forage is expected to be relatively high. For areas that have access to hay for maintaining herds, a smaller on-farm impact is expected and can be estimated as the cost of acquiring supplemental hay for feed. For annual crops, full-season

fallowing and crop switching are the most likely activities to be implemented and disruptions to operations are expected to be less than multi-year forage crops.

- **Costs of Mitigation Activities**. In addition to changes in irrigation practices, the producer will likely need to invest in certain on-farm projects to reduce the off-farm impact of the demand management activities. These mitigation activities and projects are anticipated to include: (1) cover crop establishment on fallowed fields, (2) new weed and pest control measures on perennial forage stands, and (3) replacement water sources to prevent injury to downstream water users.

The positive net income to the producer results in positive on-farm economic impacts of demand management. An important point is that positive on-farm impacts will only result if the compensation paid for demand management activities exceeds the combined cost of the on-farm impacts listed above. A premium above these on-farm costs is expected to motivate participation and to address risk and uncertainty to agricultural operations.

Off-Farm Impacts

The off-farm impacts of reduced irrigation and agricultural production that come with demand management can touch upon multiple economic sectors in a community. Off-farm impacts can also be positive and negative depending on the economic sector and location. For this review, off-farm impacts are divided into two broad categories below.

Costs / Negative Impacts

Secondary economic effects of reduced irrigation involve all sectors of the regional economy that directly or indirectly transact with irrigated agriculture. Some of the secondary impacts considered likely to occur include:

- Loss in the value of output, personal income, and employment resulting from reduced spending in industries that provide inputs and support services to agriculture (referred to as backward-linked industries),
- Loss of output, personal income, and employment in sectors that use agricultural outputs as inputs to production (referred to as forward-linked industries),
- Effects caused by changes in net income spending in the region, and
- Changes in local tax revenues.

When agricultural production declines in a region, the reduced crop production results in a lower expenditure on agricultural inputs (first round effect). As a result, workers, stores, and support services directly related to agriculture reduce spending within the economy (second round effect) and the businesses that they buy from reduce their spending (third round effect), and so on. In addition, reduced agricultural production can lead to reduced activity for agri-businesses that rely on harvested crop inputs, resulting in further economic loss. These impacts are sometimes referred to as the multiplier effect.

The results of the recent 2020 economic study of demand management in Western Colorado indicate an indirect effect multiplier of approximately 0.34 and an induced effect multiplier of approximately 0.40, resulting in a total backward-linked economic impact equal to approximately 0.74, equal to 74% of reduced agricultural on-farm production. Additional forward-linked effects on the livestock industry were estimated to have a multiplier of 0.3, or 30% of direct agricultural output. In total, the secondary economic impacts of demand management were estimated to have a multiplier of 1.04 relative to the lost agricultural production value. This study indicates that secondary economic impacts of demand management are roughly equal to the primary on-farm economic impacts of lost production value.

The impact on businesses and economic sectors that utilize farm output (forward-linked industries) depends largely on the crop type and presence of food products and food processing industries in the region. For

most of the Western Slope, irrigation is practiced producing forage crops in support of the livestock industry. Hay trucking and slaughter facilities are two forward-linked industries that may be impacted by reduced forage production. The 2020 economic analysis of demand management indicated potential forward-linked impacts equal to approximately 30% of lost agricultural output.

The economic impact of modifications to spending that typically results from agricultural net income is more difficult to quantify and predict. Demand management activities will be compensated, and compensation amounts will need to be greater than the expected loss in agricultural net income to incentivize participation from agricultural producers. The off-farm economic impact from spending depends upon the source of compensation funds and whether the compensation income is spent locally or not. The 2020 economic analysis of demand management in Western Colorado indicated that compensation payments may or may not offset secondary economic impacts, depending on the extent to which payments are spent locally within the region.

The two money flows described above (inputs to and spending from agricultural production) are based on an owner-operator farm system. Many farms and ranches in Western Colorado have absentee landowners and are farmed by long-term lease tenants. An additional negative impact results to tenant farms if the landowner decides to participate in demand management activities without collaborating with the lease tenant. Demand management can disrupt the owner-tenant relationship because compensation payments to the owner may not be shared with the tenant, who will experience lost production and income. Landowners are incentivized to work with their lease tenants before participating in demand management activities to maintain a beneficial relationship with the tenant and to maintain market lease rates for the property.

In addition to the negative effects associated with changes to agricultural production, there are several environmental and recreational impacts to consider that result from a change in the timing of water flows. Irrigation, and specifically flood irrigation from surface water sources, slows the movement of water across the landscape through soil infiltration and return flows back to the stream channel. The result is that snowmelt runoff peak flows are reduced through irrigation diversion and late-summer low-flows are increased from return flows. The long-term presence of irrigated agriculture across much of the Western Slope has resulted in an environment and recreational economies that are built on this altered hydrology. Modifying the timing and magnitude of streamflow may cause additional negative economic impacts. In particular, the following are noted:

- **Wetland and Wet Meadow Habitat**. Many irrigation ditch and canal systems have wetlands and wet meadow habitat that have been formed by irrigation practices. In addition, the canals may also provide important riparian habitat. The inefficiency of surface conveyance and flood irrigation often results in habitat development down-gradient from irrigated parcels and ditch systems. A reduction in irrigation could result in negative impacts to these habitats and environmental resources. Wetland mitigation bank credits on the Western Slope have varied values depending on location and type of wetland credit.
- **Decreased Late-Season Flows for Recreational Activities**. Water-based recreation activities, and particularly fishing and boating, could be negatively impacted by a reduction in late-season streamflow. Negative effects are only anticipated to be noticeable on smaller tributary creek and river systems. The effects are also dependent on the relative scale of reduced irrigation and streamflow impact. The methods and concepts presented in previous research for recreational benefits of improved streamflow could be modified to consider the recreational costs of reduced late-season flows.

Benefits / Positive Impacts

The possible economic benefits of demand management activities are derived from two sources: (1) higher net income to the producer resulting in greater spending, and (2) modified hydrology resulting in greater streamflow annual volume and changes to streamflow timing. In addition, previous research on off-farm benefits identified possible salinity control benefits resulting from not leaching salts in the soil profile.

The benefit of higher net income to agricultural producers has an uncertain benefit to the surrounding economy that is largely dependent on how the additional income is spent. As stated previously, limited survey data indicate that past water conservation projects have seen half to nearly all of the compensation payments spent locally. The off-farm benefits of compensation spending may be significantly reduced if projects have absentee landowners located out of the local region. The temporary nature of demand management activities helps to ensure that project participants will maintain their properties and agricultural operations, which helps to ensure local benefit of the compensation payments.

The off-farm benefits of modified hydrology are specific to a location and project, as modified hydrology may also result in off-farm costs (see above). Downstream of the project site, annual streamflow volume will be greater based on the demand management activities. The timing and magnitude of increased streamflow is critical to understanding whether a benefit results from water conservation activities. Previous research on two System Conservation Pilot Program (SCPP) projects in Colorado and Wyoming found that these two water conservation projects resulted in nominal off-farm benefits besides salinity control. The research does indicate that off-farm benefits are expected to increase with larger volumes of water conservation activity. The following points summarize benefit concepts by various end uses:

- **Recreation**. The recreational benefit of modified hydrology is most likely to impact fishing and boating activity. The benefit can be estimated as a combination of: (1) the increase in number of visitor days, and/or (2) the increased value (enjoyment) of each visitor day. For both boating and fishing, the timing of additional streamflow needs to indicate a significant improvement to result in a measurable benefit.
- **Environmen**t. The environmental benefit is typically evaluated based on the presence of threatened or endangered species. The benefit may represent reduced recovery program costs or societal benefits of improved species habitat. Similar to recreation, environmental benefits are expected to be most significant if the modified hydrology represents a significant improvement in streamflow and the timing of flow increase is critical to realizing an environmental benefit.
- **Hydropower**. Run of river hydropower facilities are likely to see a direct benefit of larger streamflow volume as long as diversion capacity is not a limiting factor. Dam hydropower facilities are less likely to see a hydropower benefit unless the modified hydrology results in significant flow volume increases or the timing of flow increase occurs outside of the snowmelt period.
- **Salinity**. Reduced irrigation results in less deep percolation below the crop root zone and less leaching of salts in the soil profile into subsurface flows. In areas of the Colorado River Basin where active salinity reduction projects are in place, the benefit of reduced leaching can be significant.
- **Municipal**. Municipalities may enjoy benefits of reduced risk of Compact administration, since the goal of a potential Demand Management program would be to ensure ongoing compliance by the Upper Division States with the Colorado River Compact. This benefit is significant and is a primary driver of current efforts.

Mitigation of Negative Economic Impacts

Mitigation of negative economic impacts associated with water supply development projects and large water transfers is most often accomplished through federal and state environmental permits and is usually motivated by legal requirements to provide mitigation. For small and localized water transfers from agriculture to other uses, mitigation is not typically a legal requirement besides ensuring non-injury to other water right holders. Water right transfers often have negative economic impacts that are not mitigated. For a demand management program, mitigation may be evaluated and categorized based on on-farm and off-farm impacts. On-farm economic impacts are expected to be fully mitigated through compensation payments defined by the producer. Program design may be more concerned with off-farm impacts. Potential off-farm economic mitigation measures include:

- **Mitigation Payments to the Affected Community**. Mitigation payments, in addition to producer compensation, could be a component of a demand management program. The payments would be utilized for local community investments, which might take the form of grant and loan programs administered by county or other local governments, capital investment in specific economic development projects or infrastructure needs, and/or direct payments to local governments. Previous research identified three water transfer programs that provided explicit mitigation payments to local communities, ranging from 4% to 30% of producer compensation. These mitigation payments were provided primarily as a lump sum payment at the start of a multi-year water transfer program which probably would not be applicable under a demand management program. Two challenges with mitigation payments have been identified: (1) distributional challenges caused by mitigation efforts not targeting the most impacted sectors of the local economy, and (2) geographic challenges associated with dispersed project sites and impacts across the West Slope. These challenges may be addressed through a combination of mitigation payment investment rules and local oversight of mitigation payment spending.
- **Alternative Cropping & Land Uses on Participating Properties**. Creating an economic use of the participating lands during the period of demand management activities is a possible mitigation tool. Alternative cropping with a low water use requirement is a possibility but will reduce the conserved consumptive use benefits of demand management activities. Dryland grazing is a widely applicable alternative land use that may provide some limited economic activity. The types of alternative land uses are likely to be site-specific but investments could be made on properties to generate alternative economic activity, particularly if the property is intending to conduct demand management activities over multiple years.
- **Compensation Payments as Mitigation**. Most of the water transfer programs previously reviewed did not include any additional mitigation payments or policies to offset negative secondary (off-farm) impacts. Many programs may consider the compensation payments to the producer to be sufficient mitigation of local economic impacts. As stated previously, the suitability of compensation payments as mitigation for off-farm impacts is directly tied to the spending habits of producers in demand management years.

The economic effects of modified hydrology due to demand management activities are previously noted as potentially: (1) environmental impact of lost wetland and riparian habitat, and (2) recreational impact of modified streamflow for boating and fishing activities.

Economic Impacts of Reduced Municipal Water Use

This section first provides examples of reduced water use in the municipal sector, followed by a discussion of direct and indirect economic impacts of municipal conservation activities. There remains uncertainty as to how municipal demand management will be quantified, particularly for trans-basin diversions diverting from the Colorado River Basin to the Front Range. It is possible that a municipal utility could accomplish verifiable demand management through operations and management without requiring a modification in water use at the customer level. For this analysis, municipal demand management is evaluated assuming that water use reductions occur. The economic impacts described in this section provide context but may or may not be applicable to demand management in the municipal sector depending on how a potential program gets vetted and what demand management activities are implemented.

Context of Municipal Water Conservation in Colorado

Over the past 30 years both the Federal government and State of Colorado have enacted laws that have impacted both water conservation and water use efficiency for municipal water providers. These laws now guide municipal water use in three critical areas: (1) plumbing fixtures, (2) landscaping and outdoor water use, and (3) motivating municipal planning for efficient water use and effective drought response.

Context is critical in understanding the operating space for future efficiency and conservation efforts in the municipal sector. Past municipal water efficiency efforts have significantly reduced per capita water consumption. Colorado statewide municipal water use rate (per person) has declined from about 240 gallons, per-capita, per-day (gpcd) in 2000 to about 160 gpcd in 2015. In the future, these municipal water conservation savings and efficiency benefits have become "hardened" into baseline consumption, such that they will likely not be available to provide for future demand management. The greatest potential for additional conservation and demand reduction is expected to be in the following five areas: (1) further limiting water use in residential and commercial landscaping, (2) extending low-flow plumbing fixture requirements into older homes and commercial properties, (3) extending efficiency requirements to smaller water providers, (4) adopting smart metering to reduce losses and inefficiencies in the distribution system and in-home, and (5) modifying water use habits and practices**.**

Actions to Reduce Municipal Water Use

Actions to reduce municipal water use have often been divided into two categories: (1) water conservation and (2) water use efficiency. Water conservation temporarily reduces water use in response to drought or supply disruption and may be scaled back once the supply disruption ends. Water use efficiency, on the other hand, aims at maximizing the water end use benefit while minimizing waste, and efficiency practices often continue indefinitely and may be expanded. Both water conservation and water use efficiency can be achieved by policies and programs designed by municipal water providers.

Cities such as Denver, Fort Collins, and Colorado Springs, where water conservation and efficiency programs have existed for over 20 years, have seen a significant reduction in per capita water use through implementing many practices. These actions have also resulted in demand hardening. The implications for hardened water demand and past conservation efforts might be considered when establishing a baseline municipal water use for demand management. In evaluating and selecting conservation and efficiency activities, municipalities have a range of criteria that could be applied.

Municipalities also have the option to make conservation activities mandatory through policy changes. Research shows that mandatory strategies yield more water savings than those that are voluntary. However, if well implemented and tied to attractive rebates, voluntary options can be effective as well.

Direct Economic Impacts

Water conservation programs directly impact water providers in three ways:

- **Revenue loss from selling less water**. Water supply has high fixed costs. Dams, reservoirs, tunnels, pipelines, treatment plants and distribution systems are all major capital investments. Once these investments have been made, the variable cost of moving an added cubic foot through the system is low. Given these high capital costs, it is more cost-efficient to have one provider serving a broad geographic area to distribute these costs over a larger customer base. Therefore, water utilities are either municipally owned or regulated by a water district. Municipal water providers have several ways of recovering their fixed cost including tap fees for new construction, monthly service charges on existing customers, and the unit charge on the volume used (water rate). Where fixed costs are covered by tap fees and the monthly service charge, water conservation activities will have less impact on utility revenues. If these costs are allocated to the water rate, conservation may result in reduced operating revenue. Rates are often adjusted periodically to offset the impact of water conservation, and to respond to inflation and other cost increases associated with capital projects and operations.
- **Costs of running conservation programs**. Program costs will vary significantly with the size of the provider and the ambition of the conservation program. Water conservation programs range from public awareness and education to subsidies for turf removal and replacing landscape irrigation. Cost efficiency requires that suppliers begin with the lowest unit cost activities. Equity implies that water conservation

opportunities are not denied to low-income households that may lack the resources to adopt more efficient water use practices.

- **Impacts on wastewater treatment**. Wastewater treatment is affected when the influent flow to the treatment plant becomes more concentrated and thus more difficult to treat to the desired effluent standard. The problem is particularly acute when effluent is reused in either potable or non-potable systems.

These direct economic impacts may be a component of the compensation or benefit sought by an individual municipal water utility seeking to conduct demand management (water use reduction) activities. Like the agricultural sector, the balance of compensation (or direct benefit) versus direct economic impact will determine the overall net impact to municipal water utilities.

Indirect Economic Impacts

Indirect impacts on urban areas are largely livability and quality of life effects. The business effects are likely to be somewhat isolated as relatively few commercial activities depend upon water. It is possible that landscaping businesses will see a decline, and heavy water use industries may struggle if pricing is used to encourage conservation. The livability impacts may be considerable and widespread, especially if conservation actions result in the die off of established trees and the desolation of parks and other urban green spaces. Unlike the indirect impacts in agriculture, these municipal impacts are not anticipated to result in reduced commercial activity and reduced profits. Nevertheless, Colorado attracts and retains both people and industry because it is a desirable place to live, both for its abundant natural beauty as well as its pleasant towns and cities with a high quality of life. These attributes that attract and retain economic activity are put at risk if significant municipal water conservation activities were to occur. A municipal water utility may incorporate some indirect impacts into its proposed compensation for conducting demand management activities, particularly those impacts that are within municipal control.

Mitigating Negative Economic Impacts

Demand management in the municipal sector may require new levels of both conservation and efficiency, and these activities may result in economic impacts as described above. Direct economic impacts to the municipal utility are expected to be evaluated by the utility and incorporated into any requested compensation to conduct demand management. Indirect impacts may or may not be included as part of the requested compensation and are a greater concern for demand management program administration and design. The following mitigation activities are targeted at both direct and indirect impacts of municipal demand management activities.

- **Colorado's Water Plan**. The state's 2015 water plan, "...sets forth the measurable objectives, goals, and actions by which Colorado will address its projected future water needs and measure its progress - all built on our shared values." The plan was developed to address supply gaps resulting from a possible doubling of the state's population by 2050. Section 6.3 identifies many actions under (1) municipal water conservation, (2) water reuse, (3) land use, (4) agricultural conservation, efficiency, and reuse, (5) self-supplied industrial conservation and reuse, and (6) state agency conservation. The conservation and efficiency measures identified in the Plan provide a foundation for future demand management efforts.
- **Regionalization**. Front Range municipalities could examine the potential benefits of regionalizing supplies to improve reliability by taking advantage of a more diversified portfolio of water supplies. It is possible that future droughts will differentially impact streamflow conditions across the state. In addition, some metro Denver suppliers are primarily dependent upon Denver Basin groundwater. By jointly managing both surface and groundwater supplies, cooperating utilities may be able to firm up supplies under demand management.

- **Water conservation extension programs**. Current CWCB water conservation guidelines apply only to utilities that serve over 6,000 accounts. The state's largest suppliers have already instituted a range of programs to conserve water. The state could fund extension programs that enable large utilities to provide the same programs to smaller utilities which could take advantage of conservation options that are both proven and lowest cost. For example, smart meters could be installed by small utilities who then contract for data support from a utility that has already set up a system. An extension program represents a knowledge transfer to smaller water utilities to help ensure that demand management activities are effective and cost-efficient.
- **Conservation pricing**. Raising prices and/or implementing an increasing block rate structure on customers are both used to reduce water demand. In contrast to mandatory water restrictions, the effectiveness of using higher prices to reduce demand is less certain. Conservation pricing is also utilized to respond to successful water conservation to cover fixed costs with less water sales. Raising prices has a disproportional impact on low-income households. When using conservation pricing, utilities may establish low-income assistance programs and consider rebates for additional revenue to avoid these negative impacts. Approximately 85 percent of Front Range and eastern slope water providers, and 77 percent of western slope water providers, have such tiered rate structures.
- **Xeriscape assistance programs**. Municipal demand management is expected to fall heavily on outdoor water uses by residences, businesses, and institutions. Large-scale water use reduction may involve turf removal and many indirect impacts results from the loss of tress and green spaces. Some of these indirect impacts can be mitigated by replacing turf with xeriscape plants and landscaping. Several Colorado communities provide education and financial assistance for water users to modify their landscaping to a xeriscape design.
- **Urban Forestry**. Many indirect impacts from water conservation result from loss of trees and urban green spaces that provide many community benefits that enhance the livability of towns and cities. Demand management may provide options for cities to maintain existing trees and even expand urban forests into low-income neighborhoods that often have fewer trees. Tree canopy mapping often reflects income inequality and Colorado is no exception. The tree canopy in Colorado Springs neighborhoods, for instance, ranges from less than 5% in low-income to more than 50% in high-income neighborhoods. Planting trees in low-income neighborhoods would both reduce inequality and increase air and water quality benefits for all. Targeted investments for tree health, such as direct irrigation and fertilization, is a way to reduce stress on the urban trees.
- **Turf Conversion in Parks**. Demand management may involve redesign of urban parks to reduce water use. Vast green spaces may give way to more selective green spaces, artificial turf on playing fields, and more extensive use of xeriscape. In addition, continued irrigation of trees in parks when turf is removed is an important consideration. In general, municipalities may consider maintaining parks and outdoor green spaces even if residential and commercial irrigation is reduced because of the community benefits.
- **Project vs. Programmatic Demand Management**. A demand management program may anticipate supporting both project (i.e., single entity) as well as programmatic (e.g. universal smart metering) as strategies for creating conserved consumptive use. Establishing a baseline, monitoring, and verifying savings generated over many users will be critical for any programmatic approach.
- **Water - Energy Nexus**. Colorado has 25 operating thermal power plants that all require water for cooling. Retiring these plants and replacing them with wind and solar farms will reduce both consumptive water uses and greenhouse gas emissions – a double-dividend.

Additional Work Completed

WestWater performed interviews with municipalities across the State to investigate demand management related to municipal operations. A memorandum summarizing municipal interviews is available upon request.

Key Takeaways

These key considerations are based on the literature review summarized in previous sections. The following activities and policy elements are key considerations related to the specific purpose of reducing and/or mitigating economic impacts of demand management activities.

- **Mitigation Payments in Program Design**. The feasibility investigation may consider a program that includes mitigation payments to offset indirect economic impacts, particularly for agricultural demand management projects. Mitigation funding requirements might be established as part of program design and should likely be standardized across all projects. Standard mitigation payments would avoid the process of evaluating economic impacts of each proposed project and will provide certainty to the program participants and funders. The mitigation funding might be given to local governments to make local decisions on spending the money.
- **Ensure that the Program is Voluntary**. From an economic perspective, it is important that demand management remain a voluntary program without any requirement or mandate to participate and reduce water use. In both the agricultural and municipal sectors, there is a large amount of diversity in risk, ability to pay, direct and indirect impacts, and required compensation related to demand management. A voluntary program ensures that significant direct economic impacts do not occur to specific water users and communities.
- **Include Environmental and Recreational Benefits and Impacts in Project Review**. The process of soliciting and evaluating demand management projects is not yet determined. The CWCB might consider some form of analysis and reporting on the environmental and recreational benefits of proposed demand management projects as part of the review process. It is important to distinguish that this type of analysis is not part of informing mitigation requirements but instead for supporting projects that may provide a specific benefit.
- **Leverage Other Funding Sources**. Reduced water use may result in other benefits and there may be other programs established to provide funding resources for reducing water use and/or realizing these indirect benefits. A demand management program could look to develop and publish (online) a reference list of complementary funding programs and sources for consideration by project participants. Example and possible funding sources include the Environmental Protection Agency (EPA), U.S. Bureau of Reclamation (USBR), Natural Resources Conservation Service (NRCS), and U.S. Fish and Wildlife Service (USFWS).
- **Indirect Impacts of Reduced Municipal Water Use**. Our literature review did not provide definitive findings on the scope or scale of indirect impacts related to reduced municipal water use, particularly for: (1) environmental impacts of reduced outdoor water use, (2) social and community impacts of reduced outdoor water use, and (3) equity implications of reduced water use. The CWCB may consider developing a work plan to better understand these impacts. Consider potential benefits and impacts for east slope agriculture (supplemental sources of water).

Data Gaps

This section provides a discussion of two types of data gaps: (1) those currently present in evaluating the feasibility of a demand management program, and (2) those that are likely to be present when evaluating the impacts of specific demand management projects.

Data Gaps in Evaluating the Economic Feasibility of Demand Management

The economic feasibility of demand management can be better evaluated when demand management activities are better defined, particularly for the municipal sector. Most of the data gaps identified during our analysis were focused on other subject areas, such as definition of qualifying activities and program administration. The following data gaps related to economic impacts were identified:

Agricultural Sector

- Further research may consider the definition of standard economic multipliers specific to West Slope agriculture for informing mitigation payments. Further work could be done to generate one or more standard multipliers which would be used to define mitigation payments for agricultural demand management projects. These multipliers may be used to determine the full costs of each project and make equivalent comparisons between projects. The 2020 economic analysis for Western Colorado provides an information basis to define these multipliers.
- Additional data gaps are identified in the Agricultural Impacts section of this report that should be incorporated into this economic review.

Municipal Sector

- Further research may be done to better define municipal demand management activities. The impacts of municipal demand management activities stem from a better definition of those activities, and impacts are difficult to evaluate without this definition. The municipal sector may not have to or be willing to reduce end uses of water to achieve demand management.
- Additional research could evaluate the ability to reduce municipal water use. It is expected that the municipal utilities will propose to conduct demand management activities based on system-specific analysis. In terms of understanding feasibility of demand management, the state might consider an analysis looking at the broad feasibility of additional water use reductions in the municipal sector. The following elements might be included in such an analysis:
    - Evaluating the existing water efficiency practices across the state to identify the potential water savings from: (a) retrofitting pre-compliance homes and commercial buildings with low flow fixtures; (b) extending proven water efficiency programs into smaller water providers; (c) reducing non-revenue water lost through systems leakage. Such efforts can generate consistent, long-term water savings.
    - Evaluating the effectiveness and experience of Colorado water providers with water pricing strategies. Water providers have used a range of conservation pricing strategies to reduce water use. These include tiered rates, seasonal pricing, conservation surcharges, and tap fees. These strategies could be assessed for effectiveness, revenue impact and fairness. Water managers may find the experience of other utilities, within Colorado and with which they are likely to have some familiarity, more compelling than experience from other states and countries.
    - Evaluating the impacts of reduced outdoor watering. The major savings in municipal water uses will likely come from reductions in outdoor water use. Practices to reduce outdoor water use have been widely applied, but we have limited understanding of the impacts on urban livability and options to mitigate these impacts.

- Further evaluate the indirect impacts of reduced municipal water use. This literature review provides information on past research related to the indirect impacts of reduced water use in the municipal sector. Our review indicates that more information is needed on the impacts of water efficiency and conservation efforts on inequality and on environmental resources beyond urban landscaping. Academic papers and utility reports note the importance of these indirect impacts; however, studies that attempt to measure or quantify such impacts have not been identified.

Data Gaps in Evaluating Economic Impacts of Specific Demand Management Project

The economic impacts associated with specific demand management projects will need to be addressed as part of compensation payments and program design. Direct impacts will be site specific for farm operations and municipal water systems. Each demand management applicant or participant is likely to evaluate the expected direct impacts, with available information resources and technical assistance, and incorporate impacts into proposed compensation terms. Indirect impacts are a greater concern for program design, and program design is anticipated to mitigate indirect impacts more than information gaps that are addressed during the application and review process. Project-specific economic analyses will be difficult to conduct due to cost and timing.

SECTION 5 – EDUCATION AND OUTREACH – LITERATURE REVIEW & ANALYSES

CDR Associates led the Education and Outreach (E&O) and Statewide Engagement processes for the Investigation. The tasks associated with these efforts specifically included:

- Participating in the Education and Outreach workgroup meetings.
- Conducting a literature review that analyzed and summarized the existing knowledge of education and outreach strategies, lessons learned, and data gaps.
- Conducting program manager interviews that collected first-hand data on education and outreach for existing water conservation and efficiency programs.
- Supporting CWCB with Statewide Engagement planning and facilitation.
- Developing a summary of the key considerations and practical education and outreach strategies relating to a potential DM program that integrates the findings from the literature review and feedback from the Education and Outreach workgroup and other key stakeholders.

The education and outreach findings detailed in this report align with the CWCB's additional policy goal statements to work with water rights holders and stakeholders in determining the feasibility of DM in Colorado:

> (6) Prioritize avoidance of disproportionate negative economic or environmental impacts to any single subbasin or region within Colorado while protecting the legal rights of water rights holders. The Board **will work with water rights holders and stakeholders** to assess the feasibility of and promote mechanisms for obtaining roughly proportionate contributions of water consumptively used from the Colorado River System to a Demand Management program over a given timeframe from participants on each side of the Continental Divide.
>
> (8) **Consider and be fully informed by the input and considerations of water rights holders and stakeholders** potentially impacted by application of demand management strategies within Colorado, and institute a public review process for any such proposed demand management program.

Literature Review

CDR's literature review aimed to:

- Identify education and outreach lessons learned from similar policy efforts.
- Develop key considerations and/or engagement toolkit (strategies and tactics) for consideration in next steps of the Investigation.
- Identify decision milestones and tradeoffs for future consideration.

The key findings informed the E&O goals and parameters for a potential DM program, as well as considerations linked to messaging, trust building, and program localization / evolution.

The literature review evaluation examined the literature through the following thematic questions:

- What would motivate people to participate in the Demand Management program?
- What components of a DM program excite potential participants? How do you build support for change? How do you build interest in a program like this?

- What disincentivizes people?
- How do you build trust in a low-trust environment? How do you build regional cooperation in a context of competition?
- Who was the target audience of the program? How familiar were people / do people need to be before adopting the program? How was the program messaged or marketed? How do you tailor messages (benefits, impacts) to different audiences?

Overall, the literature was vague in specific detail around E&O efforts, although general themes have proved to be informative for the exploration of the feasibility of a hypothetical DM framework. The literature reviewed for education and outreach themes included:

- Summary of "Lessons Learned" from UCRC's "Final Report: Colorado River System Conservation Pilot Program in the Upper Colorado River Basin", by UCRC & Wilson Water Group, 2018
- Lessons Learned from the System Conservation Partnership Program, by The Nature Conservancy, February 2016
- GVWUA Final Report on the Conserved Consumptive Use Pilot Projects, by GVWUA and J-U-B Engineers, 2019
- TNC Briefing Paper: Upper Basin Demand Management and Water Banking, by The Nature Conservancy, 2019
- Exploring Perceptions of a Voluntary Agricultural Water Conservation Program on the Western Slope of Colorado by MacIlroy, Colorado State University, 2019
- Towards Regional Sustainability Assessment Utilizing Community Based Participatory Research, Sustainability Indicators, and Future Scenario Modeling, by Dubinsky, CU Denver, 2019
- Urban Water Conservation in the Sacramento, California Region during the 2014-2016 Drought, by Talbot, UC Davis, 2019
- The Poudre Water Sharing Working Group: A Report to the CWCB, by The Poudre Water Sharing Working Group, 2015
- Appendix C: 2018 System Conservation Pilot Program Update, by the Upper Colorado River Commission, 2018

What we know

Education, outreach, and engagement is critical to the success of a program. The most perfectly designed program, without willing participants, will not accomplish the goals of a demand management program.

There is no one-size-fits-all solution: we know that each of Colorado's distinct sub-basins will need a contextualized approach, and an approach that keeps Colorado's residents at the heart of the solution.

Based upon the literature review and program manager interviews, the overarching E&O principles for designing and implementing a demand management program are:

- Engagement to develop and tailor the program to community needs: outreach prior to and during the exploration into the feasibility of a program to ensure it represents the potential participants.
- Motivate participation in a demand management program: following the establishment of a demand management program, marketing and outreach to program participants may align with local values, motivations to apply, and messages that resonate with community identities.

- Water education on broad policy impacts and benefits of the program: to inform and educate the broader public on the risks of inaction and the statewide benefits that justify the State's investment in a demand management program.

Additional Work Completed

Program Manager Interviews

Program manager interviews were conducted by CDR Associates following the literature review to fill in data gaps around education and outreach. In particular, the goal was to supplement the Investigation with information about how water conservation programs undertake education, outreach, communication, and marketing efforts.

Program Managers Interviewed

Program managers were selected because of their experience designing, managing, and/or evolving water efficiency programs for agricultural or municipal audiences. Program managers were from organizations including:

- Palo Verde Irrigation District
- San Luis Valley Subdistrict 1
- Colorado River Water Conservation District
- Central Platte Natural Resource District (NRD)
- North Platte NRD
- Tri-Basin NRD
- Twin Platte NRD
- Idaho Snake River
- NRCS CREP Programs
- Metropolitan Fallowing Program
- Denver Water
- City of Westminster
- Republic River Conservation District
- Resource Central

Methodology / Interview Approach

The goal of the interviews was to better understand successes, lessons learned, and techniques linked to education and outreach on water conservation programs. Interviewees were promised that quotes and comments would not be directly attributed to them. Meetings were not recorded to encourage candidness. The interviews ran approximately 45 to 60 minutes via Zoom or telephone.

The following questions guided the interview discussions:

1. Please describe your conservation / efficiency program.
2. Was extensive outreach conducted before the program was established?
3. If the program was voluntary, what motivated participation in the demand management program?
4. What were the general outreach strategies and specific tactics implemented?
5. What would you have done differently if you had a chance?
6. Who else would you recommend we speak with for more information?

Interview Key Themes

The following description of seven key themes represent topics and sentiments heard in two or more interviews. The intent is to identify and describe themes for further discussion with stakeholders, and not to prescribe solutions or remedies. The rural designation includes agriculture and small municipal perspectives. The urban perspective captures dense areas.

Rural Themes

1. Localization and evolution of the program
2. Proactive and hardcopy outreach
3. Trust-building with stakeholders
4. Inclusion in process

Localization and evolution of the program

A program that remains reflective of community needs results in higher participation. Several of the interviewees reported that by engaging with farmers about their needs, the co-developed program led to participation that exceeded expectations. One interviewee from the San Luis Valley takes a farm-by-farm approach to ask, "What do you need? What isn't good about the current program? What works for you?" By applying a variety of soft skills, the interviewee links input to programs.

This approach is evident in the San Luis Valley's half-usage pilot program. The program started with discussions with farmers, grew with Board input, and then our interviewee aligned the concept with timelines and budgets. The pilot was originally budgeted at $120,000; it surpassed that in the first week of enrollment, and in total a pool of $1,000,000 funded pilot participation.

Proactive and hardcopy outreach

Whereas some communities are familiar and comfortable with digital outreach and marketing, many of the agricultural-oriented interviewees emphasized that their outreach prioritizes tried-and-true methods. In part, this approach works because of the average age of producers (in some communities, interviewees estimated the average age was 50 years old). The interviewee from Nebraska's Central Platte NRD used outreach like mailed quarterly newsletters; newspaper articles; radio advertisements in the spring and fall to target farmers on tractors listening to market updates and farm news; annual information meetings; and the development of an NRD radio jingle.

Trust-building with stakeholders

Interviewees with agricultural audiences emphasized that implementing a program in ag communities takes time. "If you're going to do something like this, you've got to be in it for the long term," said one of the NRD interviewees, "There's no better PR than a satisfied customer." Producers are risk averse. In the interviewee's case, his conservation program's first year had poor participation; the following years benefited from local talk, trust, and evidence of the program's benefit.

Similarly, the San Luis Valley interviewee credited programmatic success to personal relationships. When communication can go both ways, particularly in getting questions answered, then individuals feel more confident in making a well-informed decision.

Inclusion in process

A theme echoed throughout the agricultural interviews was the importance of process inclusion for producers, farmers, ranchers, and rural water users. Ideally, decisions are made at a local level by local program managers or, even better, by potential program participants.

Urban Themes

5. Defining motivation for participation
6. Ease of application and program management
7. Engaging water managers and local government leaders

Defining motivation for participation

For urban residents and water providers, interviewees linked successful programs to marketing aligned with participants' motivations. For household users, participants in water efficiency and conservation programs typically identified water savings as the primary motivator. As a Front Range interviewee said, "The target audience is people who want to do the right thing. They understand that Colorado is semi-arid and that

they're putting too much water into their landscape." And, in a City of Westminster survey, customers identified the top two reasons for promoting water efficiency as: "It ensures long-term water supply security" and "Water is a limited resource."

For municipalities and water providers, motivators are efficiency, impact, and adaptation to the local context. One interviewee highlighted that "blanket solutions" for reducing consumptive use are difficult, as water providers have a strong sense of identity for their customers and organization. Additionally, most municipalities and water providers run lean organizations: few have dedicated staff to developing and implementing water efficiency programs. Programs need to be efficiently managed to align with capacity and need to have tangible impact to make the resources worthwhile.

Ease of application and program management

The ease of application to a program was a motivator at both the household- and water provider-levels, and the ease of program management was a motivator for water providers. Interviewees felt that complex processes would not be successful due to reasons including household attention spans, the level of effort to maintain a program, and the staff needed to run complex programs.

Engaging water managers and local government leaders

Two interviewees found success in implementing programs via water managers and local government leaders. Buy-in from local government leaders increases the likelihood of program implementation, because it provides visibility about a program and, often, elevates the prioritization and timeline of a program's implementation.

Outreach Strategies and Tactics

Interviewees pointed to a spectrum of strategies and tactics to increase participation, raise awareness, and market a program. The tactics have been divided into two categories (municipalities / urban water users and agricultural / rural water users), because approaches varied widely depending on the local context of the interviewee.

Municipalities / Urban Water Users

Messaging

- Simplify and tailor messaging: for example, consider urban programs Cash for Grass or Slow the Flow

Internal Communication Methods

- Reduce barriers to marketing and program management for staff unfamiliar with outreach, such as premade marketing toolkits:
- Flyer templates
- Sample social media posts separated out by month, with corresponding photos
- Editable text that can be used in micro-, medium-, or long-form media
- Ads for local newspapers
- Customer-service trainings for staff

External Communication Methods

- Create opportunities for in-person engagement and relationship-building
- For example, offer free audits to get a water expert into someone's home, educate that customer, build relationships, and trust, and connect them to pre-existing programs
- Outreach in consistent and audience-appropriate places.

- Strategies include:
- Utility bill inserts
- Direct mail
- Targeted social media promotion
- NextDoor posts and ads
- Posts in small local papers
- Joint press releases, often with a customer testimony
- E-news lists
- A customer survey asked: "What's the best way to reach you about water efficiency programs?"
- 42% flyers and inserts in my bill
- 40% messages on my bill
- 10% social media
- 15% website
- Advertise incentives to target audiences like developers, HOAs, and hot development areas

Leveraging Values

- Use data-based decision-making to inform and urban programs
- Define goals around scale and geography to help program managers have an equitable, balanced, and efficient approach to simplify applications for target participants

Agricultural / Rural Water Users

Messaging

- Codefined messaging: ask potential users what they need, and what would or wouldn't work. Then shape a message based on their input.
- Relationships are more important than words. Messaging may follow rapport and trust with the community.
- One-size won't fit all. Farmers have diversity in operations; different crop types have different needs.

Internal Communication Methods

- Training program employees
- Calls with the State on possible program changes

External Communication Methods

- Consider timing of outreach, such as radio ads during harvest season and newsletters in off-seasons
- Having a participant-centric approach is important for long-term participation in the program
- Outreach in consistent and audience-appropriate places. These include:
- Radio
- Radio ads in spring and fall to correlate with the timeframe that farmers are listening to market updates on their tractors

- Customized radio jingle
- Radio interviews
- Town halls, producer meetings, symposiums, and webinars
- Have included features like guest speakers and presentations about new innovations
- Provide updates on programs, aquifer levels, hydrology changes
- Newspaper updates, articles, and newsletter postings
- Newsletters and information bulletins
- Fact sheets and flyers
- Website content
- Blog to provide narrative about key issues
- Guest writers
- Press releases
- Social media, although not as successful because of age of producers
- Board member marketing, word-of-mouth marketing
- School water education on a variety of issues; best interaction with 4th, 5th, 6th graders
- Text (SMS) communication between program managers and participants for quick updates
- Local office locations allow people to come learn about conservation programs for their area

Leveraging Values

- Trust and relationships between a program manager and local communities, which could look like:
- Co-learning: host opportunities for producer / farmer roundtables to inform programmatic decisions
- Upfront time commitments: state how long a pilot or program will be around, and then be consistent.
- Long-term strategy: "There's no better PR than a satisfied customer."

Key Takeaways

The following statements capture overarching takeaways from the Education and Outreach literature review and interviews conducted, and represent common considerations for establishing buy-in for a future potential DM program.

- **Motivations to participate.** Motivation to participate is connected to information, clarity, and education about the program objectives and larger economic / social / environmental issues. Addressing these motivations includes: ensuring the protection of water rights and confirming that participation in compact security is a beneficial use under Colorado Water Law; defining short- and long-term financial benefits for participants, especially to reduce risk and increase profitability; and educating potential participants on the process, goals, and program details, to provide the context needed to relate a program to personal situations.
- **Build Support for a Demand Management Program.** Develop local communication strategies and partner with local, established networks to communicate messages. Involve communities as early as possible in program design. Inclusion of trusted local and state representatives will result in a program with higher agricultural water user participation. Additionally, align a program with producer values

like free-market economies and flexibility in operation and production schedules. Institutionalize into the program benefits for sustainable agriculture and rural communities. Create general policy parameters and rules to facilitate flexibility for the program to fit local stakeholder needs, maximize community benefits, and respond to local concerns.

- **Disincentives.** Primary reasons for nonparticipation include misconceptions about program purpose, local attitudes towards water conservation / fallowing, and concern about impacts to the economy and community. Potential participants are hesitant about overly public information about specific projects. Perceptions about whether a demand management program is necessary or unnecessary is closely linked to how an individual perceives Colorado River Basin water issues.
- **Build Trust and Regional Cooperation.** Local outreach builds trust, relationships, and community buy-in, especially when outreach results in impact and influence. Prioritize face-to-face meetings, ranging from town halls to door-to-door messaging within sub-basins. Develop clear, well-defined scenarios to help communities understand potential benefits or impacts of policy choices. Facilitate opportunities for communities to participate and/or access in research methods, datasets, reporting, and models. Enlist local key stakeholders and non-governmental organizations (NGOs) to participate in program outreach. Communicate with stakeholders, landowners, ditch and reservoir companies, and general irrigators before, during, and after projects. Define decisions that can be made at the local level, instead of the state or federal levels.
- **Defining and Communicating with Target Audiences.** Audiences with preexisting relationships with CWCB and/or partner organizations are more likely to participate in conservation programs. Use communication channels that are appropriate to the target audience. Consider the timing of messages, so the target audience has the bandwidth to engage on potentially applying to a program. Be clear and consistent in messaging so that potential participants receive one message. Develop a multi-pronged approach so that messaging to rural and urban audiences happens at state, regional, and local levels. Build upon existing water messaging platforms, such as Water Efficiency Plans and communications related to drought.

In addition to the literature review, CDR has helped facilitate the stakeholder engagement process relating to the Demand Management Framework and Demand Management more generally. Therefore, in lieu of an analysis of data gaps relating to Education & Outreach, the following section provides key observations relating to Colorado-specific issues and values. Further engagement can continue to inform what elements of a potential Demand Management program are acceptable to different sectors and communities, what elements or areas need further exploration or discussion, and what elements have buy-in or support.

Coloradan Values: A Commentary

Following the Statewide Engagement effort to engage diverse perspectives, CDR Associates provided the following anecdotal commentary to articulate Colorado-specific values. The following commentary is in no way comprehensive nor universal. However, an understanding of Colorado-specific values can help inform the advisability of a program.

Individual Choice

Coloradans appreciate individual choice and discourage government oversight. This value was articulated in rural and urban contexts; for example, producers participate in fallowing programs when it suits their financial objectives or personal lifestyles, and homeowners participate in municipal conservation programs to beautify yards or protect the environment.

Any potential demand management program may align with the value to participate when and where Coloradans choose to. Similarly, messaging and motivation for a demand management program might

recognize that individual choice applies to demand management but does not apply to Compact administration, which would not be voluntary or compensated.

Local Control

Colorado's government is designed to support and empower local control, and this is a value shared by many in the state. Many Coloradans support decision-making made at the lowest level of government possible, including town councils and county commissions. This value seems especially true on the West Slope.

Any potential demand management program may incorporate the role of local government and local decision-making into its decision-making. Inclusion from the start, such as in shaping the program framework and in designing mechanisms to protect against unintended impacts, would likely build local trust and buy-in.

Agricultural Participation in Decision Making

Agricultural communities--including many who would be eligible participants for a potential demand management program--value participation in decision-making. Agricultural stakeholders want to shape the decisions that would impact their ways of life, income, community well-being, and local economies.

Any potential demand management program may proactively include agricultural communities in the process. This includes program development, program implementation, and any changes to the program after its launch. Agricultural participants would be critical to the success of a demand management program in achieving conserved consumptive use.

SECTION 6 – ENVIRONMENTAL CONSIDERATIONS – LITERATURE REVIEW

SGM led the Environmental Considerations processes for the Investigation. The tasks associated with these efforts specifically included:

- Review and develop environmental criteria for assessing impacts of potential demand management activities.
- Identify data gaps, tradeoffs, and interrelated topics relevant to the Environmental Considerations workgroup and assist in determining methods to address data gaps as directed, as identified in the literature review.
- Summarize instream flow, environmental and recreational issues relating to past water conservation programs.

Literature Review

SGM reviewed various types of water savings, water banking, pilot projects and/or water conservation reports (listed in **Exhibit A**) and information to understand how environmental considerations, impacts and net benefits, were considered or how they influenced projects to balance these needs. Like the Monitoring and Verification literature review, SGM reviewed this information to understand how future projects could inform the integration of environmental considerations for a potential DM program, including:

- Current methodologies, data, and information to measure environmental attributes both in the agricultural and municipal contexts.

- Details associated with consumptive use and conservation estimation and monitoring, verification methods, and related issues.
- Data gaps and methods for being able to consider and measure environmental attributes within the DM monitoring and verification process.

SGM took the direction of the Environmental Considerations workgroup and summarized key topics, criteria, and considerations relating to previous conservation projects (**Exhibit B)**. Summary information included:

- Primarily purpose/goal of the project.
- Key takeaways.
- Project location.
- Program name, administration, structure, nature and duration of project practice.
- Tools uses to assess environmental impacts.
- Impacts to streamflow including magnitude, frequency, duration, timing, rate of change in hydrologic conditions, and return flow impacts.
- Impacts to species including critical stream reaches, critical land or riparian habitat, and list of species impacted.
- Impacts to water quality including salinity, temperature, and other constituents.
- Environmental considerations tradeoffs predicted outcome from activities, and proportionality.
- Ability to offset losses to environmental services and opportunities to incentivize environmental components for CCU projects.
- Evaluation of impacts (positive or negative) to instream flows, stream or watershed management plans, critical habitat, state species of concern, basin roundtable environmental values, conservation strategies, and other community goals and/or projects.

What we Know

Overall, the literature review concluded that most projects and studies did not consider nor measure how conserved consumptive use impacts or benefits environmental attributes. However, there was recognition in some studies that the environment benefits with increased streamflows due to lower diversions. In general, these streamflow impacts were correlated to better fish habitat due to higher instream flow and lower temperatures.

There was recognition that the following key elements might influence environmental impacts or benefits, and in some instances, offered suggestions for integrating potential mechanisms for measuring these benefits and impacts.

Streamflow Impacts

Generally, the literature found increased streamflow could benefit the environment. “Environmental Water Transactions in the Colorado River Basin: A Closer Look” (Stanford Woods Institute for the Environment, 2018, Exhibit A) reviewed instream flow projects including the SCPP projects. Notably, the report found that “although the total amount of water restored by these transactions is very small compared to the overall water budget of the basin, in certain watersheds, transactions have provided significant benefits for local streamflow.” Specifically, these were the Price River watershed in Utah and the Green River watershed in Wyoming.

Another report, "Salmon recovery in the Columbia River basin: analysis of measures affecting agriculture" (Aillery et al, 1999, Exhibit A) focused on the impact of diverted water and the impact of decreased streamflow on salmon species. Specifically, it found "flow alterations have significantly increased travel time for juvenile fish migrating to the ocean, a primary factor in reduced survival rates." The report investigates different methods to increase streamflow in the Columbia River basin. As this relates to a DM program, increased streamflow to move water to Lake Powell could have positive impacts on fish species.

Modeling

The literature identified the importance of modeling to be able to fully predict changes in streamflow during a demand management program. Currently, the models do not handle extra pools of water in the reservoirs and would need to be updated to help appropriately drive reservoir operation. In "Considerations for Modeling a Water Bank at the Aspinall Unit with Current Environmental Flows," (Hydros Consulting, 2011, Exhibit A), StateMod could be most easily reconfigured to simulate environmental flow targets (through Black Canyon and at Whitewater), including base flow and peak flow targets. However, modeling was not done in this analysis, so there are no results to share on how the water banking project would impact flows.

Species

Throughout the literature, different fish species are discussed with a focus on trout and salmon populations in the Western United States. One of the secondary benefits of the SCPP projects included increased streamflow in the Middle Piney Creek. As streamflow decreases, water temperature tends to rise, "often beyond ideal thresholds and also reduces available habitat." The GV CUPP (J-U-B Engineers Inc., 2017, Exhibit A) found "increased water in the river resulted in $23,000 of estimated savings not spent on endangered fish programs." More broadly in the United States, adding minimum flow requirements for the Snake River at Lower Granite Dam, and for the Columbia River at McNary Dam has improved salmon and steelhead populations (Aillery et al, 1999, Exhibit A).

Water Quality

Salinity impacts were discussed in four of the reports reviewed, mostly reviewing projects in the Grand River Valley. During the SCPP, it was estimated that the "2017 Grand Valley water conservation project is estimated to have reduced salt loading to the Colorado River by 4,960 tons." (UCRC, 2018, Exhibit A). In the Colorado River District's "Colorado River Water Bank Feasibility Study: Phase 2," (MWH, 2013, Exhibit A) water quality impacts are discussed with focus on salinity and selenium. "Salinity and selenium issues may make fallowing or deficit irrigation more attractive to Project farmers, as impacted lands might be taken out of production with less impact on overall yields. In addition, reduced irrigation of these lands may have benefits in improved quality of return flows." In this study, salinity effects (not affected or marginally affected) were a screening criterion used to select candidate systems representing a broad range of characteristics. In the "Infographic: Grand Valley Pilot Project Secondary Benefits," (TNC, 2019, Exhibit A) reduced irrigation "on salty soils improved water quality and resulted in an estimated savings of $282,720 from money not spent on other measures to reduce salinity." However, another review, "Research Synthesis: Agronomic Impacts of Reduction Irrigation," (Culp and Kelly, 2019, Exhibit A) raises the concern that "salt will move to the surface of the soil during periods of fallowing." If this occurs, "a pre-planting leaching irrigation" may be required which could "reduce the water savings from fallowing."

Additional Considerations

A summary of additional project considerations from the literature suggested the following to promote the inclusion of environmental attributes. These considerations are also discussed in the M&V section.

- Using streamflow station data helps understand the impacts to streamflow from foregone diversions.

- Increasing water in the river could result in savings due to less spending on endangered fish programs in studies.
- Reducing irrigation on salt soils could improve water quality and save money on salinity reduction programs.
- Maintaining historical return flows may be a challenge and may require storage and timed releases or construction of recharge basins but could offer net environmental benefits.
- Reducing irrigation on salty soils may improve water quality and reduce costs for salinity reduction programs. However, salty soils should be monitored as extra irrigation may be needed in subsequent years to perform leaching irrigation – reducing the long-term water savings.
- Increasing streamflows keeps temperatures low, improving fish habitats.

Key Takeaways

The key takeaways relating to a potential DM Program that support Environmental Considerations aligns with the need to ensure ongoing Compact compliance, however, there is a strong need to fill in the data gaps to be able to measure the potential impacts or benefits associated with the streamflow impacts.

List of key things that would support measuring impacts or benefits include:

- **Local Support and Participation**. Enlist local key stakeholders and non-governmental organizations (NGOs) to partner and realize opportunities to provide a net environmental benefit.
- **Alternatives Analysis**. Initiate a high-level assessment of environmental impacts of all recommended and alternate water management strategies considered.
- **Expand Project Purpose to Consider Additional Objectives**. The literature review revealed that many of the demand management programs did not have an environmental focus.

Data Gaps

The following data gaps were identified in the Environmental Considerations literature review:

- **Data**. Measured data on the impacts on fallowing and deficit irrigation on downstream streamflow and environmental resources due to changes in return flows.
- **Modeling**. The actual timing and reduction in depletions will require return flow modeling
- **Instrumentation and Monitoring Equipment**. There will be a need for cost effective flow monitoring to gage the environmental benefits in specific locations

The Environmental Considerations workgroup identified specific issues of interest to be considered in the literature review. SGM looked for mentions of these items and the following issues were not addressed in the 54 documents reviewed:

- Stream Management Plan/Watershed Management Plan objectives.
- Basin Round Tables environmental values lists/mapping.
- Colorado River Cutthroat Trout conservation strategy.
- Other known community/entity project.
- Environmental specific tradeoffs.
- Other known community/entity projects.

SECTION 7 – FUNDING – LITERATURE REVIEW & ANALYSES

WestWater Research led the Funding processes for the Investigation. The tasks associated with these efforts specifically included:

- Participation in the final meeting of the Funding Workgroup as a listener.
- Compilation and review of past studies and research regarding the costs and funding structures for other water conservation programs in the Western U.S. like a DM program.
- Analysis of design elements of a DM program as they relate to costs and beneficiaries.
- Identification of knowledge or data gaps in the ability to understand and evaluate the costs and funding options for a DM program.

Literature Review

There was found to be a lack of literature and past research on the costs and funding structures for demand management types of water conservation programs. WestWater compiled data and conducted original research on other water conservation programs in the Western U.S. to support the funding analysis.

What we know

Cost Components of Example Demand Management Programs

This section provides an inventory and analysis of other "demand management" programs in the Western U.S. In identifying comparable programs, the following selection criteria and loose definition were applied: (1) voluntary, (2) compensated, (3) consumptive water use reduction that is (4) temporary for any piece of land and is distinguished from two-party transactions because it is (5) operated by a single entity as a program over multiple years, often with a (6) regulatory or policy driver. Pilot projects were included. The costs of demand management vary by the type of water use (demand) being managed and reduced. Costs are significantly different between the agricultural and municipal sectors.

Agricultural Demand Management

Most of the demand management programs identified in the Western U.S. have been programs to reduce agricultural water use in order to utilize the savings for an alternative water use, such as municipal or environmental. A total of 17 example agricultural demand management programs were identified in more than 6 different states. A range of entities have developed and administered the agricultural demand management programs, including municipal water agencies, state government agencies, local / regional water districts, and others. The following cost components were identified in reviewing the example agricultural demand management programs:

- **Water Costs**. As defined above, all example demand management programs were compensated and therefore all had a water cost associated with agricultural conservation activities. The water costs reflect various factors: (1) the foregone agricultural value, or lost net revenue, (2) the program compensation structure and term, and (3) the type of demand management activity. A more expansive discussion of agricultural economic impacts from conducting demand management activities is provided in a previous section of this report. The water costs for agricultural participants in a Colorado demand management program are likely to reflect the predominance of perennial forage crops on the Colorado West Slope.
- **Administration Costs**. All of the example demand management programs had administrative costs, with an average annual cost $40 per acre-foot. Administration costs include regulatory approvals to

initiate projects and annual monitoring and verification activities. In one example, these costs were paid by the participating landowners and were covered as part of the compensation (water cost). With the exception of the Catlin Canal Pilot Project on the Lower Arkansas River, administration costs ranged from $4 to $48 per annual acre-foot (AF) of demand reduction. The Catlin Canal Pilot Project had estimated administration costs of $167 per AF, per year which reflects the attributes of this project and relatively stringent administrative requirements found in Colorado and particularly along the Front Range.

- **Mitigation Costs**. Only 5 of the 17 example demand management programs included mitigation payments to offset economic and related secondary (indirect) impacts from reduced agricultural water use. For the 5 programs that include mitigation as part of the program, the mitigation payments ranged from $2 to $86 per annual AF of water use reduction, with an average annual payment of approximately $50 per AF.

Municipal Demand Management

The activities to achieve demand management in the municipal sector remain uncertain, and it is likely that municipal water providers will take different approaches to implement demand management within their systems. This funding analysis considers municipal demand management through water conservation as one potential method, but it is recognized that it may not be broadly applicable. Water conservation was selected because most Colorado municipal water providers have a water conservation program or plan of activities that can be evaluated for example costs of demand management. Unlike the agricultural examples described in the previous section, municipal programs are typically not intended to produce a transferable water supply to another use. Municipal demand management programs are typically targeted at one of the following objectives:

1. Permanently reducing individual customer water use through a variety of indoor and outdoor water conservation and efficiency activities, including public outreach, rebate programs, tiered or water budget rate structures, home water audits, and others.
2. Temporarily reducing both individual customer and municipal-scale water use in response to a potential water supply shortage due to drought, infrastructure damage, or other emergencies. Regulatory measures are often applied to achieve demand management, such as every other day outdoor watering, bans or limitations on certain water uses, and temporary increases to water billing rates.

Any potential Demand Management program in Colorado would be voluntary, temporary, and compensated. Municipal demand management examples do not necessarily align with all three characteristics. Water conservation program activities in the first category above have associated direct costs (compensation) and are voluntary actions but are often intended to result in permanent water use reduction. The second category of regulatory actions are intended to be temporary but are often not voluntary or compensated. For this analysis, the cost of municipal demand management references observed costs of permanent municipal water conservation programs, but it may be recognized that temporary demand management can be achieved in the municipal sector and historically has been more likely to occur through regulatory (policy) actions at little to no direct cost. In addition, many municipal water providers may look to implement demand management activities with no water service impact to their customers and therefore with no water conservation actions by their customers.

The costs of municipal demand management were evaluated using two approaches and datasets:

- **Municipal Conservation Activities**. Municipal demand management is achieved through a combination of activities, such as those listed above. These activities each have an estimated water demand reduction and cost. Previous research indicates that indoor residential conservation activities have costs that are roughly 50% of the outdoor conservation activities. The costs also increase with greater degrees of water demand reduction. In total, past research indicates municipal conservation

activities having total direct costs of $500 per AF or more. This cost is likely to represent a permanent water use reduction, and the annual equivalent cost is estimated at approximately $20 per AF based on a 4% discount rate over an indefinite period.

- **Municipal Conservation Programs**. Many municipal water providers have annual water conservation programs with associated budgets to achieve demand reduction. Instead of looking at the cost of individual activities, it is helpful to look at the overall costs of municipal water conservation programs to understand the administrative costs, the inefficiencies in program spending, the effects of program activities that do not have associated costs, and the impact of growth in the number of service customers. A historical analysis of municipal demand management over the period 2000-2020 was completed for 9 example municipal water providers who utilize Colorado River Basin supplies. The average unit cost was found to be approximately $1,500 per AF of demand reduction, which is considered to better reflect the total cost of achieving overall volume reductions in municipal demand, as opposed to reductions in per-person water use rates.

Municipal demand management costs in Colorado may consider two important factors:

- **Trans-Basin Diversions**. Most municipal water use in the Colorado River Basin in Colorado is sourced from trans-basin diversions to the Front Range. These trans-basin diversions have historically not had any return flows to the Colorado River system from municipal effluent, and therefore any municipal diversion demand reduction from these trans-basin diversions is effectively a reduction in consumptive use from the Colorado River Basin. This contrasts with municipal water users located in the Colorado River Basin, who would mostly realize consumptive use savings only from a reduction in outdoor watering uses.
- **Water Supply Portfolio**. Most Front Range municipal water providers, particularly the largest volume users, have a water supply portfolio that sources water from a variety of river systems and projects. The composition of municipal water supplies that are sourced from the Colorado River system as a portion of the overall supply portfolio influences how total municipal demand management activities relate to water diversion reductions in the Colorado River Basin. Available data indicates that municipal water utilities in Colorado that are reliant on the Colorado River Basin for a portion of their water supply have 50% to 60% of their water supply sourced from other water systems. Therefore, municipal water providers would need to specifically reduce Colorado River Basin sources commensurate with demand management activities, otherwise the unit costs per volume of Colorado River water use reduction would potentially double.

Cost Factors for Demand Management Program

Cost estimates of a DM program are inherently uncertain because the costs can vary significantly depending on the following factors (among others):

- **Funding**. The funding structure of a demand management program is expected to influence costs, and particularly the amount of state government funding required. Decisions about who pays for demand management influences who bears the costs but also impacts the cost itself.
- **Scale / Volume**. Costs are directly a function of scale, or the annual volume of demand management being implemented. At the present time and for the near term, the scale of demand management in Colorado will be limited by volume of the conservation pool in Lake Powell created by the DCP. The annual volume of demand management will depend on how much space within the conservation pool is available to Colorado and how fast that space is intended to be filled.
- **Timing**. Costs escalate under emergency action, which has long motivated planning efforts in various subject areas. Demand management activities in the agricultural and municipal sectors may be more difficult and more costly to achieve during a drought, or if activities are required due to pending water

shortages or Compact administration. A multi-year consistent demand management program is expected to carry lower costs than a program that is reacting to stressful conditions.

- **Project Selection Process & Equity Policies**. The process for selecting demand management projects may influence program costs, depending on what type of process is established, how applicants are identified and evaluated, and how projects are compared. Several of the Workgroups have had discussions supporting equity in a demand management program, including water use sector equity between agricultural and municipal water users and spatial equity to limit the concentration (and associated impacts) of demand management activities. Implementing regulatory limits to provide for equity is expected to increase costs, due to a reduction in the pool of potential projects and deviation from a lowest-cost system of project selection.
- **Administrative Process**. The process established to conduct an upfront review of each project application, and the process established for monitoring and verification of project activities are both significant factors in overall project costs. It will be important to establish a review and monitoring process for the demand management program that is not cost prohibitive. Another aspect of approval is any environmental review and mitigation that is required as part of the program.
- **Participant Requirements**. Compensation payments are expected to reflect any lost economic opportunity associated with reduced water use, and any costs associated with meeting program requirements. As described in a separate section of this report, participant requirements may include cover crops, weed and pest controls, and other elements to reduce off-farm impacts.
- **Mitigation**. In addition to compensation paid to participants, there may be mitigation payments paid to offset economic and environment impacts resulting from the projects. Example mitigation includes: (1) payments to the larger ditch company or irrigation district for operational impacts, (2) payments to the county to offset economic impacts, (3) payments to an environmental organization to offset wetland or riparian impacts.
- **Economic Factors**. The multi-year and potentially multi-decade timeline of a demand management program results in various economic factors influencing costs. Some examples include: (1) agricultural commodity market prices influencing compensation payments, (2) interest rates influencing the cost of capital outlays, (3) inflation influencing all prices & costs, (4) population and economic growth influencing water supply & demand imbalances and water transaction values. There are other factors to consider, but the underlying point is that a variety of factors outside of the program's design and control will influence program costs.

Key Takeaways

The takeaways provided in this section are crafted to advance the demand management discussion and feasibility analysis in Colorado.

- **Activity & Scale**. Proactive programs that aim for annual demand management activities over a longer period of time are a more cost-effective method, as opposed to a surge of activity during a drought or other stressor. Therefore, funding sources may be structured to be reliable and consistent. Costs of demand management activities are a primary consideration if the program is publicly funded.
- **Certification Process**. Several of the time-intensive and costly aspects of project review and approval can be completed upfront and remain valid for many years. Therefore, other successful demand management programs have been designed with a certification process for projects that can allow each project to be thoroughly reviewed but also allow annual flexibility in participation.
- **Minimize Seller Costs**. To encourage participation in the demand management program, program design might avoid a significant cost burden for participants, or entities conducting demand

management activities. Monitoring and verification activities (and proving non-injury) may require the installation of equipment and annual data collection efforts. In addition, there may be mitigation costs associated with the ditch organization, local community, and environment. Upfront capital costs and mitigation costs could be incorporated into annual compensation payments. The program design may also consider state agency staff to conduct the initial reviews of applications and to assist in project administration. With these program design elements, the participant costs may be limited to developing application materials.

- **Incorporate Monitoring & Verification Costs into Project Selection**. The process of comparing and selecting project proposals requires that the full cost of the project be quantified. The compensation aspects of each proposal are expected to be defined by the participant. Monitoring and verification components of each project will be more difficult for the applicant to define. The costs of monitoring, verification, and administrative approval (to ensure non-injury) are expected to vary significantly across projects. Monitoring and verification costs could be evaluated with DNR assistance as part of a certification process and costs may be considered as a required element of each project application. An accurate evaluation of project proposals requires an "apples to apples" comparison of full project costs.

Data Gaps

This section provides a discussion of two types of data gaps: (1) those currently present in evaluating the feasibility of a demand management program, and (2) those that are likely to be present when structuring specific demand management funding options.

Data Gaps in Evaluating the Feasibility of Demand Management

The costs of demand management remain uncertain because of multiple variables and decision-points affecting the program. The preliminary estimates on cost feasibility may continue to be revisited by CWCB staff as the program design is explored. As continued analysis occurs, the following data gaps related to funding are identified:

- **Process Considerations**. Preliminary ideas on a program process are identified in the form of a single conceptual framework. The costs of a demand management program are inherently tied to the application and selection process, requirements for monitoring and verification, and project evaluation. It is expected that many of the data gaps involving process will be filled if, and as decisions are made regarding program structure.
- **Program Requirements**. Costs are also a function of program requirements, such as mitigation for local economic impacts and augmentation of stream depletions. Program costs can rise significantly depending on how program and participant requirements are defined.

Data Gaps in Structuring Specific Funding Options

The data gaps listed above for evaluating feasibility also apply to structuring specific funding options for demand management. Specific funding options can be developed once these data gaps are addressed.

SECTION 8 – MONITORING & VERIFICATION – LITERATURE REVIEW

SGM led the Monitoring and Verification literature review for the Investigation. The tasks associated with these efforts specifically included:

- Participation in the final two meetings of the Monitoring and Verification workgroup as a listener.
- Compilation and review of past studies and research regarding M&V considerations and practices detailed in previous CCU and ATM pilot projects, as well as western states water banking programs.
- Analysis of design elements for a potential DM program as they relate to M&V activities.
- Identification of knowledge or data gaps for consideration of the implementation of M&V requirements in a potential DM program, along with individual DM M&V project requirements.

Literature Review

SGM reviewed various types of water savings, water banking, pilot projects and/or water conservation reports and information that had similar goals and could inform the feasibility of a DM program, including:

- Current methodologies, data, and information to measure DM and water conservation both in the agricultural and municipal contexts.
- Details associated with consumptive use and conservation estimation and monitoring, verification methods, and related issues.
- Data gaps and methods for being able to continue advancing the DM monitoring and verification process.

Overall, the reports captured a summary of pilot project, such as the System Conservation Pilot Program (SCPP), and water conservation activities in Colorado and other areas across the Rocky Mountain West. The literature review considered a wide array of documents including research papers, demand-side vs supply-side municipal studies, state-mandated water conservation programs in California, crop rotations, energy-water benefits, and ATM research. The reports (shown in **Exhibit A**) generally analyzed off-farm benefits, conserved consumptive use, lessons learned and environmental impacts.

To better record the breadth and depth of information available in the literature, SGM summarized key topics, criteria, and takeaways relating to previously completed projects within a table. Summary information included:

- Primarily purpose/goal of the project.
- Key takeaways.
- Project location.
- Program name, administration, structure, nature and duration of project practice.
- Source and amount of water conserved.
- Monitoring and verification requirements, equipment, and processes:
    - Measurement of water returned to the stream.
    - Consumptive use analyses.
    - Estimate of residual field consumptive use.

  - Return flow maintenance.
  - Verification of conserved consumptive use.
  - Coordination of benefits.
  - Municipal considerations.
- Implications for storage, hydropower, recreation, and environmental considerations.
- Program lessons learned, successes and/or challenges, tradeoffs, proportionality, and alignment with M&V workgroup guiding principles.
- Project data gaps, keys to success, identified challenges, and overall findings and lessons learned.

See **Exhibit B** for the comprehensive tables documenting the overall M&V literature review findings.

What we know

Overall, few of the reports focused on the specific methods, instruments, or techniques used for monitoring and verification activities. Almost all the literature identified that projects need to be evaluated at the individual field level, as no two projects are alike. Generally speaking, the measurement devices commonly used by irrigators and municipalities are adequate to monitor and verify demand management project activities. The challenge often identified in the literature wasn't inadequate devices, but a lack of measurement devices physically installed near the project area. At the project level, a combination of existing measurement devices and field visits were used to verify conservation projects were operating as planned. However, the literature often cited that detailed measurement and verification of the achieved conservation amount wasn't completed, rather that the conservation practices were implemented. As an example, the Grand Valley Water Users Association Conserved Consumptive Use Pilot Project (GV CCUPP) relied on an independent contractor to perform site visits throughout the project to verify fallowed fields, give advice for weed control, as needed, and document compliance. The reports and lessons learned from the project emphasized the importance of utilizing an independent contractor to the success of the project. Ultimately, this increased trust between the participants and the program administration. The literature also identified that widespread and readily available remote sensing may help with monitoring and verification practices in the future, as well as to understand the historical irrigation practices and potential conservation benefits at a proposed site.

Consumptive Use Analysis

There are multiple computer programs available that can reasonably estimate the amount of historical consumptive use of agricultural operations. Each program is slightly different and requires a certain amount of input data. The ability to estimate the historical consumptive use is predicated on the availability of adequate climate data, water diversion records, cropping information, and soil characteristics. For instance, the CU analyses of SCPP projects focused on the specific amounts and associated cost of conserved water. Overall, the SCPP resulted in an estimated consumptive use reduction from all 45 projects in 2015 through 2017 of 22,116 acre-feet (AF). Additionally, projects complete in 2018 increased the reduction of consumptive use by 25,097 AF for a total of 47,213 AF over the entire SCPP timeframe.

The System Conservation Pilot Program also considered the difference between estimated consumptive use reduction on the applications and the reduction calculated during the subsequent analysis. Overall, the application estimates underestimated the reduction by 2,728 AF (approximately 7%). The SCPP identified that in order to accurately calculate the actual CU conserved in a project, thorough on the ground measurements are needed. In addition, the GV CCUPP pilot program analyzed the conserved consumptive use compared to the number of acres enrolled in the project. They found in 2017 with 1,069 acres enrolled in the pilot project resulted in 2,715 AF of water conserved. Similarly, in 2018, 1,252 acres were enrolled

which conserved 3,178 AF with both years yielding approximately 2.5 AF of conserved water per acre enrolled in the GV CCUPP pilot program.

It is important to note that the purpose of the System Conservation Pilot Program was not to create quantifiable water savings in Lake Powell, but rather to test the concept of a program incorporating temporary, voluntary, compensated reductions in conserved consumptive use.

Lessons Learned

Three primary lessons learned from the SCPP include:

- Outreach & communication is essential.
- Operational & legal issues must be addressed at ditch company/irrigation district level.
- Simplifying the process allows for greater efficiency.

Multiple participants voiced concerns about "broader economic impacts and social issues for" their communities – emphasizing the necessity of outreach and communication. For monitoring and verification purposes, the SCPP literature emphasized the importance of supporting efforts to estimated conserved consumptive use and the independence of verification work from the local administrators (such as ditch company/irrigation district staff). Additionally, The GV CCUUP found there was an increased interest in participation after the first year of the program and similarly indicated the importance of independent monitoring and verification-built trust within the pilot program.

Secondary Impacts

The SCPP literature described the benefits of a DM-type program increased environmental flows, decreased cost of alternative habitat flow restoration projects, improved societal benefits from habitat flows for endangered species, reduced salinity loading in the Colorado River, and increased municipal and hydropower benefits. Other pilot projects in Colorado observed that increased flows contributed minimal improvement to the overall recreational flow needs. Some documents did consider temporary water transfers and the associated impact to instream flows (ISF). These transfers without legally changing the water rights resulted in irrigators conserving water through a variety of means and leaving some portion of that water instream, which generally bolstered flows during the irrigation season, but may have reduced non-irrigation season return flows within a stream segment. The SCPP was documented to have the added effect of enhancing streamflow, and it was further determined that the availability of consistent funding would be crucial to success of long-term demand management efforts, whether for streamflow, water security or (most likely) multiple objectives.

SCPP Overview and General Findings

- Focused on the general administration and process of running a demand management system rather than the specifics of monitoring and verification.
- Attempted to streamline the process for participants (irrigators) and keep the barriers to entering a program/project minimal.
- Concluded that the size of the ditch and its governance/bylaws greatly influenced how conserved water projects could be operationally achieved and accounted (for).
- Realized that the size of the ditch company changed how water was managed.

    For example, large ditch companies diverted supplies and ran through their system; medium ditch companies diverted supplies and ran through their system or reduced their river headgate diversions; and small ditches reduced their river headgate diversions or closed it.

- Systems with multiple shareholders will likely require management participation (i.e., water users association or ditch company board) for success.
- The SCPP return flow maintenance practices were considered, but generally not adequately.
- Modelling considerations will need to be updated to handle water storage for potential demand management project operations.
- Flexibility to allow for locally driven solutions can drive higher engagement.

ATM Pilot Project Overview and Findings

- Avoided the need to go through a water court application process. However, complex monitoring and verification requirements may require a legal process that complicate the implementation of projects (historical consumptive use, change of use cases, etc.).
- Existing legal platforms to avoid water court are limited to instream flows leases, Substitute Water Supply Plan, and Interruptible Water Supply Agreement.
- These existing options have limitations and may not apply to every case or be useful in all projects so other options may need to be developed to avoid water court.
- Protection of vested water rights along with a flexible delivery schedules for M&I stakeholders are key for agricultural producers so they can keep growing crops/livestock.
- Guaranteed supplies are paramount for M&I water providers.
- An overall pilot project goal may be to reduce costs for M&I stakeholders such that ATMs are more affordable or more beneficial than buy-and-dry.
- The cost of installing new and/or highly accurate monitoring and verification equipment may be a participation barrier, depending upon the accounting and administration requirements.

Additional Findings

- Integrating local issues/sentiment was critical to the successful launch of conserved consumptive use pilot projects.
- Independent verification of project compliance helped maintain a level of trust and eliminated many interpersonal issues between irrigators, districts, and ditch companies.
- Sources of funding could cause contention if irrigators perceived a Front Range entity was paying for an area to be fallowed.
- Models worked well for estimating conserved consumptive use, though without on-farm analyses, the calculation of actual water savings was difficult to determine.
- Calculated estimate consumptive use and verification of conserved consumptive use in agriculture is improved with nearby climate stations.

Themes

The following statements capture overarching themes from the Monitoring and Verification literature review and represent common considerations for establishing buy-in for a future potential DM program.

Local data and input

Local focus was identified as one of the most crucial components for obtaining buy-in, finding project participants, and addressing misconceptions or apprehensions, etc. This theme cannot be emphasized

enough, as nearly every report highlighted this as contributing factor to the success of projects. Additional information surrounding the need for local data and input included:

- Generally, standard measurement equipment available and used by many irrigators and municipalities is adequate to monitor and verify conserved consumptive use projects. Locally, challenges may occur due to a lack of measurement devices, or with antiquated devices in poor condition.
- The availability of local data and equipment will inform the monitoring and verification needs and/or requirements for conserved consumptive use projects.
- A local presence is helpful to address any technical monitoring and verification needs. As a result, costs associated with local technical services for monitoring and verification could be significant.
- Regarding proportionality, M&I participants could more likely afford the engineering and legal costs than agricultural participants.
- Regarding proportionality, costs to support local technical services could prevent agricultural participation.
- Drought messaging can significantly influence a customer's response to whether or not they will conserve.

    For instance, the Drought Monitor could indicate conditions that are too regional and general and not reflect site-specific conditions. This develops a lack of trust in the regional information and represents an opportunity to change practices.

Flexible program

- Each conserved consumptive use project is different. Therefore, a flexible program structure could be more attractive to prospective applicants, especially by considering local and regional needs.
- However, a flexible program structure could require more administrative coordination and effort and could take longer to develop.

Infrastructure

- Potential participants in future pilot projects may need significant investment in infrastructure to accurately monitory and verify the conserved water and to ensure that return flows are maintained to avoid injury to downstream users.

Key Takeaways

The key takeaways relating to a potential DM Program that support M&V activities were largely based on the observed themes and may be used to fill the identified data gaps. In summary they include:

- **Utilize Local Resources.** The literature indicated obtaining local data and input to drive a monitoring and verification implementation was key to building public trust in the program, as discussed in the Education and Outreach section. Local resources were instrumental to support efforts to estimate conserved consumptive use, address any technical monitoring and verification needs for participants, as well as to provide independence for verification work from the local administrators (such as ditch company/irrigation district staff).
- **Develop a Flexible Program.** Projects in different geographic regions will require different implementation methods, project operations and local support. A project in one area will have different soil conditions, crops, ditch operations, community relations, etc. than another project. Allowing program flexibility for different implementation options increased participation in the literature reviewed.

- **Provide Funding to Support Investment in Measurement Infrastructure.** The literature highlighted it is not uncommon to have good potential projects in areas which lack the infrastructure to be able to monitor and verify the project. The initial capital costs and ongoing operations and maintenance costs required to install the measurement structures needed for accurate monitoring and verification of conservation projects needs to be addressed to promote participation in those projects.
- **Communicate with stakeholders, landowners, ditch, and reservoir companies before, during, and after projects.** The literature highlighted the importance of working directly with the program participants and those whose operations were directly impacted by participant participation (i.e. ditch companies, reservoir companies, etc.) throughout the process to future participation and trust in the monitoring and verification process.
- **Numerous takeaways from the E&O section, would support an effective M&V program implementation.** The SCPP literature highlighted the importance of a local project champion to reach out to potential project stakeholders and then work through implementation challenges, including building trust in the monitoring and verification processes.

Data Gaps

- More data would need to be collected to fully monitor and verify project yields and the resulting system increases, impacts to downstream water users, and ultimate benefit to Lake Powell.
- While standard irrigation and municipal measurement devices will likely be adequate, there is not detailed information regarding equipment or measurement instrumentation recommendations and/or data processing methods.
- There is a need for significant investments in infrastructure to accurately account for any conserved water and to ensure that return flows are maintained to avoid injury to downstream users.
- Fallowing projects are easier for monitoring and verification purposes, as general techniques include site visits to document that a field isn't being irrigated, as well as to observe the growth of any vegetation along with a review of careful accounting practices.
- Verification requirements will likely be more challenging and detailed for non-fallowing projects, as producers will seek to reduce the consumptive use of plants, while still obtaining a harvest.
- Accurately assessing the CCU from deficit irrigation or alternative crops will be harder to quantify/verify, requires more monitoring and data collection, and ultimately relying on more rigorous technical analyses.
- There may be a need for improved coverage of climate stations in regions of Colorado to support M&V activities for some future pilot projects.
- ET estimation methods vary regarding the necessary data, processing techniques, and resultant accuracy. Generally, the more plentiful the data and rigorous the analyses, the greater the cost and accuracy. Future pilot projects may explore various technical options and the resultant CCU.

ACRONYMS

AF	Acre-Feet
AFY	Acre-Feet/Year
ATM	Alternative Transfer Methods
Basin	Colorado River Basin in Colorado
BMP	Best Management Practice
CCU	Conserved Consumptive Use
CCUPP	Conserved Consumptive Use Pilot Program
CRWCD	Colorado River Water Conservation District
CFS	Cubic Feet per Second
CRCA	Colorado River Cooperative Agreement
CU	Consumptive Use
CWA	Clean Water Act
CWCB	Colorado Water Conservation Board
CWP	Colorado Water Plan
DCP	Drought Contingency Plan
DM	Demand Management
DMSA	Demand Management Storage Agreement
DNR	Department of Natural Resources
DWR	Division of Water Resources
E&O	Education and Outreach
EPA	U.S. Environmental Protection Agency
GPCD	Gallons Per-Capita per-Day
IBCC	Interbasin Compact Committee
Investigation	Demand Management Feasibility Investigation
ISF	Instream Flow
MAF	Million Acre-Feet
M&I	Municipal and Industrial
M&V	Monitoring and Verification
NGO	Non-governmental organization
NRCS	Natural Resources Conservation Service
PMT	Project Management Team

SB	Senate Bill
SEO	State Engineer's Office
SWSP	Substitute Water Supply Plan
TMD	Transmountain Diversion
UCRC	Upper Colorado River Commission
USBR	U.S. Bureau of Reclamation
USFWS	U.S. Fish and Wildlife Service

Demand Management Literature Review

EXHIBIT A

Exhibit A. Summary of Literature Review Reports and Documents.

Title	Year Published	Publisher/Authors
System Conservation Pilot Program Secondary Benefits: Final Report with Case Studies	2019	WestWater Research for TNC
Infographic: Grand Valley Pilot Project Secondary Benefits	2019	TNC
Research Synthesis: Agronomic Impacts of Reduction Irrigation	2019	Culp and Kelly for TNC
Final Report: Colorado River System Conservation Pilot Program in the Upper Colorado River Basin	2018	Upper Colorado River Commission
Final Report: Appendix C: 2018 System Conservation Pilot Program Update	2018	Upper Colorado River Commission
Pilot Program Funding Agreement	2014	Bureau of Reclamation
Colorado River Water Bank Feasibility Study: Phase 1	2012	Colorado River Water Conservation District
Colorado River Water Bank Feasibility Study: Phase 2	2013	For Colorado River District. By MWH.
Colorado River Compact Colorado water bank feasibility study: water supply technical memorandum. (Appendix B to Colorado River Water Bank Feasibility Study: Phase 1)	2012	Natural Resources Consulting Engineers, Inc
Exploring Perceptions of a Voluntary Agricultural Water Conservation Program on the Western Slope of Colorado	2019	MacIlroy, Colorado State University
Briefing Paper: Upper Basin Demand Management and Water Banking. Addressing Risk and Creating Certainty: Exploring Options for an Upper Basin Demand Management Program	2019	TNC
Colorado River Water Bank Work Group: An Overview of Previous Studies & Reports	2018	Colorado River Water Bank Working Group
GVWUA Final Report on the Conserved Consumptive Use Pilot Projects	2019	GVWUA and J-U-B Engineers
Lessons Learned from the System Conservation Partnership Program	2016	The Nature Conservancy

Title	Year Published	Publisher/Authors
Considerations for Modeling a Water Bank at the Aspinall Unit with Current Environmental Flows	2011	Hydro Consulting for TNC
Environmental Water Transactions in the Colorado River Basin: A Closer Look	2018	Stanford Woods Institute for the Environment
Lower Colorado River Basin Pilot Program	NA	Bureau of Reclamation
System Conservation: a collaborative approach to drought contingency planning the Upper Colorado River Basin	2017	Wyoming SEO Callaway, AWRA Impacts magazine
SNWA Water Resource Portfolio	2019	Southern Nevada Water Authority
Colorado River Basin Water Bank: Framework & Financial Analysis	2017	WestWater Research for TNC
Salmon recovery in the Columbia River basin: analysis of measures affecting agriculture	1999	Aillery et al, Marine Resource Economics
Feasibility of water efficiency and reuse technologies as demand-side strategies for urban water management	2017	Berhanu et al, Journal of Industrial Ecology
Response to water crisis: How do Iranian farmers think about and intent in relation to switching from rice to less water-dependent crops?	2019	Boazar et al, Journal of Hydrology
Temporary water transfers for urban water supply during drought	1992	Clark, CSU
Flexible water allocations and rotational delivery combined adapt irrigation systems to drought	2018	Cody, K.C., Ecology and Society
Water trading innovations: reducing agricultural consumptive use to improve adaptation to scarcity	2017	Colby (Ch. 3.1.4), Book eds Ziolkowska & Petersen
Towards regional sustainability assessment utilizing community based participatory research, sustainability indicators, and future scenario modeling	2016	Dubinsky, CU Denver
Economic viability of deficit irrigation in the Western US	2018	Manning et al, Agricultural Water Management.
The role of groundwater trading in spatial water management	2014	Palazzo and Brozovic, Agricultural Water Management

Title	Year Published	Publisher/Authors
Evaluating the potentials of cropping adjustment for groundwater conservation and food production in the piedmont region of the North China Plain	2019	Ren et al, Stochastic Environmental Research & Risk Assessment
Opportunities for saving and reallocating agricultural water to alleviate water scarcity	2017	Richter et al., Water Policy
Urban water conservation in the Sacramento, California region during the 2014-2016 drought	2019	Talbot, UC Davis
Remote sensing assessments of consumptive use of agricultural water in western slope of Colorado	2016	Vashisht, Colorado State University,
Deficit irrigation and surface residue cover effects on dry bean yield, in-season soil water content, and irrigation water use efficiency in western Nebraska high plains	2018	Yonts et al, J. of Agricultural Water Management
Irrigation Efficiency and Water Balance of the Little Wind Unit on the Wind River Indian Reservation in Wyoming	2017	Rosado, U of Wyoming
Standardizing Temporary Water Transfer Procedures in Colorado	2020	Nicols, Peter D, et al, University of Denver Water Law Review
Use of Alternative Transfer Methods to Increase Water Supplies for Conejos Basin Agriculture, Municipal, and Environmental Purposes	2017	DiNatale Water Consultants
Development of Land Fallowing-Water Leasing in the Lower Arkansas Valley	2011	Trout, Raley, Montano, Witwer & Freeman, P.C.
Little Thompson Farm ATM Grant Completion Report	2018	Larimer County Natural Resources
HB13-1248 Catlin Canal Company Rotational Land Fallowing-Municipal Leasing Pilot Project	2018	The Lower Arkansas Valley Water Conservancy District, Ber Hill Greenleaf Ruscitti, LLP, & Martin and Wood Water Consultants, Inc.
Yampa Basin ATM Study	2014	TNC, Trout Unlimited & CDM Smith
Grand Valley Water Users Assn Conserved Consumptive Use Pilot Project Development: Process, Procedure, and Lessons Learned: Water Banking-Next Steps Part II	Mar-17	J-U-B Engineers, Inc.

Title	Year Published	Publisher/Authors
Grand Valley Water Users Assn 2017 CCUPP In-Season Verification	2017	J-U-B Engineers, Inc.
Power Canal Capacity Report, Grand Valley Water Users Assn	Dec-2015	Olsson Associates
Completion Report: Development of Practical Alternative Agricultural Water Transfer Measures for Preservation of Colorado Irrigated Agriculture	May-2011	Brown and Caldwell
Final Project Report: Implementation of Deficit Irrigation Regimes: Demonstration & Outreach	May-2016	Chavez, CSU
The Poudre Water Sharing Working Group: A Report to the CWCB	May-2015	The Poudre Water Sharing Working Group
FLEX Water Market: Education and Implementation Phase	Dec-2015	Brown and Caldwell, Ducks Unlimited, Aurora Water and LJCG
Alternatives to Permanent Dry Up of Formerly Irrigated Lands	Jun-2013	DiNatale Water Consultants & CSU
Water Partnerships: an evaluation of alternative agricultural water transfer methods in the South Platte basin.	Mar-2012	DiNatale Water Consultants, Inc.
Project Report: Lake Canal alternative agricultural practices and in-stream flow demonstration project	Jun-2013	Colorado Water Innovation Cluster
Final Report of the Lower South Platte Irrigation Research and Demonstration Project	Jun-2014	Hansen, Chavez, Garcia & Lytle

Demand Management Literature Review

EXHIBIT B

Exhibit B

This Exhibit includes 12 different tables that summarize the findings from the SGM Literature Review. There were 3 sets of documents [SCPP, Lit (General Literature), and ATM] considered across 4 different evaluation criteria (ATM, Environmental, General, and Monitoring & Verification). The following table provides a map of these exhibits.

Exhibit	**Document Category**	**Criteria**
B-1	SCPP	ATM
B-2	Lit (General Literature)	ATM
B-3	ATM	ATM
B-4	SCPP	Environmental Criteria
B-5	Lit (General Literature)	Environmental Criteria
B-6	ATM	Environmental Criteria
B-7	SCPP	General
B-8	Lit (General Literature)	General
B-9	ATM	General
B-10	SCPP	Monitoring & Verification
B-11	Lit (General Literature)	Monitoring & Verification
B-12	ATM	Monitoring & Verification

This table lists the various areas considered for each criterion.

Criteria Category	**Specific Areas to Identify**
ATM	Identified Local Impacts
	Identified Regional Impacts
	Operational Type of Project
	Types of Crops
	Agronomic Impacts • Yield • Quality • Recovery • Water Quality Effects • Soil Health Effects
Environmental Criteria	Streamflow Impacts • Magnitude • Frequency • Duration • Timing • Rate of change of hydrologic conditions • Return Flow Impacts
	Species Impacts • Return Flow Impacts • Critical Stream Reaches Impacted • Critical Land or Riparian Habitat Impacted • Species Impacted
	Water Quality Impacts • Salinity • Temperature • Other
	Data Gaps, Questions for Future Projects • Tradeoffs – Resource Impacts • Predicted outcome for applying “avoid, mitigate, offset” hierarchy
	Program Level Goals • No net loss to environmental services, recognizing tradeoffs • Build incentives for projects with net environmental benefits
	For Proposed Future Transactions, Need to Evaluate Impacts (Positive or Negative) to: • ISFs (or other flow targets) • Stream Management Plan (SMP) or Watershed Management Plan (WMP) objectives • Critical Habitat & Flow Recommendations • State Species of Concern • Basin Roundtable (BRT) Environmental Values Lists/Mapping • CRCT Conservation Strategy • Other Known Community/Entity Projects

General	Document Title Publisher/Author(s) Document Description General Notes Story Map (hyperlink) Primary Purpose/Goal of Report or Study Key Takeaways
	Project Location Information • Project Location Description • Latitude • Longitude • Elevation
	Demand Management Program Basics • DM Program/Activity Name • DM Program Structure • Nature of DM Practices • Duration of DM Practices Implementation (Duration and Frequency)
	Source and Amount of Conserved Water • Source of Water Conserved • Amount of Water Conserved – Conserved Consumptive Use
	High Level Program Information • DM Program Administration • DM Program Monitoring and Verification Considerations • DM Program Education and Outreach Efforts • Tools Used to Measure General Outcomes • DM Program Funding Considerations • DM Economic Considerations • DM Agricultural Impacts Considerations • Recreation
	Program Effectiveness • Lessons Learned • Program Successes and/or Challenges • Pros/Cons
Monitoring and Verification	Methodologies and/or Processes • Measurement of Water Returned to the Stream • Consumptive Use Analysis • Estimated Residual Field Consumptive Use • Return Flow Maintenance • Verify Conserved Consumptive Use • Coordination of Benefits
	Necessary Data and Equipment for Agricultural Participants • Representative Crop ET Data • Verification of Conserved Consumptive Use

	• Sub-irrigation • Reservoir Operations • River Diversions & Foregone or Bypassed Diversions • Lateral Delivery and Ditch Loss • Irrigation and Non-irrigation Season Return Flows • Resulting Streamflow
	Necessary Data and Equipment for Municipal Participants • Reservoir Operations • River Diversions • Foregone or Bypassed Diversions • Ditch or Pipeline Delivery • Overall Collection Systems • Monitor System-wide Operations to Verify Conserved Consumptive Use • Detailed System-wide Accounting Records
	Program Level Considerations • Tradeoffs – Value and/or Cost Implications for More Precise Data • Proportionality
	M&V Workgroup Guiding Principles • Honest, Accurate, and Defensible • Protective of Other Water Users • Simple, Easy, and Flexible • Resulted in Added Water, rather than a Retiming of Depletions
	Lessons Learned
	Key Takeaways • Data Gaps • Keys to Success • Identified Challenges • Overall Findings and Recommendations

Exhibit B-1
SCPP Documents with ATM Criteria

								Additional ATM Specific Components				
								Agronomic Impacts (How long does it take for a crop to fully return to pre-fallowing productivity?)				
Title	**Date**	**Publisher/Authors**	**Description**	**Notes**	**Identified Local Impacts**	**Identified Regional Impacts**	**Operational Type of Project**	**Types of Crops**	**Yield**	**Quality**	**Recovery**	**Water Quality Effects**	**Soil Health Effects**
SCPP-01 System Conservation Pilot Program Secondary Benefits: Final Report with Case Studies	2019	WestWater Research for TNC	This case study report looked at whether the reduction in consumptive use in SCPP projects also generated off-farm benefits by applying select methods to quantify off-farm benefits to two case studies in Colorado and Wyoming. Note from TNC: An executive summary is also available, along with a more detailed report that outlines the framework for assessing secondary impacts/benefits and the associated methodology for quantifying or evaluating each impact/benefit.	Benefits assessed include increased environmental flows, decreased cost of alternative habitat flow restoration projects, societal benefits from habitat flows for endangered species, estimates of dramatic savings in salinity control, and municipal and hydropower benefits. Increased flows for the evaluated Colorado projects contributed minimal improvement to recreational flow needs. Cost savings were estimated by the cost of existing augmentation plans used to meet environmental and salinity management needs.	Not discussed.	Not discussed.	Annual projects.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.
SCPP-02 Infographic: Grand Valley Pilot Project Secondary Benefits	2019	TNC	This infographic summarizes the results of secondary benefits analysis as applied to the Grand Valley Pilot Project Case Study.	Grand Valley Pilot Project paid farmers to voluntarily reduce their irrigation water use in order to keep more water in the river to help increase water security within the Colorado River Basin in the face of ongoing drought. While focus was on water security several off-farm benefits occurs because of the project.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.
SCPP-03 Research Synthesis: Agronomic Impacts of Reduction Irrigation	2019	Culp and Kelly for TNC	This memo reviews research on fallowing and limited irrigation to highlight key findings related to agronomic impacts of limited irrigation or other methods to reduce consumptive use of irrigation water in the Upper Colorado River Basin. The concluding section also identifies remaining research questions and suggests potential implications and possible next steps for a demand management program. The appendix summarizes the parameters of several of the studies reviewed. All of the referenced reports and publications are available on request.	Reviews methods and findings of existing research on agronomic impacts of limited irrigation in the following categories: yield, quality, water use efficiency, recovery, soil health, weeds/diseases/pests, and ag operations. Next steps and identified research needs include understanding impacts over a variety of geographies and crops, as well as long-term recovery. Management and operations needs include understanding the benefits of rotational fallowing, deficit irrigation, and crop switching. Finally, there are many needs in the verification of conserved consumptive use.	-Reduced crop yields. -Potentially prolonged recovery periods. -Possibility for both positive and negative soil health changes. -Increased chance of weeds, pests, erosion, and loss of topsoil. -Operational challenges and limitations. -Potential for herd size reductions with reduced grass/alfalfa/hay yields.	Not discussed.	Various irrigation water management studies including deficit irrigation, full fallow, partial season irrigation, crop switching, dryland farming, rotational fallowing, irrigation efficiency and water conservation.	Alfalfa, grass/hay, corn, barley, wheat, sunflowers, beans, and tuber/root crops.	-Alfalfa: deficit irrigation can reduce yield by approximately 1-ton per acre in high elevations and 5-tons per acre in low elevations, with a similar reduction in yield for grass/hay. Limited irrigation can affect stand density of alfalfa, especially in sandy soil in hotter climates. -Corn: decrease in water of 50% will only reduce yield by 25%. It's better to restrict water during early stages. -Barley: each day of severe stress during heading equal to one-bushel per acre reduction in yield. Water stress prior to or just after flowering most impacts barley. -Wheat: stress during maturing resulted in 10% yield reduction, while stress during aerial vegetative stage had almost no effect on yield. -Sunflower: decrease in water by 20% during early vegetative period reduced yield by 5%, while same reduction during flowering stage resulted in a 50% yield reduction. -Beans: water stress during reproductive stages (flower and pod fill) has the greatest impact on yield. Moisture stress can reduce yield by 27%. -Tuber & root crops: indeterminate crops can endure 4-5 days of moisture stress throughout the growing season with limited reduction in yield or quality. For potatoes any depletion past 80 percent leads to decreases in quality and/or yield.	- Quality of alfalfa can increase with moderate water stress. - Other crops can have similar qualities to fully irrigated crops. See yield comments (left).	- Alfalfa and grass/hay generally shows full recovery when irrigation is returned following limited irrigation. - Recovery is more difficult in arid climates with sandy soil. - Recovery is more difficult after multiple years of consecutive DM activities.	Not discussed.	- Salt will move to the surface of the soil during periods of fallowing. Some fields may need a pre-planting leaching irrigation, reducing the water savings. - Recovery from limited irrigation may be affected by micronutrient availability. - Deep rooted crops (alfalfa and corn) will use moisture deeper in the soil; potentially reducing the groundwater level. - No-till increased the amount of water stored in the soil dure to reduced evaporation, improved infiltration, reduced runoff, and increased snow catching. - Fallowing is often an overall benefit to soil health.
SCPP-04 Final Report: Colorado River System Conservation Pilot Program in the Upper Colorado River Basin	2018	Upper Colorado River Commission	Full SCPP report from UCRC; project list; Lessons learned: administration & implementation, operational, cost/benefit/risk, legal constraints, outreach & education.	List of future questions to be answered p4	Not discussed.	Not discussed.	- Fallow, split season deficit irrigation, alternative cropping and deficit irrigation - Combination of fallow and split season deficit irrigation - Municipal foregone diversions and irrigation conservation project	Grass pasture, corn, winter wheat, alfalfa, beans, clover, triticale, small grains,	Not discussed.	Not discussed.	Not discussed.	Not discussed.	- There can be benefits to agriculture through soil resting.
SCPP-05 Final Report: Appendix C: 2018 System Conservation Pilot Program Update	2018	Upper Colorado River Commission	2018 update to UCRC full report, including Appendices C (2018 update), D (2017 CU analysis), and E (2018 CU analysis)	Document includes Appendices C (2018 update), D (2017 CU analysis), and E (2018 CU analysis)	Not discussed.	Not discussed.	-fallow, split season deficit irrigation, and combination of fallow and split season deficit irrigation	-Grass pasture, alfalfa, corn, and a variety	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.
SCPP-06 Pilot Program Funding Agreement	2014	Bureau of Reclamation	2014 SCPP funding agreement between CRB entities	Reviews history of compacts, storage allowances, demand management efforts by signatories. Defines goals and parameters of SCPP. Identifies NRCS programs that might support on-farm conservation improvements: EQIP and SWEP & ensures that projects will coordinate with respective NRCS State Conservationists.	Not applicable for the pilot program agreement.	Not applicable for the pilot program agreement.	Not applicable for the pilot program agreement.	Not applicable for the pilot program agreement.	Not applicable for the pilot program agreement.	Not applicable for the pilot program agreement.	Not applicable for the pilot program agreement.	Not applicable for the pilot program agreement.	Not applicable for the pilot program agreement.
SCPP-07 Colorado River Water Bank Feasibility Study: Phase 1	2012	Colorado River Water Conservation District	Water bank planning phase; conservative estimate of potential WB supplies, and demand for those supplies.	Includes potential WB uses, supply, magnitude & frequency of need, supply-use scenarios. App. A: categories of W/E slope water uses, App. B: CRC WB Feasibility Study Water Supply Technical Memo, App. C: Eval of CRC WB Hydrologic Scenarios w/UCRB model, App. D: Basic supply & use comparison scenarios for CRC WB technical memo	High percentages of fallow or deficit irrigation practices will impact local and regional economies to a greater degree.	High percentages of fallow or deficit irrigation practices will impact local and regional economies to a greater degree.	- Deficit irrigation of alfalfa and pasture grass. - Fallowing of small grains, corn, and dry beans	Alfalfa, pasture grass, small grains, corn, and dry beans	- Deficit irrigation on orchards and vineyards impacts yields and often has negative impacts on the subsequent year's production. - Fallowing is feasible for small grains and grain corn. - Deficit irrigation is possible for all crops, but best suited for perennial forage crops of alfalfa and pasture. - Pasture can be deficit irrigated every year without significant long-term impacts, including minimized stand reduction. - Alfalfa and pasture enter a stressed or dormant condition without significant loss of plant population or long-term crop damage. - In some instances pastures and alfalfa are grown successfully for many years without irrigation. - In most areas, alfalfa and pasture will produce harvestable yields with limited or no irrigation. - Deficit irrigation or no irrigation results in a significant decrease in yields.	The most critical time to provide an adequate water supply to grasses for maintaining a healthy crop is in the early spring through the first harvest.	It is important that pasture not be over-grazed during stress periods to protect the crowns of grasses which are important for plant recovery.	Not discussed.	Not discussed.
SCPP-08 Colorado River Water Bank Feasibility Study: Phase 2	2013	For Colorado River District. By MWH.	Water bank planning phase; test cases assessing on-farm impacts for representative irrigation systems	Includes candidate systems, screening criteria & selection, site visits for system evaluation, financial impacts on ag ops, operational scenarios & comparison to ATM work. App. A: Candidate system identification & evaluation; App. B Test Case site reports	- Other local impacts could include diminished aesthetics, reduced groundwater recharge for residential use, reduced baseflows to streams for fisheries and wildlife, and impacts to wetlands. - The need to reduce local cattle herds. - Depress the local economy.	- Impact and weaken the regional economy. - Potential long-lasting effects on regional cattle herds. - Impacts to regional streamflows, water and wildlife, aquifer recharge. - Increase regional prices for feed crops if a large number of producers participate. - Weaken the regioanl agricultural infrastructure.	Considered rotational fallowing, split-season irrigation, split-field irrigation, longer-term rotational fallowing, permanent fallowing, changes to crop type, and water efficienty projects.	Pasture grass, alfalfa, and row crops.	This was identified as a long-term study need, especially for high elevation pasture systems.	Not discussed.	Not discussed.	In areas underlain by the Mancos Shale, fallowing land will help the water quality of return flows to the receiving stream.	Not discussed.
SCPP-09 Colorado River Compact Colorado water bank feasibility study: water supply technical memorandum. (Appendix B to Colorado River Water Bank Feasibility Study: Phase 1)	2012	Natural Resources Consulting Engineers, Inc	Technical analysis for water bank feasibility study, included in 2012 WB planning phase 1 report .pdf	Data section includes analysis, irrigated areas, water rights categories, and climate stations. Examined CU requirements (w/StateCU & Blaney-Criddle), ET verification (Penman-Monteith w/4 CoAgMet stations), and HCU (StateCU values for elevation bands in each division multiplied by irrigated acres). Water bank supply and cost: "fallowing suitable for small grains, grain corn, & dry beans." Deficit Irr available for all crops but best suited to alfalfa & pasture. "These crops combined account for over 98% of the acreage, irr CU, and supply-limited CU." Discusses split-season irrigation.	High percentages of fallow or deficit irrigation practices will impact local and regional economies to a greater degree.	High percentages of fallow or deficit irrigation practices will impact local and regional economies to a greater degree.	-Deficit irrigation of alfalfa and pasture grass. -Fallowing of small grains, corn, and dry beans	Alfalfa, pasture grass, small grains, corn, and dry beans	-Deficit irrigation on orchards and vineyards impacts yields and often has negative impacts on the subsequent year's production. -Fallowing is feasible for small grains and grain corn. -Deficit irrigation is possible for all crops, but best suited for perennial forage crops of alfalfa and pasture. -Pasture can be deficit irrigated every year without significant long-term impacts, including minimized stand reduction. -Alfalfa and pasture enter a stressed or dormant condition without significant loss of plan population or long-term crop damage. -In some instances pastures and alfalfa are grown successfully for many years without irrigation.	The most critical time to provide an adequate water supply to grasses for maintaining a healthy crop is in the early spring through the first harvest.	It is important that pasture not be over-grazed during stress periods to protect the crowns of grasses which are important for plant recovery.	Not discussed.	Not discussed.
SCPP-10 Exploring Perceptions of a Voluntary Agricultural Water Conservation Program on the Western Slope of Colorado	2019	MacIlroy, Colorado State University	This report was designed to assist in identifying and better understanding the socio-cultural components of a potential demand management program. The research, completed in Spring 2019, explored perceptions of demand management among stakeholders on the Western Slope through individual interviews and focus groups. The findings shed light on the barriers and opportunities for a demand management program, including ideas and feedback on what a successful program would look like, and why water users may or may not want to participate.**An executive summary is also available.**	This is an interview-based report that covers perceptions of DM, definitions of voluntary, compensated, temporary, and equity (their words are proportional/parity)--and finds that these definitions are not straight-forward and must be carefully communicated. Explores relationships with water and landscape, as well as "sacred values of the Western Slope." Addresses perceptions of DM in context of 2007 Interim Guidelines and broader basin-to-basin politics. Many interviewees doubt the viability of a voluntary compensated program, and even suggest that a mandatory uncompensated call would work better, avoid equity issues, and cost less overall. Compensation was a very challenging topic, with differing views of DM as a burden vs opportunity. Highlights clash of free-market values with the perspective of water as a commodity--discussion of different role water plays for irrigators vs Front Range residents. Who bears responsibility to pay--who is responsible for the shortage problems (many don't see the Upper Basin at fault). Temporary program vs temporary participation--fraught discussion. Discussion of Western Slope Sacred Values, how water and farming is part of identity. Numerous people suggested every water user curtail use and respect water and that we should make water conservation part of being a Coloradan.	Not discussed	Not discussed	Not discussed	Not discussed	Not discussed	Not discussed	Not discussed.	Not discussed.	Not discussed.

									Additional ATM Specific Components			
									Agronomic Impacts (How long does it take for a crop to fully return to pre-fallowing productivity?)			
Title	**Date**	**Publisher/Authors**	**Description**	**Notes**	**Identified Local Impacts**	**Identified Regional Impacts**	**Operational Type of Project**	**Types of Crops**	**Yield**	**Quality**	**Recovery**	**Water Quality Effects**	**Soil Health Effects**
SCPP-11 Briefing Paper: Upper Basin Demand Management and Water Banking. Addressing Risk and Creating Certainty: Exploring Options for an Upper Basin Demand Management Program	2019	TNC	This briefing paper provides a general background on the DCP and demand management. It frames the key issues to address in evaluating a demand management program and is offered in the spirit of promoting discussion and decision-making on how to structure, govern, finance, and implement such a program.	Briefly evaluates Upper Basin risk based on drought hydrology, and discusses how to reduce that risk. Asks many questions about Dm, program governance and structure, cost and funding, policy, measurement and verification. Identifies many of the key issues being addressed by CWCB DM workgroups. Key successes from SCPP are locally-driven solutions, minimizing impacts & maximizing benefits, e.g. through local coordination of projects. Tabulates past options considered for avoiding compact curtailment.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.
SCPP-12 Colorado River Water Bank Work Group: An Overview of Previous Studies & Reports	2018	Colorado River Water Bank Working Group	This overview documents summarizes the studies completed by the Colorado River Water Bank Work Group in their effort to provide information about what types of solutions may be available to preserve communities, agriculture, power production and the river itself.	This work includes a two-phase feasibility study, an assessment of how reduced irrigation for compact purposes would work with different irrigation systems on Colorado's West Slope, economic work on pricing and payments, and scientific research on the agronomic impacts of reduced irrigation.	Not discussed	Not discussed	Not discussed	Not discussed	Not discussed	Not discussed	Not discussed.	Not discussed.	Not discussed.
SCPP-13 GVWUA Final Report on the Conserved Consumptive Use Pilot Projects	2019	GVWUA and J-U-B Engineers	This report provides a summary of the 2018 and 2019 Conserved Consumptive Use Pilot Projects completed by the Grand Valley Water Users Association (GVWUA). The initial part of the report provides a good summary of both the 2017 and 2018 pilots. Appendix H provides the details of the survey GVWUA completed of all participating producers, gathering their input on their experience and perspectives on the pilot project. Appendix I summarizes GVWUA's thinking more broadly on the pilot and demand management.	Land management contract: manage weeds & plant growth, soil erosion (leave plant residue, tillage for clods, tillage for crust), w/mid-season visit to confirm mgmt. activities are consistent w/contract; interviewees concerned w/DM externalities including local economy & aesthetics; CCU verification procedures (Exhibit B) don't specify methods to verify CU on fallowed land, but does include sites visits to verify land mgmt. and explicitly prohibits any active plant growth on fallowed land	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.
SCPP-14 Lessons Learned from the System Conservation Partnership Program	2016	The Nature Conservancy	TNC's lessons learned in their SCPP involvement, including lessons from Trout Unlimited and Colorado Water Trust	Top 3 lessons: outreach & communication is essential, operational & legal issues must be addressed at ditch company/irrigation district level simplify the process for efficiency.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.
SCPP-15 Considerations for Modeling a Water Bank at the Aspinall Unit with Current Environmental Flows	2011	Hydro Consulting for TNC	Evaluation of computer models of the Gunnison River to assess their ability to simulate a potential water bank in the basin using the Aspinall Unit reservoirs and the effect on reservoir operations, including environmental flows	StateMod, Aspinall PBO/EIS Model, and CRSS are evaluated for their capabilities to simulate Aspinall Unit operations, environmental flows, and potential water-banking. Specifically, this modeled the Black Canyon wate right, new ESI/PBO requirements at the Whitewater gage, and a water-banking option at Aspinall. Modifications to the Gunnison StateMod are necessary to simulate environmental flows and enhance reservoir accounting options.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.
SCPP-16 Environmental Water Transactions in the Colorado River Basin: A Closer Look	2018	Stanford Woods Institute for the Environment	Reviews CRB environmental transfers to track extent of activity. Examines SCPP projects by this lens, given the ISF benefits of SCPP. Found that SCPP-funded projects had the effect of enhancing streamflow.	Analysis used UCRC 2018 Final Report; no new data. 20,000ft view of ISF projects including SCPP projects.	Not discussed.	Not discussed.	Not discussed	Not discussed	Not discussed	Not discussed	Not discussed.	Not discussed.	Not discussed.
SCPP-17 Lower Colorado River Basin Pilot Program	NA	Bureau of Reclamation	Webpage with tables of projects from each pilot phase	"Although the Pilot Program will be ongoing until 2035, as of 2019, future announcements of funding opportunities and requests for additional project proposals are not being contemplated."	Not discussed	Not discussed	Not discussed	Not discussed	Not discussed	Not discussed	Not discussed	Not discussed	Not discussed
SCPP-18 System Conservation: a collaborative approach to drought contingency planning the Upper Colorado River Basin	2017	Wyoming SEO Callaway, AWRA Impacts magazine	Description of Wyoming SCPP, how it works, participation, and future efforts.	Neither extensive nor technical, but includes some description of process & participation.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.
SCPP-19 SNWA Water Resource Portfolio	2019	Southern Nevada Water Authority	Chapter from SNWA's water plan	Addresses temporary supplies including different aspects of Intentionally Created Surplus, recharge and banking, DCP, and conservation tools.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed	Not discussed.
SCPP-20 Colorado River Basin Water Bank: Framework & Financial Analysis	2017	WestWater Research for TNC	This memo evaluates different framework concepts to scale up operations of the Water Bank and provides comparative costs and other factors to consider in different approaches to developing a water bank. The information is intended to provide concepts and preliminary numbers for TNC and the Water Bank Working Group to consider and discuss in ongoing Water Bank development efforts.	Evaluates 4 frameworks of a Colorado Basin water bank sufficient to address 250,000 AF of CCU: annual water bank leases, option leases in critical years, non-option critical year leases, and response to a 1922 compact call. WestWater Research developed a cost-estimation spreadsheets based on the volume of water leases, number of associated acres, and number of farms or ranches leasing water.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.

Exhibit B-2
Lit (Gen. Literature) Documents with ATM Criteria

					Additional ATM Specific Components							
									Agronomic Impacts (How long does it take for a crop to fully return to pre-fallowing productivity?)			
Title	**Date**	**Publisher/Authors**	**Description**	**Notes**	**Identified Local Impacts**	**Identified Regional Impacts**	**Operational Type of Project**	**Types of Crops**	**Yield**	**Quality**	**Recovery**	**Water Quality Effects**	**Soil Health Effects**
Lit-01 Salmon recovery in the Columbia River basin: analysis of measures affecting agriculture	1999	Aillery et al, Marine Resource Economics	Analysis of ag impacts from salmon-recovery-related flow alterations in Columbia River	Investigates ag impacts of fish recovery measures "such as modified timing for dam releases, reservoir drawdown, and flow augmentation in the Columbia River basin, on the regional agricultural sector are evaluated. [....] Results suggest that drawdown and/or minor reductions in irrigation water diversions would reduce producers' profits by less than 1% of baseline levels. However, the most extreme scenario--a long drawdown period combined with a large reduction in irrigation diversions--would reduce producers' profits by $35 million (2.5%) annually."	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.
Lit-02 Feasibility of water efficiency and reuse technologies as demand-side strategies for urban water management	2017	Berhanu et al, Journal of Industrial Ecology	Economic model of water cost provided by above-code water efficiency and reuse technologies, including variations & uncertainty analysis.	Estimates that efficiency and reuse can meet 85% of 50yr projected needs to the Lower Colorado River Authority service area (central TX)	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.
Lit-03 Response to water crisis: How do Iranian farmers think about and intent in relation to switching from rice to less water-dependent crops?	2019	Boazar et al, Journal of Hydrology	Study of farmer response to gov't demand management, switching crops.	"Structural equation modeling showed that farmers' intention to change from rice cultivation to another crop is determined by personal norms, beliefs about their role and emotional considerations."	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.
Lit-04 Temporary water transfers for urban water supply during drought	1992	Clark, CSU	PhD dissertation modeling options for temporary water transfers	"This research develops a water right option agreement (WROA) model, methods of analysis, and legal implementation strategy under Colorado law." Interviewed professionals, estimates costs, identified that WROA "can be superior in terms of cost, reliability, and operational flexibility to both water-right purchases and construction of additional reservoir storage.	Promote a water saving status among farming community. Perhaps this is where getting information to support the No Action across the 5 Planning Horizons comes into play.	- The paper recognized the need to quantify local drought conditions (as opposed to making the decision to have a temporary transfer on a statewide decision). - The need for the transfer and benefits are locally driven	Emphasized discussing storage, which could be considered in the regional impacts category.	There is ,mention of Federal Water systems on page 24.	Not discussed.	Not discussed	Not discussed	Included a discussion on the Senate Bill 89-181 and the rulemaking by the SEO to implement water quality standards in review of water transfers Mentioned the use of the mass balance method or the mixing zone method to estimate the influence of flow on water quality standards	Not discussed
Lit-05 Flexible water allocations and rotational delivery combined adapt irrigation systems to drought	2018	Cody, K.C., Ecology and Society	Water allocation experiment in San Luis Valley, Colorado for self-governing irrigation systems.	Examines relationships between rules and physical context of water supplies; specifically the outcomes of water allocations between members and how they rotate water delivery.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.
Lit-06 Water trading innovations: reducing agricultural consumptive use to improve adaptation to scarcity	2017	Colby (Ch. 3.1.4), Book eds Ziolkowska & Petersen	Chapter from book "Competition for Water Resources: Experiences and Management Approaches in the US and Europe" collecting global examples/discussion of approaches and solutions to water supply scarcity, including western US	Ch 2.1.1: Challenges for US irrigated ag in the face of emerging demands and climate change, Ch 3.1.4: Water trading innovations: reducing agricultural consumptive use to improve adaptation to scarcity (reviews online trading systems to reduce transaction costs, methods for cost-effective verification of CCU, and other breakthroughs facilitating temporary & intermittent trading more feasible. Examples from AZ and CA (IID), NE, Australia, CO-Big Thompson.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.
Lit-07 Towards regional sustainability assessment utilizing community based participatory research, sustainability indicators, and future scenario modeling	2016	Dubinsky, CU Denver	PhD dissertation that identified San Luis Valley sustainability indicators and modeled future scenarios, developing a CU indicator for 1980-2010. Conducted scenario modeling to guide decision-makers towards desired outcomes from policy decisions. Coupled sustainability indicators with future scenario modeling to inform the SLV stakeholders about a variety of social and environmental issues. Results indicated that through specific shifting of cropping rotations and minimal land fallowing, SLV could reduce water use and Greenhouse Gas Emissions while increasing soil carbon and improving soil health. In addition, the solar energy development pathways investigated by this study showed that the potential exists to offset most or all of the region's GHG emissions.	Utilized Community Based Participatory Research to engage stakeholders & keep research relevant. Highlighted groundwater-dependence of SLV, suggests irrigation water use could be decreased 10% with shifts in crop regime and minimal fallowing.	Not discussed.	Not discussed.	Fallowing, Crop shifting	Potato, alfalfa, small grain	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Used a green manure cover crop to promote soil health
Lit-08 Economic viability of deficit irrigation in the Western US	2018	Manning et al, Agricultural Water Management.	Research on agro-economics of deficit irrigation.	Deficit irrigation (DI) can be optimal during late growth and maturation stages given elevated water prices (depending o output price and production costs).	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.
Lit-09 The role of groundwater trading in spatia water management	2014	Palazzo and Brozovic, Agricultural Water Management	Republican River Basin assessment of coupling surface-groundwater management.	Geospatial dataset of RRB irrigation wells modeling crop choice, land, and water use decisions by well. "Our analysis highlights the importance of the initial distribution of permits and the institutional context in which trading occurs." Cost savings from trading groundwater pumping are distributed unevenly between wells, counties, and groundwater management institutions.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.
Lit-10 Evaluating the potentials of cropping adjustment for groundwater conservation and food production in the piedmont region of the North China Plain	2019	Ren et al, Stochastic Environmental Research & Risk Assessment	Evaluation of different cropping patterns (including fallowing) & water supply scenarios.	Framework for using a crop model & regression to predict effects of cropping adjustments on groundwater sustainability & crop production	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.
Lit-11 Opportunities for saving and reallocating agricultural water to alleviate water scarcity	2017	Richter et al., Water Policy	- Review of literature & internet to identify water-saving strategies in irrigated agriculture. - Review of case studies in which water savings have been successfully transferred to other uses.	- Catalogs water savings opportunities, claims of irrigation-efficiency savings potential, logistics of reallocating due to other ag diverting savings. Findings suggest considerable potential to reduce irrigation CU and that savings can be reallocated when proper consideration is given to water budget accounting.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.
Lit-12 Urban water conservation in the Sacramento, California region during the 2014-2016 drought	2019	Talbot, UC Davis	UC Davis Master's Thesis cataloging/analyzing supply & demand management actions under CA's drought policies.	Evaluates outdoor watering, public outreach, media role, water-related energy savings. Makes recommendations for urban water suppliers on revenue recovery, reducing use of rebates as demand management, and scaling drought response tasks for different levels of gov't. Summarizes & analyzes CA legislation establishing approval for long-term budget-based efficiency targets.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.

							Additional ATM Specific Components					
							Agronomic Impacts (How long does it take for a crop to fully return to pre-fallowing productivity?)					
Title	**Date**	**Publisher/Authors**	**Description**	**Notes**	**Identified Local Impacts**	**Identified Regional Impacts**	**Operational Type of Project**	**Types of Crops**	**Yield**	**Quality**	**Recovery**	**Water Quality Effects**	**Soil Health Effects**
Lit-13 Remote sensing assessments of consumptive use of agricultural water in western slope of Colorado	2016	Vashisht, Colorado State University, Colorado	CSU Master's Thesis evaluating remote sensing for estimating monthly consumptive use (CU) and conserved CU (CCU) on the West Slope	Used evapotranspiration (ET) observations at experimental plots of traditional irrigation and water-banking irrigation practices to evaluate methods of verifying CCU. Reviews methods for measuring and monitoring CU, discusses limitation and potential for ReSET remote sensing CU model.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.
Lit-14 Deficit irrigation and surface residue cover effects on dry bean yield, in-season soil water content, and irrigation water use efficiency in western Nebraska high plains	2018	Yonts et al, J. of Agricultural Water Management	2010-2015 study in Nebraska of efforts to decrease ag groundwater pumping; impacts of water use efficiency and crop yield	"Reducing irrigation water by 25% caused no significant yield reduction and improved irrigation water use efficiency by 26%." Applying 50% Etc. resulted in 30% yield reductions, and planting directly in crop residue did not improve bean yield under deficit irrigation. Ample early season rainfall is a boon to pre-flowering deficit irrigation yields, but under normal-to-dry conditions post-flowering deficit yields more.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.
Lit-15 Irrigation Efficiency and Water Balance of the Little Wind Unit on the Wind River Indian Reservation in Wyoming	2017	Rosado, U of Wyoming	Master's thesis on irrigation system efficiency in Little Wind Unit	Uses ag water balance & geophysical techniques to quantify & locate water losses. "Large errors and data gaps associated with the inflows, outflows, diversions, and precipitation data, [...which] identified specific needs for better data."	Paper not found								
Lit-16 Standardizing Temporary Water Transfer Procedures in Colorado	2020	Nicols, Peter D, et al, University of Denver Water Law Review	Review of strengths and challenges of existing legal mechanisms for ATMs and recommendations for consolidation and standardization.	This article will describe the barriers in existing law to temporary transfers and the various approval mechanisms available under existing Colorado law. It will provide an assessment of the strengths and limitations of the existing transfer methods and make a recommendation for consolidation and standardization.	Not discussed	Not discussed	Not discussed	Not discussed	Not discussed	Not discussed	Not discussed	Not discussed	Not discussed

Exhibit B-3
ATM Documents with ATM Criteria

								Additional ATM Specific Components				
								Agronomic Impacts (How long does it take for a crop to fully return to pre-fallowing productivity?)				
Title	**Date**	**Publisher/Authors**	**Description**	**Notes**	**Identified Local Impacts**	**Identified Regional Impacts**	**Operational Type of Project**	**Types of Crops**	**Yield**	**Quality**	**Recovery**	**Water Quality Effects**	**Soil Health Effects**
ATM-01 Use of Alternative Transfer Methods to Increase Water Supplies for Conejos Basin Agriculture, Municipal, and Environmental Purposes	2017	https://dnrweblink.state.co.us/cwcb/ElectronicFile.aspx?docid=205333&dbid=0	Trujillo Meadows Reservoir ATM Study (TMR Study): "The primary objective of the TMR Study is to investigate the feasibility of a unique ATM that involves enlarging Trujillo Meadows to provide intra-year regulation of water supplies including direct flow storage and storage of other agricultural and augmentation water rights for agricultural users diverting from the San Antonio.	ATM w/ recreational and environmental benefits for municipal augmentation w/enlargement of Trujillo Meadows Reservoir. Stakeholder meetings for federal & state agencies, ag, and town aug needs. Model of ATM, details of benefits, recommended path fwd. Appendix A estimates of monthly inflows to reservoir. Water rights include USFS Reserved Rights decreed as ISF, interstate shepherding for flow through NM.	Improved Ag Deliveries, flood minimization, mid-summer streamflow, recretaional benefit,	Compact and river administration benefits	Storage expansion	Not discussed	Not discussed	Not discussed	Not discussed	Not discussed	Not discussed
ATM-02 Development of Land Fallowing-Water Leasing in the Lower Arkansas Valley	2011	https://dnrweblink.state.co.us/cwcb/ElectronicFile.aspx?docid=195733&dbid=0	The goal of this report is to "report on the development from 2002 through mid-2011 of rotational land fallowing-water leasing (fallowing-leasing) in the Lower Arkansas Valley of Colorado (Lower Valley) by the Lower Arkansas Valley Water Conservancy District (Lower Ark District) and the Lower Arkansas Valley Super Ditch Company, Inc. (Super Ditch)."	Return flow needs may require additional recharge ponds & stations; Return flows unnecessary at times due to trans-basin supply; considers monthly return flow "factors"; analysis by Leonard Rice Engineers found that replacement water will be required in the non-irrigation season in most cases.	More water supply benefit to northern Munis, less water supply benefit to Lower Ark communities but $$ benefit to Lower Ark communities	Benefits farmers by giving them an option to not sell water/land and move out	Lease-Fallow, associated storage expansion	Not discussed	Potential benefit to reduced upstream irrigation	Not discussed	Not discussed	Improved due to reduced overall irrigation and improved irr. efficiency	Potential improvements to selenium, TDS, salinity, and hardness from reduced irrigation
ATM-03 Little Thompson Farm ATM Grant Completion Report	2018	https://www.larimer.org/sites/default/files/uploads/2018/larimer_county_atm_final_report.pdf	Study funded through CWCB 2015 ATM Grant. The Little Thompson Farm receives supply from Handy Ditch and Reservoir Company shares and 240 C-BT units. The consultant team found that "it was feasible for Larimer County to afford, from a water supply perspective, to sell some C-BT units (115) and share some other units (80) in some years, while still having sufficient water on the farm for corn and sugar beets, as well as crops that require less water." The study looks at aspects of feasibility, including: Economics; Farm Financial Viability under wet, dry, and very dry year scenarios; dry year water value. The report also investigates potential partnerships, and outlines the final water sharing agreement. "Larimer County sold 115 C-BT units to Broomfield and retained a first right of refusal to lease back these units for assessment cost plus 10%, when available." The report also discusses Lessons Learned and Future Considerations: Legal Hurdles/Barriers to Replication (Northern Rulemaking, Direct Flow Rights, Delivery Efficiency Impacts from Water Transfers); Public Perception & Political Will (Educating and Obtaining Support of Leadership, Public Support, Out of County Partners, Continued Education); Negotiating an ATM: Successful Tips, Tricks, and Tools (Establish and Pursue Goals with an Open Mind About Implementation, Minimize the Cooks and Trust Your Team).	Cover crop & leaving crop residue prevents wind erosion, maintains soil fertility, controls weeds; non-irrigated cover crops: dryland milo, sorghum/Sudan grass for soil health, reduce weeds, potential revenue; w/no cover crop, control weeds w/herbicide or tillage (tillage can reduce erosion by forming large soil clods & enhancing infiltration); Class II and III soils, slopes 0-5%, not high enough for severe erosional problems; no/low-till also recommended to reduce direct evap, improve soil health, reduce fuel & costs; irrigation efficiency via contour farming, drip irrigation, SM & ET monitoring, drought tolerant crops, GPS irrigation guidance; no return-flow requirements due to CBT water, so no effort to quantify despite opponents	Reduced return flow from C-BT water to Little Thompson Creek; Overall, keeps farm viable; Helps shore up water security for Broomfield	In general, keeps farms operating and water in ditches, which was positive to regional communities	Interruptable Water Supply Agreement	Corn, sugar beets	Not discussed	Not discussed	Not discussed	Not discussed	Not discussed
ATM-04 HB13-1248 Catlin Canal Company Rotational Land Fallowing-Municipal Leasing Pilot Project	2018	https://dnrweblink.state.co.us/cwcb/0/edoc/210320/19%2001%2015%202018%20Annual%20Report%20-%20Catlin%20Pilot%20Project%20FINAL.pdf?searchid=3856cf32-c475-4163-840c-5361fa65041f	The Catlin Pilot Project was the first rotational land fallowing-municipal leasing pilot project under HB 13-1248: Irrigation Water Leasing Municipal Pilot Projects. This project aims to makes available up to 500 acre-feet of water for lease to three municipal water providers – the Town of Fowler, the City of Fountain, and the Security Water District (Municipal Participants) - from rotational fallowing of lands located on six farms irrigated under the Catlin Canal in the Arkansas River Basin.	Huge emphasis on return flows; using Lease Fallow Tool from DWR to calc available water & owed returns; "Pay As You Go" target deliveries for return flow; use of recharge structures supported well-timed return flows; augmentation station used for faster return flows and consumptive use water delivered to municipal participants; erosion & weed control included herbicide, disk tilling, cover crops (winter wheat, hay)	Not discussed	Not discussed	Lease-Fallow	Not discussed	Possibly no change but inconclusive due to 2018 being low water year and all-around reduced crop yield	Not discussed	No major issues found	Not discussed	No erosion, no noxious weeds
ATM-05 Yampa Basin ATM Study	2014	https://dnrweblink.state.co.us/cwcb/0/edoc/199193/Yampa%20-%20NC%20Use%20of%20ATM%20to%20Met%20Non%20%20Consumpt%20Needs_FINALReport%203-28-14_with%20apps.pdf	Study conducted by Trout Unlimited (TU) and funded by CWCB's Alternative Agricultural Water Transfers Grant Program. The purpose of the study was to identify locations in the Yampa Basin where potential ATM transactions could help to meet multiple uses (nonconsumptive needs and agricultural shortages), and identify types of ATM transactions most suitable for meeting multiple purposes. Ideal candidate reaches, as specified by project proponent TNC and its partners, would involve the following scenario: - Upstream agricultural water user with full or surplus irrigation supplies and transferable CU water - Downstream agricultural water user with an irrigation CU shortage (consumptive need) - A need for water in the reach between to improve flows for trout (including Colorado cutthroat trout) or warmwater fish (nonconsumptive need)	Used StateMod delay table to estimate historic return flows; more efficient irrigation improves water quality by lowering return flow contaminant transport, fewer excess nutrients due to fertigation in drip systems; TNC/TU partnership to support instream flows for habitat w/ATM loans used when downstream ISF right is not satisfied & to provide flow in a reach without ISF right	Not discussed	Not discussed	Not discussed	Not discussed	Not discussed	Not discussed	Not discussed	Not discussed
ATM-06 Grand Valley Water Users Assn Conserved Consumptive Use Pilot Project Development: Process, Procedure, and Lessons Learned: Water Banking-Next Steps Part II	42795	http://www.grandvalleywaterusers.com/uploads/8/2/6/0/82606774/03-01-17_ccupp_projectdevelopment_final.pdf	The Conserved Consumptive Use Pilot Project (CCUPP) is a pilot demand management project intended to test the mechanisms necessary for a Western Slope irrigation water provider to intentionally reduce consumptive use in a voluntary and compensated manner. This report summarizes the process of developing the CCUPP, the procedure used, and lessons learned.	Land management contract: manage weeds & plant growth, soil erosion (leave plant residue, tillage for clods, tillage for crust), w/mid-season visit to confirm mgmt. activities are consistent w/contract; interviewees concerned w/DM externalities including local economy & aesthetics; CCU verification procedures (Exhibit B) don't specify methods to verify CU on fallowed land, but does include sites visits to verify land mgmt. and explicitly prohibits any active plant growth on fallowed land	Not discussed	Not discussed	Not discussed	Not discussed	Not discussed	Not discussed	Not discussed	Not discussed	Not discussed
ATM-07 Grand Valley Water Users Assn 2017 CCUPP In-Season Verification	2017	https://dnrweblink.state.co.us/cwcb/ElectronicFile.aspx?docid=205144&dbid=0	Field compliance and payment summary for the 2017 CCUPP, including verification forms for each program participant for 2017.	Includes 2017 verification documentation including photographs, recommendations, comments/notes	Not discussed	Not discussed	Not discussed	Not discussed	Not discussed	Not discussed	Not discussed	Not discussed	Not discussed
ATM-08 Power Canal Capacity Report, Grand Valley Water Users Assn	12/1/2015	https://dnrweblink.state.co.us/cwcb/ElectronicFile.aspx?docid=201813&dbid=0	Very brief report on "one potential mechanism through which water associated with CCU could be protected and returned to the Colorado River under a pilot project water bank:" to convey CCU via unused capacity within the Orchard Mesa Power Canal (power canal) to deliver water to the Grand Valley Power Plant (GVPP). The report investigated the potential unused capacity within the Power Canal, including the potential for additional water to generate hydroelectric power.	Very brief report on "one potential mechanism through which water associated with CCU could be protected and returned to the Colorado River under a pilot project water bank." Compensated, temporary, voluntary. Lists current operations, water rights, data. Incomplete file in link, merged with 2017 Next Steps Part II	Not discussed	Not discussed	Not discussed	Not discussed	Not discussed	Not discussed	Not discussed	Not discussed	Not discussed
ATM-09 Completion Report: Development of Practical Alternative Agricultural Water Transfer Measures for Preservation of Colorado Irrigated Agriculture	5/1/2011	https://dnrweblink.state.co.us/cwcb/ElectronicFile.aspx?docid=195709&dbid=0	An extensive evaluation to: 1) To identify barriers to implementation of alternative transfers and to describe potential strategies for overcoming barriers. 2) To develop tools for agricultural producers to evaluate the viability of potential alternative transfers. 3) To further actual alternative transfers by evaluating three demonstration projects that include owners of agricultural water rights and potential end users of the temporarily transferred water.	Extensive final report on ATM investigation & pilot on NE South Platte covering barriers (cost, risk/uncertainty, lack of supply, reluctance, power dynamic), needs and means to address barriers, Lease Evaluation Tool (AgLET) ag economics evaluator, exchange capacity analysis, flex market pilot project w/Aurora.	Not much discussion of local impacts outside of irrigation practices and M&I use	Overall tone that keeping ag is good and that buy-and-dry by M&I should be avoided	Flex Market w/ rotational fallowing, IWSA	Not discussed	Not discussed	Not discussed	Not discussed	Not discussed	Not discussed

									Additional ATM Specific Components				
									Agronomic Impacts (How long does it take for a crop to fully return to pre-fallowing productivity?)				
Title	**Date**	**Publisher/Authors**	**Description**	**Notes**	**Identified Local Impacts**	**Identified Regional Impacts**	**Operational Type of Project**	**Types of Crops**	**Yield**	**Quality**	**Recovery**	**Water Quality Effects**	**Soil Health Effects**
ATM-10 Final Project Report: Implementation of Deficit Irrigation Regimes: Demonstration & Outreach	May-16	https://dnrweblink.state.co.us/cwcb/ElectronicFile.aspx?docid=199317&dbid=0	Evaluation of different methods of monitoring crop water stress and consumptive use (CU) under deficit irrigation. Demonstrations, workshops, educational outreach on crop stress monitoring.	Demo project to evaluate different methods of monitoring crop water stress and CU under deficit irrigation & demo educational outreach on crop stress monitoring.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.
ATM-11 The Poudre Water Sharing Working Group: A Report to the CWCB	May-15	https://dnrweblink.state.co.us/cwcb/ElectronicFile.aspx?docid=198097&dbid=0	Final report of Poudre Water Sharing Working Group - a prototype ATM water sharing group between agricultural users (North Poudre Irr Co, Water Supply & Storage Co, New Cache la Poudre Irr Co, and Larimer/Weld Irr Co) and municipal users (Fort Collins, Greeley, and Tri-Districts) on the Poudre River, facilitated by the Colorado Water Institute at Colorado State University. The report focuses on the formation of the working group, relationship building, lessons learned, survey of ag users, development of prototype agreements, and regional cooperation strategies.	Final report of prototype ATM water sharing group between ag (North Poudre Irr Co, Water Supply & Storage Co, New Cache la Poudre Irr Co, and Larimer/Weld Irr Co) and muni (Fort Collins, Greeley, and Tri-Districts) on the Poudre River. Identified CCU calculation methods as a large barrier.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.
ATM-12 FLEX Water Market: Education and Implementation Phase	December-15	https://dnrweblink.state.co.us/cwcb/ElectronicFile.aspx?docid=197916&dbid=0	Investigation of FLEX water market implementation: engagements, index based pricing, theorizing on large-scale implementation, meetings between willing shareholders. The goal of this project was to successfully implement the FLEX Water Market concept through education, facilitation, and consultation, with specific focus on developing FLEX markets in Water Division 1 with municipal, industrial, agricultural, and environmental/ conservation partners. The team consulted with multiple potential partners, but in the end this project did not result in a water sharing agreement.	Investigation of FLEX water market implementation: engagements, index based pricing, theorizing on large-scale implementation, meetings between willing shareholders.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.
ATM-13 Alternatives to Permanent Dry Up of Formerly Irrigated Lands	June-13	https://dnrweblink.state.co.us/cwcb/ElectronicFile.aspx?docid=199208&dbid=0	Review of benefits and issues of two alternatives to buy and dry that maintain some continued level of agricultural production: 1) Dry land farming, and 2) limited irrigation.	Review of benefits and issues of buy and dry and alternatives. Potential for conversion of ag land to dry land or deficit-irrigation, economic & maintenance issues w/dry land & deficit.	Limited irrigation may or may not be economically feasible depending on climate, precip, water supply issues; localized approach to evaluate benefits / Reveg can reduce tax values of adjacent properties / Dry-land farming is likely to result in economic loss	Same as previous column <----------	Feasibility study: comparison of full irrigation to limited irrigation, and revegetation	Wheat corn, sorghum, alfalfa, pasture grass/hay, native grass, millet	Limited irrigation for Front Range (South Platte) parcels wouldn't typically have high enough yields to justify cost of farming due to lack of precipitation / Dry land farming results in very low yields but is cheaper than revegetation	Not discussed	Not discussed	Potential nutrient loading if high residual N in soils from previous crop-type and fertilization	Improper planning ahead of dry-up can lead to high residual N, high compaction, poor drainage, low organic matter, noxious weeds
ATM-14 Water Partnerships: an evaluation of alternative agricultural water transfer methods in the South Platte basin.	March-12	https://dnrweblink.state.co.us/cwcb/ElectronicFile.aspx?docid=199215&dbid=0	Water market experiment, survey of municipal & industrial providers on ATM practices, leases, evaluation of shared water bank scenarios on South Platte, focused on FRICO shareholders.	Water market experiment, survey of municipal & industrial providers on ATM practices, leases, evaluation of shared water bank scenarios on South Platte	From lab experiment results, shared water bank concept doesn't necessarily increase the efficiency of water usage in ag, but impacts are lessened by comparison to typical buy-and-dry	M&I still gets water but ag gets to use more than it would during buy-and-dry	Feasibility study, survey, and some experiments to vet ATM concept called Shared Water Bank	Not discussed	Not discussed	Not discussed	Not discussed	Not discussed	Not discussed
ATM-15 Project Report: Lake Canal alternative agricultural practices and in-stream flow demonstration project	June-13	https://dnrweblink.state.co.us/cwcb/ElectronicFile.aspx?docid=203045&dbid=0	Proof of concept project planning for ATM/ISF program on Lake Canal. Monitoring/verification based on deliveries, surface returns, inflow to recharge pits, and soil moisture sensors to verify return flows by lack/presence of moisture movement below the root zone. Project was not implemented due to ongoing water scarcity at the time (2012-2013) and inability to agree on a price. Describes extensive legal work to arrive at proof of concept.	Proof of concept project planning for ATM/ISF program on Lake Canal. Monitoring/verification based on deliveries, surface returns, inflow to recharge pits, and soil moisture sensors to verify return flows by lack/presence of moisture movement below the root zone. Project was not implemented due to ongoing water scarcity at the time (2012-2013) and inability to agree on a price. Describes extensive legal work to arrive at proof of concept.	Potential for enhanced flows in the river for environmental benefits	Potential for added water throughout season to a long reach of Cache La Poudre River (Lake Canal Diversion to Greeley No. 3 Diversion)	IWSA for deficit irrigation, with some fallowing	Not discussed	Not discussed	Not discussed	Not discussed	Not discussed	Not discussed
ATM-16 Final Report of the Lower South Platte Irrigation Research and Demonstration Project	Jun-14	https://dnrweblink.state.co.us/cwcb/ElectronicFile.aspx?docid=199218&dbid=0	Technical research paper with three tasks. Task 1. Develop calculation & verification of consumptive water use and water savings, such that water court requirements can be satisfied--uses a stress coefficient, the crop water stress index CWSI, and the ReSET model of remote sensing. ReSET showed accuracy of 92-98% for fields under normal growing conditions and successfully detected abnormal growing conditions to accordingly reduce ET estimates. Task 2. Simplify the administrative burden of maintaining return flows. Task 3. Estimate supply delivery potential. Project on Lower South Platte Irrigation Research Farm near Iliff.	Goals were 1. Develop calculation & verification of consumptive water use and water savings, such that water court requirements can be satisfied--uses a stress coefficient, the crop water stress index CWSI, and the ReSET model of remote sensing. ReSET showed accuracy of 92-98% for fields under normal growing conditions and successfully detected abnormal growing conditions to accordingly reduce ET estimates. 2. Simplify the administrative burden of maintaining return flows, and 3. Estimate supply delivery potential. Project on Lower South Platte Irrigation Research Farm near Iliff.	Not really, this report primarily focused on the science, data, and accuracy of ET modeling	Not discussed	Deficit Irrigation	Corn	Not discussed	Not discussed	Not discussed	Not discussed	Not discussed
ATM-17 RGWCD Net Annual Replacement Plans	Reports exist for each year. Reviewed report for April 13, 2020	https://rgwcd.org/sd-1-annual-replacement-plan	Rio Grande Water Conservancy District plan to meet interstate compacts through forbearance agreements, leases for exchanges to meet streamflow criteria, temporary fallowing agreements, etc. Reviewed the 2020 Annual Replacement Plan (ARP), to meet requirements for the Plan Year under the provisions of the PWM for Subdistrict No. 1 decreed by the Division No. 3 Water Court in Case Nos. 2006CV64 and 2007CW52. This report describes a plan to remedy injurious stream depletions caused by the withdrawal of groundwater from Subdistrict Wells. This ARP includes a series of tables created by Subdistrict No. 1 staff and the RGDSS modeling team tabulating stream replacement quantities and locations resulting from Subdistrict No. 1 well groundwater withdrawals and a water portfolio to be used to replace such stream depletions.	Rio Grande Water Conservancy District plan to meet interstate compacts through forbearance agreements, leases for exchanges to meet streamflow criteria, temporary fallowing agreements, etc.	Agriculture is still holding on to water rights and maintaining irrigation practices at limited capacity / More water in the stream and marginal improvement in aquifer	Agriculture is still holding on to water rights and maintaining irrigation practices at limited capacity / More water in the stream and marginal improvement in aquifer	Fallowing, forbearance	Alfalfa, grain, and potatoes primarily; also oats, sudan grass hay, grass; other various crops	Not discussed	Not discussed	Not discussed	Not discussed	Not discussed
ATM-18 Alternative Water Transfers in Colorado: A Review of Alternative Transfer Mechanisms for Front Range Municipalities	2016	https://www.edf.org/sites/default/files/alternative-water-transfers-colorado.pdf	Review of ATMs in Colorado for Front Range Municipalities. The report conducted a screening analysis to identify potential case studies for a more detailed analysis of ATM, found 35 municipal water providers based on water source and demand size criteria. Two case study participants were identified: City of Fountain and Town of Windsor. The report conducted a financial analysis of water supply alternatives for the two case studies; findings include recommendations for best ATM practices to suit those municipalities.	Review of ATMs in Colorado for Front Range Municipalities. The report conducted a screening analysis to identify potential case studies for a more detailed analysis of ATM, found 35 municipal water providers based on water source and demand size criteria. Two case study participants were identified: City of Fountain and Town of Windsor. The report conducted a financial analysis of water supply alternatives for the two case studies; findings include recommendations for best ATM practices to suit those municipalities.	Not discussed	Not discussed	Not discussed	Not discussed	Not discussed	Not discussed	Not discussed	Not discussed	Not discussed

Exhibit B-4
SCPP Documents with Environ. Criteria

					Environmental Resources that May be Affected												Next Steps										
					Streamflow (Hydrology) Impacts						Species Impacts			Water Quality Impacts			Data Gaps, Questions for Future Projects										
																				Program level goals			For proposed future transactions, need to evaluate impacts (positive or negative) to:						
Title	Date	Publisher/Authors	Description	Notes	Magnitude	Frequency	Duration	Timing	Rate of change of hydrologic conditions	Return Flow Impacts	Critical Stream Reaches Impacted(where)	Critical Land or Riparian Habitat Impacted	Species Impacted	Salinity	Temperature	Other	Tradeoffs - Resource Impacts	Predicted outcome from applying "avoid, mitigate, offset" hierarchy	Proportional	No net loss to envr. services, recognizing tradeoffs	Build incentives for projects with net env. benefits.	SIFs (or other flow targets)	SMP or WMP objectives / proposed projects	Critical habitat & flow recommendations	State species of concern	IBRT environmental values lists/ mapping	CRCT conservation strategy	Other known community / entity projects
SCPP-01 System Conservation Pilot Program Secondary Benefits: Final Report with Case Studies	2019	WestWater Research for TNC	This case study report looked at whether the reduction in consumptive use in SCPP projects also generated off-farm benefits by applying select methods to quantify off-farm benefits to two case studies in Colorado and Wyoming. Noted from TNC: An executive summary is also available along with a more detailed report that outlines the framework for assessing secondary impacts/benefits and the associated methodology for quantifying or evaluating each impact/benefit.	Benefits assessed include increased environmental flows, decreased cost of alternative habitat flow restoration projects, societal benefits from habitat flows for endangered species, estimates of dramatic savings in salinity control, and municipal and hydropower benefits. Increased flows for the evaluated Colorado projects contributed minimal improvement to recreational flow needs. Cost savings were estimated by the cost of existing augmentation plans used to meet environmental and salinity management needs.	CO: See Table 4 for Monthly Flow Comparison: CCU, River Flows at top of 15-mile reach, BIOp Flow Recommendation for 15-mile Reach. "the flow contributions to the Colorado River were estimated as only the CU associated with the participating fields. Conveyance and on-farm efficiency losses associated with the reduced irrigation demands were not factored into flows redirverted to the Grand Valley Power Plant.... only the conserved CU volumes were estimated as streamflow benefits at the upper end of the 15-Mile Reach." WY: See Table 7 for Monthly Flow Comparison: CCU and Middle Piney Creek Estimated Flow. "the streamflow benefit of the project is the estimated CU savings."	Not discussed.	CO: See Table 4 for Monthly Flow Comparison: CCU, River Flows at top of 15-mile reach, BIOp Flow Recommendation for 15-mile Reach. WY: See Table 7 for Monthly Flow Comparison: CCU and Middle Piney Creek Estimated Flow.	CO: See Table 4 for Monthly Flow Comparison: CCU, River Flows at top of 15-mile reach, BIOp Flow Recommendation for 15-mile Reach. WY: See Table 7 for Monthly Flow Comparison: CCU and Middle Piney Creek Estimated Flow.	Not discussed.	Return flows identified as a data gap, but this project only quantified CCU. " Future water conservation projects may consider potential benefits of redtwerting additional water to the Power Canal to account for on-farm and conveyance system return flows. For this analysis, only the conserved CU volumes were estimated as streamflow benefits at the upper end of the 15-Mile Reach."	15 Mile Reach: "Environmental benefits of about $23,000 were estimated because of the management efforts and obligations defined under a recovery program for T&E fish species in the 15-mile reach directly below the project diversion point." Environmental benefit measured by improved habitat for endangered species. Flows in 15 mile reach: 1) Evaluate cost savings to West Slope and Front Range water diverters who are obligated to augment streamflow in 15-mile reach. 2) Evaluate the incremental benefit to society from treating the additional streamflow in the Colorado River as increasing critical habitat for the four listed fish species.	Not discussed.	Colorado: 15 Mile Reach endangered fish species: the Colorado Pikeminnow, Humpback Chub, Bonytail, and Razorback Sucker. Wyoming: Trout. "Increases in streamflow made possible by the Middle Piney Creek conservation projects would likely increase the quality of trout fishing, particularly if streamflow is a factor limiting trout productivity."	Salinity impacts measured in load reductions. "In total, the 2017 Grand Valley water conservation project is estimated to have reduced salt loading to the Colorado River by 4,960 tons. Applying a unit value of $57 per ton, the salinity benefit of the project is estimated as $282,720." "Partial season irrigation activities under the Grand Valley program are estimated to capture most of the salinity benefit, as summarized in Table 18." "Various estimates of salinity reduction were found in the literature. For this analysis, remaining salt loading after past treatments was estimated to be 4 tons/acre. FY2017 Colorado Salinity Control Unit Summary indicates salinity treatments of 143,800 tons on 43,150 acres, or 3.33 tons per acre reduction for the Grand Valley Unit. Similar values are reported by NRCS in 2011, resulting in 3.4 tons per acre and an expected 50%-60% reduction in salinity loading for well-managed flood irrigated fields. A 2013 USBR presentation by J. Sottilare on the Grand Valley Salinity Control Projects indicates that excess deep percolation results in a loading rate of 4 tons per acre (after treatments)."	Increases in streamflow made possible by the Middle Piney Creek conservation projects would likely increase the quality of trout fishing, particularly if streamflow is a factor limiting trout productivity. Specifically, low streamflow tends to raise water temperature often beyond ideal thresholds and also reduces available habitat."	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.
SCPP-02 Infographic: Grand Valley Pilot Project Secondary Benefits	2019	TNC	This infographic summarizes the results of secondary benefits analysis as applied to the Grand Valley Pilot Project Case Study.	Grand Valley Pilot Project paid farmers to voluntarily reduce their irrigation water use in order to keep more water in the river to help increase water security within the Colorado River Basin in the face of ongoing drought. While focus was on water security several off-farm benefits occurs because of the project.	"increased water in the river resulted in $23,000 of estimated savings not spent on endangered fish programs."	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	"increased water in the river resulted in $23,000 of estimated savings not spent on endangered fish programs."	Not discussed.	"increased water in the river resulted in $23,000 of estimated savings not spent on endangered fish programs."	Reduced irrigation on salty soils improved water quality and resulted in an estimated savings of $282,720 from money not spent on other measures to reduce salinity."	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.
SCPP-03 Research Synthesis: Agronomic Impacts of Reduction Irrigation	2019	Culp and Kelly for TNC	This memo reviews research on fallowing and limited irrigation to highlight key findings related to agronomic impacts of limited irrigation or other methods to reduce consumptive use of irrigation water in the Upper Colorado River Basin. The concluding section also identifies remaining research questions and suggests potential implications and possible next steps for a demand management program. The appendix summarizes the parameters of several of the studies reviewed. All of the referenced reports and publications are available on request.	Reviews methods and findings of existing research on agronomic impacts of limited irrigation in the following categories: yield, quality, water use efficiency, recovery, soil health, weeds/diseases/pests, and ag operations. Next steps and identified research needs include understanding impacts over a variety of geographies and crops, as well as long-term recovery. Management and operations needs include understanding the benefits of rotational fallowing, deficit irrigation, and crop switching. Finally, there are many needs in the verification of conserved consumptive use.	Impacts to flow not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	"Salt will move to the surface of the soil during periods of fallowing. When returning from fallowing, some fields may need a pre-planting leaching irrigation, which could reduce the water savings from fallowing."	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.
SCPP-04 Final Report: Colorado River System Conservation Pilot Program in the Upper Colorado River Basin	2018	Upper Colorado River Commission	Full SCPP report from UCRC; project list; Lessons learned: administration & implementation, operational, cost/benefit/risk, legal constraints, outreach & education.	List of future questions to be answered p4	Impacts to flow not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.
SCPP-05 Final Report: Appendix C: 2018 System Conservation Pilot Program Update	2018	Upper Colorado River Commission	2018 update to UCRC full report, including Appendices C (2018 update), D (2017 CU analysis), and E (2018 CU analysis)	Document includes Appendices C (2018 update), D (2017 CU analysis), and E (2018 CU analysis)	Impacts to flow not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed	Not discussed	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.
SCPP-06 Pilot Program Funding Agreement	2014	Bureau of Reclamation	2014 SCPP funding agreement between CRB entities	Reviews history of compacts, storage allowances, demand management efforts by signatories. Defines goals and parameters of SCPP. Identifies NRCS programs that might support on-farm conservation improvements. EQIP and SWEP A ensures that projects will coordinate with respective NRCS State Conservationists.	Impacts to flow not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed	Not discussed	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.
SCPP-07 Colorado River Water Bank Feasibility Study: Phase 1	2012	Colorado River Water Conservation District	Water bank planning phase; conservative estimate of potential WB supplies, and demand for those supplies.	Includes potential WB uses, supply, magnitude & frequency of need, supply-use scenarios. App. A: categories of WE slope water uses. App. B: CRC WB Feasibility Study Water Supply Technical Memo; App. C: Eval of CRC WB Hydrologic Scenarios w/UCRB model. App. D: Basic supply & use comparison scenarios for CRC WB technical memo	The report describes "evaluation of the magnitude and frequency of Water Bank need based on demand shortages" but does not discuss flow magnitude and frequency.	Not discussed	Not discussed	The report acknowledges "the actual timing and reduction in depletions would likely require some kind of return flow modeling."	Not discussed.	Return flow timing is recognized as a data gap. "The actual timing and reduction in depletions would likely require some kind of return flow modeling."	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.
SCPP-08 Colorado River Water Bank Feasibility Study: Phase 2	2013	For Colorado River District. By MWH.	Water bank planning phase; test cases assessing on-farm impacts for representative irrigation systems	Includes candidate systems, screening criteria & selection, site visits for system evaluation, financial impacts on ag ops, operational scenarios & comparison to ATM work. App. A: Candidate system identification & evaluation; App. B Test Case site reports	Not discussed.	Not discussed.	Not discussed.	Next steps Sec 6.2 pg.: 41 identifies this as a question/next step: "Estimate the potential impacts of fallowing or deficit irrigation on downstream streamflow and environmental resources due to changes in return flows." Return Flow Locations and Patterns addressed as a criteria: Implementation of fallowing or deficit irrigation practices could affect return flows that are a source of inflow to downstream river segments and water supply to downstream water users. Locations of return flows from test case irrigation systems were based on the link-node system definition in the StateMod model. Monthly return flow patterns were also adopted from the data in the StateMod model.	Not discussed.	Return flow locations and patterns addressed as a criteria: Implementation of fallowing or deficit irrigation practices could affect return flows that are a source of inflow to downstream river segments and water supply to downstream water users. Locations of return flows from test case irrigation systems were based on the link-node system definition in the StateMod model. Monthly return flow patterns were also adopted from the data in the StateMod model.	Not discussed.	Noted in general that return flows are a concern / data gap / next step, and that measurement of return flow impacts will be important. . "All of the site visits revealed difficulties in water banking administration. First, none of the systems had adequate measurement of diversions and return flows to directly calculate foregone CU through a mass balance." The Direct Measurement method of accounting for reduced depletions is the most accurate and defensible, but it would be very difficult to measure diversions and surface/subsurface return flows at all participating fields." . Next Steps: "Estimate the potential impacts of fallowing or deficit irrigation on downstream streamflow and environmental resources due to changes in return flows. Return Flow Locations and Patterns addressed as a criteria: Implementation of fallowing or deficit irrigation practices could affect return flows that are a source of inflow to downstream river segments and water supply to downstream water users. Locations of return flows from test case irrigation systems were based on the link-node system definition in the StateMod model. Monthly return flow patterns were also adopted from the data in the StateMod model.	Not discussed.	Not discussed.	Not discussed.	"Salinity and selenium issues may make fallowing or deficit irrigation more attractive to Project farmers, as impacted lands might be taken out of production with less impact on overall yields. In addition, reduced irrigation of these lands may have benefits in improved quality of return flows." Salinity effects (not affected or marginally affected) was a screening criteria used to select candidate systems representing a broad range of characteristics. "Soil and groundwater salinity were used as a surrogate for estimating whether a candidate irrigation system could have potential productivity issues during drought periods that would make it a better candidate for temporarily taking lands out of production. Whether a candidate system has potential salinity related issues was determined based on GIS coverage that has salt loading rates (tons/acre) in return flows from irrigated areas. The GIS coverage was developed by the U.S. Geological Survey (USGS) Utah Water Science Center for the Upper Colorado River Basin USGS SPARROW model."	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.
SCPP-09 Colorado River Compact Colorado water bank feasibility study: water supply technical memorandum. (Appendix B to Colorado River Water Bank Feasibility Study: Phase 1)	2012	Natural Resources Consulting Engineers, Inc	Technical analysis for water bank feasibility study included in 2012 WB planning phase 1 report .pdf	Data section includes analysis, irrigated areas, water rights categories, and climate stations. Examined CU requirements (w/StateCU & Blaney-Criddle), ET verification (Penman-Monteith w/4 CoAgMet stations), and HCU (StateCU values for elevation bands in each division multiplied by irrigated acres). Water bank supply and cost: "following suitable for small grains, grain corn, & dry beans." Deficit Irr available for all crops but best suited to alfalfa & pasture. "These crops combined account for over 98% of the acreage, in CU, and supply-limited CU." Discusses split-season irrigation.	"- The reduction in diversions would include the irrigation efficiencies. " The actual timing and reduction in depletions would likely require some kind of return flow modeling."	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Recognized as a data gap / next step: - "The actual timing and reduction in depletions would likely require some kind of return flow modeling."	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.
SCPP-10 Exploring Perceptions of a Voluntary Agricultural Water Conservation Program on the Western Slope of Colorado	2019	MacIlroy, Colorado State University	This report was designed to assist in identifying and better understanding the socio-cultural components of a potential demand management program. The research, completed in Spring 2019, explored perceptions of demand management among stakeholders on the Western Slope through individual interviews and focus groups. The findings shed light on the barriers and opportunities for a demand management program, including ideas and feedback on what a successful program would look like, and why water users may or may not want to participate.**An executive summary is also available.**	This is an interview-based report that covers perceptions of DM, definitions of voluntary, compensated, temporary, and equity. Their words are proportional/parity)--and finds that these definitions are not straight-forward and must be carefully communicated. Explores relationships with water and landscape as well as "sacred values of the Western Slope." Addresses perceptions of DM in context of 2007 Interim Guidelines and broader basin-to-basin politics. Many interviewees doubt the viability of a voluntary compensated program, and even suggest that a mandatory uncompensated cab would work better, avoid equity issues, and cost less overall. Compensation was a very challenging topic, with differing views on if it was a real opportunity. Highlights clash of free-market values with the perspective of water as a commodity--discussion of different role water plays for irrigators vs Front Range residents. Who bears responsibility to pay--who is responsible for the shortage problems (many don't see the Upper Basin at fault). Temporary program vs temporary participation--fraught discussion. Discussion of Western Slope Sacred Values, how water and farming is part of identity. Numerous people suggested every water user curtail use and respect water and that we should make water conservation part of being a Coloradan.	Impacts to flow not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.
SCPP-11 Briefing Paper: Upper Basin Demand Management and Water Banking. Addressing Risk and Creating Certainty. Exploring Options for an Upper Basin Demand Management Program	2019	TNC	This briefing paper provides a general background on the DCP and demand management. It frames the key issues to address in evaluating a demand management program and is offered in the spirit of promoting discussion and decision-making on how to structure, govern, finance, and implement such a program.	Briefly evaluates Upper Basin risk based on drought hydrology, and discusses how to reduce that risk. Asks many questions about Dm, program governance and structure, cost and funding, policy, measurement and verification. Identifies many of the key issues being addressed by CWCB DM workgroups. Key successes from SCPP are locally-driven solutions, minimizing impacts & maximizing benefits, e.g. through local coordination of projects. Tabulates past options considered for avoiding compact curtailment.	Section 8 (Key Lessons, identifies flow as an issue to be addressed: "Address local river flow needs for fish and wildlife - Coordinate with NGOs, local water users, and water managers on water administration methods that direct water savings in stream at strategic locations and/or strategic times."	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Return flows identified as a data gap / next step from a legal and engineering standpoint for a program to protect water rights holders. " Water users, state and federal agencies, and other stakeholders will need accurate data on consumptive water use that includes, among other things, agreed upon methods for calculating water savings and maintaining return flows. While some of these are engineering questions, policy may be needed to help translate these concepts into the rules and regulations of a long-term program." Recommends developing a standardized approach to estimating and addressing return flow impacts.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.
SCPP-12 Colorado River Water Bank Work Group: An Overview of Previous Studies & Reports	2018	Colorado River Water Bank Working Group	This overview documents summarizes the studies completed by the Colorado River Water Bank Work Group in their effort to provide information about what types of solutions may be available to preserve communities, agriculture, power production and the river itself.	This work includes a two-phase feasibility study, an assessment of how reduced irrigation for compact purposes would work with different irrigation systems on Colorado's West Slope, economic work on pricing and payments, and scientific research on the agronomic impacts of reduced irrigation.	Impacts to flow not discussed. "secondary impacts ... will need to be answered prior to deciding whether implementation of a demand management program is feasible and desirable for water users in Colorado."	Not discussed.	Not discussed.	Colorado River Water Bank Feasibility Study: Phase 2: "None of the systems had adequate measurement of diversions and return flows to directly calculate foregone CU through a mass balance." "Other benefits of irrigation could be impacted (late-season return flows, wildlife habitat, scenic open space)" Next Steps:" 2. Estimate the potential impacts of fallowing or deficit irrigation on downstream stream flows and environmental resources due to changes in return flows."	Not discussed.	Ideal candidate systems have relatively few downstream users, therefore lower return flow impacts. Site visits qualitatively assessed potential impacts of deficit irrigation or fallowing on return flows and downstream users. Mostly addressed as a data gap / next step: . "Colorado River Water Bank Feasibility Study: Phase 2: "None of the systems had adequate measurement of diversions and return flows to directly calculate foregone CU through a mass balance." . "Other benefits of irrigation could be impacted (late-season return flows, wildlife habitat, scenic open space)" . Next Steps:" 2. Estimate the potential impacts of fallowing or deficit irrigation on downstream stream flows and environmental resources due to changes in return flows."	Not discussed.	"Other benefits of irrigation could be impacted (late-season return flows, wildlife habitat, scenic open space)"	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.
SCPP-13 GVWUA Final Report on the Conserved Consumptive Use Pilot Projects	2019	GVWUA and J-U-B Engineers	This report provides a summary of the 2018 and 2019 Conserved Consumptive Use Pilot Projects completed by the Grand Valley Water Users Association (GVWUA). The initial part of the report provides a good summary of both the 2018 and 2019 pilots. Appendix H provides the details of the survey GVWUA completed of all participating producers, gathering their input on their experience and perspectives on the pilot project. Appendix I summarizes GVWUA's thinking more broadly on the pilot and demand management.	Land management contract: manage weeds & plant growth, soil erosion (leave plant residue, tillage for clods, tillage for crust), w/nod-season visit to confirm mgmt activities are consistent w/contract; interviewees concerned w/DM externalities including local economy & aesthetics; CCU verification procedures (Exhibit B) don't specify methods to verify CU on fallowed land, but does include sites visits to verify land mgmt. and explicitly prohibits any active plant growth on fallowed land	Impacts to flow not discussed. More focused on CCU and impact to farmers.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Return flow impacts not discussed. More focused on CCU and impact to farmers.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.
SCPP-14 Lessons Learned from the System Conservation Partnership Program	2016	The Nature Conservancy	TNC's lessons learned in their SCPP involvement including lessons from Trout Unlimited and Colorado Water Trust	Top 3 lessons: outreach & communication is essential, operational & legal issues must be addressed at ditch company/irrigation district level simplify the process for efficiency.	Impacts to flow not discussed.	Not discussed.	Not discussed.	"When you focus on consumptive use reductions, what about return flow issues? How do you prevent injury and keep other water right holders and non-participants whole?"	Not discussed.	Identified as a data gap / next step related to water rights. "The current program does not provide any instream protection for conserved water. A successful program must be able to administer and account for conserved water in order to create value for both buyers and sellers. In order to get participants and address community issues, the program must provide assurances that water rights will not be negatively impacted and that non-participants will not be injured...When you focus on consumptive use reductions, what about return flow issues? How do you prevent injury and keep other water right holders and non-participants whole?"	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.

																		Next Steps										
					Environmental Resources that May be Affected												Data Gaps, Questions for Future Projects											
					Streamflow (Hydrology) Impacts						Species Impacts			Water Quality Impacts						Program level goals		For proposed future transactions, need to evaluate impacts (positive or negative) to:						
Title	**Date**	**Publisher/Authors**	**Description**	**Notes**	**Magnitude**	**Frequency**	**Duration**	**Timing**	**Rate of change of hydrologic conditions**	**Return Flow Impacts**	**Critical Stream Reaches Impacted**(where)	**Critical Land or Riparian Habitat Impacted**	**Species Impacted**	**Salinity**	**Temperature**	**Other**	**Tradeoffs - Resource Impacts**	**Predicted outcome from applying "avoid, mitigate, offset" hierarchy**	**Proportional**	**No net loss to env. services, recognizing tradeoffs**	**Build incentives for projects with net env. benefits.**	**ISFs (or other flow targets)**	**SMP or WMP objectives / proposed projects**	**Critical habitat & flow recommendations**	**State species of concern**	**BRT environmental values lists/ mapping**	**CRCT conservation strategy**	**Other known community / entity projects**
SCPP-15 Considerations for Modeling a Water Bank at the Aspinall Unit with Current Environmental Flows	2011	Hydro Consulting for TNC	Evaluation of computer models of the Gunnison River to assess their ability to simulate a potential water bank in the basin using the Aspinall Unit reservoirs and the effect on reservoir operations, including environmental flows	StateMod, Aspinall PBO/EIS Model, and CRSS are evaluated for their capabilities to simulate Aspinall Unit operations, environmental flows, and potential water-banking. Specifically, this modeled the Black Canyon water right, new ESI/PBO requirements at the Whitewater gage, and a water-banking optio at Aspinall. Modifications to the Gunnison StateMod are necessary to simulate environmental flows and enhance reservoir accounting options.	Discusses how StateMod configuration could be changed to simulate environmental flow targets (through the Black Canyon and at Whitewater), including base flow and peak flow targets. However, modeling was not done in this analysis, so there are no results to share on how the water banking project would impact flows.	Discusses how StateMod configuration could be changed to simulate environmental flow targets (through the Black Canyon and at Whitewater), including base flow and peak flow targets. However, modeling was not done in this analysis, so there are no results to share on how the water banking project would impact flows.	Discusses how StateMod configuration could be changed to simulate environmental flow targets (through the Black Canyon and at Whitewater), including base flow and peak flow targets. However, modeling was not done in this analysis so there are no results to share on how the water banking project would impact flows.	Discusses how StateMod configuration could be changed to simulate environmental flow targets (through the Black Canyon and at Whitewater), including base flow and peak flow targets. However, modeling was not done in this analysis, so there are no results to share on how the water banking project would impact flows.	Not discussed.	Discusses how StateMod configuration is set up to model return flows. However, modeling was not done in this analysis, so there are no results to share on how the water banking project would impact return flows.	3 environmental flow targets below Aspinall Unit considered: - Black Canyon of the Gunnison National Park Service In-Stream Flow (01CW05) with a measuring point immediately below the Gunnison Tunnel, a few miles downstream of Crystal Reservoir, - the EIS/PBO targets at the Whitewater gage below the inflows from the North Fork and Uncompahgre rivers (The environmental flow targets at Whitewater resulted from several years of work through the Recovery Implementation Program for Endangered Fish Species in the Upper Colorado River Basin outside the San Juan River sub-basin (Recovery Program)), - and the targets for fish screening, passage and migration at the Redlands dam about 6 miles below the Whitewater gage	Not discussed.	Endangered Fish Species in the Upper Colorado River Basin, in the Gunnison River	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.
SCPP-16 Environmental Water Transactions in the Colorado River Basin: A Closer Look	2018	Stanford Woods Institute for the Environment	Reviews CRB environmental transfers to track extent of activity. Examines SCPP projects by this lens, given the ISF benefits of SCPP. Found that SCPP-funded projects had the effect of enhancing streamflow.	Analysis used UCRC 2018 Final Report; no new data. 20,000ft view of ISF projects including SCPP projects.	"Although the total amount of water restored by these transactions is very small compared to the overall water budget of the basin, in certain watersheds, transactions have provided significant benefits for local streamflow. This is particularly true in the Price River watershed in Utah and the Green River watershed in Wyoming." "TU efforts on the Price River with the Carbon Canal Company are worth specific mention. SCPP deals with irrigators that receive water from the Carbon Canal Company have both been able to focus benefits for flows in the Price River, and increase the chances that conserved water will make it downstream to Lake Powell." "From 2014 through 2018, the SCPP has funded forty six informal transactions in the state of Wyoming (Figure 13). The two most active years in the state for these deals have been 2016 and 2018, both with respect to the number of deals negotiated and the acre-feet of irrigation water involved. Although these deals all had the primary purpose of conserving water and improving water security, they have all been facilitated by Trout Unlimited in the Green River Basin and have as an additional benefit potential improvements." Specific analysis of flows was not done. Less quantitative, and more qualitative. No justification or documentation provided on how, where, when, flows were benefited.	"Most of the transactions have multiple benefits, including improving water security, piloting water conservation tools, supplementing farm and ranch revenue and improving streamflow and aquatic ecosystems. There is obvious synergy between the goals of promoting water conservation, enhancing water security and restoring streamflow. Projects that have one of these goals as a primary purpose will usually also fulfill the others. Programs focused on one of these goals can benefit from support for the other goals."	Not discussed	Not discussed	Not discussed.	Return flow impacts not discussed.	In Arizona, "TNC has been working with the Diamond ditch water users on a gradually reducing diversions. Beginning in 2013 with 5 cubic feet per second (CFS) reduction and topping out in 2016, with a 9.5 CFS reduction, these projects have added significant flows to a critical reach of the river."	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.
SCPP-17 Lower Colorado River Basin Pilot Program	NA	Bureau of Reclamation	Webpage with tables of projects from each pilot phase	"Although the Pilot Program will be ongoing until 2035, as of 2019, future announcements of funding opportunities and requests for additional project proposals are not being contemplated."	Impacts to flow not discussed.	Not discussed	Not discussed	Not discussed	Not discussed	Return flow impacts not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.
SCPP-18 System Conservation: a collaborative approach to drought contingency planning the Upper Colorado River Basin	2017	Wyoming SEO Callaway, AWRA Impacts magazine	Description of Wyoming SCPP, how it works, participation, and future efforts.	Neither extensive nor technical, but includes some description of process & participation.	Impacts to flow not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Return flow impacts not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.
SCPP-19 SNWA Water Resource Portfolio	2019	Southern Nevada Water Authority	Chapter from SNWA's water plan	Addresses temporary supplies including different aspects of Intentionally Created Surplus, recharge and banking, DCP, and conservation tools.	Impacts to flow not discussed, other than in a very general senses that the Drought Contingency Plan "keeps more water in the river for the benefit of all water users and the environment."	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Return flow impacts from temporary supplies not discussed. Does generally mention that SNWA heavily relies upon return flow credits (such as from wastewater treatment plants). Direct water reuse will reduce the amount of return-flow credits (which are reused indirectly).	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.
SCPP-20 Colorado River Basin Water Bank: Framework & Financial Analysis	2017	WestWater Research for TNC	This memo evaluates different framework concepts to scale up operations of the Water Bank and provides comparative costs and other factors to consider in different approaches to developing a water bank. The information is intended to provide concepts and preliminary numbers for TNC and the Water Bank Working Group to consider and discuss in ongoing Water Bank development efforts.	Evaluates 4 frameworks of a Colorado Basin water bank sufficient to address 250,000 AF of CCU: annual water bank leases, option leases in critical years, non-option critical year leases, and response to a 1922 compact call. WestWater Research developed a cost-estimation spreadsheets based on the volume of water leases, number of associated acres, and number of farms or ranches leasing water.	Impacts to flow not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Return flow impacts not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.

Exhibit B-5
Lit (Gen. Literature) Documents with Environmental Criteria

					Environmental Resources that May be Affected												Next Steps										
						Streamflow (Hydrology) Impacts					Species Impacts			Water Quality Impacts			Data Gaps, Questions for Future Projects										
Title	Date	Publisher/Authors	Description	Notes					Rate of change of hydrologic conditions									Predicted outcome from applying "avoid, mitigate, offset" hierarchy	Proportional	Program level goals		For proposed future transactions, need to evaluate impacts (positive or negative) to:						
					Magnitude	Frequency	Duration	Timing		Return Flow Impacts	Critical Stream Reaches Impacted (where)	Critical Land or Riparian Habitat Impacted	Species Impacted (what)	Salinity	Temperature	Other	Tradeoffs - Resource Impacts			No net loss to env. services, recognizing tradeoffs	Build incentives for projects with net env. benefits.	HDFs (or other flow targets)	SMP or WMP objectives / proposed projects	Critical habitat & flow recommendations	State species of concern	IBRT environmental values lists/ mapping	CRCT conservation strategy	Other known community / entity projects
LR-01 Salmon recovery in the Columbia River basin: analysis of measures affecting agriculture	1999	Allery et al, Marine Resource Economics	Analysis of ag impacts from salmon-recovery-related flow alterations in Columbia River	Investigates ag impacts of fish recovery measures "such as: modified timing for dam releases, reservoir drawdown, and flow augmentation in the Columbia River system." "Three flow augmentation scenarios are evaluated. [...] Results suggest that drawdown and/or minor reductions in irrigation water diversions would reduce producers' profits by less than 1% of baseline levels. However, the most extreme scenario--a long drawdown period combined with a large reduction in irrigation diversions--would reduce producers' profits by $35 million (2.5%) annually."	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Return flow impacts not discussed.	Minimum flow objectives for Snake River at Lower Granite Dam, and for the Columbia River at McNary Dam	Not discussed.	Endangered species act "Formal ESA listings for anadromous fish species, salmon and steelhead populations triggered formation of a recovery program." Minimum flow objectives for Snake River at Lower Granite Dam, and for the Columbia River at McNary Dam."	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.
LR-02 Feasibility of water efficiency and reuse technologies as demand-side strategies for urban water management	2017	Berhanu et al, Journal of Industrial Ecology	Economic model of water cost provided by above-code water efficiency and reuse technologies, including variations & uncertainty analysis.	Estimates that efficiency and reuse can meet 85% of 50yr projected needs to the Lower Colorado River Authority service area (central TX)	Impacts to flow not discussed: Focuses more on costs-benefits of various municipal efficiency practices.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Return flow impacts not discussed.	No assessment for environmental impacts associated with this specific study for the 2012 State Water Plan for Texas includes a high-level assessment of environmental impacts of all recommended and alternate water management strategies for Texas	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.
LR-03 Response to water crisis: How do Iranian farmers think about and intent in relation to switching from rice to less water-dependent crops?	2019	Rezaei et al, Journal of Hydrology	Study of farmer response to gov't demand management, switching crops.	"Structural equation modeling showed that farmers' intention to change from rice cultivation to another crop is determined by personal norms, beliefs about their role and emotional considerations."	Impacts to flow not discussed: Report focuses instead on farmers' attitudes and believes around crop switching.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Return flow impacts not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.
LR-04 Temporary water transfers for urban water supply during drought	1992	Clark, CSU	PhD dissertation modeling options for temporary water transfers	"This research develops a water right option agreement (WROA) model, methods of analysis, and legal implementation strategy under Colorado law." Interviewed professionals, estimates costs, identified that WROA "can be superior in terms of cost, reliability, and operational flexibility to both water-right purchases and construction of additional reservoir storage.	Impacts to flow are not discussed. Focus is more on technical, legal, operational framework and costs of temporary transfers.	Not discussed	Not discussed	Not discussed	Not discussed	Notes that for any agreement, historical consumptive use and return flows must be quantified. "Due to existing claims on the return flow portion of the water by downstream interests such as junior water-rights holders and instream flow consider-ations, only a portion of the irrigation water can be made available to the city by the final transfer process." Discusses considerations for determining location and calculating timing and amount of return flows, both surface and groundwater. "Location of the existing use relative to the proposed temporary use determines the return flow requirements and impacts of the transfer on other parties...Referring to Table 6.2.1, columns (1) and (2), if there is no significant depletion effects, deductions from the donor's available credits may be negotiated for mitigation of instream impacts and other effects.""	Not discussed	Not discussed	Not discussed.	Not discussed.	Not discussed.	Included a discussion on the Senate Bill 86-181 and the rulemaking by the SEO to implement water quality standards in review of water transfers Mentioned the use of the mass balance method or the mixing zone method to estimate the influence of flow on water quality standards	Not discussed.	Not discussed.	If the temporary transfer has significant depletion effects, deductions from the lessee's available credits may be negotiated for mitigation of instream impacts or other effects A plan of augmentation and an exchange agreement may yield much more water for the user	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.
LR-05 Flexible water allocations and rotational delivery combined adapt irrigation systems to drought	2018	Cody, K.C., Ecology and Society	Water allocation experiment in San Luis Valley, Colorado for self-governing irrigation systems.	Examines relationships between rules and physical context of water systems, specifically the outcomes of water allocations between members and how they rotate water delivery.	Impacts to streamflow from DM practices were not discussed. Appendix I discusses long-term climate change in the SLV. Appendix I also acknowledges the prior appropriation system already impacts environmental considerations: "Unique return flow dynamics can lead to externalities when transfers occur in water markets (Howe et al., 1982). In addition, PA has no inherent place for environmental uses of water, posing challenges for ecosystem integrity under a water constrained future; only in the past 40 to 20 years have in stream flows and non-consumptive recreational uses been incorporated into Colorado water law." Prior Appropriation may therefore be working against risk mitigation and may exacerbate inequalities and vulnerabilities in the overall agricultural sector.	Not discussed.	Not discussed.	Impacts to streamflow from DM practices not discussed. Appendix I discusses long-term climate change in the SLV, including timing of runoff.	Not discussed.	"The four institutional configurations that are possible by combining the shortage sharing and delivery rules have different implications for return flows. ..." Table 4 suggests that shortage sharing agreements may affect return flows. [Shortage sharing is defined as the alteration water allocations between users of the same irrigation system in times of drought, regardless of the original criteria used to allocate water (land owned, private rights held, historical use, etc.)] In extreme shortage, tail-enders should be the most stressed due to seepage losses, depressed hydraulic head, and decreased return flows.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.
LR-06 Water trading innovations: reducing agricultural consumptive use to improve adaptation to scarcity	2017	Colby (Ch. 3.1.4); Book via Zolnikowska & Petersen	Chapter from book "Competition for Water Resources: Experiences and Management Approaches in the US and Europe" collecting global examples/discussion of approaches and solutions to water supply scarcity, including western US	Ch 2.1.1: Challenges for US irrigated ag in the face of emerging demands and climate change, Ch 3.1.4, Water trading innovations reducing agricultural consumptive use to improve adaptation to scarcity reviews online trading systems to reduce transaction costs, methods for cost-effective verification of CCU, and other breakthroughs facilitating temporary & intermittent trading more feasible. Examples from AZ and CA (ID); NE, Australia, CO-Big Thompson.	Not discussed	Not discussed	Acknowledges in a general sense that CU trading programs have a goal of "real-time reductions in agricultural consumption to produce a desired improvement in surface flows at specific locations and seasons." "In regions where trading programs must achieve streamflow and lake-level mandates, changes in water use on farms must result in measurable increases in water availability at specific locations and seasons." Acknowledges the need to incorporate ditch loss, return flow lagging etc. "Various programs have devised strategies, such as designated trading zones with different trading ratios and multiyear trading, to address variations in hydrologic connectivity and time lags between reduced water consumption on a farm and improved surface flows at the desired location. Differences in conveyance losses and aquifer characteristics can be incorporated into trading rules to ensure that decreased water use on a specific farm will improve surface flows at a target location and time period. "	Not discussed	Addresses return flow impacts primarily as a data gap / next step. "Generally discusses the difficulties of data availability for determining return flows and historical consumptive use. Lower Colorado River Accounting System (LCRAS): In the Lower Colorado River Basin (LCRB), water use within irrigation districts receiving water under contracts with Reclamation is tracked through one of the most sophisticated water accounting systems in the world, the Lower Colorado River Accounting System (LCRAS). This system requires detailed records of diversions, return flows, CU, etc. and provides a baseline from which to quantify change in CU. However, such comprehensive water use measurement, monitoring, and accounting systems are lacking in most basins of the western United States and elsewhere in the world. Addresses variations in hydrologic connectivity and time lags between reduced water consumption on a farm and improved surface flows at the desired location. Differences in conveyance losses and aquifer characteristics can be incorporated into trading rules to ensure that decreased water use on a specific farm will improve surface flows at a target location and time period. "	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.
LR-07 Towards regional sustainability assessment utilizing community based participatory research, sustainability indicators, and future scenario modeling	2016	Dubinsky, CU Denver	PhD dissertation that identified San Luis Valley sustainability indicators and modeled future scenarios, developing a CU indicator for 1980-2010. Conducted scenario modeling to guide decision-makers towards desired outcomes from policy decisions. Coupled sustainability indicators with future scenario modeling to inform the SLV stakeholders about a variety of social and environmental issues. Results indicated that through specific shifting of cropping rotations and minimal land fallowing, SLV could reduce water use and Greenhouse Gas Emissions while increasing soil carbon and improving soil health. In addition, the solar energy development pathways investigated by this study showed that the potential exists to offset most or all of the region's GHG emissions.	Utilized Community Based Participatory Research to engage stakeholders & keep research relevant. Highlighted groundwater-dependence of SLV, suggests irrigation water use could be decreased 10% with shifts in crop regime and minimal fallowing.	Discusses declining SLV aquifer levels due to diversions compared to runoff. Pg. 66.	Not discussed.	Not discussed.	Acknowledges climate change impacts on runoff (shift from June to May) pg. 66.	Not discussed.	Return flow impacts not discussed.	Not discussed.	Discusses the importance of flood irrigation in river valleys, regarding wetland habitats and also impacts to compact compliance. Pg. 66. "Flood irrigation practices and increasing efficiency may not be the answer. Along the riparian corridors, diverted water used for growing meadows and pasture sustains a variety of wetland types that are invaluable for waterfowl, wildlife, recreation, and other ecosystem services." "While flooding land during the growing season may not appear to be an efficient use of water, it provides an important service, as these lands provide habitat for native species, as well as grazing land for livestock." "If river corridor zones were permanently dried up, there is a risk that it would cause a substantial challenge to the State's ability to meet compact requirements."	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	"On the other hand, through this analysis, we see that native vegetation consumes significant amounts of water, especially in the region's ability to maintain a sustainable aquifer. It will be important for future regional water use analyses to allocate water towards ecosystem services and environmental flow requirements. Much work has been done in the area of quantifying ecosystem services and these methodologies could be applied to river basins such as SLV (Costanza et al. 1998, 2014, 2011, Costanza 2014)."	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.
LR-08 Economic viability of deficit irrigation in the Western US	2018	Manning et al, Agricultural Water Management.	Research on agro-economics of deficit irrigation.	Deficit irrigation (DI) can be optimal during late growth and maturation stages given elevated water prices (depending on output price and production costs).	Impacts to flow not discussed. Focuses more on costs.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Return flow impacts not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.
LR-09 The role of groundwater trading in spatial water management	2014	Palazzo and Brozovic, Agricultural Water Management	Republican River Basin assessment of coupling surface-groundwater management.	Geospatial dataset of RRB irrigation wells modeling crop choice, land, and water use decisions by well. "Our analysis highlights the importance of the initial distribution of permits and the institutional context in which trading occurs." Cost savings from trading groundwater pumping are distributed unevenly between wells, counties, and groundwater management institutions.	Acknowledges that groundwater pumping impacts surface water flows, and how that impacts Republican River Basin interstate compacts (NE obligation to KS). "The effect of pumping a well on instream flows is a function of the distance of that well to the nearest stream." "Although we do not model the spatial, dynamic impact of trading on stream flows, we do account for the average, pumped water moves away from streams after trading relative to the base-line regulation. This suggests that a simple trading scheme with a single permit price may simultaneously reduce both abatement costs to farmers and damages to instream flows. Our results imply that where there is very little unused allocation and water moves away from streams after trading – such as in the Upper Republican Natural Resources District – a restricted trading scheme canthus generate both economic and stream flow benefits. Because the groundwater pumping externality on stream flow is spatial, dynamic, and lagged, a dynamic model with detailed hydrology is needed to analyze the exact impact of trading on stream flow, as well as to estimate the optimal trading ratio between wells closer to streams and further from streams."	Not discussed.	Not discussed.	Not discussed.	Not discussed.	The study found that in general, trading tends to result in applied water moving farther away from streams (a result of the specific well distribution in the study area in Nebraska). This also impacts return flows. "Moving the location of pumping further from the river will decrease stream depletion, but it will also decrease the contribution of return flows to shallow subsurface flow and thus to stream baseflow. If the reduction in stream depletion is the only change, pumped water moves average location of pumping water away from the river should reduce stream depletion in the long run." "... In the study area, reducing stream depletion rather than reducing aquifer depletion is the primary goal of regulation. This implies that water is being transferred from relatively more efficient wells to relatively less efficient wells. As a result, for a random distribution of efficiency, water trading rasults in a decrease in consumptive water use and an increase in returnflows. ... All else equal, wells with a higher (lower) technical efficiency will have a lower (higher) unconstrained water use, a lower (higher) marginal abatement cost at their current allocation, and will thus be more likely to sell (buy) water permits."	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.
LR-10 Evaluating the potentials of cropping adjustment for groundwater conservation and food production in the piedmont region of the North China Plain	2019	Ren et al, Stochastic Environmental Research & Risk Assessment	Evaluation of different cropping patterns (including fallowing) & water supply scenarios.	Framework for using a crop model & regression to predict effects of cropping adjustments on groundwater sustainability & crop production	Impacts to flow not discussed. Focuses more on nexus between food and water.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.
LR-11 Opportunities for saving and reallocating agricultural water to alleviate water scarcity	2017	Rohter et al., Water Policy	- Review of literature & internet to identify water-saving strategies in irrigated agriculture. - Review of case studies in which water savings have been successfully transferred to other uses.	- Catalogs water savings opportunities, claims of irrigation-efficiency savings potential, logistics of reallocating due to other ag diverting savings. Findings suggest considerable potential to reduce irrigation CU and that savings can be reallocated when proper consideration is given to water budget accounting.	"This paper focuses on the potential water savings that might be realized in irrigated agriculture without loss of crop production, as well as opportunities to redirect saved water toward environmental restoration or other uses." "Accurate determination of potential water savings in irrigation requires estimation of the volume of water associated with each of the water flow pathways (illustrated in Figure 2 as that the net change in 'water available for subsequent use' (including environmental uses) can be properly evaluated."	Not discussed.	Not discussed.	"Unfortunately, until recently most water conservation efforts on farms, and claims of water savings resulting from those efforts, have focused on changes in the volume of water withdrawn or applied to farm fields (large arrows in Figure 2), neglecting the volume and fate of return flow back into the original water source, creating misleading impressions of water benefits within the overall irrigation network within which water practices have been modified. This insufficient accounting can lead to counter-intuitive outcomes, or a 'water efficiency paradox' (Scott et al., 2014), in which seemingly more efficient irrigation application can result in greater net consumptive use, ultimately lessening the volume available for subsequent use."	Not discussed.	Acknowledged as a data gap that most reports and papers fail "to properly account for key elements of water budgets such as return flows." "Conservation assessments of the potential volume of water saving potential, have focused solely on changes in the volume of water withdrawn or applied to farm fields (large arrows in Figure 2), neglecting the volume and fate of return flow back into the original water source, creating misleading impressions of water benefits within the overall irrigation network within which water practices have been modified." Report describes the importance of return flows to downstream users, and the fact that some increased efficiency practices can even increase crop consumptive use and therefore increase water scarcity.	Recognizes a need to show flow benefits are being provided to reaches purportedly receiving benefits.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Paper recognizes enabling increases in agricultural production through the use of water conservation practices to allow consumptive water use to grow and river flows or groundwater levels will be further depleted, often to the point of complete drying, with attendant loss of biodiversity and social and economic benefits such as riverine fisheries.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.
LR-12 Urban water conservation in the Sacramento, California region during the 2014-2016 drought	2019	Talbot, UC Davis	JC Davis Master's Thesis cataloging/analyzing supply & demand management actions under CA's drought policies.	Evaluates outdoor watering, public outreach, media role, water-related energy savings. Makes recommendations for urban water suppliers on revenue recovery, reducing use of rebates as demand management, and scaling drought response tasks for different levels of gov't. Summarizes & analyzes CA legislation establishing approval for long-term budget-based efficiency targets.	Impacts to flow not discussed.	Not discussed	Not discussed	Not discussed	Not discussed	Noted when municipal efficiency practices were enacted, wastewater treatment plant effluent discharge was also reduced. Other than that brief mention, return flow impacts or implications are not discussed.	Not discussed	Not discussed	Discusses importance of keeping water in storage for environmental flows to keep salt water from moving up river from the ocean, (pg. 22) and to "minimize the impacts of reduced flows from Folsom Lake on fish and wildlife." (pg 74).	Discusses importance of keeping water in storage for environmental flows to keep salt water from moving up river from the ocean (fresh water releases to push back seawater). (pg. 22) and to "minimize the impacts of reduced flows from Folsom Lake on fish and wildlife." (pg. 74).	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Energy savings were realized through the water conservation efforts (GHG emission reductions and reduced kWh of electricity)	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.
LR-13 Remote sensing assessments of consumptive use of agricultural water in western slope of Colorado	2016	Vaishitt, Colorado State University, Colorado	CSU Master's Thesis evaluating remote sensing for estimating monthly consumptive use (CU) and conserved CU(CU) on the West Slope	Used evapotranspiration (ET) observations at experimental plots of traditional irrigation and water-banking irrigation practices to evaluate methods of verifying CCU. Reviews methods for measuring and monitoring CU, discusses limitation and potential for ReSET remote sensing CU model.	Impacts to flow not discussed. More about the technology used to verify any DM practice.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Briefly mentioned as a data gap, in that many methods for quantifying CU do not allow measurement of return flows.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.
LR-14 Deficit irrigation and surface residue cover effects on dry bean yield, in-season soil water content, and irrigation water use efficiency in western Nebraska high plains	2018	Yonts et al, J. of Agricultural Water Management	2010-2015 study in Nebraska of efforts to decrease ag groundwater pumping; impacts of water use efficiency and crop yield	"Reducing irrigation water by 25% caused no significant yield reduction and improved irrigation water use efficiency by 26%." Applying 50% Etc. resulted in 30% yield reductions, and planting directly in crop residue did not improve bean yield under deficit irrigation. Ample early season rainfall is a boon to pre-flowering deficit irrigation yields, but under normal-to-dry conditions post-flowering deficit yields more.	Impacts to flow not discussed. More focused on impacts to crop yield.	Not discussed	Not discussed	Not discussed	Not discussed	Return flow impacts not discussed.	Not discussed	Not discussed	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.
LR-15 Irrigation Efficiency and Water Balance of the Little Wind Unit on the Wind River Indian Reservation in Wyoming	2017	Rosado, U of Wyoming	Master's thesis on irrigation system efficiency in Little Wind Unit	Uses ag water balance & geophysical techniques to quantify & locate water losses. "Large errors and data gaps associated with the inflows, outflows, diversions, and precipitation data, [...which] identified specific needs for better data."	Paper not found																						
LR-16 Standardizing Temporary Water Transfer Procedures in Colorado	2020	Nicols, Peter D, et al, University of Denver Water Law Review	Review of strengths and challenges of existing legal mechanisms for ATMs and recommendations for consolidation and standardization.	This article will describe the barriers in existing law to temporary transfers and the various approval mechanisms available under existing Colorado law. It will provide an assessment of the strengths and limitations of the existing transfer methods and make a recommendation for consolidation and standardization.	Not addressed; other than addressing the need to find a streamlined approach to calculating and maintaining return flows.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	The difficulty of calculating and challenge of maintaining historical return flows is recognized as part of the "No Injury Rule" barrier and "Calculation of HCU" barrier to implementation. The Lease Fallow Tool is recognized as a potential solution to simplify and streamline the evaluation process, described as a "transparent, simple, and streamlined approach." Also recommends the state engineer rulemaking address a streamlined approach to determine HCU and return flows.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.

Exhibit B-6
ATM Documents with Environmental Criteria

					Environmental Resources that May be Affected													Next Steps										
								Streamflow (Hydrology) Impacts					Species Impacts					Water Quality Impacts				Data Gaps, Questions for Future Projects						
Title	Date	Publisher/Authors	Description	Notes	Magnitude	Frequency	Duration	Timing	Rate of change of hydrologic conditions	Return Flow Impacts	Critical Stream Reaches Impacted(where)	Critical Land or Riparian Habitat Impacted	Species Impacted(what)	Salinity	Temperature	Other	Tradeoffs - Resource Impacts	Predicted outcome from applying "avoid, mitigate, offset" hierarchy	Proportional	Program level goals No net loss to env. services, recognizing tradeoffs	Build incentives for projects with net env. benefits	For proposed future transactions, need to evaluate impacts (positive or negative) to: IBPs (or other flow targets)	SWP or WMP objectives / proposed projects	Critical habitat & flow recommendation s	State species of concern	BRT environmental values lists/ mapping	CRCT conservation strategy	Other known community / entity projects
ATM-01 Use of Alternative Transfer Methods to Increase Water Supplies for Comelpo Basin Agriculture, Municipal, and Environmental Purposes	2017	https://drivewebtk.state.co.us/ows/ds/ElectronicFile.aspx?docid=20533&dbid=0	Trujillo Meadows Reservoir ATM Study (TMR Study: "The primary objective of the TMR Study is to investigate the potential to operate ATMs in conjunction with Trujillo Meadows to provide intra-year regulation of water supplies including direct flow storage and storage of other agricultural and augmentation water rights for agricultural users diverting from the San Antonio.	ATM w/ recreational and environmental benefits for municipal augmentation w/emphasis on Trujillo Meadows Reservoir. augmentation w/emphasis on Trujillo Meadows Reservoir. Recommended ATM alternatives: Alt 1 (direct flow) and Alt 2 (direct flow and lease) avg needs. Model of ATM, details of benefits, recommended path fwd. Appendix A estimates of monthly inflows to reservoir. Water rights include USFS Reserved Rights decreed as ISF, interstate shepherding for flow through NM.	Potential benefits from proposed project discussed in a general sense, due to ability to time releases from additional stored water. Benefits not analyzed. "Enhance streamflow for a longer period during the runoff season." "Coordinated operations of Rio Grande, Beaver, Platoro, and Trujillo Meadows Reservoirs could provide for streamflow enhancements while replacing well-pumping depletions." Next steps identified for further analysis: "The Rio Grande Basin Plan RiverWare model should … also be used to evaluate streamflow, leading to analysis of riparian, environmental, recreational, and economic benefits."	Potential benefits from proposed project discussed in a general sense, due to ability to time releases from additional stored water. Benefits not analyzed. "Enhance streamflow for a longer period during the runoff season."	Potential benefits from proposed project discussed in a general sense, due to ability to time releases from additional stored water. Benefits not analyzed. "Enhance streamflow for a longer period during the runoff season."	Projects that involve storage have the benefit of operational flexibility for timing of releases for augmentation/replacement, primarily mid-summer releases (pg. 66) "Releases of direct flow or other legally available water stored in Trujillo Meadows could be timed to enhance streamflow while releasing water for additional supplies to irrigators." Problem this addresses: "The early runoff and inability to regulate flows on the Los Pinos and San Antonio Rivers has resulted in challenges in meeting irrigation water demands, managing delivery of Compact water, flood control, fish habitat, and riparian health." "Platoro water augmentation deliveries can be refined to provide streamflow enhancements."	Not discussed.	Assumes that ATMs will have to maintain historical return flow patterns to protect other water rights. Return flows are calculated as 85% of the ATM diversions (CU), minus a loss calibration factor, and are lagged back to the river."	No enlargement of Trujillo Meadows would also result in increased surface acres and shoreline for fish habitat, recreation opportunities for wildlife use and wildlife-related recreation (fishing, hunting, wildlife watching) and boating."	Additional releases of water in mid-summer will enhance stream and riparian values for the identified sensitive species with potential to occur in the reservoir expansion project area given in Table 7. Forest Service Management Indicator species in Table 8.	Primarily discusses impact of construction activities to species, not effects of operating ATM. Additional releases of water in mid-summer will enhance stream and riparian values for the identified sensitive species with potential to occur in the reservoir expansion project area given in Table 7. Forest Service Management Indicator species in Table 8.	Not discussed.	Not discussed.	Not discussed.	Additional releases of water in mid-summer will enhance stream and riparian values through a prolonged release of additional flow after the peak runoff. This will improve aquatic habitat quality and species diversity downstream due to prolonged stream volume, lower temperatures, and higher levels of dissolved oxygen."	Increased dissolved oxygen as a result of higher flows and lower temperatures from summer releases.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.
ATM-02 Development of Land Fallowing-Water Leasing in the Lower Arkansas Valley	2011	https://drivewebtk.state.co.us/ows/ds/ElectronicFile.aspx?docid=19573&dbid=0	The goal of this report is to "report on the development from 2002 through mid-2011 of rotational land fallowing-water leasing (fallowing-leasing) in the Lower Arkansas Valley of Colorado (Lower Valley) by the Lower Arkansas Valley Water Conservancy District (Lower Ark District) and the Lower Arkansas Valley Super Ditch Company, Inc. (Super Ditch)."	Return flow needs may require additional recharge ponds & stations; Return flows unnecessary at times due to trans-basin supply; considers monthly return flow "factors"; analysis by Leonard Rice Engineers found that replacement water will be required in the non-irrigation season in most cases.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Assumes that ATMs will have to maintain historical return flow patterns to protect other water rights, and discusses measurement structures may be required to verify this. "Most ditches, however, will require additional return flow obligations to be met by ATM water. Calculation of the return flow obligations to water rights holders in the vicinity of the affected reach of the Arkansas River to avoid injury to other water rights." Table 12 shows costs for return flow stations. Also discusses considerations for locating these return flow stations or recharge ponds. In addition to calculating CU, the locations and timing of the required return flows were estimated with the Ground Water Accounting Model (GWAM). Also identifies that streamlining the approach to maintaining return flows is a next step: the Lower Ark district is working with the Arkansas Basin Roundtable Task Force to "simplify and reduce the cost of fallowing-leasing. This includes development of an administrative tool to address historic consumptive use and return flows from fallowingleasing to simplify implementation of water leases, a pilot program, and possible statutory or administrative changes or action to facilitate fallowing-leasing."	Not discussed.	Not discussed.	Not discussed.	"In 1998, the USGS performed a water quality evaluation in the Arkansas Valley for an approximate 11-mile reach of the Arkansas River that begins near La Junta and continues below the Fort Lyon Canal headgate. A key finding from the study was that the quality of water delivered to participating irrigators could realize some benefit from lower salinity irrigation water [including] crop yields, and the ability to grow crops that are less salt tolerant and have higher cash value."	Not discussed.	Water quality issues for irrigators discussed chapter 7.4, pg.. 114. Primarily TDS. "Pat Edelmann, Southeast Colorado Chief, USGS Colorado Water Service Center, commented that the ATM scenario also anticipate some improved water quality along the Arkansas River from reduced irrigation return flows if some of the results from the simulations made with the model occur on a broad scale in the lower basin. The USGS, in cooperation with the Regional Resource Planning Group, seeks to better define the water-quality conditions, the dominant source areas, and the processes that affect water quality in the Arkansas River basin."	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.
ATM-03 Little Thompson Farm ATM Grant Completion Report	2018	https://www.larimer.org/sites/default/files/uploads/2018/larimer_county_atm_final_report.pdf	Study funded through CWCB 2015 ATM Grant. The Little Thompson Farm receives supply from Handy Ditch and Handy Supplemental Ditch (CBT). The ATM consultant team found that "it was feasible for Larimer County to afford, from a water supply perspective, to sell some C-BT units (110) and share some other units (80) in some years, while still having sufficient water on the farm for corn and sugar beets, as well as crops that require less water." The study looks at aspects of feasibility, including: Economics, Farm Financial Viability under wet, dry, and very dry year scenarios; dry year water value. The report also investigates potential partnerships, and outlines the final water sharing agreement. "Larimer County sold 115 C-BT units to Broomfield and retained a first right of refusal to lease back these units for assessment cost plus 10%, when available. " The report also discusses Lessons Learned and Future Considerations: Legal Hurdles/Barriers to Replication (Northern Rotationalizing, Direct Flow Rights, Delivery Efficiency Impacts from Water Transfers); Public Perception & Political Hurdles; Operational Considerations (Irrigation Water Supply, Support, Out of County Partners, Continued Education); Negotiating an ATM: Successful Tips, Tricks, and Tools (Establish and Pursue Goals with an Open Mind About Implementation, Minimize the Cooks and Trust Your Team).	Cover crop & leaving crop residue prevents wind erosion, maintains soil fertility, controls weeds; non-irrigated cover crops: dryland mix, 3-species mix, 6-species mix; grazing cover crops: increases farm revenue, wins cover crop, control weeds w/herbicide or tillage. (tillage can reduce erosion by forming large soil clods & enhancing infiltration); Class 6 and 7 soils, slopes 0-1%, not high enough for severe erosional problems; no/low-till also recommended to reduce direct evap, improve soil health, reduce fuel & costs; irrigation efficiency via contour farming, drip irrigation, SM & ET monitoring, drought tolerant crops, CIPS irrigation guidance; no return-flow requirements due to CBT water, so no effort to quantify despite opponents	"In ensuring a viable irrigated farm in perpetuity, the County retained a sufficient water supply. The CBT units were leased back to the farm. As exercised, its allow irrigation to continue similarly to how it has been done historically on the farm, and in most years, there will be no perceptible impact to the Little Thompson River. However, the County does not deny that this deal will, at times, result in a reduction in water flowing off the farm into the Little Thompson River, to some extent."	Not discussed.	Not discussed.	Not discussed.	Not discussed.	This report raised the unique issue of return flow impacts from transbasin supplies (CBT in this case). This issue is not fully addressed in this report, but it is important to note that if CBT water were diverted and delivered by means of excess capacity in the Power Canal, that water would not be available in stream for biological needs. However, as it would be delivered at the power plant, that water would be available in the Tchida reach.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Acknowledges that while maintaining land under agricultural production in perpetuity may have some environmental benefits as compared to buy and dry, the lease agreement will have some impacts to flow compared with historical agricultural operations.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.
ATM-04 HB13-1248 Catlin Canal Company Rotational Land Fallowing-Municipal Leasing Pilot Project	2018	https://drivewebtk.state.co.us/ows/ds/ElectronicFile.aspx?docid=21032019%2001%2015%20PM%20Arkansas%20%20Catlin%20Pilot%20Project%20FINAL.pdf?search=c3856d32-e474-4163-b40c-5361b65041f	The Catlin Pilot Project was the first rotational land fallowing-municipal leasing pilot project under HB 13-1248. Irrigation Water Leasing Municipal Pilot Projects. This project aims to makes available up to 500 acre-feet of water for lease to three municipal water providers – the Town of Fowler, the City of Fountain, and the Security Water District (Municipal Participants) - from rotational fallowing of lands located on six farms irrigated under the Catlin Canal in the Arkansas River Basin.	Huge emphasis on return flows; using Lease Fallow Tool from DWR to calc available water & owed returns. "Pay As You Go" target deliveries for return flow; use of recharge structures supported with limed return flows; augmentation station used for faster return flows and consumptive use water delivered to municipal participants; erosion & weed control included herbicide, disk tilling, cover crops (winter wheat, hay)	Return flow obligations were determined. Deliveries were measured and accounted for. "These deliveries exceeded the amounts necessary to meet return flow obligations in some months."	Not discussed.	Not discussed.	Timing of return flow obligations was considered and accounted for. "Catlin Pilot Project shall endeavor to replace the calculated amount of fallowbit return flow on a daily basis." "These return flow obligations were consistently met on a daily basis, and for the year slightly exceeded return flow obligations." Timing of deep percolation return flow obligations to the stream system was managed and accounted for using deliveries via recharge ponds. "Deep percolation return flow deliveries were necessary because neither recharge pond was capable of providing recharge to the Arkansas River as quickly as the historical deep percolation from the Diamond A West Farm returned to the river."	Not discussed.	"Deliveries were assigned to one of three categories: (1) consumptive use water available to the Municipal Participants; (2) fallowbit return flow obligations; and (3) deep percolation return flow obligations" pg. 9. Chapter V. Return Flow Obligations (pg. 10): Tailwater returned via augmentation station. Deep percolation return flows replaced through recharge ponds and augmentation station deliveries. "Deep percolation return flow deliveries were necessary because neither recharge pond was capable of providing recharge to the Arkansas River as quickly as the historical deep percolation from the Diamond A West Farm returned to the river." "Catlin Pilot Project … utilized the "Pay As You Go" approach for replacing deep percolation return flow obligations, which involves making contemporaneous deliveries of water to meet those obligations to properly located recharge facilities."	Not discussed.	Not discussed.	Not discussed.	Considers concerns of invasive species (noxious weeds) from fallowing. Study found that in 2018, "the fallowing of historically irrigated fields did not result in any problems from erosion or noxious weeds."	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.
ATM-05 Yampa Basin ATM Study	2014	https://drivewebtk.state.co.us/ows/ds/0/ledoc/19919?Yampa%20-%20ATM%20Study%20Report%203-26-14_with%20apps.pdf	Study conducted by Trout Unlimited (TU) and funded by CWCB's Alternative Agricultural Water Transfers Grant Program. The purpose of the study was to identify locations in the Yampa Basin where potential ATM transactions could help to meet multiple uses (nonconsumptive needs and agricultural shortages), and identify types of ATM transactions most suitable for meeting multiple purposes. Ideal candidate reaches, as specified by project proponent TNC and its partners, would involve the following scenario: - Upstream agricultural water user with full or surplus irrigation supplies and transferable CU water - Downstream agricultural water user with an irrigation CU shortage (consumptive need) - A need for water in the reach between to improve flows for trout (including Colorado cutthroat trout) or warmwater fish (nonconsumptive need)	Used StateMod delay table to estimate historic return flows; more efficient irrigation improves water quality by lowering return flow contaminant transport, fewer excess nutrients due to fertigation in drip systems; TNC/TU partnership to support instream flows for habitat w/ATM loans used when downstream ISF right is not satisfied & to provide flow in a reach without ISF right	Study looks for the ideal participant to maximize environmental benefit: "The ideal scenario to accomplish the goal of relieving irrigation shortages while meeting environmental needs would consist of a lease of water from a willing upstream irrigator, delivery of that water through a stream reach that has an identified environmental need for higher flows, and then delivery of that water to a downstream irrigator whose agricultural water right is short."	Not discussed.	Not discussed.	Study notes that the difficulty in matching up the timing with when CCU is available, when water is needed by downstream user, and when the environmental flows would be most beneficial. "Many variables influence whether such leases can provide benefits to the environment, with the primary variable being whether the leased water is available at times when needed by the natural environment, such as in late summer to increase flows and decrease water temperature."	Not discussed.	The StateMod analysis considered return flow obligations & understand how the magnitude and timing of return flows would be impacted by leasing activities, and how the return obligation would have to be met. Return flow maintenance recognized as part of Technical and Administrative Factors for Further Consideration in Next Steps. "Water associated with the return flows can be protected down to the historical point of return so as to avoid causing injury to water users that relied on the return flows." "The obligation is dependent upon the expected lag between time of diversion and time of return. A detailed analysis will be required to determine any lag time and (b) historical point of return. If lag time is short (e.g., 1-2 days), there may be no need to lag return flows and water can often be bypassed at the headgate for delivery to the river at the appropriate location of historical return flows. If lag time is long (e.g., 1 month), the lessor will be responsible for ensuring that downstream users by maintaining the timing of return flows."	The ideal scenario to accomplish the goal of relieving irrigation shortages while meeting environmental needs would consist of a lease of water from a willing upstream irrigator, delivery of that water through a stream reach that has an identified environmental need for higher flows, and then delivery of that water to a downstream irrigator whose agricultural water right is short." "Environmental needs considered were (a) CWCB-held ISF water rights that have historically not been satisfied; (b) moderate and high risk locations identified in the Watershed Flow Evaluation Tool study (CDM Smith. 2012), and (c) other stream reaches identified by local biologists as being at times acutely short of flows needed to sustain fish." "A less complicated scenario may exist where a CWCB ISF water right is the recipient of leased water. … [but] it does not meet the ideal of serving both irrigation shortages and environmental needs."	Not discussed.	Not discussed.	Not discussed.	The study focused on environmental benefit where ATMs can provide the MOST benefit to certain species. In screening for optimal locations for ATMs, the study mapped habitats of warm water fish (native bluehead sucker and flannel mouth) and trout (Cutthroat, Brook, Brown, and Rainbow). Trout Flow-Ecology Relationship is based on summer flows (average for August to September) and is expressed as a percent of natural mean annual flow. The lower the percentage of average August and September flows, the higher the risk of a particular location. "The effectiveness of ATMs on the trout flow-ecology relationship locations was assessed in terms of the potential to increase August and September flows, and, especially, to move from a 0, 1, or 2 rating to a 3 or 4 rating." Warmwater Fish Flow-Ecology Relationship is based on the "30-day minimum flow" - a running mean calculated over the summer-autumn flow period (July 1 to November 30) for each year, then averaged over the study period. "The effectiveness of ATMs on the warmwater fish was assessed in terms of increases in late growing season and winter month flows and by the potential for a lease of water to lower the percent reduction in potential biomass."	Report qualitatively mentions connection between flow and water quality: "Water quality improvements. Traditional furrow irrigation has high return flows that may be high in salinity and other pollutants. Through the use of these highly efficient irrigation systems the return flows are reduced along with the accompanying contaminants."	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.
ATM-06 Grand Valley Water Users Asen Conserved Consumptive Use Pilot Project Development: Process, Procedure, and Lessons Learned: Water Banking-Asset Steps Part II	42795	http://www.grandvalleywaterusers.com/upload/pdf/2/6/0826067403-01-17_ccupp_projectdevelopment_final.pdf	The Conserved Consumptive Use Pilot Project (CCUPP) is a pilot demand management project intended to test the mechanisms necessary for a Western Slope irrigation water provider to intentionally reduce consumptive use in a voluntary and compensated manner. This report summarizes the process of developing the CCUPP, the procedure used, and lessons learned.	Land management contract: manage weeds & plant growth, soil erosion (leave plant residue, tillage for clods, tillage for crust), w/mid-season visit to confirm mgmt. activities are consistent w/contract; interviewees concerned w/DM externalities including local economy & aesthetics; CCU verification procedures (Exhibit B) don't specify methods to verify CU on fallowed land, but does include sites visits to verify land mgmt. and explicitly prohibits any active plant growth on fallowed land.	Impacts to flow not discussed.	Not discussed	Not discussed	Not discussed	Not discussed	Not discussed	Not discussed	Not discussed	Not discussed	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.
ATM-07 Grand Valley Water Users Asen 2017 CCUPP In-Season Verification	2017	https://drivewebtk.state.co.us/ows/ds/ElectronicFile.aspx?docid=20514&dbid=0	Field compliance and payment summary for the 2017 CCUPP including verification forms for each program participant for 2017.	Includes 2017 verification documentation including photographs, recommendations, comments/notes	Impacts to flow not discussed.	Not discussed	Not discussed	Not discussed	Not discussed	Not discussed	Not discussed	Not discussed	Not discussed	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.
ATM-08 Power Canal Capacity Report, Grand Valley Water Users Asen	12/1/2015	https://drivewebtk.state.co.us/ows/ds/ElectronicFile.aspx?docid=20181&dbid=0	Very brief report on "one potential mechanism through which water associated with CCU could be protected and returned to the Colorado River under a pilot project water bank." to conveyy CCU via unused capacity within the Orchard Mesa Power Canal (power canal) to deliver water to the Grand Valley Power Plant (GVPP). The report investigated the potential unused capacity within the Power Canal, including the potential for additional water to generate hydroelectric power.	Very brief report on "one potential mechanism through which water associated with CCU could be protected and returned to the Colorado River under a pilot project water bank." Compensated, temporary, voluntary. Lists current operations, water rights, data, incomplete file in link, merged with 20177 Next Steps Part II	Impacts to flow in the river not discussed in this report, but it is important to note that if CCU water were diverted and delivered by means of excess capacity in the Power Canal, that water would not be available in stream for biological needs. However, as it would be delivered at the power plant, that water would be available in the Tchida reach.	Not discussed	Not discussed	Not discussed	Not discussed	Not discussed	Not discussed	Not discussed	Not discussed	Not discussed.	Not discussed.	Not discussed.	Although not discussed in the report, using CCU for hydropower generation presents a tradeoff with keeping water in the river for biological needs.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.
ATM-09 Completion Report: Development of Practical Alternative Agricultural Water Transfer Measures for Preservation of Colorado Irrigated Agriculture	5/1/2011	https://drivewebtk.state.co.us/ows/ds/ElectronicFile.aspx?docid=19570&dbid=0	An extensive evaluation to: 1) To identify barriers to implementation of alternative transfers and to describe potential strategies for overcoming barriers. 2) To develop tools for agricultural producers to evaluate the viability of potential alternative transfers. 3) To further actual alternative transfers by evaluating three demonstration projects that include owners of agricultural water rights and potential end users of the temporarily transferred water.	Extensive final report on ATM investigation & pilot on NE South Platte covering barriers (cost, risk/uncertainty, lack of supply, reluctance, power dynamics), needs and means to address barriers, Lease Evaluation Tool (AgLET) ag economics evaluator, exchange capacity analysis, flex market pilot project w/Aurora.	In the demonstration projects assessed, there will be no impact to magnitude of streamflow as historical return flows have been quantified and will be maintained through recharge facilities.	In the demonstration projects assessed, there will be no impact to magnitude of streamflow as historical return flows have been quantified and will be maintained through recharge facilities.	In the demonstration projects assessed, there will be no impact to magnitude of streamflow as historical return flows have been quantified and will be maintained through recharge facilities.	Not discussed	1) Platte Valley Irrigation Company (PVIC) Augmentation Group/Aurora Water (the Flex Water Market): Historical return flows for Base CU and Flex CU are maintained by diversion into the recharge facilities located on or very near the farms where irrigation is permanently or temporarily suspended. Return flow deliveries will infiltrate into the alluvial aquifer and will eventually accrue to the river in the correct amount, time, and location as they have historically.2) DT Ranch/Town of Wiggins (Intercompanies Water Supply Agreement): Return flows were quantified as part of the HCU analysis. Deep percolation lagging calculated with IDS AWAS. DT Ranch has multiple location options for recharge facilities. Each year the agreement is executed, DT Ranch will quantify the historical amount, location, and timing of return flows resulting from both on-farm runoff and deep percolation. Likely return flows will be delivered to a recharge facility near or on the fields that are fallowed in years when the IWSA is executed.	Not discussed	Potential benefits of using recharge wetlands as a component of alternative transfers are discussed in Section 4.3. Wetlands provide habitat benefits to birds, fish, and other wildlife.	Not discussed.	Using wetlands as a recharge method for ATMs provides habitat for migratory waterfowl and other species.	Not discussed.	Not discussed.	Potential benefits of using recharge wetlands as a component of alternative transfers are discussed in Section 4.3. Water quality benefits include: nitrogen removal, phosphorus removal, carbon sequestration, sulfur reduction from sulfate to sulfide, suspended solids filtration, metals removal.	Not discussed.	Note the tradeoff between creating wetlands with an environmental benefit and reducing the CCU generated.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.
ATM-10 Final Project Report: Implementation of Deficit Irrigation Regimes: Demonstration & Outreach	May-16	https://drivewebtk.state.co.us/ows/ds/ElectronicFile.aspx?docid=19031&dbid=0	Evaluation of different methods of monitoring crop water stress and consumptive use (CU) under deficit irrigation. Demonstrations, workshops, educational outreach on crop stress monitoring.	Demo project to evaluate different methods of monitoring crop water stress and CU under deficit irrigation & demo educational outreach on crop stress monitoring.	Impacts to flow not discussed.	Not discussed	Not discussed	Not discussed	Not discussed	Not discussed	Not discussed	Not discussed	Not discussed	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.
ATM-11 The Poudre Water Sharing Working Group: A Report to the CWCB	May-15	https://drivewebtk.state.co.us/ows/ds/ElectronicFile.aspx?docid=19809&dbid=0	Final report of Poudre Water Sharing Working Group - a prototype ATM water sharing group between agricultural users (North Poudre Irr Co, Water Supply & Storage Co, New Cache la Poudre Irr Co, and Larimer/Weld Irr Co) and municipal users (Fort Collins, Greeley, and Tri-Districts) on the Poudre River, facilitated by the Colorado Water Institute at Colorado State University. The report focuses on the formation of the working group, relationship building, lessons learned, survey of ag users, development of prototype agreements, and regional cooperation strategies.	Final report of prototype ATM water sharing group between ag (North Poudre Irr Co, Water Supply & Storage Co, New Cache la Poudre Irr Co, and Larimer/Weld Irr Co) and muni (Fort Collins, Greeley, and Tri-Districts) on the Poudre River. Identified CCU calculation methods as a large barrier.	Impacts to flow not discussed, other than a few general mentions of needing to replace return flow obligations.	Not discussed	Not discussed	Not discussed	Not discussed	The report touches on the need to maintain historical return flows, and describes this as a challenge. This may require storage and timed releases or construction of recharge basins. For interruptible supply agreements, the domestic provider wishing to utilize agricultural water under CRS 37-92-309 would be responsible for meeting the State's application for approved replacement. "In considering whether the exchange or infiltration will result in a depletion of return flows however, it will be shaped by both present or needed infrastructure could be constructed by one party with adjustments made to the lease price that would compensate the party who develops this infrastructure. Note that there are no return flow requirements for trans-basin water.	Not discussed	Appendix A to the report (values / benefits provided by irrigated agriculture) touches on the benefit agriculture provides to wildlife habitat (esp. migrating waterfowl and songbirds). The report does not however talk about impacts expected to habitat from ATM activities.	Migrating waterfowl and songbirds, resident wildlife	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.
ATM-12 FLEX Water Market: Education and Implementation Phase	December-15	https://drivewebtk.state.co.us/ows/ds/ElectronicFile.aspx?docid=19791&dbid=0	Investigation of FLEX water market implementation: engagements, index based pricing, theorizing on large-scale implementation, meetings between willing shareholders. The goal of this project was to successfully implement the FLEX Water Market concept through education, facilitation, and consultation, with specific focus on developing FLEX markets in Water Division 1 with municipal, industrial, agricultural, and environmental/ conservation partners. The team consulted with multiple potential partners, but in the end this project did not result in a water sharing agreement.	Investigation of FLEX water market implementation: engagements, index based pricing, theorizing on large-scale implementation, meetings between willing shareholders.	Impacts to flow not discussed, other than a few general mentions of needing to replace return flow obligations.	Not discussed	Not discussed	Not discussed	Not discussed	The FLEX Water Market is characterized by a focus on the use of recharge sites and other environmentally beneficial delivery methods and water management. In evaluating potential partners to implement a FLEX Water Market, BC also considered what effects the change of use would have upon other water rights, such as the timing of return flows. The candidate in the North Poudre Irrigation Company (NPIC) would have been able to provide temporary recharge facilities for delivery of subsurface return flow obligations. Also discussed methods for maintaining return flows for a large-scale FLEX Water Market on the Front Range, includign the possibility of using multiple storage facilities of moderate size at various locations along the river.	Not discussed	Not discussed	Not discussed.	Not discussed.	Externalities discussed that may affect index based pricing: "The WWPI may offer a baseline to which potential sellers (or lessors) could reference, but the index is based on historical transactions in the market for water. Historically, the market for water has suffered from several defects that violate basic economic notions of competitiveness - relatively few buyers and sellers, high transaction costs, lack of information, uneven bargaining power, and potential externalities (return flow, etc.), meaning that the market prices captured by the index may be skewed (either positive or negative)."	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.

						Environmental Resources that May be Affected																			Next Steps											
																									Data Gaps, Questions for Future Projects										
						Streamflow (Hydrology) Impacts						Species Impacts				Water Quality Impacts																					
Title	Date	Publisher/Authors	Description	Notes	Magnitude	Frequency	Duration	Timing	Rate of change of hydrologic conditions	Return Flow Impacts	Critical Stream Reaches Impacted(where)	Critical Land or Riparian Habitat Impacted	Species Impacted (what)	Salinity	Temperature	Other	Tradeoffs / Resource Impacts	Predicted outcome from applying "avoid, mitigate, offset" hierarchy	Proportional	No net loss to env. services, recognizing tradeoffs	Program level goals Build incentives for projects with net env. benefits	For proposed future transactions, need to evaluate impacts (positive or negative) to: BMPs (or other flow targets)	SWP or WMP objectives / proposed projects	Critical habitat & flow recommendation s	State species of concern	BRT environmental values lists/ mapping	CRCT conservation strategy	Other known community / entity projects
ATM-13 Alternatives to Permanent Dry Up of Formerly Irrigated Lands	June-13	https://dnrweblink.state.co.us/cwcb/Electronic File.aspx?docid=199228&dbid=0	Review of benefits and issues of two alternatives to buy and dry that maintain some continued level of agricultural production: 1) Dry land farming, and 2) limited irrigation.	Review of benefits and issues of buy and dry and alternatives. Potential for conversion of ag land to dry land or deficit-irrigation, economic & maintenance issues w/dry land & deficit.	Impacts to streamflow not discussed.	Not discussed	Not discussed	Not discussed	Not discussed	Report notes need to replace historical return flows in location, timing, quantity and rate of flow to prevent injury to other water users. Also notes that return flow patterns from limited-irrigation will be different than from full irrigation; may be contested by objectors in the water court transfer due to the deficit irrigation approach with a far less than full water supply. Methods of maintaining return flows not discussed.	Not discussed	Environmental benefits Report briefly discusses environmental benefits of dry-up associated with the CWCB program but will improve environmental health and quality. Selection of revegetation species can be used to create environmental benefit. Dried and revegetated lands can also be returned to habitat, and the farmer may be eligible for subsidies under the Conservation Reserve Program (CRP). *Once the irrigation water has been sold and the irrigated lands dried up, the landowner may be eligible for federal farm subsidies under the Conservation Reserve Program (CRP)... Enrollment in CRP is a competitive process and favors lands in environmentally sensitive areas, such as farms very close to streams or wetlands. CRP payments are not available to farmers who choose to continue farming formerly irrigated lands under dry land or limited irrigation farming practices.) Environmental Impacts Report briefly discusses possible negative impacts associated with dry-up associated with noxious weeds (invasive species) preferentially taking over in dried areas.	Not discussed.	Not discussed.	Not discussed.	Salinity Previously irrigated fields tend to have buildup of salinity in the soils, which affects revegetation species options. Impacts to water quality from salinity not discussed.	Not discussed.	Other Nitrogen (N) and Phosphorus (P) levels in the soil affect revegetation viability. High N levels encourage weeds and P can lead to introduced species. Cover crops can reduce soil N through plant uptake. Soil can also be amended with high Carbon (C:) to N ratio amendments, mulches, or compost. Another option is to allow N to be naturally attenuated through weed uptake or leaching; this can have negative impacts to water quality.	Tradeoffs / Resource Impacts "Protect disadvantage of limited irrigation: "The water court transfer of a portion of the water rights historically used on a farm, the remainder left for limited irrigation, is difficult to decree and administer because of the maintenance of historical return flows and allocation of consumptive use to the water left for limited irrigation."	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.
ATM-14 Water Partnerships: an evaluation of alternative agricultural water transfer methods in the South Platte basin.	March-12	https://dnrweblink.state.co.us/cwcb/Electronic File.aspx?docid=19521&dbid=0	Water market experiment, survey of municipal & industrial providers on ATM practices, leases, evaluation of shared water bank scenarios on South Platte, focused on FRICO	Water market experiment, survey of municipal & industrial providers on ATM practices, leases, evaluation of shared water bank scenarios on South Platte	Impacts to streamflow not discussed.	Not discussed	Not discussed	Not discussed	Not discussed	Return flows for FRICO shares had already been quantified. The 400 acre (Lawrence Ditch; GDCWHS) and the resulting ditch-wide change identifies consumptive use, storage decrees and capacities, recharge capabilities, and the timing of return flows, providing technical and water transfer information that is not typically available on irrigation delivery systems in Colorado.	Not discussed.	In the survey of FRICO shareholders, one question asked if respondents are willing to sign a lease in which the water is used to maintain instream flows for river system recreation: 24.1% are willing, 48.3% are not willing. One question asked if respondents are willing to sign a lease in which the water is used to maintain wildlife habitat: 29.3% are willing, 37.9 % are not willing.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	The report notes the costs of storge for delayed return flows (GDCWHS) and the resulting ditch-wide change identifies consumptive use, storage decrees and capacities, recharge capabilities, and the timing of return flows, providing technical and water transfer information that is not typically available on irrigation delivery systems in Colorado.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	In the survey of FRICO shareholders, one question asked if respondents are willing to sign a lease in which the water is used to maintain instream flows for river system recreation: 24.1% are willing, 48.3% are not willing.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.
ATM-15 Project Report: Lake Canal alternative agricultural practices and in-stream flow demonstration project	June-13	https://dnrweblink.state.co.us/cwcb/Electronic File.aspx?docid=203048&dbid=0	Proof of concept project planning for ATM/ISF program on Lake Canal. Monitoring/verification based on deliveries, surface returns, inflow to recharge pits, and soil moisture. sensors to verify return flows by lack/presence of moisture movement below the root zone. Project was not implemented due to ongoing water scarcity at the time (2012-2013) and inability to agree on a price. Describes extensive legal work to arrive at proof of concept.	Proof of concept project planning for ATM/ISF program on Lake Canal. Monitoring/verification based on deliveries, surface returns, inflow to recharge pits, and soil moisture sensors to verify return flows by lack/presence of moisture movement below the root zone. Project was not implemented due to ongoing water scarcity at the time (2012-2013) and inability to agree on a price. Describes extensive legal work to arrive at proof of concept.	Benefit: A goal of the project was to negotiate an interruptible water supply agreement that would yield consumptive use that would be used for stream flow enhancement in the Cache la Poudre River between the Lake Canal Co.'s river diversion (north of Fort Collins) and the Poudre River. Water Borrowers (Greeley). An agreement was not reached. Impact: it was understood that return flows would be replaced in time, amount, and location, thereby causing no negative impact to streamflow.	Impact: it was understood that return flows would be replaced in time, amount, and location, thereby causing no negative impact to streamflow.	Impact: it was understood that return flows would be replaced in time, amount, and location, thereby causing no negative impact to streamflow.	Once the amount of saved consumptive use water is documented, the Water Borrowers will influence the timing of the delivery to the Poudre River.	Not discussed	Return flows were quantified as part of the consumptive use analysis. For an average consumptive use in 2012 of 182.1 AF, the return flows (surface and sub surface) were estimated to be 108 AF. Surface return flow obligations were to be provided and measured at the mouth of the Bartzer. Temporary recharge pits were envisioned to be constructed to help meet subsurface return flow obligations in an easily defined manner, real-time measurement of return flows and transferable consumptive use was proposed rather than relying exclusively on the results of a historical use analysis to determine transferable consumptive use and return flow obligations.	A goal of the project was to negotiate an interruptible water supply agreement that would yield consumptive use that would be used for stream flow enhancement in the Cache la Poudre River between the Lake Canal Co.'s river diversion (north of Fort Collins) and the Poudre River. The Water Borrowers (Greeley). The transferred consumptive use and surface return flow obligation would be left in the Cache la Poudre River. Water Borrowers desired for the transferable consumptive use water to pass through Fort Collins. An agreement was not reached.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Participants need to outline all their needs/requirements at the onset of the negotiation process otherwise it could have unintended consequences. For example, late in the negotiation process, it was discovered that some river management elements (bypass flows, fish ladder) would have had value added for some participants. These elements were never considered in the initial discussions. These elements added another layer of complexity to the water transfer and management.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Comments on the IWSA application to the SEO on behalf of the CWCB ISF Section stated that it supported the efforts outlined in the IWSA proposal but had three comments related to C.R.S. §37-92-309: 1. Use of the term "in-stream flows" potentially creates confusion with their Instream Flow programs and protections. 2. The proposed exchanges could potentially extend to reaches of the Poudre River where CWCB holds instream flow rights. 3. Although CWCB does not hold instream flow rights in this vicinity, it'd did it would be requesting more detail about the method of consumptive use	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.
ATM-16 Final Report of the Lower South Platte Irrigation Research and Demonstration Project	Jun-14	https://dnrweblink.state.co.us/cwcb/Electronic File.aspx?docid=19521&dbid=0	Technical research paper with three tasks. Task 1. Develop calculation & verification of consumptive water use and water savings, such that water court requirements can be satisfied—uses a stress coefficient, the crop water stress index CWSI, and the ReSET model of remote sensing. ReSET showed accuracy of 82-98% for fields under normal growing conditions and successfully detected abnormal growing conditions to accordingly reduce ET estimates. 2. Simplify the administrative burden of maintaining return flows. Task 3. Estimate supply delivery potential. Project on Lower South Platte Irrigation Research Farm near Iliff.	Goals were 1. Develop calculation & verification of consumptive water use and water savings, such that water court requirements can be satisfied—uses a stress coefficient, the crop water stress index CWSI, and the ReSET model of remote sensing. ReSET showed accuracy of 82-98% for fields under normal growing conditions and successfully detected abnormal growing conditions to accordingly reduce ET estimates. 2. Simplify the administrative burden of maintaining return flows, and 3. Estimate supply delivery potential. Project on Lower South Platte Irrigation Research Farm near Iliff.	Potential benefit of Water Allocation Approach: The return flow assumptions are conservative and additional return flows may provide benefits to rivers and downstream users.	Not discussed	Not discussed	Not discussed	Not discussed	The goal of the allocation approach is to simplify and reduce the costs to administer a change use case and protect historic return flows even while maintaining some level of irrigation on the farm. In this approach, 100% of the historic return flows would be met with a secondary method (ie. constructed wetlands or recharge ponds) and the allowable diversion would be capped at the fraction of historic diversions that would be consumed. In this way, diversion allocation guarantees the target CU savings and historic return flow, and the irrigator is allowed to fully consume the diverted water. From the perspective of return flow maintenance, the allocation approach is conservative because water diverted for irrigation that becomes return flow is additional flow above the requirement. This provides a net benefit to the stream if additional return flows are generated.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.
ATM-17 RGWCD Net Annual Replacement Plans	Reports exist for each year. Reviewed report for April 13, 2020	https://rgwcd.org/sub-1-annual-replacement-plan	Rio Grande Water Conservancy District plan to meet interstate compacts through forbearance agreements, leases for exchanges to meet streamflow criteria, temporary fallowing agreements, etc. Reviewed the 2020 Annual Replacement Plan (ARP), to meet requirements for the Plan Year under the provisions of the PWM for Subdistrict No. 1 decreed by the Division No. 3 Water Court in Case Nos. 2006CV64 and 2007CW52. This report describes a plan to remedy injurious stream depletions caused by the withdrawal of groundwater from Subdistrict Wells. This ARP includes a series of tables created by Subdistrict No. 1 staff and the RGCDSS modeling team tabulating stream replacement quantities and locations resulting from Subdistrict No. 1 well groundwater withdrawals and a water portfolio to be used to replace such stream depletions.	Rio Grande Water Conservancy District plan to meet interstate compacts through forbearance agreements, leases for exchanges to meet streamflow criteria, temporary fallowing agreements, etc.	Not discussed in report.	Not discussed	Not discussed	Not discussed	Not discussed	Not discussed	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.
ATM-18 Alternative Water Transfers in Colorado: A Review of Alternative Transfer Mechanisms for Front Range Municipalities	2016	https://www.estf.org/sites/default/files/alternative-water-transfers-colorado.pdf	Review of ATMs in Colorado for Front Range Municipalities. The report conducted a screening analysis to identify potential case studies for a more detailed analysis of ATM, found 35 municipal water providers based on water source and demand size criteria. Two case study participants were identified: City of Fountain and Town of Windsor. The report conducted a financial analysis of water supply alternatives for the two case studies; findings include recommendations for best ATM practices to suit those municipalities.	Review of ATMs in Colorado for Front Range Municipalities. The report conducted a screening analysis to identify potential case studies for a more detailed analysis of ATM, found 35 municipal water providers based on water source and demand size criteria. Two case study participants were identified: City of Fountain and Town of Windsor. The report conducted a financial analysis of water supply alternatives for the two case studies; findings include recommendations for best ATM practices to suit those municipalities.	The report identifies that a goal of ATMs in general is "to maintain or improve streamflow which support environmental and recreational activities" and that environmental interests can be involved in water transfers. "The instream flow benefits from diversion reductions are two-fold: (1) an increase in streamflow equal to the full diversion reduction between the canal point of diversion and the location of the return flows, and (2) a reduction in streamflow equal to the consumptive use fraction between the location of return flows and all downstream reaches." Instream flow benefits of diversion reductions are only realized for the stream reach between the point of diversion and the location of return flows. Specific benefits and impacts are not discussed in this report.	Not discussed	Not discussed	Not discussed	Not discussed	The report mentions that in general, the water right holder is responsible to maintain historic return flow patterns and complete any other activities to ensure that all other (surrounding) water right holders are not impacted by the transfer or change.	The report identifies that a goal of ATMs in general is "to maintain or improve streamflow which support environmental and recreational activities" and that environmental interests can be involved in water transfers. Specific benefits and impacts are not discussed in this report.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	In the discussion of different transfer methods, the report mentions that "water rights may be temporarily leased to the Colorado Water Conservation Board to provide for instream flows. Such instream flow leases can occur for up to 120 days in a calendar year. The CWCB is required to adopt criteria and keep records of instream flow leases, and obtain a decree quantifying HCU for the water right." It also discusses briefly the possibility to use an interruptible water supply agreement for environmental instream flow uses.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.

Exhibit B-7
SCPP Documents with General Criteria

Title	Date	Publisher/Authors	Description	Notes
SCPP-01 System Conservation Pilot Program Secondary Benefits: Final Report with Case Studies	2019	WestWater Research for TNC	This case study report looked at whether the reduction in consumptive use in SCPP projects also generated off-farm benefits by applying select methods to quantify off-farm benefits to two case studies in Colorado and Wyoming. Note from TNC: An executive summary is also available, along with a more detailed report that outlines the framework for assessing secondary impacts/benefits and the associated methodology for quantifying or evaluating each impact/benefit.	Benefits assessed include increased environmental flows, decreased cost of alternative habitat flow restoration projects, societal benefits from habitat flows for endangered species, estimates of dramatic savings in salinity control, and municipal and hydropower benefits. Increased flows for the evaluated Colorado projects contributed minimal improvement to recreational flow needs. Cost savings were estimated by the cost of existing augmentation plans used to meet environmental and salinity management needs.
SCPP-02 Infographic: Grand Valley Pilot Project Secondary Benefits	2019	TNC	This infographic summarizes the results of secondary benefits analysis as applied to the Grand Valley Pilot Project Case Study.	Grand Valley Pilot Project paid farmers to voluntarily reduce their irrigation water use in order to keep more water in the river to help increase water security within the Colorado River Basin in the face of ongoing drought. While focus was on water security several off-farm benefits occurs because of the project.
SCPP-03 Research Synthesis: Agronomic Impacts of Reduction Irrigation	2019	Culp and Kelly for TNC	This memo reviews research on fallowing and limited irrigation to highlight key findings related to agronomic impacts of limited irrigation or other methods to reduce consumptive use of irrigation water in the Upper Colorado River Basin. The concluding section also identifies remaining research questions and suggests potential implications and possible next steps for a demand management program. The appendix summarizes the parameters of several of the studies reviewed. All of the referenced reports and publications are available on request.	Reviews methods and findings of existing research on agronomic impacts of limited irrigation in the following categories: yield, quality, water use efficiency, recovery, soil health, weeds/diseases/pests, and ag operations. Next steps and identified research needs include understanding impacts over a variety of geographies and crops, as well as long-term recovery. Management and operations needs include understanding the benefits of rotational fallowing, deficit irrigation, and crop switching. Finally, there are many needs in the verification of conserved consumptive use.
SCPP-04 Final Report: Colorado River System Conservation Pilot Program in the Upper Colorado River Basin	2018	Upper Colorado River Commission	Full SCPP report from UCRC; project list; Lessons learned: administration & implementation, operational, cost/benefit/risk, legal constraints, outreach & education.	List of future questions to be answered p4
SCPP-05 Final Report: Appendix C: 2018 System Conservation Pilot Program Update	2018	Upper Colorado River Commission	2018 update to UCRC full report, including Appendices C (2018 update), D (2017 CU analysis), and E (2018 CU analysis)	Document includes Appendices C (2018 update), D (2017 CU analysis), and E (2018 CU analysis)
SCPP-06 Pilot Program Funding Agreement	2014	Bureau of Reclamation	2014 SCPP funding agreement between CRB entities	Reviews history of compacts, storage allowances, demand management efforts by signatories. Defines goals and parameters of SCPP. Identifies NRCS programs that might support on-farm conservation improvements: EQIP and SWEP & ensures that projects will coordinate with respective NRCS State Conservationists.
SCPP-07 Colorado River Water Bank Feasibility Study: Phase 1	2012	Colorado River Water Conservation District	Water bank planning phase; conservative estimate of potential WB supplies, and demand for those supplies.	Includes potential WB uses, supply, magnitude & frequency of need, supply-use scenarios. App. A: categories of W/E slope water uses, App. B: CRC WB Feasibility Study Water Supply Technical Memo, App. C: Eval of CRC WB Hydrologic Scenarios w/UCRB model, App. D: Basic supply & use comparison scenarios for CRC WB technical memo
SCPP-08 Colorado River Water Bank Feasibility Study: Phase 2	2013	For Colorado River District. By MWH.	Water bank planning phase; test cases assessing on-farm impacts for representative irrigation systems	Includes candidate systems, screening criteria & selection, site visits for system evaluation, financial impacts on ag ops, operational scenarios & comparison to ATM work. App. A: Candidate system identification & evaluation; App. B Test Case site reports
SCPP-09 Colorado River Compact Colorado water bank feasibility study: water supply technical memorandum. (Appendix B to Colorado River Water Bank Feasibility Study: Phase 1)	2012	Natural Resources Consulting Engineers, Inc	Technical analysis for water bank feasibility study, included in 2012 WB planning phase 1 report .pdf	Data section includes analysis, irrigated areas, water rights categories, and climate stations. Examined CU requirements (w/StateCU & Blaney-Criddle), ET verification (Penman-Monteith w/4 CoAgMet stations), and HCU (StateCU values for elevation bands in each division multiplied by irrigated acres). Water bank supply and cost: "fallowing suitable for small grains, grain corn, & dry beans." Deficit Irr available for all crops but best suited to alfalfa & pasture. "These crops combined account for over 98% of the acreage, irr CU, and supply-limited CU." Discusses split-season irrigation.
SCPP-10 Exploring Perceptions of a Voluntary Agricultural Water Conservation Program on the Western Slope of Colorado	2019	MacIlroy, Colorado State University	This report was designed to assist in identifying and better understanding the socio-cultural components of a potential demand management program. The research, completed in Spring 2019, explored perceptions of demand management among stakeholders on the Western Slope through individual interviews and focus groups. The findings shed light on the barriers and opportunities for a demand management program, including ideas and feedback on what a successful program would look like, and why water users may or may not want to participate. **An executive summary is also available.**	This is an interview-based report that covers perceptions of DM, definitions of voluntary, compensated, temporary, and equity (their words are proportional/parity)--and finds that these definitions are not straight-forward and must be carefully communicated. Explores relationships with water and landscape, as well as "sacred values of the Western Slope." Addresses perceptions of DM in context of 2007 Interim Guidelines and broader basin-to-basin politics. Many interviewees doubt the viability of a voluntary compensated program, and even suggest that a mandatory uncompensated call would work better, avoid equity issues, and cost less overall. Compensation was a very challenging topic, with differing views of DM as a burden vs opportunity. Highlights clash of free-market values with the perspective of water as a commodity--discussion of different role water plays for irrigators vs Front Range residents. Who bears responsibility to pay--who is responsible for the shortage problems (many don't see the Upper Basin at fault). Temporary program vs temporary participation--fraught discussion. Discussion of Western Slope Sacred Values, how water and farming is part of identity. Numerous people suggested every water user curtail use and respect water and that we should make water conservation part of being a [illegible]
SCPP-11 Briefing Paper: Upper Basin Demand Management and Water Banking. Addressing Risk and Creating Certainty: Exploring Options for an Upper Basin Demand Management Program	2019	TNC	This briefing paper provides a general background on the DCP and demand management. It frames the key issues to address in evaluating a demand management program and is offered in the spirit of promoting discussion and decision-making on how to structure, govern, finance, and implement such a program.	Briefly evaluates Upper Basin risk based on drought hydrology, and discusses how to reduce that risk. Asks many questions about Dm, program governance and structure, cost and funding, policy, measurement and verification. Identifies many of the key issues being addressed by CWCB DM workgroups. Key successes from SCPP are locally-driven solutions, minimizing impacts & maximizing benefits, e.g. through local coordination of projects. Tabulates past options considered for avoiding compact curtailment.
SCPP-12 Colorado River Water Bank Work Group: An Overview of Previous Studies & Reports	2018	Colorado River Water Bank Working Group	This overview documents summarizes the studies completed by the Colorado River Water Bank Work Group in their effort to provide information about what types of solutions may be available to preserve communities, agriculture, power production and the river itself.	This work includes a two-phase feasibility study, an assessment of how reduced irrigation for compact purposes would work with different irrigation systems on Colorado's West Slope, economic work on pricing and payments, and scientific research on the agronomic impacts of reduced irrigation.
SCPP-13 GVWUA Final Report on the Conserved Consumptive Use Pilot Projects	2019	GVWUA and J-U-B Engineers	This report provides a summary of the 2018 and 2019 Conserved Consumptive Use Pilot Projects completed by the Grand Valley Water Users Association (GVWUA). The initial part of the report provides a good summary of both the 2017 and 2018 pilots. Appendix H provides the details of the survey GVWUA completed of all participating producers, gathering their input on their experience and perspectives on the pilot project. Appendix I summarizes GVWUA's thinking more broadly on the pilot and demand management.	Land management contract: manage weeds & plant growth, soil erosion (leave plant residue, tillage for clods, tillage for crust), w/mid-season visit to confirm mgmt. activities are consistent w/contract; interviewees concerned w/DM externalities including local economy & aesthetics; CCU verification procedures (Exhibit B) don't specify methods to verify CU on fallowed land, but does include sites visits to verify land mgmt. and explicitly prohibits any active plant growth on fallowed land
SCPP-14 Lessons Learned from the System Conservation Partnership Program	2016	The Nature Conservancy	TNC's lessons learned in their SCPP involvement, including lessons from Trout Unlimited and Colorado Water Trust	Top 3 lessons: outreach & communication is essential, operational & legal issues must be addressed at ditch company/irrigation district level simplify the process for efficiency.
SCPP-15 Considerations for Modeling a Water Bank at the Aspinall Unit with Current Environmental Flows	2011	Hydro Consulting for TNC	Evaluation of computer models of the Gunnison River to assess their ability to simulate a potential water bank in the basin using the Aspinall Unit reservoirs and the effect on reservoir operations, including environmental flows	StateMod, Aspinall PBO/EIS Model, and CRSS are evaluated for their capabilities to simulate Aspinall Unit operations, environmental flows, and potential water-banking. Specifically, this modeled the Black Canyon water right, new ESI/PBO requirements at the Whitewater gage, and a water-banking option at Aspinall. Modifications to the Gunnison StateMod are necessary to simulate environmental flows and enhance reservoir accounting options.
SCPP-16 Environmental Water Transactions in the Colorado River Basin: A Closer Look	2018	Stanford Woods Institute for the Environment	Reviews CRB environmental transfers to track extent of activity. Examines SCPP projects by this lens, given the ISF benefits of SCPP. Found that SCPP-funded projects had the effect of enhancing streamflow.	Analysis used UCRC 2018 Final Report; no new data. 20,000ft view of ISF projects including SCPP projects.
SCPP-17 Lower Colorado River Basin Pilot Program	NA	Bureau of Reclamation	Webpage with tables of projects from each pilot phase	"Although the Pilot Program will be ongoing until 2035, as of 2019, future announcements of funding opportunities and requests for additional project proposals are not being contemplated."
SCPP-18 System Conservation: a collaborative approach to drought contingency planning the Upper Colorado River Basin	2017	Wyoming SEO Callaway, AWRA Impacts magazine	Description of Wyoming SCPP, how it works, participation, and future efforts.	Neither extensive nor technical, but includes some description of process & participation.

Title	Primary Purpose / Goal of Report / Study	Key Takeaways (Related to Objective / Goal)
SCPP-01	"This project explores whether the reduction in CU provided by the SCPP also generates off-farm benefits in addition to the 'system' water." Also seeks to quantify the economic benefits of two SCPP project case studies. The benefit sectors evaluated in this memorandum for the two case-studies include the following: 1. Environmental 2. Recreation 3. Hydropower 4. Salinity 5. Municipal	Grand Valley Project - Hydropower benefits of close to $10,000 resulted from the dedicated diversion of CU savings to the Grand Valley Power Plant. - Environmental benefits of about $23,000 were estimated because of the management efforts and obligations defined under a recovery program for T&E fish species in the 15-mile reach directly below the project diversion point. - Salinity benefits of over $280,000 were the most surprising benefits evaluated in this study and should be further verified. - In total, off-farm benefits of the Grand Valley project were estimated to total $315,710, which is equivalent to approximately $99 per acre-foot of conserved water and approximately 30% of total project costs. Middle Piney Creek Projects - Hydropower benefits were estimated to be insignificant because of the operation plans for the two downstream reservoirs. - Environmental benefits for T&E species are focused on the Green River below Flaming Gorge Reservoir, and reservoir outflows would be unchanged. Local environmental benefits in Wyoming were evaluated but not quantified. - Salinity benefits were estimated to be negligible because the project is not located in a defined salinity management area under the Salinity Control Program. - Recreational benefits were estimated to be approximately $600, dependent upon the level of recreational access below the project location. This $600 benefit represents $0.44 per acre-foot of conserved water and 0.2% of project costs.
SCPP-02	Infographic to put monetary benefit to secondary benefits from the Grand Valley Pilot Project: Hydropower, Salinity, Environmental, Recreation.	"In total, the secondary benefits of the Grand Valley Project were estimated at $315,710, or $100/acre-foot of water savings." Note this infographic summarizes same conclusions as SCPP-01 secondary benefits.
SCPP-03	"This paper reviews and synthesizes the identified, compiled body of research work to highlight key findings related to agronomic impacts of limited irrigation or other methods to reduce consumptive use of irrigation water and identify the factors that are showing up with some regularity." Agronomic impacts summarized include: Yield, quality, water use efficiency, recovery, soil health, weed disease and pests, and agricultural operations.	"A unifying theme across the reviewed research is that site-specific variables can lead to large variations in water use efficiency and crop yield—critical factors in evaluating potential water savings and financial returns of changed irrigation practices."
SCPP-04	Report on SCPP in Upper CO River [illegible] report is intended to summarize the [illegible] year Colorado River System Conser[illegible] the Upper Colorado River Basin (Up[illegible] primary objective of the pilot progra[illegible] conservation as a future means of in[illegible]	[illegible]
SCPP-05	Report on SCPP in Upper CO River [illegible] an update to the Final Report on the [illegible] (SCPP) in the Upper Colorado River [illegible] from the 2018 SCPP project year, inc[illegible] the final year of the SCPP."	[illegible]
SCPP-06	Agreement between the US Bureau [illegible] Conservation District (CAWCD), Met[illegible] (MWD), Denver Water (DW), Southe[illegible] cooperate with water users for agricu[illegible] reductions of consumptive use of wa[illegible]	[illegible]
SCPP-07	"Phase 1 of the Water Bank Study c[illegible] - Estimate water uses on the East Sl[illegible] rights that are not 'present perfected [illegible] Compact water rights"). - Estimate water supply available to [illegible] agricultural water rights - Estimate the potential magnitude a[illegible] curtailment that could be mitigated th[illegible] - Develop and evaluate regional wate[illegible] and apply a Scenario Analysis Tool t[illegible]	[illegible]
SCPP-08	"The purpose of Phase 2 was to ass[illegible] Bank for a number of representative [illegible] defining requirements and preferenc[illegible] and selecting candidate irrigation sys[illegible] irrigation operation, deficit irrigation a[illegible] irrigation system level." "Screening criteria were applied to a [illegible] select eight systems that represente[illegible] division, type of ownership, type of c[illegible] Compact water rights, and whose ow[illegible] "Defining requirements and preferen[illegible] considered as test cases for conduct[illegible] - Identifying candidate systems for fu[illegible] - Screening candidate irrigation syste[illegible] cases - Conducting on-site assessments of [illegible] operations for the test case systems [illegible] the Water Bank - Describing alternatives for Water Ba[illegible] - Describing potential economic impa[illegible] case systems."	[illegible]
SCPP-09	"This report discusses the methodolo[illegible] irrigation consumptive use for irrigate[illegible] reduced consumptive irrigation use f[illegible] irrigation is the potential water suppl[illegible] conducted to determine the agronom[illegible] and deficit irrigation of certain crops i[illegible] consider the acceptance or willingnes[illegible] deficit irrigation program."	[illegible]
SCPP-10	"This report, commissioned by TNC, [illegible] identifying, and addressing some of t[illegible] been least explored by stakeholders [illegible] date."	[illegible]
SCPP-11	The briefing paper addresses the fol[illegible] them, but not claiming definitive answ[illegible] 1. What Is the Issue? Understanding [illegible] 2. What Can Be Done? An Upper Ba[illegible] 3. Questions Posed by a Demand Ma[illegible] 4. Program Governance 5. Program Costs and Funding 6. Policy Considerations 7. Measurement and Verification of C[illegible] 8. Key Lessons from the System Co[illegible] 9. Past Options Discussed to Addres[illegible]	[illegible]
SCPP-12	"The purpose of the WBWG and the [illegible] information about what types of solut[illegible] agriculture, power production and the[illegible] compiles prior work done by the WB[illegible] the next steps in our effort to answer [illegible] including an evaluation and emphasi[illegible] answered prior to deciding whether i[illegible] program is feasible and desirable for [illegible] Phase 1 (2012): The purpose of this [illegible] potential mechanism that would allow [illegible] event of a shortage situation under th[illegible] estimates the potential demand and [illegible] pre-compact and post-compact wate[illegible] size and how often a water bank wou[illegible] Phase 2 (2013): The purpose of this [illegible] work for several representative irriga[illegible] identified eight representative irrigati[illegible] completed an assessment for each s[illegible] water supply, irrigated acres, and cro[illegible] site visits with system managers to d[illegible] water bank could work with their ope[illegible] review of the agricultural impacts of f[illegible] discussion of the financial impacts. L[illegible] scenarios for a water bank that addre[illegible] operate, methods for reducing deplet[illegible]	[illegible]
SCPP-13	The overarching goals of the 2017 pr[illegible] - Gauge farmer interest - Determine scalability - Mitigate financial cost and risk to th[illegible] - Continue to comply with existing GV[illegible] - Explore potential benefit to the GV[illegible] - Generate questions and concerns s[illegible] - Execute a pilot project within a defi[illegible]	[illegible]
SCPP-14	Lessons learned from the SCPP. The[illegible] SCPP: Program Perception, Project [illegible] Rights & Water Law, Operational Iss[illegible]	[illegible]
SCPP-15	"In this report, several computer mod[illegible] assess their ability to simulate a pote[illegible] Unit reservoirs and the effect on rese[illegible] Our working assumption is that the b[illegible] reservoirs to store and build up cons[illegible] any compact call and that the space [illegible] account for currently committed envi[illegible] We also assume that a clear accoun[illegible] operations at Aspinall will not only inf[illegible] will provide a foundation for examinin[illegible] different water banking concepts at A[illegible]	[illegible]
SCPP-16	"The purpose of this project was to a[illegible] instream and other environmental us[illegible] "This report is intended to begin… ta[illegible] transaction activity in each the five st[illegible] River watershed: Arizona, Colorado, [illegible] close look at environmental transfer a[illegible] water rights holders that enhance str[illegible] to or transfer of their water right."	[illegible]
SCPP-17	Document key metrics for the Lower [illegible] Tables document Participant, State, [illegible] Conservation, Total Cost, and Cost/A[illegible]	[illegible]
SCPP-18	The paper describes the SCPP: Bac[illegible] efforts.	[illegible]

Title	Project Location Information: Project Location(s) Description	Latitude	Longitude	Elevation (feet)	DM Program Basics: DM Program/Activity Name	DM Program Structure	Nature of DM Practices	Duration of DM Practices Implementation (Program Duration and Frequency)	Source and Amount of Conserved Water: Source of Water Conserved	Amount of Water Conserved-Conserved Consumptive Use (CCU)
SCPP-01	-Grand Valley (CO) -Middle Piney Creek (WY)	CO: 39.189107 WY: 42.514320	CO: -108.280763 WY: -110.234874	CO: 4793 WY: 7097	System Conservation Pilot Project in the Upper Colorado River Basin	SCPP is an effort initiated by the USBR with several large municipal water providers to conduct water lease agreements with water users within the Colorado River Basin to generate water to benefit reservoir elevations in Lake Powell and Lake Mead. GVWUA held a voluntary lottery for producers to participate in 1 of 4 program activities. A total of 10 participates were selected based on overall funding for the Grand Valley CCUPP.	FF - Full Season Fallow WW - Irrigation after 10/1 SS - Irrigation after 9/1 AA - Irrigation after 8/1	Colorado River: 2017 Middle Piney Creek: 2015 - 2016	Colorado River (CO), Piney Creek (WY)	Grand Valley Project: 3,226 AF CCU Total, see Table 2. Middle Piney Creek: 133 CCU Total in 2015, 1,347 AF CCU Total in 2016, see Table 6.
SCPP-02	Grand Valley, CO	Not discussed.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
SCPP-03	Literature review of many studies, primarily Colorado. See Appendix A for list of studies reviewed.	N/A	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
SCPP-04	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
SCPP-05	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
SCPP-06	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
SCPP-07	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
SCPP-08	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
SCPP-09	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
SCPP-10	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
SCPP-11	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
SCPP-12	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
SCPP-13	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
SCPP-14	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
SCPP-15	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
SCPP-16	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
SCPP-17	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
SCPP-18	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Title	High Level Program Structure: DM Program Administration	DM Program Monitoring & Verification Considerations	DM Program Education and Outreach Efforts	Tools Used to Measure General Outcomes	DM Program Funding Considerations	DM Program Economic Considerations	DM Program Agricultural Impacts Considerations	Recreation
SCPP-01	Not discussed.	Not discussed.	Not discussed.	Streamflow data (USGS gages) GVWUA diversions were measured at the Roller Dam and Power Canal to measure participants supply used at the Grand Valley Power Plant and returned at the top of the 15 Mile Reach.	Funding for the Grand Valley Project came from SCPP and other funding sources. Funding for the 2 ranches DM activities near Middle Piney Creek came from SCPP.	In total, off-farm benefits of the Grand Valley project were estimated to total $315,710, approximately $99/AF of CCU, approximately 30% of total project costs. In total, off-farm benefits of the Middle Piney Creek projects were estimated to total $600, approximately $0.44/AF of CCU, approximately 0.2% of project costs	Not discussed.	CO: Rafting, kayaking. WY: Fishing. "This analysis of recreational benefits resulting from the Grand Valley conservation project focuses on recreational river boating along the Colorado River downstream from the Grand Valley Power Plant discharge into the Colorado River near Palisade, CO." "The focus of [the Middle Piney Creek] analysis is on fishing because rafting and kayaking on Middle Piney Creek and the Green River downstream are not considered as popular recreational activities." "Average year recreational benefits of the Middle Piney Creek project are estimated to be $605, while dry year benefits double to $1,122." "Increase in the number of fishing trips: A search of the literature indicated that a 1980 study on the effect of Middle Piney Creek. The 1980 study showed that angler days would be expected to increase with increases in streamflow up to a maximum angler use at about 65% of bank full. If streamflow [illegible]
SCPP-02	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
SCPP-03	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
SCPP-04	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
SCPP-05	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
SCPP-06	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
SCPP-07	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
SCPP-08	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
SCPP-09	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
SCPP-10	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
SCPP-11	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
SCPP-12	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
SCPP-13	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
SCPP-14	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
SCPP-15	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
SCPP-16	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
SCPP-17	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
SCPP-18	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Title	Program Effectiveness: Program Lessons Learned	Identified Program Successes and/or Challenges	Program Pros/Cons
SCPP-01	- Off-farm benefits range from municipal, hydropower, environmental, salinity, and recreation. - For boating and fishing, the value of water is not only related to the amount of water, but the timing of water. - The size of the two projects (generally) did not provide a measurable benefit in many of the sectors analyzed. - Scaling up of the projects would have generally resulted in more measurable benefits in many of the sectors analyzed. - Surprisingly the biggest benefit achieved came from the reduction in salt load associated with the Grand Valley Project. - The size of the two projects would have had a more measurable benefit had the activities taken place in a dry year like 2002. - Hydropower benefits were assumed to be zero if the inflows into power generation stations if the baseline plus project water exceeded the power generation stations' maximum capacity.	Successes: The GV CCUPP had several off-farm benefits: - Hydropower benefits of $9,950. - Environmental benefits of $23,040. - Societal benefits of $88,600. - Salinity benefits of $287,720. Challenges: - The Middle Piney Creek Project had minimal off-farm benefits. Shepherding and/or administering of CCU to Lake Powell was not possible. - Projects had little to no increase in the levels in Lake Powell.	Pros: - Off-farm benefits were measurable and achieved for the Grand Valley Project. - Recreational and environmental benefits can be achieved by increasing late-season flows. - Off-farm benefits showed the ability to offset program costs. Cons: - Off-farm benefits were negligible for the Middle Piney Creek projects. - Upscaling of the projects would be necessary to significantly impact Lake Powell lake levels. - Water could not be shepherded and/or administered down to Lake Powell.
SCPP-02	[illegible]	[illegible]	[illegible]
SCPP-03	[illegible]	[illegible]	[illegible]
SCPP-04	[illegible]	[illegible]	[illegible]
SCPP-05	[illegible]	[illegible]	[illegible]
SCPP-06	[illegible]	[illegible]	[illegible]
SCPP-07	[illegible]	[illegible]	[illegible]
SCPP-08	[illegible]	[illegible]	[illegible]
SCPP-09	[illegible]	[illegible]	[illegible]
SCPP-10	[illegible]	[illegible]	[illegible]
SCPP-11	[illegible]	[illegible]	[illegible]
SCPP-12	[illegible]	[illegible]	[illegible]
SCPP-13	[illegible]	[illegible]	[illegible]
SCPP-14	[illegible]	[illegible]	[illegible]
SCPP-15	[illegible]	[illegible]	[illegible]
SCPP-16	[illegible]	[illegible]	[illegible]
SCPP-17	[illegible]	[illegible]	[illegible]
SCPP-18	[illegible]	[illegible]	[illegible]

							Project Location / Description				DM Program Basics				Source and Amount of Conserved Water		High Level Program Outcomes									
																							Program Effectiveness		
Title	Date	Publishers/Authors	Description	Notes	Primary Purpose / Goal of Report / Study	Key Takeaways (Purpose / Objective / Goal)	Project Location(s) Description	Latitude	Longitude	Elevation (feet)	DM Program Activity Name	DM Program Structure	Nature of DM Practices	Fraction of DM Program Implementation (Project and Timescale)	Source of Water Conserved	Amount of Water Conserved / Consumptive Use (CU)	DM Program Administration	DM Program Monitoring & Verification Considerations	DM Program Education and Outreach Efforts	Tools Used to Measure Desired Outcomes	DM Program Funding Considerations	DM Program Economic Considerations	DM Program Agricultural Impacts Considerations	Recreation	Program Lessons Learned	Identified Program Successes and/or Challenges	Program Pros/Cons
[SCAN ID: 1] ENSO Water Resource Portfolio	2019	Northern Nevada Water Authority	Topics from ENSO's water plan	Addresses temporary supplies including different aspects of Intentionally Created Surplus, recharge and banking, ICS, and conservation tools.	No paper describes Northern Nevada Water Authority (ENSO)'s water resources portfolio, including: Permanent Resources, Temporary Resources, and Future Resources.	Permanent Resources include: Colorado River supplies (including return flow credits); Tributary Conservation Intentionally Created Surplus (ICS), permitted groundwater rights in the Lake Lahontan Basin, and Truckee River Operating Agreement (TROA). Temporary Resources (defined as banked water) include banked water locally and through the Nevada Environmental Response Trust (NERT) Water Bank, California Water Bank, Arizona Water Bank, Intentionally Created Surplus. Future Resources ("defined as those resources expected to be available to ENSO, of some quantity, at some point in the future") include Fallon Basin, Lahontan Valley Groundwater, Virgin River/Colorado River Augmentation, Truckee/Carson/Lahontan. Water Conservation is also discussed.	Northern Nevada Water Authority	N/A	N/A	N/A	This is not a specific DM program but rather an review of ENSO's portfolio and the many DM&O programs that are implemented over and availability of water in future years.	Not discussed.			Water, Storage Assets, or all of the above		Not discussed.	Not discussed.	ENSO has performed stakeholder outreach and education opportunities to incentivize residents to conserve water. Additionally, ENSO has set up the municipal rubber watering which cannot be disciplined and reused.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	ENSO has found its plans on water used it estimates and for meeting as that these users cause for water to be local to the system when their be recognized and equally created. ENSO has water records by focusing on the following areas: - Water Conservation - Changed irrigation clocks to follow evaporatory lines of drip and dry-all week watering restrictions.	Barriers: Outreach and education across all sectors is the community helped to improve efficiency and decrease truly unconsumed water uses.	Not discussed.
[SCAN ID: 2] Colorado River Water Bank Rule Framework & Financial Analysis	2021	WestWater Research, LLC	This memo evaluates different framework concepts to scale up operations of the State Water Bank and provides recommendations for the state boards to consider in different implementation scenarios. The framework information is intended to provide concepts for consideration by members of the Water Bank Working Group for further and discuss in ongoing State Bank development efforts.	Evaluates 3 frameworks of a Colorado Basin water bank (defined to address 250,000 AF of CU): annual water bank, long-term water bank, and long-term water bank with short-term assets, and responds to a 1922 compact call. Evaluates the financial viability of each framework and demonstrates based on the volume of water banked, variable costs, fixed costs, and number of banks to subdivide among water.	Estimate costs of a water bank under two frameworks which could have a Colorado Basin water bank could operate at a scale sufficient to address 250,000 AF of Colorado River Compact shortages and conserve water in the Water of Colorado River Basin Virgin agricultural. - Framework #1 – Annual Colorado River Basin bank. - Framework #2 – Option I needs to Critical Years. - Framework #3 – Critical Year I years. - Response to Compact Call.	"The total cost of water leasing is significant, with first response assumptions from 250,000 AF bounds need to be leased from the Colorado Shasta / Supa over a 10-year period." "The annual cost of a water bank operating at a scale sufficient to address the Compact call, the analysis shows that such an effort could be more expensive from a proactive approach." "Water banks can be a valuable tool to address Compact shortages, but a robust conservation intervention is likely required to help lease rates low during a drought period, when water supplies will be scarcest."	Gladen Rope, CO	N/A	N/A	Varies	Not a DM program. "Water Bank Framework Analysis.	The rate not a DM program. The evaluated Framework for leasing water - specifically the financial costs of water banking.	Leasing economic. The annual leasing would be structured as a traditional fallowing program," with different structures under the two frameworks.	Not discussed - full consumptive use rights	Agriculture	Not discussed.	Not discussed - analysis of 3 water leasing frameworks. Includes costs for monitoring but not verification of the amount of CU water saved.	Not discussed.	Not discussed.	Not discussed.	Not discussed - analysis of each framework.	Not discussed - does not discussed funding sources. Identifies costs for implementing the different frameworks.	Not discussed.	Not discussed.	Not discussed.	Not discussed - concludes a framework to prevent spilling of tools of leased water during times of drought.	Not discussed.	Not discussed.	This analysis displays the importance of a framework to keep water leasing costs stable during times of drought. Frameworks which lessend water costs are not secured prior to drought shows higher framework costs as 10%-15% of the modelled frameworks are direct water costs.	Barriers: The costs set lower in the annual water leasing framework (Same in the program saved fallow case) are not discussed and the framework using options to lease water in actual drought years (case Lake Powell is low).	Not discussed.

Exhibit B-8
Lit (Gen. Literature) Documents with General Criteria

Title	Date	Publisher/Authors	Description	Notes
Lit-01 Salmon recovery in the Columbia River basin: analysis of measures affecting agriculture	1999	Aillery et al, Marine Resource Economics	Analysis of ag impacts from salmon-recovery-related flow alterations in Columbia River	Investigates ag impacts of fish recovery measures "such as: modified timing for dam releases, reservoir drawdown, and flow augmentation in the Columbia River basin, on the regional agricultural sector are evaluated. [....] Results suggest that drawdown and/or minor reductions in irrigation water diversions would reduce producers' profits by less than 1% of baseline levels. However, the most extreme scenario--a long drawdown period combined with a large reduction in irrigation diversions--would reduce producers' profits by $35 million (2.5%) annually."
Lit-02 Feasibility of water efficiency and reuse technologies as demand-side strategies for urban water management	2017	Berhanu et al, Journal of Industrial Ecology	Economic model of water cost provided by above-code water efficiency and reuse technologies, including variations & uncertainty analysis.	Estimates that efficiency and reuse can meet 85% of 50yr projected needs to the Lower Colorado River Authority service area (central TX)
Lit-03 Response to water crisis: How do Iranian farmers think about and intent in relation to switching from rice to less water-dependent crops?	2019	Boazar et al, Journal of Hydrology	Study of farmer response to gov't demand management, switching crops.	"Structural equation modeling showed that farmers' intention to change from rice cultivation to another crop is determined by personal norms, beliefs about their role and emotional considerations."
Lit-04 Temporary water transfers for urban water supply during drought	1992	Clark, CSU	PhD dissertation modeling options for temporary water transfers	"This research develops a water right option agreement (WROA) model, methods of analysis, and legal implementation strategy under Colorado law." Interviewed professionals, estimates costs, identified that WROA "can be superior in terms of cost, reliability, and operational flexibility to both water-right purchases and construction of additional reservoir storage.
Lit-05 Flexible water allocations and rotational delivery combined adapt irrigation systems to drought	2018	Cody, K.C., Ecology and Society	Water allocation experiment in San Luis Valley, Colorado for self-governing irrigation systems.	Examines relationships between rules and physical context of water supplies; specifically the outcomes of water allocations between members and how they rotate water delivery.
Lit-06 Water trading innovations: reducing agricultural consumptive use to improve adaptation to scarcity	2017	Colby (Ch. 3.1.4), Book eds Ziolkowska & Petersen	Chapter from book "Competition for Water Resources: Experiences and Management Approaches in the US and Europe" collecting global examples/discussion of approaches and solutions to water supply scarcity, including western US	Ch 2.1.1: Challenges for US irrigated ag in the face of emerging demands and climate change, Ch 3.1.4: Water trading innovations: reducing agricultural consumptive use to improve adaptation to scarcity (reviews online trading systems to reduce transaction costs, methods for cost-effective verification of CCU, and other breakthroughs facilitating temporary & intermittent trading more feasible. Examples from AZ and CA (IID), NE, Australia, CO-Big Thompson.
Lit-07 Towards regional sustainability assessment utilizing community based participatory research, sustainability indicators, and future scenario modeling	2016	Dubinsky, CU Denver	PhD dissertation that identified San Luis Valley sustainability indicators and modeled future scenarios, developing a CU indicator for 1980-2010. Conducted scenario modeling to guide decision-makers towards desired outcomes from policy decisions. Coupled sustainability indicators with future scenario modeling to inform the SLV stakeholders about a variety of social and environmental issues. Results indicated that through specific shifting of cropping rotations and minimal land fallowing, SLV could reduce water use and Greenhouse Gas Emissions while increasing soil carbon and improving soil health. In addition, the solar energy development pathways investigated by this study showed that the potential exists to offset most or all of the region's GHG emissions.	Utilized Community Based Participatory Research to engage stakeholders & keep research relevant. Highlighted groundwater-dependence of SLV, suggests irrigation water use could be decreased 10% with shifts in crop regime and minimal fallowing.
Lit-08 Economic viability of deficit irrigation in the Western US	2018	Manning et al, Agricultural Water Management.	Research on agro-economics of deficit irrigation.	Deficit irrigation (DI) can be optimal during late growth and maturation stages given elevated water prices (depending on output price and production costs).
Lit-09 The role of groundwater trading in spatial water management	2014	Palazzo and Brozovic, Agricultural Water Management	Republican River Basin assessment of coupling surface-groundwater management.	Geospatial dataset of RRB irrigation wells modeling crop choice, land, and water use decisions by well. "Our analysis highlights the importance of the initial distribution of permits and the institutional context in which trading occurs." Cost savings from trading groundwater pumping are distributed unevenly between wells, counties, and groundwater management institutions.
Lit-10 Evaluating the potentials of cropping adjustment for groundwater conservation and food production in the piedmont region of the North China Plain	2019	Ren et al, Stochastic Environmental Research & Risk Assessment	Evaluation of different cropping patterns (including fallowing) & water supply scenarios.	Framework for using a crop model & regression to predict effects of cropping adjustments on groundwater sustainability & crop production
Lit-11 Opportunities for saving and reallocating agricultural water to alleviate water scarcity	2017	Richter et al., Water Policy	- Review of literature & internet to identify water-saving strategies in irrigated agriculture. - Review of case studies in which water savings have been successfully transferred to other uses.	- Catalogs water savings opportunities, claims of irrigation-efficiency savings potential, logistics of reallocating due to other ag diverting savings. Findings suggest considerable potential to reduce irrigation CU and that savings can be reallocated when proper consideration is given to water budget accounting.
Lit-12 Urban water conservation in the Sacramento, California region during the 2014-2016 drought	2019	Talbot, UC Davis	UC Davis Master's Thesis cataloging/analyzing supply & demand management actions under CA's drought policies.	Evaluates outdoor watering, public outreach, media role, water-related energy savings. Makes recommendations for urban water suppliers on revenue recovery, reducing use of rebates as demand management, and scaling drought response tasks for different levels of gov't. Summarizes & analyzes CA legislation establishing approval for long-term budget-based efficiency targets.
Lit-13 Remote sensing assessments of consumptive use of agricultural water in western slope of Colorado	2016	Vashisht, Colorado State University, Colorado	CSU Master's Thesis evaluating remote sensing for estimating monthly consumptive use (CU) and conserved CU (CCU) on the West Slope	Used evapotranspiration (ET) observations at experimental plots of traditional irrigation and water-banking irrigation practices to evaluate methods of verifying CCU. Reviews methods for measuring and monitoring CU, discusses limitation and potential for ReSET remote sensing CU model.
Lit-14 Deficit irrigation and surface residue cover effects on dry bean yield, in-season soil water content, and irrigation water use efficiency in western Nebraska high plains	2018	Yonts et al, J. of Agricultural Water Management	2010-2015 study in Nebraska of efforts to decrease ag groundwater pumping; impacts of water use efficiency and crop yield	"Reducing irrigation water by 25% caused no significant yield reduction and improved irrigation water use efficiency by 26%." Applying 50% Etc. resulted in 30% yield reductions, and planting directly in crop residue did not improve bean yield under deficit irrigation. Ample early season rainfall is a boon to pre-flowering deficit irrigation yields, but under normal-to-dry conditions post-flowering deficit yields more.
Lit-15 Irrigation Efficiency and Water Balance of the Little Wind Unit on the Wind River Indian Reservation in Wyoming	2017	Rosado, U of Wyoming	Master's thesis on irrigation system efficiency in Little Wind Unit	Uses ag water balance & geophysical techniques to quantify & locate water losses. "Large errors and data gaps associated with the inflows, outflows, diversions, and precipitation data, [...which] identified specific needs for better data."
Lit-16 Standardizing Temporary Water Transfer Procedures in Colorado	2020	Nicols, Peter D, et al, University of Denver Water Law Review	Review of strengths and challenges of existing legal mechanisms for ATMs and recommendations for consolidation and standardization.	This article will describe the barriers in existing law to temporary transfers and the various approval mechanisms available under existing Colorado law. It will provide an assessment of the strengths and limitations of the existing transfer methods and make a recommendation for consolidation and standardization.

Title	Primary Purpose / Goal of Report / Study	Key Takeaways (Related to Objective / Goal)
Lit-01	Analysis of ag impacts from salmon-recovery-related flow alterations in Columbia River. "This paper presents an analysis of changes in profit from agricultural production under alternative salmon recovery measures. (Rather opposite of other DM literature, which analyzes impacts to Ag as primary and ecological impacts as secondary.)	Investigates ag impacts of fish recovery measures "such as: modified timing for dam releases, reservoir drawdown, and flow augmentation in the Columbia River basin, on the regional agricultural sector are evaluated. [....] Results suggest that drawdown and/or minor reductions in irrigation water diversions would reduce producers' profits by less than 1% of baseline levels. However, the most extreme scenario--a long drawdown period combined with a large reduction in irrigation diversions--would reduce producers' profits by $35 million (2.5%) annually."
Lit-02	- "Estimate the technically feasible levelized cost of water provided by seven above-code water efficiency (i.e., beyond that required by building code) and reuse technologies." - Model uncertainty and variation in technology adoption cost and performance ..... differentiate between new construction and retrofits. - Developed a conservation supply curve to compare the levelized cost of efficiency and reuse technologies with conventional supply-side water management strategies.	"- We estimate that efficiency and reuse in the residential sector can meet 85% of 50-year projected needs (the difference between projected demand and estimated supplies) for the LCRA service area. - We also estimate lower levelized costs for immediate retrofits of most technologies, promoting incentives for early technology adoption. - The fraction of demands met by demand-side strategies range from around 60% to 100%. Occupancy drives much of the variability because it significantly affects demand. - Water-efficient showerheads and bathroom faucet aerators perform well over a variety of assumptions, indicating that these technologies should be a priority for [illegible]
Lit-03	Estimate costs of a water bank under four frameworks which model how a Colorado Basin water bank would operate at a scale sufficient to address 250,000 AF of demand management (or consumptive use reduction) in the State of Colorado from Western Slope agriculture : 1. Avoidance #1 - Annual Water Bank Leases. 2. Avoidance #2 – Option Leases in Critical Years. 3. Avoidance #3 – Critical Year Leases. 4. Response to Compact Call.	"To achieve our goal, we used a social psychological theory known as the Theory of Interpersonal Behavior. A sample of 250 rice growers in southwest Iran was selected. Structural equation modeling showed that farmers' intention to change from rice cultivation to another crop is determined by personal norms, beliefs about their role and emotional considerations.
Lit-04	"The objectives of the research are to: l) identify the variables which determine the feasibility of the WROA [water rights option agreement] for urban water supply, 2) locate any existing WROA applications, 3) formulate a WROA model by examining technical, legal, and operational factors, and 4) perform a case study to evaluate the WROA model and analysis methodology. The perspective of the investigation has been from the viewpoint of the municipal water utility.	"Results of the analysis of alternative dry-year supply scenarios suggest that the WROA can be superior in terms of cost, reliability, and operational flexibility to both water-right purchases and construction of additional reservoir storage." Findings: "1) During the 1976-1978 Colorado drought short-term water transfers were the most widely used method for obtaining additional water during shortage. 2) Seasonal temporary water transfers are routinely done in several areas of the state. 3) The use of long-term agreements for temporary water transfers is not widespread. 4) There is risk in entering WROA because of potential challenge by objectors. 5) Criteria govern the decision-making process for dry-year water supply. These criteria are water supply reliability and control of the source, customer satisfaction, cost of water supply, and operational limitations of water supply alternatives. [illegible]
Lit-05	[illegible]	[illegible]
Lit-06	[illegible]	[illegible]
Lit-07	[illegible]	[illegible]
Lit-08	[illegible]	[illegible]
Lit-09	[illegible]	[illegible]
Lit-10	[illegible]	[illegible]
Lit-11	[illegible]	[illegible]
Lit-12	[illegible]	[illegible]
Lit-13	[illegible]	[illegible]
Lit-14	[illegible]	[illegible]
Lit-15	Paper not found.	[illegible]
Lit-16	1) Describe the barriers in existing [illegible] 2) Describe the various approval [illegible] Colorado law 3) Provide an assessment of the [illegible] transfer methods 4) Make a recommendation for [illegible]	[illegible]

Title	Project Location Information: Project Location(s) Description	Latitude	Longitude	Elevation (feet)	DM Program Basics: DM Program/Activity Name	DM Program Structure	Nature of DM Practices	Duration of DM Practices Implementation (Program Duration and Frequency)
Lit-01	Columbia-Snake River Basin, ID, OR & WA	N/A	N/A	N/A	Augmentation of flows in the Snake-Columbia River Basin	Not discussed - looks at possible implications for ag by moving water from irrigation to instream flows to increase time/distance travelled by young salmon to the ocean.	Unlike other reports, this report describes the primary motivation for flow alterations as environmental (salmon recovery). Ag impacts are addressed as a consequence.	Seven scenarios of recovery measures presented in Table 2, page 28.
Lit-02	Lower Colorado River Authority service area (central TX)	30.294	-97.782	550	Demand-side management for urban water management	Not discussed.	Municipal demand-side management strategies: - 5 "above-code" (water use efficiency beyond that required by building code) efficiency - 2 reuse technologies (household rainwater harvesting and integrated toilet-sink devices)	Not discussed.
Lit-03	Iran	N/A	N/A	N/A	Demand-side management	Voluntary	Switching to less water intensive crops [illegible] growing, as a water intensive crop).	[illegible]
Lit-04	General study of Colorado. Case study: Greeley CO, Boyd Lake System				Not discussed.	Referenced a drought water supply plan as a proposed framework for implementing a water right option agreement (WROA). The drought water supply plan would be submitted to the State Engineer's Office (SEO) for review and approval under existing Colorado statutes.	Temporary transfers from Agriculture using [illegible] Right Option Agreement (WROA).	[illegible]
Lit-05	San Luis Valley (SLV), Rio Grande Basin, Colorado. 700 active self-governing irrigation systems.	37.434331 W	-105.866664 N	7000	Common Pool Resource (CPR) governance and influence of irrigation performance of shortage sharing and delivery methods during drought.	Not discussed.	"Two common drought responses of irrigation [illegible] (1) water delivery via rotation and (2) shortage sharing, in four configurations [illegible]	[illegible]
Lit-06	United States and Australia. Specific programs discussed in CA, AZ, NE, and Murray-Darling Basin of Australia	Several project locations across several states discussed in this paper.	Several project locations across several states discussed in this paper.	Several project locations across several states discussed in this paper.	An analysis of water trading markets	Not discussed.	Suspending irrigation for an entire year [illegible] has a documented history of regular irrigation [illegible] "regulated deficit irrigation", Seasonal [illegible] year-round) suspension of irrigation	[illegible]
Lit-07	San Luis Valley, Rio Grande Basin, Colorado.	37.58 W	-106.15 N	7600	Not discussed - document analyzes current practices rather than demand management practices.	Not discussed - document analyzes current practices rather than demand management practices.	Document analyzes current practices [illegible] demand management practices. It also [illegible] are the consumptive uses of water in the [illegible] Valley.	[illegible]
Lit-08	Northern Colorado	40.433 degrees N	104.633 degrees W	4,685	Deficit irrigation viability for maize producers in Colorado.	Used an agro-economic model connecting plant growth-stage specific evapotranspiration (ET) targets to farm profitability.	Deficit irrigation. "One potential alternative [illegible]	[illegible]
Lit-09	Republican River Basin (RRB) of Nebraska	39 degrees N	96 degrees W	~1,000	Models and analyzes costs of alternate spatial water management policies on individual groundwater users across a large ag watershed (groundwater trading).	Models and analyzes costs of alternate spatial water management policies on individual groundwater users across a large ag watershed (groundwater trading).	Trading of groundwater rights (e.g. pump [illegible] groundwater back to the stream).	[illegible]
Lit-10	North China Plain	36 to 40 degrees N	114 to 119 degrees E	160	Not discussed - no formal program.	Not discussed - no formal program.	Simulated how different cropping patterns [illegible]	[illegible]
Lit-11	See Table 1 pdf pg.. 9, for table of water saving measures, primary flow pathway estimated, saved volume, % savings, and location.	Several project locations across several states discussed in this paper.	Several project locations across several states discussed in this paper.	Several project locations across several states discussed in this paper.	Not discussed.	Not discussed.	Lit review of many practices. See Table [illegible]	[illegible]
Lit-12	California, Sacramento region	38.669 W	-121.27 N	231	Urban water conservation	Report discusses drought policies, drought planning and drought legislation	Municipal efficiency measures: "During [illegible]	[illegible]
Lit-13	Western Slope of Colorado, Uncompahgre Valley	38.509 N	-107.874 W	5,775	Not discussed - although chose to evaluate grass and alfalfa pastures because they occupy a large portion of irrigated agriculture in the study area and are economically fit for a water bank.	Not discussed.	More about the technology used to verify [illegible] practices than about the practices themselves [illegible]	[illegible]
Lit-14	Western Nebraska high plains (Panhandle District)	41.89 N	103.68 W	3900	Water conservation and deficit irrigation strategies for dry bean production in western Nebraska High Plains.	Not discussed.	Effect of the following in yield, soil water [illegible] irrigation water use efficiency of dry bean [illegible] Multiple irrigation scenarios (full irrigation, [illegible] irrigation, and rainfed) Surface residue conditions (bare versus [illegible] covered)	[illegible]
Lit-15								
Lit-16	NA, review of legal framework	NA	NA	NA	Not discussed.	Report presents a Proposed Uniform Temporary Transfer Procedure (from assessment of best features of all reviewed temporary transfer types). See lessons learned.	ATM.	[illegible]

Title	Source and Amount of Conserved Water: Source of Water Conserved	Amount of Water Conserved- Conserved Consumptive Use (CCU)	High Level Program Structure: DM Program Administration	DM Program Monitoring & Verification Considerations	DM Program Education and Outreach Efforts	Tools Used to Measure General Outcomes	DM Program Funding Considerations	DM Program Economic Considerations	DM Program Agricultural Impacts Considerations	Recreation	Program Effectiveness: Program Lessons Learned	Identified Program Successes and/or Challenges	Program Pros/Cons
Lit-01	Idaho Water Bank and permeant water purchased by USBR	"Reclamation has been purchasing water in the upper Snake River basin since 1993. More than 57,500 acre-feet in permanent water rights and an average of 267,000 acre-feet of in annual leases from the Idaho Water Bank have been procured through voluntary transactions. Combined, these purchases total roughly 75% of the interim goal for flow augmentation of 0.427 maf. "	Analysis of economic impacts to ag for possible scenarios to improve salmon and steelhead populations in the Snake-Columbia River Basin.	Not discussed - analysis of economic impacts to ag for possible scenarios to improve salmon and steelhead populations in the Snake-Columbia River Basin.	Not discussed - analysis of economic impacts to ag for possible scenarios to improve salmon and steelhead populations in the Snake-Columbia River Basin.	Not discussed - analysis of economic impacts to ag for possible scenarios to improve salmon and steelhead populations in the Snake-Columbia River Basin.	As the USBR has stated reductions in agricultural deliveries would need to be voluntary and would thus need to be compensated by the federal government at a level high enough to cover profit losses	Figure 2 summarizes the percent change in profit for each of the 7 scenarios of reservoir drawdowns and/or flow augmentations. Decreases in producer profits for the region are as follows: Scenario 1 (Core management measures which were already set for implementation in 2000) - 0.15% Scenario 2 (Flow augmentation (low flow))- 0.27% Scenario 3 (Flow augmentation (high flow)) - 2.38% Scenario 4 (Reservoir draw down (2 month)) - 0.33% Scenario 5 (Reservoir draw down (4.5 month)) - 0.67% Scenario 6 (Flow augmentation (low flow) and Reservoir draw down (2 month)) - 0.46% Scenario 7 (Flow augmentation (high flow) and Reservoir draw down (4.5 month)) - 2.77%	The analysis considers which crops would be most heavily impacted (specifically higher-valued specialty crops which have a lower profit margin), which areas would be most impacted (the Idaho portion of the Snake River Basin), and the specific impact to profits. Other than impacts to lost profits from crop sales, the analysis also considered increased power costs due to lower hydroelectric outputs and increased shipping costs due to impacted barge transportation were included in the profit impacts.	Not discussed.	Not discussed.	Not discussed - an analysis of possible scenarios to improve salmon and steelhead populations.	Not discussed - an analysis of possible scenarios to improve salmon and steelhead populations.
Lit-02	Municipal demand management activities	Not discussed.	Not implemented; studied by the Lower Colorado River Authority (LCRA)	Not discussed.	Not discussed.	No assessment for environmental impacts associated with this specific study for the 2012 State Water Plan for Texas includes a high-level assessment of environmental impacts of all recommended and alternate water [illegible]	Studied the levelized costs for technologies in a "replace-immediately" scheme versus a "replace-as-retire" scheme	Studied the levelized costs for technologies in a "replace-immediately" scheme versus a "replace-as-retire" scheme	Not discussed.	Not discussed.	This study highlighted demand-management options to traditional water supply provisions and developed a supply curve to guide economically efficient incentive programs that achieve optimal water savings. Also recognized was the need to understand the potential indirect effects on [illegible]	Not discussed.	Studied the levelized costs for technologies in a "replace-immediately" scheme versus a "replace-as-retire" scheme Recognized further studies will be needed and the need to understand environmental impacts
Lit-03	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Lit-04	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Lit-05	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Lit-06	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Lit-07	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Lit-08	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Lit-09	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Lit-10	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Lit-11	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Lit-12	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Lit-13	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Lit-14	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Lit-15	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Lit-16	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Exhibit B-9
ATM Documents with General Criteria

Title	Date	Publisher/Authors	Description	Notes	Storymaps
ATM-01 Use of Alternative Transfer Methods to Increase Water Supplies for Conejos Basin Agriculture, Municipal, and Environmental Purposes	2017	https://dnrweblink.state.co.us/cwcb/ElectronicFile.aspx?docid=205333&dbid=0	Trujillo Meadows Reservoir ATM Study (TMR Study): "The primary objective of the TMR Study is to investigate the feasibility of a unique ATM that involves enlarging Trujillo Meadows to provide intra-year regulation of water supplies including direct flow storage and storage of other agricultural and augmentation water rights for agricultural users diverting from the San Antonio.	ATM w/ recreational and environmental benefits for municipal augmentation w/enlargement of Trujillo Meadows Reservoir. Stakeholder meetings for federal & state agencies, ag, and town aug needs. Model of ATM, details of benefits, recommended path fwd. Appendix A estimates of monthly inflows to reservoir. Water rights include USFS Reserved Rights decreed as ISF, interstate shepherding for flow through NM.	https://storymaps.arcgis.com/stories/a7139282761f4468a98d50db7b5b0aa5
ATM-02 Development of Land Fallowing-Water Leasing in the Lower Arkansas Valley	2011	https://dnrweblink.state.co.us/cwcb/ElectronicFile.aspx?docid=195733&dbid=0	The goal of this report is to "report on the development from 2002 through mid-2011 of rotational land fallowing -water leasing (fallowing-leasing) in the Lower Arkansas Valley of Colorado (Lower Valley) by the Lower Arkansas Valley Water Conservancy District (Lower Ark District) and the Lower Arkansas Valley Super Ditch Company, Inc. (Super Ditch)."	Return flow needs may require additional recharge ponds & stations; Return flows unnecessary at times due to trans-basin supply; considers monthly return flow "factors"; analysis by Leonard Rice Engineers found that replacement water will be required in the non-irrigation season in most cases.	https://storymaps.arcgis.com/stories/c287ea9b04404a54a82ddddcfed875b0
ATM-03 Little Thompson Farm ATM Grant Completion Report	2018	https://www.larimer.org/sites/default/files/uploads/2018/larimer_county_atm_final_report.pdf	Study funded through CWCB 2015 ATM Grant. The Little Thompson Farm receives supply from Handy Ditch and Reservoir Company shares and 240 C-BT units. The consultant team found that "it was feasible for Larimer County to afford, from a water supply perspective, to sell some C-BT units (115) and share some other units (80) in some years, while still having sufficient water on the farm for corn and sugar beets, as well as crops that require less water." The study looks at aspects of feasibility, including: Economics; Farm Financial Viability under wet, dry, and very dry year scenarios; dry year water value. The report also investigates potential partnerships, and outlines the final water sharing agreement. "Larimer County sold 115 C-BT units to Broomfield and retained a first right of refusal to lease back these units for assessment cost plus 10%, when available. " The report also discusses Lessons Learned and Future Considerations: Legal Hurdles/Barriers to Replication (Northern Rulemaking, Direct Flow Rights, Delivery Efficiency Impacts from Water Transfers); Public Perception & Political Will (Educating and Obtaining Support of Leadership, Public Support, Out of County Partners, Continued Education); Negotiating an ATM: Successful Tips, Tricks, and Tools (Establish and Pursue Goals with an Open Mind About Implementation, Minimize the Cooks and Trust Your Team).	Cover crop & leaving crop residue prevents wind erosion, maintains soil fertility, controls weeds; non-irrigated cover crops: dryland milo, sorghum/Sudan grass for soil health, reduce weeds, potential revenue; w/no cover crop, control weeds w/herbicide or tillage (tillage can reduce erosion by forming large soil clods & enhancing infiltration); Class II and III soils, slopes 0-5%, not high enough for severe erosional problems; no/low-till also recommended to reduce direct evap, improve soil health, reduce fuel & costs; irrigation efficiency via contour farming, drip irrigation, SM & ET monitoring, drought tolerant crops, GPS irrigation guidance; no return-flow requirements due to CBT water, so no effort to quantify despite opponents	https://storymaps.arcgis.com/stories/db070907b9a74aa38e503b718dc7beb1
ATM-04 HB13-1248 Catlin Canal Company Rotational Land Fallowing-Municipal Leasing Pilot Project	2018	https://dnrweblink.state.co.us/cwcb/0/edoc/210320/19%2001%2015%202018%20Annual%20Report%20-%20Catlin%20Pilot%20Project%20FINAL.pdf?searchid=3856cf32-c475-4163-840c-5361fa65041f	The Catlin Pilot Project was the first rotational land fallowing-municipal leasing pilot project under HB 13-1248: Irrigation Water Leasing Municipal Pilot Projects. This project aims to makes available up to 500 acre-feet of water for lease to three municipal water providers – the Town of Fowler, the City of Fountain, and the Security Water District (Municipal Participants) - from rotational fallowing of lands located on six farms irrigated under the Catlin Canal in the Arkansas River Basin.	Huge emphasis on return flows; using Lease Fallow Tool from DWR to calc available water & owed returns; "Pay As You Go" target deliveries for return flow; use of recharge structures supported well-timed return flows; augmentation station used for faster return flows and consumptive use water delivered to municipal participants; erosion & weed control included herbicide, disk tilling, cover crops (winter wheat, hay)	https://storymaps.arcgis.com/stories/c3299ac9dcc34b0caa0ab9a9958bd000
ATM-05 Yampa Basin ATM Study	2014	https://dnrweblink.state.co.us/cwcb/0/edoc/199193/Yampa%20-%20NC%20Use%20of%20ATM%20to%20Meet%20Non%20Consumpt%20Needs_FINALReport%203-28-14_with%20apps.pdf	Study conducted by Trout Unlimited (TU) and funded by CWCB's Alternative Agricultural Water Transfers Grant Program. The purpose of the study was to identify locations in the Yampa Basin where potential ATM transactions could help to meet multiple uses (nonconsumptive needs and agricultural shortages), and identify types of ATM transactions most suitable for meeting multiple purposes. Ideal candidate reaches, as specified by project proponent TNC and its partners, would involve the following scenario: - Upstream agricultural water user with full or surplus irrigation supplies and transferable CU water - Downstream agricultural water user with an irrigation CU shortage (consumptive need) - A need for water in the reach between to improve flows for trout (including Colorado cutthroat trout) or warmwater fish (nonconsumptive need)	Used StateMod delay table to estimate historic return flows; more efficient irrigation improves water quality by lowering return flow contaminant transport, fewer excess nutrients due to fertigation in drip systems; TNC/TU partnership to support instream flows for habitat w/ATM loans used when downstream ISF right is not satisfied & to provide flow in a reach without ISF right	https://storymaps.arcgis.com/stories/ee2fa0ebadce44ca85b7bf43bac33ddf
ATM-06 Grand Valley Water Users Assn Conserved Consumptive Use Pilot Project Development: Process, Procedure, and Lessons Learned: Water Banking-Next Steps Part II	42795	http://www.grandvalleywaterusers.com/uploads/8/2/6/0/82606774/03-01-17_ccupp_projectdevelopment_final.pdf	The Conserved Consumptive Use Pilot Project (CCUPP) is a pilot demand management project intended to test the mechanisms necessary for a Western Slope irrigation water provider to intentionally reduce consumptive use in a voluntary and compensated manner. This report summarizes the process of developing the CCUPP, the procedure used, and lessons learned.	Land management contract: manage weeds & plant growth, soil erosion (leave plant residue, tillage for clods, tillage for crust), w/mid-season visit to confirm mgmt. activities are consistent w/contract; interviewees concerned w/DM externalities including local economy & aesthetics; CCU verification procedures (Exhibit B) don't specify methods to verify CU on fallowed land, but does include sites visits to verify land mgmt. and explicitly prohibits any active plant growth on fallowed land	https://storymaps.arcgis.com/stories/4df25832c5a44a28ba7c23d5fa907b77
ATM-07 Grand Valley Water Users Assn 2017 CCUPP In-Season Verification	2017	https://dnrweblink.state.co.us/cwcb/ElectronicFile.aspx?docid=205144&dbid=0	Field compliance and payment summary for the 2017 CCUPP, including verification forms for each program participant for 2017.	Includes 2017 verification documentation including photographs, recommendations, comments/notes	https://storymaps.arcgis.com/stories/98e07093392249e8a1f2acd5e35bcae6
ATM-08 Power Canal Capacity Report, Grand Valley Water Users Assn	12/1/2015	https://dnrweblink.state.co.us/cwcb/ElectronicFile.aspx?docid=201813&dbid=0	Very brief report on "one potential mechanism through which water associated with CCU could be protected and returned to the Colorado River under a pilot project water bank" to convey CCU via unused capacity within the Orchard Mesa Power Canal (power canal) to deliver water to the Grand Valley Power Plant (GVPP). The report investigated the potential unused capacity within the Power Canal, including the potential for additional water to generate hydroelectric power.	Very brief report on "one potential mechanism through which water associated with CCU could be protected and returned to the Colorado River under a pilot project water bank." Compensated, temporary, voluntary. Lists current operations, water rights, data. Incomplete file in link, merged with 2017 Next Steps Part II	https://storymaps.arcgis.com/stories/36c55be4c1e64858b16b417c10d9125e
ATM-09 Completion Report: Development of Practical Alternative Agricultural Water Transfer Measures for Preservation of Colorado Irrigated Agriculture	5/1/2011	https://dnrweblink.state.co.us/cwcb/ElectronicFile.aspx?docid=195709&dbid=0	An extensive evaluation to: 1) To identify barriers to implementation of alternative transfers and to describe potential strategies for overcoming barriers. 2) To develop tools for agricultural producers to evaluate the viability of potential alternative transfers. 3) To further actual alternative transfers by evaluating three demonstration projects that include owners of agricultural water rights and potential end users of the temporarily transferred water.	Extensive final report on ATM investigation & pilot on NE South Platte covering barriers (cost, risk/uncertainty, lack of supply, reluctance, power dynamic), needs and means to address barriers, Lease Evaluation Tool (AgLET) ag economics evaluator, exchange capacity analysis, flex market pilot project w/Aurora.	
ATM-10 Final Project Report: Implementation of Deficit Irrigation Regimes: Demonstration & Outreach	May-16	https://dnrweblink.state.co.us/cwcb/ElectronicFile.aspx?docid=199317&dbid=0	Evaluation of different methods of monitoring crop water stress and consumptive use (CU) under deficit irrigation. Demonstrations, workshops, educational outreach on crop stress monitoring.	Demo project to evaluate different methods of monitoring crop water stress and CU under deficit irrigation & demo educational outreach on crop stress monitoring.	
ATM-11 The Poudre Water Sharing Working Group: A Report to the CWCB	May-15	https://dnrweblink.state.co.us/cwcb/ElectronicFile.aspx?docid=198097&dbid=0	Final report of Poudre Water Sharing Working Group - a prototype ATM water sharing group between agricultural users (North Poudre Irr Co, Water Supply & Storage Co, New Cache la Poudre Irr Co, and Larimer/Weld Irr Co) and municipal users (Fort Collins, Greeley, and Tri-Districts) on the Poudre River, facilitated by the Colorado Water Institute at Colorado State University. The report focuses on the formation of the working group, relationship building, lessons learned, survey of ag users, development of prototype agreements, and regional cooperation strategies.	Final report of prototype ATM water sharing group between ag (North Poudre Irr Co, Water Supply & Storage Co, New Cache la Poudre Irr Co, and Larimer/Weld Irr Co) and muni (Fort Collins, Greeley, and Tri-Districts) on the Poudre River. Identified CCU calculation methods as a large barrier.	
ATM-12 FLEX Water Market: Education and Implementation Phase	December-15	https://dnrweblink.state.co.us/cwcb/ElectronicFile.aspx?docid=197916&dbid=0	Investigation of FLEX water market implementation: engagements, index ba	Investigation of FLEX water market implementation: engagements, index based pricing, theorizing on large-scale implementation, meetings between willing shareholders.	
ATM-13 Alternatives to Permanent Dry Up of Formerly Irrigated Lands	June-13	https://dnrweblink.state.co.us/cwcb/ElectronicFile.aspx?docid=199208&dbid=0	Review of benefits and issues of two alternatives to buy and dry that maintain some continued level of agricultural production: 1) Dry land farming, and 2) limited irrigation.	Review of benefits and issues of buy and dry and alternatives. Potential for conversion of ag land to dry land or deficit-irrigation, economic & maintenance issues w/dry land & deficit.	https://storymaps.arcgis.com/stories/bb77395b6a7c4501bb1b3090c2102d7a
ATM-14 Water Partnerships: an evaluation of alternative agricultural water transfer methods in the South Platte basin.	March-12	https://dnrweblink.state.co.us/cwcb/ElectronicFile.aspx?docid=199215&dbid=0	Water market experiment, survey of municipal & industrial providers on ATM practices, leases, evaluation of shared water bank scenarios on South Platte, focused on FRICO shareholders.	Water market experiment, survey of municipal & industrial providers on ATM practices, leases, evaluation of shared water bank scenarios on South Platte	
ATM-15 Project Report: Lake Canal alternative agricultural practices and in-stream flow demonstration project	June-13	https://dnrweblink.state.co.us/cwcb/ElectronicFile.aspx?docid=203045&dbid=0	Proof of concept project planning for ATM/ISF program on Lake Canal. Monitoring/verification based on deliveries, surface returns, inflow to recharge pits, and soil moisture sensors to verify return flows by lack/presence of moisture movement below the root zone. Project was not implemented due to ongoing water scarcity at the time (2012-2013) and inability to agree on a price. Describes extensive legal work to arrive at proof of concept.	Proof of concept project planning for ATM/ISF program on Lake Canal. Monitoring/verification based on deliveries, surface returns, inflow to recharge pits, and soil moisture sensors to verify return flows by lack/presence of moisture movement below the root zone. Project was not implemented due to ongoing water scarcity at the time (2012-2013) and inability to agree on a price. Describes extensive legal work to arrive at proof of concept.	
ATM-16 Final Report of the Lower South Platte Irrigation Research and Demonstration Project	Jun-14	https://dnrweblink.state.co.us/cwcb/ElectronicFile.aspx?docid=199218&dbid=0	Technical research paper with three tasks. Task 1. Develop calculation & verification of consumptive water use and water savings, such that water court requirements can be satisfied--uses a stress coefficient, the crop water stress index CWSI, and the ReSET model of remote sensing. ReSET showed accuracy of 92-98% for fields under normal growing conditions and successfully detected abnormal growing conditions to accordingly reduce ET estimates. Task 2. Simplify the administrative burden of maintaining return flows. Task 3. Estimate supply delivery potential. Project on Lower South Platte Irrigation Research Farm near Iliff.	Goals were 1. Develop calculation & verification of consumptive water use and water savings, such that water court requirements can be satisfied--uses a stress coefficient, the crop water stress index CWSI, and the ReSET model of remote sensing. ReSET showed accuracy of 92-98% for fields under normal growing conditions and successfully detected abnormal growing conditions to accordingly reduce ET estimates. 2. Simplify the administrative burden of maintaining return flows, and 3. Estimate supply delivery potential. Project on Lower South Platte Irrigation Research Farm near Iliff.	https://storymaps.arcgis.com/stories/f5143e8862254df6bbdfd3128d27f165
ATM-17 RGWCD Net Annual Replacement Plans	Reports exist for each year. Reviewed report for April 13, 2020	https://rgwcd.org/sd-1-annual-replacement-plan	Rio Grande Water Conservancy District plan to meet interstate compacts through forbearance agreements, leases for exchanges to meet streamflow criteria, temporary fallowing agreements, etc. Reviewed the 2020 Annual Replacement Plan (ARP), to meet requirements for the Plan Year under the provisions of the PWM for Subdistrict No. 1 decreed by the Division No. 3 Water Court in Case Nos. 2006CV64 and 2007CW52. This report describes a plan to remedy injurious stream depletions caused by the withdrawal of groundwater from Subdistrict Wells. This ARP includes a series of tables created by Subdistrict No. 1 staff and the RGDSS modeling team tabulating stream replacement quantities and locations resulting from Subdistrict No. 1 well groundwater withdrawals and a water portfolio to be used to replace such stream depletions.	Rio Grande Water Conservancy District plan to meet interstate compacts through forbearance agreements, leases for exchanges to meet streamflow criteria, temporary fallowing agreements, etc.	
ATM-18 Alternative Water Transfers in Colorado: A Review of Alternative Transfer Mechanisms for Front Range Municipalities	2016	https://www.edf.org/sites/default/files/alternative-water-transfers-colorado.pdf	Review of ATMs in Colorado for Front Range Municipalities. The report conducted a screening analysis to identify potential case studies for a more detailed analysis of ATM, found 35 municipal water providers based on water source and demand size criteria. Two case study participants were identified: City of Fountain and Town of Windsor. The report conducted a financial analysis of water supply alternatives for the two case studies; findings include recommendations for best ATM practices to suit those municipalities.	Review of ATMs in Colorado for Front Range Municipalities. The report conducted a screening analysis to identify potential case studies for a more detailed analysis of ATM, found 35 municipal water providers based on water source and demand size criteria. Two case study participants were identified: City of Fountain and Town of Windsor. The report conducted a financial analysis of water supply alternatives for the two case studies; findings include recommendations for best ATM practices to suit those municipalities.	

Title	Primary Purpose / Goal of Report / Study	Key Takeaways (Related to Objective / Goal)
ATM-01	Trujillo Meadows Reservoir ATM Study (TMR Study): "The primary objective of the TMR Study is to investigate the feasibility of a unique ATM that involves enlarging Trujillo Meadows to provide intra-year regulation of water supplies including direct flow storage and storage of other agricultural and augmentation water rights for agricultural users diverting from the San Antonio. This reregulation of existing and augmentation supplies could provide a more reliable supply for existing agricultural users and potentially allow these agricultural users to lease their Project Water to the Towns for replacement of well-pumping depletions owed by the Towns. In addition, the project evaluated other potential multiple-objective benefits, such as enhanced recreational opportunities at Trujillo Meadows and retiming of releases from Trujillo Meadows for environmental benefits such as enhanced riparian habitat and streamflow on the Rio De Los Pinos (Los Pinos). Potential indirect benefits include retimed streamflow on the Conejos River below Platoro Reservoir (Platoro) due to the release of Project Water for augmentation of the Towns' pumping depletions and meeting Compact delivery requirements."	- "Coordinated operations between Platoro, Trujillo Meadows and a potential new reservoir near Ortiz could improve streamflow and agricultural yields." - "Between 660 and 1,900 acres of irrigated agriculture would need to be dried up to meet the Towns' well pumping depletions." "The CWCD would prefer that The Towns avoid acquiring and transferring agricultural rights for well replacement since this would result in a loss of irrigated agricultural land." - "Estimated annual inflow into Trujillo Meadows varies greatly from a minimum of 1,850 to a maximum of 27,600." - "There is very little priority water on The Los Pinos that can be stored in Trujillo Meadows." - "The Federal Reserved Right on the Los Pinos River limits the opportunity to store water in Trujillo Meadows Reservoir." - "Additional direct flow and priority storage for The agricultural users will improve The water supplies to The agricultural users."
ATM-02	The goal of this report is to "report on the development from 2002 through mid -2011 of rotational land fallowing -water leasing (fallowing -leasing) in the Lower Arkansas Valley of Colorado (Lower Valley) by the Lower Arkansas Valley Water Conservancy District (Lower Ark District) and the Lower Arkansas Valley Super Ditch Company, Inc. (Super Ditch)." "The goal of fallowing -leasing is to provide an alternative to historical "buy -and-dry" transfers of agricultural water rights to meet municipal water needs to avoid further harm to the agricultural economy and communities of the Lower Valley." "The concept behind the Super Ditch is the creation of a negotiating agent that can act on behalf of water ditch shareholders who are interested in leasing water on a rotational basis to cities. Farmers believe they will have greater bargaining power to receive the best price from municipalities when acting together, while retaining ownership of their water rights." "The Report then reviews the various issues and technical investigations the Lower Ark District undertook to foster fallowing -leasing and the Super Ditch. Both the Lower Ark District and the farmers paid particular attention to the economics of fallowing-leasing, not only for irrigated agriculture but also for the cities who may lease water."	" - In sum, Super Ditch fallowing -leasing is on the verge of becoming operational (in 2012). Significant challenges remain, although it appears likely that current and planned efforts by the Lower Ark District and the Super Ditch to implement fallowing -leasing will be successful. " "- Fallowing-leasing in the Lower Valley has moved towards reality faster than many predicted, although too slowly for others. Municipal acceptance of leasing rather than buying water rights remains the principal challenges to fallowing -leasing, although significant progress is evident. - Requirements of Colorado Water Law to implement fallowing -leasing remain a challenge – primarily because of cost and effort – although the Super Ditch can implement leases under current law. - The Lower Ark District is diligently pursuing storage capacity to maximize the amount of water Lower Valley farmers could lease. - Lower Valley farmers recently expressed overwhelming interest in participating in fallowing -leasing. The Lower District and Super Ditch are working with Honey Creek Resources to develop a spreadsheet tool (Farm Budget) to allow farmers to evaluate the economics of fallowing -leasing at a farm level. This effort is funded by an Alternative Agricultural Transfer Methods CWCB Grant, awarded January 2011."
ATM-03	Goals: "1) conserving a viable, irrigated farm in perpetuity, 2) offsetting the costs through piloting a water-sharing agreement with a municipal water provider, and 3) providing a catalyst for a viable model for future ATMs, Larimer County set out to execute the first perpetual agriculture-to-municipal ATM in the state." In 2016, Larimer County was "approached by a willing landowner to purchase and conserve 211 acres of prime farmland with scenic vistas, wildlife habitat, a community buffer, and historic value, plus almost $7million of water rights. To determine if an ATM would be feasible for this farm, the Colorado Water Conservation Board (CWCB) funded a team of experts to help Larimer County and its citizen advisory boards compile the water, agricultural, and legal knowledge needed to design an agreement that would work for both the farm and a municipality, while meeting the above-stated goals."	"Ultimately, Larimer County and Broomfield reached a deal on a water-sharing agreement where Larimer County could conserve a viable 211-acre farm (see Figure 1) in perpetuity for about half of the initial purchase price, and Broomfield could acquire a dependable water supply and reliable drought, drought-recovery, and emergency water supply at a reduced cost."
ATM-04	The Catlin Pilot Project was the first rotational land fallowing-municipal leasing pilot project under HB 13-1248: Irrigation Water Leasing Municipal Pilot Projects (codified at C.R.S. § 37-60-115(8)). A primary goal of this study was to meet the legislative policy goals articulated in H.B. 13-1248. This project aims to makes available up to 500 acre-feet of water for lease to three municipal water providers – the Town of Fowler, the City of Fountain, and the Security Water District (Municipal Participants) - from rotational fallowing of lands located on six farms irrigated under the Catlin Canal in the Arkansas River Basin. The purpose of the report is to document accounting, acres and shares fallowed, HCU generated, return flow obligations, impact on erosion and weeds, costs of operations, lease payments, obstacles encountered, etc.	"2018 marked a fourth highly successful year of Catlin Pilot Project operations. More than 300 acre-feet of water was supplied to the Town of Fowler, the City of Fountain, and the Security Water District. Operations were able to consistently meet all return flow obligations through the use of project facilities, including two recharge ponds that performed well. The Catlin Pilot Project operated exchanges into Pueblo Reservoir at all times desired to make deliveries to Fountain and Security. The fallowing of historically irrigated fields did not result in any problems from erosion or noxious weeds. An aspect of project design that proved particularly helpful in utilizing all water generated by operations was differing delivery locations for the multiple municipal participants (Fountain and Security by exchange in Pueblo Reservoir and Fowler at the point of delivery to the Arkansas River) such that operation of an exchange was not always necessary. Participating Farms received an average of $688.87 per fallowed acre. Fountain and Security obtained water during times of high demand for $500 per acre-foot. Experience gained during 2015, 2016, and 2017 operations was used to fine-tune accounting and streamline operations, which were successfully implemented in 2018. The cooperation and communication among the State and Division Engineers, water users, Kansas, and the Catlin Pilot Project facilitated identification and resolution of obstacles to operation of rotational fallowing-leasing." "In addition to meeting the legislative policy goals of H.B. 13-1248, the Catlin Pilot Project is significant to the entire State of Colorado because it is the first "proof of concept" in the State of rotational land fallowing-municipal leasing. This fourth year of operations again successfully demonstrated that rotational land fallowing-municipal leasing can be a viable alternative to permanent buy-and-dry. Specifically, the success of the Catlin Pilot Project in 2018 increased irrigators' interest in rotational fallowing-municipal leasing. It has also reduced other water users' anxiety about temporary transfers for municipal use and demonstrated the successful exchange and delivery of wet water at a reasonable cost. Additionally, Catlin Pilot Project operational experience has allowed the Super Ditch to submit a proposal to the CWCB for another larger fallowing-leasing pilot project to provide up to 5,000 acre-feet of water to Colorado Springs." The concept of an "Owe-the-River" was successful, and was recommended for future projects.
ATM-05	The specific objectives of the project were to: 1. Identify locations in the Yampa Basin where potential ATM transactions could help to meet nonconsumptive needs and agricultural shortages. 2. Identify the types of ATM transactions that are most suitable for meeting multiple purposes. 3. Conduct outreach to water rights owners, governmental entities and other interested parties to i) share the premise of the study, and ii) seek feedback for informing our understanding of potential ATM transactions. 4. Produce a final report describing potential ATM transactions, and 5. If willing participants are found, begin working toward implementation of a pilot ATM transaction.	23 candidate reaches were identified. "four remaining candidate reaches were selected to be analyzed in Level 4 screening. These included two reaches which showed potential for transfers between agricultural users (Reach 6 and Reach 10) and two reaches which showed potential for agriculture-to-ISF water right transfers (Reach 1 and Reach 12)" "This study identified several locations where ATMs meeting needs of both the environment and consumptive uses could be implemented, while also illustrating challenges that, if surmounted, could expand the number of leasing transactions that meets the needs for flexibility and increased mutual benefit among consumptive and nonconsumptive interests. There are also hopeful signs in the interest expressed across these sectors and in technical and policy innovations being pursued across Colorado. With the right set of collaborative efforts along with technical and legal tools, the type of leasing arrangement studied in this project could offer substantial benefit to both irrigators and the environment." "The ideal scenario... (upstream lessor, delivery to a downstream short irrigator, meeting environmental needs in between) is challenging to put together because of the mismatches in timing of water availability and shortages as well as challenges around water rights administration." " Leasing to meet both agricultural and environmental shortages simultaneously will benefit from collaboration among water users on a stream." "During this study, we heard clear interest in leasing from some individuals stemming from a desire to: - Increase options for deriving economic benefit from their water right, - Put their water right to a recognized use while dealing with short-term issues that prevent water use in any given year, such as needed maintenance, and - Benefit the environment."

Title	Project Location Information				DM Program Basics				Source and Amount of Conserved Water		High Level Program Structure								Program Effectiveness		
	Project Location(s) Description	Latitude	Longitude	Elevation (feet)	DM Program/Activity Name	DM Program Structure	Nature of DM Practices	Duration of DM Practices Implementation (Program Duration and Frequency)	Source of Water Conserved	Amount of Water Conserved- Conserved Consumptive Use (CCU)	DM Program Administration	DM Program Monitoring & Verification Considerations	DM Program Education and Outreach Efforts	Tools Used to Measure General Outcomes	DM Program Funding Considerations	DM Program Economic Considerations	DM Program Agricultural Impacts Considerations	Recreation	Program Lessons Learned	Identified Program Successes and/or Challenges	Program Pros/Cons
ATM-01	Colorado, Rio Grande Basin, Conejos Water Conservancy District (CWCD)	37.050966	-106.45169	10000	ATM / Storage enlargement	Reservoir expansion with possible dry-up required to meet augmentation for Rio Grande Compact obligations	ATM involving reservoir expansion of Trujillo Meadows Reservoir from 617 AF to 4,300 AF or 5,750 AF (two options).	Not discussed.	Agriculture transfer, proposed direct storage right, transmountain exchange	Reservoir expansion would increase reservoir storage of 3,683 to 5,133 AF (two alternative proposed alternatives).	This program could be described as administered by the DWR but is not clear	Stream flow measurement, storage measurement, dry-up associated with water right transfers to municipalities	Not discussed.	"Developed an operations model for this project and incorporated the model into the existing RiverWare Rio Grande Basin Planning model."	Not discussed.	Not discussed.	Project would be implemented to improve late-season deliveries to ag users, meet augmentation needs of Towns, and RG Compact obligations	"An enlargement of Trujillo Meadows would also result in increased surface acres and shoreline miles that would provide benefits for wildlife use and wildlife-related recreation (fishing, hunting, wildlife watching) and boating."	- "Coordinated operations between Platoro, Trujillo Meadows and a potential new reservoir near Ortiz could improve streamflow and agricultural yields." - "Between 660 and 1,900 acres of irrigated agriculture would need to be dried up to meet the Towns' well pumping depletions." - "The CWCD would prefer that The Towns avoid acquiring and transferring agricultural rights for well replacement since this would result in a loss of irrigated agricultural land." - "Estimated annual inflow into Trujillo Meadows varies greatly from a minimum of 1,850 to a maximum of 27,600." - "There is very little priority water on The Los Pinos that can be stored in Trujillo Meadows." - "The Federal Reserved Right on the Los Pinos River limits the opportunity to store water in Trujillo Meadows Reservoir." - "Additional direct flow and priority storage for the agricultural users will improve the water supplies to the agricultural users."	Challenges with filling Trujillo Meadows Reservoir: - "Estimated annual inflow into Trujillo Meadows varies greatly from a minimum of 1,850 to a maximum of 27,600." - "There is very little priority water on The Los Pinos that can be stored in Trujillo Meadows." - "The Federal Reserved Right on the Los Pinos River limits the opportunity to store water in Trujillo Meadows Reservoir."	Lots of potential benefits to operations and recreation as well as augmentation for Towns to address new groundwater pumping rules from DWR
ATM-02	Lower Arkansas Valley of Colorado				CWCB Alternative Transfer Methods (ATM) Grant Program (2015) Contract No C150427	Lease-fallow	ATM: rotational land fallowing -water leasing	This reports on development from 2002 through mid -2011.	Agriculture	3600 AF (dry year), 22500 AF (median), 53000 AF (wet year)	Lower Arkansas Valley Water Conservancy District and the Lower Arkansas Valley Super Ditch Company, Inc.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	NA	Municipalities were worried about another entity buying up water rights during lease and leaving the municipality high-and-dry after lease term expires	Not discussed.	Not discussed.

Exhibit B-10
SCPP Documents with M&V Criteria

Title	Date	Publisher/Authors	Description	Notes	Measurement of water returned to the stream
					e.g. analytical processes and whether or not M&V activities were measured, estimated, or not considered
SCPP-01 System Conservation Pilot Program Secondary Benefits: Final Report with Case Studies	2019	WestWater Research for TNC	This case study report looked at whether the reduction in consumptive use in SCPP projects also generated off-farm benefits by applying select methods to quantify off-farm benefits to two case studies in Colorado and Wyoming. Note from TNC: An executive summary is also available, along with a more detailed report that outlines the framework for assessing secondary impacts/benefits and the associated methodology for quantifying or evaluating each impact/benefit.	Benefits assessed include increased environmental flows, decreased cost of alternative habitat flow restoration projects, societal benefits from habitat flows for endangered species, estimates of dramatic savings in salinity control, and municipal and hydropower benefits. Increased flows for the evaluated Colorado projects contributed minimal improvement to recreational flow needs. Cost savings were estimated by the cost of existing augmentation plans used to meet environmental and salinity management needs.	-Grand Valley Project relied on existing ditch infrastructure to measure diversion at the Roller Dam and into the Power Canal. No specific methodologies or processes were identified. -Both projects relied on USGS stream gages to measure streamflow.
SCPP-02 Infographic: Grand Valley Pilot Project Secondary Benefits	2019	TNC	This infographic summarizes the results of secondary benefits analysis as applied to the Grand Valley Pilot Project Case Study.	Grand Valley Pilot Project paid farmers to voluntarily reduce their irrigation water use in order to keep more water in the river to help increase water security within the Colorado River Basin in the face of ongoing drought. While focus was on water security several off-farm benefits occurs because of the project.	Not discussed.
SCPP-03 Research Synthesis: Agronomic Impacts of Reduction Irrigation	2019	Culp and Kelly for TNC	This memo reviews research on fallowing and limited irrigation to highlight key findings related to agronomic impacts of limited irrigation or other methods to reduce consumptive use of irrigation water in the Upper Colorado River Basin. The concluding section also identifies remaining research questions and suggests potential implications and possible next steps for a demand management program. The appendix summarizes the parameters of several of the studies reviewed. All of the referenced reports and publications are available on request.	Reviews methods and findings of existing research on agronomic impacts of limited irrigation in the following categories: yield, quality, water use efficiency, recovery, soil health, weeds/diseases/pests, and ag operations. Next steps and identified research needs include understanding impacts over a variety of geographies and crops, as well as long-term recovery. Management and operations needs include understanding the benefits of rotational fallowing, deficit irrigation, and crop switching. Finally, there are many needs in the verification of conserved consumptive use.	Not discussed.
SCPP-04 Final Report: Colorado River System Conservation Pilot Program in the Upper Colorado River Basin	2018	Upper Colorado River Commission	Full SCPP report from UCRC; project list; Lessons learned: administration & implementation, operational, cost/benefit/risk, legal constraints, outreach & education.	List of future questions to be answered p4	Not discussed.
SCPP-05 Final Report: Appendix C: 2018 System Conservation Pilot Program Update	2018	Upper Colorado River Commission	2018 update to UCRC full report, including Appendices C (2018 update), D (2017 CU analysis), and E (2018 CU analysis)	Document includes Appendices C (2018 update), D (2017 CU analysis), and E (2018 CU analysis)	Not discussed.
SCPP-06 Pilot Program Funding Agreement	2014	Bureau of Reclamation	2014 SCPP funding agreement between CRB entities	Reviews history of compacts, storage allowances, demand management efforts by signatories. Defines goals and parameters of SCPP. Identifies NRCS programs that might support on-farm conservation improvements: EQIP and SWEP & ensures that projects will coordinate with respective NRCS State Conservationists.	Not discussed.
SCPP-07 Colorado River Water Bank Feasibility Study: Phase 1	2012	Colorado River Water Conservation District	Water bank planning phase; conservative estimate of potential WB supplies, and demand for those supplies.	Includes potential WB uses, supply, magnitude & frequency of need, supply-use scenarios. App. A: categories of W/E slope water uses, App. B: CRC WB Feasibility Study Water Supply Technical Memo, App. C: Eval of CRC WB Hydrologic Scenarios w/UCRB model, App. D: Basic supply & use comparison scenarios for CRC WB technical memo	Not discussed.
SCPP-08 Colorado River Water Bank Feasibility Study: Phase 2	2013	For Colorado River District. By MWH.	Water bank planning phase; test cases assessing on-farm impacts for representative irrigation systems	Includes candidate systems, screening criteria & selection, site visits for system evaluation, financial impacts on ag ops, operational scenarios & comparison to ATM work. App. A: Candidate system identification & evaluation; App. B Test Case site reports	- For high elevation grass pasture, [illegible] return flows are rarely measured or [illegible] accounting of foregone CU difficult. - For private ditch systems, diversio[illegible] not adequately measured to directly [illegible] consumptive use. - For tribal irrigation systems, insuff[illegible] diversions and return flows make c[illegible] impractical. - For USBR projects, There are hig[illegible] measurement, it is still not adequat[illegible] consumptive use. These projects w[illegible] estimation of reduced CU through r[illegible] meteorological data, or yield estima[illegible] - All of the site visits revealed difficu[illegible] administration. First, none of the sy[illegible] measurement of diversions and ret[illegible] calculate foregone CU through a m[illegible]
SCPP-09 Colorado River Compact Colorado water bank feasibility study: water supply technical memorandum. (Appendix B to Colorado River Water Bank Feasibility Study: Phase 1)	2012	Natural Resources Consulting Engineers, Inc	Technical analysis for water bank feasibility study, included in 2012 WB planning phase 1 report .pdf	Data section includes analysis, irrigated areas, water rights categories, and climate stations. Examined CU requirements (w/StateCU & Blaney-Criddle), ET verification (Penman-Monteith w/4 CoAgMet stations), and HCU (StateCU values for elevation bands in each division multiplied by irrigated acres). Water bank supply and cost: "fallowing suitable for small grains, grain corn, & dry beans." Deficit Irr available for all crops but best suited to alfalfa & pasture. "These crops combined account for over 98% of the acreage, irr CU, and supply-limited CU." Discusses split-season irrigation.	Not discussed.
SCPP-10 Exploring Perceptions of a Voluntary Agricultural Water Conservation Program on the Western Slope of Colorado	2019	MacIlroy, Colorado State University	This report was designed to assist in identifying and better understanding the socio-cultural components of a potential demand management program. The research, completed in Spring 2019, explored perceptions of demand management among stakeholders on the Western Slope through individual interviews and focus groups. The findings shed light on the barriers and opportunities for a demand management program, including ideas and feedback on what a successful program would look like, and why water users may or may not want to participate. **An executive summary is also available.**	This is an interview-based report that covers perceptions of DM, definitions of voluntary, compensated, temporary, and equity (their words are proportional/parity)--and finds that these definitions are not straight-forward and must be carefully communicated. Explores relationships with water and landscape, as well as "sacred values of the Western Slope." Addresses perceptions of DM in context of 2007 Interim Guidelines and broader basin-to-basin politics. Many interviewees doubt the viability of a voluntary compensated program, and even suggest that a mandatory uncompensated call would work better, avoid equity issues, and cost less overall. Compensation was a very challenging topic, with differing views of DM as a burden vs opportunity. Highlights clash of free-market values with the perspective of water as a commodity--discussion of different role water plays for irrigators vs Front Range residents. Who bears responsibility to pay--who is responsible for the shortage problems (many don't see the Upper Basin at fault). Temporary program vs temporary participation--fraught discussion. Discussion of Western Slope Sacred Values, how water and farming is part of identity. Numerous people suggested every water user curtail use and respect water and that we should	Not discussed.
SCPP-11 Briefing Paper: Upper Basin Demand Management and Water Banking. Addressing Risk and Creating Certainty: Exploring Options for an Upper Basin Demand Management Program	2019	TNC	This briefing paper provides a general background on the DCP and demand management. It frames the key issues to address in evaluating a demand management program and is offered in the spirit of promoting discussion and decision-making on how to structure, govern, finance, and implement such a program.	Briefly evaluates Upper Basin risk based on drought hydrology, and discusses how to reduce that risk. Asks many questions about Dm, program governance and structure, cost and funding, policy, measurement and verification. Identifies many of the key issues being addressed by CWCB DM workgroups. Key successes from SCPP are locally-driven solutions, minimizing impacts & maximizing benefits, e.g. through local coordination of projects. Tabulates past options considered for avoiding compact curtailment.	Not discussed.
SCPP-12 Colorado River Water Bank Work Group: An Overview of Previous Studies & Reports	2018	Colorado River Water Bank Working Group	This overview documents summarizes the studies completed by the Colorado River Water Bank Work Group in their effort to provide information about what types of solutions may be available to preserve communities, agriculture, power production and the river itself.	This work includes a two-phase feasibility study, an assessment of how reduced irrigation for compact purposes would work with different irrigation systems on Colorado's West Slope, economic work on pricing and payments, and scientific research on the agronomic impacts of reduced irrigation.	Not discussed.
SCPP-13 GVWUA Final Report on the Conserved Consumptive Use Pilot Projects	2019	GVWUA and J-U-B Engineers	This report provides a summary of the 2018 and 2019 Conserved Consumptive Use Pilot Projects completed by the Grand Valley Water Users Association (GVWUA). The initial part of the report provides a good summary of both the 2017 and 2018 pilots. Appendix H provides the details of the survey GVWUA completed of all participating producers, gathering their input on their experience and perspectives on the pilot project. Appendix I summarizes GVWUA's thinking more broadly on the pilot and demand management.	Land management contract: manage weeds & plant growth, soil erosion (leave plant residue, tillage for clods, tillage for crust), w/mid-season visit to confirm mgmt. activities are consistent w/contract; interviewees concerned w/DM externalities including local economy & aesthetics; CCU verification procedures (Exhibit B) don't specify methods to verify CU on fallowed land, but does include sites visits to verify land mgmt. and explicitly prohibits any active plant growth on fallowed land	Water returned to the stream was n[illegible]
SCPP-14 Lessons Learned from the System Conservation Partnership Program	2016	The Nature Conservancy	TNC's lessons learned in their SCPP involvement, including lessons from Trout Unlimited and Colorado Water Trust	Top 3 lessons: outreach & communication is essential, operational & legal issues must be addressed at ditch company/irrigation district level simplify the process for efficiency.	Not discussed.
SCPP-15 Considerations for Modeling a Water Bank at the Aspinall Unit with Current Environmental Flows	2011	Hydro Consulting for TNC	Evaluation of computer models of the Gunnison River to assess their ability to simulate a potential water bank in the basin using the Aspinall Unit reservoirs and the effect on reservoir operations, including environmental flows	StateMod, Aspinall PBO/EIS Model, and CRSS are evaluated for their capabilities to simulate Aspinall Unit operations, environmental flows, and potential water-banking. Specifically, this modeled the Black Canyon water right, new ESI/PBO requirements at the Whitewater gage, and a water-banking option at Aspinall. Modifications to the Gunnison StateMod are necessary to simulate environmental flows and enhance reservoir accounting options.	Not discussed.
SCPP-16 Environmental Water Transactions in the Colorado River Basin: A Closer Look	2018	Stanford Woods Institute for the Environment	Reviews CRB environmental transfers to track extent of activity. Examines SCPP projects by this lens, given the ISF benefits of SCPP. Found that SCPP-funded projects had the effect of enhancing streamflow.	Analysis used UCRC 2018 Final Report; no new data. 20,000ft view of ISF projects including SCPP projects.	Not discussed.
SCPP-17 Lower Colorado River Basin Pilot Program	NA	Bureau of Reclamation	Webpage with tables of projects from each pilot phase	"Although the Pilot Program will be ongoing until 2035, as of 2019, future announcements of funding opportunities and requests for additional project proposals are not being contemplated."	Water conserved was measured by [illegible] diversions/withdrawal.
SCPP-18 System Conservation: a collaborative approach to drought contingency planning the Upper Colorado River Basin	2017	Wyoming SEO Callaway, AWRA Impacts magazine	Description of Wyoming SCPP, how it works, participation, and future efforts.	Neither extensive nor technical, but includes some description of process & participation.	Not discussed.
SCPP-19 SNWA Water Resource Portfolio	2019	Southern Nevada Water Authority	Chapter from SNWA's water plan	Addresses temporary supplies including different aspects of Intentionally Created Surplus, recharge and banking, DCP, and conservation tools.	Not discussed.
SCPP-20 Colorado River Basin Water Bank: Framework & Financial Analysis	2017	WestWater Research for TNC	This memo evaluates different framework concepts to scale up operations of the Water Bank and provides comparative costs and other factors to consider in different approaches to developing a water bank. The information is intended to provide concepts and preliminary numbers for TNC and the Water Bank Working Group to consider and discuss in ongoing Water Bank development efforts.	Evaluates 4 frameworks of a Colorado Basin water bank sufficient to address 250,000 AF of CCU: annual water bank leases, option leases in critical years, non-option critical year leases, and response to a 1922 compact call. WestWater Research developed a cost-estimation spreadsheets based on the volume of water leases, number of associated acres, and number of farms or ranches leasing water.	Not discussed.

Title	Consumptive use analysis	Estimated residual field consumptive use	Return flow maintenance	Verify conserved consumptive use	Coordination of Benefits
	e.g. analytical processes and whether or not M&V activities were measured, estimated, or not considered				
SCPP-01	Not discussed.	Not discussed.	Not discussed.	Not discussed.	The two identified SCPP case studies were complete as originally planned, and the off-farm benefits were analyzed after the projects were completed. There was not a mention of direct coordination of benefits. The report did indicate that in the future a retiming of the release of CCU (if possible) could increase the environmental and recreational benefits by increasing streamflow in the late summer and fall.
SCPP-02	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.
SCPP-03	Not discussed.	Not discussed.	Not discussed.	Not discussed.	[illegible]
SCPP-04	In general, the applicants in CO, NM, and UT calculated historical potential consumptive use based on Modified Blaney-Criddle with an elevation adjustment, while the applicants in Wyoming used remote sensed data (Landsat satellite imagery) with the energy balance model METRIC (Mapping Evapotranspiration with High Resolution and Internalized Calibration). -The lack of consistent streamflow and streamflow data made analyses from each state challenging. In CO, StateCU, HydroBase were relied upon and were generally sufficient.	-2015: N/A -2016 and 2017 - two options were available: 1: Assume one day of irrigation provides one-weeks' worth of supply. 2: Assume the entire soil zone was filled during irrigation and would be fully consumed thereafter.	Not discussed.	-Use climate data from nearby climate station defined in each verification [illegible] -Estimate the potential CU using the daily Penman-Monteith calculation o[illegible] modified Blaney-Criddle calculation (reduced by effective precipitation) d[illegible] the project-specific contracted participation period. -Adjust the daily calculations based on water supply limitations (either diversion records, coordination with ditches, or discussions with SEO/DW[illegible] staff in each state).	[illegible]
SCPP-05 to SCPP-20	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Title	Representative Crop ET Data	Verification of conserved consumptive use	Sub-irrigation	Reservoir operations	River diversions & foregone or bypassed diversions	Lateral delivery and ditch loss	Irrigation and non-irrigation season return flows	Resulting streamflow
	Monitoring and Verification — Necessary Data and Equipment — Agricultural Participants							
	e.g. field specific data or regional data?	e.g. visual verification, regional data, or specific data?	e.g. wells monitored or piezometers	e.g. staff gauge reading or outlet meter?	e.g. flume or pump, regular or continuous readings?	e.g. regular or continuous flume readings?	e.g. measured and returned via aug station?	e.g. available streamflow measurements?
SCPP-01	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Based on the topography and satellite imagery for the Middle Piney Creek Projects, the conveyance losses and on-farm irrigation losses were estimated to have a relatively quick and proximal return to Middle Piney Creek.	No specific information was provided, but USGS gages were listed as being used to determine streamflow.
SCPP-02	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.
SCPP-03 to SCPP-20	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Title	River diversions	Foregone or bypassed diversions	Reservoir operations	Ditch or pipeline delivery	Overall collection systems	Monitor system-wide operations to verify conserved consumptive use	Detailed system-wide accounting records
	Municipal Participants						
	e.g. flume or pump, regular or continuous	e.g. estimated from streamflow measurements or	e.g. staff gauge reading or outlet meter?	e.g. flume or pump, regular or continuous readings?	e.g. monitor other diversion from the same basin?	e.g. compare overall basin diversions to previous years and	e.g. are system-wide accounting records
SCPP-01	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.
SCPP-02	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.
SCPP-03 to SCPP-20	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Title	Tradeoffs - Value and/or cost implications for more precise data	Proportionality	Honest, accurate, and defensible	Protective of other water users	Simple, easy, and flexible	Resulted in added water, rather than a retiming of depletions	Lessons learned
	Program Level Considerations		Monitoring & Verification Workgroup Guiding Principles				
	e.g. value between estimating a lower yield vs. obtaining measurements to increase yields?	e.g. geographic diversity?	e.g. accuracy of estimates and/or data collected?	e.g. consideration of adjacent and/or downstream water users?	e.g. amount of effort required to equip farm and/or implement project?	e.g. activity resulted in a net increase in water in the stream?	e.g. critical items, or considerations for future projects?
SCPP-01	Not discussed.	Not discussed.	The report discussed the lack of recent, local boating data on the Colorado and fishing data on the Middle Piney limited the ability to estimate the recreational benefits for both projects.	Not discussed.	Not discussed.	The GV CCUPP redirected the foregone irrigation diversions from the Grand Valley Canal into the Power Canal for hydropower generation and then returned the unconsumed water back to the Colorado River at the top of the designated 15-mile critical reach of the Colorado River for managed for endangered fish. The Middle Piney Creek projects did not divert water, thus the streamflow benefit was the CCU.	-The report identified a framework to evaluate municipal, hydropower, environmental, salinity, and recreational benefits within the context of a Colorado River Basin conservation project. -A scaled-up conservation effort (approximately 10 times greater than the Grand Valley and Middle Piney projects) would be needed to see more significant values of off-farm benefits. -Off-farm benefits are very dependent upon the project location and local constraints and/or opportunities. -In a USBR designated salinity control basin, one of the economically largest benefits would be the reduction in salt load to the Colorado River. -The timing and quantity of the CCU supply is very important for recreational benefits, namely boating and fishing. -The ability to quantify off-farm benefits may result in economic gains, which can offset program/operational costs.
SCPP-02	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	While water security was the main focus, changes in water management that resulted from the project led to several positive secondary benefits to the larger region.
SCPP-03 to SCPP-20	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Title	Data gaps	Keys to success	Identified challenges	Overall findings and recommendations
	Key Takeaways			
	e.g. data and/or information necessary for future projects?	e.g. crucial paths and/or processes that should be replicated?	e.g. mistakes that should be avoided?	e.g. comments on the feasibility of DM activities?
SCPP-01	Current and more proximal streamflow data would have been resulted in more accurate benefit measurements. There was not a sufficient amount of recreational fish user data, nor estimated daily angler benefit yields ($/day/angler). There was not a sufficient amount of recreational boater data for some stretches of the Colorado River, and none for the Middle Piney River.	Not discussed.	The ability to get recent, local, and representative off-farm data (electrical rates, boater days, economic data, streamflow data, salinity control program rates, and municipal lease costs) is paramount for accurate benefit analyses.	One of the analyzed DM project did result in off-farm benefits in multiple sectors. The anticipated benefit to Lake Powell was likely negligent, given the inability to shepherd water to Lake Powell, and the relatively small amount of water consumed. Future conservation projects should be upscaled to see increased benefits. Local and regional off-farm benefits are very dependent upon the local of the project and nearby opportunities.
SCPP-02	Not discussed.	Not discussed.	Not discussed.	Not discussed.
SCPP-03 to SCPP-20	[illegible]	[illegible]	[illegible]	[illegible]

Exhibit B-11
Lit (Gen. Literature) Documents with M&V Criteria

Title	Date	Publisher/Authors	Description	Notes	Monitoring and Verification																															
					Methodologies and/or Processes						Necessary Data and Equipment															Program Level Considerations							Key Takeaways			
											Agricultural Participants								Municipal Participants									Monitoring & Verification Workgroup Guiding Principles								
					Measurement of water returned to the stream	Consumptive use analysis	Estimated residual field consumptive use	Return flow maintenance	Verify conserved consumptive use	Coordination of Benefits	Representative Crop ET Data	Verification of conserved consumptive use	Sub-irrigation	Reservoir operations	River diversions & foregone or bypassed diversions	Lateral delivery and ditch loss	Irrigation and non-irrigation season return flows	Resulting streamflow	River diversions	Foregone or bypassed diversions	Reservoir operations	Ditch or pipeline delivery	Overall collection systems	Monitor system-wide operations to verify conserved consumptive use	Detailed system wide accounting records	Tradeoffs - Value and/or cost implications for more precise data	Proportionality	Honest, accurate, and defensible	Protective of other water users	Simple, easy, and flexible	Resulted in added water, rather than a retiming of depletions	Lessons learned	Data gaps	Keys to success	Identified challenges	Overall findings and recommendations
					e.g. analytical processes and whether or not M&V activities were measured, estimated, or not considered						e.g. field specific data or regional data?	e.g. visual verification, regional data, or specific data?	e.g. wells monitored or piezometers installed?	e.g. staff gauge reading or outlet meter?	e.g. flume or pump, regular or continuous readings?	e.g. regular or continuous flume readings?	e.g. measured and returned via aug station?	e.g. available streamflow measurements?	e.g. flume or pump, regular or continuous readings?	e.g. estimated from streamflow measurements or historical records?	e.g. staff gauge reading or outlet meter?	e.g. flume or pump, regular or continuous readings?	e.g. monitor other diversion from the same basin?	e.g. compare overall basin diversions to previous years and total system	e.g. are system-wide accounting records considered	e.g. value between estimating a lower yield vs. obtaining measurements to increase yields?	e.g. geographic diversity?	e.g. accuracy of estimates and/or data collected?	e.g. consideration of adjacent and/or downstream water users?	e.g. amount of effort required to equip farm and/or implement project?	e.g. activity resulted in a net increase in water in the stream?	e.g. critical items, or considerations for future projects?	e.g. data and/or information necessary for future projects?	e.g. crucial paths and/or processes that should be replicated?	e.g. mistakes that should be avoided?	e.g. comments on the feasibility of DM activities?
Lit-01 Salmon recovery in the Columbia River basin: analysis of measures affecting agriculture	1999	Aillery et al, Marine Resource Economics	Analysis of ag impacts from salmon-recovery-related flow alterations in Columbia River	Investigates ag impacts of fish recovery measures "such as: modified timing for dam releases, reservoir drawdown, and flow augmentation in the Columbia River basin, on the regional agricultural sector are evaluated. [....] Results suggest that drawdown and/or minor reductions in irrigation water diversions would reduce producers' profits by less than 1% of baseline levels. However, the most extreme scenario--a long drawdown period combined with a large reduction in irrigation diversions--would reduce producers' profits by $35 million (2.5%) annually."	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed	Not discussed.	Not discussed.	Not discussed.	To decrease the time to the ocean for juvenile fish, flow through rates would need to be increased by targeted reservoir drawdowns which would also have an impact on hydroelectric operations.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.
Lit-02 Feasibility of water efficiency and reuse technologies as demand-side strategies for urban water management	2017	Berhanu et al, Journal of Industrial Ecology	Economic model of water cost provided by above-code water efficiency and reuse technologies, including variations & uncertainty analysis.	Estimates that efficiency and reuse can meet 85% of 50yr projected needs to the Lower Colorado River Authority service area (central TX)	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Urban water management demand-side strategies should focus on the immediate adoption of net-benefit technologies, which produce considerable water savings and simultaneously provide monetary savings to the consumer.	Not discussed.	Not discussed.	Not discussed.	The study includes a review of the environmental impacts study associated with this specific study for the 2012 State Water Plan for Texas; includes a high-level assessment of environmental impacts of all recommended and alternate water management strategies for Texas.
Lit-03 Response to water crisis: How do Iranian farmers think about and intent in relation to switching from rice to less water-dependent crops?	2019	Boazar et al, Journal of Hydrology	Study of farmer response to gov't demand management, switching crops.	"Structural equation modeling showed that farmers intention to change from rice cultivation to another crop is determined by personal norms, beliefs about their role and emotional considerations."	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Water managers could place too much reliance on customer water restrictions in coping with drought	Not discussed	Not discussed	Not discussed	Not discussed	Not discussed	Not discussed	Not discussed.	Not discussed.	Not discussed.	Not discussed.
Lit-04 Temporary water transfers for urban water supply during drought	1992	Clark, CSU	PhD dissertation modeling options for temporary water transfers	"This research develops a water right option agreement (WROA) model, methods of analysis, and legal implementation strategy under Colorado law." Interviewed professionals, estimates costs, identified that WROA "can be superior in terms of cost, reliability, and operational flexibility to both water-right purchases and construction of additional reservoir storage.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	- Willingness to pay and willingness to accept discussions (Education and Outreach) - "Risk-adverse" attitude increases cost but may not reduce risk - Customer satisfaction is related directly to reliability but inversely to cost	- Equity positions on farm properties can be complex in the case of ag water rights. - Property description and refusal rights have the function of protecting the equity interests of one party while placing constraints upon the other. - Shortage will precipitate a loss of value to the water customer in proportion to the severity and frequency of the shortage.	Not discussed.	The water rights option agreement (WROA), as part of a drought water supply plan, executes a temporary transfer of water at an unknown time in the future. When and how to exercise the option is an element of concern for both parties, related to the protection of other water users.	Not discussed.	Not discussed.	The Colorado Drought Response Plan uses the SWSI to activate the Water Availability Task Force. The SWSI acts as a triggering mechanism to implement predetermined levels of response. Use threshold values of various hydrologic statistics to support triggering mechanisms (if they don't exist or aren't localized enough). The implementation of a local water supply index and the use of triggering mechanisms will assist decision makers in the implementation of the WROA. Figure 6.1.1 has a Dry-Year Water Supply Planning Process, as a reference.	Locally based water supply forecasting and water monitoring schemes are recommended to support implementation of the temporary water transfer. The following criteria were judged significant to the water resources manager and were used as measures of performance: - Reliability and control of the water source - Costs of both reliability and shortage - Operational constraints and other effects Need to define shortage	- Water planning is a regional issue. - Water shortage is a local problem and there is a need for more local data and information to inform the use of a temporary water transfer. - Consider variability of drought across watersheds to inform decision or need for data - Lack of ground water data and resources - Consider cumulative effects of drought within critical watersheds - Defined levels of action promote public awareness and facilitate decision-making for future investments.	The temporary transfer of a water right is supported by an existing framework (drought water supply plan).	Drought severity should be assessed on a local area basis rather than statewide basis
Lit-05 Flexible water allocations and rotational delivery combined adapt irrigation systems to drought	2018	Cody, K.C., Ecology and Society	Water allocation experiment in San Luis Valley, Colorado for self-governing irrigation systems.	Examines relationships between rules and physical context of water supplies; specifically the outcomes of water allocations between members and how they rotate water delivery.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	- Benefits of rotation are that it may generate the necessary hydraulic head to push water the length of the ditch system, minimize seepage losses, ease monitoring of water use, affirmatively require delivery to all users, and ensure that enough water is delivered to saturate the root zone of crops. - The potential drawbacks of rotation are that it can be costly to negotiate, requires more work and infrastructure investment to operate that simultaneous delivery, can deliver unequal amounts of water over equal amounts of time, and may be wasteful if individual farmers receive more water than they can use efficiently during their turn in the rotation.	A lack of wealth data to the irrigation systems or individual farmers limited the ability to understand the farm-level effects (for instance the money to support maintenance and operation of the irrigation system).	- Would be a challenge to verify and defend the operations of irrigation systems without measurement devices. - Few gates and gages are in use along the San Luis Valley irrigation systems (by "eye).	A self-governing irrigation system considers many factors, including head-enders and tail-enders along the system. So, protective of other users within the system while operating within the larger Prior Appropriation and water rights structure.	- Annual meetings inform the collective choice rules of the irrigation systems, operational rules of allocation and delivery. Selected through majority vote, consensus, inherited tradition, hegemonic behavior of powerful irrigators. - Numerous irrigation system governance considerations that may or may not make it easy to replicate, however offers flexibility in the delivery of water.	- The study advances the literature by considering the combined effects on irrigation performance of shortage sharing and delivery method. - The study determined that rotational delivery with shortage sharing was the most robust institutional configuration (of those examined). This provided the most equality between head-enders and tail-enders overall and had positive marginal productivity up and down the canal at all levels of water availability. - The rotational delivery with shortage sharing also appeared to be well-suited for systems large and small, growing a wide array of crops, with different social and cultural norms, and various technological and infrastructural mixes.	- The study advances the literature by considering the combined effects on irrigation performance of shortage sharing and delivery method. - The study determined that rotational delivery with shortage sharing was the most robust institutional configuration (of those examined). This provided the most equality between head-enders and tail-enders overall and had positive marginal productivity up and down the canal at all levels of water availability. - The rotational delivery with shortage sharing also appeared to be well-suited for systems large and small, growing a wide array of crops, with different social and cultural norms, and various technological and infrastructural mixes.	- Need farm-level data to measure delivery and use of water and determine the exact rules that would optimize performance under a diverse set of conditions. - Need farm-level data to determine the ability of all users on the system to operate under a self-governing irrigation system.	Not discussed.	Not discussed.	Future work should include direct measures of welfare, identify farm units, use simulation, and investigate different water rights and climactic regions.
Lit-06 Water trading innovations: reducing agricultural consumptive use to improve adaptation to scarcity	2017	Colby (Ch. 3.1.4), Book eds Ziolkowska & Petersen	Chapter from book "Competition for Water Resources: Experiences and Management Approaches in the US and Europe" collecting global examples/discussion of approaches and solutions to water supply scarcity, including western US	Ch 2.1.1: Challenges for US irrigated ag in the face of emerging demands and climate change, Ch 3.1.4: Water trading innovations: reducing agricultural consumptive use to improve adaptation to scarcity (reviews online trading systems to reduce transaction costs, methods for cost-effective verification of CCU, and other breakthroughs facilitating temporary & intermittent trading more feasible. Examples from AZ and CA (IID), NE, Australia, CO-Big Thompson.	Not discussed.	- "The baseline will consider temperature, precipitation, wind, and other factors that determine CU." - Other factors should "include irrigation management practices, temperature and rainfall patterns, soil characteristics, irrigation practices on neighboring farms, eco-nomic incentives to plant competing crops, and returnflow patterns. These data are not available in many areas." - In CA, "farmers wishing to enroll irrigated land for fallowing must document 5years of farm crop production including estimated ET" of applied water.	"Additionally, deep-rooted crops such as alfalfa may consume groundwater when left unirrigated. Well-defined baselines are necessary to address these problems and identify the actual water "savings" from leaving some fields unirrigated. Also, if farmers are paid to practice intentional deficit irrigation (termed regulated deficit irrigation in Colorado), the program needs to account for the fact that deep-rooted crops such as alfalfa may consume groundwater when left unirrigated by surface water."	Not discussed.	"Contract language needs to be crafted to effectively prohibit increased CU on the portion of a participating farmer's land (that is, a farmer with somefields enrolled in the program) that is not enrolled in an irrigation suspension program."	Not discussed.	Remote sensing can be used to increase the number of data sets available.	Not discussed	Not discussed.	Not discussed.	The ability to accurately track diversions, especially forgone/bypassed diversions allows for better data and makes the process easier	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	M&V has been implemented for trading markets in the Western United States and Australia to comply with legal mandates	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.
Lit-07 Towards regional sustainability assessment utilizing community based participatory research, sustainability indicators, and future scenario modeling	2016	Dubinsky, CU Denver	PhD dissertation that identified San Luis Valley sustainability indicators and modeled future scenarios, developing a CU indicator for 1980-2010. Conducted scenario modeling to guide decision-makers towards desired outcomes from policy decisions. Coupled sustainability indicators with future scenario modeling to inform the SLV stakeholders about a variety of social and environmental issues. Results indicated that through specific shifting of cropping rotations and minimal land fallowing, SLV could reduce water use and Greenhouse Gas Emissions while increasing soil carbon and improving soil health. In addition, the solar energy development pathways investigated by this study showed that the potential exists to offset most or all of the region's GHG emissions.	Utilized Community Based Participatory Research to engage stakeholders & keep research relevant. Highlighted groundwater-dependence of SLV, suggests irrigation water use could be decreased 10% with shifts in crop regime and minimal fallowing.	Compact compliance measurement devices	StateCU for scenario planning	Not discussed.	Not discussed.	Not discussed.	Considered greenhouse gas emission reductions with consumptive use and pumping reductions	Alamosa climate station	Not discussed	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	- Reduced pumping resulted from modeled crop regime changes. - Reduced irrigation resulted in reduced electricity demand and lowered GHG.	Not discussed.	- Yes, through Compact Compliance obligations - Groundwater sub-districts managing water use and delivery	- Compact compliance obligations. - Groundwater sub-districts.	Not discussed.	Scenario planning assumed: 1) Change in rotational practice among the alfalfa growers from 7 years of alfalfa and 1 year of grain to 5 years of alfalfa and 2 years of grain; 2) Fallowing of 7,500 acres of alfalfa/grain (7 yr../1 yr..) rotation land; 3) Fallowing of 25,000 acres of land in the potato/grain (1 yr../1 yr..) rotation land area, and 4) Shifting of 35,000 acres of land in the potato/grain (1 yr../1 yr..) rotation to a potato/green manure cover crop rotation (1 yr../1 yr..)	See previous summary.	Not discussed.	- Local data to support scenario planning - Concurrent BIP efforts and projects planned that align with overall need to reduce pumping the aquifer, improve soil health, offset GHG, integrate ecosystem functions - A strong community engagement process - Groundwater management sub-districts responsible for supporting compact compliance; managing water saving incentives	Not discussed	See previous comments.
Lit-08 Economic viability of deficit irrigation in the Western US	2018	Manning et al, Agricultural Water Management.	Research on agro-economics of deficit irrigation.	Deficit irrigation (DI) can be optimal during late growth and maturation stages given elevated water prices (depending on output price and production costs).	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	- Used hourly weather data and the Standardized Penman-Monteith equation to calculate reference ET on an hourly basis. Hourly reference ET was then summed by day to create daily estimates of reference ET.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	The analysis was conducted through the use of an agro-economic model and therefore the defensibility is a function of the inputs and data to reflect site conditions.	Not discussed.	Not discussed.	Not discussed.	- Water costs could increase as irrigation districts impose fees to cover increased costs to acquire and deliver water or as energy costs increase to pump water. - The market value of water would also likely continue to increase as population growth in water-scarce regions raises municipal and industrial willingness to pay for water. - There may also be an increase in environmental values of water. As this occurs a producer may realize an increased opportunity cost of water used on the farm.	- Further research should analyze DI within a context of other water conservation options, including crop selection and other management strategies such as tillage. - Multiple crops should also be considered as well as the ET target per crop. - Changing planting dates and timing of irrigation could also influence the costs and benefits associated with DI.	Output price of maize must be relatively high (compared to input costs) for DI to be optimal at any water cost.	Efforts to conserve water through DI require water prices that likely exceed historical levels in the US high plains.	- If DI is to be used with maize, it should be done first in the late vegetative stage and only within a range of water costs. - DI in the maturation/grain filling stage requires even higher water costs.
Lit-09 The role of groundwater trading in spatial water management	2014	Palazzo and Brozovic, Agricultural Water Management	Republican River Basin assessment of coupling surface-groundwater management.	Geospatial dataset of RRB irrigation wells modeling crop choice, land, and water use decisions by well. "Our analysis highlights the importance of the initial distribution of permits and the institutional context in which trading occurs." Cost savings from trading groundwater pumping are distributed unevenly between wells, counties, and groundwater management institutions.	Not discussed - all wells are metered and annual reporting of pumped volume is mandatory, monitoring and verification of groundwater use is already in place, with strong enforcement.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed - used the Nebraska Department of Natural Resources Well Database, soil type, evapotranspiration requirements, and irrigated and dryland crop yields to inform the analyses.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Pumping locations further from the river will decrease stream depletion, but it will also decrease the contribution of return flows to shallow subsurface flow and thus to the stream baseflow.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	#REF!	Not discussed.	The analysis was conducted through the use of a water optimization model and therefore the defensibility is a function of the inputs and data to reflect site conditions.	Water use limited by water rights and enforced by metering.	Not discussed.	Pumping locations further from the river will decrease stream depletion, but it will also decrease the contribution of return flows to shallow subsurface flow and thus to the stream baseflow.	Effective trading over a large area might require a simultaneous reduction in water rights in at least some parts of the basin, so that the large majority of potential market participants were constrained.	Site specific data to reflect model outputs.	See Lessons Learned.	Pumping locations further from the river will decrease stream depletion, but it will also decrease the contribution of return flows to shallow subsurface flow and thus to the stream baseflow.	For wells constrained by current regulations, the optimal deficit irrigation strategy is to irrigate less than the full certified area, but to apply an amount approaching the optimal depth of water.
Lit-10 Evaluating the potentials of cropping adjustment for groundwater conservation and food production in the piedmont region of the North China Plain	2019	Ren et al, Stochastic Environmental Research & Risk Assessment	Evaluation of different cropping patterns (including fallowing) & water supply scenarios.	Framework for using a crop model & regression to predict effects of cropping adjustments on groundwater sustainability & crop production	- The study simulated the groundwater response across different cropping patterns. - There were 3 groundwater sustainability targets and IWR.	The study used the DSSAT (Decision Support for Agrotechnology Transfer), one-dimensional model to simulate crop growth and agricultural water use based on inputs of weather, soil, crop cultivar and management practices.	Not discussed.	Not discussed.	The DSSAT model was re-simulated for a 31 year period of record (1985-2015) to match available irrigation data with monitored groundwater data and to establish a stable relationship between IWR and groundwater level changes.	Discussed the cropping pattern, groundwater level targets and influence on the production of wheat and maize.	- Used meteorological data and soil characteristics measured at the Luancheng Station, an Agriculture-Ecosystem-Experiment Station of the Chinese Academy of Science (LAEES). - Irrigation Water Requirement (IWR) was estimated as the simulated ET minus the amount of precipitation.	Not discussed.	Not discussed.	There is a South-North Water Transfer (SNWT) Project that was assumed to provide extra water supply in meeting two of the sustainable groundwater targets (Targets 2 and 3).	Not discussed.	Not discussed.	Not discussed.	Groundwater levels (3 sustainability targets) were used to gauge the cropping pattern adjustments.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	- The modeling outputs need to be informed by good and representative data and have people knowledgeable about how to use the information for informing decisions.	- There were 3 groundwater sustainability targets used to assess the IWR of the crops under the cropping patterns. Hence, there was a recognition of the need to protect groundwater for other water users.	- The DSSAT model used available data to calibrate the model and run the simulations. - It could be replicated if have the information available needed to run the model. Also need people who understand the inputs and modeling outputs.	Not discussed.	- The study provided insights that resting the cropland in summer allows moisture stored in the soil to be reused by wheat in winter. - Recommended that agricultural practices be improved in order to preserve soil water content for the next growing season. - Weed control is a critical factor and should be suppressed (tradeoff is environmental issues that arise from the use of herbicides).	- Consider cropland management during the fallow period.	See Lessons Learned.	The concept of "household food security" makes farmers who are of a low-income community that being exposed to a market-oriented economy could undermine their purchasing power and diminish their food security. Hence, they prefer to grow their own food despite receiving subsidies from the government (making purchase of food affordable).	See Lessons Learned.
Lit-11 Opportunities for saving and reallocating agricultural water to alleviate water scarcity	2017	Richter et al., Water Policy	- Review of literature & internet to identify water-saving strategies in irrigated agriculture. - Review of case studies in which water savings have been successfully transferred to other uses.	- Catalogs water savings opportunities, claims of irrigation-efficiency savings potential, logistics of reallocating due to other ag diverting savings. Findings suggest considerable potential to reduce irrigation CU and that savings can be reallocated when proper consideration is given to water budget accounting.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	- The paper highlights a lack of sufficient accounting leads most often to counter-intuitive outcomes, or a 'water efficiency paradox,' in which seemingly more efficient irrigation application can result in greater net consumptive use, ultimately lessening the volume available for subsequent use. - There is a need for accurate determination of the volume of water associated with each water flow pathway so that the net change in 'water available for subsequent use' can be properly evaluated.	Need for data that supports proper water budget accounting.	- Formal water rights systems supported the successful transfer of water saved in irrigated agriculture to other uses and environmental restoration (Table 4). - 3 examples of successful transactions included: 1) San Diego County and Imperial Irrigation District, 2) Murray-Darling Basin, Australia; and 3) Chaobai River Basin, China. - Issuance of well-defined rights, supported by proper monitoring and enforcement is essential to the process of transferring water use rights to other uses of the environment, and accounting for the cumulative consumptive use of a water source. - Base the volume of the water right on the allowable consumptive use, rather than on allowable withdrawal volumes, to determine the net impact of the use on the hydrologic system. - The total volume of CU authorized through water rights should be explicitly tied to water availability, with consideration of the water that needs to be left in freshwater ecosystems at any time to support their ecological health. - Cap CU. Tie the cap to allow for an adjustment based upon seasonal or annual variability in water supply. - Monitor CU to verify cap. Enable regulators to limit, monitor, and enforce the allowable flow of water into an [illegible]	- Greater revenue and water-saving benefits could be realized from other crop-shifting transitions, particularly when converting to crops with very high water productivity. These crop shifts could entail upfront capital costs in converting the farm fields from one crop to another and likely require expenditures in new farm machinery or irrigation infrastructure to enable more efficient irrigation of the new crop type. - However, such conversions can be expected to yield attractive revenue and water benefits in many cases.	- Strategies for reducing beneficial consumptive use through crop management (i.e., by temporary fallowing or shifting to a new crop type) stand out in terms of reliability in water savings and may be some of the easiest and cheapest strategies to pursue. - Crop prices and trends across many different regions indicate that there are possibilities for farmers to shift to alternate crops, thereby saving substantial volumes of water while enabling them to sustain or even increase agricultural revenues (refer to Tables 2 and 3).
Lit-12 Urban water conservation in the Sacramento, California region during the 2014-2016 drought	2019	Talbot, UC Davis	UC Davis Master's Thesis cataloging/analyzing supply & demand management actions under CA's drought policies.	Evaluates outdoor watering, public outreach, media role, water-related energy savings. Makes recommendations for urban water suppliers on revenue recovery, reducing use of rebates as demand management, and scaling drought response tasks for different levels of gov't. Summarizes & analyzes CA legislation establishing approval for long-term budget-based efficiency targets.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	- Demand management relies on customer participation; while reductions can be large and demand actions require considerable staff time, funding and ongoing customer commitment to change behavior. - Fines were part of the water conservation strategy by the state and it could have been cheaper for a water supplier to pay the fine than implement the water conservation strategies to meet the goal. - Lower compliance/water conservation targets resulted in greater compliance.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Yes, a 25% water conservation target resulted in 524,000 million gallons of water saved from June 2015 - May 2016	-Demand management relies on customer participation; while reductions can be large and demand actions require considerable staff time, funding and ongoing customer commitment to change behavior. - Prioritizing reducing outdoor water use achieved significant savings - Executive Order B-29-15 required water suppliers to report monthly information on water use, conservation achieved and any related enforcement actions - State, media, and community members created and maintained widespread attention on the drought - Drought provided numerous opportunities for water suppliers throughout the State to work together	Exploring a "proof of concept" for water transfers (testing the physical and legal systems) - e.g., pumping and delivering groundwater in lieu of pumping surface water to meet local demands, to make surface water available for transfer	- Water suppliers collaboratively met (within 0.5%) the Governor-mandated cumulative 25% water savings from the State's urban areas (compared to 2013 water production) from June 2015-May 2016. This amounts to 524,000 Mgal in water savings. This was achieved because the program: - used an enforcement strategy - was a big coordinated effort on conservation messaging across water suppliers - calculated regional targets was helpful for public outreach and media related inquiries	- Demand management relies on customer participation - while reductions can be large, demand actions require considerable staff time and funding and ongoing customer commitment to change behavior. - Local land use codes still allow for predominate turf grass landscapes, although codes are changing to include text discussing lower water use plantings and sustainable designs (in the context of trying to reduce outdoor water usage) - Proposition 218 requires a water supplier not charge more to a customer than it costs to deliver water to the customer (in the context of trying to reduce cost implications of lower water usages with watering restrictions and conservation) - Multiple level of active communication presents challenges (terminology or communication of misinformation)	- Need to align water conservation targets with actual local water supply conditions. - Need a State supply-based drought policy that requires water suppliers to motivate customers to reduce water even when the local water supply is sufficient (supports State and local water manager credibility). - Consider how larger water suppliers (usually with greater volume of supply) implement water conservation differently than smaller water systems who typically have smaller volumes of storage/rights and are in Need most during droughts.
Lit-13 Remote sensing assessments of consumptive use of agricultural water in western slope of Colorado	2016	Vashisht, Colorado State University, Colorado	CSU Master's Thesis evaluating remote sensing for estimating monthly consumptive use (CU) and conserved CU (CCU) on the West Slope	Used evapotranspiration (ET) observations at experimental plots of traditional irrigation and water-banking irrigation practices to evaluate methods of verifying CCU. Reviews methods for measuring and monitoring CU, discusses limitation and potential for ReSET remote sensing CU model.	Not discussed.	- Determined monthly CCU from ReSET. - Determined local crop growth stage lengths for different cutting cycles for grass and alfalfa pastures. - Developed VI-Kc model for grass pastures for use with reflectance based crop coefficient method. - Evaluated reflectance-based models for grass.	Not discussed.	Not discussed.	- Verified the crop cover classification mapping information (USDA NASS Cropscape) with on-the-ground observations for the grass and alfalfa crops. - Used ground instruments (LAS setup) at the limited treatment plot to evaluate stress-condition ET. Noted challenges with the LAS measurements due to low battery and disruption of good quality data collection.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	- Consider the datum selection and sensitivity of the model to the datum value (i.e., locations with higher elevations are at a lower temperature than lower elevations causing the model to potentially detect higher locations as having higher ET values). - ET values could be mis-represented by using data from locations that aren't representative of the project (over/under-estimating CCU).	Not discussed.	- The difference between the daily LAS-estimated and ReSET-derived ET was 24.8% on a daily basis, with a maximum difference of 57.1%. - Overall, it was observed that ReSET-derived ET is lower, and may underestimate both stressed and non-stressed categories. - However, ReSET overestimated ET for the peak growth season of grass for some scenarios evaluated in the study (Path 34 / Row 33).	Not discussed - however there is the potential to over or underestimate ET and CU, potentially leading to miscalculations.	- There are multiple variables that factor into the ET calculations, which in turn can result in over or underestimated values. -Site-specific data would support more accurate representation of ET and CU.	Not discussed.	- Traditional point-based consumptive use estimates do not capture intra- and inter-field variability, and water delivery records may not be reliable enough (even if available for project and site parcels) to differentiate between consumptive and non-consumptive uses. - This study investigated the use of ReSET on the Western Slope to determine CU, specifically evaluating its use for the energy-limiting (non-soil-water limiting) and soil-water limiting conditions.	- Consider the datum selection and sensitivity of the model to the datum value (i.e., locations with higher elevations are at a lower temperature than lower elevations causing the model to potentially detect higher locations as having higher ET values). - An energy balance model that is not based on anchor pixels, like Two-Source model, may perform better and worth evaluating in future work. - Need more than one image per month to estimate CU, especially for pasture crops that will experience different cutting cycles and rapidly changing phenology over a month. - MODIS Aqua/Terra should be used in conjunction with Landsat after using a pixel sharpening technique to run ReSET or using an approach that doesn't require a thermal band (like Sentinel in conjunction with Landsat).	-Site-specific data would support more accurate representation of ET and CU. - The NDVI-Kc approach can be a promising tool for estimating near-real time ET in the future, especially when combined with Landsat 7, Landsat 8, Sentinel 2a MSI and Sentinel 2b MSI satellites. - The monthly CU (and subsequent CCU) estimation using this approach on an enhanced temporal scale has a potential to overcome the limitations of using the energy balance approach which relies on the thermal bands, thus a limited temporal frequency of only Landsat satellites.	- There are multiple variables that factor into the ET calculations, which in turn can result in over or underestimated values. - Site-specific data would support more accurate representation of ET and CU.	- Further evaluation of ReSET under both full and limited irrigation conditions on a monthly time-scale is recommended. - Further validation needs to be done using lysimeter or neutron probe ET estimation.
Lit-14 Deficit irrigation and surface residue cover effects on dry bean yield, in-season soil water content, and irrigation water use efficiency in western Nebraska high plains	2018	Yonts et al, J. of Agricultural Water Management	2010-2015 study in Nebraska of efforts to decrease ag groundwater pumping; impacts of water use efficiency and crop yield	"Reducing irrigation water by 25% caused no significant yield reduction and improved irrigation water use efficiency by 26%." Applying 50% Etc. resulted in 30% yield reductions, and planting directly in crop residue did not improve bean yield under deficit irrigation. Ample early season rainfall is a boon to pre-flowering deficit irrigation yields, but under normal-to-dry conditions post-flowering deficit yields more.	Not discussed.	- Predetermined crop evapotranspiration requirement determined irrigation reductions - Irrigation application was limited to 20 mm every 3 days to avoid runoff and simulate a center pivot sprinkler system (51 ha)	Aimed to have no runoff to reduce residual field CU	Not discussed.	Not discussed.	Attempted to reduce runoff from the field Targeted growth stages of the crop across the 9 irrigation treatments (See Table 2 in study)	- Yes, data from High Plains Climate Center	Not discussed.	Sub-surface drip irrigation was used	Not discussed.	'9 different deficit irrigation scenarios from 2010-2015	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Water was not pumped	Not discussed.	Not discussed.	The study avoided runoff systems.	Measured by pumping and sub-surface irrigation. Crop yield was the overall focus.	NRDs limit pumping	Invested in soil water monitoring probes (503 DR Hydro probe, CPN International) MMAOV macro in SAS 9.4 software program used to analyze data	Not discussed	The measurement of pumping supports the amount of irrigation water applied	Reduced pumping (irrigation) could benefit groundwater levels, but is not discussed	The following equipment is needed: - pumps with meters - probes to measure sub-surface soil conditions	Resulted in retiming of groundwater depletions	Timing of irrigation relative to the growth of the plant could be helpful when timing deficit irrigation In arid western Nebraska, it was noted that ET almost always exceeded precipitation. A[illegible] could be helpful in understanding timing and application of water	Higher elevation snowpack and timing of deficit irrigation was not applicable as they rely on flood irrigation however, this study could be helpful for a range of elevations where different surface irrigation practices begin	Multiple consecutive years across a variety of hydrologic/precipitation seasons	None but study limited to dry beans	Consider deficit irrigation to support critical growth of crop for higher yield
Lit-15 Irrigation Efficiency and Water Balance of the Little Wind Unit on the Wind River Indian Reservation in Wyoming	2017	Rosado, U of Wyoming	Master's thesis on irrigation system efficiency in Little Wind Unit	Uses ag water balance & geophysical techniques to quantify & locate water losses. "Large errors and data gaps associated with the inflows, outflows, diversions, and precipitation data, [...which] identified specific needs for better data."	Paper not found	Paper not found	Paper not found	Paper not found	Paper not found	Paper not found	Paper not found	Paper not found	Paper not found	Paper not found	Paper not found	Paper not found	Paper not found	Paper not found	Paper not found	Paper not found	Paper not found	Paper not found	Paper not found	Paper not found	Paper not found	Paper not found	Paper not found	Paper not found	Paper not found	Paper not found	Paper not found	Paper not found	Paper not found	Paper not found	Paper not found	Paper not found
Lit-16 Standardizing Temporary Water Transfer Procedures in Colorado	2020	Nicols, Peter D, et al, University of Denver Water Law Review	Review of strengths and challenges of existing legal mechanism for ATMs and recommendations for consolidation and standardization.	This article will describe the barriers in existing law to temporary transfers and the various approval mechanisms available under existing Colorado law. It will provide an assessment of the strengths and limitations of the existing transfer methods and make a recommendation for consolidation and standardization.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed	Not discussed.	Not discussed.	Not discussed.	Not discussed.	See Table 2 in study	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed	Not discussed	Not discussed	Not discussed	Not discussed	Not discussed	Not discussed	Not discussed	Not discussed	Not discussed	Not discussed

Exhibit B-12
ATM Documents with M&V Criteria

Title	Date	Publisher/Authors	Description	Notes	Measurement of water returned to the stream	Consumptive use analysis	Estimated residual field consumptive use	Return flow maintenance	Verify conserved consumptive use	Coordination of Benefits	Representative Crop ET Data
					Methodologies and/or Processes						Necessary Data and Equipment – Agricultural Participants
					e.g. analytical processes and whether or not M&V activities were measured, estimated, or not considered						*e.g. field specific data or regional data?*
ATM-01 Use of Alternative Transfer Methods to Increase Water Supplies for Conejos Basin Agriculture, Municipal, and Environmental Purposes	2017	https://dnrweblink.state.co.us/cwcb/ElectronicFile.aspx?docid=205333&dbid=0	Trujillo Meadows Reservoir ATM Study (TMR Study): "The primary objective of the TMR Study is to investigate the feasibility of a unique ATM that involves enlarging Trujillo Meadows to provide intra-year regulation of water supplies including direct flow storage and storage of other agricultural and augmentation water rights for agricultural users diverting from the San Antonio.	ATM w/ recreational and environmental benefits for municipal augmentation w/enlargement of Trujillo Meadows Reservoir. Stakeholder meetings for federal & state agencies, ag, and town aug needs. Model of ATM, details of benefits, recommended path fwd. Appendix A estimates of monthly inflows to reservoir. Water rights include USFS Reserved Rights decreed as ISF, interstate shepherding	Like-basin methodology using nearby basin with stream measurement -- Conejos River basin selected	2004 Rio Grande StateCU from 1950-2002 for districts 20-22, 24-27, and 35	Not discussed.	Coordinated releases from Platoro Reservoir and Trujillo Meadows	Not discussed.	Not discussed	RGDSS and StateCU
ATM-02 Development of Land Fallowing-Water Leasing in the Lower Arkansas Valley	2011	https://dnrweblink.state.co.us/cwcb/ElectronicFile.aspx?docid=195733&dbid=0	The goal of this report is to "report on the development from 2002 through mid-2011 of rotational land fallowing -water leasing (fallowing-leasing) in the Lower Arkansas Valley of Colorado (Lower Valley) by the Lower Arkansas Valley Water Conservancy District (Lower Ark District) and the Lower Arkansas Valley Super Ditch Company, Inc. (Super Ditch)."	Return flow needs may require additional recharge ponds & stations; Return flows unnecessary at times due to trans-basin supply; considers monthly return flow "factors"; analysis by Leonard Rice Engineers found that replacement water will be required in the non-irrigation season in most cases.	Return flow stations, ponds, flumes	Hydrologic-Institutional (H-I) Model, Groundwater Accounting Model (GWAM)	Not discussed.	Not discussed.	Not discussed.	Not discussed	Not discussed.
ATM-03 Little Thompson Farm ATM Grant Completion Report	2018	https://www.larimer.org/sites/default/files/uploads/2018/larimer_county_atm_final_report.pdf	Study funded through CWCB 2015 ATM Grant. The Little Thompson Farm receives supply from Handy Ditch and Reservoir Company shares and 240 C-BT units. The consultant team found that "it was feasible for Larimer County to afford, from a water supply perspective, to sell some C-BT units (115) and share some other units (80) in some years, while still having sufficient water on the farm for corn and sugar beets, as well as crops that require less water." The study looks at aspects of feasibility, including: Economics; Farm Financial Viability under wet, dry, and very dry year scenarios; dry year water value. The report also investigates potential partnerships, and outlines the final water sharing agreement. "Larimer County sold 115 C-BT units to Broomfield and retained a first right of refusal to lease back these units for assessment cost plus 10%, when available. " The report also discusses Lessons Learned and Future Considerations: Legal Hurdles/Barriers to Replication (Northern Rulemaking, Direct Flow Rights, Delivery Efficiency Impacts from Water Transfers); Public Perception & Political Will (Educating and Obtaining Support of Leadership, Public Support, Out of County Partners, Continued Education); Negotiating an ATM: Successful Tips, Tricks, and Tools (Establish and Pursue Goals with an Open Mind About Implementation, Minimize the Cooks and Trust Your Team)	Cover crop & leaving crop residue prevents wind erosion, maintains soil fertility, controls weeds; non-irrigated cover crops: dryland milo, sorghum/Sudan grass for soil health, reduce weeds, potential revenue; w/no cover crop, control weeds w/herbicide or tillage (tillage can reduce erosion by forming large soil clods & enhancing infiltration); Class II and III soils, slopes 0-5%, not high enough for severe erosional problems; no/low-till also recommended to reduce direct evap, improve soil health, reduce fuel & costs; irrigation efficiency via contour farming, drip irrigation, SM & ET monitoring, drought tolerant crops, GPS irrigation guidance; no return-flow requirements due to CBT water, so no effort to quantify despite opponents	Parshall flume on farm for normal irrigation, Ditch company rules dictate when/amount of different water types for irrigation (direct, storage, C-BT)	Integrated Decision Support Consumptive Use model (IDSCU)	Not discussed.	Sometimes, when C-BT credits not transferred to Broomfield	Not discussed.	Farm keeps irrigating most years (9 or 10 out of 11) and gets cash for sold credits	Soil moisture and ET monitoring station recommended, not implemented
ATM-04 HB13-1248 Catlin Canal Company Rotational Land Fallowing-Municipal Leasing Pilot Project	2018	https://dnrweblink.state.co.us/cwcb/0/edoc/210320/19%2001%2015%202018%20Annual%20Report%20-%20Catlin%20Pilot%20Project%20FINAL.pdf?searchid=3856cf32-c475-4163-840c-5361fa65041f	The Catlin Pilot Project was the first rotational land fallowing-municipal leasing pilot project under HB 13-1248: Irrigation Water Leasing Municipal Pilot Projects. This project aims to makes available up to 500 acre-feet of water for lease to three municipal water providers – the Town of Fowler, the City of Fountain, and the Security Water District (Municipal Participants) - from rotational fallowing of lands located on six farms irrigated under the Catlin Canal in the Arkansas River Basin.	Huge emphasis on return flows; using Lease Fallow Tool from DWR to calc available water & owed returns; "Pay As You Go" target deliveries for return flow; use of recharge structures supported well-timed return flows; augmentation station used for faster return flows and consumptive use water delivered to municipal participants; erosion & weed control included herbicide, disk tilling, cover crops (winter wheat, hay)	Timpas Creek augmentation station	LFT	Not discussed.	LFT and coordinated exchanges/releases at Timpas Creek Augmentation Station and nearby recharge ponds	Accounting for exchanges and water deliveries to munis	Not discussed	Not discussed.
ATM-05 Yampa Basin ATM Study	2014	https://dnrweblink.state.co.us/cwcb/0/edoc/199193/Yampa%20-%20NC%20Use%20of%20ATM%20to%20Meet%20Non%20%20Consumpt%20Needs_FINALReport%203-28-14_with%20apps.pdf	Study conducted by Trout Unlimited (TU) and funded by CWCB's Alternative Agricultural Water Transfers Grant Program. The purpose of the study was to identify locations in the Yampa Basin where potential ATM transactions could help to meet multiple uses (nonconsumptive needs and agricultural shortages), and identify types of ATM transactions most suitable for meeting multiple purposes. Ideal candidate reaches, as specified by project proponent TNC and its partners, would involve the following scenario: - Upstream agricultural water user with full or surplus irrigation supplies and transferable CU water - Downstream agricultural water user with an irrigation CU shortage (consumptive need) - A need for water in the reach between to improve flows for trout (including Colorado cutthroat trout) or warmwater fish (nonconsumptive need)	Used StateMod delay table to estimate historic return flows; more efficient irrigation improves water quality by lowering return flow contaminant transport, fewer excess nutrients due to fertigation in drip systems; TNC/TU partnership to support instream flows for habitat w/ATM loans used when downstream ISF right is not satisfied & to provide flow in a reach without ISF right	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed	Not discussed.
ATM-06 Grand Valley Water Users Assn Conserved Consumptive Use Pilot Project Development: Process, Procedure, and Lessons Learned: Water Banking-Next Steps Part II	42795	http://www.grandvalleywaterusers.com/uploads/8/2/6/0/82606774/03-01-17_ccupp_projectdevelopment_final.pdf	The Conserved Consumptive Use Pilot Project (CCUPP) is a pilot demand management project intended to test the mechanisms necessary for a Western Slope irrigation water provider to intentionally reduce consumptive use in a voluntary and compensated manner. This report summarizes the process of developing the CCUPP, the procedure used, and lessons learned.	Land management contract: manage weeds & plant growth, soil erosion (leave plant residue, tillage for clods, tillage for crust), w/mid-season visit to confirm mgmt. activities are consistent w/contract; interviewees concerned w/DM externalities including local economy & aesthetics; CCU verification procedures (Exhibit B) don't specify methods to verify CU on fallowed land, but does include sites visits to verify land mgmt. and explicitly prohibits any active plant growth on fallowed land	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed	Not discussed.
ATM-07 Grand Valley Water Users Assn 2017 CCUPP In-Season Verification	2017	https://dnrweblink.state.co.us/cwcb/ElectronicFile.aspx?docid=205144&dbid=0	Field compliance and payment summary for the 2017 CCUPP, including verification forms for each program participant for 2017.	Includes 2017 verification documentation including photographs, recommendations, comments/notes	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed	Not discussed.
ATM-08 Power Canal Capacity Report, Grand Valley Water Users Assn	12/1/2015	https://dnrweblink.state.co.us/cwcb/ElectronicFile.aspx?docid=201813&dbid=0	Very brief report on "one potential mechanism through which water associated with CCU could be protected and returned to the Colorado River under a pilot project water bank:" to convey CCU via unused capacity within the Orchard Mesa Power Canal (power canal) to deliver water to the Grand Valley Power Plant (GVPP). The report investigated the potential unused capacity within the Power Canal, including the potential for additional water to generate hydroelectric power.	Very brief report on "one potential mechanism through which water associated with CCU could be protected and returned to the Colorado River under a pilot project water bank." Compensated, temporary, voluntary. Lists current operations, water rights, data. Incomplete file in link, merged with 2017 Next Steps Part II	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed	Not discussed.
ATM-09 Completion Report: Development of Practical Alternative Agricultural Water Transfer Measures for Preservation of Colorado Irrigated Agriculture	5/1/2011	https://dnrweblink.state.co.us/cwcb/ElectronicFile.aspx?docid=195709&dbid=0	An extensive evaluation to: 1) To identify barriers to implementation of alternative transfers and to describe potential strategies for overcoming barriers. 2) To develop tools for agricultural producers to evaluate the viability of potential alternative transfers. 3) To further actual alternative transfers by evaluating three demonstration projects that include owners of agricultural water rights and potential end users of the temporarily transferred water.	Extensive final report on ATM investigation & pilot on NE South Platte covering barriers (cost, risk/uncertainty, lack of supply, reluctance, power dynamic), needs and means to address barriers, Lease Evaluation Tool (AgLET) ag economics evaluator, exchange capacity analysis, flex market pilot project w/Aurora.	Potentially new flumes in tailwater laterals; measurement devices at recharge stations or wetlands/ponds	Standard methods	Not discussed.	Accounting at recharge stations primarily, or estimated from irrigation efficiencies and diversion records (with ditch losses)	Depends on the ATM program: fallowing vs. deficit irrigation, etc.	Not discussed	Standard methods
ATM-10 Final Project Report: Implementation of Deficit Irrigation Regimes: Demonstration & Outreach	May-16	https://dnrweblink.state.co.us/cwcb/ElectronicFile.aspx?docid=199317&dbid=0	Evaluation of different methods of monitoring crop water stress and consumptive use (CU) under deficit irrigation. Demonstrations, workshops, educational outreach on crop stress monitoring.	Demo project to evaluate different methods of monitoring crop water stress and CU under deficit irrigation & demo educational outreach on crop stress monitoring.	Standard methodologies	Study focused on comparing measurement techniques to estimate crop coefficients (and therefore ET and therefore CU): Crop coefficient (Kc), soil water balance, infrared thermometers, Crop Water Stress Index, Landsat NDVI, ground based NDVI and ReSET methods	Not discussed.	Not discussed.	Not discussed.	Not discussed	Soil moisture sensors, infrared thermometers (IRTs), landsat images
ATM-11 The Poudre Water Sharing Working Group: A Report to the CWCB	May-15	https://dnrweblink.state.co.us/cwcb/ElectronicFile.aspx?docid=198097&dbid=0	Final report of Poudre Water Sharing Working Group - a prototype ATM water sharing group between agricultural users (North Poudre Irr Co, Water Supply & Storage Co, New Cache la Poudre Irr Co, and Larimer/Weld Irr Co) and municipal users (Fort Collins, Greeley, and Tri-Districts) on the Poudre River, facilitated by the Colorado Water Institute at Colorado State University. The report focuses on the formation of the working group, relationship building, lessons learned, survey of ag users, development of prototype agreements, and regional cooperation strategies.	Final report of prototype ATM water sharing group between ag (North Poudre Irr Co, Water Supply & Storage Co, New Cache la Poudre Irr Co, and Larimer/Weld Irr Co) and muni (Fort Collins, Greeley, and Tri-Districts) on the Poudre River. Identified CCU calculation methods as a large barrier.	Standard methodologies	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.
ATM-12 FLEX Water Market: Education and Implementation Phase	##########	https://dnrweblink.state.co.us/cwcb/ElectronicFile.aspx?docid=197916&dbid=0	Investigation of FLEX water market implementation: engagements, index based pricing, theorizing on large-scale implementation, meetings between willing shareholders. The goal of this project was to successfully implement the FLEX Water Market concept through education, facilitation, and consultation, with specific focus on developing FLEX markets in Water Division 1 with municipal, industrial, agricultural, and	Investigation of FLEX water market implementation: engagements, index based pricing, theorizing on large-scale implementation, meetings between willing shareholders.	Standard methodologies	Standard methodologies	Not discussed.	Not discussed.	Not discussed.	Not discussed	Not discussed.
ATM-13 Alternatives to Permanent Dry Up of Formerly Irrigated Lands	June-13	https://dnrweblink.state.co.us/cwcb/ElectronicFile.aspx?docid=199208&dbid=0	Review of benefits and issues of two alternatives to buy and dry that maintain some continued level of agricultural production: 1) Dry land farming, and 2) limited irrigation.	Review of benefits and issues of buy and dry and alternatives. Potential for conversion of ag land to dry land or deficit-irrigation, economic & maintenance issues w/dry land & deficit.	Standard methodologies	Standard methodologies	Not discussed.	Not discussed.	Depends on farming practice...Permanent dry-up is site visits to verify no irrigation and reveg process in underway; Limited Irrigation is more complicated to track amount of water being applied to land (what is partial CU for a crop?)	Some discussion where limited irrigation could benefit both M&I and ag user: when there are surplus water in their supply portfolio that cannot be directly used or stored, so this can be leased back to irrigators, which are accounted for in the form of recharge stations and any surplus credits. The recharge credit framework takes care of lagged return flow timing issues and allows better coordination between M&I and ag	None - standard methodologies applied
ATM-14 Water Partnerships: an evaluation of alternative agricultural water transfer methods in the South Platte basin.	March-12	https://dnrweblink.state.co.us/cwcb/ElectronicFile.aspx?docid=199215&dbid=0	Water market experiment, survey of municipal & industrial providers on ATM practices, leases, evaluation of shared water bank scenarios on South Platte, focused on FRICO shareholders.	Water market experiment, survey of municipal & industrial providers on ATM practices, leases, evaluation of shared water bank scenarios on South Platte	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Not discussed.	Report details an economic experiment where volunteers played a game to test out scenarios of a "shared water bank" to see whether M&I or Ag users benefit the most by tracking who gets more water under different market conditions and regulations	Not discussed
ATM-15 Project Report: Lake Canal alternative agricultural practices and in-stream flow demonstration project	June-13	https://dnrweblink.state.co.us/cwcb/ElectronicFile.aspx?docid=203045&dbid=0	Proof of concept project planning for ATM/ISF program on Lake Canal. Monitoring/verification based on deliveries, surface returns, inflow to recharge pits, and soil moisture sensors to verify return flows by lack/presence of moisture movement below the root zone. Project was not implemented due to ongoing water scarcity at the time (2012-2013) and inability to agree on a price. Describes extensive legal work to arrive at proof of concept.	Proof of concept project planning for ATM/ISF program on Lake Canal. Monitoring/verification based on deliveries, surface returns, inflow to recharge pits, and soil moisture sensors to verify return flows by lack/presence of moisture movement below the root zone. Project was not implemented due to ongoing water scarcity at the time (2012-2013) and inability to agree on a price. Describes extensive legal work to arrive at proof of concept.	This project was not actually implemented - By-pass of diversions from the Lake Canal headgate on the Cache La Poudre River - Storage water conserved would remain in Storage at S. Gray Res or Timnath Res - Project goal was to allow conserved CU to flow past Fort Collins, but that could only be directly accomplished for in-priority diversions from Cache La Poudre into Lake Canal; stored conserved use had to be exchanged upstream with C-BT water based on agreement with WC and Lake Canal Co superintendent	HCU to quantify water right, and another Transferrable CU analysis based on crops used for deficit irrigation This project was not actually implemented	Computed from baseline CU (i.e. HCU) and measured CU by only deficit irrigating a portion of each participating farm This project was not actually implemented	Same This project was not actually implemented	This project was not actually implemented '- Integrated SCADA system to collect and record data from measurement structures at participating farms - Diversion Flows: in-situ real-time measurements at existing Parshall flumes into an integrated SCADA system - Surface Return Flows: in-situ real-time measurements at proposed flumes at all surface runoff outfalls at partipicating farms (number and placement dependent on site topography/hydrology - Soil Moisture: capacitance soil sensor arrays integrated into SCADA to monitor soil moisture in root zone and below, taking difference between two to estimate subsurface return flow - Recharge pits mointored with long-throated flumes - Weekly aerial imagery captured for particpating farms to inlcude RGB, NIR, and heat signature (IR)	Hyptothetically yes, irrigators get paid for conserving water (fallowing or deficit irrigation) and the M&I interest in maintaining environmental flows for longer reach through Fort Collins could've been achieved This project was not actually implemented	ACSE-PM and Blaney-Criddle calibrated for periods where data for ASCE-PM was insufficient This project was not actually implemented
ATM-16 Final Report of the Lower South Platte Irrigation Research and Demonstration Project	Jun-14	https://dnrweblink.state.co.us/cwcb/ElectronicFile.aspx?docid=199218&dbid=0	Technical research paper with three tasks. Task 1. Develop calculation & verification of consumptive water use and water savings, such that water court requirements can be satisfied--uses a stress coefficient, the crop water stress index CWSI, and the ReSET model of remote sensing. ReSET showed accuracy of 92-98% for fields under normal growing conditions and successfully detected abnormal growing conditions to accordingly reduce ET estimates. Task 2. Simplify the administrative burden of maintaining return flows. Task 3. Estimate supply delivery potential. Project on Lower South Platte Irrigation Research Farm near Iliff.	Goals were 1. Develop calculation & verification of consumptive water use and water savings, such that water court requirements can be satisfied--uses a stress coefficient, the crop water stress index CWSI, and the ReSET model of remote sensing. ReSET showed accuracy of 92-98% for fields under normal growing conditions and successfully detected abnormal growing conditions to accordingly reduce ET estimates. 2. Simplify the administrative burden of maintaining return flows, and 3. Estimate supply delivery potential. Project on Lower South Platte Irrigation Research Farm near Iliff.	- Assumption is that return flow obligations are met through augmentation so reservoir releases of stored water are applied to cover CCU and Return flows (i.e. no surface return flow from deficit irrigated fields)	Root zone water balance (RZWB) to get estimates of stress coefficient (Ks) and ET for corn in well-irrigated vs. deficit-irrigated plots	Limited/Deficit Irrigating ET estimates were compared in actual test plots: - Stress coefficient - Crop Water Stress Index (CWSI) - ReSET mode (satellite based method)	Water allocation approach -- diversions are limited to what is needed for deficit consumptive use and either augmentation flows are used to maintain return flows	- Stress coefficient -- neutron probe readings used to estimate initial soil moisture conditions for input into the FAO-56 model, which could then estimate changes in stress coefficient (thus ET) over time. - Crop Water Stress Index -- research-grade infrared thermometer used to measure crop canopy temperature changes over time and stress index and thus ET are estimated, with lots of complicated corrections of the infrared thermometer data - ReSET Model -- satellite imagery is tracked over irrigation season and the ReSET model is applied to estimate ET	Not discussed	A control field, ideally in the same property or proximal to project site would need to be fully irrigated and measured in the same method used to quantity CCU (stress coefficient, CWSI, or ReSET).
ATM-17 RGWCD Net Annual Replacement Plans	Reports exist for each year. Reviewed report for April 13, 2020	https://rgwcd.org/sd-1-annual-replacement-plan	Rio Grande Water Conservancy District plan to meet interstate compacts through forbearance agreements, leases for exchanges to meet streamflow criteria, temporary fallowing agreements, etc. Reviewed the 2020 Annual Replacement Plan (ARP), to meet requirements for the Plan Year under the provisions of the PWM for Subdistrict No. 1 decreed by the Division No. 3 Water Court in Case Nos. 2006CV64 and 2007CW52. This report describes a plan to remedy injurious stream depletions caused by the withdrawal of groundwater from Subdistrict Wells. This ARP includes a series of tables created by Subdistrict No. 1 staff and the RGDSS modeling team tabulating stream replacement quantities and locations resulting from Subdistrict No. 1 well groundwater withdrawals and a water portfolio to be used to replace such stream depletions.	Rio Grande Water Conservancy District plan to meet interstate compacts through forbearance agreements, leases for exchanges to meet streamflow criteria, temporary fallowing agreements, etc.	Well meters and diversion records	Assumed pumped groundwater used for irrigation with an 83% efficiency for sprinklers and 60% for flood.	Fallowing is the only CCU, otherwise it's forbearance on pumping/diverting	Met through "augmentation" and releases from upstream reservoirs (Rio Grande Reservoir)	Other than using meter and diversion records, it's not really addressed in the report	Detailed accounting of groundwater withdrawals to assess the storage level of the aquifer and track it over time	Not discussed.
ATM-18 Alternative Water Transfers in Colorado: A Review of Alternative Transfer Mechanisms for Front Range Municipalities	2016	https://www.edf.org/sites/default/files/alternative-water-transfers-colorado.pdf	Review of ATMs in Colorado for Front Range Municipalities. The report conducted a screening analysis to identify potential case studies for a more detailed analysis of ATM, found 35 municipal water providers based on water source and demand size criteria. Two case study participants were identified: City of Fountain and Town of Windsor. The report conducted a financial analysis of water supply alternatives for the two case studies; findings include recommendations for best ATM practices to suit those municipalities.	Review of ATMs in Colorado for Front Range Municipalities. The report conducted a screening analysis to identify potential case studies for a more detailed analysis of ATM, found 35 municipal water providers based on water source and demand size criteria. Two case study participants were identified: City of Fountain and Town of Windsor. The report conducted a financial analysis of water supply alternatives for the two case studies; findings include recommendations for best ATM practices to suit those municipalities.	Not discussed	Not discussed	Not discussed	Not discussed	Not discussed	Not discussed	Not discussed.