Technical Memorandum

Alternative Agricultural Water Transfer Methods Grant Program Summary and Status Update

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Acronyms

AF	acre-feet
AFY	acre-feet per year
AgLET	Agricultural Water Lease Evaluation Tool
ArkDSS	Arkansas Decision Support System
ARS	Agricultural Research Service
ATMs	alternative agricultural water transfer methods
CCGA	Colorado Corn Growers Association
CDSS	Colorado Decision Support System
CSU	Colorado State University
CU	consumptive use
CWCB	Colorado Water Conservation Board
CWIC	Colorado Water Innovation Cluster
CWSI	crop water stress index
DWR	Division of Water Resources
ECCV	East Cherry Creek Valley Water and Sanitation District
ET	evapotranspiration
FRICO	Farmers Reservoir & Irrigation Company
Fry-Ark	Fryingpan-Arkansas
GRC	Grant Review Committee
ISAM	Irrigation System Analysis Model
ISFs	instream flows
IWSA	Interruptible Water Supply Agreement
K_5	stress coefficient
LAVWCD	Lower Arkansas Valley Water Conservancy District
LFAT	Lease-Fallowing Accounting Tool
LFTAC	Lease-Fallowing Technical Advisory Committee
LSPWCD	Lower South Platte Water Conservancy District
M&I	municipal and industrial
PPRWA	Pikes Peak Regional Water Authority
PWSD	Parker Water & Sanitation District
ReSET	Remote Sensing of Evapotranspiration
SDI	sub-surface drip irrigation
SDS	Southern Delivery System
SECWCD	Southeastern Colorado Water Conservancy District
SEO	State Engineer's Office
Super Ditch	Lower Arkansas Valley Super Ditch Company, Inc.
SWSI	Statewide Water Supply Initiative
SWSP	Substitute Water Supply Plan
TNC	The Nature Conservancy
UAWCD	Upper Arkansas Water Conservancy District
USDA	U.S. Department of Agriculture
WSL CU	water supply limited consumptive use
WSRA	Water Supply Reserve Account

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Technical Memorandum

Alternative Agricultural Water Transfer Methods Grant Program Summary and Status Update

1.0 Introduction

The Statewide Water Supply Initiative (SWSI) 2010 (Colorado Water Conservation Board [CWCB] 2011a) estimated that by 2050, the State of Colorado may lose 500,000 to 700,000 acres of currently irrigated farmland. These losses are predicted due to a number of reasons, including urbanization, inadequate augmentation water supplies for out-of-priority well pumping, enrollment of lands in conservation programs, declining aquifers, and compact compliance. Additional irrigated acres are anticipated to be lost due to planned agricultural-to-municipal water transfers and transfers to meet the future water supply gap. **Table 1** summarizes the SWSI 2010 estimates of future irrigated land losses.

Historically, agricultural-to-municipal water transfers have been implemented through a process commonly referred to as "buy-and-dry" or traditional agricultural transfers. In such transfers, a water provider—such as a municipal water utility—typically purchases agricultural water rights or shares in a ditch company, and the use of consumptive use (CU) water from those water rights is changed in water court to allow municipal and industrial (M&I) uses. The formerly irrigated farmland must be permanently dried up and revegetated using native plant species (to prevent erosion and growth of noxious weeds) or converted to dryland farming practices. In cases where the parcels are located near a rural/urban interface, the land may be developed and urbanized. It is in this manner that large tracts of Colorado's historically irrigated lands have been lost and will continue to be lost in the future.

In order to reduce the burden on irrigated farmland and agriculture-dependent economies associated with traditional buy-and-dry transfers of agricultural water to municipal use, recent years have seen increased efforts to identify alternative agricultural water transfer methods (ATMs). In general, these ATMs are techniques that seek to provide agricultural water for M&I use on an as-needed basis while keeping rural farmlands irrigated and producing crops.

Senate Bill 07-22 authorized the CWCB to develop a grant program to facilitate the development and implementation of ATMs in the state. Since its inception in 2007, the CWCB's Alternative Agricultural Water Transfer Methods Grant Program has awarded nearly $3 million to municipal water providers, ditch companies, conservancy and conservation districts, university research teams, nonprofit organizations, and other entities to pursue the goal of turning the conceptual idea of ATMs into a practical reality.

Table 1. Future Irrigated Acres by River Basin

Basin	Current Irrigated Acres	Decrease in Irrigated Acres Due to Urbanization		Decreases in Irrigated Acres Due to Other Reasons[1]	Decreases in Irrigated Acres from Planned Agricultural to Municipal Transfers	Decreases in Irrigated Acres from Agricultural to Municipal Transfers to Address M&I Gap		Estimated 2050 Irrigated Acres	
		Low	High			Low	High	Low	High
Arkansas	428,000	2,000	3,000	—	7,000	26,000	63,000	355,000	393,000
Colorado	268,000	40,000	58,000	—	200	11,000	19,000	190,800	216,800
Gunnison	272,000	20,000	26,000	—	—	1,000	2,000	244,000	251,000
North Platte	117,000	—	—	—	—	—	—	117,000	117,000
Republican	550,000	300	600	109,000	—	—	—	440,400	440,700
Rio Grande	622,000	800	1,000	80,000	—	2,000	3,000	538,000	539,200
South Platte	831,000	47,000	58,000	14,000	19,000	100,000	176,000	564,000	651,000
Southwest	259,000	4,000	6,000	—	—	3,000	7,000	246,000	252,000
Yampa-White	119,000	1,000	2,000	—	—	3,000	64,000	53,000	115,000
Statewide Total	**3,466,000**	**115,100**	**154,600**	**203,000**	**26,200**	**146,000**	**334,000**	**2,748,200**	**2,975,700**

[1] Decreases in irrigated acres due to other reasons include enrollment in conservation programs, declining aquifers, and compact compliance measures in the Republican Basin; declining aquifers and protection of senior water rights in the Rio Grande Basin; and inadequate augmentation supplies for well pumping in the South Platte Basin.

At the request of the CWCB, this technical memorandum was prepared to provide an update on the status of the ATM grant program and to summarize findings of the funded projects with regard to identifying solutions to the barriers to implementation. Section 1 identifies each of the ATM grant recipient projects and provides a series of targeted recommendations for moving forward with the ATM grant program and eventual implementation of ATMs as viable means to secure M&I water supplies in Colorado. Section 2 revisits the first round of grant recipients in more detail. Final reports for most of those projects were completed after the publication of the previous ATM grant program summary report (CWCB 2011b), so this technical memorandum seeks to place the findings of those projects in context of the barriers to implementation. Section 3 summarizes the objectives of the projects receiving second round grant funding and also provides a status update on each project as of October 2012.

1.1 First Round of ATM Grants (2009-2011)

The first round of ATM grant funding awarded $1.5 million to six project groups in early 2009. Funding amounts are shown in **Table 2** below, along with the dates of final report submittal for each project. The ATM project proposed by the High Line Canal Company was later withdrawn.

Table 2. Recipients of CWCB Alternative Agricultural Water Transfer Methods Grants, 2009-2011

Name	Grant Funding	Date of Final Report
Parker Water & Sanitation District (PWSD) and Colorado State University (CSU)	$477,500	December 2011
Colorado Corn Growers Association (CCGA)	$349,650	May 2011
Lower Arkansas Valley Water Conservancy District (LAVWCD) Super Ditch Company	$320,000	June 2011
Farmers Reservoir & Irrigation Company (FRICO)	$202,500	March 2012
CSU Extension Office	$80,350	Not final, due 2013
High Line Canal Company	$70,000	Withdrawn
TOTAL	**$1,500,000**	**—**

The objectives and preliminary findings of those initial ATM projects were compiled in a report titled *Alternative Agricultural Water Transfer Methods Grant Program Summary* (CWCB 2011b). Five ATM concepts—interruptible supply agreements, rotational fallowing, water banks, reduced crop CU, and purchase and lease-back—were discussed at length in that report. The report also elaborated on the current state of agricultural transfers in the South Platte and Arkansas Basins, which have historically lost the most acres of irrigated land to traditional buy-and-dry transfers, and will likely continue to do so in the future.

Through these projects and discussions with the project participants, barriers to the implementation of ATMs in Colorado were identified as follows:

1. Potentially high transaction costs associated with water rights transfers.
2. Water rights administration uncertainties and water rights accounting questions.
3. Certainty of long-term supply and desire for water providers to have permanence of long-term supply.
4. Infrastructure needs and water quality issues.

1.2 Second Round of ATM Grants (2011-2012)

In September 2010, the CWCB Board of Directors approved revised criteria and guidelines for the ATM grant program that indicated a preference to fund projects that aim to address the barriers to implementation identified during the course of the first round of ATM grant studies. A second round of ATM grant funding ($1.5 million) was awarded to 10 project sponsors in 2011 and 2012, as shown in **Table 3** below. Some projects are continuations of projects from the first round of grants, some are investigating and building upon concepts that emerged from the first round of funding, and some projects are entirely new and unique to this phase of the ATM grant program.

Table 3. Recipients of CWCB Alternative Agricultural Water Transfer Methods Grants, 2011-2012

Name	Grant Funding
The Nature Conservancy	$132,000
Colorado River Water Conservation District	$180,000
Lower Arkansas Valley Water Conservancy District	$31,633
Colorado Water Innovation Cluster	$135,105
East Cherry Creek Water & Sanitation District	$111,030
Parker Water & Sanitation District	$320,166
Lower South Platte Water Conservancy District	$300,477
Colorado Corn Growers Association	$158,365
Upper Arkansas Water Conservancy District	$121,500
Colorado State University Agricultural Experiment Station	$9,611
TOTAL	**$1,499,887**

The CWCB (2010, 2011b) documentation on the first round of ATM grant projects also included an "issues matrix," which attempted to evaluate the applicability of each project to resolving technical issues, legal and institutional issues, and financial issues or economic considerations. **Table 4** identifies which types of ATM issues are being studied in the second round of studies.

Table 4. Types of Issues Studied by ATM Grant Projects, 2011-2012

Name	Primary Types of Issues Studied
The Nature Conservancy	Technical, Legal/Institutional
Colorado River Water Conservation District	Technical, Legal/Institutional
Lower Arkansas Valley Water Conservancy District	Financial/Economic
Colorado Water Innovation Cluster	Technical, Legal/Institutional, Financial/Economic
East Cherry Creek Valley Water and Sanitation District	Technical, Financial/Economic
Parker Water & Sanitation District	Technical, Legal/Institutional
Lower South Platte Water Conservancy District	Technical, Legal/Institutional, Financial/Economic
Colorado Corn Growers Association	Technical, Legal/Institutional, Financial/Economic
Upper Arkansas Water Conservancy District	Technical, Legal/Institutional
Colorado State University Agricultural Experiment Station	Technical

1.3 Recommendations for the Future of the ATM Grant Program

As Colorado's population continues to grow in the coming decades, it is likely that increased transfers of agricultural water rights will occur in order to satisfy increased M&I water demands. While it is expected that Colorado's future water demands will be met through all of the "four legs of the stool" (conservation, new supply, identified projects and processes, and agricultural transfers), the CWCB through the SWSI 2010 report (CWCB 2011a) and other analyses has indicated in the coming decades, irrigated acreage is expected to decline throughout the state due to a variety of reasons:

- Urbanization
- Planned agricultural to municipal transfers
- Additional agricultural to municipal transfers necessary to address the M&I water supply gap
- Other reasons, including compact compliance (e.g., Republican River) and augmentation requirements

The CWCB found that the water providers' identified projects and processes that are planned for implementation to meet future water demands could yield approximately 500,000 acre-feet (AF) if 100 percent successful. Even if completely successful, there still remains a water supply gap. Over the past several years, many of these water projects have been proceeding through the federal permitting process with no guarantee of success. Considering the difficulty of successfully permitting water projects, the alternative for many water providers is likely to be the transfer of agricultural water rights. The CWCB has found that if the "Status Quo" development trend continues, the South Platte Basin is estimated to lose 301,000 to 424,000 acres of currently irrigated land by 2050.

Due to the likelihood that increased transfers of agricultural water rights will occur in the coming decades, there is an urgency to implement alternatives to traditional transfers resulting in permanent dry-up in order to minimize the negative socioeconomic impacts to rural communities that so often result from such transfers. Rotational fallowing, interruptible supply agreements, water banks, purchase and lease backs, deficit irrigation, and changing crop type are the kinds of options that are available as alternatives to permanent agricultural transfers.

The Colorado General Assembly through support of past CWCB "Projects Bills" has tasked the CWCB with finding and facilitating viable alternatives to the buy-and-dry approach to agricultural water transfers. To date, the Legislature has provided funding through the 2007, 2009, and the 2012 CWCB Projects Bills for a total of $4 million to assist in numerous ATM studies and pilot projects that have helped move these important water supply management options forward. Notably, this program was recently recognized by the Western Governors' Association as a successful model for other Western states to adopt to help promote innovative water sharing strategies.

Through this program and CWCB's efforts, significant progress has been made towards making ATMs a viable option for municipalities. Since 2011, several pilot projects have been initiated to determine how some of these projects could be implemented on a large scale. Partnerships between the cities, farmers, land conservancies, funding partners, and environmentalist have been created through this program and appear to have great potential for success.

Basin roundtables recognize the need to focus on basin level planning and look for ways to increase the flexibility within the system through alternative transfers, cooperative agreements, drought plans, and additional infrastructure while respecting Colorado Water Law and individual property rights. While there is much work to be done, there is reason to believe that alternative water transfers will provide a viable option for municipal water providers in the not so distant future.

To-date the ATM grant program has provided funding for 15 projects; 5 in 2009 (see Table 2) and 10 during 2011-2012 (see Table 3). Some projects have moved toward conceptual implementation of ATMs, while others have been of a research nature. Solutions to some of the barriers to implementation (see Section 1.1) have been recommended through the findings of the ATM grant projects, but more work is needed to fully realize the goals of the grant program. Certain barriers to implementation, such as infrastructure needs (especially with regard to associated funding issues) and water quality have received limited attention. It is time to transition the ATM program to an

application and integration phase that will more fully integrate the findings of the first two rounds of ATM grant funding to achieve the dual objectives of overcoming the barriers to implementation and establishing realistically implementable ATM scenarios. Below is a set of targeted recommendations for the South Platte, Arkansas, and West Slope.

1.3.1 South Platte Basin

The South Platte Basin is facing the largest threat in the state with respect to agricultural dry up. Water is needed by municipalities for both a drought supply and an average year supply. The need for additional water for a drought supply is directly related to the discussions using the water supply portfolio tool, and the discussion on water conservation and the amount of water applied to the gap. If municipalities can be assured of dry year water, more water can be applied to the gap from water conservation. The next phase for the South Platte Basin, together with a basin planning effort, should emphasize the implementation of an ATM program that focuses on the flexibility to move water around the basin. The following are recommendations for the South Platte Basin:

- Recognizing that each municipal water system and each ditch company are unique, the CWCB should continue to promote and facilitate agreements between irrigators and municipal water providers.
- Continue to support demonstration/pilot projects to determine the feasibility of new concepts or techniques as needed.
- Additional suggestions for the South Platte Basin Planning effort:
  - The CWCB should consider supporting the modification of the Interruptible Water Supply Agreement (IWSA) statute by allowing an IWSA to be approved by the State Engineer for more than one 10-year period. If multiple 10-year periods could be allowed, it may encourage municipal water providers to pursue an IWSA with irrigated land owners that would give them a firm water supply during dry conditions with the limitation that it is 3 years in 10. A series of IWSAs could be established to provide a firm supply over a multiple of 3-year IWSAs so that a longer term dry year firm supply could be available. In light of the desire to maintain irrigated agriculture, there may be a good chance that the statute change would be approved.
  - The CWCB should consider supporting amending Colorado Revised Statute § 37-92-305 to "grandfathering in" usages made within 50 years of entry into a decree. This would recognize the longstanding use and restore certainty and help support the water rights market.
  - The CWCB should continue its support of coupling conservation easements with interruptible supply agreements, which has the potential to provide a reliable source of water and preserve agricultural productivity in perpetuity. This strategy should be examined in more detail including an analysis of which lands and/or ditches are most amenable to this approach, the identification of funding partners (e.g., Great Outdoors Colorado, Colorado Department of Revenue/Tax Credits, etc.), and terms of the conservation easement deeds and interruptible supply agreements.
  - The South Platte Basin Roundtable and interests could also address other important issues such as the development of a South Platte Basin water bank and infrastructure sharing. As

part of South Platte Basin planning, an infrastructure evaluation would need to take into account the Aurora Water Prairie Waters Project pipeline, the United Water infrastructure, the East Cherry Creek Valley (ECCV) pipeline, the proposed pipeline from the Poudre River basin to Thornton, and other infrastructure needs. There may be possible ways to share pipelines, storage, and pumping plants that could result in some benefits and cost savings.

- Water quality issues and concerns could also be considered by this group since treatment will be an important part of an ATM program. There may be ways to partner in this area as treatment plant costs are a significant part of any municipal water supply. The results of the Zero Liquid Discharge program (funded through the Water Supply Reserve Account [WSRA] program) should be evaluated.

1.3.2 Arkansas Basin

The Arkansas Basin is facing the second largest threat in the state with respect to agricultural dry-up. As municipalities turn to agriculture for additional supplies, efforts of the Super Ditch have led the state's ATM efforts. The next phase for the Arkansas is for their basin planning efforts to focus on the needs of the basin and implementation of the ATM. Following are recommendations for the Arkansas Basin.

- Advance the Super Ditch's efforts to implement pilot projects to lease water in 2013 using a temporary approval by the State Engineer under 37-92-308 (5). The authority to approve these under this statute has been challenged in water court.
- The CWCB should continue its support of coupling conservation easements with interruptible supply agreements, which has the potential to provide a reliable source of water and preserve agricultural productivity in perpetuity. This strategy should be examined in more detail including an analysis of which lands and/or ditches are most amenable to this approach, the identification of funding partners (e.g., Great Outdoors Colorado, Colorado Department of Revenue/Tax Credits, etc.), and terms of the conservation easement deeds and interruptible supply agreements.
- Complete the study by the Upper Arkansas Water Conservancy District (UAWCD) to develop a set of tools (Administration Tool) to simplify the engineering and reduce the costs related to a rotational fallowing ATM. If and when completed, support the promulgation of rules to determine how the Administration Tool can be applied in administrative approvals and/or water court cases.
- Support the Arkansas Basin Roundtable efforts in basin planning; analysis of varying hydrologies; native and imported water; future municipal, agricultural, and nonconsumptive needs; and existing, planned, and needed infrastructure to help meet their future water supply needs.

1.3.3 West Slope

The West Slope presents a unique opportunity with respect to ATM. On the West Slope the use of ATM can be used for both municipal supply and to address a Colorado River compact curtailment. Following are the recommendations for the ATM program for the West Slope, which includes efforts in the Colorado, Gunnison, Southwest, and Yampa Basins.

- Advance the Colorado River Compact Water Banking study and its focus on rotational fallowing by integration using the results from the Aspinall Water Bank study and Yampa ATM study.
- Continue the Yampa ATM study to determine the acceptability by ranchers of an ATM and the concurrent benefits to fish habitat. These identified lands and associated water can also be used for the Compact Water Banking project and should be integrated.
- Continue the study by CSU and others on the suitability of pasture grass for rotational fallowing.

2.0 First Round of ATM Grants (2009-2011)

As discussed in Section 1.1, ATM grant funding totaling nearly $1.5 million was awarded in 2009 and was used by five project teams to conduct analyses related to various ATM concepts. The grant recipients were directed by the CWCB to provide final reports on the ATM program that the recipient was investigating as set forth in the scope of work for each project. The following is a summary of each final report (submitted in 2011 or 2012) with emphasis on describing the solutions offered to the barriers to implementation of the specific ATM.

2.1 Parker Water & Sanitation District and Colorado State University

The ATM grant program summary report (CWCB 2011b) discussed the results of Phase 1 and Phase 2 of this study. The Final Report of The Lower South Platte Irrigation Research and Demonstration Project (Hansen et al. 2011) summarized the work on Phase 3 and 4.

2.1.1 Phase 3: Regional Adoption and Economic Impacts

The objectives of Phase 3 were to evaluate the potential of South Platte River Basin farmers to adopt ATM systems such as limited irrigation, rotational cropping, or other water-saving cropping systems and to evaluate the barriers to adoption of ATMs. A producer survey was used to gauge potential adoption of limited irrigation strategies, the amount of water that might be made available in water leasing arrangements, the necessary compensation needed for farmers to participate, and their perceptions of lease arrangements. Another objective of Phase 3 was to develop a regional economic impact model to quantify effects on farm cash flow and productivity. The results of Phase 3 were that:

- The South Platte River Basin could fallow up to 266,000 irrigated acres to meet the M&I gap. Each irrigated acre is estimated to generate economic activity equivalent to $690 in the basin.
- More than 60 percent of the farmers surveyed were willing to lease their water as an alternative to selling their water right, with an aggregate of between 50,000 AF and 60,000 AF of potentially transferable water just among those who responded to the survey.
- The preferred compensation for a lease of water was from $300 to $500 per acre of irrigated cropland.
- With regard to the barriers to implementation, it was noted that the next step in this research was to uncover the barriers to adopting limited irrigation practices, noting where they might be overcome with cost shares and technical assistance.

2.1.2 Phase 4: Administration and Basin Level Hydrology

The primary focus of this phase was to identify practical means of documenting water savings from rotational fallowing or limited irrigation cropping systems. Satellite imaging methods (remote sensing) were identified as a potential means of documenting irrigation water use and water savings.

A model called Remote Sensing of Evapotranspiration (ReSET), which was developed at CSU, was used to estimate daily evapotranspiration (ET). This tool was used to estimate ET on four fields of 125 to 130 acres in size. The remote sensing ET compared closely with actual measured ET on three of the four fields with other issues being identified to explain the discrepancy for the fourth field. The study concluded that remote sensing of ET on fields with partial or reduced irrigation holds significant potential of computing the water savings. A study has been funded by the CWCB to further develop and validate ET measurements, crop coefficients, and stress coefficients under cropping practices with reduced CU.

2.2 Colorado Corn Growers Association

The CCGA project involves a group of sponsors that includes the CCGA, Duck Unlimited, Aurora Water, and the Lower South Platte Water Cooperative. In May 2011, the project published its completion report titled *Development of Practical Alternative Agricultural Water Transfer Measures for Preservation of Colorado Irrigated Agriculture* (CCGA et al. 2011).

The project had three objectives:

1. To identify barriers to implementation of ATMs and to describe potential strategies for overcoming barriers.
2. To develop tools for agricultural producers to evaluate the viability of potential ATMs.
3. To further actual ATMs by evaluating three demonstration projects that includes owners of agricultural water rights and potential end users of the temporarily transferred water.

2.2.1 Identified Barriers to an ATM Market

The CCGA et al. (2011) completion report sets forth five distinct barriers to an ATM market, including high transaction costs, risk and uncertainty, lack of delivery capability, need for permanent supply and a reluctance to commit, and power imbalance. These issues are summarized below.

- **High transaction cost** – The most significant factor inhibiting temporary ATMs in Colorado is the high transaction costs associated with implementing them. The cost related to water court approval of changes in use of the agricultural water right to allow an ATM is viewed as equivalent or higher as a permanent buy-and-dry change in each water court case.
- **Risk and uncertainty** – Agricultural water right owners are concerned a water court case quantifying the historical CU may place them at some risk based on recent water court cases that limited the historical CU due to interpretations of lawful historical CU. There is also uncertainty over ATMs involving deficit irrigation or alternative crops and concerns that the ATM would encounter such opposition in water court that it would either fail entirely or have terms and conditions imposed to make its implementation difficult or even impossible.
- **Lack of delivery capability** – M&I water users in the Denver Metro area have expressed concern about the ability to deliver water from downstream ATMs. Of particular concern are the costs of infrastructure that would be needed to move the water upstream because exchange potential on the South Platte River is limited during the irrigation season when senior water rights dry up the stream at their headgates.
- **Need for permanent supply/reluctance to commit** – M&I water users want certainty, and permanent buy-and-dry water right changes are used to provide such certainty. ATMs as

proposed to-date involve leases that may not provide the certainty that the M&I providers desire even with leases of 20 years or more. Agricultural water users prefer shorter leases that would allow them to respond to escalating water values and economic volatility in the farm sector.

- **Power imbalance** – Agricultural water users often don't have access to the resources and information that is available to M&I water users. This perceived disadvantage fosters distrust and constrains effective communication.

2.2.2 Solutions to the Identified Barriers

The CCGA et al. (2011) report contains a thorough discussion of concepts for solutions to the barriers identified above. These proposed solutions are summarized in the following sections.

Education and Decision-making Support

The report contains recommendations regarding methods to educate water users about ATMs and recommends that the CWCB produce educational materials that would assist a lay person with understanding water transfers. The report contains a suggested guidance document for consideration.

The project team also identified a need for a decision-making support tool to help agricultural water users evaluate the impact of a proposed ATM on their individual farm economics. The Agricultural Water Lease Evaluation Tool (AgLET) is available for agricultural water users to use for this purpose.

Technical Analysis of Delivery Potential

The report does not focus on pumpback infrastructure to facilitate delivery of water from an ATM to an upstream water user, but instead analyzes the potential of exchanging water upstream during varying daily river flow conditions for the study period including Water Years 2000 to 2008. The exchange analysis performed in the study relied on daily diversion and streamflow gage data to compute the amount of water at each headgate on the South Platte River from the Burlington Canal to the stream gage on the South Platte River near Julesburg. The river call is also used to identify where calling water rights are located for each day of the study period. A condition of an exchange is there can be no calling water right between the points of exchange. The results of the exchange analyses are depicted in the study in useful graphs and maps. The report also shows that some limited infrastructure to pump water above a dry-up point or a calling water right can increase exchange potential. It also correctly points out that conditional exchanges have been decreed in water court that if implemented would significantly reduce the exchange potential shown in this study.

Joint Ownership

M&I water users have stated many times that they do not want to participate in an ATM because of the lack of a permanent water supply to meet their firm yield requirements. In their view, the transaction costs for a leased or temporary water supply do not merit participation in an ATM.

To address this barrier, the project team suggests a concept called the "Flex Contract Model" (Flex Market). The Flex Market combines elements of a long-term ATM project with purchase and leasing agreements between one or more M&I users and agricultural water users under a canal system. The Flex Market would be decreed in water court as part of a change in use of the agricultural water to M&I uses. The agricultural water users would provide two types of water to the M&I user(s) referred to as Base CU and Flex CU. The Base CU would be a small portion of the agricultural water that is permanently sold to the M&I user(s). The Flex CU would be leased to the M&I users, and ownership of

the water rights would be retained by the agricultural water users. The agricultural users and the M&I user(s) would jointly file a water court change in use of 100 percent of the agricultural users' water rights to M&I use and would include terms under which the delivery of Base CU and Flex CU would be administered.

Collective Organizations

To overcome the reluctance of agricultural water users to participate in an ATM on an individual basis due to the complex issues involved in obtaining approval of an ATM, the project team suggests that a collective entity be created to facilitate ATMs. The collective entity would represent the agricultural water users in putting together a large block of water that would be attractive to M&I water providers. The collective entity with broad support could address a number of the barriers to ATM and allow the M&I water providers to negotiate with a single entity. The collective entity could also have the ability to secure legal counsel and technical advice that helps address the perceived balance of power between the parties. The report includes a suggestion that the Lower South Platte Water Cooperative is a collective entity that could achieve many of the desired goals discussed in the report.

Local Partnerships

The CCGA project team suggests that local smaller and mid-sized M&I water providers also need to add to their water rights portfolios and that ATMs at the local level have merit and should not be overlooked as a way to maintain local agriculture and supply water for growth of the M&I provider. The DT Ranch/Town of Wiggins Demonstration Project described in the report utilizes an IWSA and is an example of such a local ATM project.

2.3 Lower Arkansas Valley Water Conservancy District

The LAVWCD submitted a report to the CWCB titled *Development of Land Fallowing-Water Leasing in the Lower Arkansas Valley (2002 through mid-2011)* (LAVWCD 2011). This report is a comprehensive summary of the efforts from 2002 to mid-2011 to establish a rotational fallowing-water leasing program in the Lower Arkansas Valley by the LAVWCD and Lower Arkansas Valley Super Ditch Company, Inc. (Super Ditch). The report includes discussions on how the Super Ditch would operate a rotational fallowing program with leases of CU water from the fallowing of irrigated lands to M&I water providers.

In earlier status reports, the Super Ditch project sponsors provided descriptions of the barriers to implementing the rotational fallowing and leasing program. These same barriers were stated in the summary report (LAVWCD 2011) and in Section 4 of the CWCB (2011b) overall summary report on the ATM Grant program. The Super Ditch report does not directly address how it would overcome each of these barriers to implementation. It does, however, indirectly address progress in overcoming the barriers in Section 9: Fallowing-Leasing Conclusions and Challenges Ahead. Some of the progress made is summarized in the sections that follow.

2.3.1 Progress Toward Acceptance of Leasing by M&I Water Providers

The principal challenge continues to be the acceptance by M&I water providers of the leasing of water rather than buying water through conventional buy-and-dry water acquisition programs. The Super Ditch has made progress in encouraging some water providers to implement pilot lease programs in 2012 and 2013 and include the following programs with the provision that the State Engineer can approve the programs under CRS 37-92-308 (5).

1. A pilot project was planned for 2012 for a lease of water to the City of Fountain and the Security Water and Sanitation District using shares under the Catlin Canal for fallowing of irrigated land that would provide each of the above entities with 125 AF of water each year for up to 5 years. However, the pilot project was not carried out because of drought and because the proposed Substitute Water Supply Plan (SWSP) never received final approval from the State Engineer.

2. The Super Ditch is also developing a pilot program with the City of Colorado Springs for 2013 using the lands that would be fallowed under the Catlin and Fort Lyon Canals to provide 2,500 AF of water.

3. The Super Ditch is hopeful that the City of Colorado Springs and Pikes Peak Regional Water Authority (PPRWA) successfully reach agreement on a carriage agreement(s) for Colorado Springs to deliver leased waster from Pueblo Reservoir through the Southern Delivery System (SDS) when it is completed. This would facilitate a long-term lease involving the PPRWA and the Super Ditch.

2.3.2 Progress Toward Implementation of ATMs Under Current Colorado Water Law

Another challenge identified is to satisfy the requirements of Colorado water law in implementing a rotational fallowing-water leasing program as envisioned by the Super Ditch. The following actions have been taken:

1. The LAVWCD and the Super Ditch are pursing adjudication of the exchange application, Case Nol. 2010CW04 in Division 2 Water Court. There are several objectors to the exchange and settlement is being pursued with the hope of avoiding litigation.

2. The LAVWCD is working with the Arkansas Basin Roundtable to develop an administrative tool to address historic CU and return flows from a rotational fallowing and leasing program. The purpose is to simplify implementation of water leases and to protect decreed water rights and to maintain historical return flows.

2.3.3 Progress Toward Meeting Infrastructure Requirements

The LAVWCD is pursuing infrastructure needs by acquiring storage capacity to maximize the amount of water that the Super Ditch can lease through the following:

1. The use of the Winter Water Storage Program is being evaluated by a consultant to the Super Ditch and has been funded by the Arkansas Basin Roundtable and the CWCB through the Water WSRA.

2. The Southeastern Colorado Water Conservancy District (SECWCD) is moving forward with in-district excess contracting for storage space in the Fryingpan-Arkansas (Fry-Ark) Project. The LAVWCD is requesting 5,000 AF of storage space, all or some of which the LAVWCD could make available to the Super Ditch.

2.4 Farmers Reservoir & Irrigation Company

FRICO submitted a final report titled *An Evaluation of Alternative Water Transfer Methods in the South Platte River Basin* (FRICO 2012). The report summarized the work done under the ATM grant awarded to FRICO in 2009. The focus was on the FRICO Barr Lake Division and various ATM opportunities for irrigated lands in this division.

The primary purpose of the study according to the report is to evaluate opportunities for FRICO Barr Division shareholders to realize economic value from their water rights and water assets through ATMs rather than traditional buy-and-dry water transfers. The study used surveys of agricultural water users and of M&I providers to gain knowledge on attitudes toward ATMs. It also conducted a classroom water marketing experiment to evaluate temporary water leasing and permanent water transfer markets as they impact rural communities.

The survey of 22 M&I water providers revealed that the majority (74 percent) intend to acquire and change the use of agricultural water rights. The water providers are familiar with the more traditional ATMs such as IWSAs, rotational fallowing, and long-term water leases, but they indicated that none of these ATMs are likely to be used as part of future water supply planning. Survey results showed that the most important factors for M&I providers when considering water supply acquisitions and evaluating ATMs were as follows:

1. The need for a permanent supply.
2. Ownership of water rights.
3. Need for certainty and reliable yield.
4. The unwillingness to develop water supplies that may not be permanent at the end of the agreement period.

The study then evaluated a different concept for an ATM in the context of the above survey results and in consideration of the impact of a water court decision on the attitude of FRICO Barr Division towards any ATM that could reduce the supply of water to agricultural water users. This concept is referred to as a Shared Water Bank. This ATM would take advantage of excess supplies that some M&I water providers have in most years except dry years. The infrastructure of the FRICO system, including those of the United Water District that are connected to the FRICO system, provide an opportunity to store excess M&I water supplies, which could then be used to meet both M&I and agricultural needs.

For example, the City of Thornton owns shares in the Burlington Canal and takes delivery of water from the canal. It also has excess municipal water supplies that can be stored in United Reservoir, a clay lined gravel pit, which receives water from the South Platte River and has pumps to deliver water by pipeline to Barr Lake. The shared water bank concept was modeled to evaluate the benefits to both FRICO and Thornton for a study period of 2001 to 2004. The results show that both entities would benefit from the shared water bank and may be a viable ATM where FRICO Barr Division shareholders would gain water while not having to fallow any land. The water made available is limited by the capacity of United Reservoir No. 3, owned by FRICO, which is 933 AF. For the simulation study period, excess water owned by Thornton was stored in United Reservoir No. 3 and shared by both FRICO and Thornton with FRICO receiving 869 AF and Thornton 415 AF. While this is not a significant amount of water, it shows that a shared water bank has potential as an additional ATM and may be viable in other parts of the South Platte River Basin if storage capacity and infrastructure exists to allow a shared water bank.

2.5 Colorado State University Extension Office

The CSU Extension submitted a memo titled "2012 Fall Annual Report to Colorado Water Conservation Board" (Cabot et al. 2012). The study focused on quantifying changes in yield, nutrient needs, and profitability that result on irrigated fields when they are brought back into production

after various periods of fallowing. The study period included the 2009 through 2012 growing seasons; production from test fields are not yet available for 2012, so the report will be finalized in 2013 after yields are quantified.

3.0 Second Round of ATM Grants (2011-2012)

In September 2010, the CWCB Board of Directors approved revised criteria and guidelines for the ATM grant program that indicated a preference to fund projects that aim to address the barriers to implementation identified during the course of the first round of ATM grant studies. A second round of ATM grant funding was awarded to 10 project sponsors in 2011 and 2012, as shown in **Table 5** below.

Table 5. Recipients of CWCB Alternative Agricultural Water Transfer Methods Grants, 2011-2012

Name	Grant Funding
The Nature Conservancy	$132,000
Colorado River Water Conservation District	$180,000
Lower Arkansas Valley Water Conservancy District	$31,633
Colorado Water Innovation Cluster	$135,105
East Cherry Creek Valley Water and Sanitation District	$111,030
Parker Water & Sanitation District	$320,166
Lower South Platte Water Conservancy District	$300,477
Colorado Corn Growers Association	$158,365
Upper Arkansas Water Conservancy District	$121,500
Colorado State University Agricultural Experiment Station	$9,611
TOTAL	**$1,499,887**

The following sections will summarize the objectives and work to be completed for each ATM grant project, as well as provide a project status update as of October 2012. This information is compiled from a number of sources, including scope of work documentation submitted with each project's grant application; project summaries previously prepared for the CWCB Board of Directors; and project status reports submitted by the proponents of each of the second round ATM grant projects.

The CWCB (2010, 2011) documentation on the first round of ATM grant projects also included an "issues matrix," which attempted to evaluate the applicability of each project to resolving technical issues, legal and institutional issues, and financial issues or economic considerations. **Table 6** identifies which types of ATM issues are being studied.

Table 6. Types of Issues Studied by ATM Grant Projects, 2011-2012

Name	Primary Types of Issues Studied
The Nature Conservancy	Technical, Legal/Institutional
Colorado River Water Conservation District	Technical, Legal/Institutional
Lower Arkansas Valley Water Conservancy District	Financial/Economic
Colorado Water Innovation Cluster	Technical, Legal/Institutional, Financial/Economic
East Cherry Creek Valley Water and Sanitation District	Technical, Financial/Economic
Parker Water & Sanitation District	Technical, Legal/Institutional
Lower South Platte Water Conservancy District	Technical, Legal/Institutional, Financial/Economic
Colorado Corn Growers Association	Technical, Legal/Institutional, Financial/Economic
Upper Arkansas Water Conservancy District	Technical, Legal/Institutional
Colorado State University Agricultural Experiment Station	Technical

3.1 The Nature Conservancy

The ATM study undertaken by The Nature Conservancy (TNC) is intended to build on the findings of the Yampa-White Basin needs assessments to identify potential projects and methods that could be used to meet both nonconsumptive and consumptive needs in the Yampa Basin. This effort will leverage existing studies funded by CWCB to identify the most favorable candidate locations for implementing ATM projects to meet nonconsumptive and consumptive needs. The main targeted needs of this project will be environmental attributes and agricultural shortages. The project will examine available water rights and a variety of ATM mechanisms to ensure that the final report identifies the best candidates possible for ATM projects.

3.1.1 Study Objectives

The intention of this project is to enhance relationships between irrigators and habitat conservationists by meeting the needs of water-short rights with leased water while simultaneously improving instream flows (ISFs) in key reaches. Good communication from those executing this project and the ranching community is essential for success of this effort, and the technical analysis has been somewhat slowed by our recognition that this communication had not yet been sufficiently thorough. TNC and its partners have worked and will continue to work through the Agriculture Subcommittee of the Yampa/White/Green Basin Roundtable to improve our understanding of the needs of the ranching community, and to keep that community apprised of our activities. It is the intention of the habitat conservation community to bring financial resources to the Yampa Basin to implement an ATM pilot project upon completion of the technical analysis now being conducted.

Following are the study objectives for this project:

1. Identify locations in the Yampa Basin where ATMs could help to meet nonconsumptive needs and agricultural shortages.
2. Analyze ATM transactions that might be used to meet multiple needs in specific candidate locations.
3. Identify which ATM mechanisms are most suitable for meeting multiple purposes in each candidate location.
4. Conduct outreach to water rights owners, governmental entities, and other interests to gage, and develop, interest in ATM transactions.
5. Produce a final report describing in detail the most favorable ATM transactions and describing the next steps for implementing each of those transactions.
6. Begin working toward implementation of ATM transactions recommended in the final report.

The Yampa Basin ATM project may yield valuable information that is transferable to other basins, including the technical aspects of ATM assessment and implementation as well as insights regarding outreach to local communities in efforts to encourage irrigators to willingly participate in such programs. This project may also prove useful in identifying possible water rights to be used in a West Slope water bank should that concept become a reality. The project also seeks to expand the scope of ATMs to the benefit of both consumptive and nonconsumptive uses.

3.1.2 Progress Update and Preliminary Findings (TNC 2012)

The project team recently met with the Division Engineer and the Water Commissioners in Water Division 6 to apprise them of the work underway. Much was learned about specific issues that may be challenges in implementing an ATM, and the TNC team will continue to work with this staff to ensure that appropriate attention is given to all relevant details.

The project scope as described in the ATM Grant program application contains six tasks, as outlined above. Progress on each of those tasks is described below.

Task 1 – Identify Location and Timing of Nonconsumptive and Consumptive Needs

The TNC team has identified several potential locations where water-short irrigation rights could possibly be met by leasing water on a temporary basis from an upstream water-long right, while improving water-short ISFs along the way. Additional locations for ATM implementation were identified based on potential opportunities for temporary leases of water to satisfy CWCB ISFs. These locations were identified using the following sources of data:

- Irrigated lands from the Colorado Decision Support System (CDSS), which were reviewed during the Yampa-White Agricultural Study
- Water-short agricultural areas based on existing studies
- Environmental needs based on existing information from sources such as the Nonconsumptive Needs Assessment, WFET, and Trout Unlimited's Conservation Success Index
- ISF mapping based on shapefiles obtained from CWCB.

Having identified potential locations where an ATM transaction might be implemented, TNC and its partners now intend to reach out to the ranching community to seek individuals who may be interested in working on a pilot transaction.

Task 2 – Analyze Possible ATM Transactions

Possible on-field approaches making CU water available for lease include:

1. Full-season fallowing, likely on a rotational basis.
2. Reduced crop CU (deficit or split-season irrigation).
3. Crop type changes.

Initial analysis indicates that the legal mechanisms through which CU could be leased include the following:

1. Loan of water between two agricultural water users as allowed under CRS 37-83-105 (1).
2. Loan of water to the CWCB for ISFs pursuant to a decreed ISF water right as allowed in CRS 37-83-105 (2).
3. Operation under an IWSA pursuant to CRS 37-92-309 and the State Engineer's Regulations 2CCR 402-15.
4. Operation under a SWSP pursuant to CRS 37-92-308 (5).

In addition to existing legal mechanisms under which an ATM could be operated, this project will also explore—in collaboration with the Colorado River Water Bank working group—the possibility of operating ATMs that could make water available under a Water Bank agreement.

Having identified locations where water-short and water-long irrigation rights can be connected in a way that also benefits the ISFs, TNC and its partners intend to prepare an inventory of the water rights associated with identified potential locations. Once the inventory is complete, the timing and amounts of water that would be made available through application of an ATM to these water rights will be analyzed. Other factors to be considered include exchange potential, return flow obligations, and infrastructure capacity. The project team will also analyze potential environmental improvement based on the amount of lease water that may be available, as well as potential impacts on late season flows.

Task 3 – Identify the Best ATM for Implementation in each Location

The best location for an ATM will be, first and foremost, a location where a water-long right owner and a water-short right owner in a potential location want to work with us to conduct a willing buyer-willing seller transaction. This location must also take account of the timing and location of water available through the ATM and the timing and location of the nonconsumptive and consumptive need.

Task 4 – Conduct Outreach to Water Rights Owners, Governmental Entities, and Other Interested Parties

Since the beginning of this project TNC and its partners have conducted outreach to the Community Agriculture Alliance, CSU Extension, CSU researchers, and water interests in the Yampa Basin, including the Yampa/White/Green Basin Roundtable, to provide information about the study and receive feedback. This outreach will continue as the project progresses. Later, information from the preceding tasks will be used to identify specific landowners, water rights holders, and other interested parties to contact and work with to develop interest in specific ATM transactions to meet multiple-purpose needs.

Tasks 5 and 6 – Documentation and Implementation

Anticipated completion of this project is May 30, 2013. Once complete, the project partners will work to facilitate implementation of the recommended ATMs that can best meet both nonconsumptive and consumptive needs in the Yampa Basin. Implementation is anticipated in 2013 at the earliest. In addition to the water transaction, implementation will have to include a thorough study of changes in crop productivity and savings of CU.

3.2 Colorado River Water Conservation District

A participant group composed of representatives of the Colorado River Water Conservation District, CWCB, Front Range Water Council, Southwestern Water Conservation District, and TNC (the Water Bank Group) is investigating the development of a water bank that may prevent a curtailment of water allocations under the Colorado River Compact of 1922, or allow continued water use in the event of a compact curtailment. A compact curtailment may occur in the event that the 10-year running average flow at Lee Ferry, Arizona falls below 75 million AF. The water bank would seek to provide a means for pre-compact (pre-1922, and therefore not subject to curtailment) water rights and post-compact reservoir storage to be used to allow critical post-compact water rights to continue to divert rather than be curtailed under these circumstances.

The Colorado River Water Bank is envisioned as a potential strategy for using pre-Compact (pre-1922) agricultural water rights on the West Slope to meet a portion of East Slope and West Slope uses supplied by post-Compact water rights that could be affected during periods of shortage due to requirements of the Colorado River Compact.

At a conceptual level, the water bank would operate as follows: Willing agricultural participants in the water bank would temporarily fallow certain lands that are irrigated by pre-1922 water rights. These willing participants would be compensated for the loss of economic value that is incurred while the irrigated lands remain fallow, and the historical CU associated with the fallowed land would be available for storage in a water bank. Post-1922 water users would subscribe to the water bank, and thereby gain access to pre-1922 water that would offset or replace water use that would otherwise be curtailed by Colorado River Compact administration. It is anticipated that any land that is fallowed may be done so on a rotational basis in conjunction with other irrigated lands. The rotational fallowing may avoid permanent irrigation dry-up and may minimize the resulting economic and environmental impacts that can occur in surrounding communities and economies.

3.2.1 Study Objectives

The objective of the Colorado River Water Bank Feasibility Study is to determine the viability of a water bank to help mitigate effects of nondepletion requirements from the Colorado River during times of shortage under the Colorado River Compact.

The Water Bank Study will be completed in three distinct phases:

- Phase 1 of the study evaluated the amount of water supplies that may be available to a Colorado River Water Bank, and will also evaluate the potential demand for these supplies.
- Phase 2 of the study will assess the actual on-farm implementation of a water bank for representative pre-1922 irrigation systems.
- Phase 3 of the study will assess regional economic and environmental considerations.

It is anticipated that the three work phases will be implemented sequentially, with each subsequent phase building upon previous information. The proposed water bank ATM project is intended to complement the Colorado River Compact Compliance Study. While the Water Bank Study tackles critical issues that need to be addressed in order to establish a water bank, several additional elements will be needed to establish and operate the bank. The scope of work funded by the ATM Grant Program is not intended to fully address all aspects of establishing the water bank.

The purpose of Phase 1, which was completed in July 2012, was to estimate the amount of supplies that could be associated with the Colorado River Water Bank, and to estimate the potential demand for those supplies. At the completion of Phase 1 the Water Bank Group determined that the feasibility of the Colorado River Water Bank was sufficiently promising to authorize Phase 2 of the Feasibility Study.

The purpose of Phase 2, which was initiated in July 2012, is to assess the feasibility of implementing the Colorado River Water Bank for representative pre-Compact irrigation systems. This will involve defining requirements and preferences for candidate irrigation systems; screening and selecting candidate irrigation systems; and conducting assessments of irrigation operation, deficit irrigation and fallowing benefits and impacts, and economic impacts at the irrigation system level. In addition, Phase 2 will involve an outreach program to the West Slope agricultural community (performed by

the Water Bank Group) and compilation of available research on the feasibility of deficit irrigation for the crop types and climate zones that could potentially supply water to the Colorado River Water Bank.

3.2.2 Progress Update and Preliminary Findings (MWH 2012)

MWH Americas, Inc., under the guidance of the Water Bank Group, completed Phase 1 of the Colorado River Water Bank Feasibility Study in July 2012. Estimates of maximum potential use of water from a Colorado River Water Bank by users of post-Compact water rights using past studies and available data are summarized in **Table 7**.

Table 7. Estimated Post-Compact Water Use on the East Slope and West Slope

Water Use Category	Current Average Annual Water Use (AFY)
West Slope Post-Compact M&I Depletions	
Residential Indoor	1,390
Residential Outdoor	16,675
Commercial/Industrial	4,210
Self Supplied Industrial	32,940
Subtotal	**55,215**
East Slope Post-Compact M&I Depletions	
Residential Indoor	107,930
Residential Outdoor	82,375
Commercial/Industrial	105,170
Self Supplied Industrial	-
Subtotal	**295,475**
Total Post-Compact M&I Depletions	
Residential Indoor	109,320
Residential Outdoor	99,050
Commercial/Industrial	109,380
Self Supplied Industrial	32,940
Total	**350,690**
West Slope Post-Compact Agricultural Depletions Not Readily Deficit Irrigated or Fallowed	
Vegetables	3
Orchards (cover and no cover)	2,155
Total	**2,158**

Source: "Categories of Existing West Slope and East Slope Water Uses – Task 1.2," Water Bank Group, November 18, 2011
AFY = acre-feet per year

Grass pasture and alfalfa represent over 90 percent of the irrigated acreage in the study area and would provide virtually all of the potential Water Bank supply. The potential water supply generated from deficit irrigation or fallowing of lands irrigated with pre-Compact water rights was estimated. Maximum potential supply was based on estimates of water supply limited consumptive use (WSL CU) associated with pre-Compact water rights. This is summarized in **Table 8**.

Table 8. Estimated Pre-Compact WSL CU on the West Slope

Crop	Total Basin CU (AFY)	Pre-Compact CU (1929) (AFY)	Pre-Compact CU % of Total
Alfalfa and Grass Pasture	1,101,684	791,840	72%
Small Grain, Corn Grain, and Dry Beans	79,646	65,494	82%
Total	**1,181,330**	**857,335**	**73%**

Water supply and water use scenarios for the Colorado River Water Bank were developed by assuming supply comes from deficit irrigation of alfalfa and grass pasture in the study area and by varying the assumed level of participation by West Slope irrigators and the level of deficit irrigation to meet a specified water-use target. Scenarios were developed to meet uses of up to 200,000 AFY from the Colorado River Water Bank. The Water Bank alone could not compensate for all potential diversion limitations from the Colorado River necessary to meet nondepletion obligation requirements. The level of participation required to meet significant East and West Slope uses could be in the range of 25 to 50 percent, requiring partial or full deficit irrigation on 130,000 to 260,000 acres on the West Slope.

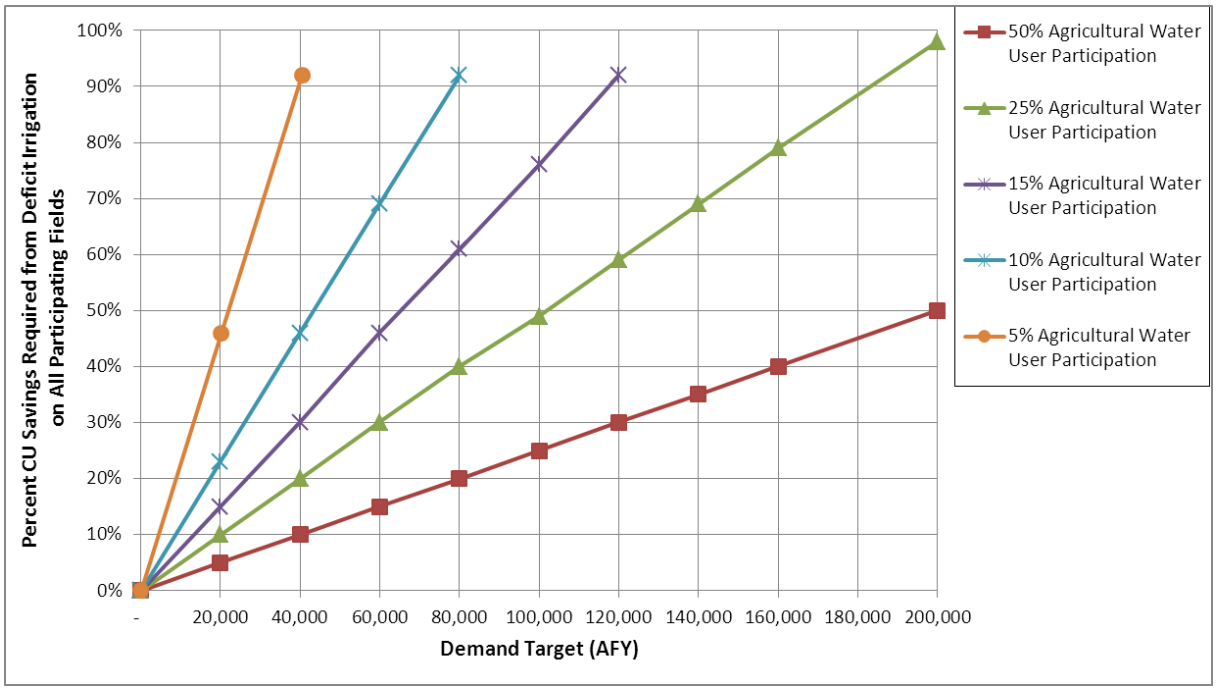

Figure 1. Percent of CU savings required to achieve demand targets for varying levels of participation by agricultural water users.

The frequency of Water Bank usage would be affected by future Colorado River streamflow relative to the 75 million AF 10-year average flow target at Lee Ferry, and by Upper Basin depletions. Frequency of Water Bank use would also be affected by whether it is used proactively to try to avoid flow shortages leading to diversion modifications to meet nondepletion obligations, or only reactively after diversion limitations are necessary to meet nondepletion obligations.

3.3 Lower Arkansas Valley Water Conservancy District

The LAVWCD conducted an ATM grant-funded project as an additional component of the analyses in support of the Super Ditch Company, which was previously funded through the first round of ATM grants as well as WSRA grants. The Super Ditch Company was created as an alternative to historical buy-and-dry of agricultural water rights for M&I uses. More specifically, it seeks to create a viable alternative to historical M&I purchases, permanent transfers, and dry-up of irrigated land to make irrigation water rights available for municipal use and also preserve irrigated agriculture.

3.3.1 Study Objectives (LAVWCD 2012)

The purpose of this specific effort funded by the ATM grant program is to provide irrigators contemplating leasing a portion of their water to municipalities, or other end uses, a tool for evaluating the economic desirability of potential lease terms. This spreadsheet-based tool compares the long-term profitability of farming against the profitability of entering into a long-term water supply lease. Either rotational fallow types of leases, or a year-to-year leases can be evaluated.

This effort is the logical extension to recent efforts by CWCB in developing the AgLET model, which provides a present day "snapshot" comparing the profitability of farming against that of several different types of leases. In effect, the original AgLET model provides the baseline conditions and the model version developed under the ATM grant extends this analysis over the time of a potential lease by explicitly considering possible future changes and uncertainties in crop and livestock profitability against offered lease terms. Alternatively, the model has potential to develop terms that irrigators might find acceptable prior to negotiating with other end users.

It should be noted that AgLET is one of several existing models, or models under development, that examine the impacts of reduced farm water usage on the Front Range or in the nearby Plains. These models include CropOptimizer, an established crop-water optimization model from the University of Nebraska, and efforts currently under development by the Agricultural Research Service (ARS) in Fort Collins and privately-funded efforts by the Regenesis Corporation. However, since all of these efforts tend to focus on a single-year snapshot under certain conditions, the model developed here uses results common to all in order to provide future "tie-ins," if desired.

Planning horizons and uncertainties have not been previously addressed in these farm-level models due to the historically large difference in values of water used for irrigation and the value of water for municipal use. More precisely, municipalities' willingness to pay for water has greatly exceeded the water's marginal value for irrigation, with little need to further demonstrate the obvious conclusion that an irrigator could make more money by giving up some water instead of using it for irrigation. However, crop price levels, especially for feed and food grains, have increased dramatically since 2007 and, according to some experts, have reached new, higher plateaus. Therefore, an agricultural water sale or lease whose economics appeared to be a "slam dunk" in 2007 may not be such a sure thing with when viewed with $7.00 per bushel corn and $8.00 per bushel wheat.

This effort is targeted to users of the AgLET model, including Extension staff, water agency staff, and irrigators. Little additional training would be necessary above that already needed to implement AgLET because the enhanced model's additional data needs would be relatively modest compared to that of the baseline model itself.

The project scope includes the following tasks:

1. Cash Flow Model
2. Case Studies
3. Uncertainty Analysis
4. Irrigator Workshops
5. Draft and Final Reports

The analysis explored important economic factors that are critical to the operations and success of the Super Ditch Company.

3.3.2 Progress Update and Preliminary Findings (LAVWCD 2012)

Enhancements were made to the existing AgLET model to meet the desired objectives of the study with regard to assessing the economics of farming versus leasing irrigation water to municipal or other uses. The enhanced model was given the name AgLET Plus. Operation of AgLET Plus requires the following user input:

- The farm operation's current irrigated crop mix.
- The terms of a potentially lease, including the number of acres fallowed, the frequency in which the acreage will be fallowed, the compensation ($ per acre) in fallow years and in nonfallow years, and a price escalator that ties the lease price to a price, or inflation, index.
- The cropping mix on nonfallowed acres, or how the operator adapts to the reduction in irrigated acreage.

Three case studies were evaluated in order to test the enhanced model:

1. For Case Study 1, the model's assumptions and results were geared towards a financially-secure, medium-sized grain-forage operation in the Lower Arkansas Valley. Total irrigated area was assumed to be 480 acres, or 3 quarter sections, divided between four irrigated crops: corn, wheat, alfalfa, and dry edible beans.
2. Case Study 2 examined a smaller operation with a higher debt load, assumed located in Weld County.
3. Case Study 3 was intended to address a mixed livestock-crop operation in order to observe how on-farm demand for livestock feed might influence the leasing decisions. However, in the early stages of development of this case study it became apparent that the number of specific assumptions needed to make the model work limited its usefulness. It was decided to forego these modifications and focus upon the crop production components of the leasing model.

Specific assumptions and results associated with each case study were documented in draft and final reports (LAVWCD 2011b, 2012). A workshop was held March 16, 2012 with CSU Extension Specialists Perry Cabot and Jeff Tranel to review the AgLET Plus model and solicit comments for possible further development. The meeting was held at Extension's offices in Pueblo.

Both specialists found the new model an upgrade from the original AgLET model in several areas:

- The development of a time component, so that the analysis can be conducted over a long period of time rather than at a single snapshot in time. This period of analysis can be adjusted to match the terms of a potential water lease contract, if desired.
- The inclusion of uncertainty in the estimates future yields, prices, and resulting net returns.
- The model is more user-friendly than its predecessor due to the greater use of default values (that can be changed by the user), resulting in fewer initial data needs. In addition, the screens are less crowded and sources of input data are easier to find.
- Overall, the AgLET Plus model developed here should supersede its previous version.

Recommendations for future improvements were also noted in the March 2012 final report for the study.

3.4 Colorado Water Innovation Cluster

The Colorado Water Innovation Cluster (CWIC) is an organization of public, academic, and private entities with an interest in water resources issues. CWIC was formed in early 2010 with the purpose of leveraging the capabilities of member organizations to collaborate to produce project-driven, innovative solutions to global water issues.

3.4.1 Study Objectives

This project seeks to provide a demonstration of techniques and technologies useful in addressing the municipal, industrial, and environmental water supply gap identified by the SWSI reports. Willing shareholders of the Lake Canal will implement fallowing, deficit irrigation, and/or other alternative agricultural practices. The saved portion of their direct flow CU will then be leased for instream flows in the Cache La Poudre River between the Lake Canal diversion and the Greeley No. 3 diversion, west of Greeley. This transfer will be facilitated by an IWSA between the Lake Canal Company, TNC, and the Fort Collins Natural Areas program. As specified by the IWSA statutory rules, the term of the agreement will be 10 years with the ability to exercise the option during 3 years of the term. Lake Canal will accomplish the demonstration using a packaged software/field instrumentation solution, developed by Regenesis Management Group, in concert with research and development agreements with CSU and the U.S. Department of Agriculture (USDA).

The project will explore how a package of software and field instrumentation can help in administering and verifying that alternative agricultural practices deliver proportional CU water outside the ditch service area while maintaining return flows to prevent injury. The project seeks to show the technical ability of these systems for planning, transferring, monitoring, and reporting to meet the administrative requirements of the State Engineer's Office (SEO) and applicable law.

In addition, the project will explore the use of an IWSA. An IWSA is a temporary water transfer mechanism allowable under Colorado Statute (CRS 37-92-309). The IWSA is proposed as an ideal vehicle for the project due to the flexibility of a short duration, administrative approval by the SEO, and no required Water Court application. Therefore, the IWSA mechanism could be used for a trial period of new technologies without the permanency, high transaction cost, and risk associated with more traditional transfer mechanisms.

Water from the project would be leased to augment instream flows in the Cache la Poudre River, demonstrating a viable alternative to CWCB ownership of dedicated water rights. As a partner, the City of Fort Collins recognizes the increasing interest in understanding, evaluating, and augmenting ISFs in the Cache la Poudre River.

This project seeks to demonstrate how municipal, environmental, and agricultural interests can partner to address difficult issues, while preserving or enhancing the viability of agriculture. More importantly, this project seeks to serve as a demonstration of the key components necessary to implement new, more complicated forms of water transfers in the future, which will be of statewide benefit.

The proposed project builds upon previously-completed/ongoing CWCB projects including: Lower Arkansas River Rotational-Fallowing (Super Ditch), PWSD Lower South Platte Project, and the CCGA

Project. Many of these projects have identified alternative agricultural practices that may be considered here, as well as legal and institutional mechanisms to support their application.

Transaction costs have been cited as a hurdle to implementation of these approaches. Though small, this project proposes a limited-transaction cost approach to demonstrating the utility of some of these alternative agricultural practices at low risk to the project participants and third-parties in the basin. This allows the Division Engineer, the State Engineer, opposers, and potential future users of these technologies to see them enacted in real-time.

This project should inform future efforts with the technical, administrative, and institutional processes that will be tried and established, thus improving the level of certainty for others. Verification and administration issues are directly addressed by the software under development by Regenesis, through support of its research partners (USDA/CSU). This software and the accompanying instrumentation is intended to collect administrative data in near-real time, which should support this and future alternative transfer efforts, while reducing the cost and effort of collecting and analyzing these data. It is envisioned that the software should assist both project proponents and Division Engineer staff in operating and administering these complex transfers, and the utility of this software will be demonstrated as a part of this project.

3.4.2 Progress Update and Preliminary Findings (CWIC 2012)

On March 1, 2012, the application for an IWSA between the Lake Canal Co., the City of Fort Collins, and TNC was made with the SEO. Comments on the IWSA application were received from four entities. Those entities were:

- SEO
- CWCB Stream and Lake Protection Section
- New Cache la Poudre Irrigating Company
- Northern Colorado Water Conservancy District (Northern Water)

A meeting with representatives from the SEO was held on April 9, 2012 to discuss the comments. A memorandum responding to the issues was drafted but not formally presented to the SEO because of the eventual delay in exercising the IWSA. During April 2012, the below normal snowpack dropped dramatically and in addition there was little spring precipitation. In May 2012, the Lake Canal river decree could only be used for initial start up and flushing of the canal system. There was no direct flow water available for irrigating under the Lake Canal system or operation of the IWSA.

Consultation with Division of Water Resources (DWR) staff in May 2012 resulted in a recommendation to submit an amended IWSA plan in the fall of 2012 for transfer of water in 2013 assuming adequate snowpack during the winter of 2012/2013. Representatives of the project team met with the City of Fort Collins and TNC on May 18, 2012. Both entities reaffirmed their desire to participate in 2013. At that point, it was understood and agreed by the water borrowers that the transfer of water would be postponed until 2013 since there was no water available to operationally transfer in 2012.

The Lake Canal service area was flown on August 10, 2012 to obtain multi-spectral imagery to include RGB, NIR, and thermal sensors. This imagery will be available now to help in the ongoing discussion of alternative practices and maintenance of historic return flows.

In the process of developing, submitting, and following up on the IWSA this past spring, the project team identified a number of key issues that are, in effect, preliminary project outcomes or observations as follows:

- Lake Canal river decree as a primary water source: It was initially envisioned that the Lake Canal river decree—which, in a normal year is in priority in the May 15 to June 30 timeframe—would be the primary water for the IWSA. As farmer participants were identified and as discussions continued with the water borrowers, it became evident that the river decree coupled with the late season water sources utilized by farmers were needed together to have a suitable proof of concept. So, the full season water sources will be again brought to bear so that water can be delivered

- Water Lease Rate: The compensation level or water lease rate to be paid per leased AF of CU water has been a difficult discussion element within the project to date. In spring 2012, corn and wheat prices were high and potential participating farmers were quite concerned about a rate for saved water that adequately made up for the opportunity cost of using all their CU water for crop production. Now, corn and wheat prices are at record levels. The ongoing rate discussion will be important as participating farmers are identified and practices considered. The project participants intend to host a special Lake Canal shareholder meeting, assuming that the Lake Canal board is supportive, to review project concepts and goals.

- Interaction with DWR: The meeting with DWR staff was a significant and positive interaction. The meeting was held in Windsor and was attended by 12 people with half representing DWR and half the project team. The discussion was detailed and positive. Most discussion revolved around river management with respect to when, where, and how the transfer could take place. Secondly, much discussion occurred around the instrumentation of headgates and fields and the monitoring of the water balance for the fields made a part of the IWSA. This discussion and ideas brought forth will be utilized in the updated IWSA submittal during fall 2012.

- Historic relationships and sociology: There is a long history of past difficulties between the City of Fort Collins and the Lake Canal Co. There has been some progress in mitigating the history with a presentation to the Lake Canal board in the spring of 2012. John Stokes with the City of Fort Collins attended the board meeting along with Stephen Smith and a number of good ideas were discussed. A successful project, such as this IWSA, could form a basis for improved future cooperation.

- CCGA project interaction: Several CWIC/Lake Canal project participants are also involved with the CCGA ATM project. The instrumentation of water balances under Lake Canal might be considered a "boots on the ground" proof of concept project and the CCGA project more of a desk top analysis and proof of concept. In a perfect world, the CWIC / Lake Canal project would have followed the CCGA project in order to incorporate lessons learned. With the snowpack situation, fate has now intervened and the CCGA project is proceeding ahead of the CWIC / Lake Canal project. Outcomes from the CCGA project will be brought into the CWIC / Lake Canal project as much as is possible.

Since the transfer of water could not be achieved due to developing drought circumstances beyond our control, the CWIC Grant Project Team made a request to CWCB for a 1-year extension for the grant. The project team also views this as an opportunity to potentially address some of the issues identified as the IWSA application is finalized and resubmitted.

3.5 East Cherry Creek Valley Water and Sanitation District

Through this project, the ECCV is exploring opportunities to maintain some level of agricultural productivity on lands that are the subject of a water court transfer to M&I uses, either permanently or as part of a rotational fallowing or interruptible supply agreement. The two primary alternatives to revegetation of fallowed land that are the subject of this project are:

- Dryland farming
- Dryland farming with the allocation of a specified limited amount of water (limited irrigation) needed to provide greater assurances of producing a dryland crop yield under most climatic conditions

While a priority has been placed in this study on developing alternatives to permanent dry-up and/or revegetation with native grasses, in some situations involving a permanent transfer of water rights, permanent revegetation is the most logical outcome due to the preference of the land owner or to soil and environmental conditions. Approaches and costs of revegetation are being evaluated.

This proposal aims to keep agricultural productivity on lands that could very easily fall out of production due to the removal/transfer of its irrigation water due to urban transfers. One of the key goals and objectives of this grant program is to minimize the negative effects of urban transfers and help sustain Colorado's agricultural economy. In SWSI 2010 (CWCB 2011a), it was recognized that municipal water providers plan on using agricultural transfers as a portion of their future water supply. Given this reality, this project has the potential to identify means to minimize the impacts that are expected to occur.

3.5.1 Study Objectives

Agricultural transfers are likely to occur in the South Platte Basin as predicted in the SWSI report. Many M&I water providers prefer traditional water transfers and require dry-up covenants at the time of purchase. As a result, most agricultural lands that are the subject of transfers no longer remain in any type of agricultural productivity. This project will:

- Examine the opportunities to maintain some level of productivity on lands that are the subject of water transfers, either through limited irrigation or dryland farming as a result of permanent dry-up or a rotational fallowing or interruptible supply agreement
- Continue the field studies on revegetation currently being conducted by CSU researchers at LaSalle, Colorado
- Develop and compare the costs and issues with dryland farming, limited irrigation, rotational fallowing, or revegetation with no agricultural activity

These objectives will be accomplished through the evaluation of the following six topics:

1. Task 1 – Conversion to dryland farming and limited irrigation.
2. Task 2 – Revegetation of previously irrigated lands.
3. Task 3 – Identification and mapping of lands by suitability for revegetation, dry land, or limited irrigation.
4. Task 4 – Economic issues with conversion to dry land or limited irrigation.
5. Task 5 – Water court transfer issues.
6. Task 6 – Benefits to M&I end users.

Furthermore, this project will build on the findings and results of the current first round of ATM grant projects in the South Platte. Even with the preference of most South Platte M&I providers for traditional transfers that result in permanent dry-up, there is an opportunity to evaluate other approaches other than a permanent dry-up and/or revegetation with native grasses that eliminates any continued agricultural productivity with of those lands. The Parker ATM study detailed potential crop yields and CU under deficit irrigation techniques. The FRICO ATM project revealed that there is a very strong bias among M&I users to hold the ownership of transferred agricultural water rights and for traditional transfers. Other projects, such as the Super Ditch, have developed rotational fallowing as an approach that results in temporary, rotated dry-up of historically irrigated lands.

A significant portion of M&I water rights acquisitions include dry-up covenants as an assurance of achieving the maximum CU through the water court transfer process. The Division Engineer and other objectors in water court seek assurances through the water court change of use process that the consumptive transferred to M&I use does not continue on the historically irrigated lands. Dry-up covenants typically require the seller of the water right to agree to permanently cease irrigation of the lands historically irrigated with the water rights that are sold and transferred. The dry up covenants are normally recorded to ensure that the dry-up provision is enforceable with future land owners. The end result is that agricultural use on the land ceases.

3.5.2 Progress Update and Preliminary Findings (ECCV 2012)

The study area for the ECCV project is shown on the map in **Figure 2** below.

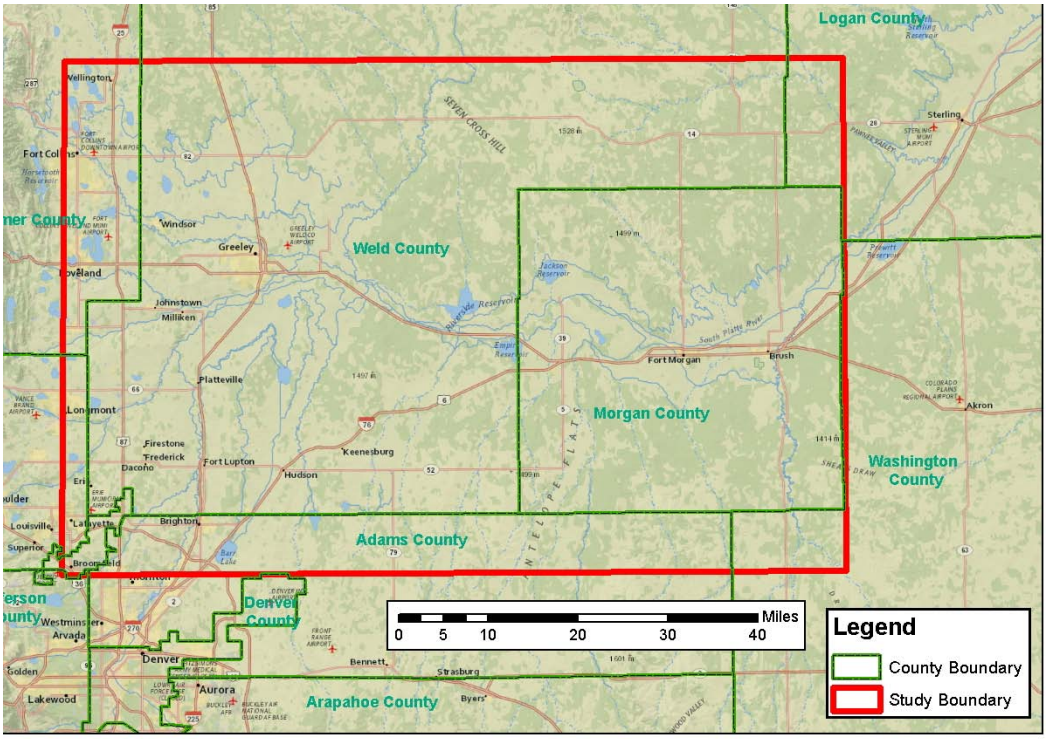

Figure 2. ECCV Project Study Area

The status of each of the six tasks identified in the study objectives is summarized in the sections that follow.

Task 1 – Conversion to dry land farming and limited irrigation

Existing research on dryland farming within the study area has been conducted to describe potential dryland crop rotations and ranges of potential crop yields for the study region. In addition, the potential for limited irrigation cropping systems in the area is also being evaluated. Crop rotations being emphasized for dryland or limited irrigation cropping are winter wheat-summer fallow, winter wheat-corn-summer fallow, winter wheat-annual forage crop-summer fallow. Tables of potential crop yields and yield variability under strict dryland and dryland with a minimal, fixed allocation of irrigation water are under development.

Task 2 – Revegetation of previously irrigated lands

CSU has been evaluating several cover crop options on a farm near LaSalle, Colorado and the continuation of the project is supported by this grant. The goal is to provide cover crop recommendations for farmers who need to temporarily fallow irrigated land such as under a rotational following or an IWSA, assume dryland production, or establish grasses in formerly irrigated fields that are subject to dry-up covenants.

The ongoing field demonstration of techniques for revegetating previously irrigated land is being continued at a field site near LaSalle. Small plot and large scale demonstration work continues in collaboration with a local land owner. Below is a schematic illustration (**Figure 3**) of the field layout and main demonstration components in the field.

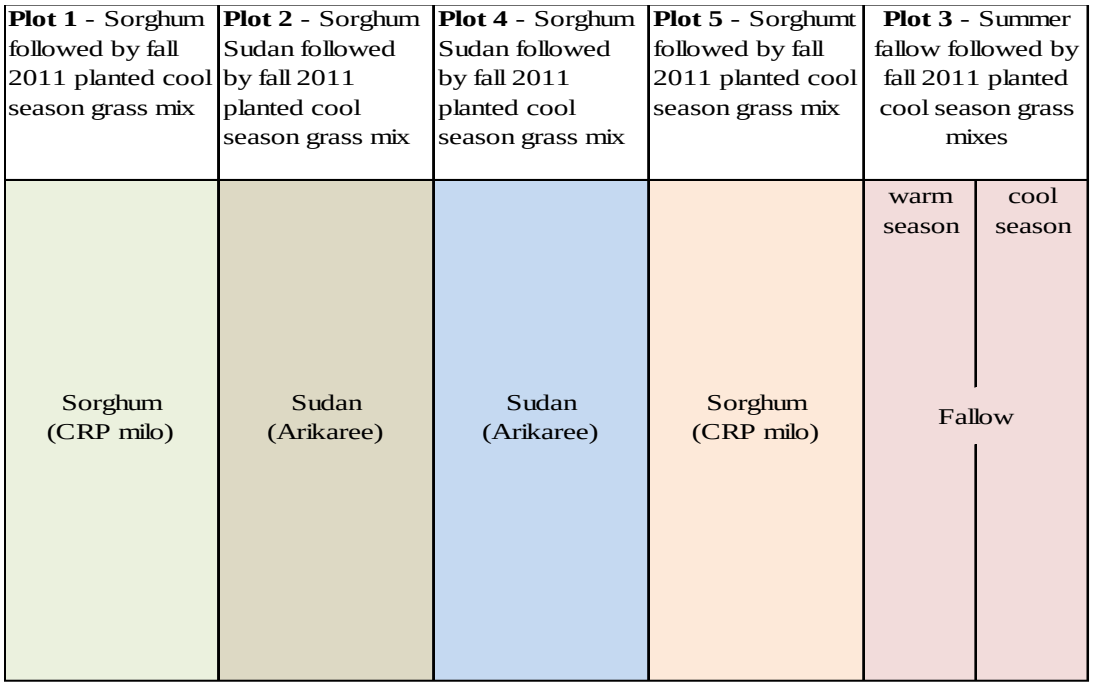

Figure 3. Plot Design, LaSalle Large Scale Demonstration Plots – Reclamation of Formerly Irrigated Land

Extreme drought conditions during 2012 created a very challenging environment for revegetation in newly planted plots and caused injury to established grass stands. Despite the challenging year some important lessons have been learned throughout this study. Cover cropping has been successful at reducing weed pressure, providing soil cover and residue, and reducing excess soil nutrients. Cover crops can reduce available soil moisture, a critical consideration in drought years or if water is unavailable for grass establishment. No-till grass establishment is challenging due to irregular seed bed conditions. Weed control is critical to successful revegetation (either via mechanical or chemical means), especially under extreme drought conditions when moisture is at a premium. Revegetation requires patience, and it may take three to five years from planting to stand establishment. Educational and technical materials are being prepared.

Task 3 – Identification and mapping of lands by suitability for revegetation, dryland, or limited irrigation

In this task, crop-water production functions (validated relationships that estimate crop yield based on water input) are coupled with global positioning system data for precipitation and soil water holding capacity to estimate dryland and limited irrigation production potential of irrigated land. Several data layers have been used to map potential productivity of dryland corn, including the depth-weighted soil water holding capacity (Weld County – South) and average precipitation over two time periods. April to June precipitation corresponds to the vegetative growth period of corn. July to August precipitation corresponds to the reproductive growth period of corn during which corn grain formation and yield production occurs.

Some probability-based yield estimates can then be made when layering the precipitation and soil water holding capacity to predict spatial variation of potential productivity of a crop. Dryland corn production estimates were created for years with average precipitation as well as for a scenario that assumes an additional 5 inches of effective water input from limited-irrigation management. Example figures depicting estimated yield, shown in **Figures 4 and 5** below, still require refining and validation, but are presented here to demonstrate the concept and approach being used.

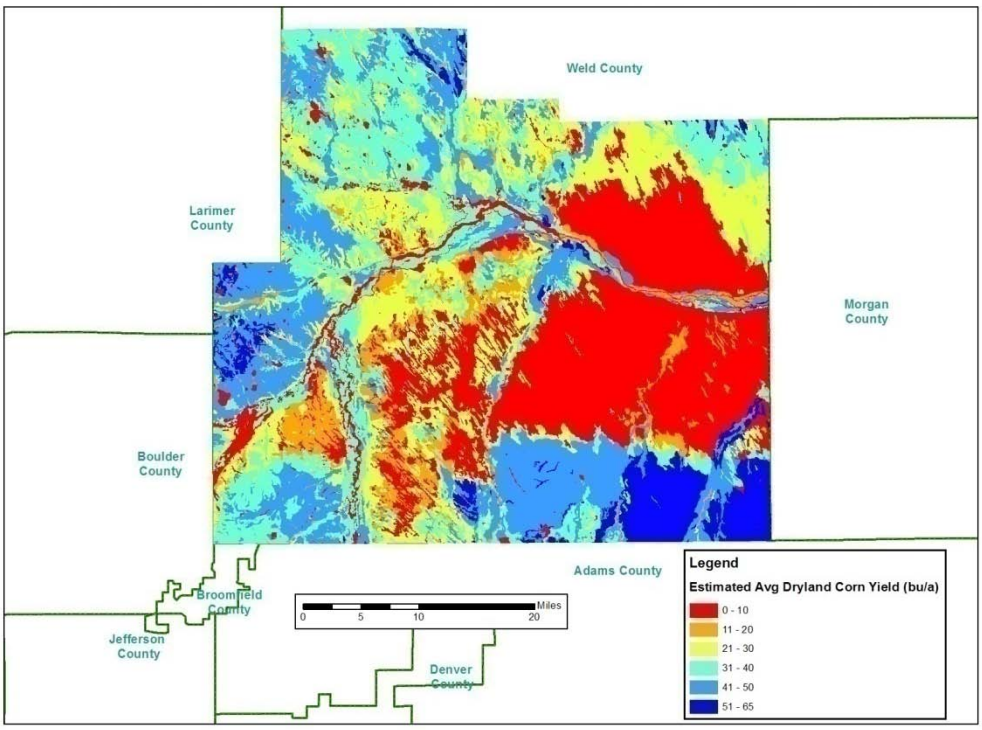

Figure 4. ECCV Project – South Weld Estimated Average Dryland Corn Yield

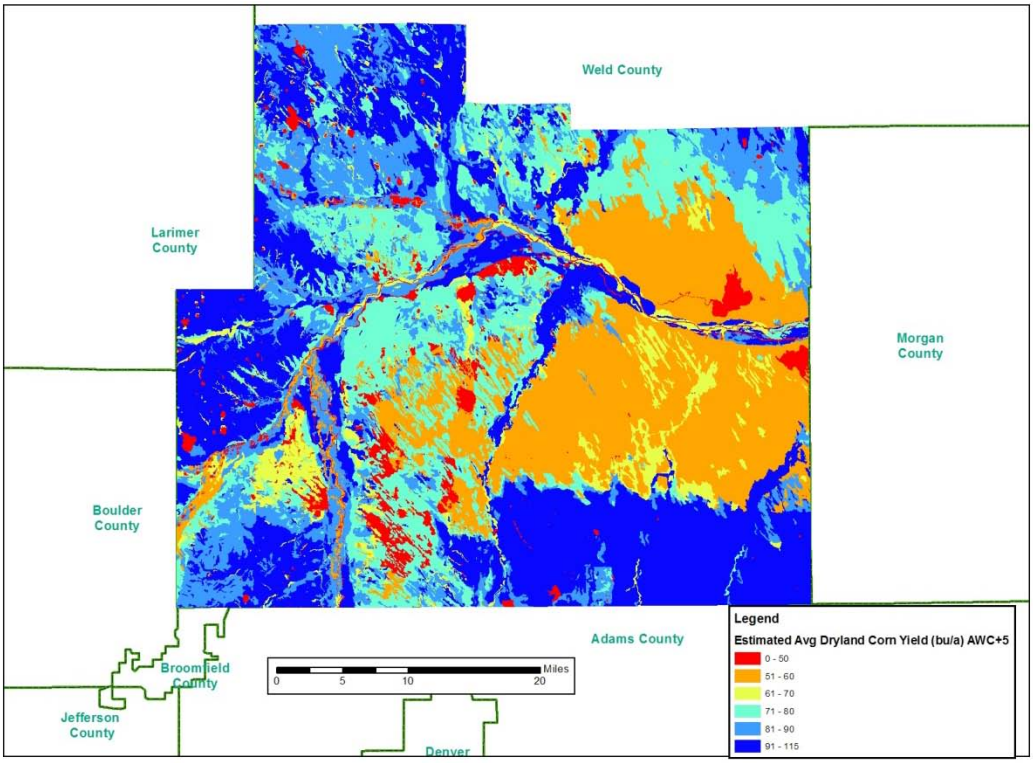

Figure 5. ECCV Project – South Weld Estimated Average Dryland Corn Yield with AWC+5

Task 4 – Economic issues with conversion to dryland or limited irrigation

The following economic issues associated with the possible conversion of irrigated land to dryland or limited irrigation will be examined:

- The crop insurance implications of having a specified volume of irrigation supply for a dryland crop
- The costs to the farmer to maintain an irrigation system that would only be used infrequently to provide limited irrigation for a dryland crop
- The likely property tax classification that would result if a dry land crop were to have very limited irrigation
- The net economic production of this land under conventional dryland and partial irrigation/dryland cropping

An information gathering phase is partially completed. Contacts have been made with tax assessors and crop insurance agents. Informational notes from these communications were included in documentation submitted to CWCB in October 2012. Additional information gathering will be conducted and assembled into a final report.

Task 5 – Water court transfer issues

The purpose of this task is to examine the technical and legal aspects associated with continued agricultural productivity on the historically irrigated lands that are the subject of a water transfer. Progress toward completion as of October 2012 includes the following:

- Engineering and legal issues associated with a water court transfer have been identified
- Information and feedback from the Flex Market Project have also been incorporated
- Issues that have been identified include:
  - Methods to verify reduced CU
  - Return flow accounting
  - Return lows from limited irrigation and if these can be claimed as a credit
  - Division Engineer and water commissioner acceptance and monitoring
  - Water consumption by crops from water table rather than limited irrigation water
  - Dry-up versus limited dry-up provisions in decrees

Task 6 – Benefits to M&I end users

The comparative costs to M&I users under a standard dry-up covenant versus dryland cropping or limited irrigation are being evaluated. This task will evaluate the potential benefits to M&I users in avoiding revegetation or other mitigation costs and include the value of water that could remain with the historically irrigated land under a limited irrigation scenario. Several M&I end users will be contacted to present potential benefits and evaluate interest in alternatives to permanent dry-up/fallowing.

As of October 2012, preliminary cost estimates for revegetation have been collected based on CSU studies and experimental plots and City of Thornton costs for revegetation of the Water Supply and Storage Company lands. Staff effort and time required for successful revegetation and follow up monitoring have also been analyzed. Successful revegetation can often take multiple years of effort including reseeding and weed management.

Preliminary conclusions are that there are benefits to water providers when transferring agricultural water if the land can remain in some form of agricultural production, thus eliminating revegetation requirements and follow up monitoring, if required by court decree. A summary of revegetation costs versus water requirement and associated costs for limited irrigation will be compared.

3.6 Parker Water & Sanitation District

The work on this project is centered on a research site in the Lower South Platte Basin located near Iliff, Colorado. Research on the site has been conducted since 2008 on limited irrigation, rotational cropping, and partial season irrigation approaches for water conservation and has demonstrated viable cropping practices that reduce CU while avoiding dry-up of irrigated land.

3.6.1 Study Objectives

The current phase of the project works to develop a practical means of calculating and verifying consumptive water use to bring limited irrigation and alternative crop rotations into the feasible set of water saving options. The previous CWCB-funded research also evaluated the role of deficit irrigation in farm level economics, the willingness of farmers to participate in alternative water sharing arrangements, and the contribution that irrigated agriculture makes to the economic vitality of rural communities.

The next major step forward is development of a detailed, specific, and sophisticated water sharing program that addresses the following—how much water can be released as a result of adopting alternative water saving practices, how much must farmers be paid to participate in the program, what is the cost of this water to the municipal leaser, and how will the alternative transfers impact

local businesses and the environment relative to permanent fallowing that follows a buy-and-dry transfer.

Specific tasks associated with the current phase of the PWSD ATM grant project include the following:

1. Develop a practical means of calculating and verifying consumptive water use and water savings in alternative systems that will satisfy Water Court requirements.
2. Demonstrate a water allocation approach to simplify the administrative burden to maintain return flows.
3. Develop a model water transfer institution based on a case study water organization that will establish a water delivery plan and organizational structure.

This project addresses specific barriers to ATM implementation that were identified during the implementation of the first round of ATM grant projects. Specifically, PWSD seeks to address how the SEO would administer an alternative method to ensure that there is no enlargement of the irrigator's water rights while maintaining historic return flows. In addition, the proposal seeks to further evaluate water quality/treatment and delivery options that are key considerations with moving water from lower in the river basin up to the metro area.

3.6.2 Progress Update and Preliminary Findings

Status updates on Task 1 and Task 2 were submitted to CWCB in October 2012. Results and findings are summarized in the sections below; more detailed results are included the source documentation (Jaeger et al 2012).

Task 1 – Develop a practical means of calculating and verifying consumptive water use and water savings in alternative systems that will satisfy Water Court requirements

In this task, PWSD and its partners are developing, testing, and validating three different approaches to calculate CU and water savings of limited irrigation cropping practices. They are emphasizing peer-reviewed publications as task deliverables in order to provide defendable materials for potential future water court activity. The task is broken into three subtasks, as follows:

- **Sub-task 1A.** This subtask uses observed corn data from the previous CWCB funded research (Iliff site, 2008-2010) to evaluate the use of stress coefficients (K_s) to calculate CU under limited irrigation scenarios. The stress coefficients can be used with standardized methods, such as the Penman-Monteith equation. The results show that a standardized ET calculation approach, such as the Penman-Monteith equation, can be modified with a K_s for limited irrigation scenarios for valid estimation of crop CU. Calculating K_s requires measurement or reasonable assumptions of site-specific soil moisture content at planting, soil water holding capacity, and the weather observations needed for the Penman-Monteith equation. Alternatively, remote sensing approaches outlined in Sub-tasks 1B and 1C could be used to determine K_s.
- **Sub-task 1B.** This sub-task is a field-scale validation of the K_5 and CU calculations under limited irrigation by independently measuring actual crop ET. The independent ET measurement is based on in-field soil moisture sensors, infrared radiometry, and a land surface energy balance. The use of infrared thermometers to measure the temperature of the crop canopy has been related to crop water stress and ET rates. The method has been employed under controlled irrigation conditions at the Iliff, Colorado field location in 2011 and 2012 to validate the use of

the K_s method, but also as a potential independent method of assessing consumptive water use of crops under limited irrigation. Crop canopy temperature and corresponding air temperature measurements are manipulated mathematically to determine the crop water stress index (CWSI). Results show that CWSI can accurately identify crop water stress associated with limited irrigation.

- **Sub-task 1C.** This sub-task uses satellite based remote sensing to further develop and validate ET measurements, crop coefficients, and stress coefficients under cropping practices with reduced CU. Satellite imagery and a surface energy balance model developed at CSU called ReSET have been used to estimated actual ET (ET_{act}) for three corn plots at the Iliff research location with variation in irrigation and soil conditions. The ET_{act} values are then further used to determine the site-specific actual corn crop coefficient $K_{c\text{-}act}$, K_5, and the seasonal crop water use.

Task 2 – Demonstrate a water allocation approach to simplify the administrative burden to maintain return flows

Implementation of cropping practices that reduce CU without complete dry-up or fallow is dependent on a reliable approach to maintain and verify historical return flows. Past study results from the Iliff location do show a reduced volume of water moving below the root zone from limited irrigation, suggesting that return flows would be diminished under these practices. Under a change-of-use case involving any of these practices, a secondary approach to maintain return flows may be implemented (recharge ponds, wetlands, etc). Field scale approaches to determine and verify the contributions to return flow under limited irrigation have the potential to be very complex and expensive, making this a significant barrier to adoption of these alternative methods.

PWSD and its partners have proposed a water allocation approach to simplify the administrative burden of maintaining return flows when a deficit irrigation or alternative crop rotation is implemented. In this approach, 100 percent of the historic return flows would be met with a secondary method (i.e., constructed wetlands or recharge ponds). In this way, the historic CU changed to municipal use, the historic CU that continues to be used for irrigation, and the historic return flow components are all kept separate and discrete and can be administratively tracked. This allocation method quantifies the target CU savings and historic return flow, and the irrigator is allowed to fully consume the diverted water, minus the historic losses.

A major advantage to this approach is that it motivates the use of efficient irrigation practices. Diversion/flow measurements are needed for the farm and for the diversion into the secondary return flow system, but this approach avoids the need for expensive and complicated instruments such as soil moisture sensors, drainage gauges, etc. at the field level. 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. Pending work will use existing field research results to synthesize the costs, strengths, and weaknesses of the allocation.

3.7 Lower South Platte Water Conservancy District

The Lower South Platte Water Conservancy District (LSPWCD) is the applicant for an ATM grant project aimed at developing a proposed organizational structure and operational plan for a potential water organization in the Lower South Platte River (currently known as the Lower South Platte Water Cooperative) that would facilitate more efficient use of water in the South Platte River Basin. Several entities have expressed interest in the formation of this organization, including individual agricultural

producers, augmentation plans, ditch companies, municipalities, and water conservancy districts. Many of these entities provided matching funds and letters of support for the grant applications. This project is also funded in part through a WSRA grant.

3.7.1 Study Objectives

The ATM grant portion of this project focuses on developing an operations plan for the Water Cooperative. This project will analyze and address:

- Technical issues such as identifying, quantifying, and determining reliability of long-term water supplies (from alternative transfer methods, excess augmentation water, and newly developed water rights), as well as implementing accounting and data management needs in order to exchange, retime, and store such water on a daily basis.
- Legal issues such addressing third-party and internal water rights and injury concerns.
- Economic issues such as individual farmer and individual organizational financial assessment for potential Water Cooperative members as well as financial considerations for a new water marketing / leasing organization such as the Water Cooperative.

In addition, substantially more technical, institutional, legal, and economic analysis will be conducted as part of this project to develop an operations plan and assist in detailing an organizational structure for a potential new organization. Through initial work by the group, water users made it clear that the success of the Water Cooperative will be directly related to two key issues:

- The organizational structure chosen to govern and operate the Water Cooperative must be fair, open, and transparent; and
- The operational plan for the Water Cooperative must be able to function within the existing system of water right decrees, and be done so that no injury to existing water rights occurs.

The objectives of the ATM grant are to develop an operational plan and strategy for the potential organization and to research economic issues associated with alternative transfer programs. The specific project objectives as described in the ATM grant application are:

- Develop an operational plan that identifies water supplies (including direct flow and/or storage water transferred through alternative means, excess recharge credits, new junior water rights, etc.), demands, and the means and infrastructure needed to provide water when and where it is needed.
- Identify existing and potential infrastructure that could help increase the ability of the Cooperative to match supplies with demands.
- Obtain feedback from stakeholders on the operational plan.
- Identify specific data, water measurement, and accounting needs and work with potential Cooperative members on developing data transfer methods.
- Gain a general understanding of options for funding the operation of the Cooperative.

This project is a component of a larger concept that recognizes the existence of available augmentation credits (made available from recharge projects) in the South Platte River Basin and the

creation of an organization that serves as a mechanism for moving these credits to other users. If successful, this project may help to optimize the use of the South Platte Basin's water resources.

3.7.2 Progress Update and Preliminary Findings (Frank et al 2012)

The project team has been working under the ATM grant since August 2011. A Grant Review Committee (GRC), consisting of 10 individuals (5 from District 64 and 5 from District 1), was appointed to oversee work done by contractors and to collaborate and provide input on organizational and operational plans. The GRC and contractors have been meeting approximately monthly to discuss issues, check progress, etc.

Significant progress has been made in reaching the objectives of the ATM grant. Progress on the operational plan as of October 2012 is summarized below.

- Quantified various types of potential water supplies.
- Quantified many water demands and are continuing this process.
- Updated tools for assessing exchange and free river conditions.
- Developed an operational planning tool that incorporates supply, demand, and delivery information.
- Working on operational scenarios.
- Conducting economic analysis of alternative transfers.

The goal of the GRC is to develop an organizational and operational plan for potential members to evaluate at the beginning of 2013. The following sections elaborate on the findings associated with the progress points listed above; further detail can be found in the status report submitted by the project team (Frank et al 2012).

Quantification of potential supplies

Potential supplies that could pass through the cooperative include unused recharge credits and senior water rights that could be used to "firm up" deliveries to end users. Firming supplies could be made available in an alternative transfer context (i.e., rotational fallowing or interruptible supply agreements). In addition, the cooperative could apply for new water rights for storage or recharge in strategic locations along the river where reliability of delivery is not sufficient. Assessments were conducted to quantify the potential sources of water and to identify the locations and reliability of the sources. The quantification of unused recharge credits found the following:

- Amounts of unused recharge credit vary annually. Substantially more unused recharge credits occurred in 2009 and 2010 than in 2008.
- The amount of unused recharge credit appears to be less variable in District 64. Annual amounts of unused recharge credits in District 64 varied from 5,000 to 10,000 AFY.
- Annual amounts of unused recharge credit appear to be more variable in District 1 than in District 64. Annual amounts of unused recharge credits varied from 6,000 AF in 2008 up to 50,000 AF in 2010.

- 2008 through 2010 were good years for recharge. It is likely that, during drought, unused recharge credits will be much reduced, if not eliminated.

Further analysis suggests that availability of water for new water rights is highly variable on a temporal and locational basis, but in general, seems to peak near the confluence of the South Platte and Cache la Poudre Rivers. In some years, very little water was available for new water rights, but in other years, 200,000 to 500,000 AF of available water passed various points on the river. Not all of this water would be divertible (i.e., it may have occurred during flooding conditions), but it does suggest that new storage rights would be in priority periodically.

To assess amounts of water that could be available through alternative transfers, the project team used CU modeling data from StateCU available from the South Platte Decision Support System. The team assumed that firming supplies could be made available through rotational fallowing programs under ditch systems in Districts 1 and 64. In addition, the team assumed that 65 percent of shareholders would be interested in participating in a rotational fallowing program (if the price is right for water) and that 25 percent of their land would be fallowed to generate transferrable CU. Using these assumptions approximately 30,000 to 40,000 AFY may be available through rotational fallowing. However, the total could be more or less depending on shareholder interest, the price for water, and the method of alternative transfer.

Quantification of potential demands

The project team has conducted meetings and interviews with various water providers and augmentation plans to assess potential demands for water that could be made available through the cooperative. Water needs have varied. For example, most users have expressed interest in water supplies during droughts. Augmentation plans generally need water in the second year of drought conditions. In the first year of a drought, accretions from previous years' recharge activities are generally adequate to meet their needs. However, if their junior recharge rights are not in priority during the first year of drought, their available recharge credits dwindle in the second year. Municipal providers generally have adequate supplies in most years, but may need water during drought conditions or for drought recovery. The Central Colorado Water Conservancy District expressed a need for consistent supplies to allow full pumping. The project team is continuing its investigation of potential demands.

Exchange capacity

The exchange capacity tool developed for the CCGA ATM grant project was updated to include more recent point flow and call data as a part of this study. The tool has been useful to the project team in understanding opportunities for and limitations to exchange in various reaches.

Assessment of existing infrastructure

Existing infrastructure could potentially be useful to the cooperative for storing or retiming supplies if agreements can be established with owners. The GRC identified numerous existing and proposed storage reservoirs, pumping stations and pipelines, and recharge facilities that could potentially be investigated further once operational strategies are further developed. These facilities were mapped in GIS. The maps and list of infrastructure will be updated as needed.

Operational planning tool

An operational planning tool was developed and is being updated as work progresses. The planning tool runs on a monthly time step and uses data from the analyses described above. The tool assesses

supplies, demands, and deliveries and conducts a water balance in five reaches of the South Platte River in Districts 1 and 64. The South Platte River was divided into reaches in order to simplify the planning tool. The reaches were delineated based on exchange characteristics of different segments of the river. The tool includes the following:

- A listing of potential supplies in each reach (including supplies passed down from upstream reaches or supplies exchanged from downstream reaches)
- A listing of demands in each reach
- A listing of storage reservoirs and recharge facilities in each reach
- Amounts of water targeted in each reach for exchange upstream or for delivery
- Estimates of transit loss for water passed to downstream reaches
- A summary to assess the amount of demand that was met in each reach.

The planning tool will be used to evaluate different hydrologic scenarios and operational strategies to successfully meet demands under the scenarios. The scenarios are currently under development.

Operations and financing of similar organizations

Research is being conducted to assess how other, similar organizations operate and finance their operations. The proposed Lower South Platte Water Cooperative is fairly unique, though water banks and the Super Ditch have similar goals and objectives. Organizations like this have been set up in other states, although each one has different goals and legal settings.

This study is ongoing. Some initial findings from these investigations are as follows:

- Many water bank organizations are run by government entities.
- Data management is an important aspect of operations. Effective tools are needed to manage large amounts of data.
- Most organizations tend to rely wholly or in part on per-acre-foot transaction fees to finance themselves. Incremental pricing for supplies with varying reliability has been used as a tool to capture the differing values of water rights transferred into water banks.
- In one particular instance, a water bank organization did not have an adequate understanding of the water demands they were attempting to serve. The organization paid farmers for water supplies but could not complete transactions for all of the water they purchased, resulting in financial losses. In subsequent years of operations, end user agreements were established ahead of time.
- Generally, two to three people are needed to run the organizations that were interviewed. However, in some instances, work backlogs have hindered customer responsiveness and service.
- Several types of example materials have been gathered by the project team including applications for leases or water deposits, annual reports, staff job descriptions, operations handbooks, member databases, member responsibility materials, etc.

The information derived from this analysis will be useful to the cooperative organizers in planning operational activities and needs.

Economic considerations

Agricultural producers will potentially have the opportunity to enter into lease-fallow or deficit irrigation programs with the Lower South Platte Water Cooperative. An important part of this decision is choosing an alternative cropping system that will give the best chances for profits within existing land, equipment, capital, and labor constraints. Examples of alternative cropping systems might include an irrigated corn-fallow rotation, an irrigated corn-dryland wheat rotation, reduced irrigation alfalfa and others.

In this situation, the producer's task becomes balancing the tradeoffs between price and yield risk and profitability. This study considers price and yield risks as they are associated with producer profits under various cropping systems with conserved water.

Accurate cropping system enterprise budgets are needed to evaluate the tradeoffs of adopting alternative cropping systems. These budgets can be integrated into AgLET, a decision support tool that helps farmers determine a minimum level of compensation for entering into water leasing agreements. The results from this study will help to refine AgLET's recommendations and incorporate an estimate of farm-level risk.

With this in mind, the economic analysis has the following objectives:

- Characterizing the alternative cropping systems and how much water might be saved
- Quantifying the costs and revenues of alternative cropping systems with the expertise of current farm managers
- Explaining how a farmer's profit and risk profiles change when alternative cropping systems are used to "conserve" water
- Calculating average opportunity cost that is created when water is removed from agricultural production

Substantial progress has been made on all objectives. Expert analysis and farmer input has been used to create a set of enterprise budgets for traditional and alternative cropping systems that conserve water. A stochastic simulation model has been created and iterated to generate results. These are being refined through review process with experts and farmers.

Using a stochastic simulation process, the preferred alternative cropping system is a corn-dryland wheat rotation. Subject to capital constraints, personal preferences and equipment limitations, this appears to be the most likely crop rotation to be adopted when entering a leasing arrangement. In addition, a number of notable results are beginning to emerge. As an example, $143 per acre or $119 per AF is the mean difference between a continuous corn cropping system and a water-conserving corn-dryland wheat rotation for a typical Weld County farm. One might view this as a minimum level of compensation needed to adopt the water conserving cropping system. However, a substantially larger payment is needed to reduce the chance of failing to meet a critical cash flow amount, or to ensure the same likelihood of achieving above average profits. These results are considered preliminary and subject to updating with additional review.

In addition to the research described above, the project team will be engaging a group of farmers in a workshop format and allow them to use the AgLET tool to assess their individual operational and financial needs and risk tolerances with respect to alternative transfers. The results of the workshop exercise will be aggregated (protecting the confidentiality of the participants) and will be compared with amounts that end users are willing to pay to see if there is an economic climate favorable for alternative transfers. This work has not yet begun.

3.8 Colorado Corn Growers Association

The CCGA; City of Aurora, Colorado; Ducks Unlimited; and Regenesis Management Group, LLC are co-applicants on an ATM grant to develop the framework for innovative partnerships aimed at sustainably securing water supplies. The framework, dubbed the "Flex Water Market," contemplates the establishment of a long-term, sustainable contractual partnership among agricultural water users, municipal and industrial users, and environmental interests.

Distinguishing characteristics of the Flex Water Market include the following:

- The potential to purchase a small percentage of a farm's overall supply by a municipal, industrial, or environmental/conservation user and deliver this "base" amount via alternative methods (fallowing, growing crops with low water use, or regulated deficit irrigation)
- An agreement regarding intermittent leasing (short- or long-term) of the remaining water supply at the farm
- A focus on use of recharge sites and other environmentally beneficial delivery methods and management

3.8.1 Study Objectives (Sponsler et al 2012)

Three work products are being collaboratively developed during the course of the study by engaging agricultural, M&I, environmental, legal, and engineering experts. The work products are listed below:

- Flex Water Market contract templates
- Model terms and conditions pertaining to Colorado Water Court decrees for the market
- Survey-level engineering analyses of major ditch companies, which summarize the potential transferrable water supplies available and assess the potential for delivery to end water users

The FLEX Market Contract template is intended to provide a scalable, easily duplicated legal document that can be used by entities in the future as a starting point for the negotiation of actual contracts. The FLEX Partnership Model is the product of the CCGA ATM grant first round study. The FLEX Model contemplates the establishment of a long term, sustainable contractual partnership between agricultural water users, M&I users, and environmental interests. Distinguishing characteristics of the FLEX Model include:

- Purchase of a small percentage of overall CU by an M&I or environmental/conservation user and delivery of this "base" amount via alternative methods (fallowing, reduced CU cropping, or deficit irrigation)
- Agreement regarding intermittent leasing (short- or long-term) of the remaining CU

- Focus on use of recharge sites and other environmentally beneficial delivery methods and management

The applicants wish to expand the review of the FLEX Model to a broader group of ditch companies, M&I users, and environmental/conservation interests in a collaborative process, with the goal of producing a contract template that is consensus-based and reflects the input of multiple stakeholders.

The second component of the study is the development of Model Terms and Conditions for alternative transfers. One of the major issues that has restrained the implementation of ATMs on a broader scale is concern over the ability of those seeking to apply alternative methods to develop terms and conditions that are acceptable to water users at-large, the state engineer, and the water courts. The applicants propose to invite the State and Division Engineers and a broad spectrum of water users, including those that have traditionally been most skeptical of alternative methods, to a collaborative process with the goal of establishing a set of terms that represent a common ground regarding what may be necessary to implement alternative transfers on a broader scale. The applicants understand that each case is unique, and that one size does not fit all. However, the applicants believe that the opportunity for water users to discuss these issues outside of a water court context will prove helpful, and are hopeful that basic parameters can be established that will be informative to future water court applications or substitute water supply plan processes. The presence of Regenesis in the discussion, which has developed hardware and software it expects to provide the necessary monitoring and enforcement of alternative transfers, will advance the discussion beyond the theoretical and increase the likelihood of achieving progress towards consensus.

The survey-level engineering analyses will be conducted as part of this project via three demonstration projects. The objectives of the demonstration projects are as follows:

- Work with water owners and end users that are interested in exploring a Flex Water Market to understand how much water might be involved, how it would be delivered, etc.
- Position the project for future implementation

The collaboration process with agricultural, municipal, industrial, and environmental water users was very valuable in developing the demonstration projects. Key takeaways from the collaboration process include the following:

- Agricultural proponents of a Flex Water Market will need to be able to explain the project to fellow shareholders on a ditch system. The project team will consider this when developing deliverables describing the project. The use of easily understood summary graphics will be important.
- Costs of implementation and infrastructure will be important. The demonstration projects will focus on ways to save money and will identify necessary infrastructure.
- Flexibility in water delivery is important. The demonstration projects will identify different points of delivery.
- Reliability of delivery may be an issue. The demonstration projects will focus on ways to enhance delivery reliability.

The demonstration projects involve the Lower Latham Ditch Company, the Platte Valley Irrigation Company, and initially included the Lupton Bottoms Ditch Company. The Lupton Bottom Ditch Company recently declined further involvement as a demonstration project, and the project team is currently working to develop the third demonstration project.

3.8.2 Progress Update and Preliminary Findings (Sponsler et al 2012, Lindburg 2012)

The focus of the project to-date has been the development of Flex Water Market template agreements and decree terms and conditions. Since project initiation, the project team has completed the collaboration process with various user groups, issued and edited several drafts of the agreement and terms and conditions, and are now making final revisions to the documents. The Flex Water Market agreement consists of two parts. One part of the agreement establishes the overall relationship of the parties to the agreement and sets up the framework of the market. The other part consists of agreements among various participants in the market to establish water leases (either annual or longer term) and describes payments, amounts of water transferred, points of delivery, etc.

The template for Flex Water Market decree terms and conditions was the primary topic of collaboration in the water attorney/engineer participant group. In addition, the Division Engineer was consulted on the terms and conditions of the decree. Two primary objectives of the decree terms and conditions were to allow water to be used by both agricultural users and municipal/industrial/ environmental end users and to maintain historical return flow obligations. The decree terms and conditions also describe parameters associated with changes in use, description of end uses, the ability to use transferred water to extinction, points of delivery, provisions for annual water use projections, and accounting requirements. In addition, the decree terms and conditions seek to allow quantification and transfer of water using alternative transfer methods such as regulated deficit irrigation and reduced consumptive use cropping (i.e., growing irrigated wheat rather than irrigated alfalfa).

In addition, a project summit meeting has been scheduled for mid-January 2013 so that project participants can collectively discuss their thoughts on the Flex Water Market and alternative transfers and see the final version of the agreement and terms and conditions.

The survey level engineering analyses (demonstration projects) are underway but in the beginning stage. The collaboration of agricultural, M&I, and environmental users has been useful in formulating the study objectives of the demonstration projects. The scope of the demonstration projects does not include an actual water transfer.

The project team's goal with regard to the demonstration projects is to answer some key questions for potential participants in a Flex Market so that, at the conclusion of the project, they can determine if they want to pursue participation. The project team has been working with interested ditch boards, so actual water suppliers as involved as prospective participants.

With regard to potential end-users in a Flex Market, it is currently estimated that actual M&I users and points of delivery will be evaluated for two of the three demonstration projects. For the demonstration project without an actual end user, the CCGA project team is evaluating a few points of delivery options. Items for investigation in the demonstration projects include:

- How much water might be made available under a rotational fallowing or interruptible supply program? Answering this question involves an investigation of historical use of shares under a ditch system.

- How will we maintain historical return flow obligations during the transfer?
- How can we incorporate recharge wetlands as a mechanism for delivering historical subsurface return flows or transferrable CU?
- Where does the water need to go?
- What are the delivery options (i.e., exchange or infrastructure)?
- What are the reliability requirements of the end user?
- Can delivery reliability be enhanced using storage or recharge facilities?

The CCGA project team would also like to estimate potential infrastructure costs associated with the demonstration projects. The ultimate goal would be to see an actual transfer take place as a result of the demonstration projects. It is the project team's belief that, with a little upfront investment to help both parties understand the Flex Market and how it would work, the likelihood of an actual deal would be greatly increased.

3.9 Upper Arkansas Water Conservancy District

The ATM project sponsored by the UAWCD will build and assess a tool to quantify values of transferrable CU and assess impacts to the stream-aquifer system. The tools built and assessed will help make available water supplies through lease fallowing by reducing transactional costs, protecting existing water rights from injury in the least costly fashion, maintaining the area agricultural economy, and preserving the institutionalized and long-recognized water court process.

3.9.1 Study Objectives

The project will build and assess a tool to quantify values of transferrable CU and assess impacts to the stream-aquifer system. The tools built and assessed will help make available water supplies through lease fallowing by reducing transactional costs, protecting existing water rights from injury in the least costly fashion, maintaining the area agricultural economy, and preserving the institutionalized and long-recognized water court process.

The main objective of this project is to develop and assess accounting and administration tools that calculate transferrable CU and assess impacts to return flows pursuant to lease fallowing agreements. The result will be a common platform that can be a template to others for accurately calculating transferrable CU and assess impacts. A common platform will facilitate implementation of rotational crop fallowing/leasing such as the Super Ditch.

The purpose of this project is not to transfer water via temporary leases but make possible the water transfer by constraining costs, protecting other water rights from potential injury, maintaining agricultural economies, and preserving the institutionalized and long-recognized water court process. Without a common technical and widely accepted platform to quantify CU and return flow impacts, the marketing of water through programs similar to the Super Ditch may very well be futile due to the high water costs of changing the water rights through water court. In this regard this project helps advance alternative transfer methods via rotational crop fallowing/leasing forward to an actual on the ground program that can provide a reliable water supply while sustaining key elements of the agricultural area from which the water is transferred.

The objectives of the accounting and administration tools are to:

1. Quantify the transferrable CU derived from fallowed land parcels.
2. Quantify the associated changes in the amount, timing, and location of:
   (a) Surface runoff to drains and to the river.
   (b) Recharge to the alluvial aquifer.
   (c) Groundwater return flow to drains and to the river;
3. Support the development of plans to maintain return flows at or above historical levels and to quantify transferrable CU at or below historical levels in a manner that complies with Colorado water law and the Arkansas River Compact.
4. Develop data interfaces that will complement the Arkansas River Decision Support System (ArkDSS) and build a common technical platform for the transfer of data to and from HydroBase.

If successful these tools will help address three identified barriers to ATM implementation: (1) the lack of specific methodologies to ensure noninjury of other water rights, (2) potentially high transaction costs with alternative methods, and (3) water rights administration and accounting. This effort will also comply with the recommendation to develop specific methodologies for measuring, calculating, and monitoring CU water transferred through ATM projects.

As the application indicates, this effort has been a collaborative effort from the start and includes five sponsors: the UAWCD, SECWCD, LAVWCD, Pueblo Board of Water Works, and Colorado Springs Utilities. In addition, the project/technical team has put in significant effort to provide a well thought out scope of work and to ensure the incorporation and coordination of past and current related modeling efforts in the Arkansas basin such as the DWR's Irrigation System Analysis Model (ISAM), CSU's enhanced model (predicts groundwater flows and return flows), and the CWCB's ArkDSS.

3.9.2 Progress Update and Preliminary Findings (Scanga 2012, Walter 2012)

In July 2012 contracts were finalized with the CSU Engineering department and the CWCB to conduct the assessment and development of the tool. The Lease-Fallowing Technical Advisory Committee (LFTAC) met in August 2012. This technical committee is tasked with guiding the CSU Engineering Department developers. The CSU team includes the following personnel:

- Dr. Tim Gates, Principal Investigator
- Dr. Ryan Bailey, Associate Researcher
- Cale Mages, Graduate Research Assistant

At the August meeting the LFTAC discussed what the tool would look like and what functions it would perform. Although ISAM was developed as an *Excel* spreadsheet it was decided that the Lease-Fallowing Accounting Tool (LFAT) would need a more robust platform. The robust platform should be easily used by nontechnical users and can have a front end such as ArcGIS Explorer or Desktop Basic, formerly ArcView, which is a relatively inexpensive application. The front end and accounting tool geographic information system application would be separate from the database application but the data could move to and from the accounting tool application as needed. Data will be developed as a first block and flow modeling/ accounting as a second block. Several programming languages could be

used to develop the various parts of the tool. The committee also discussed the advantages and disadvantages of a web based tool versus a locally accessed one. Depending on the level of technical sophistication a prospective user could utilize some basic aspects of the tool and as the level increased more functions would be easily available.

As well as the system and tool design discussion, the committee discussed the specific aspects of a regional groundwater model and the necessary components to make the tool and its methodology defensible in the traditional water court setting. Further the accounting tool attributes and accounting inputs such as field water balance components, crop ET, and effective precipitation were refined. Accounting tool outputs of off-farm and on-farm water balance, aquifer recharge, and alluvial response to recharge were discussed. Thoughts on the computational aspects of running the tool and verification methods were refined.

3.10 Colorado State University Agricultural Experiment Station

This study is a side-by-side comparison of furrow and sub-surface drip irrigation (SDI) on alfalfa over 2 years starting in 2012. The study will be performed on about 3 acres at the Fruita Research Center in the Grand Valley of Western Colorado. The program is needed to determine first how much conserved water SDI irrigated alfalfa provides. If significant, it has the potential to be an alternative to municipal water providers over the purchase of additional farms and ranches for their water rights. Secondly it will hopefully provide commercial farms a profitable and proven alternative to the subdivision of Grand Valley agricultural land into smaller "ranchettes."

3.10.1 Study Objectives (Reich 2012)

The study will test a series of SDI configurations (tape type, depth, and row spacing) for water savings, yield improvement, and water quality benefits (salt, nutrients, selenium) against furrow irrigation; the traditional irrigation system for the Grand Valley.

With savings and benefits quantified this analysis can educate local farmers and ranchers on the advantages of SDI. With a broader understanding of SDI the adoption of sub-surface drip in the Grand Valley among commercial alfalfa producers should increase.

Also a delivery system has an opportunity to make significant jumps in conveyance efficiency with ditch-wide adoption of systems like SDI, since SDI is less dependent on gravity pressure and water levels in laterals to be effective.

3.10.2 Progress Update and Preliminary Findings

A first year progress summary and second year work plan for this ATM grant project were provided in documentation submitted to CWCB in October 2012 (Reich 2012). These updates are summarized in the following sections.

First year progress summary

Upon successful grant procurement the applicant contracted with Watson Boring and Excavation Inc. to refurbish existing research scale sub-surface filters and install sub-surface drip tape at CSU's Agricultural Experiment Station in Fruita.

The filtration refurbishment was completed May 10, 2012. After some basic filter skid testing, the sub-surface tape was installed at two depths (8 and 16 inches) in a 1.5-acre plot at the Fruita Research Station on May 15, 2012. After bed preparation and alfalfa planting, irrigation to wet the bed commenced on May 17, 2012.

The bed was challenging to wet out and much was learned about bed preparation for SDI in the process. Germination problems required a short surface irrigation to overcome. Lessons learned were successfully translated to the on-farm portion of the project that was installed late August.

In parallel with the SDI plot another 1.5-acre plot was concurrently planted with the same alfalfa variety, the only difference being the second plot was irrigated with gated pipe (surface irrigated). Bed preparation, planting date, and commencement of irrigation was the same for both the SDI plot and the furrow plot.

Two alfalfa cuttings were taken on July 27, 2012 and September 23, 2012, with the SDI plots averaging 3.35 and 3.58 tons/acre of total annual dry matter for the 8 inch deep and 16 inch deep tape treatments respectively. The furrow plot averaged an annual total of 3.62 tons/acre of dry matter.

As of September 26, 2012 the CoAgMet weather station at the Experiment Station suggested the cumulative ET for a full stand of alfalfa with the described planting and cutting was 32.05 inches. The seasonal average ET according to the Colorado Irrigation Guide (1988) for alfalfa grown in the Fruita area is 36.22 inches. Water applied by the SDI was calculated at 44.965 inches for the same period. Seasonal efficiency can be estimated at 71 percent or better (noting this is an establishment year).

Second year work plan

The second year work plan for this ATM demonstration project is as follows:

- **Task 1: Installation.** Complete. SDI filtration units were refurbished and tape was installed May 2012. Irrigation commenced May 17, 2012.
- **Task 2: Planting. Complete.** Alfalfa round-up ready variety "Denali" variety was planted at a rate of 20 pounds/acre in furrow irrigated plots on May 14, 2012 and then in the SDI irrigated plots (at the same rate) on May 15, 2012.
- **Task 3: Monitoring. Commenced.** Water use is continuing to be monitored through a CoAgMet weather station onsite at the Experiment Station, an atmometer, pipe flow meters, and flumes. Full water balance calculations will be completed over the winter once irrigation is complete.
- **Task 4: Yield Comparison. Commenced.** The first year of Alfalfa is an establishment period. Two cuttings have been taken from both SDI and furrow plots. Detailed yield data is available in the progress update documentation (Reich 2012). It is important to note that establishment is a thirsty process, filling the profile and germination required a large volume of water. This is evidenced by more than 30 inches of water applied per dry ton for the first cutting but less than 3 inches of water per dry ton for the second.
- **Task 5: Outreach and Reporting. Commenced.** Field days with middle school students were scheduled for October 9, 2012 and October 16, 2012. The latter field day was planned to include an additional period for visiting with local producers. Press and media were invited.

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