Completion Report: Development of Practical Alternative Agricultural Water Transfer Measures for Preservation of Colorado Irrigated Agriculture

May | 2011

Project Sponsors

Colorado Corn Growers Association

Ducks Unlimited

Aurora Water

Lower South Platte Water Cooperative

In association with

Brown and Caldwell

Colorado Water Resources Research Institute

Harvey Economics

Lawrence Jones Custer Grasmick LLP

Completion Report: Development of Practical Alternative Agricultural Water Transfer Measures for Preservation of Colorado Irrigated Agriculture

Prepared for

Colorado Water Conservation Board, Denver, Colorado

May, 2011

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List of Abbreviations

AgLET	The Agricultural Water Lease Evaluation Tool
ATM	The Alternative Agricultural Water Transfer Methods Grant Program
Aurora	The City of Aurora
AWAS	Alluvial Water Accounting System
AWC	Available water content
CCGA	Colorado Corn Growers Association
cfs	Cubic feet per second
Co-op	The Lower South Platte Water Cooperative
CSU	Colorado State University
CU	Consumptive use
CWCB	Colorado Water Conservation Board
DU	Ducks Unlimited
DWR	Department of Water Resources
FMRICO	Fort Morgan Reservoir and Irrigation Company
fps	Feet per second
GIS	Geographic Information System
IDS	Integrated Decision Support Group
IWSA	Interruptible water supply agreement
KAF	Thousand acre-feet
M&I	Municipal and industrial water users or water providers
NRCS	Natural Resources Conservation Service
PAG	PVIC Augmentation Group
PVIC	Platte Valley Irrigation Company
PWP	Prairie Waters Project
SPDSS	South Platte Decision Support System
SWSI	Statewide Water Supply Initiative

Executive Summary

The 2010 Statewide Water Supply Initiative (2010 SWSI) documents the fact that municipal suppliers anticipate mitigating future gaps in water supply, in large part, through transfers of agricultural water. Colorado regards water rights as private property, able to be bought and sold in a free market. When such transactions occur, the historically irrigated lands must be dried up in the process.

Permanent transfers of water off the land can be economically attractive from the individual producer's perspective and are a reasonable option for many producers. However, permanent transfers have an impact on rural economies. Land values decline when irrigation permanently ceases, and agricultural suppliers could be negatively impacted by lower demands for agricultural inputs.

The State of Colorado recognizes these third-party impacts and the value of maintaining irrigated agriculture. As a result, the Colorado Legislature authorized the Colorado Water Conservation Board (CWCB) to develop the Alternative Agricultural Water Transfer Methods Grant Program (the ATM grant program) to encourage water users to explore alternatives to permanent agricultural water transfers. Alternative transfer methods seek to transfer water out of agriculture for a short or long time period while retaining agricultural ownership of the water and/or maintaining irrigation on agricultural lands.

The project described in this report was funded through the ATM grant program. It had three objectives:

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

The Colorado Corn Growers Association (CCGA), Ducks Unlimited (DU), and the City of Aurora (Aurora) applied jointly for the ATM grant used to fund this project. They collaborated during the course of this project with the Steering Committee of the proposed Lower South Platte Water Cooperative, the Colorado Water Resources Research Institute (research engineers and economists from Colorado State University); Lawrence Jones Custer Grasmick, LLP (attorneys); Harvey Economics; and Brown and Caldwell (engineers). The grant applicants and collaborators are referred to as the Project Team.

ES.1 Assessment of Alternative Transfer Methods

ES.1.1 Methods

The project focused on seven different types of alternative water transfers:

1. Rotational fallowing

   In rotational fallowing an agricultural user would agree to suspend irrigation for certain years out of a set period, or for a certain portion of his or her land, either regularly or intermittently. Typically, the lands taken out of irrigation change from year to year. The transferrable water is that which would have been consumed, had the fallowed acreage been irrigated. Historical return flows must be maintained, and accounting must be submitted to the State. Responsibility for these functions, as well as water delivery, would likely be negotiated between the agricultural producer(s) and the end user.

2. Interruptible water supply agreements

Interruptible water supply agreements (IWSAs) provide for temporary suspension of irrigation in order to transfer water on an as-needed basis, typically during drought. The amount of water that would have been consumed from irrigation that year represents the transferrable amount. Frequency of the transfer is typically limited, partly because Colorado law allows the interruption to be invoked in up to three years out of ten without having to go through Water Court. Responsibility for delivery of transferrable water, return flow maintenance, and accounting would be negotiated by the parties to the agreement.

3. Excess augmentation credits

In the Lower South Platte River, well augmentation plans use intentional recharge as a source of augmentation water supply. From time to time, the need for augmentation is less than the supply. The excess supply, if it is properly accounted for, can be leased to other water users who need augmentation supply. Leasing excess recharge credits has become relatively commonplace in the Lower South Platte River.

4. Deficit or limited irrigation

Deficit irrigation involves limiting irrigation at specific times during the crop growth cycle to minimize water use while maintaining crop yield. Since less water is consumed by the crop under limited irrigation, the difference in consumption between limited and full irrigation could become available for transfer.

This method is attractive because it allows for agricultural land to remain in production, even while providing a transferrable amount of consumable water. As such, impacts to local businesses are minimized, the producer gains diversity of income, and land values are maintained. On the other hand, there is a risk or perceived risk that crop yields would be less, administration of the transfer may be challenging, and producers could face additional costs to purchase equipment or technologies to support administration of the transfer. A deficit irrigation transfer would have to go through Water Court, and because that has never been done, the initial case(s) may have many issues to resolve.

5. Alternative cropping

Alternative cropping involves changing from crops with higher annual consumptive use (CU) to crops with lower annual consumptive use (CU), on either a short-term or more permanent basis. Transferrable water can be generated based on the difference in consumptive use between previous crops with higher CU and new crops with lower CU. Like deficit irrigation, alternative cropping is an attractive but untested transfer method. Benefits and challenges associated with alternative cropping are similar to those described above for deficit irrigation. Additional challenges include the risk or perceived risk that the market for lower water use crops is not as strong as for higher water use crops, and the need to adapt equipment and practices to a different crop.

6. Water banks

Water banks are organizational frameworks for marketing water. The Colorado Legislature has authorized implementation of water banks, but they have not been widely implemented in Colorado. A water banking pilot project was implemented in the Arkansas River basin in the year 2001. By 2005, it was canceled due to lack of interest and participation. The lack of interest may have been due to certain restrictions such as limitations on exporting the water out of the Arkansas basin and the prohibition of marketing direct flow rights (the bank was limited to storage rights only). Despite the experience with the Arkansas basin bank, water banks remain an option for marketing water and can potentially help avoid the time delays and expense of Water Court.

7. Purchase-leaseback

A purchase and leaseback arrangement occurs when a user purchases an agricultural water right with the agreement that the water will be leased back to the producer or ditch during certain years, usually during normal or wet years. This type of arrangement allows for the land to remain in agricultural production during most years, and provides the purchaser with additional supply during dry years when it is needed. The arrangement can be similar to an IWSA, except that in a purchase and leaseback agreement the purchaser is the new owner of the water right, rather than the agricultural producer.

ES.1.2 Evaluation of Methods

The alternative transfer methods described above each have engineering, legal, and administrative considerations associated with their implementation. The Project Team researched issues associated with various methods, which helped them identify barriers to implementation of methods. The findings are summarized in Table ES-1 below:

Table ES-1. Summary of engineering and legal issues related to alternative transfers

Method	Historical use analysis necessary?	Considerations for quantifying and verifying transferrable water	Maintenance of historical return flows required?	Are there challenges in delivering water to end users?	Ditch system or on-farm infrastructure required to conduct an alternative transfer	Does the legal framework currently exist?	If so, what is required to implement the measure?	Has the measure been implemented successfully?	What legal changes could improve the process?
			Engineering Issues			Legal Issues			
Rotational Fallowing	Yes	Quantification based on historical use. Fallowing is likely an acceptable means of verification.	Yes	Potentially	• Infrastructure necessary to deliver water to the river likely similar to that used in traditional buy-and-dry transfers. • Maybe more infrastructure needed to maintain historical return flows.	Yes. §37-92-305, C.R.S. explicitly recognizes a fallowing program as a type of change in use subject to Water Court approval, and provides guidance to the Water Court regarding terms and conditions.	Water Court Application for Change of Water Rights	Limited. Primarily in Arkansas Basin	Unclear
Interruptible Water Supply Agreements	Yes	Quantification based on historical use. Fallowing is likely an acceptable means of verification.	Yes	Potentially	• Infrastructure necessary to deliver water to the river likely similar to that used in traditional buy-and-dry transfers. • Maybe more infrastructure needed to maintain historical return flows.	Yes, *See* §37-92-309, C.R.S. allowing use 3 out of 10 years.	Application to the State Engineer	No. No known attempts.	Standardized approval criteria (C.U., return flow, lagging criteria, dry up terms and conditions)
Excess Recharge Credits	No	Quantification and verification based on augmentation plan accounting.	No	Potentially	• Measurement equipment to quantify deliveries to recharge facilities and recharge amounts.	Yes	Accounting, an agreement between parties	Yes	None needed
Deficit or Limited Irrigation	Yes	Unclear. Groups are working on technology to quantify and verify transferrable water.	Yes	Potentially	• Equipment to measure components of the on-farm water budget (consumptive use, return flows, etc.) • Infrastructure necessary to deliver water to the river likely similar to that used in traditional buy-and-dry transfers. • Maybe more infrastructure needed to maintain historical return flows.	Probably. §37-92-305 does not explicitly recognize reduced CU cropping or deficit irrigation, but these practices are likely to be considered a "change in use" authorized by the statute.	Water Court Application for Change of Water Rights	No. No known applications.	Clarification in Statute recognizing these practices explicitly could eliminate argument
Alternative Cropping	Yes	Unclear.	Yes	Potentially	• Equipment to measure components of the on-farm water budget (consumptive use, return flows, etc.) • Infrastructure necessary to deliver water to the river likely similar to that used in traditional buy-and-dry transfers. • Maybe more infrastructure to maintain historical return flows.	Probably. §37-92-305 does not explicitly recognize reduced CU cropping or deficit irrigation, but these practices are likely to be considered a "change in use" authorized by the statute.	Water Court Application for Change of Water Rights	No. No known applications.	Clarification in Statute recognizing these practices explicitly could eliminate argument
Water Banks	Depends on the source of water	Depends on the source of water. A water bank would likely need to provide accounting for water transferred through the bank	Depends on the source of water	Potentially, but a water bank may have geographically diverse supplies	• Depends on the source of water	Yes. §37-80.5-104.5, C.R.S. authorizes the creation and operation of water banks in all water divisions of the state.	Sponsoring water conservancy or water conservation district, State Engineer rulemaking	No. Arkansas Pilot Project failed for lack of participation. No known applications in other basins.	Unclear
Purchase and Leaseback	Yes	Quantification based on historical use.	Historical return flows maintained by using water for irrigation or by active maintenance	Potentially	• New infrastructure probably not necessary while water is used for irrigation	Yes. §37-92-305, C.R.S. authorizes Water Court to approve changes in type and place of use	Water Court Application for Change of Water Rights	Yes	None needed.

Administrative issues related to alternative methods of transfer are generally reflected in the table above, under Engineering Issues. Administering the transfer means determining the transferrable amount of water, ensuring that return flows are maintained, and potentially delivering water to the end user via exchange. Many of the same processes that the State Engineer uses for traditional transfers can be adapted for rotational fallowing and IWSA's. The amount of excess recharge credit available from augmentation plans may change on a daily basis, and real-time quantification of available credits will be required for administration. The State Engineer is currently addressing this issue, developing tools to help quantify excess recharge credits on a real-time basis. Researchers and proponents of deficit/limited irrigation programs (including Colorado State University (CSU), the U.S. Department of Agriculture, the City of Parker, the Regenesis Management Group, and other advisors and collaborators) are currently working to develop technologies and methods to allow for efficient administration.

ES.1.3 Barriers to Implementation

After interviewing both municipal and industrial (M&I) and agricultural water users and assessing previous Colorado transfers, the Project Team identified five distinct barriers to a robust alternative transfer market.

1. High transactional cost

   The most significant factor inhibiting temporary alternative transfer arrangements in Colorado is the high transactional cost associated with implementing them. M&I users' perception is that transactional costs for an alternative transfer arrangement are equal to or greater than for a "buy and dry" approach. Similarly, agricultural water mentioned the high cost of services necessary to adequately explore and implement an alternative transfer.

2. Risk and uncertainty

   Agricultural water users cite the risk associated with any process that quantifies a senior right based upon historical use, in light of recent decisions curtailing the use of senior water rights based on "lawful" versus "unlawful" historical use. They are also concerned that their water rights will be limited or prevented from returning to irrigation uses. Would-be alternative transfer participants express concern that an alternative transfer arrangement, particularly an alternative cropping or deficit irrigation scheme, would encounter such resistance that it would either fail entirely or be approved with terms so onerous as to effectively cancel any benefit.

3. Lack of delivery capability

   M&I users in the Denver Metro area expressed concern about the ability to deliver water to them from downstream users, and believe the issue has not received adequate attention in discussions of alternative transfer methods to date.

4. Need for permanent supply/reluctance to commit

   M&I users universally prefer permanent supplies when available and affordable. In the context of proposed alternative transfers, they want leases of 20 years or more. Conversely, agricultural water users prefer shorter terms that let them respond to rapidly escalating water values and economic volatility in the farm sector.

5. Power Imbalance

   Agricultural water users cite a sense of disparity between their resources and information, compared to those of an M&I user. This perceived disadvantage fosters distrust, reticence to engage in frank discussions, and the tendency to stake out positions chosen for their safety, as opposed to their potential to facilitate a deal

ES.1.4 Solutions: Five Concepts

1. Education and Decision-making Support

   Better tools and information can help overcome reluctance to pursue alternative transfers. Sustained and substantial efforts to educate users about alternative methods can potentially lower the sense of risk, elevate creativity in designing workable transfers or facilitating arrangements, and reduce the sense of power imbalance. CWCB is encouraged to produce educational materials describing key concepts related to water transfers, using language and methods accessible to the lay person. The Project Team offers a Guidance Document, described in Section ES.2.2 herein, as its contribution to this body of material.

   The Project Team identified a need for decision making support designed to help agricultural producers assess the economic aspects of proposed transactions, specifically the opportunity cost of limiting or ceasing irrigation on a portion or on all of their lands. Agricultural producers are already acutely aware of input costs and commodity prices, and are regularly engaged in decisions about inputs and crop selection intended to maximize financial gain. The AgLET Tool, described in Section ES.2.1, is designed to be used by agricultural water users for this purpose.

2. Technical Analysis of Delivery Potential

   Without variation, M&I users said that the inability to deliver water to their intake facilities is a principal hindrance to alternative transfers. In the South Platte River, the largest M&I users are located in the Denver Metro area while the basin's principal irrigated areas, served by the most reliable water rights, are downstream. Although water can be delivered upstream "by exchange," exchanges are hampered by "dry-up points" in the river. An understanding of both the potential and the limitations of exchanges is a first step to removing this barrier; accordingly, the Project Team prepared an analysis as set forth in Section ES.3.1 . The analysis points to localities where small infrastructure projects could increase exchange potential, with relatively little cost compared to conveyances from the Lower South Platte to the Metro area. Portions of the exchange analysis were further developed and applied in the demonstration projects described in Section ES.4.2 .

3. Joint Ownership

   M&I users frequently commented that they were reluctant to invest in transfers involving alternative methods because of the temporary nature of the deliveries. They did not want to invest large amounts of capital in water supplies that were not guaranteed on a permanent basis. Conversely, agricultural water users prefer shorter terms that let them respond to rapidly escalating water values and economic volatility in the farm sector.

   To address this barrier, the Project Team conceptualized the "Flex Contract Model" (Flex Market). The Flex Market provides a framework for both permanent and temporary transfers of water between the participants, with the express goal of establishing a long term, mutually beneficial relationship between ditch company shareholders and municipal providers and that accommodates the voluntary, market based delivery of a portion of the ditch company's water right for municipal purposes while preserving integrity of the ditch system as a productive agricultural area.

The Flex Market is a Water Court approved contractual relationship between one or more M&I users and one or more agricultural suppliers. The agricultural user provides two types of water to the M&I user, “Base Consumptive Use” (Base CU) and “Flex Consumptive Use” (Flex CU). Base CU is a small portion of the CU associated with the agricultural user’s shares (10 percent is a suggested number) that is permanently sold to the M&I user. Flex CU is the remaining 90 percent of the CU, which remains titled in the agricultural user, and can be leased to the M&I user on terms agreed upon between the agricultural user and the M&I user. It is anticipated that both the permanent and temporary transfers could be done via rotational fallowing so that permanent dryup can be avoided.

Colorado’s Water Court adjudication process prevents the creation of large, public water markets that permit leasing from agricultural users to M&I users at large; however, smaller private “Water Court approved” markets could be adjudicated. The Flex Market Contract facilitates such a “private” water market between agricultural water users and specified M&I users. The market could be as small as one agricultural water user and one M&I user, but have the potential to expand and involve multiple agricultural water users and multiple M&I users. An example of the Flex Market is included in Section ES.4.1 .

4. Collective Organizations

   Many agricultural producers were reluctant to consider alternative transfer methods as individuals because of their complexity, cost, and administrative requirements. M&I users were reluctant to enter into contracts with individual agricultural producers for similar reasons. For the costs of a transaction to be justified, M&I users tend to be interested in large amounts of water, which can only be obtained by working with numerous individual owners; yet, negotiating with multiple individual users was unattractive because of the time and complexity involved.

   A collective entity could assemble larger blocks of water, consistent with M&I user’s express desire to reduce transactional cost. If the collective agricultural entity was broad enough in geographic scope, reliability of delivery could be improved. In addition, agricultural members in the collective entity might allow the entity to use existing ditches, reservoirs and recharge facilities to manage and deliver supplies. From the agricultural water users’ perspective, a larger collective entity would provide a means to share the costs and risks of water transfers, significantly reducing each individual’s exposure. A larger collective entity’s standing and ability to secure quality legal counsel and technical advice could help balance the perceived power imbalance between M&I users and individual agricultural water users. The potential “Lower South Platte Water Cooperative” described in Section ES.4.2 is a grass roots collective entity meeting many of the above described parameters.

5. Local Partnerships

   There is a common perception that larger, Metro area M&I users will “lead the way” in the alternative transfer arena, based on their ability to endure the high transactional costs likely to come with the initial round of proposed alternative transfers. However, smaller to mid-sized M&I providers in the lower South Platte River have advantages of proximity to the water source and smaller demand quantities, commensurate with use on a single farm. The relative simplicity of the arrangement may mean less complex legal issues, technical issues, and monitoring and reporting needs. The established relationship between the M&I provider and local residents provides a foundation to build cooperative arrangements, in contrast to the perceived resistance to “exporting” a local resource to distant Metro municipalities. Ironically, these smaller transfers between small to mid-sized M&I providers on the South Platte River and local ditch and reservoir companies may prove to be the best testing ground for alternative transfer ideas. The “DT

Ranch/Town of Wiggins" Demonstration Project described in Section ES.4.3 exemplifies this type of arrangement

ES.2 Tools for Agricultural Producers

ES.2.1 Economic Evaluation Tool (AgLET)

The Agricultural Water Lease Evaluation Tool (AgLET) was developed by Harvey Economics with input from Dr. James Pritchett and the Project Team. Its purpose is to help agricultural producers evaluate the financial feasibility of alternative agricultural water transfers. It is a user-friendly Excel spreadsheet that should be fully usable by a novice in a matter of an hour or two, and it is an example of decision support that can mitigate an agricultural producer's perceptions of risk and power imbalance.

Three alternative transfer methods are currently reflected in AgLET – rotational fallowing, interruptible supply, and deficit irrigation. Users first input the county in which their irrigated farm(s) are located. He or she then has the option of relying on default, county-based data for farm-related inputs, which include tillable acres, acres of different crops planted, water applied, irrigation methods and efficiency, water use data, yields, commodity prices, production expenses by activity, and ditch assessments. Most default data are customizable. Data characterizing the alternative transfer includes lease rates (in dollars per acre), area of land enrolled in the transfer, and the amount of land to remain in irrigation during the transfer.

Based on farm and water lease inputs, AgLET estimates impacts to yields, production costs, and revenues during the term of the alterative transfer. AgLET generates a financial summary table, which displays gross margins under current and proposed conditions, break even gross margins, and revenues from the alternative transfer AgLET also allows the user to evaluate the financial outcome of a potential alternative transfer if yields and/or crop prices increase or decrease. As an option, fixed costs (e.g., debt service, property taxes, living expenses) can be addressed after the variable outcome or gross margin has been determined. AgLET provides useful analysis – even without considering alternative water transfers – as it shows a producer the sensitivity of financial outcomes to numerous farming variables.

The Project Team believes that user support and training are key to widespread use and acceptance of AgLET. The Colorado State University (CSU) Extension is an ideal candidate to serve as long term host for AgLET, to promote its use, sponsor group training, provide local expertise, and maintain the tool as it evolves. Accordingly, the Project Team held an AgLET training session on the CSU campus, for CSU Extension personnel, on September 27, 2010. Similar training was offered to Individuals from water conservancy districts and ditch companies, in March, 2011, so that they too can provide support to members. Finally, an opportunity to publicize and describe AgLET to end users occurred during the Ag Classic conference in December 2010 in Loveland, Colorado.

ES.2.2 Guidelines Document

The Project Team created a document to provide user-friendly guidelines to help interested parties understand steps involved and economic potential of alternative transfers. The objective of the document is to lessen producers' "knowledge gaps"; which contribute to real or perceived power imbalances and have a chilling effect on alternative transfers.

The Project Team determined that the document should focus on alternative transfer methods that agricultural producers can currently use. As a result, the document primarily addresses rotational fallowing and interruptible water supply agreements.

A copy of the guidelines has been included in Appendix A.

ES.2.3 Long Term Maintenance of AgLET and Guidelines

In the first year beyond this project, it is envisioned that CSU Extension staff will incorporate publicity and education on the tools into regularly held workshops (e.g., Extension winter workshops, the water and fertility workshop, Central Plains Irrigation Association conference). These presentations are expected to generate requests for smaller workshops or training, which Extension staff can provide. Extension staff could also help water conservancy districts or ditch companies develop expertise needed to support their members. Further training needs will be evaluated at the conclusion of these activities, but ideally, support needs will prove minimal and conservancy districts, ditch companies, or CSU Extension staff will be well-equipped to provide them.

On a periodic basis into the future, CSU Extension staff will update the default data and other calculation processes in the AgLET tool. Changes in legislation and new rules or regulations may compel modifications to the Guidelines. In addition to keeping tools current, CSU Extension would distribute them to the public through the internet and regularly scheduled or special workshops. Converting the tools to internet-based applications would enhance dissemination and allow access to the most up-to-date default data in AgLET.

Funding for long term maintenance and support of the tools remains an outstanding issue that may impact the ability to update, distribute, and support the AgLET tool and Guidance Document. Potential funding sources include agricultural organizations, fees collected at training sessions, and fees for use of the tools.

ES.3 Technical Analysis

To better understand certain technical issues and help select demonstration projects with a high likelihood of success, the Project Team conducted analyses in three areas:

1. Exchange potential in the South Platte River from Denver to the Nebraska state line, to help understand opportunities and limitations with respect to water delivery
2. Maps, developed incidental to other investigations
3. Use of wetlands to help manage and deliver water available under alternative transfer methods, and their environmental benefits

Information derived from these analyses has been useful for the demonstration projects as well as other applications. For example, the exchange analysis is relevant to feasibility of the Lower South Platte Water Cooperative, and mapping will serve DU in assessing strategic locations for future constructed wetlands.

ES.3.1 Exchange Analysis

This analysis was undertaken to generally characterize exchange potential throughout the study area, both in terms of quantity and location. Besides providing a better understanding of delivery limitations, it identifies opportunities for improving exchange potential with relatively small infrastructure projects.

Exchange potential is based on two criteria:

- An exchange can only be conducted if there is no calling water right between the points of exchange. A calling water right would be injured if exchanged water were diverted without replacement upstream of the calling right.
- Exchange rate is limited to a flow rate less than or equal to the lowest flow rate in the exchange reach.

A study period of October 1999 through September 2008 was selected, and two kinds of information were developed to analyze these criteria. First, the Project Team estimated daily flow at each headgate between the Burlington Ditch and the Colorado/Nebraska state line. Second, daily historical calls were gathered. The combination of flow and call data at each point determines the exchange capacity through that point; the river-wide analysis showed where there are "bottlenecks" to exchange, that is, locations in the river where exchange may be difficult due to low flows or frequent calls.

There are 7 gages on the South Platte River in the 226-mile long study reach. There are also approximately 50 measured diversions and 9 measured inflow points including tributaries, return stations, and effluent discharge points. Daily flow data at these locations are available through the Colorado Decision Support System (CDSS). The point flow analysis calculated ungaged gains and losses between measured points by simple mass balance, and estimated their spatial distribution, to produce physical flow at numerous points along the South Platte River.

Daily historical call data were also obtained from CDSS. On days when a water right was calling, the exchange capacity through that point was zero. On days when the water right for that structure was not calling, the exchange capacity was equal to the physical flow in the river minus bypass required to satisfy downstream uses. With input from Division 1 staff, the numbers shown in the table below were adopted as reasonable estimates of bypass flows. Since exchanges cannot be made against a bypass flow, these amounts were subtracted from the estimated physical flows at each structure.

Table ES-2. Bypass flow estimates (cfs) for different reaches of the South Platte River used in exchange analysis.

Months	Burlington Ditch to upstream of St. Vrain Creek Confluence (Jay Thomas Ditch)	Downstream of St. Vrain Creek Confluence (Union Ditch) to Riverside Canal	Bijou Canal to State Line
Apr – Oct	15	20	10
Nov – Mar	15	10	5

Free river days (days when there is no call on the river) were not counted, since there is no need to exchange water under these conditions.

Results of the analysis are presented on an average annual basis in Figures ES-1 and ES-2 and on a seasonal basis for the average across all years, a wet year, and a dry year, in Figure ES-3.

Actual exchange potential for a specific reach is the minimum of the capacity through the reach, assessed on a daily basis. Thus the amounts shown in the figures are upper limits on what might be achieved in practice. However, the information indicates generally where and how much water could be moved. It suggests that a marketing entity with access to storage or other infrastructure throughout a reach may be useful to help deliver water more reliably to end users. For example, within the marketing entity, water derived from several alternative transfers in various locations in the river could be managed collectively to increase the reliability of delivery. If the entity has access to storage, water from alternative transfers could be stored and then exchanged when exchange capacity is available. The Lower South Platte Water Cooperative is an example of a marketing entity that could help deliver water from alternative transfers. The demonstration project that focused on the Lower South Platte Water Cooperative, described below, extended this analysis to assess exchange capacity over specific reaches.

ES.3.2 Mapping

Several maps of the South Platte River between Denver and the Colorado/Nebraska state line were developed as visual aids to help determine the feasibility of the demonstration projects, but these could be applied to other analyses in the reach. These maps are included in the report.

- Study area with all points of diversion
- Study area with ditch service areas
- Exchange capacity and bottlenecks
- Free river capacity
- Potential DU wetland demonstration project locations including ditch service areas
- Lagging characteristics of the South Platte alluvial aquifer
- Section 303(d) water bodies

ES.3.3 Wetlands in Alternative Transfers

To the extent possible, the Project Team attempted to include recharge wetlands in the demonstration projects as a tool for delivering transferred water or for historical return flows. Over the past twelve years, Project Team member DU has constructed recharge wetlands or ponds that provide high quality habitat for migrating waterfowl. They have worked cooperatively with agriculture, municipalities and industry to provide recharge credits through agreements and contracts. These projects contribute other benefits including recreational hunting, bird watching and water quality improvements through contamination filtering.

A portion of the water delivered to wetlands for recharge purposes is either evaporated from open water surfaces or is consumed by wetland vegetation. Consumptive losses from wetlands would need to be assessed if the wetlands are used for recharge purposes. The Project Team conducted an evaluation of evapotranspiration from wetlands and compared the results to evaporation rates from open water surfaces from typical recharge facilities to understand whether consumptive losses from wetlands are similar to, more, or less than losses from typical recharge facilities.

The Penman-Monteith method, a widely accepted empirical technique that requires meteorological data and vegetation-specific coefficients, was used to calculate evapotranspiration (ET_c) from wetlands. ET_c was calculated using meteorological data from Colorado Agricultural Meteorological Network (CoAgMet) stations at Fort Morgan and Fort Lupton. Crop coefficients and growth stage parameters were adopted from those given in “Crop evapotranspiration - Guidelines for computing crop water requirements” published by the Food and Agriculture Organization of the United Nations (FAO). The report includes coefficients for wetlands consisting of cattails and bulrushes. To compare wetland consumptive use to that of a conventional recharge pond, ET_c calculations were also conducted for open water areas less than two meters deep. The FAO document provided crop coefficients for the open water that are constant throughout the growing season.

Table ES-3 shows results of the Penman-Monteith method of computing evapotranspiration for both open water and wetlands, at Fort Morgan and Fort Lupton.

Table ES-3. Comparison of wetland and open water ET calculated using the Penman-Monteith method

	Average Monthly ET_c (inches)			
	Fort Morgan		Fort Lupton	
Month	Wetland	Open Water	Wetland	Open Water
May	3.0	6.2	2.8	5.8
June	8.0	7.3	7.4	6.7
July	8.9	7.8	8.6	7.5
August	7.2	6.3	6.8	6.0
September	2.1	3.2	2.0	3.1
Seasonal Total	29.2	30.8	27.6	29.1

The Penman-Monteith estimates of evaporation from open water compare well with open water evaporation rates in *NOAA Technical Report NWS 33 - Evaporation Atlas for the Contiguous 48 United States* (NWS 33). Table 4-3ES-3 suggests that wetlands generally consume a similar amount of water over the growing season (May through September) as open water recharge facilities. This conclusion corresponds to SPDSS recommendations for estimating evaporation in wetland recharge facilities on the Tamarack Ranch State Wildlife Area (SWA).

ES.4 Demonstration Projects

ES.4.1 PVIC Augmentation Group/Aurora Water (the Flex Water Market)

The Project Team proposed the Flex Water Market as a mechanism to foster alternative transfers through joint ownership of water (see Section ES.1.4). The PVIC Augmentation Group (PAG) and team member Aurora agreed to participate in a case study of the Flex Market concept using details of their respective systems and water rights. The Project Team expresses gratitude to these entities for their contribution of time and resources to flesh out the example.

Proposed Operation

The Platte Valley Irrigation Company (PVIC) provides water to its shareholders from the Platte Valley Canal and the Evans No. 2 Ditch under a 10/5/1871 priority. There are 344 outstanding shares in the ditch company. PAG is a group of PVIC shareholders who collectively own 44 shares, 8 of which they have changed to include augmentation and replacement uses. The PVIC service area and PAG facilities are shown in Figure ES-4.

The City of Aurora, located in the eastern part of the Denver metropolitan area, has a population of approximately 312,000. Aurora recently constructed the Prairie Waters Project (PWP), which consists of alluvial wells located between Brighton and Fort Lupton, surface storage, pre-treatment facilities near the wellfield, and a pipeline and pumping stations that convey water to treatment and storage in southeast Aurora. Aurora's PWP facilities are also shown in Figure ES-4.

In a given year, the transferrable water for the Flex Market will come from PAG farms suspending irrigation on a portion of land corresponding to the amount of historical consumptive use amount per acre for the shares being transferred. Irrigation may be suspended permanently on specific agricultural fields, or rotational fallowing could be used to change the location of the dried-up lands associated with Base CU each year. For the Flex CU portion, Aurora would determine each year prior to the irrigation season if and how much of the total potential Flex CU is needed. An appropriate portion of land would be temporarily fallowed based on the historical consumptive use per acre. The fallowed lands would likely be distributed among all of the PAG farms so that each farm had some fallowed land, rather than concentrating all the fallowed areas onto one farm.

Changed consumptive use from PAG shares could be delivered to the river immediately upon diversion through a proposed augmentation station near the Platte Valley Canal river headgate. Alternatively, it could be delivered to recharge facilities to generate recharge credits that would accrue to the South Platte River at a later time. Each PAG farm has or plans to have a recharge facility at or near the farm. The farms are located at least three miles from the South Platte River, and return flow timing is relatively slow. Because of the long lag time, regular year-round supplies of recharge credit would result from consecutive years of recharge with transferred consumptive use water.

Aurora would take delivery of PAG's transferrable Base or Flex CU by 1) exchanging water delivered through an augmentation station, to the PWP wells or gravel pits; or 2) by exchanging recharge credits accruing from the PAG recharge facilities (and attributable to earlier diversions of Base or Flex CU), to the PWP wells or gravel pits. The exchange reach for the first option is relatively short, and the few intervening rights do not typically place a call on the river.

For the second option (exchanging lagged recharge credits), the long return time from the PAG recharge sites means that Aurora would need to wait for several years until they could take delivery of the majority of water delivered to recharge facilities. For example, if water were delivered to the recharge facilities with the shortest return time, it would take 7 years before Aurora could claim 75 percent of the water delivered to recharge in the first year of the agreement. Furthermore, recharge accretions would reach the South Platte River downstream from senior water rights (i.e. the Jay Thomas and Hewes Cook Ditches) that frequently place calls on the river. As a result, there would be times during the irrigation season when Aurora could not exchange their recharge credits to their PWP facilities. However, credits would be available during the non-irrigation season, because of re-timing coupled with the lack of senior calls within the exchange reach. This may become an advantage to Aurora in the future if they need to secure more winter supplies.

A third delivery alternative is to deliver Base or Flex CU into a recharge facility closer to the South Platte River and upstream of senior calling rights. Decreed recharge facilities owned by others exist, and might by usable by agreement, or PAG could construct their own strategically located recharge pond or wetland.

Regardless of the delivery scenario, PAG would need to maintain historical return flows from transferred water (both for Base CU and Flex CU) with respect to timing, amount, and location. This can easily be accomplished by delivering the return flow portion (separate from the transferrable consumptive use) into PAG recharge facilities. Since the recharge facilities are located at the historical place of use, the timing and location of return flows would match historical return flow timing and location.

The Flex Market arrangement allows the majority, if not all, of PAG lands to remain in agriculture, while providing additional water supply to Aurora on a permanent basis and during dry or drought recovery years. Based on an assessment of historical consumptive use of PVIC shares in support of

Water Court Case No. 08CW71, one share yields approximately 38 acre-feet of transferrable consumptive use. Thus the initial Flex Market might involve approximately 300 acre-feet associated with 8 shares, but have the potential to grow to 1,670 acre-feet of transferrable consumptive use.

Timing of Notification to PAG Water Users

Each spring, Aurora reviews snow pack, streamflows, and storage amounts, to develop their annual water supply plan. The plan is then reviewed by City Council, generally in March or April. From PAG's perspective, it would be ideal to know Aurora's intent with regard to Flex water as early as November or December, when users start planning the upcoming growing season by purchasing seed, fertilizer, and other inputs. This discrepancy in planning needs will need to be worked out, perhaps by structuring the price of Flex water to include incentives for early commitment.

Administration

Administration would be a cooperative effort between the PAG, PVIC, and Aurora and could potentially be facilitated by a Flex Market Administrator. Areas of responsibility for each party are envisioned as follows:

- PAG (or individual shareholders) - administration on farm, e.g., taking deliveries into recharge, drying up appropriate acreage, accounting of transferrable CU delivered to the river or to recharge, accounting of recharge credits as applicable, accounting of historical return flow deliveries.
- PVIC – deliveries to individual farms and/or to the river on the request of PAG.
- Aurora - administration from the point of delivery on the river to the point of use, accounting of diversions of transferred CU.
- Flex Market Administrator - ensuring compliance with the Water Court decree and the contracts between the parties, that is, facilitate communication between parties, gather individual information and perform group accounting, and be the principal contact for the parties and the State and Division Engineers.
- State Engineer's Office - properly administer the various uses of water in the Flex Water Market, e.g., verify and confirm that those lands are not being actively irrigated that year.

Legal Issues

PAG and Aurora would jointly prosecute a Water Court application to change the use of 100 percent of PAG's shares to municipal and other uses. The Water Court decree would allow for the delivery of the Base and Flex CU amounts to Aurora, and would set the terms and conditions upon which the shares could be moved from irrigation to M&I uses and back to irrigation. In addition, it would adjudicate necessary exchanges to facilitate delivery of water and/or re-capture of unused recharge credits. The decree would contain retained jurisdiction provisions addressing the addition of PAG, other PVIC shares, or other agricultural suppliers and M&I participants to the water market subsequent to the entry of the decree, allowing the growth of the Flex Market. Substitute water supply plans could facilitate delivery of the water while the Water Court case is pending.

Contractual and Economic Issues

Contracting for the Flex Market will be explored under a future ATM grant. That project is expected to develop contracting templates and decree terms and conditions, addressing such legal and economic issues as:

- Compensation for Base CU and Flex CU.

- Terms related to the minimum number of PAG participants or shares needed to trigger a Water Court application.
- Potential for IWSA prior to Water Court adjudication.
- The degree to which Water Court costs will be shared among the participants.
- Decree terms and conditions and contract terms that will allow other parties to join the Flex Market.
- Reliability of water delivery.
- Cost sharing for new infrastructure.
- Deadlines for notifying the water right owner of the amount of Flex CU needed in a particular year.
- Right of first refusal for sale of shares contracted for Flex CU.
- Length of contract for Flex CU
- Ability to adjust compensation rates for Flex CU over time.

Economic considerations and benefits of this project include the following:

- The Flex Market concept seeks to mitigate high transactional costs by including the pooled resources of several shareholders into the market and by allowing for the expansion of the market.
- There is ample exchange potential between PAG water users and Aurora. As a result, water quality issues can potentially be mitigated, resulting in lower water treatment costs than supplies that might be acquired and conveyed from locations further downstream.

Conclusions

A Flex Water Market is an innovative mechanism for agricultural water transfers that helps overcome barriers regarding the need for permanency, high transactional costs, and power imbalances. This demonstration project provides some of the technical details that would be required to implement this Flex Water Market between PAG and Aurora. The analysis suggests that this demonstration project could benefit both parties by providing both permanent and temporary supplies to Aurora while sustaining irrigated agriculture in the rural area served by PVIC.

ES.4.2 Lower South Platte Water Cooperative (Marketing Framework)

A cooperative marketing framework could mitigate several identified barriers to alternative transfers:

- A municipality's reluctance to contract with numerous individual producers for water transferred through alternative methods.
- An individual producer's inability to offer a large quantity of water under an alternative transfer
- Distance between water supplies and water demands, which limits the marketability of an agricultural producer's water.

The objective of this demonstration project was to build an understanding of the ability to market and exchange water, using excess recharge credits as an example type of supply. The information is applicable to marketing other types of water, including that generated by alternative transfers. The exchange capacity study described in Section ES.3.1 was used to evaluate the feasibility of exchanging water supplies that are potentially available in Districts 1 and 64.

The demonstration project focused on a potential marketing framework that is being explored in the lower South Platte River. The potential marketing entity is currently in its formative stages and is referred to as the Lower South Platte Water Cooperative.

Quantification of Excess Recharge Credits

In Districts 1 and 64 numerous well augmentation plans rely on recharge credits for operation. During certain times of the year, the recharge sites operated for augmentation generate credits in excess of the amount needed to offset well depletions. To quantify these excess credits, the Project Team obtained augmentation accounting data from the State Engineer's Office in Division 1 for the 2008 augmentation year (April through March). Each augmentation plan's monthly recharge credit was compared to its monthly depletion. If recharge credits exceeded depletions, the augmentation plan was considered to have excess recharge credits. As described below, not all excess credits were included in the demonstration project:

- Excess augmentation credits already associated with large current or pending leases were assumed to be unavailable for marketing through the cooperative. As a result, 6,100 acre-feet of excess recharge credit from 2008 were removed from the analysis.
- Excess credits that occurred under free river conditions were ignored, because there is no demand for credits when the river is free. In 2008, there was no call on the river below the Harmony Ditch headgate from November through March, and there was no call anywhere in District 64 from December through February. These conditions are fairly typical in this part of the river.
- In District 1, excess recharge credits are frequently leased among augmentation plans. Excess recharge credits were not counted to the extent that they were matched by excess depletions by another plan or plans in District 1 – except for excess depletions under the Bijou and Public Service Company augmentation plans. These plans have other sources to cover their depletions and do not lease or trade credits.

Using the procedure and assumptions above, the 2008 excess recharge credits totaled 13,800 acre-feet and 10,900 acre-feet for Districts 1 and 64, respectively. If and when leases of Riverside and FMRICO credits expire, additional excess recharge credit may be available for transfer.

Actual marketable excess recharge may be smaller if augmentation plans include terms and conditions that limit transfers. The scope of this study prevented a detailed review of the decrees for all of the augmentation plans that were included.

Exchange of Excess Recharge Credits

The ability to reliably exchange water supplies upriver was explored next, because exchange capacity greatly affects marketability of a downstream supply. To simplify analysis, the exchange evaluation focused on two specific exchange reaches:

- From the downstream end of District 1 to the mouth of the Cache la Poudre River, and
- From the Sterling No. 1 headgate to the mouth of the Cache la Poudre River.

If water can be exchanged to the Cache la Poudre River, it could be marketed to a number of agricultural, municipal, and industrial end users. The exchange analysis tool described in Section ES.3.1 was used to assess the reliability of exchange over the 2002 to 2008 time period. It was assumed that the amount of water available for exchange at the bottom of the first reach was the sum of marketable excess recharge credits in District 1 for 2008. The amount of water available for exchange from the Sterling No. 1 headgate was assumed to be the sum of marketable credits from the downstream end of District 1 to the Sterling No. 1 headgate. It was also assumed that these amounts were typical from year to year, but the ability to deliver them by exchange differs with hydrologic conditions.

Annual summaries of the daily exchange analysis are presented in Table ES-5. Percentages are relative to the estimated marketable excess recharge credits available for exchange.

Table ES-5. Summary of exchange analysis for excess recharge credits derived using adjusted net effects

	Exchanging from Downstream end of District 1 to Mouth of Poudre		Exchanging from Just Upstream of Sterling #1 to Mouth of Poudre	
	Average annual amount	Range over study period	Average annual amount	Range over study period
Volume of excess recharge (acre-ft)	13,800	--	5,000	--
Volume of recharge potentially exchanged (acre-feet)	9,700	7,500 – 11,700	2,200	1,500 – 3,300
Percentage of recharge potentially exchanged	70%	54% - 85%	45%	31% - 66%
Percentage of recharge accretions occurring when exchange not necessary (free river)	8%	0% - 24%	8%	0% - 24%
Percentage not exchanged for lack of exchange potential	21%	15% - 31%	47%	33% - 68%

Table 5-6 shows that:

- The majority (54 to 85 percent) of the excess recharge credits typically available in District 1 could have been exchanged from upstream of the North Sterling Canal to the mouth of the Cache la Poudre River.
- The average annual percentage of excess recharge credit exchanged between the Sterling No. 1 headgate and the mouth of the Cache la Poudre River is significantly lower than for the first reach. Exchange is impacted by bottlenecks such as the North Sterling Canal and the Prewitt Inlet.
- The annual percentage of recharge that could potentially be exchanged varied substantially across years in both exchange reaches.

The Project Team next explored the effectiveness of pumping water from below the Prewitt Inlet, into the North Sterling Canal and the Prewitt Inlet Canal when these structures are calling. These two ditches, located at the downstream end of District 1, frequently place calls on the river. Together they are the primary reason for the differences in exchange reliability for the two exchange reaches.

The analysis assumed that a pumping station and pipeline could bring alluvial groundwater from downstream of the North Sterling Canal or Prewitt Inlet into either of these waterways. Pump capacities of 5 cfs, 10 cfs, and 15 cfs were analyzed. On days when the North Sterling Canal or the Prewitt Inlet was calling, an exchange capacity corresponding to the pumping rate was assumed for the calling structure. Results of the daily analysis are summarized below.

Table ES-6. Comparison of percent of recharge exchanged through the North Sterling Canal/Prewitt Inlet using pumping stations of various flow rates

Year	No pumping station	Flow rate of pumping station		
		5 cfs	10 cfs	15 cfs
2002	43%	44%	45%	45%
2003	32%	47%	60%	69%
2004	61%	66%	68%	68%
2005	35%	46%	54%	60%
2006	66%	76%	80%	82%
2007	31%	42%	51%	56%
2008	47%	64%	70%	72%
Average	45%	49%	54%	57%

At a pumping rate of 15 cfs, most of the excess recharge credits accruing in the Prewitt Inlet to Sterling No. 1 reach could be exchanged to the mouth of the Cache la Poudre River in every year but 2002. There was no additional benefit for pumping stations larger than 15 cfs, because the rate of excess recharge accretions between the Prewitt Inlet and Sterling No. 1 Ditch never exceeded 15 cfs. If other types of water become available for exchange through the pumping station (i.e., water from alternative transfers), larger pumping stations might provide additional enhancement. A cost-benefit analysis should also be conducted on pumping stations of various sizes

Exchange of Free River Water

The Lower South Platte Water Cooperative could potentially apply for new, junior storage rights to help boost delivery of supplies. To investigate feasibility of this concept, the point flow and call assessment components of the exchange analysis tool were used to estimate water available to a new right. For each headgate between the Burlington Ditch and the state line, daily flow for days without a call were summed across the year. Figure ES-5 shows the average annual amounts of free river along the South Platte River for 2002 through 2008.

On average, approximately 50,000 acre-feet of free river annually passed by headgates on the South Platte River between the Burlington Ditch and the state line. The amount varied geographically, from nearly 80,000 acre-feet in the reach from Union Ditch to Empire Ditch, to 30,000 acre-feet below the Burlington Ditch and near the North Sterling Canal and Prewitt Inlet. Annual free river volume also varied greatly among the years in the analysis. For instance, up to 340,000 acre-feet of free river passed through the Union Ditch to Empire Ditch reach during 2007, while no free river was available in 2003 and 2004 upstream of the North Sterling Canal. The analysis suggests that, while 50,000 acre-feet of free river may occur on an average annual basis, annual amounts vary greatly, and storage or recharge facilities would be useful for firming the annual yield of junior water rights dependent on free river.

The North Sterling Canal/ Prewitt Inlet bottleneck has been described above. There are times when either of these structures is calling, but the river is free below them. Free river in District 64 could potentially be exchanged upstream of the North Sterling Canal or Prewitt Inlet using a pumping station and pipeline as described earlier for enhancing exchange potential. Table 5-8ES-7 shows the amount of free river at the Pawnee Ditch for the years 2002 through 2008, when there is a call in District 1. The annual amount of free river that occurred at the Pawnee Ditch headgate varied from 1,300 to 27,400 acre-feet and averaged 16,500 acre feet.

Table ES-7. Amount of free river at the Pawnee Ditch headgate when there was a call in District 1

Year	Amount of free river (acre-feet)
2002	27,400
2003	4,200
2004	1,300
2005	22,500
2006	18,900
2007	15,400
2008	25,600
Average	16,500

Yield of the exchange was tested for pumping rates of 5, 10, 20, and 30 cfs, with the results shown in Table ES-8.

Table ES-8. Amounts of District 64 free river that could be exchanged to the mouth of the Cache la Poudre River using various sizes of pumping stations near the North Sterling Canal/Prewitt Inlet

Size of pumping station	Volume exchanged (AF/yr)	Percent of free river exchanged
5 cfs	400	2%
10 cfs	800	5%
20 cfs	1,400	8%
30 cfs	2,000	12%

The results suggest that pumping station capacity limits the amount of District 64 free river water that could be exchanged upstream of the North Sterling Canal or Prewitt Inlet, and that only a relatively small amount of available District 64 free river could have been exchanged. Storage or recharge downstream of the North Sterling Canal or Prewitt Inlet could be useful in capturing and retiming District 64 free river so that it could be exchanged on a more regular basis.

Administrative and Legal Issues

Comments and conclusions regarding institutional and legal issues related to this demonstration project are summarized below:

- Potential participants in the cooperative stated strongly that the cooperative should work within the framework of the water rights system so that senior water rights are not injured.
- Water Court approval of the cooperative should be obtained. Though exchanges could operate administratively, the cooperative would want to adjudicate exchanges and obtain a priority date for them.
- The cooperative should examine whether individual augmentation decrees limit transfers of excesses to other users.
- Administration would likely be a joint effort between the individual recharge credit providers, the cooperative, and the end users. For example:

- – The individual recharge credit providers would manage their individual recharge activities and provide accounting to the cooperative.
- – The cooperative would manage group accounting, direct re-diversion and re-timing, and manage deliveries to end users at specified locations.
- – The end users would be responsible for administration from the point of delivery to the point of use.
- Physical exchange capacity and river calls vary on a day-to-day basis. Both the cooperative and the State Engineer will need timely information on exchange capacity and available recharge credits in order to effectively and legally deliver, store, or retime supplies.
- The initial and administrative costs for the cooperative are unknown at this time. However, these costs could be shared among participants, and once established, the resulting project has the potential to provide water on a semi-permanent to permanent basis to end users. Exchanges and methods of enhancing exchange and delivery will require funding for planning; legal, engineering and other professional expertise; construction; and support from the cooperative participants. Loans or grants may be available for up-front planning, and both up-front costs and operating costs could be designed into exchange and leasing programs.

Summary

- Significant exchange capacity exists between the Cache la Poudre River and the North Sterling Canal. This capacity could be used to exchange both excess recharge credits and water transferred through alternative methods such as rotational fallowing or interruptible supply. Water exchanged to the mouth of the Cache la Poudre River could be marketed to augmentation plans or water providers.
- Pumping stations could potentially enhance exchange capacity through exchange bottlenecks.
- In recent years, there have been a significant periods of free river in the lower South Platte River. The location of free river occurrence and the annual amounts have varied significantly.
- Free river in District 64 could be exchanged to locations upstream of the North Sterling Canal or Prewitt Inlet exchange bottleneck through the use of pumping stations.
- The ability to exchange excess recharge credits to the mouth of the Cache la Poudre varied by year and by “exchange from” location. Facilities for capturing and/or retiming excess recharge credits would be helpful in enhancing the ability to deliver water upstream when exchange potential is available.
- The Lower South Platte Water Cooperative has options for managing and exchanging available supplies in the South Platte River. Specific exchanges, methods of enhancing exchange, and strategic locations for storage and recharge should be evaluated collectively to develop an operating plan for the cooperative.
- The cooperative could provide an important function in aggregating the water resources of small water users who are interested in alternative water transfers but who do not have the means to conduct these transfers individually.

Future Work

The steering committee recently applied for and was awarded a grant through the Water Supply Reserve Account to research an organizational structure for the cooperative. In addition, a grant was recently awarded from the CWCB’s Alternative Transfer Methods grant program to develop an operations plan for the cooperative. These steps are the outcome of stakeholder interest in establishing the cooperative, expressed in meetings of the steering committee with ditch and reservoir companies, irrigation districts, augmentation groups, and water conservancy districts.

ES.4.3 DT Ranch/Town of Wiggins (Interruptible Water Supply Agreement)

This demonstration project focused on a potential IWSA between a relatively small municipal water provider, the Town of Wiggins, and a nearby water right owner, the DT Ranch. It is an example of a local partnership whose circumstances appear to favor a successful alternative transfer for several reasons:

- Proximity of the parties, meaning minimal potential for delivery interruptions due to calls on the river
- Adequate exchange capacity, at least on an average annual basis
- Local relationships: the two points of diversion in the exchange reach are the Fort Morgan Canal and the Weldon Valley Ditch; the Fort Morgan Canal is the source of the water in the IWSA, and the Weldon Valley Ditch is the source of augmentation supplies for Wiggins.

Overview of Proposed Operation

Wiggins is in the process of constructing a wellfield in the South Platte alluvium and a pipeline to deliver water to the town's treatment and distribution systems. The town uses its shares in the Weldon Valley Ditch to augment depletions attributable to their alluvial wells. Wiggins will deliver these shares to recharge facilities on the farm where the shares were historically used. The alluvial wellfield, pipeline, and recharge facilities are shown in Figure ES-6.

When Wiggins needs water, the DT Ranch would suspend irrigation associated with a portion of their shares so that the water could be transferred to Wiggins. The consumptive use portion of shares included in the IWSA could be delivered directly to the South Platte River and exchanged upstream either to the point of the wellfield depletion, or into the Weldon Valley Ditch for delivery to Wiggins' recharge facilities. Alternatively, the transferred water could stay in the Fort Morgan Canal for delivery to a recharge facility on DT Ranch property. This strategy could return water to the South Platte during months when Wiggins' other water supplies are not plentiful.

The recharge facility located on the DT Ranch may be a wetland area constructed in cooperation with DU. Both recharge facilities, on the DT Ranch and on Wiggins' farmland, are close enough to the river to provide recharge credits relatively quickly. Because they would provide similar return flow timing, either could be used to maintain historical return flows associated with the transferred consumptive use.

In years when Wiggins does not require implementation of the IWSA, irrigated agriculture would continue on the DT Ranch.

Facilities Associated with DT Ranch

DT Ranch receives its irrigation supplies primarily from the Fort Morgan Canal. The primary direct flow right associated with FMRICO is for 323 cubic feet per second (cfs) with a priority date of October 18, 1882. Call records maintained by the State Engineer's Office over the last 61 years (1950-2010) show that FMRICO was subject to call an average of 30 days per year during the irrigation season. However, in 24 of the years there were no calls issued that were senior to FMRICO. FMRICO is also the calling right on an occasional basis. In recent years, the FMRICO calls have occurred in the early to mid irrigation season. Overall, FMRICO provides consistent and reliable deliveries and is well suited for use in the proposed demonstration project.

The DT Ranch encompasses approximately 2,039 acres along the south bank of the South Platte River in Morgan County, Colorado, and is immediately downstream of the FMRICO diversion. It is a farming operation and water fowl hunting club. Beneficial uses of irrigation water have been for wildlife habitat preservation and for crop production. Historically, DT Ranch has irrigated approximately 200 acres of corn, beans, and sorghum and meadow grass. Occasionally, some of the fields not used for crop production are irrigated but are not harvested to provide forage for water fowl. Seasonal irrigation patterns allow for a later harvest and provide for wildlife foraging. The locations of the DT Ranch, Fort Morgan Canal and headgate, and irrigated fields on the DT Ranch are shown on Figure ES-7.

DT Ranch operates several recharge sites adjacent to the river that provide recharge credits for augmentation, as well as wildlife habitat. These recharge sites could potentially be utilized in an alternative transfer to provide recharge credit for other users or to maintain the timing of historical return flows.

Historical Water Use at DT Ranch

To estimate historical consumptive use and return flows associated with DT Ranch's FMRICO shares, the Project Team reviewed an engineering report produced by HRS Water Consultants Inc. (HRS) for the FMRICO Plan for Augmentation (Case No W-2692). Based on the data presented by HRS and DT Ranch's ownership of 31.5 shares in FMRICO, the estimated annual transferrable consumptive use for DT Ranch's FMRICO would be 175 ac-ft/yr. An analysis using DT Ranch's historical cropping patterns or a different study period will result in different estimates of transferrable consumptive use.

Historical return flows associated with DT Ranch's shares were roughly estimated. DT Ranch applies water for irrigation using flood methods. For flood irrigated fields, a typical estimate of farm efficiency is 50 percent. Therefore, using an efficiency of 50 percent the Project Team estimated that the average annual historic return flow volume for the DT Ranch on a per share basis was approximately 175 acre-feet/year.

Rates of Groundwater Return at DT Ranch

To develop a strategy for delivering recharge when Wiggins needs it, groundwater return rates were calculated using the Integrated Decision Support Alluvial Water Accounting System (AWAS), developed by Colorado State University.

The Project Team analyzed cumulative recharge returns over time for a total of eleven recharge sites on the ranch. To simplify the assessment of returns, the Project Team quantified recharge returns based on the streamflow accrual of 50 percent of the original recharge amount. Table 5-10 shows the resulting return rate for each site analyzed at DT Ranch.

Table ES-9. Unit lagging responses for various recharge sites at DT Ranch

Well Name	Transmissivity (gpd/ft)	Aquifer Width (ft)	Distance to Well (ft)	Return Rate (Weeks)	Return Rate (Days)
Field 1	189,200	59,780	1,795	5	35
Field 2	189,000	62,328	2,006	3	21
Field 3	189,000	61,987	686	1	7
Field 4	187,000	34,030	1,636	2	14
Field 5	188,900	64,697	1,584	2	14
Field 6	189,500	41,639	1,912	2	14
Field 7	180,600	61,653	2,107	4	28
Field 8	179,000	40,119	1,930	3	21
Field 9	149,900	66,272	1,214	3	21
Recharge1	128,000	50,138	4,100	17	119
Recharge2	190,700	63,650	3,100	14	98

The results of the above lagging analysis were used to develop strategies for operating the IWSA and for delivering water when needed by Wiggins.

Proposed IWSA Operation

Town of Wiggins

Wiggins operates a small water system for its 900 residents. Their primary source of water is Kiowa-Bijou designated basin ground water. Pending the results of upcoming Water Court actions, the Kiowa-Bijou water will be supplemented by South Platte River alluvial wells (see Figure ES-6).

Wiggins' alluvial wellfield depletions will need to be augmented when there is a senior, downstream call. With that objective, Wiggins purchased shares in the Weldon Valley Ditch and the associated irrigated farm. The town will construct a recharge facility on the farm and deliver their Weldon Valley shares to it. Ideally the accrual of recharge credits to the South Platte River would be similar to the timing of their wellfield depletions. According to the water resources engineer for Wiggins, however, return flow timing from the farm is shorter than the well depletion timing. While Weldon Valley Ditch shares should be more than sufficient to augment depletions during the irrigation season and through the fall, it may be necessary to retime excess recharge credits that occur in the summer so that they are available to replace depletions in January and February. Water from the DT Ranch, strategically retimed, could be used as an alternative or supplement to Wiggins' existing augmentation supplies during January and February.

When Wiggins' return flow credits are greater than lagged well depletions, as happens for short periods of the year, Wiggins intends to exchange excess recharge credit upstream to the Weldon Valley Ditch and deliver them back into their recharge facility. With the cooperation of DT Ranch and the FMRICO, Wiggins could instead divert their excess augmentation supplies into the Fort Morgan Ditch and deliver the water to recharge facilities on the DT Ranch. Wiggins would benefit from the longer lag times and greater operational flexibility, and DT Ranch would gain water for their wetland/recharge areas, which would enhance wildlife habitat.

This agreement could operate separately from the IWSA, but inclusion of IWSA water in the agreement would help optimize Wiggins' use of recharge credits. In addition to delivering water for recharge, water from DT Ranch could potentially be delivered directly to the South Platte River for

Wiggins' use, for example, if Weldon Valley shares are curtailed or under future increased M&I demand at Wiggins.

DT Ranch Operation

Under the IWSA, Wiggins can take delivery of Fort Morgan Canal water for up three years over the ten-year agreement. When Wiggins requests the water, all or portions of DT Ranch crops would need to be fallowed in order to deliver the agricultural water for municipal use. Historical consumptive use per acre would need to be estimated using more rigorous analysis than this project allowed, but once established, the fallowed acreage would be the based on the estimate.

Existing decreed recharge ponds on the DT Ranch do not have a long enough lag time to serve all of Wiggins' needs. Therefore, alternative sites were investigated. The Fort Morgan Canal, which is adjacent to DT Ranch, flows in a southeasterly direction. Southwest of the canal, a bluff rises approximately 60 feet above the elevation of the canal. Non-irrigated land along the edge of the bluff could serve as a site for recharge wetlands (see Figure ES-7). The Project Team analyzed these sites using AWAS and found that the lag time to return 50 percent of recharge from these proposed sites ranged from approximately 100 to 200 days. If transferrable water from the IWSA were delivered to recharge facilities on the bluff in the late irrigation season, recharge credits would accrue during the winter months and would be available to Wiggins during times when other augmentation supplies may not be plentiful.

Figures ES-8 and ES-9 illustrate how deliveries could be manipulated to meet a variety of timing requirements. The Project Team used AWAS to estimate accruals to the South Platte River on a per share basis, using the average daily diversions of the Fort Morgan Canal from 2005 through 2009. For Figure ES-8, the share was delivered to the recharge sites on the bluff south of the canal during April and May; in June and July, deliveries were split between the facilities on the bluff and the facilities adjacent to the South Platte River; finally, for August and September, the share was again delivered to the facilities on the bluff. For Figure ES-9, the share was delivered to the site on the bluff throughout the irrigation season. The figures show that slightly more water would accrue to the South Platte River during the winter months if water is consistently delivered to the recharge site on the bluff.

DT Ranch will need to maintain the amount, timing, and location of historical return flows from irrigation during years when the IWSA is executed. Prior to implementing the IWSA, DT Ranch should quantify the historical amount, location, and timing of both on-farm runoff and deep percolation. Surface water return flows could be provided by diverting an appropriate proportion of the transferred shares into a lateral and conveying the water directly to the South Platte River. Subsurface return flows could be delivered to recharge facilities that are very near or on the fields that are fallowed. In both cases, the return flows will need to be quantified and reported to the State Engineer's Office under water accounting that will be conducted for the IWSA.

New Infrastructure Necessary for the Transfer

The amount of infrastructure necessary to conduct this IWSA would be similar to that needed to conduct a traditional, buy-and-dry transfer. DT Ranch could use their existing recharge facilities to manage transferrable consumptive use and historical subsurface return flows. Existing laterals could be used to deliver historical surface return flows to the South Platte River. Additional measuring devices (flumes) may be needed to measure flows returned to the South Platte River or to recharge facilities.

The recharge wetlands at the top of the bluff south of the river will be the most significant infrastructure need for this project. In addition to constructing the wetland, a pumping station and pipeline will be necessary to deliver water from the Fort Morgan Canal. Based on general “rules of thumb”, costs for the pumping station and pipeline are estimated at $200,000. However, depending on site conditions (i.e. availability of power, configuration and necessity of an intake structure, etc.), the cost could rise to $300,000 or more.

The potential cost of the pumping station and pipeline could be offset by partners. For example, if the recharge facility is a constructed wetland, proponents of wetland habitat might be engaged. If the recharge facilities could serve entities like augmentation plans, water markets, etc., they may either help to fund construction or pay a fee for future use of the pumping station and pipeline.

Other Operational Activities

Interruptible supply agreements must contain provisions to prevent erosion and blowing soils in years when the option to transfer water is exercised. The agreement must also provide a description of compliance with local county noxious weed regulations and other land use provisions. Meeting these requirements is the responsibility of DT Ranch.

Administrative Considerations

The enabling legislation for IWSAs specifies the following procedures:

- Parties to the IWSA agreement must submit an application to the State Engineer. The application must include a written report prepared by a registered engineer, that quantifies the historical consumptive use and return flows, and describes the potential to injure senior water rights as a result of operation of the IWSA. The application also needs to include provisions for preventing injury to senior water rights.
- Other water right holders have 30 days to review the application and file comments on the IWSA. Upon review of comments, the State Engineer will determine whether the IWSA will cause injury to other water rights. The State Engineer may also provide terms and conditions for the IWSA that will prevent injury to other water rights. The State Engineer has the option of approving the IWSA with or without a public hearing. Once the IWSA is approved by the State Engineer, no additional approvals are necessary for the duration of the IWSA.
- In a year when the IWSA is to be exercised, notice must be provided to the State Engineer by March 1. Earlier notice may be provided if the parties agree to this in the IWSA.

The legislation for IWSAs provides no guidance regarding the type of monumenting that would be required in order for the State Engineer to verify dry-up in years when the IWSA is exercised, beyond general statements that any plan should prevent erosion and blowing soils and should mandate compliance with county weed regulations. Based upon experience in Water Court change of use cases, the notification will need to include at a minimum the legal location of lands to be fallowed, a map identifying the dry-up, and a demonstration that the lands will not receive water from the shares being delivered under the IWSA. These lands will likely be inspected and the dry-up approved by the water commissioner on an annual basis to confirm compliance with dry-up conditions.

Contractual Issues

DT Ranch and the Town of Wiggins would need to enter into an interruptible water supply agreement. The statute requires the agreement to address:

- A quantification of the historical consumptive use of the water right;
- An accurate description of the location the water is decreed for use;
- A plan to prevent erosion and blowing soils; and

- A description of compliance with local county noxious weed regulations and other land use provisions

Under the statute (§37-92-309(3)(b), C.R.S.), the agreement may be exercised only three years out of a ten year period. In addition to the term, the agreement should also address, without limitation, the compensation to be paid; the construction of necessary infrastructure including location, costs, and easements; notice provisions; the responsibility for taking measurements and providing accounting to the water commissioner and division engineer; and cost sharing arrangement between the parties for legal and engineering costs. The agreement should be reviewed by qualified water counsel for both parties to ensure that it complies with §37-92-309 and adequately protects the interests of the parties.

Conclusions and Recommendations for Future Work

DT Ranch is in an ideal location to enter into an IWSA with the Town of Wiggins. Water from DT Ranch could be readily exchanged to a variety of locations that are useful for augmenting depletions associated with Wiggins' wellfield. Using the recharge facilities on DT Ranch, water temporarily transferred to Wiggins could be retimed in order to better meet Wiggins' seasonal needs for augmentation supplies. Historical return flows can be managed with relative ease given the variety of recharge facilities on the DT Ranch property and the laterals that can deliver surface flows directly to the South Platte River. This demonstration project is a good example of an alternative transfer capitalizing on local relationships in the Lower South Platte, outside of the Denver metropolitan area.

The Project Team recommends several future tasks if this demonstration project is to go forward:

- Wiggins and DT Ranch should meet to discuss the project, review potential operational goals of the two parties, and refine the operational characteristics of the IWSA as presented in this report.
- DT Ranch should conduct a study of the historical consumptive use and return flows associated with their FMRICO shares. DT Ranch should also develop erosion and weed control plans for years when the IWSA is executed.
- The parties should negotiate terms of the IWSA including:
  - Rates of compensation for water during years when the IWSA is executed.
  - Rates of compensation (if any) for water during years when the IWSA is not executed.
  - Dates by which Wiggins will notify DT Ranch that they intend to exercise the IWSA.
  - Responsibilities for accounting and other reporting.

ES.5 Conclusions

The Project Team has been encouraged by the interest that water users, the CWCB, and others have shown in the demonstration projects and concepts developed under this ATM grant. Each of the demonstration projects will be explored in greater detail after the ATM grant funding expires, as described below:

ES.5.1 PVIC Augmentation Group/City of Aurora

The Flex Market concept will be further assessed by the Project Team through a new ATM grant from the CWCB. The objectives of the upcoming study are as follows:

- Develop a Flex Market contract template.

- Develop model decree terms and conditions for the Flex Market and for alternative transfers that would potentially be conducted within the market.
- Conduct a survey level engineering analysis of three major ditch companies in Division One, focusing on District 2 (Denver to Greeley), but extending to Districts 1 and 64 if entities in these districts want to participate. The survey will summarize potential CU available to ATM projects and assess potential for delivery of CU from these companies to major Metro M&I users.

ES.5.2 The Lower South Platte Water Cooperative

With support of the South Platte Basin Round Table and CWCB via grants from the Water Supply Reserve Account and the ATM Grant Program, potential organizational structures and operational strategies for a future Lower South Platte Water Cooperative will be researched. The initial formation of a new organization would likely include water users in Water Districts 1 and 64 (Kersey to the Colorado/Nebraska state line).

The organizational analysis will research water law and water rights issues related to the Cooperative, and produce estimated costs, benefits, impacts, risks and other issues associated with alternative organizational structures. Draft organizational documents will be prepared for evaluation by water users.

Operational strategies will also be researched. An operations plan will be developed that identifies water supplies (including direct flow and/or storage water transferred through alternative methods, excess recharge credits, new junior water rights, etc.), demands, and the means and necessary infrastructure to provide water when and where it is needed. Additional objectives of the operational study include:

- 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.

An economic analysis will be conducted to explore the economic attractiveness of alternative transfers among ditch companies.

ES.5.3 DT Ranch/Town of Wiggins IWSA

The results of the analyses conducted for this demonstration project were shared with Town of Wiggins, DT Ranch, and DU staff. The parties are interested in this potential alternative transfer and look forward to future collaboration. Discussions with the parties suggest that other alternative methods besides IWSA, such as rotational fallowing, may be of interest as well.

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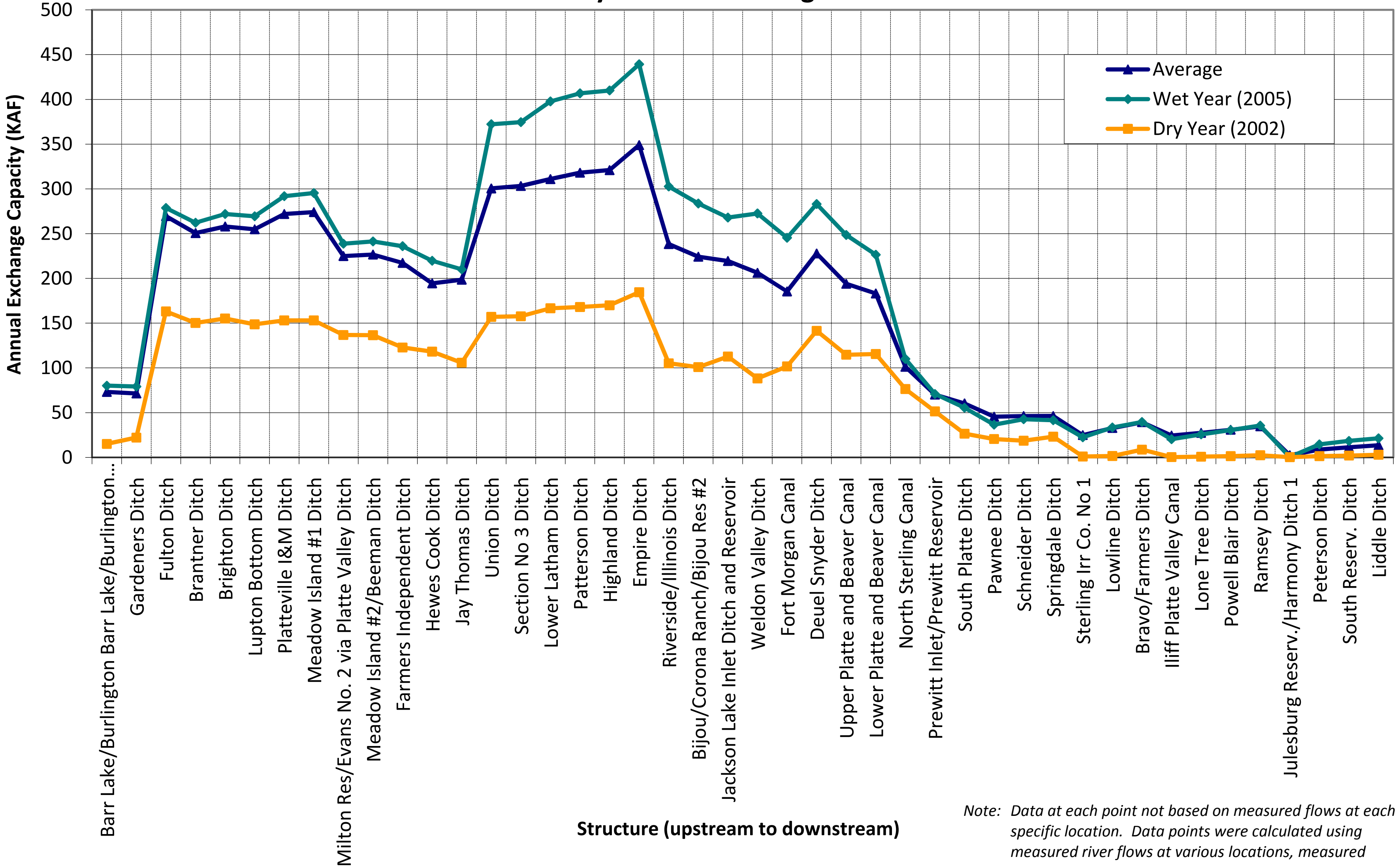
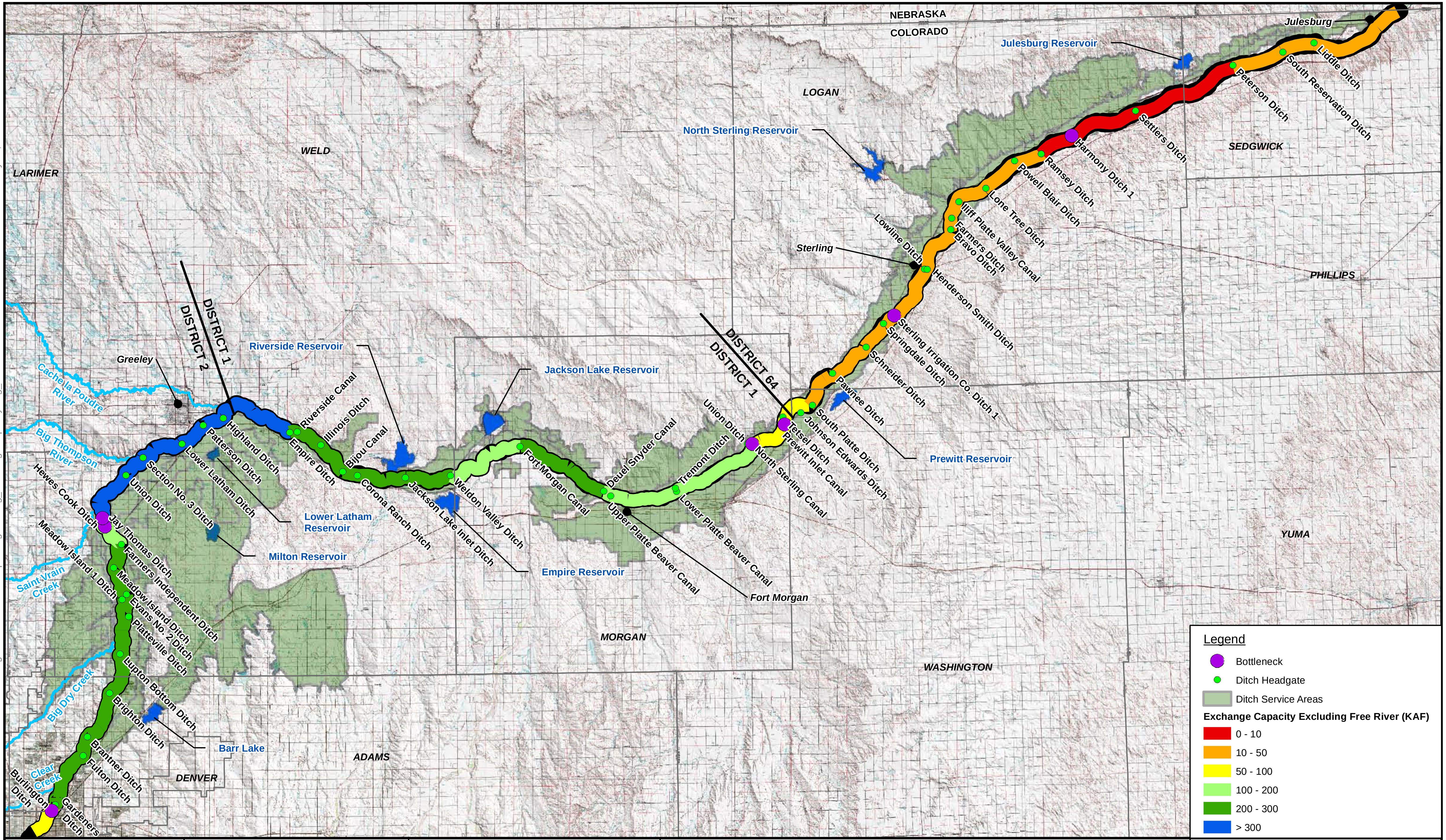
Figure ES-1. Variation in annual exchange capacity at various points along the South Platte River for water years 2002 through 2008



Note: Data at each point not based on measured flows at each specific location. Data points were calculated using measured river flows at various locations, measured



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Brown AND Caldwell

Date: May 2011

Colorado Water Conservation Board

Project: 137559

1 in = 10 miles

N E S W

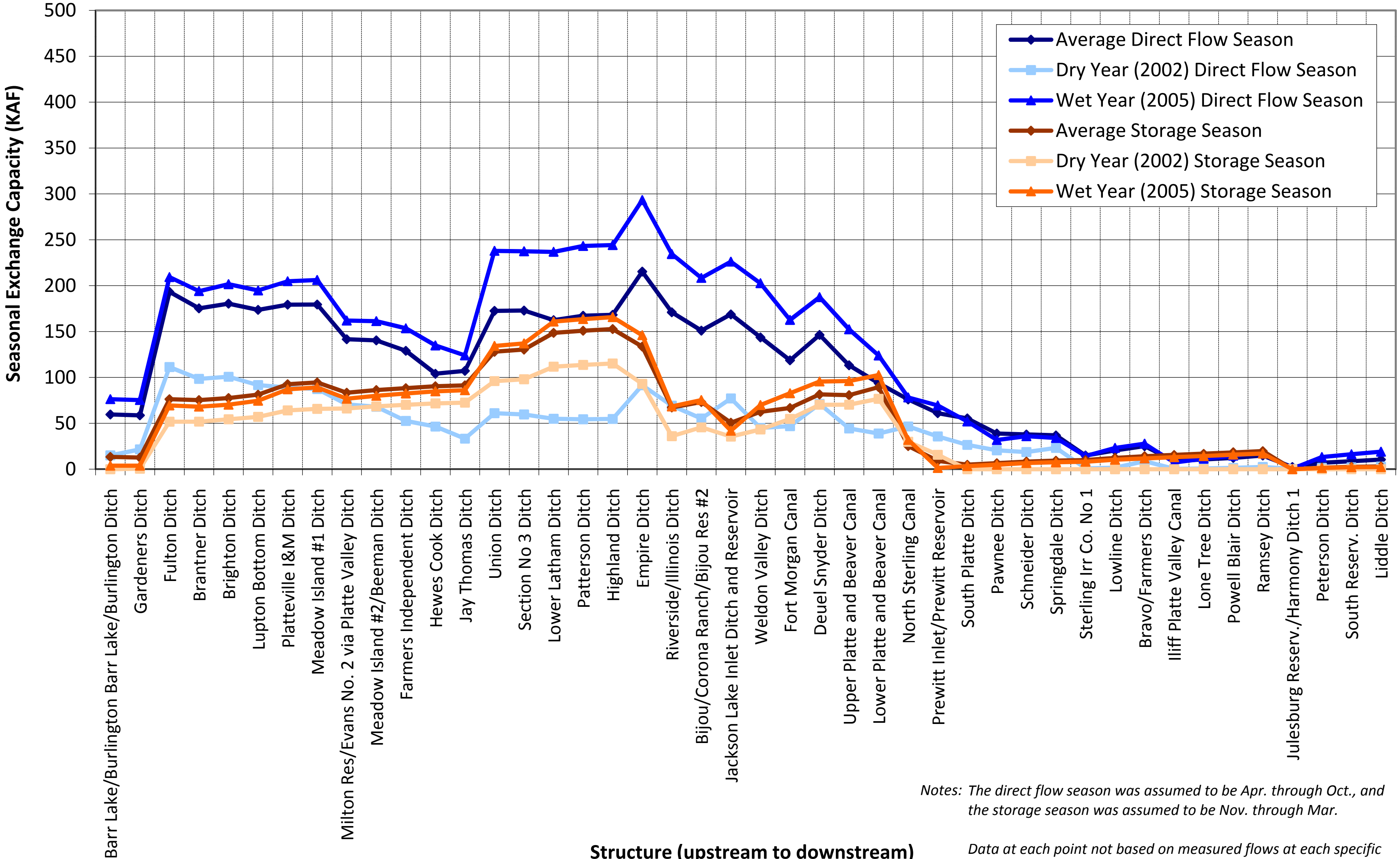
Notes

Projection: Universal Transverse Mercator, Zone 13 North, 1983 North American Datum (meters).

Locations of ditch headgates from South Platte Decision Support System

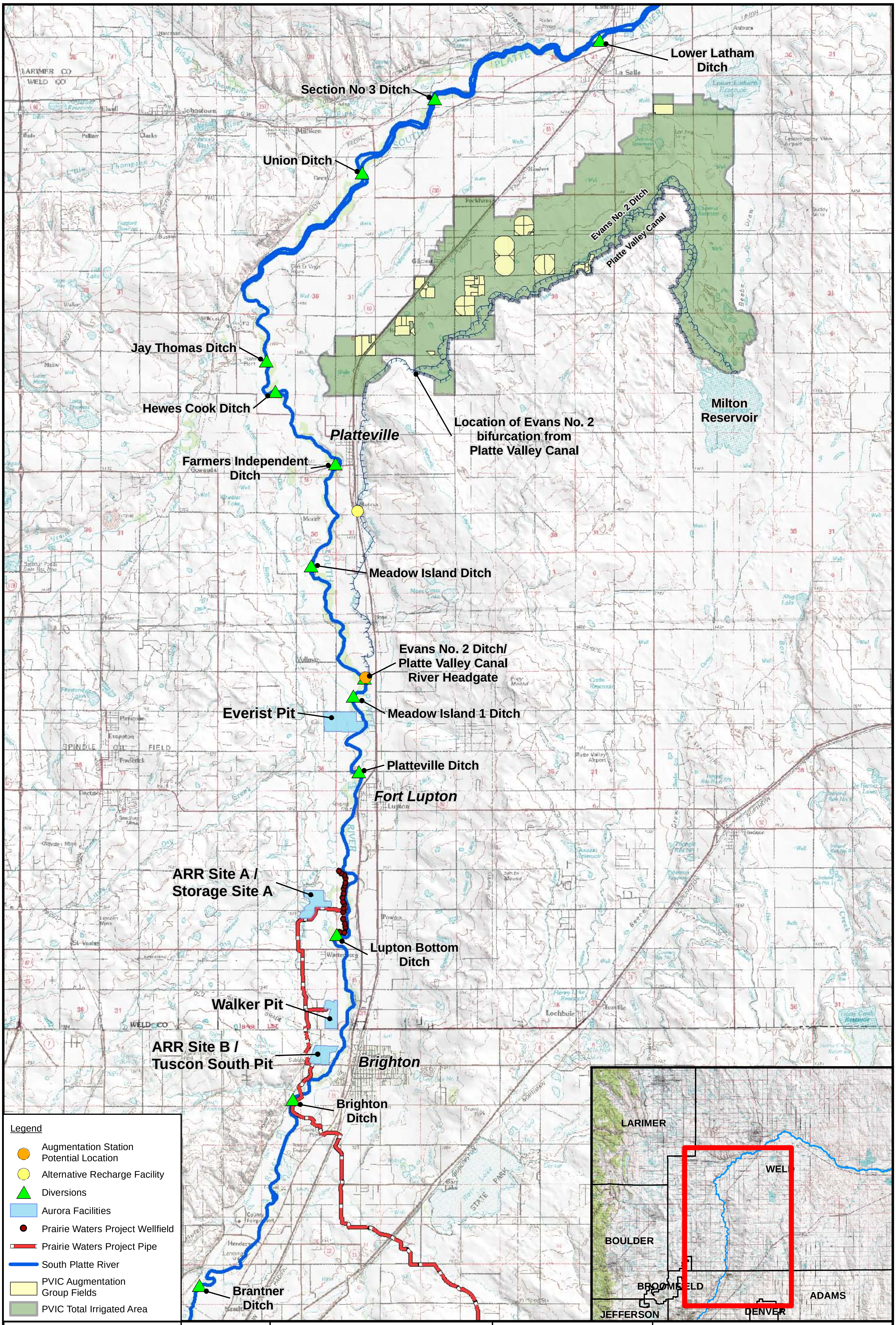
FIGURE ES-2
Average annual exchange capacity (2002 through 2008) and exchange bottlenecks along the South Platte River in Districts 1, 2, and 64

Figure ES-3. Seasonal variation in exchange capacity at various points along the South Platte River for water years 2002 through 2008



Notes: The direct flow season was assumed to be Apr. through Oct., and the storage season was assumed to be Nov. through Mar.

Data at each point not based on measured flows at each specific location. Data points were calculated using measured river flows at various locations, measured diversions, and river losses/gains.



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Brown AND Caldwell

Date: May 2011

Colorado Water Conservation Board

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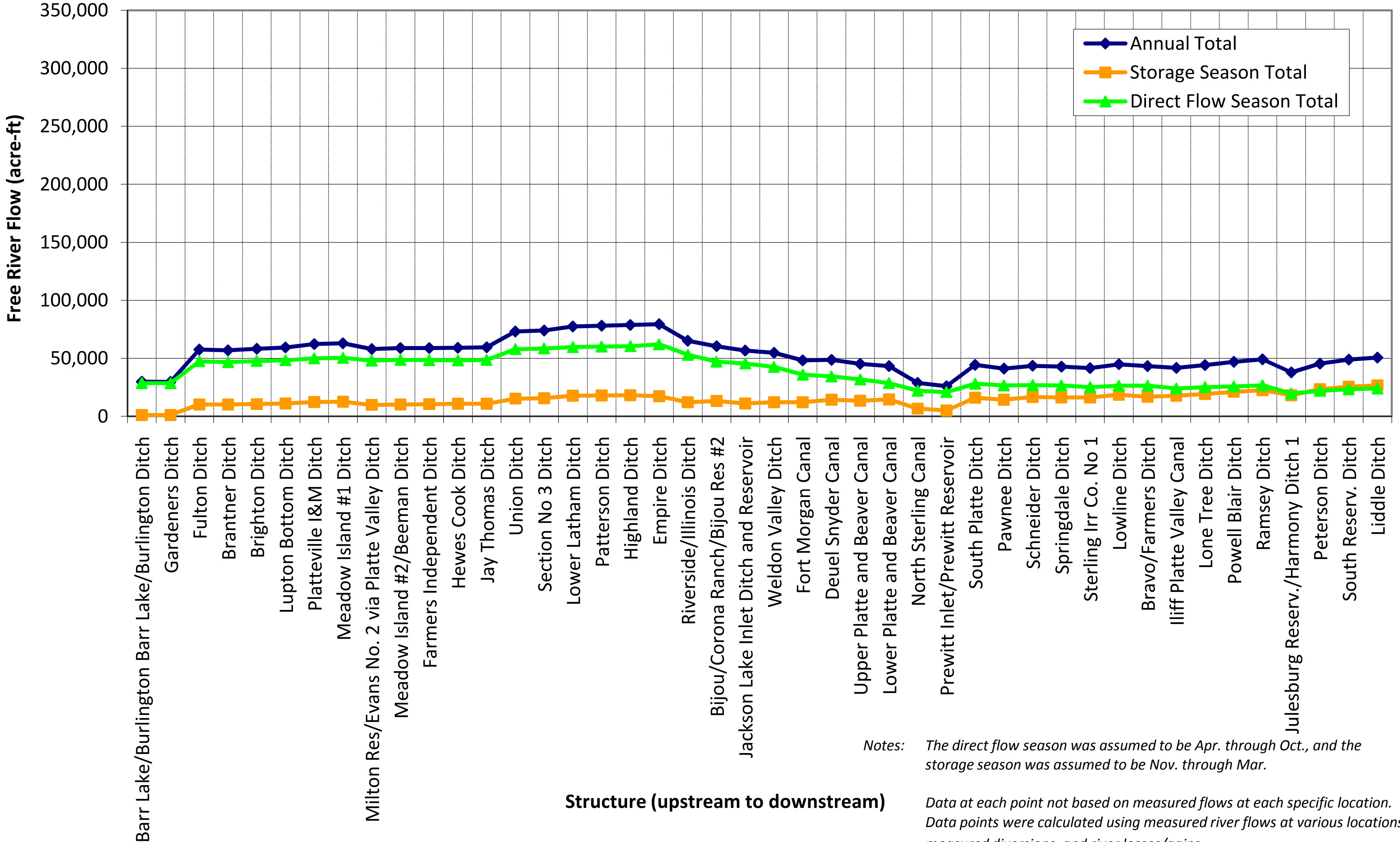
Notes

Projection: Universal Transverse Mercator, Zone 13 North, 1983 North American Datum (meters).

FIGURE ES-4

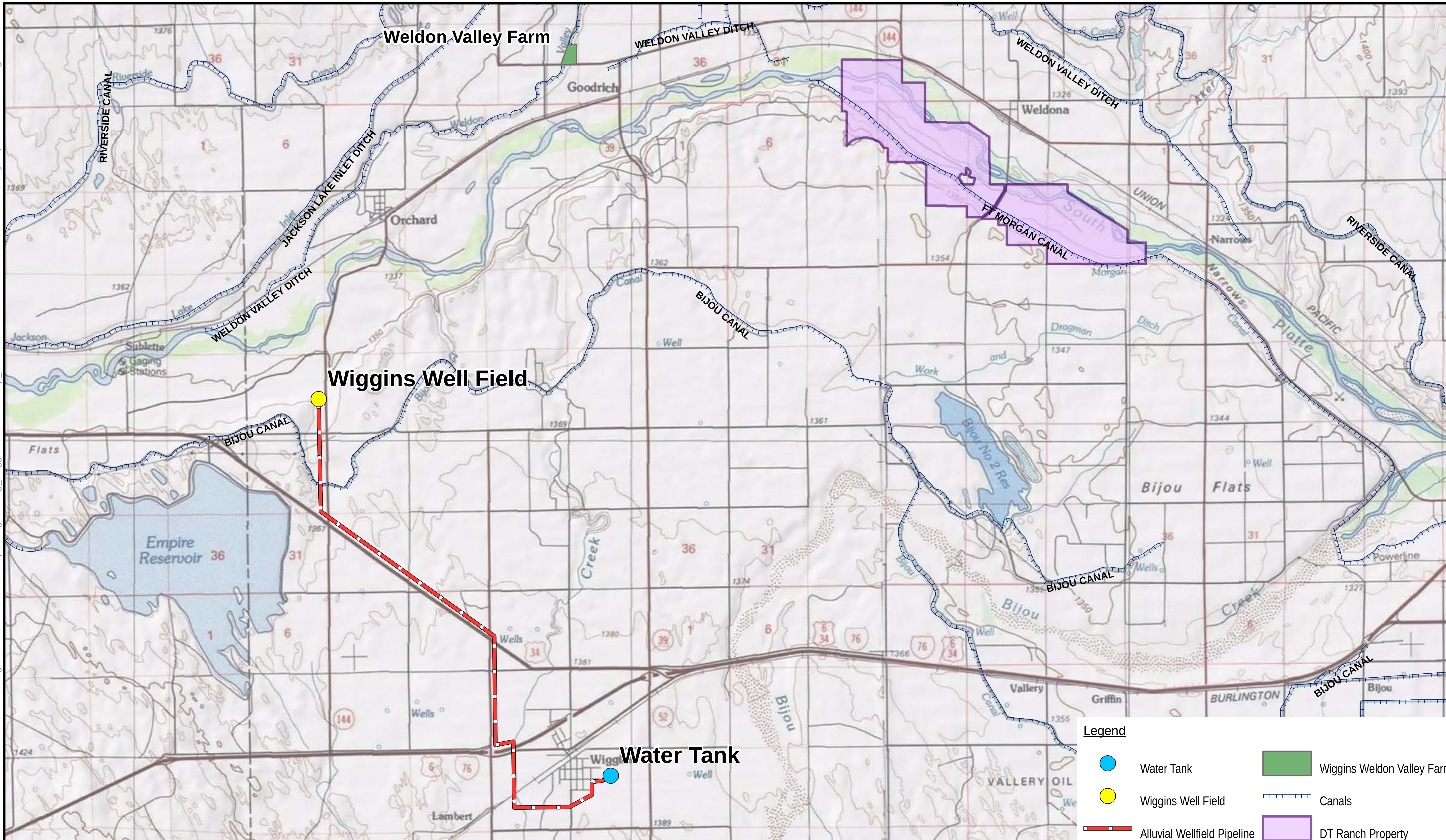
Locations of facilities potentially involved in the PAG/Aurora demonstration project

Figure ES-5. Variation in the average annual volume of free river flow passing various points along the South Platte River for water years 2002 - 2008



Notes: The direct flow season was assumed to be Apr. through Oct., and the storage season was assumed to be Nov. through Mar.

Data at each point not based on measured flows at each specific location. Data points were calculated using measured river flows at various locations, measured diversions, and river losses/gains.



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Colorado Water Conservation Board

Project: 137559

Notes

Projection: Universal Transverse Mercator, Zone 13 North, 1983 North American Datum (meters).

FIGURE ES-6

Location of DT Ranch and Town of Wiggins Water Supply Facilities

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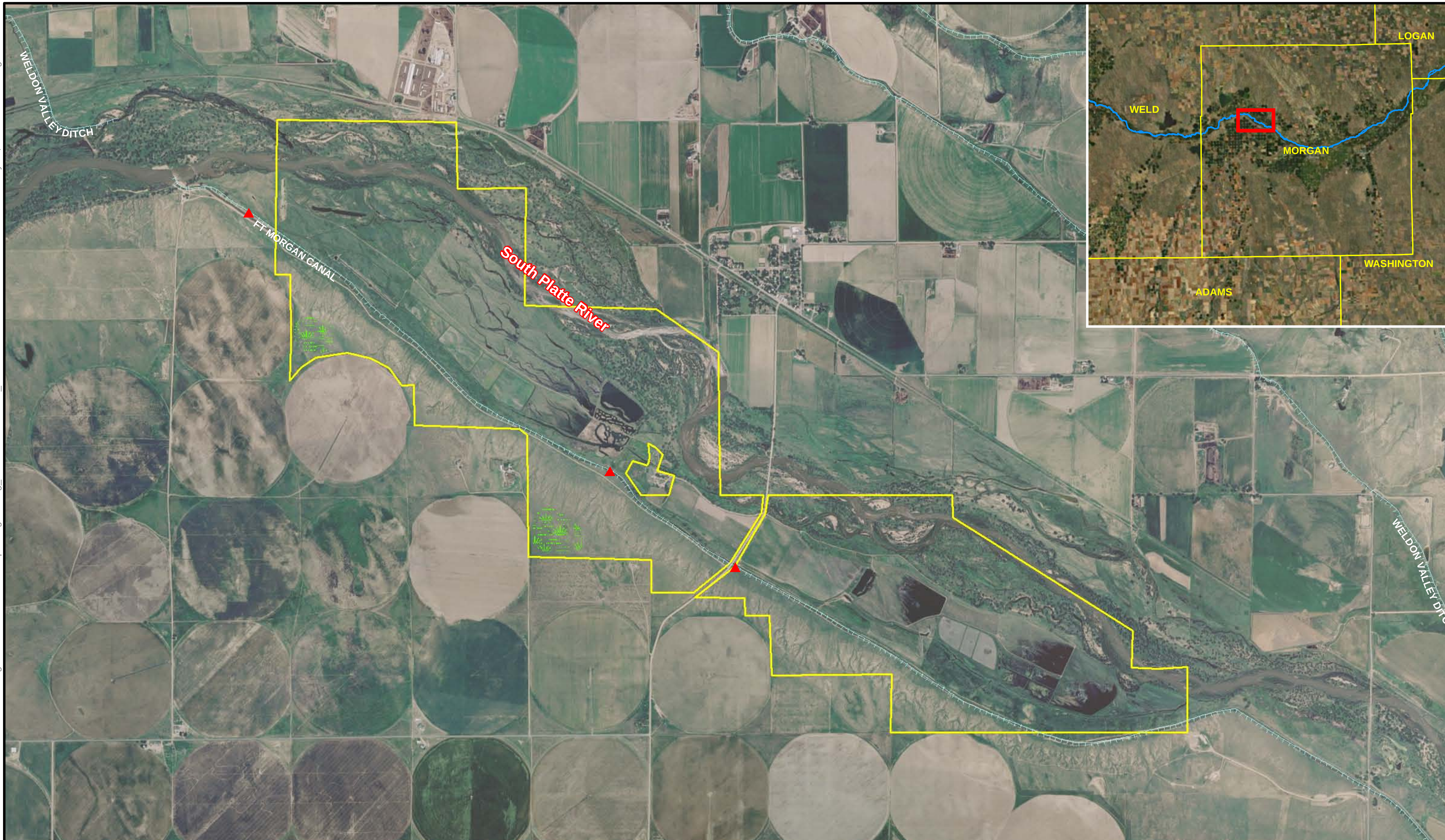

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Date: May 2011

Colorado Water Conservation Board

Project: 137559

Legend

- DT Ranch Farm Headgates
- Potential Recharge Sites
- Canals
- DT Ranch Boundary

Notes

Projection: Universal Transverse Mercator, Zone 13 North, 1983 North American Datum (meters).

FIGURE ES-7

Overview of DT Ranch

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Figure ES-8. Return flow response from deliveries to short and long term recharge facilities on the DT Ranch

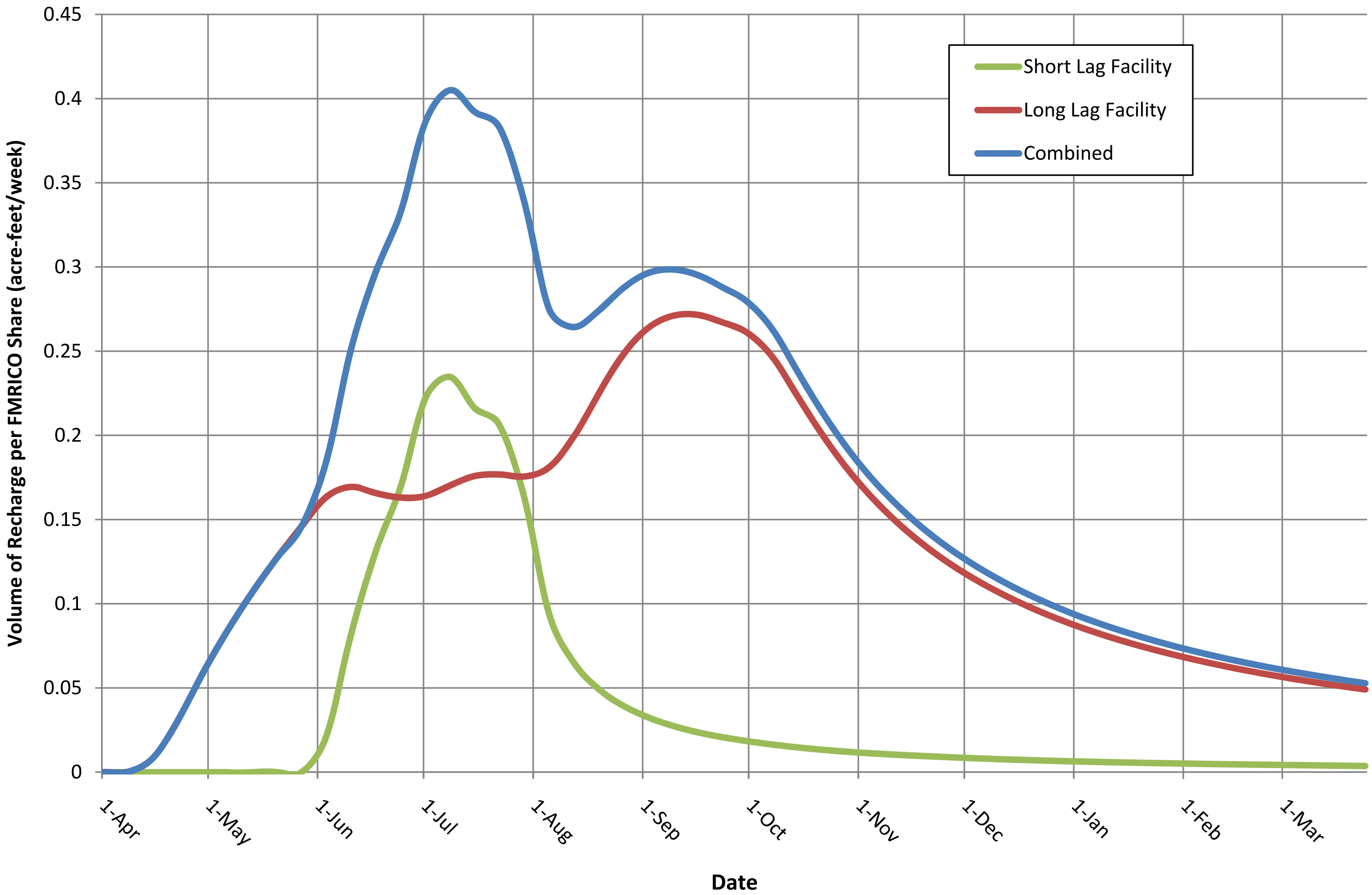
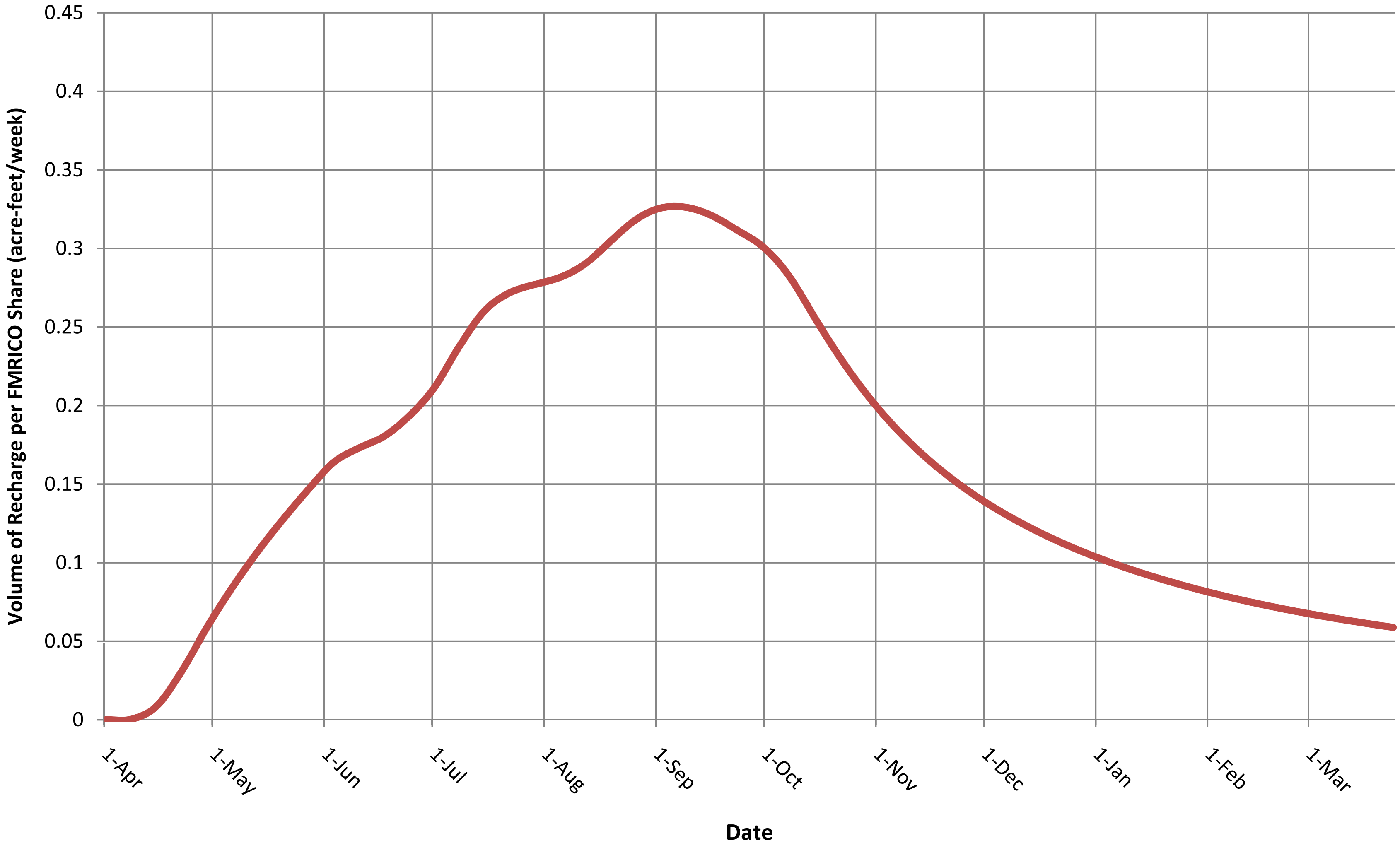


Figure ES-9. Return flow response from deliveries to long term recharge facilities on the DT Ranch



Section 1
Introduction

“When the well’s dry, we know the worth of water.” Benjamin Franklin’s insightful quote aptly sets the stage for the project described in this report. As a reliable and renewable source of supply, senior agricultural water rights have gained great value, as growing cities, with considerable financial resources, contemplate a figurative dry well. Agricultural water supplies have played and will continue to play a significant role in water providers’ portfolios. As such, they are very valuable.

In Colorado, water rights are private property; it is entirely legal and acceptable for agricultural producers to sell their water to other users, permanently “drying up” their irrigated lands in the process. In many situations, the sale of water to another user makes the most sense. For example, if an agricultural producer retires, and his or her children have no interest in maintaining the family business, a permanent transfer is a reasonable option from the producer’s perspective. Accordingly, it is anticipated that permanent transfers will continue into the future.

Permanent transfers of water can, however, have an impact on rural economies. For example, land values decline when irrigation permanently ceases, and as a result, property tax revenues decrease. Agricultural suppliers such as equipment dealers lose customers when irrigated lands are retired.

The State of Colorado recognizes the value of maintaining irrigated agriculture and the third-party economic impacts resulting from permanent transfers of water out of agriculture. However, the 2010 Statewide Water Supply Investigation (2010 SWSI) documents the fact that municipal suppliers anticipate mitigating future gaps in water supply, in large part, through agricultural transfers. As a result, the Colorado Legislature authorized the Colorado Water Conservation Board (CWCB) to develop a grant program that encourages water users to explore alternatives to traditional “buy and dry” agricultural water transfers.

Alternative transfer methods are those in which water is transferred out of agriculture to another use for a short or long time period, but the ownership of the water remains all or in part with the agricultural producer. Alternative transfers have been conducted in the western United States but have not been commonplace in Colorado.

In order to foster interest and implementation of alternative transfers in Colorado, the CWCB has funded several projects through the Alternative Agricultural Water Transfer Methods Grant Program (the ATM grant program). The project described in this report was funded through the ATM grant program.

1.1 Project Objectives

The purpose of this project was to further develop and promote alternative agricultural transfer methods, which is consistent with the goals of the ATM grant program. This project had two objectives originally, and a third objective evolved during the course of the project. The objectives are described below:

1) To develop tools for agricultural producers and others to use to evaluate the viability of potential alternative transfers.

2) To further actual alternative transfers by evaluating three demonstration projects that include owners of agricultural water rights and potential end users of the temporarily transferred water.
3) To identify barriers to implementation of alternative transfers and to describe potential strategies for overcoming barriers.

The first project objective resulted from a recognized need for tools that agricultural producers can use to evaluate alternative transfers. Alternative transfers can be complicated, and they involve one of an agricultural producer's most valuable assets – their water. The tools developed for this project will allow agricultural producers to evaluate economic implications of conducting alternative transfers, and understand the steps necessary to conduct the transfer.

The ultimate goal of the second objective is to develop some "success stories" of alternative water transfers. Few alternative transfers have taken place in Colorado. The intent of the demonstration projects is to study specific, potential transfers and to work with the participants so that both parties understand how much water could be transferred and how the transfer would take place. With a better understanding of how the alternative transfer may work, the parties may then pursue its implementation at the conclusion of the demonstration project.

The third objective evolved as the project progressed. As research was conducted on technical, legal, and administrative issues involved with alternative transfers, barriers to implementation began to emerge. In addition, the CWCB solicited input on barriers and strategies for overcoming barriers from project teams working on ATM grant projects. The demonstration projects described in the second objective were designed to be examples of strategies for overcoming barriers.

Legal, economic, and technical aspects of alternative transfers were analyzed during this project. The purposes of the analyses were to understand what alternative transfer methods are currently legally and technically acceptable in Colorado, to identify demonstration projects that have a high potential to result in an actual alternative transfer, and to help guide the development of tools for agricultural producers to use in evaluating alternative water transfers. In addition, the analyses were used to develop new ideas for encouraging and furthering alternative water transfers in Colorado.

1.2 The Project Team

The Colorado Corn Growers Association (CCGA), Ducks Unlimited (DU), and the City of Aurora (Aurora) applied jointly for the ATM grant used to fund this project. Although the CCGA, DU, and Aurora are a diverse team, they share a common goal – to develop win-win alternative transfers of water that can both meet growing urban and industrial demands and also maintain irrigated agriculture in Colorado.

These three entities joined forces with a group of water users and suppliers interested in forming a water cooperative in the lower South Platte River (the Lower South Platte Water Cooperative, or Cooperative). One of the interests of the potential Cooperative's organizers is helping agricultural and other interests to efficiently redistribute and beneficially use excess water, generally in the form of recharge credits, that is available from time to time in the lower South Platte River. The common goals and diverse viewpoints of the Cooperative, CCGA, DU, and Aurora led to productive collaboration and creative thinking.

Assisting in the research and collaboration on this project were the Colorado Water Resources Research Institute (research engineers and economists from Colorado State University); Lawrence Jones Custer Grasmick, LLP (attorneys); Harvey Economics; and Brown and Caldwell (engineers). The group described above is hereinafter referred to as the Project Team.

Section 2

Assessment of Alternative Transfer Methods

2.1 General Overview

Alternative transfers can be defined as a process in which water is transferred out of agriculture to another use for a short or long time period, but the ownership of the water remains all or in part with the agricultural producer. The length of alternative transfer is negotiable and is dependant on water owner and end user needs.

There are several potential methods for conducting alternative transfers, many of which are described in Section 2.2. Some of these methods are legally acceptable in Colorado, and some methods are currently being researched for possible future implementation. Each method has its own unique requirements and application for both water right holders and end users. Section 2.3 describes some of these requirements and applications.

Alternative transfers can offer several benefits to agricultural producers, municipal water suppliers, and local economies. Examples of these benefits include:

To Agricultural Producers

- Alternative transfers can help an agricultural producer lower their economic risks. If a producer can market and receive a revenue stream from part of their historical consumptive use, the producer will have a stable source of revenue and profit.
- An alternative transfer may provide some diversity to the agricultural producer’s business. In essence, water is treated like an additional cash crop within the farming operation.
- The stable revenue stream provided by the alternative transfer could help sustain a farming operation over the long term.

To Municipal or Industrial Water Providers

- Water providers can avoid the expense of outright purchases by conducting alternative transfers.
- Alternative transfers are focused on the asset of interest – the water. The water provider can avoid the burden of managing land assets, which often accompanies a permanent purchase of water rights and agricultural land.
- Permanent, buy-and-dry purchases of water rights can be politically damaging to water providers. Alternative transfers may be perceived as a win-win solution that benefits the water provider and the agricultural producer while partially avoiding negative impacts to the local economy.

To the Local Economy

- In most rural areas in the South Platte River basin and in Colorado, agricultural is the primary economic driver. Alternative transfers help keep agriculture in business and maintain the economic mainstay of rural areas.

- Many rural areas are experiencing population and economic declines. Maintaining irrigated agricultural may help rural communities that support farming to avoid further erosion of their business base.
- Property taxes are higher on lands that are irrigated. By maintaining the irrigated status of lands involved in an alternative transfer (as opposed to conversion to dryland in a buy-and-dry transfer), the property tax base is sustained

2.2 Methods

There are several techniques for alternative transfers that have either been implemented in Colorado and in other area of the United Stated or are currently being researched and are discussed with a fair amount of regularity. For example, excess recharge credits from augmentation plans are commonly transferred in Districts 1 and 64 in the South Platte River basin. Purchase and leaseback is another method that has been conducted in Colorado. While this method involves the transfer of water ownership, it does keep the water in agriculture on a temporary or periodic basis. Rotational fallowing and interruptible supply are methods of alternative transfer that have general acceptance in Colorado but have not been widely implemented. Other methods involving the reduction of consumptive use on irrigated fields (deficit/limited irrigation or alternative cropping) are currently being researched. The Project Team anticipates that methods which rely on reducing consumptive use will be evaluated in Water Court at some time in the future. A summary of various methods is provided below.

Rotational Fallowing

Rotational fallowing is an alternative transfer method where an agricultural user would agree to either not irrigate for certain years out of a set period of years, or not irrigate a certain portion of land out of the total amount of irrigated land. Typically, the lands not irrigated change from year to year. In other words, during each year of a rotational fallowing program, a different field or set of fields are not irrigated. The water that would have otherwise been consumed as a result of irrigation would be quantified; this amount is the transferrable amount of water that becomes available to a different end user. This alternative transfer method allows most of the agricultural land to remain in production, while at the same time providing a transferrable water supply for another user.

Rotational fallowing could be applied on a smaller scale by one agricultural user, or could also be implemented on a larger scale if applied to an entire ditch/canal company. The degree to which the agricultural producer is responsible for delivery of water and historical return flows likely depends on the scale of the rotational fallowing program. For example, if a group of ditch company shareholders participates in a rotational fallowing program, it is possible that the ditch company or the shareholder group would manage delivery of transferrable water and return flows. In this case, individual agricultural producers may simply be responsible for determining the fields to be fallowed. If a single agricultural producer is conducting the rotational fallowing program, that producer may be responsible for most aspects of water delivery, return flow maintenance, accounting, etc. Responsibilities for various aspects of the rotational fallowing program will likely be a matter of contract negotiation between the agricultural producer(s) and the end user.

Interruptible Water Supply Agreements

Interruptible water supply agreements (IWSAs) provide for temporarily suspending irrigation in order to transfer that water to a different user. This alternative transfer method is typically implemented on an as-needed basis. For example, during drought conditions a municipal user may call on a farmer under their IWSA agreement to provide water. The amount of water that would have been consumed from irrigation that year would be quantified and represents the transferrable amount. Typically the agricultural user is notified before the irrigation season in a year when the IWSA is implemented.

This alternative transfer method allows for agricultural land to remain in production in most years, since irrigation is temporarily suspended only in years when the water is needed by the other user and is limited as to frequency of the transfer. Like rotational fallowing, the degree to which an agricultural producer is responsible for delivery of transferrable water, return flow maintenance, accounting, etc. likely depends on the scale of the interruptible supply program and results of contract negotiations with the end user.

These agreements may be temporary or long-term; however, current Colorado law limits implementation to no more than three years in a ten year period without having to go through Water Court.

Excess Recharge Credits

In the lower South Platte River and in other areas of the state, well augmentation plans use intentional recharge as a source of augmentation water supply. From time to time, the need for augmentation supply is less than the supply itself, resulting in an excess of supply. This excess supply, if it is properly accounted for, can be leased to other water users who do not have enough supply. The leasing of excess recharge credits has become relatively commonplace in the lower South Platte River.

Deficit or Limited Irrigation

Deficit or limited irrigation involves limiting irrigation at specific times during the crop growth cycle to minimize water use while still maintaining crop yield (although potentially less than full yield). Since less water is consumed by the crop during the times of limited irrigation, the difference in consumption between limited and full irrigation could become available for transfer to another user. This alternative transfer method also allows for agricultural land to remain in production, while still providing a transferrable amount of consumable water.

Deficit or limited irrigation has not yet been implemented in a decreed transfer in Colorado. It is a method that is currently being researched by several parties including Colorado State University (CSU), the U.S. Department of Agriculture, the City of Parker, the Regenesis Management Group, and other advisors and collaborators. If successfully implemented, this method could provide many opportunities for alternative transfers. There are several benefits and challenges associated with this method of transfer. They are described below:

Benefits

- All of the irrigated land that an agricultural producer owns could still be farmed.
- Farming input costs could be reduced.
- Demand for agricultural inputs is generally maintained (although potentially at a lower level), and impacts to the local economy from the transfer are minimized.
- The farming business would gain more diversity of income while still raising crops.
- Because the land continues to be irrigated, the land holds its value, which benefits the farmer and the county (assessed land values stay the same).

Challenges

- Agricultural producers may be concerned that crop yields would be less.

- It is unclear how the State Engineer would administer the transfer. There are efforts underway to quantify saved consumptive use accurately and in a way that could be used by the Department of Water Resources (DWR) for verification. Some of these efforts are being funded by the ATM grant program.
- A transfer based on deficit or limited irrigation would need to go through Water Court. Because deficit irrigation transfers are not yet commonplace, it is possible that the initial Water Court cases dealing with deficit or limited irrigation will have many issues to resolve.
- Additional costs may be incurred by agricultural producers to purchase equipment or other technologies to monitor or quantify transferrable consumptive use and to demonstrate that historical return flows are being provided in the correct timing and amount.
- It may be necessary to cooperate with several other agricultural producers to accumulate enough transferrable water that it would be attractive to a municipality or industry.

Alternative Cropping

Alternative cropping involves changing cropping patterns from crops with higher to lower annual consumptive use (CU). These crop substitutions may occur either on a short-term or a more permanent basis. Water that would have been consumed by the higher CU crop that is no longer required by the new crop represents the amount of water transferrable to a different user. This alternative transfer method allows for the agricultural land to remain in production, while still providing a transferrable amount of water.

Like deficit irrigation, alternative cropping is also an attractive but untested transfer method. Benefits and challenges associated with this method are listed below. Many of these are the same as deficit irrigation.

Benefits

- All of the benefits of deficit/limited irrigation are applicable to alternative cropping.
- A rotation of lower water use crops may fit easily into an agricultural producer’s operations.

Challenges

- An alternative cropping transfer program would need to go through a Water Court proceeding and would face many of the same challenges as deficit irrigation.
- Methods would need to be developed for verifying the amount of transferrable consumptive use.
- The market for lower water use crops may not be as strong as for higher water use crops.
- Some lower water use crops may require different equipment or inputs than higher water use crops.

Water Banks

Water banks are organizational frameworks for marketing water that have been authorized by the Colorado Legislature. Water banks must be formed by a governmental agency, such as a water conservancy district or a water conservation district.

Water banks have not been widely implemented in Colorado. A water banking pilot project was implemented in the Arkansas River basin in the year 2001. By 2005, the pilot project was canceled due to lack of interest and participation. The lack of interest may have been due to certain restrictions that were put on the water bank such as limitations on exporting the water out of the Arkansas basin and the prohibition of marketing direct flow rights through the water bank (the bank was limited to storage rights only). In addition, the short duration of the pilot water bank likely discouraged the establishment of long term leases that would provide the supply security that municipalities or industry frequently need.

Even though the pilot water bank was not as successful as desired, water banks are still an option for marketing alternative transfers of water. They can provide a transparent means for marketing water and can potentially help avoid the time delays and expense of Water Court.

Purchase-Leaseback

A purchase and leaseback arrangement occurs when a non-agricultural water user, for example a municipality, purchases an agricultural water right with the agreement that the water will be leased back to the agricultural producer (or ditch system) during certain years, usually during normal or wet years. This type of arrangement allows for the land to remain in agricultural production during most years, when the water is leased back to the producer and the purchaser does not need the additional supply. It also provides the purchaser with additional supply during dry years when it is needed. This type of arrangement is similar to an IWSA, except that in a purchase and leaseback agreement the purchaser is the new owner of the water right, rather than the agricultural producer.

2.3 Evaluation of Methods

Each of the alternative transfer methods described in Section 2.2 has engineering, legal, and administrative considerations associated with implementation. Some methods are more implementable than others given current engineering and administrative practices and legal acceptability. The Project Team researched and discussed engineering, legal, and administrative issues associated with various methods and barriers to implementation of methods. This section describes the results of this research.

2.3.1 Engineering

The Project Team identified several engineering and technical issues as potential barriers to alternative transfers. Some of these issues are similar to those associated with traditional buy-and-dry transfers. Others are associated with specific methods of alternative transfers. In addition, some engineering and technical issues are applicable on a more broad scale and apply to most, if not all, methods of alternative transfer. The Project Team reviewed the engineering and technical issues associated with various methods of alternative transfer and summarized the overarching issues as described below:

- The historical consumptive use associated with the water to be transferred must be quantified so that the use of the water is not expanded beyond historical limits.
- The transferrable consumptive use of the water right involved in a transfer must be quantifiable so that the transferred water can be measured and administered.
- Historical return flows must be maintained in timing, location, and amount so that other water rights which depend on return flows are not injured.
- Other water users on a ditch system should not be impacted by the operation of the transfer.
- The transferred water must be delivered to the end user. Challenges with water delivery apply generally to all methods of alternative transfer.

Many of the above issues relate to the ability of the State Engineer to administer and verify an alternative transfer. For example, the State Engineer needs to verify the amount of transferred consumptive use and that historical return flows associated with the transferred water are being maintained. For several alternative transfer methods, current engineering practices provide sufficient information to verify consumptive use and maintenance of return flow obligations. Conversely, technological advances may be required for other alternative transfer methods before the State Engineer can verify transferrable consumptive use and the maintenance of return flows.

Table 2-1 summarizes engineering issues as they relate to each transfer method. Additional details are provided in the text following the table.

Table 2-1. Summary of engineering issues related to alternative transfers

Method	Historical use analysis necessary?	Considerations for quantifying and verifying transferrable water	Maintenance of historical return flows required?	Are there challenges in delivering water to end users?	Ditch system or on-farm infrastructure required to conduct an alternative transfer
Rotational Fallowing	Yes	Quantification based on historical use. Fallowing is likely an acceptable means of verification.	Yes	Potentially	• Infrastructure necessary to deliver water to the river likely similar to that used in traditional buy-and-dry transfers. • Maybe more infrastructure needed to maintain historical return flows.
Interruptible Supply Agreements	Yes	Quantification based on historical use. Fallowing is likely an acceptable means of verification.	Yes	Potentially	• Infrastructure necessary to deliver water to the river likely similar to that used in traditional buy-and-dry transfers. • Maybe more infrastructure needed to maintain historical return flows.
Excess Recharge Credits	No	Quantification and verification based on augmentation plan accounting.	No	Potentially	• Measurement equipment to quantify deliveries to recharge facilities and recharge amounts.
Deficit or Limited Irrigation	Yes	Unclear. Groups are working on technology to quantify and verify transferrable water.	Yes	Potentially	• Equipment to measure components of the on-farm water budget (consumptive use, return flows, etc.) • Infrastructure necessary to deliver water to the river likely similar to that used in traditional buy-and-dry transfers. • Maybe more infrastructure needed to maintain historical return flows.
Alternative Cropping	Yes	Unclear.	Yes	Potentially	• Equipment to measure components of the on-farm water budget (consumptive use, return flows, etc.) • Infrastructure necessary to deliver water to the river likely similar to that used in traditional buy-and-dry transfers. • Maybe more infrastructure to maintain historical return flows.
Water Banks	Depends on the source of water	Depends on the source of water. A water bank would likely need to provide accounting for water transferred through the bank	Depends on the source of water	Potentially, but a water bank may have geographically diverse supplies	• Depends on the source of water
Purchase and Leaseback	Yes	Quantification based on historical use.	Historical return flows maintained by using water for irrigation or by active maintenance	Potentially	• New infrastructure probably not necessary while water is used for irrigation

Additional information and commentary regarding the categories of information in Table 2-1 are provided below.

Historical use analysis necessary?

For most of the alternative transfer methods, a historical consumptive use analysis is required to determine the amount of consumptive use available for transfer. Transferrable amounts of consumptive use are determined based on historical data describing crops grown, irrigation acreage, climate conditions, and deliveries of water to the farm. Procedures for determining historical consumptive use are well-established and are commonly utilized in change of use cases in Water Court.

Transferring excess recharge credits will not require a historical use analysis. Excess recharge credit available for transfer is determined by comparing augmentation demand and augmentation supply, per augmentation plan accounting.

Transferrable amounts marketed through a water bank will need to be quantified based on historical use, unless the source of the water is excess recharge credits.

Considerations for quantifying and verifying transferrable water

Quantifying and verifying the amount of water transferred is an essential requirement of an alternative transfer. Quantification requires measurement of water delivered to the river or to the end user. Verification of transferred amounts is important for administration of an alternative transfer by the State Engineer.

The State Engineer has traditionally relied on fallowing to verify that no irrigation took place on lands from which water was transferred. Flow measurement structures have been used to quantify the amounts transferred. Currently, rotational fallowing and interruptible supply methods of alternative transfer enjoy higher levels of acceptance than other methods, partly because these approaches to quantification and verification are readily adapted to them.

The quantification of transferrable consumptive use under a deficit or limited irrigation program is more difficult because irrigation will still be occurring, albeit in a lesser amount. Transferrable amounts of consumptive use are derived, because irrigated crops under a deficit or limited irrigation program consume less water than fully irrigated crops. Quantifying consumptive use under a deficit or limited irrigation program requires measurement technologies that are available but have not been considered in Water Court. Likewise, verification of transferrable consumptive use for administration purposes will require data and information that the State Engineer can review and confirm in an efficient manner. Work is currently being conducted in the South Platte River basin to develop and test methods of quantification and verification for use in deficit/limited irrigation programs.

Transfers conducted under an alternative cropping program would face some of the same challenges as deficit/limited irrigation.

Challenges related to quantification and verification for alternative transfers marketed through a water bank depend on the alternative method chosen (see above commentary). The State Engineer would be responsible for developing rules governing water bank activities. These rules would address, among other things, the quantification of deposits and withdrawals and limitations designed to prevent material injury to vested water rights (*see* §37-80.5-105, C.R.S.)

Maintenance of historical return flows required?

Return flows in the form of end-of-field runoff and deep percolation occur as a result of inefficiencies associated with most irrigation practices (subsurface drip irrigation is commonly considered to be

100 percent efficient). Most of the transfer methods will require maintenance of historical return flows in timing, amount, and location, because downstream water users depend on return flows for part of their water supply. The only exception is transfers conducted using excess recharge credit. Excess recharge credits, as described previously, occur as the result of augmentation plan operations and not irrigation practices.

Are there challenges to delivering water to end users?

Delivering water to end users may be a challenge for all of the alternative transfer methods listed in Table 2-1. A significant amount of water supplies that could be provided by alternative transfers is located far downstream of the Denver metropolitan area. Exchanges, storage facilities, pipelines, and water treatment plants will likely be required to deliver large volumes of water to Denver-area water providers.

Exchanges offer an opportunity to move water to upstream users without pumps and pipelines, but they can be unreliable and subject to changing river flows and call regimes. Additional facilities may be needed to enhance exchange in some portions of the river. Whether used for direct delivery or to enhance exchange potential, any infrastructure adds to the cost of the implementing the transfer and potentially introduces technical or engineering issues.

Smaller alternative transfers conducted between water users who are close to each other can likely occur without the engineering issues associated with large scale, long distance alternative transfers. Water demands of small and large municipal and industrial water users downstream of Denver could potentially be supplied by alternative transfers via exchange or smaller-scale conveyance facilities.

Water banks may reduce the engineering challenges of providing water through alternative methods. With supplies distributed over larger geographic areas, water banks may have several alternatives for serving end users in different locations.

Ditch system or on-farm infrastructure required to conduct an alternative transfer

Some infrastructure or equipment will likely be required to successfully implement any of these transfer methods. Some infrastructure requirements for alternative transfers are generally the same as for traditional buy-and-dry transfers and will depend on the conditions associated with specific ditches, farms, and transfer methods.

In addition to infrastructure required for traditional buy-and-dry transfers, rotational fallowing and interruptible supply programs may need extra facilities to provide historical return flows in the appropriate time and location. Under a rotational fallowing program, return flows that historically accrued to the river will differ depending on which field is currently fallowed. As a result, multiple facilities may need to be constructed to provide return flows under different timing regimes and at different locations. The degree to which additional facilities will be required will depend on the distances between fields and the river, aquifer characteristics, the location of downstream senior water rights, and existing delivery facilities that are available for use. Interruptible supply programs may face the same challenge depending on the number of participants and the geographic diversity of participating farms. Minimizing the number of additional facilities will be a challenge for both rotational fallowing and interruptible supply programs.

Deficit and limited irrigation programs may require additional infrastructure to measure deep percolation and runoff return flows that occur during irrigation application, consumptive use, and water deliveries to the farm. In addition, new infrastructure may be needed to provide additional return flow requirements and to deliver water to end users or to the river. Similar infrastructure may be needed for alternative cropping programs.

Water banks would not typically need to install new infrastructure within ditch systems or on farms. Rather, water banks would be the means through which ditch companies or individual agricultural producers market their water to end users.

2.3.2 Legal

The Project Team assessed legal issues related to five distinct alternative transfer methods including Interruptible Water Supply Agreements, long term rotational fallowing, water banks, reduced consumptive use (deficit/limited irrigation and alternative cropping), and purchase-leaseback. As an initial matter, four key questions were asked with regard to each method:

1. Does the legal framework currently exist?
2. If so, what is required to implement the measure?
3. Has the measure been implemented successfully in Colorado?
4. What legal changes could improve the process?

Table 2-2 summarizes the results of the legal research.

Table 2-2. Summary of legal issues related to alternative transfers

Method	Does the legal framework currently exist?	If so, what is required to implement the measure?	Has the measure been implemented successfully?	What legal changes could improve the process?
Interruptible Water Supply Agreements	Yes, *See* §37-92-309, C.R.S. allowing use 3 out of 10 years.	Application to the State Engineer	No. No known attempts.	Standardized approval criteria (C.U., return flow, lagging criteria, dry up terms and conditions)
Rotational Fallowing	Yes. §37-92-305, C.R.S. explicitly recognizes a fallowing program as a type of change in use subject to Water Court approval, and provides guidance to the Water Court regarding terms and conditions.	Water Court Application for Change of Water Rights	Limited. Primarily in Arkansas Basin	Unclear
Water Banks	Yes. §37-80.5-104.5, C.R.S. authorizes the creation and operation of water banks in all water divisions of the state.	Sponsoring water conservancy or water conservation district, State Engineer rulemaking	No. Arkansas Pilot Project failed for lack of participation. No known applications in other basins.	Unclear
Reduced Consumptive Use	Probably. §37-92-305 does not explicitly recognize reduced CU cropping or deficit irrigation, but these practices are likely to be considered a “change in use” authorized by the statute.	Water Court Application for Change of Water Rights	No. No known applications.	Clarification in Statute recognizing these practices explicitly could eliminate argument
Purchase and Leaseback	Yes. §37-92-305, C.R.S. authorizes Water Court to approve changes in type and place of use	Water Court Application for Change of Water Rights	Yes	None needed.

2.3.2.1 Summary of Legal Analysis

At the present time, Colorado does not have a legal mechanism for approving alternative transfers that has gained widespread acceptance by water users. Three of the five alternative transfer methods in Table 2-2 that are available to Colorado water users require Water Court adjudication. Participants in these transactions are likely to experience transaction costs and time frames to completion equivalent to or greater than a Water Court application to permanently change the water rights in a “buy and dry” scenario. As a result, there is no advantage in time frame or cost to pursuing these alternative transfer methods. In fact, Water Court applicants who are the first to pursue novel alternative transfer methods may encounter increased opposition and a concomitant increase in transaction costs as compared to a “typical” change in use case. Municipal/industrial water providers interviewed by the Project Team understandably expressed a reluctance to seriously pursue temporary supplies where transaction costs and delays could be equal to or more than those associated with developing an equivalent permanent supply under a traditional "buy and dry" transfer.

Of the two remaining alternative transfer avenues, the water banking approach requires extensive organization and rulemaking at an institutional level (water conservancy district and State Engineer), and is not available to an individual water user. However, if successfully implemented, it has the potential to substantially reduce transactional costs and stimulate viable alternative transfer markets in "stored water" (see §37-80.5-105, C.R.S.). The principle mechanism of cost reduction contemplated by the statute is the State Engineer's rulemaking authority, which is intended to provide the framework for banking and to prevent material injury to existing water users on a systemic basis. This approach would likely be faster and less expensive than the existing Water Court approach, which evaluates the material injury question on a costly and time consuming case-by-case basis. To date, there has been only one effort to create a pilot-scale water bank (see Section 2.2).

The Interruptible Water Supply Agreement statute (see §37-92-309, C.R.S.) is the only option available to Colorado water users seeking to implement an alternative transfer arrangement outside of Water Court. The statute permits approval of IWSAs by the State Engineer, and the State Engineer has the option of holding a hearing prior to approving IWSAs if significant issues exist between applicants and opposers. Water users uniformly perceive the requirements of the statute to be equivalent to a Water Court process in scope and cost, because they anticipate that a hearing would be necessary to obtain approval of an IWSA. Though the statute outlines an accelerated time frame, and allows the State Engineer to approve the application without initial Water Court involvement, there is a direct appeal to the Water Court. In that appeal, the State Engineer's determination is entitled to no deference. This direct appeal, in combination with the detailed requirements of the statute, which essentially charge the State Engineer to make the same determinations that the Water Court would in a change of use case, have substantially chilled any implementation of the statute.

In every transfer mechanism and in many of Colorado's administrative practices and allowances, there is a fundamental tension between Colorado's dual goals for water administration—protection of vested rights and maximization of use. Solutions do not lie in favoring either of these goals over the other, rather, in finding the appropriate mid-point between them. For example, augmentation plans are a solution that fits between these goals. Absolute protection of senior rights would dictate that no out-of-priority depletions ever be allowed. However, in an effort to maximize use of water, out-of-priority depletions are allowed if they are replaced or "augmented" to prevent injury to senior rights. In the context of transaction costs, the continuum between the two goals exists from intense, case-specific scrutiny on one end of the spectrum (absolute protection of senior rights) to limited process governed by rules of broad application (favoring maximization of use) on the other.

The IWSA statute was intended to represent a balance between protecting vested water rights, and increasing flexibility for temporary arrangements. The lack of implementation by Colorado water users, however, suggests that the statute's provisions protecting vested rights inadvertently inhibit its application, defeating its effectiveness in maximizing use. If the statute is to enjoy widespread application, the General Assembly will need to find a way to protect senior rights at a greatly reduced transactional cost.

The CWCB solicited input from all of the ATM grant recipients on concepts for removing barriers to alternative transfers. One potential approach to this issue is to explore the concept of rulemaking. Applications for temporary transfer could potentially be processed efficiently and at reduced transaction costs if the State Engineer were given the authority to promulgate rules of general application governing some parts or all of applications to temporarily change the use of water rights located in a particular basin, district or ditch system. This, in turn, could make alternative transfers more attractive. Presumably, any such rules of general application could be conservative enough to cover case by case variations and achieve the equally important goal of protecting vested rights.

Some potential solutions for lifting barriers to alternative transfers may be met with opposition in the water community. Each water user in the South Platte River basin (and even within the Project Team) has a different interest or position in the continuum between absolute protection of vested water rights and maximization of use. Finding solutions within the continuum will require collaboration among water users, research on legal or technical issues, and time.

2.3.3 Administration

The State Engineer will need to be able to efficiently administer alternative transfers. To successfully and efficiently administer a transfer, the State Engineer will need information that clearly documents the amount of consumptive use transferred and that historical return flows were provided. The Project Team identified several administrative issues that should be considered when implementing alternative transfers.

- As stated above, the State Engineer needs to be able to efficiently administer alternative transfers. Alternative transfer methods that involve fallowing (rotational fallowing and interruptible supply programs) as the method of generating transferrable water currently have the highest level of acceptance from an administrative perspective. The State Engineer has administered numerous traditional buy-and-dry transfers in which land is permanently fallowed. Procedures for administering rotational fallowing and interruptible supply programs could be readily adapted from the processes the State Engineer uses for traditional transfers.
- Technical and engineering challenges associated with deficit/limited irrigation and alternative cropping programs are related to the ability to efficiently administer these programs. Researchers and proponents of these programs are currently working towards the development of technologies and methods to allow for efficient administration.
- The State Engineer will need to be able to administer exchanges that may be conducted to deliver water from alternative transfers. Before the State Engineer will allow an exchange to proceed, the State Engineer needs to know the amount of water to be exchanged. Water from rotation fallowing programs would likely be delivered in relatively regular amounts over an irrigation season, and it would potentially be measured using a flume or other structure. Administering exchanges of water from rotational fallowing programs would likely be a straightforward process for the State Engineer. However, the amount of excess recharge credit available from augmentation plans may change on a daily basis, and real-time quantification of available credits will be required for administration. The State Engineer is currently developing tools to help quantify excess recharge credits on a real-time basis.

2.4 Barriers to Implementation: Defining the Problem

Having surveyed the existing "lay of the land" with respect to the alternative transfer methods legally and technologically available, the Project Team explored the reasons these methods have not been applied in Colorado in a meaningful way to date. After interviewing M&I users and agricultural water users and assessing previous Colorado transfers, the Project Team identified five distinct barriers to a robust alternative transfer market.

2.4.1 High Transactional Cost

The single most significant factor inhibiting temporary alternative transfer arrangements in Colorado is the high transactional cost associated with implementing them. M&I users' perception is that the transactional cost associated with implementing an alternative transfer arrangement is equal to or greater than the cost of purchasing the water rights outright in a "buy and dry" approach. As such, there is little incentive to enter into temporary arrangements. Similarly, agricultural water users report an unwillingness to explore alternative methods because of the high cost of legal and technical services necessary to adequately explore and implement an alternative transfer. The legal and administrative processes for gaining approval for an alternative transfer are thought to be excessively complex and costly, which is a substantial disincentive to pursuing alternative transfers.

2.4.2 Risk and Uncertainty

In addition to the perception of excessive complexity and high transactional costs, M&I users and agricultural water users alike report concerns about the risks associated with an alternative transfers. For agricultural water users, recent Colorado Supreme Court and Division 1 Water Court decisions curtailing the use of senior water rights based on detailed analyses of what the courts identified as "lawful" versus "unlawful" historical use have created a perception that there are substantial risks associated with any process that seeks to quantify a senior right based upon historical use. Few water rights owners are willing to risk the value of their water rights in a permanent change in use process; to do so in the context of a temporary change is even more unlikely because of the real potential that the water rights at issue will be limited or prevented from returning to irrigation uses.

M&I users and agricultural water users are concerned about the novel nature of the alternative transfer concept. The level of scrutiny applied to proposed changes in use in Division 1 and resulting, burdensome decree terms and conditions have increased exponentially in the last 15 years. Would-be alternative transfer participants express a real concern that an alternative transfer arrangement, particularly a reduced consumptive use cropping or deficit irrigation scheme, would encounter such resistance that it would either fail entirely or be approved with terms so onerous as to effectively cancel any benefit. This uncertainty is a major factor preventing increased use of alternative transfer arrangements.

2.4.3 Lack of Delivery Capability

M&I users expressed a concern over the relatively little attention paid in the alternative transfer studies to date addressing the means by which water freed from downstream water users for M&I uses could be delivered to Metro-area providers. While some M&I users might be interested in alternative transfer arrangements, at least on an experimental scale, the lack of effective delivery mechanisms prevents meaningful discussions with downstream users.

2.4.4 Need for Permanent Supply/Reluctance to Commit

M&I users universally express a preference for permanent supplies when available and affordable. In the context of proposed alternative transfers, this translates into a desire for longer term leases of 20 or more years. Conversely, agricultural water users are reluctant to enter into long term arrangements, preferring the flexibility of shorter term deals in what they perceive to be an environment of rapidly escalating water values and economic volatility in the farm sector. This tension is a barrier to increased alternative transfer activity.

2.4.5 Power Imbalance

M&I users typically have access to greater resources, including expert legal and technical advice, than agricultural water users. This disparity in the relative amount of information relevant to the proposed transaction can result in a perceived power imbalance in which agricultural water users, aware that their counterparts have access to more information, are reticent to engage in frank discussions and tend to stake out positions chosen for their relative safety, as opposed to their potential to facilitate a deal. In many cases, this reticence is expressed as a mistrust of M&I users generally. Though it is difficult to generalize, the Project Team concludes that this perceived power imbalance between the parties is both common and significant enough to merit discussion.

2.5 Overcoming Barriers: Characteristics of Solutions

With an understanding of the barriers contributing to Colorado's relatively low rate of success of alternative transfer implementation, the Project Team began brainstorm viable alternatives that could address the identified barriers. As an initial step, the Project Team identified the general characteristics of a solution that would address each barrier. The Project Team determined that solutions should have the following characteristics:

2.5.1 Reduce Transaction Cost

An ideal solution would lower the transactional cost of a proposed alternative transfer so that it is significantly less than a permanent "buy and dry" alternative. Though there are potential solutions to this issue that involve proposed revisions to existing statutes and policy, the Project Team chose to work principally within the boundaries of existing law and policy in brainstorming solutions for this project.

2.5.2 Reduce Risk and Uncertainty

An ideal solution would provide a means for reducing the risk and uncertainty to the individual parties engaging in the transaction. Again, though there may be ways to address this issue with proposed changes to law and policy, the Project Team chose to remain focused on existing legal mechanisms.

2.5.3 Consider Means of Delivery

Solutions must not only provide a framework for viable alternative transfers at the location of the transfer, but must also consider issues related to delivery to the M&I user. As a result, specific facts related to the relative locations of the agricultural water user and the M&I user and intervening infrastructure are necessary considerations in alternative transfers.

2.5.4 Balance M&I Need for Permanence with Ag User Need for Flexibility

Ideal solutions should present a framework that addresses M&I users' need for permanence and agricultural water users' desire for flexibility, This could be accomplished by providing a mix of temporary and permanent elements, or by establishing compensation in other portions of the proposed framework in the event the M&I user sacrifices permanence or the agricultural water user gives up flexibility.

2.5.5 Address Power Imbalance

Ideal solutions would eliminate any perceived imbalance of power. Education and collective organizations both have the potential to close this gap. Solutions should include a framework to encourage meaningful dialogue and to establish long term, beneficial relationships between M&I users and agricultural communities.

2.6 Solutions: Five Concepts

2.6.1 Education and Decision Making Support

Water rights transactions are complex. M&I users typically have substantial resources at their disposal -- attorneys, hydrologists, and other water professionals – to assist them in understanding and facilitating transactions. Larger M&I users have full time staff whose sole job is to develop and manage water supplies. In contrast, agricultural producers are engaged in the business of farming and ranching and employ these professionals only on an "as needed" basis to protect or secure needed water supplies. Faced with a potential alternative water transfer, an agricultural producer is likely to have a difficult time assessing the potential risks and benefits associated with the transfer without costly legal and engineering advice. Agricultural producers are aware of these complexities, and the need for professional assistance, but at the same time reticent to invest in professional advice absent some assurance that the proposed transfer is technically and financially viable. In this environment, many transfers go unexplored. Though an opportunity may be missed, the agricultural producer, like any business person, is acutely aware of value of his or her time and reluctant to participate in discussions that do not have a perceived likelihood of resulting in net positive income.

In the complex environment of water transfers, the agricultural producer needs a time-effective way to assess alternative transfer proposals – an ability to separate the "wheat from the chaff" and determine whether a given proposal is likely to lead to positive results and is therefore worth exploring in greater detail.

The Project Team suggests that there are two ways that the CWCB can assist agricultural producers in this area. First, it is important to continue to produce quality, accessible educational materials that provide a background for assessing water transfers. This material should not be in the form of technical treatises, nor should it be so simplified and abbreviated to be devoid of merit. Rather, it should describe all of the key concepts related to water transfers using language and methods accessible to the lay person. Further, it should be widely disseminated in a variety of media formats – print, internet, video, and live presentations. If alternative transfers are to gain wider acceptance in the agricultural community, it is imperative that educational efforts are sustained and substantial. The Project Team offers its Guidance Document, described in Section 3.2 herein, as its contribution to this body of material.

In addition to a sustained effort to provide relevant and accessible general information to agricultural water users, the Project Team concluded that there is also a need for decision making support designed to help agricultural producers asses the economic aspects of specific proposed transactions. For an agricultural producer interested in an alternative transfer, the critical economic question is one of opportunity cost. Every acre foot of water destined for M&I or environmental uses is one less acre foot that can be used for crop production. For a temporary transfer to make economic sense, the compensation received from the M&I provider must exceed the value lost by ceasing or reducing irrigation.

Like any other business enterprise, there are a fixed number of economic inputs that go into crop production, each with an incremental cost. Similarly, at any given time, there is a price at which the crops produced may be sold. Agricultural producers are already acutely aware of input costs and commodity prices, and are regularly engaged in decisions about inputs and crop selection intended to maximize financial gain. As such, it is not difficult to imagine that these same producers would make use of a decision support tool that forecasts financial outcomes given varying combinations of inputs, including greater or lesser water supply. The AgLET Tool, described in Section 3.1, is designed to be used by agricultural water users for this purpose.

2.6.2 Technical Analysis of Delivery Potential

Without variation, the M&I users said that the inability to deliver water to their intake facilities is a principal hindrance to alternative transfers. In the South Platte River, the largest M&I users are located in the Denver Metro area while the basin's principal irrigated areas, served by the most reliable water rights, are downstream. Regardless of how innovative alternative methods of transfer become, they are simply not a viable alternative to most Metro M&I users due to lack of delivery capability. Many M&I users are in the process of constructing facilities downstream of the Denver Metro area – gravel pits and in-situ storage - that are designed to serve the dual purpose of capturing re-usable transbasin supplies and storing purchased downstream agricultural water rights. However, to date, these systems extend only a short distance north of the Metro area, and can take deliveries from only a small fraction of the agricultural area served in the South Platte River basin. Large expanses of irrigated agricultural areas, served by reliable senior water rights, remain essentially inaccessible to Metro M&I users, effectively eliminating the potential for transfers of any kind. In particular, Districts 1 and 64, downstream of Greeley, have tremendous potential for alternative transfer partnerships but remain inaccessible because of a lack of a means of delivery.

No large scale alternative market can be developed until a means of delivery exists. The State's current budget crisis hinders State funded design and installation of pipelines and related large scale delivery mechanisms that would ideal for creating large scale alternative transfer markets. However, the potential exists to deliver water upstream using "exchanges." Under the right conditions, it is possible for a downstream right to deliver water to the stream and for an upstream right to divert an equivalent amount of water, effectively completing a "delivery" of water from the downstream right. Because exchanges are hampered by "dry-up points" in the river, it may be possible to design and install infrastructure that increases flows at critical points, thereby improving the reliability of exchange mechanisms. Though exchanges are less reliable than a pipeline because of their sensitivity to river flow and call conditions, they nevertheless represent an avenue the Project Team feels has not been adequately explored to date. The Exchange Analysis set forth in Section 4.1 is the Project Team's assessment of the potential for exchange in the South Platte River. Portions of the exchange analysis were further developed and applied in the PVIC Augmentation Group/Aurora Water (the Flex Water Market), the Lower South Platte Water Cooperative (Marketing

Framework), and the DT Ranch/Town of Wiggins (Interruptible Water Supply Agreement) demonstration project analyses.

2.6.3 Joint Ownership

M&I users interviewed by the Project Team frequently commented that they were reluctant to invest in transfers involving alternative methods because of the temporary nature of the deliveries. Colorado transactional costs are high for both permanent and temporary transfers, and most M&I users interviewed perceived no substantial difference in the amount of transaction costs for a temporary or a permanent transfer. Given the fact that there is no perceived "break" in transaction costs for temporary transfers under Colorado's current legal and administrative system, M&I users expressed a consistent sentiment that it was more desirable for them to acquire permanent supplies than to spend time on alternative methods. In addition, though the Project Team discovered some need for temporary "drought" supplies - to refill reservoirs, for example – the majority of M&I users stated that their intent was to build permanent water supplies. They did not have a great of interest in investing large amounts of capital in water supplies that were not guaranteed on a permanent basis. In short, given the current administrative and legal environment, most M&I users would rather own their water than lease it.

2.6.3.1 The Flex Water Market

In an effort to address this barrier, the Project Team began to brainstorm methods by which an M&I User could obtain a permanent "stake" in an agricultural water right that would justify the initial investment in infrastructure and transaction costs, lay a foundation for a long term partnership involving alternative transfer methods, and create conditions under which ditch systems could continue to be viable and productive agricultural areas. The results of the Project Team's work to date is the "Flex Water Market" or "Flex Market."

The Flex Market concept combines elements of long term rotational fallowing, reduced consumptive use, purchase, leasing and interruptible supply. The Flex Market is a water court approved contractual relationship between one or more M&I users and one or more agricultural suppliers. The agricultural user provides two types of water to the M&I user, referred to as "Base Consumptive Use" (Base CU) and "Flex Consumptive Use" (Flex CU). Base CU is a small portion of the CU associated with the agricultural user's shares (10 percent is a suggested number) that is permanently sold to the M&I user. Flex CU is the remaining 90 percent of the CU, which remains titled in the agricultural user, and can be leased to the M&I user on terms agreed upon between the agricultural user and the M&I user. These leases could be for short terms, longer terms or interruptible supply.

The agricultural user manages his or her land through rotational fallowing or reduced CU to produce the Base and Flex CU for the M&I user each year. Recharge sites, installed in cooperation with Ducks Unlimited, meet conservation goals and serve as vehicles for the delivery of CU and return flows.

The Flex CU can be sold by the agricultural user at any time, whether to the M&I partner or to another water user, subject to a right of first refusal for the M&I user partner. The agricultural user and M&I user cooperate in a Water Court application to seek approval of a change in use of 100 percent of the agricultural user's water, to establish terms under which the delivery "Base" and "Flex" CU will be administered. The program is intended to establish a mutually beneficial partnership between the M&I user and agricultural user that supplies additional water for M&I needs while creating conditions conducive to maintaining a healthy agricultural economy under the ditch.

2.6.3.2 Sample Flex Contract Terms

The Flex Market is driven by the contract entered into between the parties. The following provides a summary of the primary obligations and responsibilities of the three parties, in this example, a shareholder under a ditch company, an M&I User, and Ducks Unlimited. Ideally, once developed, the terms of the "Flex" contract would become relatively standard, so that a similar form could be used across a wide variety of situations. Phase 2 of the Flex Market study, funded by the CWCB in 2011, is focused on developing these standardized terms (see Section 6.1 for more detail).

Agricultural Producer

In this example, the agricultural producer involved is an owner of shares in a mutual ditch company with a headgate located downstream of the Denver Metro area in a predominately rural area. The agricultural producer owns and farms lands served by the mutual ditch. In addition, the lands owned by the agricultural producer have one or more viable locations for recharge site/wetland facilities.

The agricultural producer would permanently sell a portion of the consumptive use associated with his or her water right to the M&I user. This permanent portion of the transfer is referred to as the "Base CU" in the model. For illustration purposes, the Project Team suggested 10 percent of the total CU associated with the shares. The agricultural user would retain title to the shares, subject to an encumbrance on the face of the share certificate in favor of the M&I user.

In addition to the base CU, the agricultural producer would establish a contractual relationship with the M&I user allowing the lease of the remaining 90 percent of the CU associated with shares on a temporary basis. The terms of any temporary transfer would be negotiated at a future date. The 90 percent of the CU available for future leases is referred to as the "Flex CU."

Each year, the agricultural producer would manage his or her land and water rights to deliver the Base CU and any agreed upon Flex CU at a location specified in the contract, either by fallowing, or as alternative methods of reduced consumptive use become more established, deficit irrigation or the cultivation of reduced CU crops. Deliveries of water to the M&I user could be by direct bypass of the shares to the river, or via recharge accretions. In addition, the agricultural producer would meet all return flow obligations associated with the shares, either by direct delivery to the river or by placing the return flow component of the shares into recharge sites constructed on the agricultural producer's land. The cost and responsibility for installation of necessary structures and improvements would be shared according to the terms of the agreement.

Assuming a recharge site is a part of the plan, the agricultural user could negotiate a conservation easement with Ducks Unlimited. In exchange, Ducks Unlimited may be able to help the agricultural user secure available funding to offset the cost of the site.

In order to achieve administrative and legal approval of the change in use, the agricultural producer would agree to participate in and support an application to Water Court to change the use of the shares to include the M&I user's beneficial uses. In addition, the agricultural user would agree to support an application for approval of interruptible water supply agreement, if desired by the M&I user prior to the Water Court application, and substitute water supply plan applications during the pendency of the Water Court proceeding. The cost of these proceedings would be shared by the parties as determined in the Flex contract.

The Water Court case would adjudicate a change in use permitting the use of the shares for the existing irrigation use as well as the new M&I uses, and set terms and conditions governing the administration of the plan and the delivery of Base CU and Flex CU to the M&I user. In addition, the case would adjudicate the recharge site or sites on the agricultural producer's land, and any exchange desired to facilitate delivery of the CU upstream.

The contract would contain an "exit" clause for the agricultural producer, allowing the sale of the water rights to a third party outside the contract, subject to a right of first refusal in favor of the M&I partner. Any sale of the shares to a third party would recognize the M&I partner's ownership of and continued delivery of the CU.

Municipal and Industrial User

For this example, the M&I user considered is a Denver Metro water provider with the ability to take delivery of supplies by exchange at a point upstream of the mutual ditch headgate that diverts water for delivery to the agricultural producer. While the Project Team focused on Denver Metro water providers for the purposes of this project, the Flex Market concept is general enough that it could include any M&I water provider in the State.

The M&I user would agree to purchase the Base CU amount, and could negotiate additional Flex leases. It would be the primary applicant in the Water Court case, though the cost of the case may be shared under the terms of the contract. The M&I user may share in the cost of installing infrastructure and improvements necessary to implement the change in use. To address efficiency of scale concerns, the contract could be contingent upon assembly of a sufficient number of shares in a specific ditch system to warrant the change in use application. If the target number of shares were not obtained, the contract could operate as an interruptible water supply agreement and terminate upon a date certain.

Environmental User

The environmental user considered in this example is Ducks Unlimited, a study sponsor. DU cooperates with agricultural producers to fund and install wetland environments that serve the dual purpose of aquifer recharge and habitat creation and conservation.

Ducks Unlimited would pay the agricultural user for the conservation easement, and may fund or help secure funding for the construction of the recharge site and associated wildlife habitat. The terms of the contract may include provisions designed to maximize the beneficial use of the site for conservation and wildlife purposes. DU would also be a co-applicant in the Water Court case, where it could seek approval for use of Base or Flex CU for wildlife purposes. DU could be entitled to lease Flex CU under the contract for delivery to the river and subsequently to other sites adjudicated for wildlife purposes.

2.6.3.3 Additional Flex Market Features

Growth and Development

The purpose of the proposed structure is to facilitate a "private" water market between agricultural water users and specified M&I users. Colorado's Water Court adjudication process requires the court to individually examine every water right to be changed, as well as every proposed new use. In addition, any party that desires to use the water right must be named in the change case. As a result, the process prevents the creation of large, public water markets that permit leasing from agricultural users to M&I users at large; however, smaller private "Water Court approved" markets could be adjudicated. The sellers in the private market are agricultural water users who have sold a small amount of CU to an M&I user (likened to an entrance fee). Buyers are M&I users who have purchased the CU (their entrance fee), and thereby gained access to the agricultural water user's overall supply via the Flex CU concept.

A "private" market established via contract and Water Court adjudication could be as small as one agricultural water user and one M&I user. It also has the potential to expand and involve multiple agricultural water users and multiple M&I users. Each time a new contract or set of contracts go to

Water Court, it would be possible to "grandfather in" all previous adjudications, so that any agricultural water user in the private market could sell Flex CU to any M&I user in the same "Water Court approved" market. It may also be possible to get a Water Court decree that has a process for adding agricultural water users and M&I users under retained jurisdiction. In such a scenario, agricultural water users would provide the Base CU amount to the M&I user that bought it, but could play the broader market and lease the Flex CU to the highest bidder.

The contracts between the agricultural water users and the M&I users would themselves lay the foundation for future growth. Two types of contracts are envisioned, a "Base-Flex" contract and a "Flex" contract. The Base-Flex contracts function as independent private markets between one buyer and one seller. The Flex contracts are the glue that binds the Base-Flex contracts into larger private markets. The example below illustrates this concept.

Upon the initial sale of 10 percent CU to the M&I user, Ag User A and M&I User 1 would enter into a "Base-Flex" contract that committed the Base CU to M&I User 1 and contemplated future lease of Flex CU to M&I User 1. M&I User 1 could agree to allow Ag User A to lease Flex CU to other water users, on the condition that other users contractually join the private market, and that M&I User 1 is given a right of first refusal on the leases. The Base-Flex contract could further provide that M&I User 1 could lease its Base CU to other M&I users on the condition that they contractually join the Flex Market. With this Base-Flex contract in hand, Ag User A and M&I User 1 would seek a Water Court decree.

When Ag User B and M&I User 2 join the market, they would execute a Base-Flex contract governing the relationship between them. In addition, M&I User 2 could enter into a "Flex" contract with Ag User A that contemplates potential leases between Ag User A and M&I User 2. Similarly, Ag User B could enter into a Flex Contract with M&I User 1. Finally, M&I User 1 and M&I User 2 could enter into a Flex contract of their own contemplating potential leases of Base CU amount between them. In this way, all of the parties are related by contract in a way sufficient to complete the second adjudication.

If framed properly, the CU amount determined in first Water Court adjudication would be protected by principles of issue preclusion, thereby preventing re-litigation of Ag User A CU determinations made in Water Court application number one. The only function of Water Court adjudication number two as to Ag User A is to add M&I User 2 as a potential user of the already determined CU.

The extent of the market is controlled by the contracting parties at every stage. No Flex contracts are mandated. Once an agricultural water user enters the market by the sale of 10 percent CU to an M&I user, the number of parties that an agricultural water user could lease to would be measured by the number of Flex contracts he or she had with M&I users. The core of the model is the independent Base-Flex contract. Base-Flex contracts could be joined in various ways by Flex contracts to create larger private markets. The addition of one or more Flex contracts would be the triggering event requiring an updating Water Court adjudication.

Since the markets form by voluntary association, it is possible that several markets could exist under the same ditch system, depending upon the needs and negotiations of the parties. It is also possible that these independently existing markets could join together at a later date.

Since each change of use is adjudicated separately and subject to its own terms and conditions, the proposed model could operate in a single ditch system or across a number of systems, on a parcel specific or ditch wide basis. However, transaction and administration costs would be the lowest if the market was based on a single ditch system that had been the subject of a ditch wide change in use case. The ditch wide adjudication would simplify successive adjudications of new users joining the group by providing an established standard for CU, return flows, and administrative terms.

Each private market would operate under the terms and conditions set forth in its Water Court decree. These terms and conditions are likely to include annual reporting of Flex leases, dry up acreages and fallowing provisions, revegetation, etc.

If Flex Markets increase in size substantially, it is possible that a “manager” could be interposed to perform some or all of the agricultural water users’ duties under the contracts and decree and manage deliveries to third parties. This managing entity could be the ditch company, a private user group (formed as a limited liability corporation, a cooperative, or a corporation) or a hired third party.

The use of a standardized contract, pre-negotiated with the ditch company or a user group, is intended to the level the playing field and allow M&I users to accumulate multiple contracts in the same ditch system, thereby reducing overall transactional costs to the agricultural water user and the M&I user alike.

Risk Management

For the M&I user initiating the process, risks can be kept low by including a contract condition that requires a specific number of contracts under a ditch system before the Water Court process is initiated. If the M&I user fails to assemble a sufficient number of contracts, the contract for sale converts to a lease, no final payment is made, and the deal expires under its terms. The M&I user has the benefit of the IWSA potential during the “assembly” period, but is not required to purchase the water and change the use if a viable Water Court case does not develop. For a low entrance fee, the M&I user can gain access to Flex CU in the dedicated market.

The “Exit Clause” is important to agricultural water users, who are reluctant to commit to a sale or lease for fear of losing flexibility. Should the agricultural water user decide to sell the farm and water and retire, he or she may do so, subject only to the requirement that the 10 percent CU amount sold to M&I user stays with the M&I user in the form of shares issued to the M&I user, and Base CU dry-up requirements are maintained. For 10 percent of his or her CU, the agricultural water user can join the Flex Market, participate by leasing Flex CU, and then retire from the market with a sale. The M&I user is given a right to first refusal because the shares are adjudicated for the M&I user’s beneficial uses, making the M&I user the natural buyer. This term also serves as an incentive to the M&I user to enter the market.

Promoting Alternative Agricultural Transfers

The proposed concept supports alternatives to traditional buy and dry because it encourages rotational fallowing, reduced CU, and ongoing agricultural production on participating farms. The ability for agricultural water users to enter the market with a nominal sale of CU (10 percent) and remain farming may open up CU for M&I users on farms that are not interested in a traditional buy and dry. The “Flex CU” concept is intended to create a marketplace where agricultural water users are managing working farms to deliver “water as cash crop” while maintaining the bulk of agricultural production.

2.6.4 Collective Organizations

Many agricultural producers expressed a reluctance to consider alternative transfer methods as individuals because of the complexity of water transactions, the high cost of legal and technical advice, and the difficulty of administrative and Water Court processes necessary to implement a transfer. Some M&I users expressed a reluctance to enter into contracts with individual agricultural producers for the similar reasons. For the costs of a transaction to be justified, M&I users tend to be interested in larger blocks of water, which can only be obtained by working with numerous individual owners. At the same time, M&I users are reticent to attempt negotiations with large numbers of individual users because of the time and complexity involved.

Under these conditions, a collective entity representing agricultural producers could be an effective way to further alternative agricultural transfers. A properly organized entity with broad support in the agricultural community could address a number of the identified barriers to increased alternative transfer activity. Presumably, such an entity would be able to assemble larger blocks of water, consistent with M&I user's express desire to achieve efficiencies in scale. If the collective agricultural entity was broad enough in scope, covering large reaches of the South Platte River, reliability of delivery could be improved through diversification of the individual water rights composing the leased water "block." In addition, agricultural water users participating the collective entity may be willing to allow the entity to use existing ditches, reservoirs and recharge facilities to manage and deliver the agreed upon supplies. The ability for M&I users to negotiate with a single entity, as opposed to numerous individual users, could significantly reduce transactional costs and simplify the transaction. From the agricultural water users' perspective, a larger collective entity would provide a means to share the costs and risks of water transfers, significantly reducing each individual's exposure. In addition, a larger collective entity's standing and ability to secure quality legal counsel and technical advice could help balance the perceived power imbalance between M&I users and individual agricultural water users.

The proposed "Lower South Platte Water Cooperative" described in Section 5.2 of the report is a grass roots collective entity meeting many of the above described parameters.

2.6.5 Local Partnerships

In many cases, smaller local water providers face unique challenges (see SWSI findings). Lacking the funding and staffing of larger M&I users, these entities can find it difficult to negotiate the fiscal, legal, technical and infrastructure challenges inherent in meeting growing demand for treated water supply. Though the amounts smaller providers need to secure are not large in relative terms, they do not have the ability, acting alone, to install infrastructure to deliver supplies over significant distances. As a result, the projects favored by these local providers tend to fall into two categories—either participation in a larger project with a number of other smaller to mid-sized entities or pursuing local supplies, generally the senior right or rights in close proximity to the provider.

The Project Team's interaction with smaller to mid-sized M&I providers indicates that there is significant potential for increasing the number of alternative transfers between these entities and local agricultural water users. There is a common perception that larger, Metro M&I users will "lead the way" in the alternative transfer arena. This perception may be well founded, in the sense that larger M&I providers have the means and economic incentives to endure the high transactional costs likely to come with the initial round of proposed alternative transfers. At the same time, the geographical distance between the agricultural providers and these M&I users and the large amounts of water needed by Metro M&I users increase the complexity of legal and technical issues surrounding these transfers and provide resistance to their implementation.

In contrast, an alternative transfer arrangement between a smaller, local water provider on the South Platte River and a nearby agricultural water rights user or group of users appears relatively straightforward. The fact that the local M&I user does not need to assemble large amounts of water makes a transfer with a single water rights user viable, reducing the need for an intervening collective entity and associated complexities of organization and management. The transfer is likely to be of single water right (a ditch share or shares) used historically on a single farm, dramatically reducing the legal and technical complexity of the proposed transfer, as well as the monitoring and reporting needs. The established relationship between the local M&I provider and local residents provides a foundation to build cooperative arrangements, in contrast to the perceived resistance to accepting Metro M&I user "outsiders" often encountered in efforts to build cooperative arrangements with distant Metro municipalities. Ironically, these smaller transfers between small to mid-sized M&I providers on the South Platte River and local ditch and reservoir companies may prove to be the best testing ground for alternative transfer ideas.

The "DT Ranch/Town of Wiggins" Demonstration described in Section 5.3 project is a specific example of an alternative transfer agreement between an individual agricultural water user and a smaller M&I provider.

Section 3

Tools for Agricultural Producers

One objective of this project was to develop tools that agricultural producers can use to evaluate alternative transfers. This objective was reinforced during the project as the Project Team discussed potential barriers to alternative transfers from an agricultural producer's perspective.

If an agricultural producer is to commit part of his or her water, perhaps the farm's most valuable asset, to an alternative transfer, the producer needs to be confident that the commitment will be financially advantageous. Alternative transfers may seem overly complicated and possibly intimidating without a full understanding of the financial implications and legal, engineering, and administrative considerations in implementing the transfer.

Two tools were developed to help agricultural producers understand the business risks and considerations of conducting alternative transfers. One is a spreadsheet-based financial analysis tool that allows producers to examine the economic implications of a potential transfer on his or her own operation and to independently determine terms that would make the transfer beneficial. The other is a set of guidelines that a producer can use to understand the necessary steps for implementing a transfer. Both of these tools are described in this section.

3.1 Economic Evaluation Tool

The Agricultural Water Lease Evaluation Tool (AgLET) was developed by Harvey Economics with input from Dr. James Pritchett and the Project Team. The tool is a spreadsheet-based application that will help agricultural producers evaluate the financial feasibility of alternative agricultural water transfers. The farmer or ditch system manager enters information about their particular operation into AgLET, and AgLET then calculates the potential financial returns of the proposed transfer. The tool requires information on farming operations such as acres planted, crop types, water application, yields, input costs, and details on potential water transfers. The tool uses the input provided by the agricultural producer to provide two financial summaries – one reflecting current operations and one that includes an alternative transfer.

3.1.1 Development Considerations

During the development of AgLET, several user-based issues were considered:

- **Software:** Microsoft Excel was chosen as the software platform for AgLET. Excel is widely used in the agricultural community so familiarity with those spreadsheet functions will facilitate understanding and acceptance. Furthermore, it was cost-effective to use Excel, relative to developing custom software.
- **User-friendliness:** The Project Team wanted to develop a tool that agricultural producers can use without reading and studying a lengthy user manual. The AgLET tool includes a module that provides concise instructions and input examples, allowing the user to effectively use the tool in short order. Throughout the various data input sheets, pop-up comments were included to help

explain the types of information needed by AgLET. The tool is intended for introduction and full use in a four hour period, assuming the data about the farming operation is at hand.

- **Complexity of Inputs**: The Project Team was very concerned with the extent and complexity of inputs and the potential time required to compile and enter data. Extensive or complicated input requirements might discourage acceptance of the tool, but conversely, overly simplified inputs could produce financial summaries that are neither relevant nor applicable to the agricultural producer's farming operation. The Project Team therefore developed AgLET in a way that requires users to enter a minimum of water use, financial and operational data by giving users the option of relying on default, county-based data for many inputs. Almost all the default data is customizable if the user wants a more accurate analysis of his operation. As a result, AgLET provides a high degree of flexibility to the user in their ability to tailor the tool to meet their expectations and needs.
- **Variable cost focus.** AgLET primarily accounts for the variable aspects of farming. Agricultural methods, water supplies, efficiencies, water costs, crop types, prices and expenses are all recognized as variables in AgLET and subject to change. As a result, AgLET accommodates the fact that these variables are unique to each farm and that they vary over time. Fixed costs are addressed after the variable outcome or gross margin have been determined.
- **Testing the Tool**: Potential AgLET users such as members of the CCGA board were consulted on potential inputs and features that would make AgLET a more valuable and user-friendly tool. Also, the diverse Project Team offered several suggestions throughout the project. In addition, a farm manager associated with the DT Ranch undertook a full utilization of AgLET tool in association with the DT Ranch/Town of Wiggins demonstration project described later in this report. Finally, two meetings were held, one with Colorado agricultural extension agents and one with irrigation organizations to introduce the tool and gain additional feedback. The feedback during these introduction and training sessions was very valuable in refining AgLET.

3.1.2 Overview of AgLET Features

The following paragraphs briefly describe AgLET's primary features, input requirements, and output.

- **General Farm Information.** Users first input the county in which their irrigated farm(s) are located, because much of the default information in AgLET is county-based. General farm information requirements include tillable acres, acres of different crops planted, water applied, irrigation methods and efficiency, water use data, yields, commodity prices, production expenses by activity, and ditch assessments. Much of this information can be based on default data, but AgLET allows users to input their own data for all of these categories if desired.
- **Information on Alternative Transfers.** Three alternative transfer methods are currently reflected in AgLET – rotational fallowing (referred to as "water leases" in AgLET), interruptible supply, and deficit irrigation. Data inputs describing potential alternative transfers include lease rates (in dollars per acre), area of land enrolled in the transfer, and the amount of land to remain in irrigation during the transfer. Based on farm and water lease inputs, AgLET estimates impacts to yields, production costs, and revenues during the term of the alterative transfer. Combinations of alternative transfer methods could potentially be evaluated with AgLET with assistance from the developers or entities such as Colorado State University Extension.
- **Financial Summary.** The "bottom line" of AgLET is in the financial summary table, which displays gross margins under current and proposed conditions, break even gross margins, and revenues from the alternative transfer. The user can also input fixed expenses such as debt service, property taxes, and living expenses in order to determine if he can meet both fixed and variable

expenses with the alternative transfer program. A risk analysis allows the user to evaluate the financial outcome of a potential alternative transfer if yields and/or crop prices increase or decrease. If the transfer does not appear favorable, the agricultural producer can go back and change the transfer terms until the deal is sufficiently attractive to proceed.

- **Default Data for Counties in the South Platte River Basin.** AgLET's database currently includes default data only for counties in the South Platte River basin. In the interest of having a statewide tool and broadening its support, the Project Team recommends that AgLET be updated to include default data for more counties in the future.
- **Other features.** AgLET is also a useful farm analytical tool – even without considering alternative water transfers. A grower can vary crop types, water application amounts and methods, operational expenses and other factors and immediately see the financial implications. The sensitivity of farming variables on financial outcomes might be of considerable use to Colorado farmers.

3.1.3 Training in AgLET

The Project Team's vision for AgLET training reflects these principles:

- Group training is expected to engage users more effectively than self-training using available documentation.
- It is likely that some agricultural producers will want support in using AgLET, preferably from local organization or agency.
- Expert advice should be available to users when AgLET is rolled out to the general public.
- Colorado State University Extension is an ideal candidate to serve as long term host for AgLET and to provide long term maintenance.

The above factors were considered when targeting groups who should receive initial training in AgLET. The Project Team felt that it was important to train those who will provide support to end users in the future. It is also important publicize AgLET and to establish familiarity with AgLET among potential users of the tool.

The Project Team facilitated three training sessions in the use of the AgLET tool. The training sessions provided information on input requirements, calculation processes, and the results of AgLET evaluations. Two of those training sessions targeted organizations and people who would eventually provide support to end users. The third session targeted end users. Descriptions of the training sessions are provided below:

- **Session 1 - CSU Extension**: On September 27, 2010 the Project Team held an AgLET training session on the CSU campus, for CSU Extension personnel. This group was targeted because, ideally, the CSU Extension Office will eventually house and maintain AgLET. In addition, it is anticipated that CSU Extension staff will have opportunities to promote and provide additional training in AgLET. The training session included a description of AgLET as well as opportunities to use AgLET in example evaluations of alternative transfers.
- **Session 2 – End users**: An opportunity to publicize and describe AgLET to end users occurred during the Ag Classic conference on December 10, 2010 in Loveland, Colorado. Mr. Ed Harvey (Harvey Economics) and Dr. James Pritchett (CSU Extension) provided background on AgLET, described AgLET input requirements and output, and gave an overview of how AgLET could benefit an agricultural producer interested in alternative transfers.
- **Session 3 – Water Conservancy Districts and Ditch Companies**: The Project Team anticipates that agricultural producers may seek AgLET support from their water conservancy districts and

ditch companies. Individuals from water conservancy districts and ditch companies were invited to the third training session, which was held on March 25, 2011 in the CCGA conference room. The training session included a description of AgLET as well as opportunities to use AgLET in example evaluations of alternative transfers.

3.1.4 Future Improvements for AgLET

This tool holds considerable promise but it faces challenges to widespread implementation:

- **Increasing AgLET utility.** Farmers may, understandably, be reluctant to use a new tool extensively. Unless a transfer is imminent, it might be difficult to convince farmer to use and experiment with AgLET. Efforts to provide exposure to AgLET in the agricultural community and to promote its usefulness as a farm analytical tool may mitigate this reluctance.
- **Refinement of the default variables.** The tool currently represents a farm's operations reasonably well, but greater precision and flexibility will help with its accuracy. Field tests and case studies will help satisfy this need. However, every agricultural operation is unique and a single model cannot capture all the differences among operations.
- **Increasing user friendliness.** Spreadsheet models can be intimidating to some people. A more simple question/answer-based data input process may help some users overcome their intimidation. However, until AgLET is exposed to a wide variety of users, the model developers do not know if a revised data input process would be beneficial.
- **Geographic expansion.** AgLET can be applied anywhere in Colorado if the underlying data is modified and if certain functionality is altered to meet particular river basin conditions. In fact, the Project Team has received inquiries about adapting AgLET for other basins. The Project Team recommends that the CWCB pursue this as a way to provide agricultural water users in other basins with tools that they can use to evaluate alternative water transfers.

3.2 Guidelines Document

The Project Team created a document to provide user-friendly guidelines to help interested parties understand steps involved and economic potential of alternative transfers. The objective of the document is to lessen producers' "knowledge gaps"; which contribute to real or perceived power imbalances and have a chilling effect on alternative transfers. A copy of the guidelines has been included in Appendix A.

As the Project Team developed the document, it became clear that rotational fallowing and interruptible supply are the two methods that are currently most acceptable from a legal and administrative perspective. As a result, the document addresses these methods specifically. Other methods are referenced, but the document does not contain guidelines on them.

The Project Team discussed the following considerations, which impacted the scope and size of the document.

- The document should be short enough to hold the reader's interest.
- Complicated technical and legal language should be avoided so that the document is easily consumable by a broad range of readers.
- The document should focus on the alternative transfer methods that agricultural producers can currently use. As a result, the Project Team only referenced methods such as deficit irrigation and alternative cropping in the manual and did not provide detailed guidance on these methods.

- The document will need to be updated in the future as other methods of transfer are researched, developed, and considered in Water Court.
- The document will be updated, promoted, and distributed by CSU Extension and/or the Colorado Corn Growers Association.

3.3 Long Term Maintenance of AgLET and Guidelines

Because the Project Team's efforts on AgLET and the guidelines lasted only for the duration of the project grant, concerns were raised regarding the long term viability of these tools:

- How should these tools be "rolled out" to the public so that they are used and not put on a shelf?
- How will these tools be maintained and updated in the long term?
- How will user support be provided in the long term?

The Project Team, working in conjunction with CSU Extension, developed the following vision for these tools after the conclusion of this project.

3.3.1 Mid-term Vision

Over the year after the conclusion of the grant project, CSU Extension staff will conduct educational workshops on the tools or incorporate sessions on the tools into regularly held workshops such as:

- Extension winter workshops
- The water and fertility workshop
- Central Plains Irrigation Association conference

The purpose will be to publicize the tools and to provide training and information. Extension staff anticipate that specific user groups may request workshops as a result of presentations at larger workshops.

In addition, CSU Extension staff could be a resource to water conservancy districts or ditch companies who need help with the tools.

Some interest in the tools was generated among agricultural producers during the project. However, it is anticipated that during the "mid-term" phase, the tools will receive more publicity through discussions at the workshops described above. This publicity should serve to increase interest among agricultural producers.

3.3.2 Long-term Vision

Further training needs will be evaluated at the conclusion of mid-term activities. Ideally, the tools will be self explanatory, support needs for individual agricultural producers will prove minimal, and conservancy districts, ditch companies, or CSU Extension staff can provide the support required.

On a periodic basis into the future, CSU Extension staff will update the default data and other calculation processes in the AgLET tool. As changes in legislation occur or as new rules or regulations are promulgated, information in the guidelines document will need to be updated. Extension staff will update the tools and distribute them to the public through the internet and through regularly scheduled or special workshops. Additional funding would allow AgLET and the guidelines document to be converted to internet-based applications, which would eliminate the need to disseminate updated versions of the tools and would allow users to access the most up-to-date default data in AgLET.

Funding for long term maintenance and support of the tools is still an outstanding issue. The level of funding will depend on the level of support or maintenance that is needed. Potential funding sources include agricultural organizations, fees collected at training sessions, and fees for use of the tools.

Section 4

Technical Analyses

To investigate certain technical issues and help select demonstration projects with a high likelihood of success, the Project Team conducted several technical analyses, which are presented in this section.

The Project Team undertook three technical analyses of general application. First, the Project Team explored, on a survey level, the potential for delivering water in the South Platte River Basin via administrative exchange. This general exchange analysis is relevant to all three demonstration projects described in Section 5, and was applied to each as discussed in subsections under each demonstration project.

Second, incidental to other activities, the Project Team developed mapping products that may prove useful in furthering alternative transfer arrangements. This section presents the maps and describes the processes used to develop them.

Finally, the Project Team identified an interest in assessing the use of wetlands to help manage and deliver water freed for municipal and industrial use via alternative transfer methods. Each of the demonstration projects contemplates installing or using recharge facilities, which could function as intermittent wetlands. Section 4.3 describes generally the potential benefits of this strategy. The specific role and use of recharge sites in each demonstration is discussed in greater detail in Section 5.

The information derived from these analyses has been useful for the demonstration projects, and it is anticipated that it will be useful for other applications. For example, the exchange analysis described in Section 4.1 will be useful in future feasibility studies conducted for the Lower South Platte Water Cooperative. Maps described in Section 4.2 will be used by DU to assess strategic locations for future constructed wetlands.

4.1 Exchange Analysis

Exchange capacity can potentially impact the success of alternative transfers. The value of transferred water can be positively related to the ability to reliably deliver it by exchange. Accordingly, a producer interested in an alternative water transfer will have more success if he or she can demonstrate that water can be reliably exchanged to end users. For the Lower South Platte Water Cooperative (the "Co-op") project, the exchange analysis was especially important. In this demonstration project the analysis was used to estimate the potential for exchanging excess recharge credits from the lower portion of the South Platte River upstream to other users, such as municipalities or other agricultural users.

Exchange potential is based on two criteria:

- An exchange can only be conducted if there is no calling water right between the points of exchange. A calling water right would be injured if exchanged water were diverted without replacement upstream of the calling right.
- Exchange rate is limited to a flow rate less than or equal to the lowest flow rate in the exchange reach.

Two kinds of information were developed to analyze these two exchange criteria. First, the Project Team estimated daily flow at each headgate on the South Platte River between the Burlington Ditch and the Colorado/Nebraska state line for the study period. The flow data were developed using a point flow model of the South Platte River, which is described in Section 4.1.1. The second type of information developed was a daily analysis of calls along the South Platte River. The combination of flow and call data at each point is what determines the exchange capacity through that point.

The study period for the exchange capacity analysis was October 1999 through September 2008, or water years 2000 through 2008. This period includes a very dry period (2002 drought) as well as wetter years toward the end of the study period. Also, the recent study period reflects current administrative practices by the Division 1 Engineer with respect to exchanges, augmentation releases, and diversion patterns. The exchange capacity study assumes that, in using a time period with varying hydrologic conditions and current administrative practices, the results indicate what may be expected in the future.

The data sets described above were input into a spreadsheet for processing and analysis. This spreadsheet provided a framework that was used to evaluate exchange potential at 44 points along the South Platte River, from the Burlington Ditch to the state line. The analysis showed where there are “bottlenecks” to exchange, which are locations in the river where exchange may be difficult due to low flows or frequent calls.

4.1.1 Point Flow Analysis

The point flow analysis was used to estimate the flow available for exchange on a daily basis through numerous points along the South Platte River. As stated above analysis extended from just downstream of Denver (the Burlington headgate) to the South Platte River stream gage at Julesburg (just upstream of the state line), a reach of approximately 226 miles.

4.1.1.1 Methodology

There are 7 gages on the South Platte River in the study reach. Between these measured points, tributaries contribute to the river and ditches divert from the river. Besides these measured additions and subtractions to river flow, unmeasured gains and losses occur. Gains or losses may be attributed to unmeasured inflows and/or outflows between the stream and the surrounding alluvium; unmeasured inflows from irrigation return flows and recharge; unmeasured inflows from ephemeral streams; unmeasured direct contributions from precipitation events; consumptive use by riparian vegetation; and evaporation. Since exchange potential depends on the amount of physical flow throughout the study reach, all of these gains and losses need to be quantified and considered for numerous points between stream flow gages on the South Platte River.

A mass balance approach was used to estimate South Platte River losses and gains on a daily basis. Reaches were delineated based on the locations of South Platte River stream flow gages. Each reach was bounded on the upstream and downstream ends by a stream flow gage. The mass balance was applied to each reach by adding measured tributary inflows to the upstream gage reading, and subtracting diversions. The result of this calculation was compared to the measured flow at the downstream gage. If the calculated value was higher than the measured outflow from the reach, the river lost flow in that reach. Conversely the river gained flow in that reach if the calculated value was less than the measured outflow. The calculated gains or losses were generally assumed to occur linearly along the reach between the upstream and downstream gages.

Daily South Platte River flows at locations between gages were computed starting at the upstream end of each reach. Flows were calculated at each successive point of inflow and diversion. Losses or gains in river flow were added/subtracted based on the distance between each point of inflow and diversion. River flows at each point in the river were estimated starting with the gaged inflow to the reach and adding or subtracting gains/losses to the next downstream tributary inflow or point of diversion. This calculation resulted in an estimate of river flow just upstream of the inflow or diversion. Inflows or diversions were added or subtracted from river flows to estimate the flow in the river just downstream of the inflow or diversion. Gains or losses in river flow to the next downstream point of inflow or diversion were added or subtracted to estimate the river flow just upstream of the next point.

In long reaches, the assumption of uniformly-occurring gains or losses occasionally led to negative estimated stream flows. In particular, this occurred at points where a diversion was taking all of the available flow and drying up the river. To avoid negative stream flows, the point flow model assigned a zero to river flow just downstream of those points, and then it redistributed the remaining overall reach gain in downstream segments of the reach.

4.1.1.2 Input Data

Data for the point flow analysis were acquired primarily through the Colorado Decision Support System (CDSS). Distances between stream gages, diversions, and tributary inflows within each reach were calculated using Division 1 Geographic Information System (GIS) mapping. Daily data obtained from CDSS Hydrobase included measured stream flows, diversions and inflows. Table 4-1 below summarizes the stream gages, inflows and outflows used in the point flow analysis.

At the Riverside Canal and at the Empire Ditch, which convey water into Riverside Reservoir and Empire Reservoir, respectively, diversion data were measured just upstream of the reservoirs and not at the river headgate. In order to estimate the amount of water actually diverted from the river, ditch losses between the river headgate and the reservoirs were added to the measured data. The District 1 Water Commissioner recommended that a 20 percent ditch loss be applied to the Riverside Canal diversions and a 25 percent ditch loss be applied to the Empire Ditch diversions (Schantz, 2009).

Table 4-1 Data used in point flow analysis including stream gages, diversions and inflows (note that data points are listed in upstream to downstream order).

Data Point	Structure ID	Data Type
South Platte River at Denver	06714000; PLADENCO	Stream Flow (South Platte River)
Burlington Ditch	0200802	Diversion
Gardeners Ditch	0200806	Diversion
South Platte River at 64th Ave Commerce City	06714215; PLASIXCO	Stream Flow (South Platte River)
Denver Metro Effluent [1]	METSEWCO	Inflow
Sand Creek at mouth near Commerce City	SANCOMCO	Stream Flow (Inflow)
Clear Creek at mouth near Derby	06720000; CLEDERCO	Stream Flow (Inflow)
Fulton Ditch	0200808	Diversion
Brantner Ditch	0200809	Diversion
South Platte River at Henderson	06720500; PLAHENCO	Stream Flow (South Platte River)
Brighton Ditch	0200810	Diversion
Lupton Bottom Ditch	0200812	Diversion
Big Dry Creek at mouth near Fort Lupton	06720990; BIGDAFCO	Stream Flow (Inflow)
Platteville Ditch	0200813	Diversion
Meadow Island #1 Ditch	0200821	Diversion
Evans No. 2 Ditch / Platte Valley Canal (shared headgate)	0200817 / 0200818	Diversion
Meadow Island #2 Ditch / Beeman Ditch (shared headgate)	0200822 / 0200819	Diversion
Farmers Independent Ditch	0200824	Diversion
Hewes Cook (aka Western) Ditch	0200825	Diversion
Jay Thomas Ditch	0200826	Diversion
St. Vrain Creek at Mouth near Platteville	06731000; SVCPLACO	Stream Flow (Inflow)
Union Ditch	0200828	Diversion
Section No. 3 (aka Godfrey Bottom) Ditch	0200830	Diversion
Big Thompson River at mouth near La Salle	06744000; BIGLASCO	Stream Flow (Inflow)
Lower Latham Ditch	0200834	Diversion
Patterson Ditch	0200836	Diversion
Highland (aka Plum) Ditch	0200837	Diversion
Cache la Poudre River near Greeley	06752500; CLAGRECO	Stream Flow (Inflow)
South Platte River near Kersey	06754000; PLAKERCO	Stream Flow (South Platte River)
Empire Ditch [2]	0100501	Diversion
Riverside Canal [3] / Illinois Ditch (shared headgate)	0100503 / 0100504	Diversion
Bijou Canal / Corona Ranch (shared headgate)	0100507 / 0100509	Diversion
Jackson Reservoir Inlet Ditch	0100513	Diversion
Weldon Valley Ditch	0100511	Diversion
Jackson Lake Reservoir Releases (via Jackson Lake Outlet Canal)	0103817	Reservoir Releases (Inflow)
Fort Morgan Canal	0100514	Diversion
South Platte River near Weldona	06758500; PLAWELCO	Stream Flow (South Platte River)
Weldon Valley Ditch Return	0100511 (Q7 releases)	Inflow
Deuel Snyder Canal	0100517	Diversion

Upper Platte and Beaver Canal	0100515	Diversion
Lower Platte and Beaver Canal	0100518	Diversion
Tremont Ditch	0100519	Diversion
North Sterling Canal	0100687	Diversion
Union Ditch	0100688	Diversion
South Platte River at Cooper Bridge near Balzac	06759910; PLABALCO	Stream Flow (South Platte River)
Tetsel Ditch	0100525	Diversion
Prewitt Inlet Canal / Johnson & Edwards (shared headgate)	0100829 / 0100526	Diversion
South Platte Ditch	6400535	Diversion
Prewitt Outlet	6403522	Reservoir Releases (Inflow)
Pawnee Ditch	6400533	Diversion
Schneider Ditch	6400531	Diversion
Springdale Ditch	6400530	Diversion
Sterling No. 1 Irrigation Company Ditch (Sterling No. 1)	6400528	Diversion
Lowline Ditch	6400524	Diversion
Henderson and Smith Ditch	6400525	Diversion
Bravo Ditch	6400522	Diversion
Iliff and Platte Valley Canal	6400520	Diversion
Lone Tree Ditch	6400518	Diversion
Powell and Blair Ditch	6400516	Diversion
Ramsey Ditch	6400514	Diversion
Harmony No. 1 Ditch	6400511	Diversion
Peterson Ditch	6400504	Diversion
South Reservation Ditch	6400503	Diversion
Liddle Ditch	6400502	Diversion
South Platte River at Julesburg (Channels 1, 2, 4)	ONEJURCO, PLAJURCO PLAJULCO	Stream Flow (South Platte River)

1. *Historical effluent data was obtained directly from Denver Metro since Division of Water Resources data was only for the current water year and not for the period of study, October 1999 through September 2008 (August 2009).*
2. *Empire Ditch diversions available in CDSS are measured just before entering Empire Reservoir, not at the South Platte River. A 25% ditch loss was applied to the measured diversion data to represent the amount of water diverted at the headgate from the South Platte River (based on conversations with the District 1 Water Commissioner).*
3. *Riverside Canal diversions available in CDSS are measured just before entering Riverside Reservoir, not at the South Platte River. A 20% ditch loss was applied to the measured diversion data to represent the amount of water diverted at the headgate from the South Platte River (based on conversations with the District 1 Water Commissioner).*

4.1.2 Call Data

Water cannot be exchanged through a calling water right. As a result, the exchange capacity analysis needed to incorporate an assessment of call data.

Daily historical call data were obtained from CDSS to determine what structures, if any, had placed a call on the South Platte River during the study period. This data was combined with the point flow analysis. The call data and point flow analysis were used to make a daily determination of exchange capacity through each structure on the river during the period of study. On days when a water right associated with a diversion structure was calling, the exchange capacity through that point was zero. On days when the water right for that structure was not calling, the exchange capacity was equal to the physical flow in the river minus any bypass requirements (see Section 4.1.3.1 for explanation of bypasses).

Figure 4-1 presents a summary of call data October 1, 1999 through September 30, 2008. The figure shows the percentage of time that structures were placing calls on the South Platte River over this period. In addition, the calling rights are shown in the order of the number of days that they placed a call over the time period of the analysis. Figure 4-1 shows that the Harmony Ditch, the Sterling No. 1 Ditch, Jay Thomas Ditch, Prewitt Inlet/Reservoir, North Sterling Canal, Burlington Ditch, Julesburg Reservoir, and Hewes Cook Ditch structures placed calls on the river most frequently.

It should be noted that the sum of the percentages shown on the figure is well over 100 percent. In many instances, calls were being placed by various structures in different parts of the river at the same time.

4.1.3 Exchange Calculations

The first step in the exchange capacity analysis included assessing the daily exchange capacity through individual points on the South Platte River. To accomplish this, two matrices were developed. The first matrix contained daily flow data for each diversion point on the river. The second matrix contained daily call data for each diversion point. The point flow data was in the form of estimated physical flow in cubic feet per second (cfs) just below each point of diversion/inflow. Daily call data for each structure were represented by either a “0” or a “1” depending on whether a structure was placing a call on the river (“0”) or not placing a call on the river (“1”).

The point flow matrix was multiplied by the call data matrix, which resulted in unadjusted daily exchange capacity through individual structures on the river (adjustments were made for bypass flows and free river as described in subsequent sections). For example, if a structure was placing a call on the river, the exchange capacity through that structure was considered to be 0 cfs (as a result of the daily point flow being multiplied by a 0 in the call matrix). Conversely, if a structure was not placing a call on the river, the unadjusted exchange capacity through that structure was considered to be the physical flow rate just downstream of the structure (as a result of the daily point flow being multiplied by a 1 in the call matrix).

4.1.3.1 Bypass Flows

Required bypass flows were incorporated into the exchange analysis. Bypass flows are augmentation supply or other releases that need to be “shepherded” down the river by the Water Commissioner. They are flows that need to bypass other diversion structures so that they can get to the point where they are needed, for example, to replace downstream depletions. Bypass flows are not available for diversion by structures they pass along the way, and they should not be considered as flows against which exchanges can be made.

Limited data was available regarding specific bypass flow values for different structures; therefore, after coordinating with the District 1 and 64 Water Commissioner and the Division of Water Resources augmentation plan coordinator, reasonable estimates of bypass flows were adopted for different reaches of the river (see Table 4-2 below). Since exchanges cannot be made against a bypass flow, these flows were subtracted from the estimated physical flows at each structure.

Table 4-2. Bypass flow estimates (cfs) for different reaches of the South Platte River used in exchange analysis.

Months	Burlington Ditch to upstream of St. Vrain Creek Confluence (Jay Thomas Ditch)	Downstream of St. Vrain Creek Confluence (Union Ditch) to Riverside Canal	Bijou Canal to state line
Apr – Oct	15	20	10
Nov – Mar	15	10	5

4.1.3.2 Free River

Free river days (days when there is no call on the river) were considered in the calculation of exchange capacity. When there is free river, there is no need for exchange since there is no calling water right. As a result, the exchange capacity analysis excluded days when there was free river in the South Platte River from Denver to the state line and when there was free river in District 64 only.

4.1.3.3 Other Exchanges

Other decreed exchanges were not specifically assessed for the purposes of this report. Daily flow records reflect decreed exchanges that were run historically during the analysis period. The Project Team understands that some conditional exchanges have been decreed in certain reaches of the river and Water Court applications have been filed for other exchanges. The extent to which conditional rights of exchange will be made absolute is unknown at this time. Other exchanges could decrease the available exchange capacity shown in the results below.

4.1.4 Results

This section presents generalized results for the exchange capacity analysis. An assessment of exchange capacity over specific reaches was conducted as a part of the Lower South Platte Water Cooperative demonstration project. Results of that assessment are presented in Section 5.2.

Exchange capacity at various points in the South Platte River was summarized on average annual, average seasonal, and wet and dry year bases. In addition, exchange capacities at various "bottlenecks" in the river were examined more closely.

4.1.4.1 Average Annual Exchange Capacity

Figure 4-2 shows the average annual exchange capacity through each headgate along the South Platte River over the 2002 to 2008 time period. The figure was developed by summing the daily exchange capacities at each headgate for each year in the study period and then averaging the annual amounts of exchange capacity through each headgate. Figure 4-3 shows the geographic variation and values of average annual exchange capacity. This figure indicates that the annual exchange capacity can vary greatly depending on the location along the South Platte River. In the upper reaches of the South Platte River, there are several tributaries to the South Platte River (Big Dry Creek, St. Vrain Creek, Big Thompson River and the Cache la Poudre River) that boost exchange capacity, even though there are several headgates within those reaches diverting water out of the river. This area, which is between the Jay Thomas Ditch headgate and the Empire Ditch headgate, had the highest average annual exchange capacity of the study period. The maximum average annual exchange capacity occurred just downstream of Kersey, Colorado, which is just upstream of the Empire Ditch headgate. In District 1 from Kersey downstream, there are no large tributaries and there are a number of major water users, for example Riverside Canal, Fort Morgan Canal, North Sterling Canal, and the Prewitt Inlet Canal, and exchange capacity decreases further downstream toward District 64. District 64 is similar in that there are no large tributaries and numerous major water users, for example Sterling No. 1 and Harmony No. 1 Ditch. Therefore the exchange capacity in District 64 appears to be quite limited in comparison to upstream reaches. The reasons for the lack of exchange capacity varied depending on hydrologic conditions and call regime. For example, free river conditions occur in District 64 at times when there is a call in District 1. During free river conditions in District 64, exchange would not be necessary. In addition, in some locations in District 64, river flows are generally lower than in Districts 1 and 2.

Figures 4-2 and 4-3 show impacts that frequently-calling water rights have on exchange capacity. For example, the figure shows significant decreases in average annual exchange capacity at the Platte Valley Ditch, Jay Thomas Ditch, Riverside/Illinois Ditch, North Sterling Canal/Prewitt Inlet, Sterling No. 1 and Harmony Ditch. These ditches act as “bottlenecks” to exchange capacity.

4.1.4.2 Wet and Dry Year Exchange Capacity

Figure 4-2 also shows exchange capacity for wet and dry years that occurred during the study period. The representative years for wet and dry conditions were 2005 and 2002, respectively. As shown on the figure, the pattern of exchange capacity for wet and dry years mimics the pattern for average annual exchange capacity from Denver to the state line. In both wet and dry years, the highest amounts of exchange capacity were located between the Union Ditch and Empire Ditch headgates. Exchange capacity decreased significantly for both wet and dry years downstream of the North Sterling Canal and Prewitt Inlet headgates. In the dry year (2002), there was almost no exchange capacity downstream of the Sterling No. 1 headgate.

4.1.4.3 Seasonal Variation in Exchange Capacity

Average annual exchange capacities during the direct flow season (April through October) and storage season (November through March) are shown in Figure 4-4. Daily values of exchange capacity were summed over the direct flow and storage seasons for each year and then averaged to develop the data used for Figure 4-4.

During the direct flow season, the spatial variations in exchange capacity are somewhat similar to the variations in Figure 4-2. Exchange capacity during both the direct flow and storage seasons is higher in Districts 1 and 2 than in District 64. During the storage season, exchange capacity is limited between the Riverside and Jackson Lake inlet ditches and in District 64, because reservoir storage rights place calls on the river. The highest exchange capacity during both the storage and direct flow seasons is in the reach from Union Ditch to Empire Ditch.

Figure 4-4 indicates that there is generally more exchange capacity during the direct flow season, because flows are higher in spring and summer, and large diversions to storage are not occurring. The graph also shows that the exchange capacity upstream of the North Sterling Canal varied more during the direct flow season among wet/dry/average conditions than it did during the storage season. The general reason for this is that river flows varied more during the direct flow season than the storage season.

4.1.4.4 Frequency Distribution of Exchange Capacity at Various Locations

The evaluation of call data identified several water rights that could impede exchange because they frequently place calls on the river (see Figure 4-1). These water rights were further analyzed to assess the variability of exchange capacity through these structures when they are not placing a call on the river. The Hewes Cook, Jay Thomas, Riverside, North Sterling/Prewitt Inlet (these two structures were assessed jointly for this analysis), Sterling No. 1, and Harmony No. 1 Ditches were included in this analysis.

Figure 4-5 summarizes results of a frequency analysis of daily South Platte River flow at these structures when the structures were not calling. The analysis was conducted over water years 2002 through 2008. The figure shows the percentage of time that exchange capacity through each structure was greater than the value indicated on the x-axis. For example, approximately 36 percent of the time during water years 2002 through 2008, there was at least 100 cfs of exchange capacity through the North Sterling and Prewitt Inlet Ditches combined. There was at least some exchange capacity (more than 10 cfs) at this location 49 percent of the time, suggesting that 51 percent of the time, there were free river conditions, the North Sterling Canal or Prewitt Inlet was placing a call on the river, or there was very little flow past these structures (less than 10 cfs).

Figure 4-5 shows geographic patterns similar to those discussed above. Exchange capacities tend to be higher through calling rights in the upper portions of the South Platte River (i.e. Jay Thomas, Hewes Cook, and Riverside). Exchange capacities decrease through downstream headgates (i.e. North Sterling and Prewitt Inlet, Sterling No. 1, and Harmony No. 1). Moderate to high amounts of exchange capacity (50 cfs or more) were available through the Hewes Cook and Jay Thomas Ditches between 75 and 80 percent of the time during water years 2002 through 2008. These ditches generally call during the irrigation season, so the exchange capacity was most available during the storage season (but also periodically during the irrigation season).

As shown on Figure 4-5, there was very little exchange capacity available through the Harmony Ditch. Frequent calls, periodic free river, and low flows during the study time period all impacted the exchange capacity at this location.

4.1.4.5 Summary of Results

Exchange capacity exists in the majority of the South Platte River study reach during most years. During dry years, exchange capacity is very low to non existent below the North Sterling Canal/Prewitt Inlet. During normal years, exchange potential upstream North Sterling Canal/Prewitt Inlet is relatively high, but there are several bottlenecks that may impede exchange potential during certain times of the year.

Exchange capacity upstream of the Jay Thomas Ditch is relatively high, but there are a few bottlenecks during the direct flow season. During the storage season, exchange capacity appears to be relatively consistent. It should be noted that there are a number of decreed or pending exchanges in the reach immediately below the Denver metropolitan area. A ditch company or other entity interested in alternative transfers in this area should do additional research on existing exchanges in this area of the river.

The exchange capacity study suggests that alternative transfers may be somewhat successful if they rely on exchange to deliver water to end users. The reliability of exchange can be increased if the exchange from and exchange to locations are relatively close together and do not span a reach of the river with an exchange bottleneck.

Reliability requirements of the end user will impact the potential success of alternative transfers that rely on exchange. For example, if an end user needs water from alternative transfers for drought recovery purposes, it may not be necessary to conduct the transfer and exchange water during dry years. In this situation, water could be delivered via exchange during normal or wet years when exchange capacity is higher.

The exchange capacity study also indicates that a marketing entity with access to storage or other infrastructure may be useful to help deliver water more reliably to end users. For example, within the marketing entity, water derived from several alternative transfers in various locations in the river could be managed collectively to increase the reliability of delivery. If the entity has access to storage, water from alternative transfers could be stored and then exchanged when exchange capacity is available. The Lower South Platte Water Cooperative is an example of a marketing entity that could help deliver water from alternative transfers. The demonstration project that focused on the Lower South Platte Water Cooperative is described later in this report.

4.2 Mapping

Maps of various features along the South Platte River were created using GIS to provide additional information related to the demonstration projects. These maps include general features such as ditch service areas and points of diversion, as well as specific features such as exchange capacity, free river capacity, and lagging rates for recharge credits.

The maps were used as visual aids to help determine the feasibility of the demonstration projects. They were also used to help determine the potential for exchange of excess recharge credits from the lower South Platte River to points further upstream. Many of the maps could also be useful to a variety of water users on the South Platte River. The following are general descriptions of the maps developed in GIS:

- Overview of South Platte River including all points of diversion
- Overview of ditch service areas along South Platte River
- Exchange capacity and bottlenecks along South Platte River
- Free river capacity along South Platte River
- Potential DU wetland demonstration project locations including ditch service areas
- Lagging characteristics along the South Platte River
- Section 303(d) water bodies in South Platte River basin

The source of most of the information in the maps was the South Platte Decision Support System (SPDSS), which is specific to the Division 1 South Platte River basin and is available to the public (http://cdss.state.co.us). The SPDSS provides data sets for GIS that can be used to create individualized GIS maps that highlight different features, for example ditch service areas or diversion structures.

Examples of SPDSS spatial data sets that were used are:

- Rivers and tributaries
- Diversion structures
- Ditch service areas
- District boundaries
- Stream gages

Project specific map features, such as ones showing Aurora pipelines and wells and potential DU wetland locations were provided by the project participants.

Several maps were created in GIS to represent different features and characteristics along the South Platte River from Denver to the state line. The following subsections list and described these maps.

4.2.1 Overview of South Platte River Including All Points of Diversion

This map shows the South Platte River from Denver to the state line, including general water rights features such as major tributaries, stream gages, points of diversion, major reservoirs, and Water District boundaries (see Figure 4-6). This map was useful as a general reference with respect to the locations of points of diversion and large reservoirs in Districts 1, 2, and 64.

4.2.2 Overview of Ditch Service Areas along South Platte River

This map shows the South Platte River from Denver to the state line, including ditch service areas in Districts 1, 2, and 64 (see Figure 4-7). The ditch service areas indicate the boundaries within which surface water is delivered for irrigation as delineated in SPDSS GIS coverages. This map was useful to show the geographic area over which surface water can be delivered, which was helpful when considering different potential locations for wetlands that could receive deliveries of consumptive use or return flows in the demonstration projects described in Section 5. This map could also be useful to future alternative transfer projects beyond this specific study.

4.2.3 Exchange Capacity and Free River along the South Platte River

The maps shown in Figures 4-3 and 5-5 were useful for all three demonstration projects and for general information on exchange capacity and free river conditions along the South Platte River. The data analyses reflected in these maps are discussed in Sections 4.1 and 5.2.4.

4.2.4 Potential DU Wetland Demonstration Project Locations Including Ditch Service Areas

This map shows the locations of potential wetland recharge projects along with ditch service areas (see Figure 4-8). The potential wetland recharge locations were obtained by DU based on their knowledge and relationship with the land owners. The ditch service areas shown in the map indicate the source (ditch system) of water that could potentially be used to supply wetlands.

4.2.5 Lagging Characteristics along the South Platte River

A map was created showing subsurface return flow lagging characteristics based on the Glover methodology along the South Platte River (see Figure 4-9). Several steps were required to generate the lagging data displayed in this map. First, aquifer characteristics for the South Platte River alluvium were obtained using the Alluvial Water Accounting System (AWAS) Parameter Calculator Tool available from the Integrated Decision Support Group (IDS) at Colorado State University. The calculator estimates parameters needed by AWAS (transmissivity, distance to the river, and distance from the river to the alluvial boundary) to compute lagged accretions from recharge (or depletions from pumping) for specific locations input by the user. The data used by the AWAS Parameter Calculator Tool to compute these parameters are maps of river location, alluvial aquifer boundaries, and transmissivity. The following list describes the maps used by the AWAS Parameter Calculator Tool:

- River location: GIS-based map from the SPDSS showing the main stem of the South Platte River.

- Alluvial aquifer boundary: GIS-based map from the SPDSS showing the extent of the alluvium surrounding the South Platte River. The map was based on the Hurr and Schneider (1972) reports describing the hydrogeologic characteristics of the alluvial aquifer from Brighton to Julesburg. Although these reports are from 1972, the hydrogeologic data for the alluvial boundary of the South Platte River is still widely used today and was accepted for publication and use in SPDSS.
- Transmissivity: GIS-based raster (or grid) file developed by SPDSS. The SPDSS created this map using maps of hydraulic conductivity and saturated thickness.

The tool was used to calculate AWAS parameters for a grid of points that covered the South Platte River alluvium. The points within the grid had a half-mile spacing.

In the second step of the process, the AWAS program was used to determine lagging characteristics at each point in the grid. In the final step, the lagged accretion output data from AWAS were contoured to indicate the time in months/years for 50 percent of recharged water to return to the South Platte River.

This lagging map provided generalized lagging characteristics that were useful to the Project Team in considering demonstration projects involving potential recharge wetlands. By overlaying the lagging map with the potential wetland project locations, the Project Team could readily see which sites would yield faster or slower recharge to the river. Once specific sites were chosen for the demonstration projects, more precise lagging assessments were conducted.

4.2.6 Section 303(d) Water Bodies in South Platte River Basin

Figure 4-10 shows water bodies that are included in the Section 303(d) list of water quality limited segments requiring Total Maximum Daily Loads (TMDLs). This information for the South Platte River basin was obtained through the Colorado Department of Public Health and Environment (CDPHE) Water Quality Control Commission (5 CCR 1002-93, dated April 30, 2010), which is based on the information the state submits to the United States Environmental Protection Agency to fulfill Section 303(d) of the Clean Water Act. A wetland recharge project may provide water quality benefits to surrounding water bodies because the water discharged from a wetland can either be naturally filtered and released as surface water or infiltrated into the alluvial aquifer, trapping potential contaminants in the wetland. This map was useful for showing the locations of 303(d) listed water bodies relative to potential wetland demonstration project locations.

4.3 Benefits of Wetlands in Alternative Transfers

Recharge wetlands can be a very useful component of alternative transfers. To the extent possible, the Project Team attempted to include recharge wetlands in the demonstration projects as a tool for delivery of transferred water or for historical return flows.

Team member DU has a twelve-year history of working cooperatively with agricultural producers, municipalities and industry along the South Platte River in Colorado to provide water through alternative agricultural water transfers for multiple benefits. Historically, DU has constructed recharge wetlands or ponds that provide high quality habitat for migrating waterfowl. In addition, these projects have for many years provided recharge credits to agricultural producers or to wildlife agencies through various agreements and contracts. These projects contribute other benefits including recreational hunting, bird watching and water quality improvements through contamination filtering. Ecological benefits of wetlands are described in detail below.

4.3.1 Hydrologic Benefits

Wetlands play a critical role in regulating the movement of water within watersheds as well as in the global water cycle. Wetlands, by definition, are characterized by water saturation in the root zone, at, or above the soil surface, for a certain amount of time during the year. The fluctuation of the water table (hydroperiod) above the soil surface is unique to each wetland type.

Wetlands typically store precipitation and surface water and then slowly release the water into associated surface water resources, ground water, and the atmosphere. Wetland types differ in this capacity based on a number of physical and biological characteristics, including: landscape position, soil saturation, the fiber content/degree of decomposition of the organic soils, vegetation density and type of vegetation.

Wetlands help maintain the level of the water table and exert control on the hydraulic head. This provides force for ground water recharge and discharge to other waters as well. Several factors impact the potential for wetlands to provide ground water recharge. These factors include soil type, vegetation, site characteristics, perimeter to volume ratio, and water table elevation and gradient.

4.3.2 Water Quality Benefits

Wetlands may transform or function as a sink for nutrients, organic compounds, metals, and components of organic matter. Wetlands may also act as filters of sediments and organic matter. A wetland may be a permanent sink for these substances if the compounds become buried in the substrate or are released into the atmosphere; or a wetland may retain them only during the growing season or under flooded conditions. Wetland processes play a role in the global cycles of carbon, nitrogen, and sulfur by transforming them and releasing them into the atmosphere. Specific water quality benefits of wetlands are listed below with respect to specific water quality constituents:

- Nitrogen: The biological and chemical process of nitrification/denitrification in the nitrogen cycle transforms the majority of nitrogen entering wetlands, causing between 70 percent and 90 percent to be removed.
- Phosphorus: Phosphorus can enter wetlands with suspended solids or as dissolved phosphorus. Significant quantities of phosphorus associated with sediments are deposited in wetlands. Phosphorus removal from water in wetlands occurs through use of phosphorus by plants and soil microbes; adsorption by aluminum and iron oxides and hydroxides; precipitation of aluminum, iron, and calcium phosphates; and burial of phosphorus adsorbed to sediments or organic matter.
- Carbon: Wetlands store carbon within peat and soil. Storing carbon is an important function within the carbon cycle, particularly given observations of increasing levels of carbon dioxide in the atmosphere and concerns about global warming.
- Sulfur: Wetlands are capable of reducing sulfate to sulfide. Sulfide is released to the atmosphere as hydrogen, methyl, and dimethyl sulfides or is bound in insoluble complexes with phosphate and metal ions in wetland sediments.
- Suspended Solids: Wetlands filter suspended solids from water that comes into contact with wetland vegetation. Stems and leaves provide friction for the flow of the water, thus allowing

settling of suspended solids and removal of related pollutants from the water column. Wetlands may permanently retain sediment in the peat or as substrate.

- **Metals**: Wetlands can remove metals from surface and ground water as a result of the presence of clays, humic materials (peats), aluminum, iron, and/or calcium. Wetlands remove more metals from slow flowing water since there is more time for chemical processes to occur before the water moves out of the wetland. Burial in the wetland substrate will keep bound metals immobilized.

4.3.3 Biological Benefits

Wetlands are among the most productive ecosystems in the world. Immense varieties of species of microbes, plants, insects, amphibians, reptiles, birds, fish, and other wildlife depend in some way on wetlands. Wetlands with seasonal hydrologic pulsing are the most productive.

Wetland plants play an integral role in the ecology of the watershed. Wetland plants provide breeding and nursery sites, resting areas for migratory species, and refuge from predators. Decomposed plant matter released into the water is important food for many invertebrates and fish both in the wetland and in associated aquatic systems. Physical and chemical characteristics such as climate, topography, geology, hydrology, and inputs of nutrients and sediments determine the rate of plant growth and reproduction of wetlands.

4.4 Consumptive Use of Water in Wetlands

Groundwater recharge in Colorado is commonly conducted using shallow infiltration basins. Constructed wetlands can serve the same purpose while providing many additional benefits such as water quality improvements and enhanced wildlife habitat. However, consumption of water by wetland vegetation is a consideration when using wetlands for recharge purposes. For example, if transferrable consumptive use associated with ditch shares is delivered to a recharge wetland, some of the water is lost due to consumption by wetland vegetation and evaporation from open water surfaces in the wetland. The Project Team researched evapotranspiration rates from wetlands to understand the potential significance of losses.

4.4.1 Consumptive Use Calculation

Water consumption by wetland vegetation occurs through two mechanisms, evaporation from open water surfaces and transpiration through wetland vegetation. Because both of these mechanisms occur simultaneously at varying rates within wetlands, it is very difficult to isolate the losses attributed to each mechanism alone. As a result the losses due to evaporation and transpiration are most frequently expressed as a single combined term referred to as evapotranspiration (ET).

Evapotranspiration amounts can be determined using a number of approaches. One approach is to measure ET directly using very specialized instruments that quantify various physical parameters or the soil water balance. Another common approach is to compute ET using empirical equations that use meteorological data as input. Empirical equations are very effective tools for calculating ET for both long periods of time and in a variety of geographic areas, because meteorological data have been recorded at weather stations in many locations and for a relatively long period of time. For the purposes of this report, the Penman-Monteith equation was used to calculate ET from wetlands.

The calculation of ET was conducted in two steps. The first step involved the calculation of a reference crop ET (ET_0) using meteorological data and the Penman-Montieth equation. Reference crop ET represents the rate of evapotranspiration for a reference crop which is usually grass. The second step related the reference crop ET to crop specific ET (ET_c) through the use of crop coefficients. ET_c calculations were conducted for both wetlands and open water to provide a comparison between wetlands and conventional recharge ponds,

Reference crop ET was calculated using meteorological data from the Fort Morgan and Fort Lupton weather stations. These two locations are relatively close to the demonstration projects described in this report, and are located where alluvial aquifer recharge is typically conducted. Inputs needed to calculate the reference ET are maximum and minimum air temperature, maximum and minimum relative humidity, solar radiation, wind speed and location data. Daily meteorological data for these two locations was obtained from the Colorado Agricultural Meteorological Network (CoAgMet) for years 1996 through 2009.

Reference crop ET was calculated for each day when adequate data existed between 1996 and 2009. Adequate data were available for 95 percent and 98 percent of the time period for the Fort Morgan and Fort Lupton stations, respectively. Days with inadequate data were eliminated from the analysis and were not included in calculations of average monthly ET shown in Table 4-3.

Crop-specific ET was calculated by applying crop coefficients to daily estimates of reference crop ET. Crop coefficients vary over the course of each growing season and were applied based on the length of each growth stage of wetland vegetation. Both the crop coefficients as well as the growth stage parameters were adopted from those given in “Crop evapotranspiration - Guidelines for computing crop water requirements” published by the Food and Agriculture Organization of the United Nations (FAO). The report includes coefficients for wetlands consisting of cattails and bulrushes. To compare wetland consumptive use to that of a conventional recharge pond, ET_c calculations were also conducted for open water areas less than two meters deep. The FAO document provided crop coefficients for the open water that are constant throughout the growing season. Daily and average annual consumptive use were estimated by calculating the mean ET_c for each day of the growing season for both wetlands and open water. Average ET_c values were derived from the daily results.

Table 4-3 shows results of the Penman-Monteith method of computing evapotranspiration for both open water and wetlands. It includes results for both the Fort Morgan and Fort Lupton weather stations, and gives average monthly ET_c as well as the average total ET_c for a single growing season.

Table 4-3. Comparison of wetland and open water ET calculated using the Penman-Monteith method

	Average Monthly ET_c (inches)			
	Fort Morgan		Fort Lupton	
Month	Wetland	Open Water	Wetland	Open Water
May	3.0	6.2	2.8	5.8
June	8.0	7.3	7.4	6.7
July	8.9	7.8	8.6	7.5
August	7.2	6.3	6.8	6.0
September	2.1	3.2	2.0	3.1
Seasonal Total	29.2	30.8	27.6	29.1

The Penman-Monteith estimates of evaporation from open water compare well with open water evaporation rates in *NOAA Technical Report NWS 33 - Evaporation Atlas for the Contiguous 48 United States* (NWS 33). NWS 33 provides maps showing annual evaporation from open water surfaces. Evaporation amounts during the months of May through September were derived by applying a monthly distribution of open water evaporation included in *General Guidelines for Substitute Water Supply Plans for Sand and Gravel Pits* (published by the Colorado State Engineer). NWS 33 suggests that evaporation totals near Fort Morgan and Fort Lupton are approximately 48 inches and 45 inches per year, respectively. Using the monthly distribution of evaporation recommended by the SEO, May through September open water evaporation at Fort Morgan and Fort Lupton is approximately 31.2 inches and 29.2 inches, respectively. Seasonal evaporation amounts estimated using Penman-Monteith are within one inch of amounts estimated using NWS 33 maps.

Results of the ET_c calculation using the Penman-Monteith method in Table 4-3 suggest that seasonal ET from wetlands is slightly less than seasonal evaporation from open water surfaces. The reason for the slight difference in water consumption can be explained by comparing the physical characteristic of the two environments.

In wetlands, areas of open water are generally bordered year round by tall reeds, grass, and bushes. During the initial stage of the growing season, wetland vegetation consumes very little water, and biomass from previous years' growth provides shade to areas of wet soil and water. As a result, evaporation is reduced in shaded areas. As the growing season progresses and wetland vegetation develops, water consumed by the vegetation increases. The consumptive use of a wetland will begin to approach and then surpass that of open water. Once the wetland vegetation surpasses maturity during the season, it consumes less water but maintains its level of surface shading, which results in a decreasing rate of consumption through the end of the growing season. Results in Table 4-3 reflect this effect. Estimates of wetland ET are less than open water evaporation in May and September, but they are higher during the peak growing season months of June, July, and August.

Like all analytical methods, the accuracy of the Penman-Monteith method is limited by how closely the simulated system resembles the ideal system on which the method is based. For example, the crop coefficients used for this assessment were based on cattails and bulrushes. Wetlands with other species of vegetation could use different amounts of water. In addition, vegetation density could impact water use in wetlands. For example, studies that took place in Logan, Utah found that the mid season crop coefficient for wetland vegetation was greater than that recommended by the FAO when measured in a densely vegetated wetland covering only 36 square meters. However, in tests conducted over larger, more typical wetland areas, the experimentally-derived crop coefficient was smaller than the FAO crop coefficient.

The results of this analysis suggest that wetlands generally consume a similar amount of water over the growing season (May through September) as compared to open water recharge facilities. This conclusion corresponds to SPDSS recommendations for estimating evaporation in wetland recharge facilities on the Tamarack Ranch State Wildlife Area (SWA). In SPDSS Task No. 70, recommendations were provided for addressing consumptive use of water for the creation and maintenance of wetland and wildlife areas, and the Tamarack Ranch SWA was one of the wildlife areas considered. The Tamarack Ranch SWA was constructed as a recharge facility and wildlife habitat area in the lower South Platte River for the Platte River Recovery Implementation Program. Water from the South Platte River is delivered to recharge facilities at the SWA during times of high flow in an effort to retime these flows to make them available during months when flows in the South Platte River are low. In the memorandum describing the results of Task No. 70, the authors recommended that evaporative losses from Tamarack Ranch SWA recharge facilities be estimated using methods that quantify open water evaporation from other water bodies.

Figure 4-1. Structures on the South Platte River with the most days of call over the period 10/1/1999 through 9/30/2008

(Structures with less than 25 days of call are not shown)

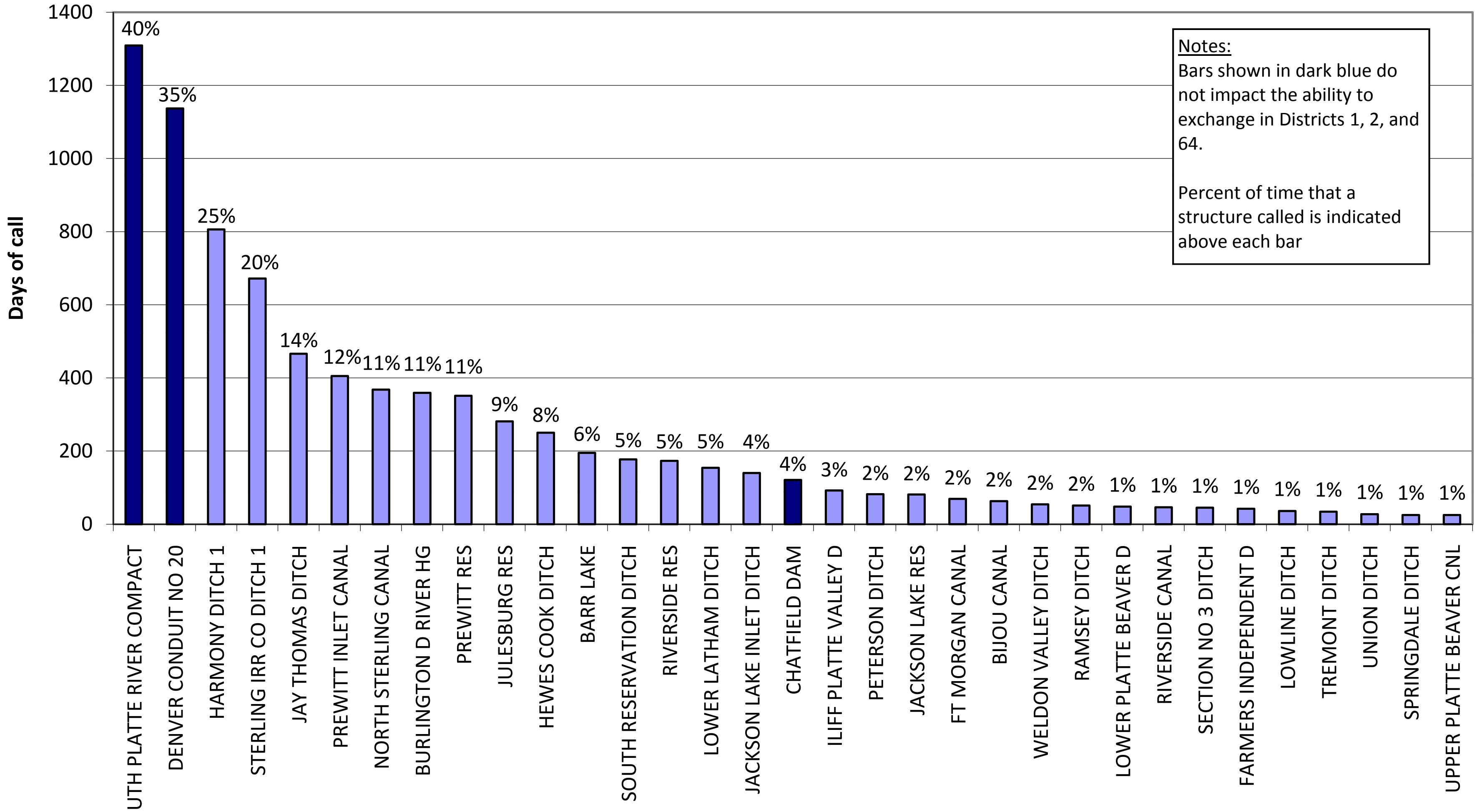
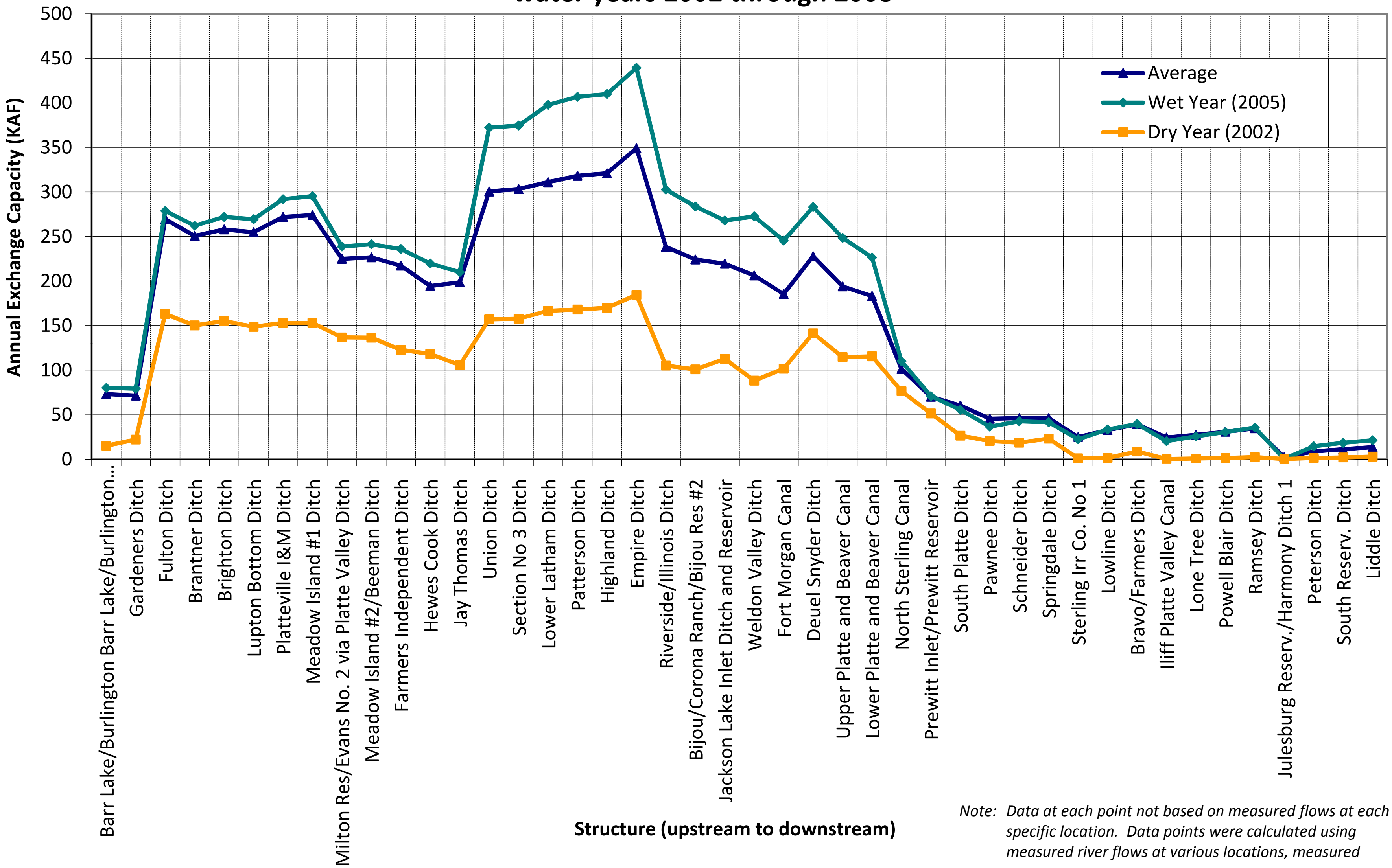
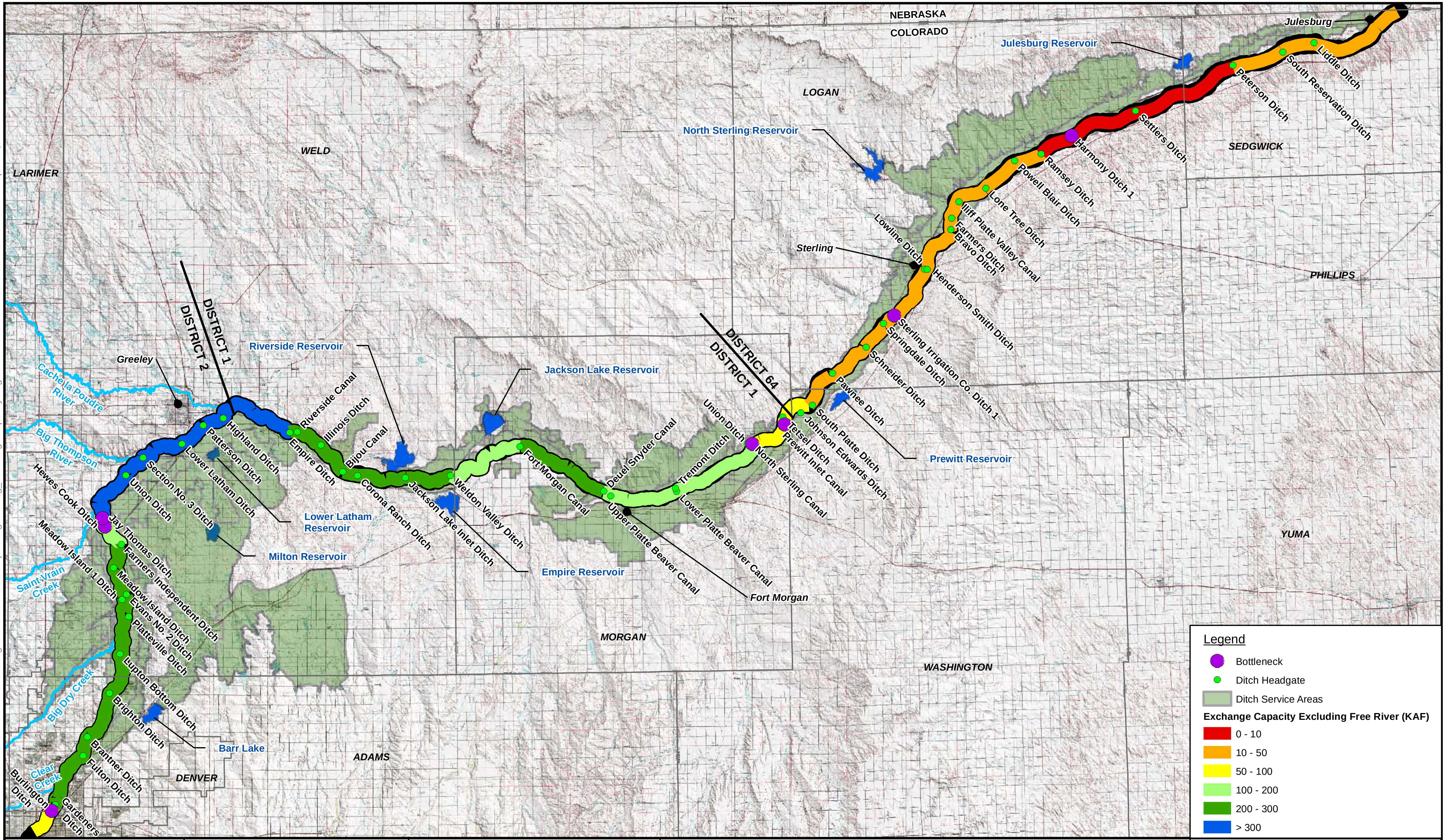


Figure 4-2. Variation in annual exchange capacity at various points along the South Platte River for water years 2002 through 2008



Note: Data at each point not based on measured flows at each specific location. Data points were calculated using measured river flows at various locations, measured



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1 in = 10 miles

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Notes

Projection: Universal Transverse Mercator, Zone 13 North, 1983 North American Datum (meters).

Locations of ditch headgates from South Platte Decision Support System

FIGURE 4-3
Average annual exchange capacity (2002 through 2008) and exchange bottlenecks along the South Platte River in Districts 1, 2, and 64

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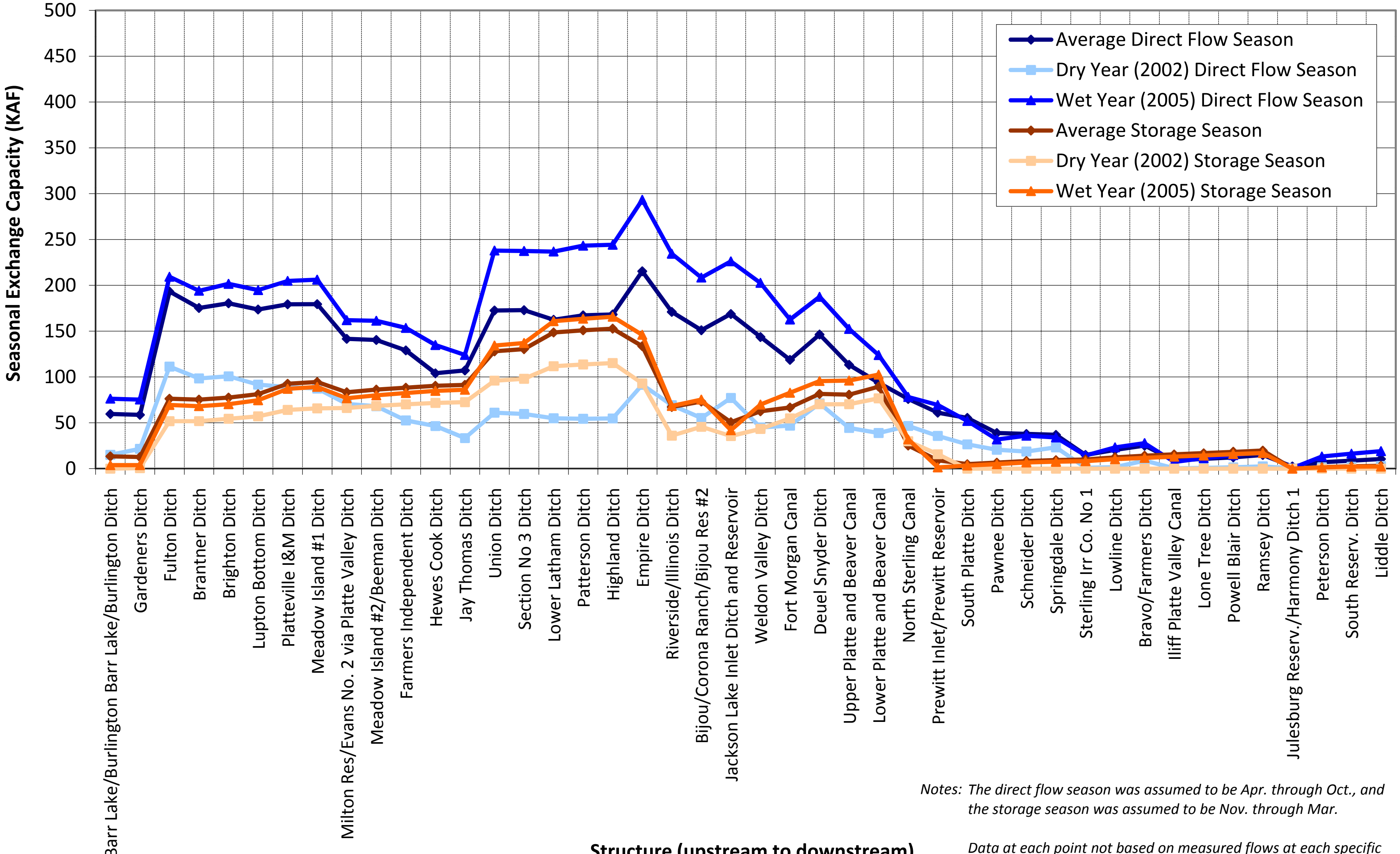
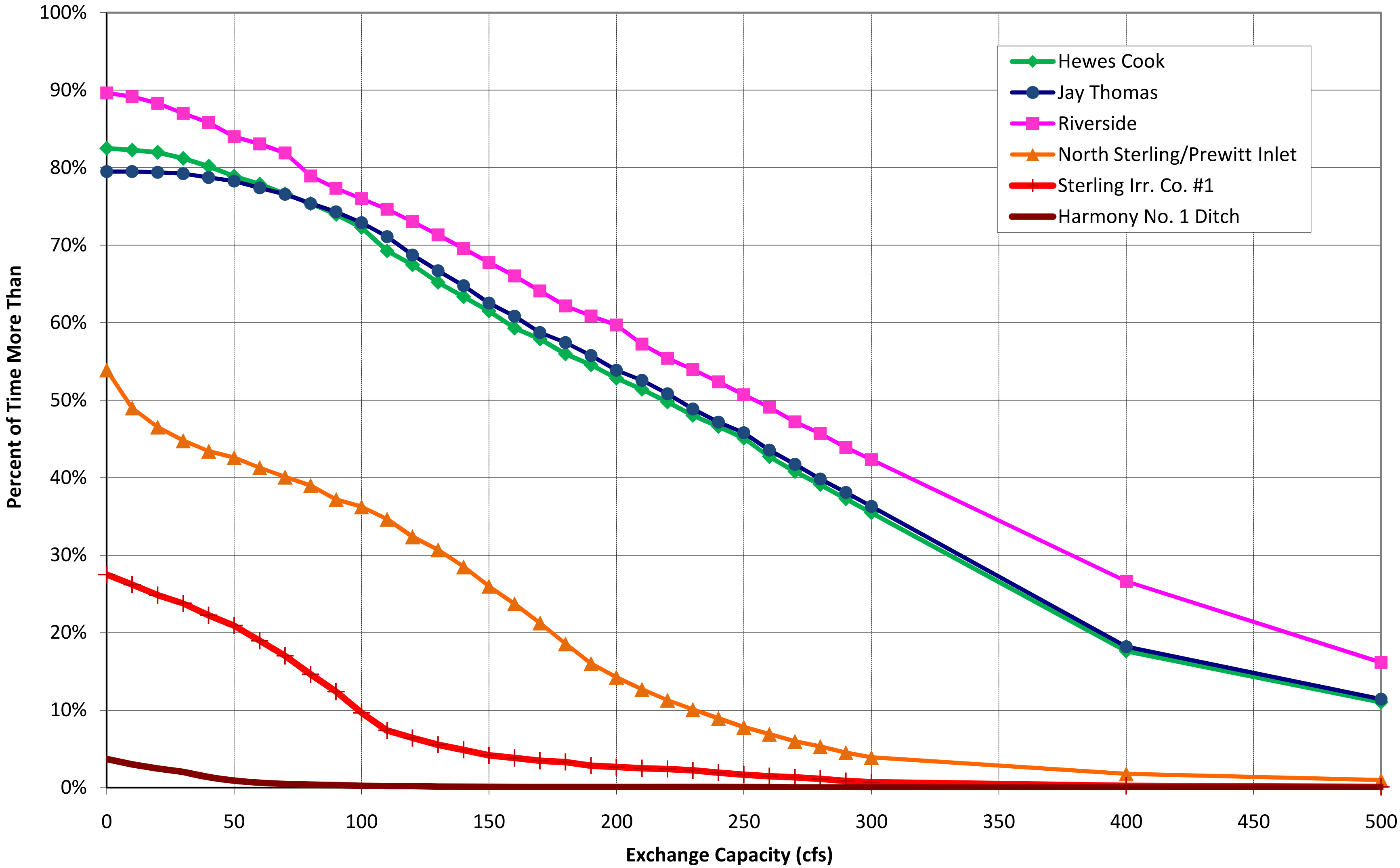
Figure 4-4. Seasonal variation in exchange capacity at various points along the South Platte River for water years 2002 through 2008

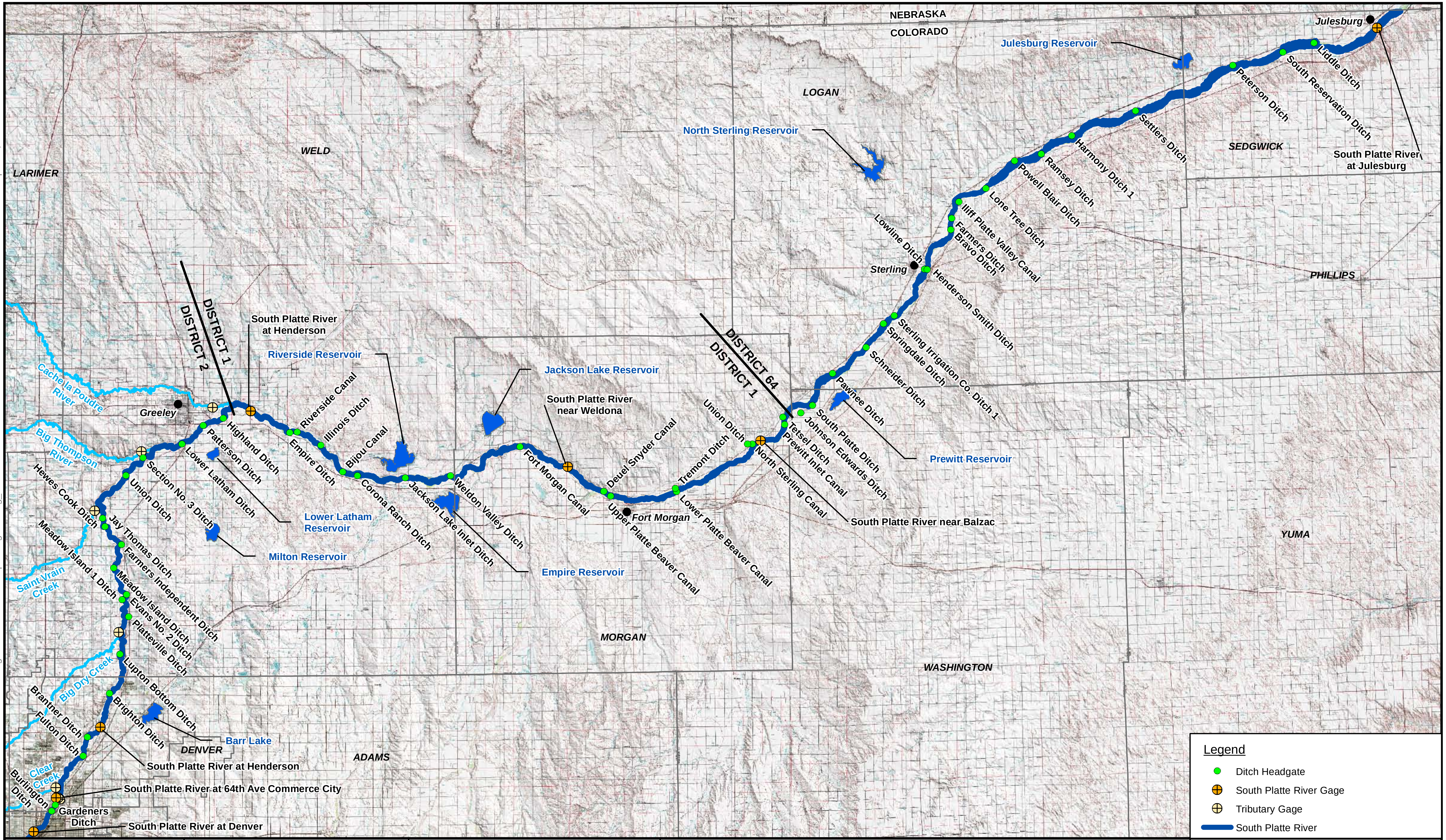


Notes: The direct flow season was assumed to be Apr. through Oct., and the storage season was assumed to be Nov. through Mar.

Data at each point not based on measured flows at each specific location. Data points were calculated using measured river flows at various locations, measured diversions, and river losses/gains.

Figure 4-5. Frequency distribution of exchange capacity through various locations along the South Platte River for water years 2002 through 2008





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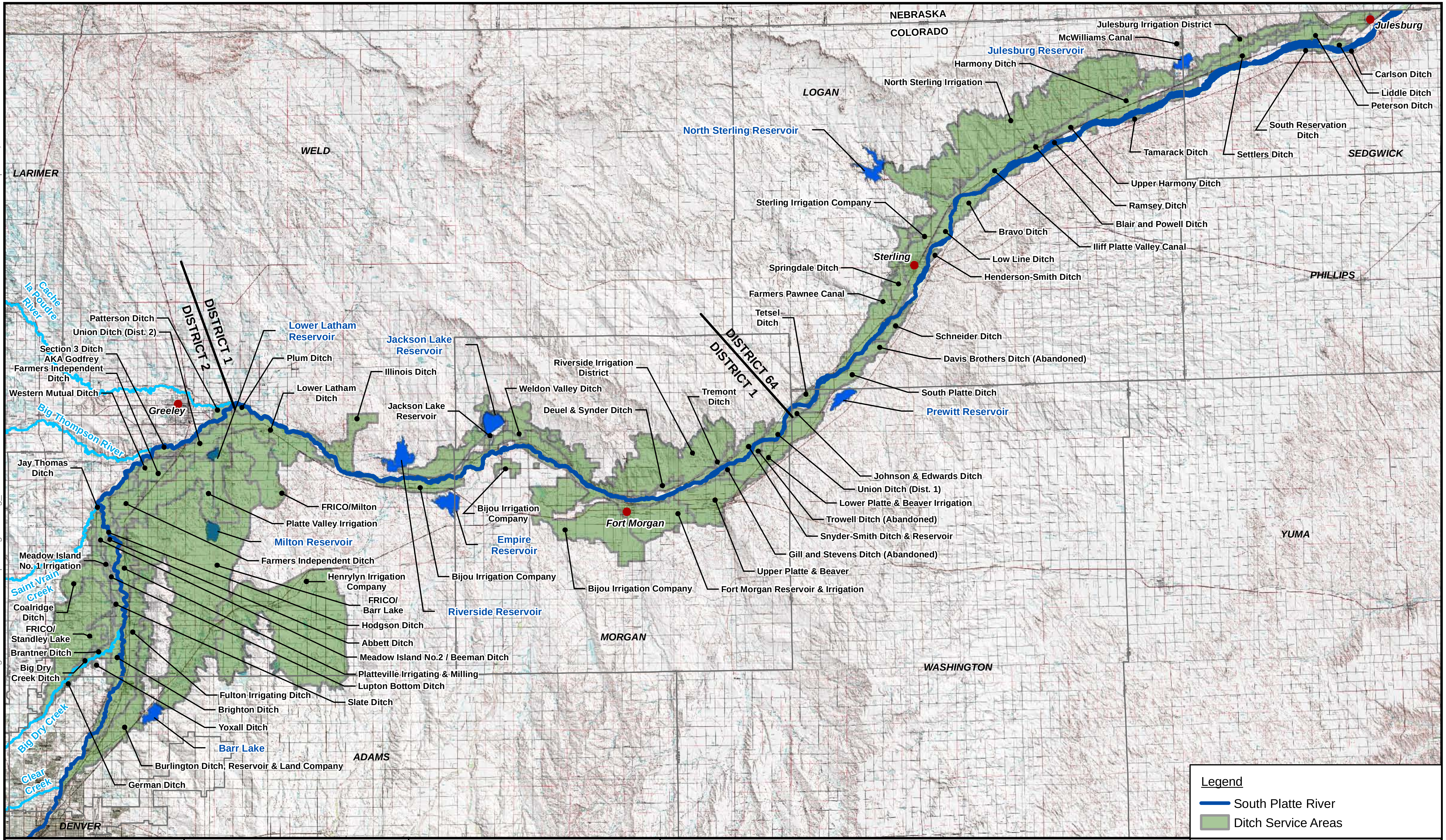
Brown AND Caldwell	Date: April 2011	1 in = 10 miles	Notes	FIGURE 4-6
	Colorado Water Conservation Board		Projection: Universal Transverse Mercator, Zone 13 North, 1983 North American Datum (meters). Locations of ditch headgates and stream gages from South Platte Decision Support System	**Overview of diversion structures in Districts 1, 2, and 64 along the South Platte River**
	Project: 137559			



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Date: April 2011

Colorado Water Conservation Board

Project: 137559

1 in = 10 miles

N E S W

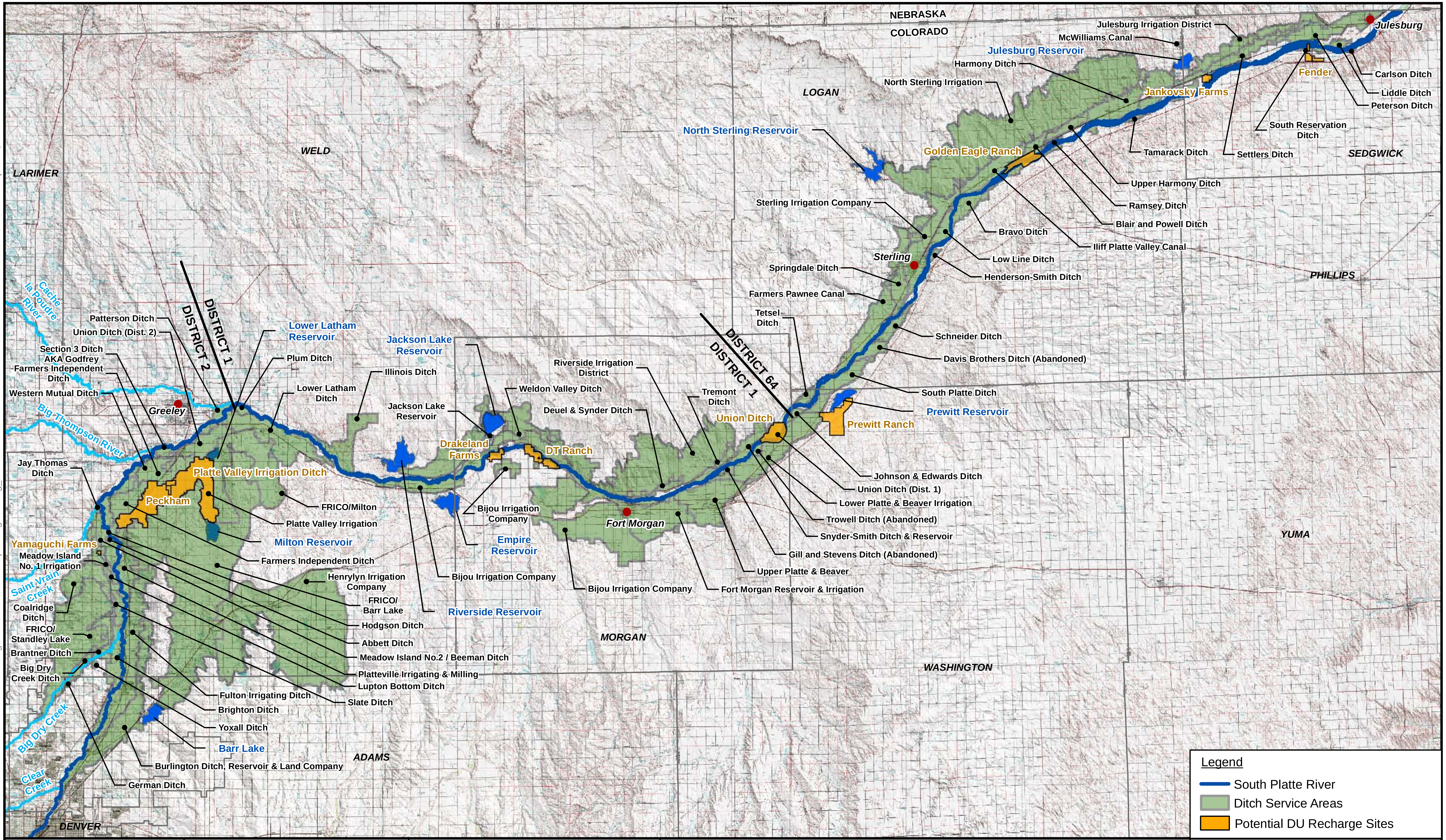
Notes

Projection: Universal Transverse Mercator, Zone 13 North, 1983 North American Datum (meters).

Locations of ditch service areas from South Platte Decision Support System

FIGURE 4-7

Overview of ditch service areas in Districts 1, 2, and 64 along the South Platte River



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1 in = 10 miles

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Projection: Universal Transverse Mercator, Zone 13 North, 1983 North American Datum (meters).

Locations of ditch service areas from South Platte Decision Support System

FIGURE 4-8

Overview of potential locations for Ducks Unlimited wetlands and ditch service areas

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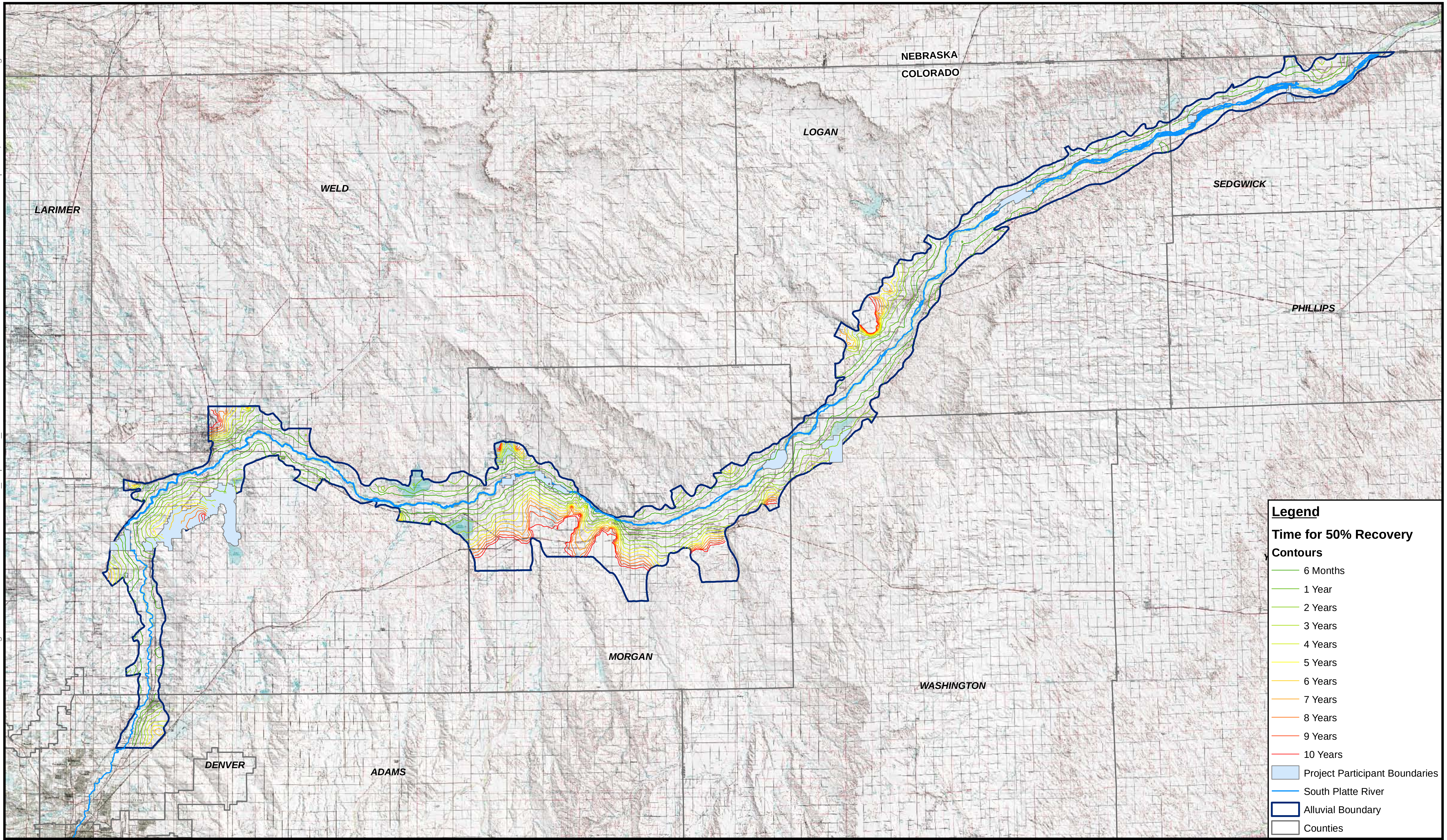

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Colorado Water Conservation Board

Project: 137559

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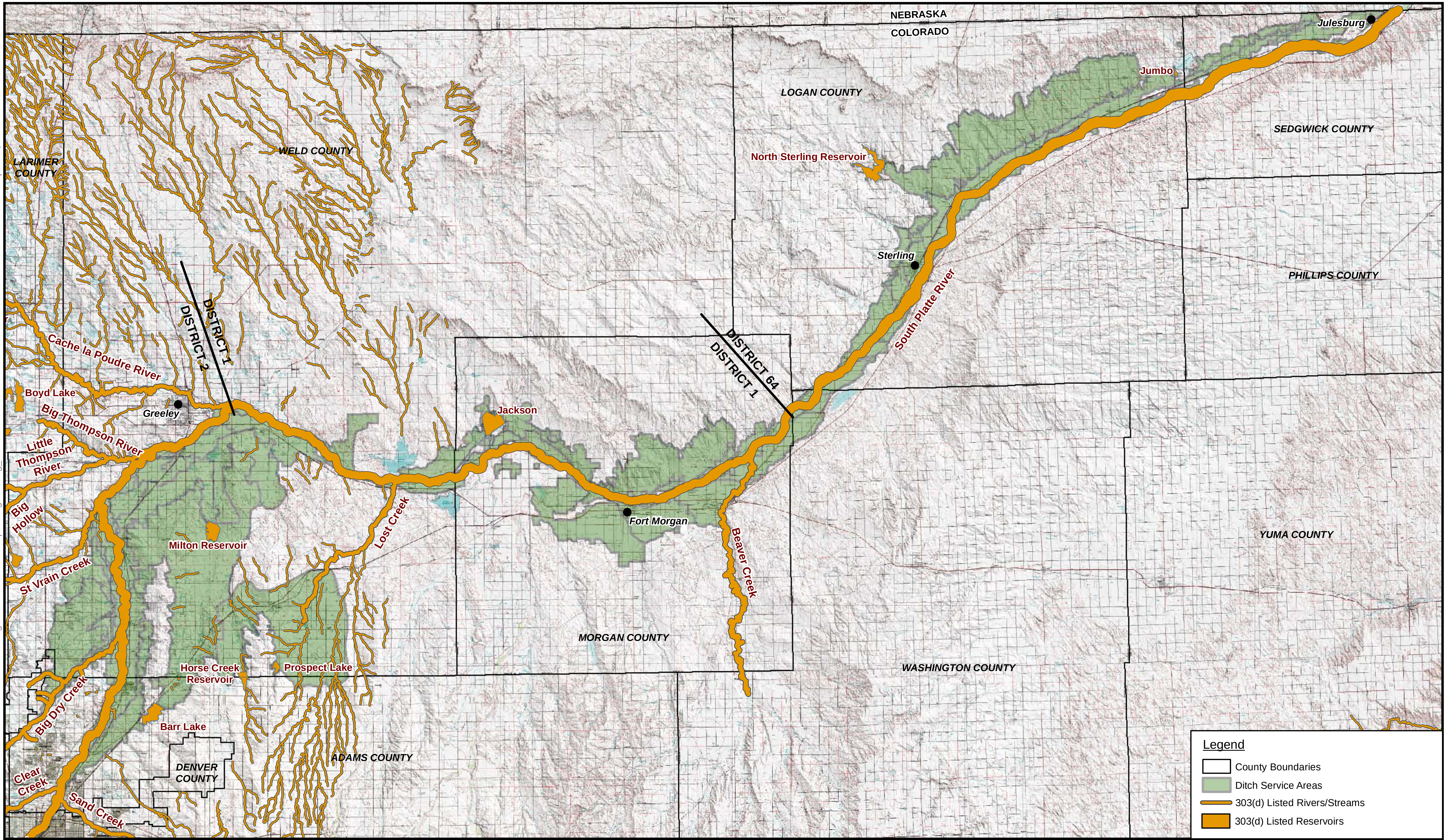
Projection: Universal Transverse Mercator, Zone 13 North, 1983 North American Datum (meters).

FIGURE 4-9

Lagging characteristics of the South Platte alluvial aquifer based on the Glover methodology



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Date: April 2011

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Project: 137559

1 in = 10 miles

Notes

Projection: Universal Transverse Mercator, Zone 13 North, 1983 North American Datum (meters).

Section 303(d) reference from Colorado Department of Public Health and Environment (effective April 30, 2010 revised every two years)

FIGURE 4-10

Tributaries and reservoirs in the South Platte River (Districts 1, 2, and 64) that are included on the Section 303(d) list

Section 5

Demonstration Projects

5.1 PVIC Augmentation Group/Aurora Water (the Flex Water Market)

5.1.1 Introduction

The first demonstration project focuses on the development of a Flex Water Market between the PVIC Augmentation Group (PAG) agricultural water users and the City of Aurora (Aurora). As described earlier in this report, the Flex Water Market has been proposed by the Project Team as an example of the concept of Joint Ownership as a potential mechanism to foster additional alternative transfers. For this demonstration project, several technical, legal, and administrative considerations were explored in the context of establishing a Flex Water Market between PAG and Aurora. PAG and Aurora agreed to participate in the exploration of the Flex Market concept using the details of their respective systems and water rights. The Project Team expresses gratitude to these entities for their contribution of time and resources in the effort to flesh out the example.

5.1.1.1 Flex Water Market

A Flex Water Market is a potential alternative transfer that allows for water transfers between agricultural water users and municipalities in varying amounts from year to year. The agricultural water user or group of users would permanently transfer some minimum percentage ("Base CU") of their historical consumptive use to a municipality, leaving the remaining percentage of consumptive use ("Flex CU") available to that municipality on an as needed or negotiated basis. In concept, Base CU could be provided by permanently drying up a portion of the land historically irrigated with the ditch shares included in the market, or the Base CU could be provided via a rotational fallowing program. Flex CU could be provided by periodic dry-up of lands (similar to an IWSA), or it could also be provided via rotational fallowing. Methods such as deficit irrigation may be used in the future as research on technologies and administration progresses.

Part of the purpose of this demonstration project between PAG and Aurora is to provide specific information regarding the feasibility of successfully implementing a Flex Market between PAG and Aurora, including addressing potential technical, administrative, and legal components.

5.1.1.2 Overview of the Proposed Operation

PAG is a group of Platte Valley Irrigation Company (PVIC) shareholders in the Platte Valley Canal/Evans No. 2 ditch system who have changed some of their irrigation shares to include other uses such as augmentation and replacement. They have changed the use for 8 of their shares, but the group collectively owns 44 shares that could be changed for augmentation and municipal purposes. Changed consumptive use from PVIC shares could be delivered directly to the river through an augmentation station near the Platte Valley Canal river headgate or delivered as recharge credits accruing to the river from a number of recharge facilities.

Aurora is a municipality that could potentially use water transferred from PAG. In a Flex Market, Aurora would receive annual delivery of Base CU purchased from PAG, with the option of obtaining more water (Flex CU) if needed in a given year. Water delivered to the South Platte River by PAG would be exchanged upstream to storage or pumping facilities owned by Aurora.

PAG would need to maintain historical return flows from transferred water (both for Base CU and Flex CU) with respect to timing, amount, and location. PAG can maintain historical return flows by delivering their return flow obligations (separate from the transferrable consumptive use) into their own recharge facilities.

The Flex Market arrangement allows the majority, if not all, of PAG lands to remain in agriculture, while at the same time providing additional water supply to Aurora on a permanent basis and during years of additional need, for example during a dry year or for drought recovery.

The Flex Market Project was pursued as a demonstration project for several reasons as listed below:

- PAG has already changed some of their shares and may change additional shares in the future.
- Aurora could use transferrable consumptive use from PAG either directly as surface water deliveries or as recharge credits from recharge facilities.
- The 2002 to 2008 average annual exchange capacity of the South Platte River in the longest potential exchange reach between the location of PAG recharge accretions north of Gilcrest and Aurora's water facilities is between 100 to over 300 KAF per year but is subject to seasonal interruptions due to calls from senior water rights.
  - The exchange analysis indicates a significant amount of exchange capacity is available in a typical year, however the Jay Thomas and the Hewes Cook Ditches are two potential dry up points, or exchange bottlenecks, between the most downstream location of PAG recharge accretions and Aurora facilities. Exchange may be difficult through these locations during the irrigation season.
- Because the PAG recharge facilities are several miles from the South Platte River, Base or Flex CU from PAG delivered to those recharge facilities would have a return timing such that Aurora would have access to recharge credits on a year-round basis. In addition, PAG could explore the construction or use of alternative recharge facilities that are much closer to the Aurora facilities, which would both shorten recharge return timing and greatly shorten the potential exchange reach.

PAG and Aurora have discussed the potential for working together on an alternative agricultural transfer in the past; therefore it is useful for this demonstration project to explore such a transfer in additional detail to potentially implement in the future. In addition, it is possible that additional PVIC shareholders may be interested in participating in a Flex Water Market, resulting in the expansion of the market.

5.1.2 Facilities

5.1.2.1 PVIC

The PVIC provides water to its shareholders from the Platte Valley Canal and the Evans No. 2 Ditch under a 10/5/1871 priority for irrigation for a diversion up to 177.07 cfs (Adjudication Date: 4/28/1883; Admin No.: 7948.00000; Case No. CA6009). There are 344 outstanding shares in the ditch company.

The farms associated with the PAG are located in Sections 4, 5, and 6 of Township 3N, Range 66W, Sections 23, 25, 26, 33, and 24 of Township 4N, Range 66W, and Section 30 of Township 4N, Range 65W of the 6th P.M. The Platte Valley Canal headgate diverts from the South Platte River in

Water District 2 in the NW ¼ of Section 19, Township 2N, Range 66W between Fort Lupton and Platteville. PAG shares are diverted from the river and delivered via the Platte Valley Canal to the Evans No. 2 Ditch, which bifurcates from the Platte Valley Canal north of Platteville, approximately 10 miles downstream of the river headgate. PAG facilities are shown in Figure 5-1.

Each PAG farm has an existing or planned recharge facility located on or very close to the farm. The recharge facilities can be used to retime historical return flows or to create recharge credits at the South Platte River. The farms and corresponding recharge facilities are located at least three miles from the South Platte River, and return flow timing is relatively slow. Because of the long lag time of aquifer recharge, regular, year-round supplies of recharge credit would result from consecutive years of recharge. In addition, recharge accretions would persist for several years if recharge deliveries were curtailed due to senior calls or other interruptions to recharge deliveries. Since the recharge facilities are located on or very close to the farms themselves, the timing and location of return flows delivered to recharge facilities would correspond to historical return flow timing and location. Delivery of historical return flows to PAG recharge facilities would be a convenient way to maintain historical return flows and to prevent injury to downstream, senior water rights.

It is possible that future PAG recharge facilities may be constructed as wetlands in cooperation with DU. Wetlands provide benefits such as high quality habitat for migrating waterfowl and improved water quality through contamination filtering while at the same time generating recharge credits. Although there is some consumptive use as a result of wetland vegetation, it is comparable to consumptive use resulting from open water evaporation in a typical recharge facility.

In the future, PAG will likely have an augmentation station at or near the Platte Valley Canal river headgate (see Figure 5-1). An augmentation station could be used to deliver PAG's transferrable consumptive use to the South Platte River.

5.1.2.2 Aurora

The City of Aurora is located in the eastern part of the Denver metropolitan area, and it has a population of approximately 312,000. Aurora has several sources of water supply including wells, storage facilities, and surface water rights. Aurora recently constructed the Prairie Waters Project (PWP), which consists of alluvial wells located between Brighton and Fort Lupton, water storage and treatment facilities near the wellfield, and a pipeline and pumping stations that convey water from the wellfield site to additional treatment and storage facilities. Water diverted from the South Platte River via the PWP can be delivered to Aurora's municipal water distribution system or to storage. There are also a number of storage facilities that Aurora uses located near the PWP wellfield, primarily the Everist Pit and Walker Pit. Aurora's facilities are shown in Figure 5-1.

In the Flex Water Market, Aurora would take delivery of PAG's transferrable Base or Flex CU by exchanging water delivered directly to the South Platte River through an augmentation station or by exchanging recharge credits that would accrue to the South Platte River at various locations downstream of Aurora's facilities. Water delivered through PAG's future augmentation station could be exchanged upstream and transferred into one of Aurora's storage facilities. For example, water could be transferred via exchange and delivered to the Everist Pit, which is just upstream of the Platte Valley Canal headgate or to the Walker Pit, which is just downstream of Brighton. In addition, Aurora could use recharge credits accruing to the South Platte River from the PAG recharge facilities. These recharge credits could be exchanged upstream to replace out of priority depletions from the PWP wells or they could be diverted via exchange into storage.

5.1.3 Historical Consumptive Use and Return Flows of PAG Shares

5.1.3.1 Historical Consumptive Use

Based on a recent assessment of historical consumptive use, the 8 PVIC shares owned by PAG water users yield approximately 38 acre-feet of transferrable consumptive use per share. The assessment was conducted in support of Water Court Case No. 08CW71. In the assessment, each farm was considered independently with respect to historical cropping patterns, irrigation methods, and soils. The yield per share estimate is based on the average yield of the PAG farms included in the analysis.

The assessment of historical consumptive use was conducted using the IDSCU model, which was developed by the IDS group at CSU. Inputs to IDSCU include climate data, irrigation methods and efficiencies, cropping patterns, soil types, and irrigation amounts. The following describes the input data to the analysis and the sources of input data:

- Climate data: Mean monthly temperature, monthly precipitation, and frost dates were obtained from HydroBase for weather stations near the Greeley area. Climate data was obtained for the 1950 to 2007 time period.
- Irrigation methods and efficiencies: PAG shareholders were interviewed to obtain the methods used for irrigation over the study period. It was assumed that flood irrigation methods would have a maximum irrigation efficiency of 60 percent, and center pivot irrigation would have a maximum efficiency of 80 percent.
- Cropping patterns: The irrigated acres for each parcel, as well as the cropping patterns, were derived from interviews with the members of the PAG, the current owners of the lands included in the historical use analysis. Historically, PAG shareholders grew a mix of corn (for grain), potatoes, sugar beets, alfalfa, irrigated pasture, wheat, and small amounts of barley, dry beans, and turf grass.
- Soil types: GIS data for soils were available from the SPDSS irrigated lands assessment. The soil coverages were derived from Natural Resources Conservation Service (NRCS) soil maps for counties in Colorado, and included information regarding the available water holding capacity (AWC) of each soil type. The average AWC for soil types on PAG farms was 1.27 inches per foot.
- Irrigation amounts: Pro-rata farm headgate deliveries were estimated assuming an average 16.25 percent ditch loss. The pro-rata farm headgate deliveries were then adjusted based on an analysis of actual irrigation water demands by the crops grown on each farm.

In the future, PAG may change up to 44 PVIC shares historically used for irrigation to augmentation and municipal use. The 44 shares could yield approximately 1,670 acre-feet of transferrable consumptive use on an average annual basis. The water available each year would depend on hydrologic conditions and the call regime on the river.

5.1.3.2 Historical Return Flows

Historical return flows associated with the use of PAG's shares were also quantified in the recently-conducted historical use analysis. The historical use analysis found that the average annual amount of subsurface return flows associated with PAG's shares was 18.6 acre-feet per share. The total amount of historical return flow accruing to the South Platte River from the 44 PVIC shares owned by PAG would be 818 acre-feet per year. In the historical use analysis, it was assumed that return flows were generated from deep percolation of water on each farm and not from end-of-field runoff. The PAG farms are not located near the South Platte River, and it is likely that end-of-field runoff accumulates in road ditches and other depressions, and it seeps into and recharges the alluvial aquifer.

5.1.4 Operation of Flex Market

5.1.4.1 Generation of Transferrable Consumptive Use

In a given year, the transferrable water for the Flex Market will come from suspending irrigation on a portion of land corresponding to the amount of historical consumptive use amount per acre for the shares being transferred. For example, if 1.2 acre-feet of water was historically consumed on each acre of land irrigated, then irrigation would need to be suspended on 10 acres if 12 acre-feet of transferrable water is to be generated. PAG will need to manage the way in which irrigation is suspended on the agricultural fields available to them. For example, to generate transferrable water for Base CU, irrigation may be suspended permanently on specific agricultural fields, or rotational fallowing could be used to change the location of the dried-up lands associated with Base CU each year.

For the Flex CU portion, Aurora would determine each year prior to the irrigation season if and how much of the total potential Flex CU is needed. Depending on the Flex CU amount for a given year, an appropriate portion of land would be temporarily fallowed based on the historical consumptive use per acre. The fallowed lands would likely be distributed among all of the PAG farms so that each farm had some fallowed land, rather than concentrating all the fallowed areas onto one farm.

5.1.4.2 Maintenance of Historical Return Flows

Historical return flows for the PAG shares will need to be maintained in time, location, and amount in order to prevent injury to downstream, senior water rights. Historical return flows for Base CU would need to be maintained consistently from year to year based on the amount of consumptive use permanently transferred in the Flex Market. The historical return flows associated with the Flex CU portion must also be maintained, regardless of whether water is used for irrigation or for augmentation or municipal purposes.

Any portion of the Flex CU still being used for irrigation would naturally create return flows back to the river in the correct amount, time, and location, as had occurred historically. Historical return flows associated with transferred Base CU or Flex CU will also need to be maintained. To do so, the non-transferrable portion of the shares, or the historical return flow portion, would be diverted into the recharge facilities on PAG lands. The recharge facilities into which return flows are delivered will be located on or very near the farms where irrigation is permanently or temporarily suspended. The return flows delivered to the recharge facilities will infiltrate into the alluvial aquifer and will eventually accrue to the river in the correct amount, time, and location as they have historically. Consumptive use of water from the recharge wetlands would need to be considered and added to the amount of water to be delivered to maintain historical return flows. As described above, there are no surface water return flows associated with the historical use of PAG's shares, and therefore, no provision of surface water return flows is necessary in the operation of this Flex Market.

5.1.4.3 Delivery of Water through Augmentation Stations

As described earlier, Aurora has a variety of available water supplies in terms of supply location, timing, volume, etc. Aurora generally has some flexibility in the sources of water they choose to supply their needs. Because of this flexibility, Aurora is not dependent on a specific regime of water deliveries from PAG. In other words, whenever PAG can deliver water, Aurora can use it in a variety of ways.

The most straightforward way for PAG to deliver water to Aurora is to convey transferrable consumptive use to the South Platte River through an augmentation station and to exchange that water upstream to one of Aurora's storage facilities or to the PWP wellfield.

Exchanging transferrable consumptive use from PAG to Aurora via delivery through an augmentation station near the Platte Valley Canal headgate may be the most desirable method for Aurora. The exchange reach is relatively short, and although there are a few intervening rights, they do not typically place a call on the river. Aurora would be able to exchange and use the water as it is delivered to the river and divert to one of their storage facilities for later use or replace depletions from pumping occurring at that time.

PAG could use their proposed augmentation station near the Platte Valley Canal headgate for direct delivery of transferrable consumptive use to the South Platte River. PAG's transferrable consumptive use would need to be exchanged from the point of delivery on the South Platte River to Aurora's facilities, which include the PWP wellfield, the Everist Pit, or the Walker Pit (see Figure 5-1). A description of the various exchange alternatives and potential constraints to exchange are described below:

- The PWP wellfield is located approximately six miles upstream of the Platte Valley Canal headgate. If the augmentation station just downstream of the Platte Valley Canal headgate is used to deliver water to the South Platte River, there are two intervening ditches in this exchange reach - the Meadow Island 1 Ditch and the Platteville Irrigating and Milling Ditch.
- The Everist Pit is filled via Lupton Bottom Ditch with an intake capacity of 35 cfs, approximately seven miles upstream of the Platte Valley Canal point of diversion. If the river headgate augmentation station is used, the same two intervening ditches exist within this reach, Meadow Island 1 Ditch and Platteville Ditch.
- Walker Pit is filled via Brighton Ditch with an intake capacity of 60 cfs, approximately 12 miles upstream of the Platte Valley Canal point of diversion. If the river headgate augmentation station is used there are several intervening ditches including Meadow Island 1 Ditch, Platteville Ditch and Lupton Bottom Ditch.

For these three exchange reaches, all intervening ditches would be senior to Aurora's exchange, and exchange could occur only when none of those intervening rights are calling on the South Platte River. These rights call very infrequently and it is not anticipated that they will significantly impact the ability to exchange water between PAG and Aurora. Between October of 1999 and October of 2008, the Meadow Island No. 1 and the Platteville Irrigating and Milling Ditch did not place a call at any time, and the Lupton Bottom Ditch placed a call for only 3 days.

Delivering water at the augmentation station will require some coordination with the ditch rider. In the Flex Water Market, some of the PVIC shares owned by PAG may still be used for irrigation depending on how much Flex CU is transferred. Shares still used for irrigation would need to be delivered to the PAG farms via the Platte Valley Canal/Evans No. 2 Ditch as they had been historically. Transferred shares delivered to the South Platte River as Base CU or Flex CU would need to be split from designated irrigation shares and accounted for at the augmentation station. The non-consumable portion of PAG's shares designated as historical return flows would need to be delivered to recharge facilities located on PAG farms. PAG would need to coordinate with the ditch rider so that the appropriate amount of water is delivered to PAG farms and through the augmentation station for exchange to Aurora.

5.1.5 Augmentation Credits from Recharge

5.1.5.1 PAG Recharge Facilities

Another option for providing water through the Flex Market is to exchange transferrable consumptive use from PAG to Aurora as recharge credits. As described previously, most of the PAG farms already have or will have on-site recharge facilities. Transferrable consumptive use delivered to these recharge facilities will return to the South Platte River at different times depending on the location and characteristics of each recharge facility. These recharge credits can then be exchanged upstream so that Aurora can use them. For example, the recharge credits could be used to replace out of priority depletions resulting from pumping at the PWP wellfield.

The Alluvial Water Accounting System (AWAS) was used to estimate the lag between the time when recharge is delivered to each of the PAG recharge facilities and the time when the recharge accrues to the South Platte River as streamflow. This model, developed by IDS, uses the Glover Method to lag groundwater returns to the river under an alluvial aquifer condition. The model utilizes input data describing alluvial aquifer characteristics and geometry including harmonic average transmissivity, specific yield, distance from the recharge location to the river, and distance from the river to the alluvium boundary. The Project Team used data acquired from the IDS SPMAP Geographic Information System to determine the appropriate Glover parameters for each recharge location.

Glover parameters were collected for each PAG recharge location and entered into AWAS to determine the timing and amount of recharge credits accreting to the South Platte River. The modeling results showed that the recharge credits take a long time to return the river, in part because of the long distance between PAG recharge facilities and the river (three or more miles). The PAG recharge facilities with the shortest return times are the Hunt Recharge Site 1 and the potential Thompson Recharge Facility (this facility would be in the southwest portion of PAG farms and would be the closest recharge facility to the river headgate). The lag for 75 percent of recharge to return to the river is approximately 7 years at this location.

The Glover parameters and return rates for 75 percent of recharge to return to the river are shown in Table 5-1 below. These return rates are the same for maintaining historical return flows since the same recharge facilities will be used.

Table 5-1. Glover parameters and groundwater return rates for PAG on-farm recharge facilities

Farm	Distance from river to alluvial boundary (feet)	Transmissivity (gpd/ft)	Specific Yield	Distance from river to farm (feet)	75% Groundwater Return Rate (years)
Cecil Potential Recharge	26,559	162,000	0.2	20,210	11
Thompson Potential Recharge	20,153	157,800	0.2	15,929	7
Sandau Properties Potential Recharge	23,957	114,100	0.2	21,193	14
Sandau 5 Star Turf Potential Recharge	27,038	129,700	0.2	24,786	15
Hunt Recharge Site 3	24,855	112,900	0.2	20,720	15
Hunt Recharge Site 2	19,534	128,800	0.2	16,695	8
Hunt Recharge Site 4	21,007	117,700	0.2	20,168	10
Hunt Recharge Site 1	19,002	135,600	0.2	15,183	7
E. Schmidt Potential Recharge	27,405	163,900	0.2	18,707	11

Although ideal for maintaining historical return flows, the recharge facilities located on the PAG farms may not be ideal for retiming and delivering transferrable consumptive use to Aurora. The long return time would mean that Aurora would need to wait for several years until they could take delivery of the majority of water delivered to recharge facilities. For example, if water were delivered to the recharge facilities with the shortest return time, it would take 7 years before Aurora could claim 75 percent of the water delivered to recharge in the first year of the agreement. Also, the recharge accretions would reach the South Platte River at a location downstream from senior water rights (i.e. the Jay Thomas and Hewes Cook Ditches) that frequently place a call on the river. As a result, there would likely be times when Aurora could not exchange their recharge credits to their storage or pumping facilities.

An advantage of using PAG's recharge facilities to generate recharge credits is that the slow and steady return rate would create longer term and year round recharge credits for Aurora to use. Even though the recharge credits generated from PAG recharge facilities may be not be available via exchange during the summer months due to frequent intervening calls, they may be available during the non-irrigation season (November through March), because the recharge credits could be exchanged more frequently due to the lack of senior calls within the exchange reach. This may become an advantage to Aurora in the future if they need to secure more winter augmentation sources. When Aurora is prevented from exchanging their recharge credits during the summer months, they could potentially lease those credits to downstream water users.

5.1.5.2 Alternative Recharge Facility

Another delivery alternative is to deliver transferrable consumptive use from PAG shares into a recharge facility located closer to the South Platte River and upstream of senior calling rights. The Project Team is unaware of potential recharge sites that are accessible to PAG. However, there are several existing recharge sites that PAG could potentially use if they could establish an agreement with the owner. In addition, PAG could consider constructing their own recharge facility in a strategic location near the South Platte River.

The Project Team assessed potentials benefits of delivering transferrable consumptive use to a recharge facility near to the river and that is upstream of the Jay Thomas and Hewes Cook Ditches. The Herman Pond is an example of a decreed recharge facility in this area. If the PAG were to construct a recharge facility within a mile of the South Platte River and in the vicinity of the Herman Pond, the return timing would much faster than for the PAG recharge facilities. It should be noted that the PAG does not have any agreements to deliver water to existing recharge facilities near the South Platte River nor do they have specific plans to construct a recharge facility in this area. The discussion regarding new recharge facilities is only hypothetical.

The AWAS model was used to assess the timing of recharge credits delivered to recharge a site close to the South Platte River upstream of the Jay Thomas and Hewes Cook Ditches. The Glover parameters used for this analysis are shown in Table 5-2.

Table 5-2. Glover parameters and groundwater return rate associated with the hypothetical alternative recharge site for PAG

Distance from river to alluvial boundary (feet)	Transmissivity (gpd/ft)	Specific Yield	Distance from river to recharge facility (feet)	75% Groundwater Return Rate (months)
3,600	60,000	0.2	2,500	7

Figure 5-2 shows the results of the AWAS analysis and the return pattern of recharge credits generated at the South Platte River from the hypothetical recharge site. As shown in Figure 5-2, most of the recharge credits (75 percent) accrue to the river within 7 months, and virtually all recharge reaches the river within 24 months (two years). Transferrable consumptive use delivered to the recharge facility would quickly return to the river, which would benefit Aurora. If a call senior to PVIC's priority date were placed on the river and deliveries to recharge were curtailed, recharge credits at the South Platte River would persist for several months after recharge curtailment and would be available for exchange to Aurora.

5.1.5.3 Summary of Operational Considerations

As shown in the analysis above, there are several options for delivery of transferrable consumptive use from PAG to Aurora. It is likely that Aurora will prefer to simply take delivery of PAG shares via direct conveyance of shares (the consumptive use portion) to the South Platte River and exchange to Aurora's facilities. It is possible that some recharge and retiming of transferrable consumptive use could be advantageous to Aurora if a senior call impacts PVIC's ability to divert water. If PAG were to construct a new recharge facility near the South Platte River, or if they were able to establish an agreement to recharge water using an existing facility, PAG could have several alternatives for tailoring a delivery schedule of recharge credits.

5.1.6 Additional Considerations

5.1.6.1 Timing of Notification to PAG Water Users

PAG would need to know prior to the irrigation season if and how much land they need to fallow in a particular year to provide Flex CU to Aurora. PAG water users start planning for the upcoming irrigation year by purchasing seed, fertilizer, and other inputs starting after harvest the previous year and continuing through the following spring. Ideally PAG water users would be notified if and how much land they would need to fallow before making those planning decisions and purchases (for example before November or December). However, at the latest they would need to know by February 1, or at the very latest March 1, prior to the irrigation season. One of the PAG water users indicated that the fallowed land would likely be shared among the multiple farms since there are several farms included in PAG, rather than concentrating all the fallowed land on one farm.

Each spring, Aurora reviews the status of their water supply for the upcoming season. They review information such as snow pack, streamflows, storage amounts, etc. Aurora's annual water supply plan is reviewed by their city council, and in the past a decision has been reached by March or April regarding the status of their water supply. In the Flex Water Market, Base CU is a permanent transfer; therefore Aurora would have access to some amount of transferrable consumptive use each year. For PAG's planning purposes, it would be ideal if Aurora could notify PAG as early as possible in the spring, for example by March 1, if and how much Flex CU they would like to use from PAG that year. If notification is received at a later date, it is likely that the compensation rate for Flex CU would need to increase to cover PAG input costs incurred during the spring.

5.1.6.2 Administration

Administration would be a cooperative effort between the PAG, PVIC, and Aurora and could potentially be facilitated by a Flex Market Administrator. The PAG or individual shareholders would be responsible for administration on each individual farm unit—taking deliveries into recharge, drying up appropriate acreage, etc. The ditch company would be responsible for coordinating deliveries to the individual farm units and/or to the river on the request of PAG. Aurora would be responsible for administration from the point of delivery on the river to the point of use. The Flex Market Administrator would be responsible for ensuring compliance with the Water Court decree and the contracts between the parties. In this role, he or she would facilitate communication between the parties, gather individual information and perform group accounting, and be the principal contact for the parties and the state and division engineers. There will need to be a mechanism or procedure for the State to properly administer the various uses of water in the Flex Water Market. Agricultural land will need to be fallowed for both Base and Flex CU transfers to Aurora. The State will need to be able to verify and confirm that those lands are not being actively irrigated that year. Some potential methods for verifying land fallowing may include satellite imagery or monumenting.

Accounting will be the responsibility of both Aurora and PAG. PAG will need to provide accounting to the SEO showing the amount of transferrable consumptive use either delivered to the South Platte River or to recharge facilities. If transferrable consumptive use is delivered to recharge facilities, PAG will also need to provide accounting that shows the accrual of recharge credits to the South Platte River. PAG will also need to provide accounting showing that historical return flows were delivered to recharge and that the timing of historical return flows will be matched. PAG may also be responsible for accounting associated with exchanges of water to Aurora, however this may be negotiated in the Flex Market contract. Once water is delivered to Aurora, Aurora will be responsible for accounting for the transferred consumptive use.

5.1.6.3 Legal Issues

Water Court approval of the Flex Market would be necessary. The parties to the Flex Market (in this case, PAG and Aurora) would jointly prosecute a Water Court application seeking to change the use of 100 percent of PAG's shares to municipal and industrial uses (as well as augmentation and other uses that would be beneficial to Aurora). The Water Court decree would allow for the delivery of the Base and Flex CU amounts to Aurora, and would set the terms and conditions upon which the shares could be moved from irrigation to M&I uses and back to irrigation. In addition, it would adjudicate necessary exchanges to facilitate delivery and/or re-capture of unused credits. The decree would contain retained jurisdiction provisions addressing the addition of PAG, other PVIC shares, or other agricultural suppliers and M&I participants to the water market subsequent to the entry of the decree, allowing for growth of the Flex market. Substitute water supply plans could facilitate delivery of the water while the Water Court case is pending.

5.1.6.4 Contractual Issues

Contracting for the Flex Market is an important topic of research and negotiation that the Project Team realized will take more time and effort than was possible under this project. In fact, the sponsors for this project (the CCGA, DU, and Aurora) applied for and were awarded a subsequent ATM grant to develop Flex Market contracting templates and decree terms and conditions. In the next grant project, several parties will be engaged including various agricultural water right owners, water providers, environmental groups, etc. to develop contracting templates and decree terms and conditions. It is anticipated that the next phase of work will explore contracting issues including, but not limited to, the following:

- Compensation for Base CU and Flex CU.
- Terms related to the minimum number of PAG participants or shares needed to trigger a Water Court application.
- Potential for an IWSA prior to Water Court adjudication.
- The degree to which Water Court costs will be shared among the participants.

- Decree terms and conditions and contract terms that will allow other parties to join the Flex Market.
- Reliability of water delivery.
- Cost sharing for new infrastructure.
- Deadlines for notifying the water right owner of the amount of Flex CU needed in a particular year.
- Right of first refusal for sale of shares contracted for Flex CU.
- Length of contract for Flex CU.
- Ability to adjust compensation rates for Flex CU over time.

5.1.6.5 Economic Issues

There are different types of costs associated with the transferred water in a Flex Water Market. Since the Base CU is a permanent transfer, there will likely be a one time cost for that water. The use of Flex CU will vary from year to year. There may be an annual cost for the municipality to "reserve the right" to call on the Flex CU water in a given year, with an additional cost for the amount of Flex CU transferred to the municipality in a year where they need the water. The rates of compensation for both Base and Flex CU are subject to negotiations between the participants in the Flex Market.

High costs associated with Water Court and administration of alternative transfer programs can be an impediment to their potential success. The Flex Market concept seeks to mitigate this by including the pooled resources of several shareholders into the market and by allowing for the expansion of the market. Several PVIC shareholders could be involved with this demonstration project. Because they are under one ditch system, their pooled resource is attractive to Aurora. Also, because the water market is expandable, the amount of water that could be transferred into the program can increase. Additionally, the PVIC service area is located just downstream of the Denver metropolitan area; water quality issues can potentially be mitigated, resulting in lower water treatment costs than supplies that might be acquired and conveyed from locations further downstream. As described previously, there is the potential to exchange water from PAG water users to the PWP wellfield and into Aurora's storage facilities. If water is exchanged to the PWP, then the quality of the water being diverted by the PWP wellfield will be same as other waters diverted by the wellfield.

5.1.7 Conclusions

A Flex Water Market provides an innovative mechanism for alternative agricultural water transfers. This type of transfer provides flexibility to participants, because the amount of water transferred from year to year may vary depending on the end user's needs. Base CU is permanently transferred from the agricultural user to the municipal user, whereas Flex CU is optional for the municipal user to implement in any amount in a given year. Also, as is the case for this demonstration project between PAG and Aurora, the municipality enters into agreement with the agricultural user as a group entity, rather than entering into agreement with each individual farmer.

This demonstration project provides some of the technical details that would be required to implement this Flex Water Market between PAG and Aurora in the future. PAG could provide transferrable consumptive use to Aurora either through direct delivery of water to the river, or as recharge credits to be used to replace out of priority depletions or to be exchanged into Aurora's pumping or storage facilities. The analysis suggests that this demonstration project could benefit both parties by providing both permanent and temporary supplies to Aurora while sustaining irrigated agriculture in the rural area served by PVIC.

5.2 Lower South Platte Water Cooperative (Marketing Framework)

As described in Section 2, establishing a marketing framework for alternative water transfers could aid in removing several barriers to alternative transfers. These barriers include:

- A municipality may be reluctant to contract with numerous individual agricultural producers for water transferred through alternative methods. Establishing numerous, individual contracts would be time consuming and expensive.
- An individual producer may not be able to offer a large quantity of water under an alternative transfer. If numerous individual producers were to pool their water, however, large quantities of water could potentially be offered to prospective water users.
- In many cases, the distance between water supplies and water demands may limit the marketability of an agricultural producer's water.

While the Project Team was researching alternative transfers, a small group of water users and water professionals focused in the Lower South Platte River (the "steering committee") was discussing the possibility of organizing a water cooperative in the area of Water Districts 1 and 64. Members of the steering committee and the Project Team discussed the possibility of working together to further the concept of the marketing mechanism or cooperative. To that end, the Project Team expanded to include the steering committee.

The cooperative would create a mechanism for leasing and exchanging water, allowing those with water supplies to market water to those with water demands. There are a wide variety of water supplies that could be marketed through the cooperative. As described above, the cooperative could provide a much-needed marketing framework for water transferred through alternative methods. In addition, the cooperative could facilitate the marketing of excess augmentation supplies (recharge, direct flow rights, storage, etc.), and newly developed water rights. The cooperative could market these supplies to users who need water, including augmentation plans with less than a 100 percent pumping quota and municipal and industrial water providers.

This demonstration project focused on the feasibility of marketing and exchanging excess recharge credits within the framework of the potential cooperative. The objective of this approach was to build an understanding of the ability to market and exchange different types of supplies using excess recharge credits as an example. The exchange capacity study described in Section 4.1 was used to evaluate the feasibility of exchanging water supplies that are potentially available in Districts 1 and 64.

In Districts 1 and 64 there are a number of well augmentation plans that rely upon recharge credits for operation. In most years, the recharge sites owned and operated by members in these augmentation plans generate recharge credits in excess of the amount needed to offset well depletions during various times of the year. These credits accrue to the river and can potentially be retimed and exchanged. Excess recharge credits that have accrued to the river in recent years are a supply that could readily be marketed through the cooperative. The Project Team viewed excess recharge credits as a surrogate for supplies that could be transferred by alternative methods. If the cooperative could exchange and market excess recharge credits, it could potentially become a marketing mechanism for a variety of water supplies, including alternative transfers.

Specific tasks conducted by the Project Team under this demonstration project included the following:

- Reviewed recent augmentation plan accounting to estimate the amount of excess recharge credits accruing in Districts 1 and 64 (Section 5.2.1).
- Used the exchange capacity analysis to estimate the potential reliability of exchange between various points of supply and demand (Section 5.2.2).
- Identified exchange bottlenecks that could limit the cooperative's ability to reliably exchange water and explored methods to enhance exchange through bottlenecks (Section 5.2.3).
- Estimated the amount of free river in recent years (Section 5.2.4).
- Evaluated the potential to exchange water when there is a call in District 1 and free river in District 64 (Section 5.2.4.1).

5.2.1 Quantification of Excess Recharge Credits

Augmentation accounting data were obtained for the augmentation years of 2005 through 2008 from the State Engineer's Office in Division 1 regarding recharge accretions generated in augmentation plans that operate in Districts 1 and 64. Augmentation years run from April of the current year to March of the next year.

The demonstration project focused on excess recharge credits that were available in 2008. The year 2008 was used for two primary reasons. First, augmentation plan accounting in previous years was not as complete as in 2008. Second, the amount of excess recharge credit that occurred in 2008 was fairly typical, and it could be taken as a relatively representative amount of available excess recharge credit.

The amount of excess augmentation credits accruing to the river in 2008 was estimated using two methods. In the first method, a direct comparison was made between each augmentation plan's monthly recharge credit and its monthly depletion. If recharge credits exceeded depletions, the augmentation plan had a positive net effect on the river and had excess recharge credits that could potentially be exchanged. Negative net effects were included in the sum of excess recharge credits in both Districts 1 and 64. Large leases of excess augmentation credits were also considered. Excess recharge credits associated with the Riverside augmentation plan were reduced by 3,000 acre-feet to account for a known, potential future lease arrangement. Likewise, the excess recharge credits associated with Fort Morgan Reservoir and Irrigation Company (FMRICO) were reduced by 3,100 acre-feet to reflect leases to the Public Service Company and other water users. For the purposes of this demonstration project, it was assumed that the excess recharge credits associated with these leases would not be available to market through the cooperative. If, however, these leases expire or are terminated, these excess recharge credits could potentially be marketed through the cooperative.

In the second method, the net effects were adjusted to account for the fact that most augmentation plans have additional replacement supplies to compensate for deficits in recharge credits, and for free river conditions in District 64, under which the recharge credits are not needed. The adjusted net effect on the river was the amount of excess recharge credit that augmentation plans could potentially market. In the Project Team's opinion, the adjusted net effects are more representative of actual excess recharge credits than the net effects.

The adjusted net effects were estimated using the following assumptions:

- District 64 augmentation plans include replacement supplies other than recharge credits to cover depletions. Negative net effects for District 64 augmentation plans were removed from the analysis.
- There was no call on the river below the Harmony Ditch headgate in the months of November 2008 through March 2009. This is typical during the winter in this section of the river. As a result, positive net effects (excess recharge credits) were removed for augmentation plans below the Harmony.
- There was no call in District 64 during the months of December 2008 through February 2009 (which is typical). Positive net effects were removed from the analysis during these months.
- The Public Service Company and Bijou augmentation plans include sources other than recharge to cover depletions. Negative net effects from these plans were removed from the analysis.
- Excess recharge credits are frequently leased among the augmentation plans in District 1. Therefore, negative net effects were allowed to remain in the District 1 analysis under the assumption that plans with positive net effects leased credits to plans with deficits.
- Reductions in excess recharge credits associated with leases from the Riverside and FMRICO applied to the analysis of adjusted net effects.

Table 5-3 and Table 5-4 show the estimated net effects (excess recharge credits calculated using the first method) and estimated adjusted net effects (excess recharge credits calculated using the second method) for each augmentation plan included in the analysis. As shown in Table 5-3 and Table 5-4, excess recharge credits in District 1 range from 5,900 acre-feet to 13,800 depending on the assumptions and method used to estimate excess recharge credits. In District 64, the range of available excess recharge credits in 2008 was 5,400 acre-feet to 11,000 acre-feet. Note that these totals include reductions to account for the Riverside and FMRICO leases described above. If or when these leases expire, or if the lessees do not use the all of the water leased to them, there may be additional excess recharge credit available for transfer.

Table 5-5 shows a summary of excess recharge credits broken out into several “aggregation points.” The aggregation points were developed to simplify and limit the locations from which excess recharge credits would be exchanged. Net effects and adjusted net effects were summed for augmentation plans located between aggregation points. The aggregation points used for this analysis are reflected in Table 5-5 and are described in more detail in Section 5.2.2.

It should be noted that the total net effects in District 64 shown in Table 5-5 increased above the amounts shown in Table 5-3. When net effects in District 64 were evaluated at the three aggregation points, larger excesses were estimated primarily because augmentation plans with negative net effects in the Sterling No. 1 to Harmony No. 1 reach did not impact net effects calculated above Sterling No. 1 and below the Harmony No. 1. The augmentation plans with negative net effects in the Sterling No. 1 to Harmony No. 1 reach did, however, impact the estimate of total net effects on a district-wide basis.

The Project Team assumed that excess recharge credits generated by augmentation plans would be available for transfer. However, some augmentation plans may include terms and conditions that limit the ability to transfer excess recharge credits. The scope of this study prevented a detailed review of the decrees for all of the augmentation plans that were included. In addition, the Project Team did not want to limit the quantification of excess recharge credits that are available for transfer, because the potential exists for augmentation plans to re-open their decrees in the future in an effort to more efficiently manage excess recharge credits. In the future the cooperative’s research team will be conducting a legal review of conditions that could limit the ability of augmentation plans to transfer excess recharge credits.

Table 5-3. Calculation of recharge accretions minus depletions (net effects) for augmentation year 2008

District 1 Augmentation Plan	2008									2009			Total
	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	
LP&B	406	354	249	151	108	132	87	158	86	111	92	154	2,088
Pioneer	271	409	214	79	-7	36	138	285	219	166	124	237	2,170
Wind	0	-3	-3	-3	-3	-2	0	-3	-3	-3	-3	-3	-27
UP&B	1,417	653	192	188	302	370	933	579	248	186	236	1,502	6,806
English Feedlot	2	2	2	2	2	1	1	0	2	0	1	6	20
Pinneo Feedlot	29	28	29	30	32	33	35	38	37	34	32	31	389
City of Brush	0	0	0	0	0	0	0	19	18	15	13	15	79
Badger Beaver	0	0	0	0	0	0	0	0	0	0	0	0	0
D&S	72	57	47	41	86	57	43	38	88	80	48	49	706
T&M Livestock	0	0	0	1	7	2	2	2	2	2	2	0	20
Riverside	27	36	26	24	31	44	39	32	17	14	21	33	343
FMRICO	485	467	420	331	425	386	373	377	323	202	138	323	4,248
PSCO	-269	0	-5	5	-54	0	-592	-655	-644	-243	-410	-137	-3,002
City of Ft. Morgan	-4	-12	-30	-48	-50	-47	-46	-35	-29	-22	-17	-20	-359
MCQWD	0	0	1	1	1	1	1	-1	1	-1	-1	-1	1
Ft. Morgan Farms	-56	-57	-55	-57	-58	-57	-61	-60	-63	-63	-56	-52	-694
Jensen Teague	-92	-142	-132	-140	-128	-128	-92	-233	-257	-393	-299	-311	-2,347
Bijou	-322	-338	-424	-499	-558	-552	-535	-474	-516	-551	-585	-541	-5,895
Groves Farms	-47	-31	-56	-69	-93	-92	-90	-63	-84	-48	-42	-37	-751
OWW	22	22	21	21	18	14	12	9	8	6	2	3	158
Goodrich	72	75	73	76	77	75	77	75	77	76	68	75	896
Subtotal	192	-307	-200	-439	1,426	1,929	1,429	533	119	-101	0	268	4,849
[1]Total	**192**	**0**	**0**	**0**	**1,426**	**1,929**	**1,429**	**533**	**119**	**0**	**0**	**268**	**5,897**

District 64 Augmentation Plan	2008									2009			Total
	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	
LSPWCD	166	204	241	121	65	20	1	-245	-243	-227	-146	-520	-563
SCWU	13	2	-196	-612	-681	-591	-480	-451	-464	-331	-243	-170	-4,204
Dinsdale	107	69	61	-193	-340	-305	-192	-440	-507	-599	-459	-480	-3,278
Harmony	289	192	162	141	108	109	121	124	131	132	119	252	1,881
Condon	544	513	277	44	-118	-173	-57	64	-35	-12	1	384	1,432
LLWU	131	399	587	275	73	-165	-76	-151	-1,755	-2,513	-2,292	-1,070	-6,557
Harris	51	16	-27	-37	-10	-11	-27	-5	-8	-3	0	14	-46
Hurst	82	-49	-95	-210	-192	-165	-58	26	54	114	149	155	-189
North Sterling	75	307	364	280	212	169	144	120	101	86	75	78	2,011
Lowline	106	79	44	0	0	16	72	83	41	36	108	171	756
LWU	459	277	-194	-667	-931	-819	-590	-447	-350	-110	85	488	-2,799
PWU	162	155	124	62	52	67	89	107	103	90	73	74	1,158
City of Sterling	-39	-302	-418	-480	-363	-324	-68	35	0	0	0	2	-1,957
SPDWU	153	150	109	91	74	67	86	103	128	138	141	56	1,296
Vandemoer	37	42	27	12	2	7	16	15	17	28	29	40	270
Quint	0	0	0	0	0	0	-7	-17	-14	38	-9	-6	-14
Valley View	-2	-1	-3	-3	-3	-4	-3	-3	-3	-4	-3	-3	-35
FL Gill	0	0	0	-1	-2	-1	-1	-1	0	0	0	-1	-6
Subtotal	2,334	2,052	1,062	-1,176	-2,053	-2,103	-1,029	-1,081	-2,805	-3,136	-2,374	-536	-10,844
[1]Total	**2,334**	**2,052**	**1,062**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**5,448**

[1]Negative values were removed from totals to account for other sources of augmentation supply that are used by augmentation plans to prevent the occurrence of negative net effects

Table 5-4. Adjusted calculation of recharge accretions minus depletions (adjusted net effects) for augmentation year 2008

District 1 Augmentation Plan	2008									2009			Total
	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	
LP&B	406	354	249	151	108	132	87	158	86	111	92	154	2,088
Pioneer	271	409	214	79	-7	36	138	285	219	166	124	237	2,170
Wind	0	-3	-3	-3	-3	-2	0	-3	-3	-3	-3	-3	-27
UP&B	1,417	653	192	188	302	370	933	579	248	186	236	1,502	6,806
English Feedlot	2	2	2	2	2	1	1	0	2	0	1	6	20
Pinneo Feedlot	29	28	29	30	32	33	35	38	37	34	32	31	389
City of Brush	0	0	0	0	0	0	0	19	18	15	13	15	79
Badger Beaver	0	0	0	0	0	0	0	0	0	0	0	0	0
D&S	72	57	47	41	86	57	43	38	88	80	48	49	706
T&M Livestock	0	0	0	1	7	2	2	2	2	2	2	0	20
Riverside	27	36	26	24	31	44	39	32	17	14	21	33	343
FMRICO	485	467	420	331	425	386	373	377	323	202	138	323	4,248
PSCO	--	0	--	5	--	0	--	--	--	--	--	--	5
City of Ft. Morgan	-4	-12	-30	-48	-50	-47	-46	-35	-29	-22	-17	-20	-359
MCQWD	0	0	1	1	1	1	1	-1	1	-1	-1	-1	1
Ft. Morgan Farms	-56	-57	-55	-57	-58	-57	-61	-60	-63	-63	-56	-52	-694
Jensen Teague	-92	-142	-132	-140	-128	-128	-92	-233	-257	-393	-299	-311	-2,347
Bijou	--	--	--	--	--	--	--	--	--	--	--	--	0
Groves Farms	-47	-31	-56	-69	-93	-92	-90	-63	-84	-48	-42	-37	-751
OWW	22	22	21	21	18	14	12	9	8	6	2	3	158
Goodrich	72	75	73	76	77	75	77	75	77	76	68	75	896
Total	**1,321**	**852**	**594**	**555**	**2,104**	**2,520**	**1,767**	**961**	**618**	**511**	**552**	**1,395**	**13,751**

District 64 Augmentation Plan	2008									2009			Total
	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	
LSPWCD	166	204	241	121	65	20	1	--	--	--	--	--	818
SCWU	13	2	--	--	--	--	--	--	--	--	--	--	15
Dinsdale	107	69	61	--	--	--	--	--	--	--	--	--	237
Harmony	289	192	162	141	108	109	121	--	--	--	--	--	1,123
Condon	544	513	277	44	--	--	--	--	--	--	--	--	1,378
LLWU	131	399	587	275	73	--	--	--	--	--	--	--	1,465
Harris	51	16	--	--	--	--	--	--	--	--	--	14	81
Hurst	82	--	--	--	--	--	--	26	--	--	--	155	263
North Sterling	75	307	364	280	212	169	144	120	--	--	--	78	1,749
Lowline	106	79	44	0	0	16	72	83	--	--	--	171	571
LWU	459	277	--	--	--	--	--	--	--	--	--	488	1,224
PWU	162	155	124	62	52	67	89	107	--	--	--	74	892
City of Sterling	--	--	--	--	--	--	--	35	--	--	--	2	37
SPDWU	153	150	109	91	74	67	86	103	--	--	--	56	889
Vandemoer	37	42	27	12	2	7	16	15	--	--	--	40	196
Quint	0	0	0	0	0	0	--	--	--	--	--	--	0
Valley View	--	--	--	--	--	--	--	--	--	--	--	--	0
FL Gill	0	0	0	--	--	--	--	--	--	--	--	--	0
Total	**2,375**	**2,404**	**1,996**	**1,026**	**585**	**455**	**530**	**490**	**0**	**0**	**0**	**1,078**	**10,938**

Table 5-5. Excess recharge credits summed at various aggregation points

2008 Excess Recharge Accretions Based on Net Effects

Month	District 1 (cfs)	District 64 — Prewitt to Sterling #1 (cfs)	District 64 — Sterling #1 to Harmony #1 (cfs)	District 64 — Harmony #1 to State Line (cfs)	District 64 Total
January	0	7	0	0	
February	0	12	0	0	
March	23	15	0	0	
April	32	16	0	22	
May	23	12	2	19	
June	9	6	0	11	
July	2	0	0	0	
August	0	0	0	0	
September	0	0	0	0	
October	4	4	0	0	
November	3	7	0	0	
December	0	5	0	0	
Total in AF	5,897	5,049	127	3,161	8,337

2008 Excess Recharge Accretions Based on Adjusted Net Effects

Month	District 1 (cfs)	District 64 — Prewitt to Sterling #1 (cfs)	District 64 — Sterling #1 to Harmony #1 (cfs)	District 64 — Harmony #1 to State Line (cfs)	District 64 Total
January	10	0	0	0	
February	10	0	0	0	
March	34	12	6	0	
April	42	15	4	22	
May	29	15	5	19	
June	16	10	8	15	
July	10	7	3	6	
August	8	6	1	3	
September	9	5	0	2	
October	23	5	1	2	
November	22	6	2	0	
December	14	0	0	0	
Total in AF	13,751	4,954	1,813	4,144	10,911

5.2.2 Exchange Analysis and Results

As shown in Table 5-3 and Table 5-4, there are several augmentation plans in various parts of the South Platte River that have periodic excess recharge credits. One of the goals of the potential Lower South Platte Water Cooperative is to help augmentation plans with excess recharge credits market and transfer their excess supplies. The ability to reliably exchange water supplies upriver is important to the marketability of excess recharge credits and of water transferred using alternative methods.

Excess recharge credits and potential end users of those credits (i.e. municipal and industrial water providers, augmentation plans, etc.) are located at numerous points on the river. If each augmentation plan with excess recharge credits and each potential user of those credits were considered in the exchange analysis, the number of exchange analyses that could be conducted under this demonstration project would be excessively large. To streamline the analysis, the exchange evaluation conducted for this demonstration project focused on assessing the reliability of a few specific exchange reaches.

Table 5-5 summarized the excess recharge credits at four aggregation points. The aggregation points were established in order to simplify the analysis. At each aggregation point, excess recharge credits were summed. The aggregation points and exchange reaches were developed using the following assumptions and considerations:

- The total monthly excess in District 1 could be aggregated near the bottom of District 1, just upstream of the North Sterling Canal and could be represented as an individual “exchange from” point.
- The “exchange to” point was considered to be the mouth of the Cache la Poudre River. If water can be exchanged to the Cache la Poudre River, it could be marketed to a number of agricultural, municipal, and industrial end users.
- Excess recharge credits accruing to the South Platte River between the bottom of District 1 and the Sterling No. 1 headgate could be aggregated just upstream of the Sterling No. 1 headgate. As a result, the Sterling No. 1 headgate became another “exchange from” point.
- It would be difficult to exchange between points on the river downstream of Sterling No.1 upstream to the Poudre because there are several exchange bottlenecks in this reach. As a result, the demonstration project focused on the exchange reaches below.
  - The downstream end of District 1 (just upstream of the North Sterling Canal) to the mouth of the Cache la Poudre River.
  - The Sterling No. 1 headgate to the mouth of the Cache la Poudre River.
- Future analyses of the Lower South Platte will incorporate an evaluation of exchanges from points below the Sterling No. 1 headgate.

The exchange analysis tool described in Section 4.1 was used to assess the reliability of exchange over the 2002 to 2008 time period for the two exchange reaches described above. It was assumed that the amount of water available for exchange in each year corresponded to the amounts of excess recharge credits shown in Table 5-5. Using this methodology, an evaluation was conducted to quantify the potential to exchange typical amounts of excess recharge credits (as represented by 2008 amounts) over differing hydrologic conditions (2002 through 2008 conditions).

Using the exchange analysis tool, the daily amount of excess recharge credit (in terms of cfs) was compared with the minimum flow rate within the exchange reach on a daily basis. The lower of the minimum flow rate in the exchange reach and the amount of excess recharge was considered to be the amount exchanged on each day. On days when there was a call in the exchange reach, no water was exchanged. In addition, on days when there was free river, no exchange was necessary. This process was used to assess exchange potential for both the downstream end of District 1 – Cache la Poudre River reach and the Sterling No. 1 – Cache la Poudre River reach.

The daily amounts of water exchanged were summed on a monthly and annual basis. The results of the analysis are summarized in Table 5-6. Results presented in Table 5-6 are relative to excess recharge credits calculated using assumptions for adjusted net effects. As stated earlier in this section, the Project Team concluded that the adjusted net effects are more representative of the actual amount of excess recharge credit that was available in 2008.

Table 5-6. Summary of exchange analysis for excess recharge credits derived using adjusted net effects

	Exchanging from downstream end of District 1 to mouth of Poudre		Exchanging from just upstream of Sterling No. 1 to mouth of Poudre	
	Average annual amount	Range over study period	Average annual amount	Range over study period
Volume of excess recharge (acre-ft)	13,800	--	5,000	--
Volume of recharge potentially exchanged (acre-feet)	9,700	7,500 – 11,700	2,200	1,500 – 3,300
Percentage of recharge potentially exchanged	70%	54% - 85%	45%	31% - 66%
Percentage of recharge accretions occurring when exchange not necessary (free river)	8%	0% - 24%	8%	0% - 24%
Percentage not exchanged for lack of exchange potential	21%	15% - 31%	47%	33% - 68%

Several conclusions can be drawn from the data in Table 5-6:

- Most of the excess recharge credits that are typically available could have been exchanged from the downstream end of District 1 (just upstream of the North Sterling Canal) to the mouth of the Cache la Poudre River.
- The average annual percentage of excess recharge credit exchanged between the Sterling No. 1 headgate and the mouth of the Cache la Poudre River is significantly lower than the average annual percentage of water exchanged from the downstream end of District 1 to the mouth of the Cache la Poudre River. Exchange between the Sterling No. 1 headgate and the Cache la Poudre River is impacted by bottlenecks such as the North Sterling Canal and Prewitt Inlet.
- The annual percentage of recharge that could potentially be exchanged varied substantially in both exchange reaches. Some end users of excess recharge credits may need a more reliable supply than what could be supplied by exchange alone. Storage could help enhance the cooperative's ability to deliver water to end users when exchange capacity is not available.
- Notwithstanding the above, there is a significant amount of excess recharge credit that could be exchanged upstream and made available for other water users.

5.2.3 Enhancing Exchange Potential

Bottlenecks decrease average exchange capacity and can prevent exchange during key times of the year. The Project Team explored a method of enhancing exchange potential through bottlenecks that involves pumping water from downstream of a calling right into the ditch owned by the calling right. The amount of additional water provided to the calling right could be diverted upstream in an exchange without injuring the calling right. In other words, an exchange through the calling right could potentially be conducted at a flow rate equivalent to the flow rate of additional water provided to the calling right.

This concept was tested on one of the most significant bottlenecks on the South Platte River. The North Sterling Canal and Prewitt Inlet are located at the downstream end of District 1. The headgate for the North Sterling Canal is approximately 4 miles upstream of the Prewitt Inlet. These structures frequently place calls on the river. As shown on Figures 4-2 and 4-3, exchange potential decreases significantly at these locations. The exchange bottleneck created by these two structures is the primary reason for the differences in exchange reliability for the two exchange reaches described in Table 5-6.

The exchange analysis tool was used to assess potential increases in exchange capacity resulting from the installation of a pumping station downstream of the North Sterling Canal and Prewitt Inlet. The analysis assumed that a pumping station and pipeline could be installed to convey alluvial groundwater from downstream of the North Sterling Canal/Prewitt Inlet and into either of these waterways. Various sizes of pumping stations were analyzed with flow rates of 5 cfs, 10 cfs, and 15 cfs. On days when the North Sterling Canal or the Prewitt Inlet was calling, an exchange capacity corresponding to the flow rate of the various pumping stations was used. The amount of water exchanged through the North Sterling Canal or Prewitt Inlet when they were calling was the minimum of the pumping station flow rate, the minimum flow rate in the exchange reach, or the flow rate associated with the excess recharge credits. The exchange reach for this analysis was assumed to be the Sterling No. 1 headgate to the mouth of the Cache la Poudre River. The results of the daily analysis performed with the exchange analysis tool were summed on a monthly and annual basis.

5.2.3.1 Results

The results of the analysis showed varying levels of benefit from the pumping station. Table 5-7 shows the benefits to exchange potential resulting from various pumping station flow rates. The information in the table is also depicted in Figure 5-3.

Table 5-7. Comparison of percent of recharge exchanged through the North Sterling Canal/Prewitt Inlet using pumping stations of various flow rates

Year	No pumping station	Flow rate of pumping station		
		5 cfs	10 cfs	15 cfs
2002	43%	44%	45%	45%
2003	32%	47%	60%	69%
2004	61%	66%	68%	68%
2005	35%	46%	54%	60%
2006	66%	76%	80%	82%
2007	31%	42%	51%	56%
2008	47%	64%	70%	72%
Average	45%	49%	54%	57%

Both Table 5-7 and Figure 5-3 show that exchange capacity through the North Sterling Canal/Prewitt Inlet can be enhanced with the addition of a pumping station and pipeline. The percentage of excess recharge credits that could be exchanged increased 4, 9, and 12 percent with pumping station flow rates of 5, 10, and 15 cfs, respectively. At a pumping station flow rate of 15 cfs, most of the excess recharge credits accruing in the Prewitt Inlet to Sterling No. 1 reach could be exchanged to the mouth of the Cache la Poudre River in every year but 2002. For this analysis, there was no additional benefit for pumping stations larger than 15 cfs, because the maximum flow rate of excess recharge accretions used in this analysis was 15 cfs in the Prewitt Inlet to Sterling No. 1 reach of the South Platte River.

This analysis should be refined in the future. While this analysis did not show benefits for pumping stations greater than 15 cfs, it only considered flow rates associated with excess recharge credits. If other types of water become available for exchange through the pumping station in the future (i.e. water from alternative transfers), larger pumping stations would potentially provide additional enhancements to exchange. A cost-benefit analysis should also be conducted on pumping stations of various sizes. For example, it is expected that the full capacity of larger pumping stations would be used less frequently than the full capacity of smaller pumping stations. An analysis should be conducted to determine the size of pumping station that results in the optimum return on investment considering frequency of use and amount of additional water exchanged. In addition, pumping stations could be analyzed at other exchange bottlenecks in the South Platte River.

5.2.4 Free River Analysis

The Lower South Platte Water Cooperative could potentially apply for new, junior storage rights to help boost delivery of supplies to end users or “customers.” A new, junior storage right will only be able to divert when there is free river. To better understand how much and where free river has recently occurred, an investigation was conducted to assess amounts and locations of free river over the 2002 to 2008 time period.

The point flow and call assessment components of the exchange analysis tool were used to develop a data set describing the amount of free river that passed various headgates on the South Platte River from 2002 to 2008. On days when there was no call on the river, the flow at each headgate between the Burlington Ditch and the state line was summed as a part of the free river analysis. Free river amounts were summarized on monthly and annual bases.

Figure 5-4 shows the average annual amounts of free river on the South Platte River broken down into storage season, direct flow season, and total annual results for the years 2002 through 2008. Average annual amounts of free river are also shown on Figure 5-5 which includes a map of the South Platte River basin in Districts 1, 2, and 64. On average, approximately 50,000 acre-feet of free river annually passed by headgates on the South Platte River between the Burlington Ditch and the state line. The amount varied geographically. The highest amounts of free river occurred in the Union Ditch to Empire Ditch reach (nearly 80,000 acre-feet) while the lowest average annual amounts of free river occurred just downstream of the Burlington Ditch and near the North Sterling Canal and Prewitt Inlet (approximately 30,000 acre-feet)

Seasonal results in Figure 5-4 show that more free river was available in the upstream reaches of the South Platte River during the direct flow season (April through October) than the storage season (November through March). The majority of free river occurred in the direct flow season (as opposed to the storage season) between the Burlington Ditch and the North Sterling Canal. Downstream of the Prewitt Inlet, the amount of free river occurring in the direct flow and storage seasons was nearly the same. The maximum average annual amount of free river during the direct flow season occurred at the Empire Ditch headgate (nearly 60,000 acre-feet), and the maximum average annual amount of free river during the storage season occurred at the Liddle Ditch headgate just upstream of the state line (approximately 27,000 acre-feet).

Annual results of the free river analysis were also assessed. Figure 5-6 shows the amount of free river that occurred in each year of the analysis from the Burlington Ditch to the state line. The amount of free river varied greatly among the years in the analysis. Up to 340,000 acre-feet of free river passed through the Union Ditch to Empire Ditch reach during 2007, while no free river was available in 2003 and 2004 upstream of the North Sterling Canal. In 2002, 2003, 2004, 2006, and 2008, there was as much or more free river available downstream of the Prewitt Inlet than upstream.

The results of the free river analysis suggest that, while 50,000 acre-feet of free river may occur on an average annual basis, annual amounts vary greatly, and storage or recharge facilities would be useful for firming the annual yield of junior water rights dependent on free river. In addition, it is unknown to what degree diversion of free river for new water rights would trigger a call (this should be assessed in future analyses). In the future, the Lower South Platte Water Cooperative will be able to use these results in assessing strategies for providing reliable supplies for end users of excess recharge credits or water transferred through alternative methods.

5.2.4.1 Exchange of District 64 Free River

The North Sterling Canal or Prewitt Inlet routinely place calls on the South Platte River that impact upstream diverters. However, there are times of free river in District 64 when either the North Sterling Canal or Prewitt Inlet is placing a call on the river. The Project Team quantified the amount of free river in District 64 during these times using the point flow and call assessment components of the exchange analysis tool.

Free river occurring in District 64 could potentially be exchanged upstream of the North Sterling Canal or Prewitt Inlet using a pumping station and pipeline in the same manner as described earlier in this section for enhancing exchange potential. District 64 free river could be exchanged upstream of the North Sterling Canal or Prewitt Inlet if the amount diverted upstream for exchange purposes was replaced by pumping an equal amount of District 64 free river water directly into the North Sterling Canal or Prewitt Inlet when one or both of these structures are calling.

Free river occurring in District 64 was quantified at the Pawnee Ditch headgate. The free river analysis described above was used to quantify the amount of free river at this location. This location was chosen, because the reach between the South Platte Ditch and the Pawnee Ditch may be a suitable location for a pumping station to capture free river in District 64. Table 5-8 shows the amount of free river at this location for the years 2002 through 2008. The annual amount of free river that occurred at the Pawnee Ditch headgate varied from 1,300 to 27,400 acre-feet and averaged 16,500 acre feet.

Table 5-8. Amount of free river occurring at the Pawnee Ditch headgate when there was a call in District 1

Year	Amount of free river (acre-feet)
2002	27,400
2003	4,200
2004	1,300
2005	22,500
2006	18,900
2007	15,400
2008	25,600
Average	16,500

The exchange analysis tool was used to quantify the amount of District 64 free river that could be exchanged from the Pawnee Ditch headgate to the mouth of the Cache la Poudre River assuming that a pumping station could be used to exchange through the North Sterling Canal or Prewitt Inlet when these structures are calling. Pumping station flow rates of 5, 10, 20, and 30 cfs were included in this analysis. On a daily basis from 2002 to 2008, the exchange analysis tool evaluated the amount of District 64 free river water that could potentially be exchanged by comparing the amount of free river water available at the Pawnee Ditch headgate, pumping station capacity, and the minimum flow rate in the South Platte River downstream of the Cache la Poudre River and upstream of the North Sterling Canal or Prewitt Inlet. The minimum flow rate among those three parameters was the amount of water that could have been exchanged. No exchange was possible on days when there was a call on the South Platte River between the Cache la Poudre River and the North Sterling Canal or Prewitt Inlet. The results of this analysis were summarized on an average annual basis and are shown in Table 5-9 below.

Table 5-9. Amounts of District 64 free river that could be exchanged to the mouth of the Cache la Poudre River using various sizes of pumping stations near the North Sterling Canal/Prewitt Inlet

Size of pumping station	Volume exchanged (AF/yr)	Percent of free river exchanged
5 cfs	400	2%
10 cfs	800	5%
20 cfs	1,400	8%
30 cfs	2,000	12%

The results of the analysis suggest that pumping station flow rates limit the amount of District 64 free river water that could be exchanged upstream of the North Sterling Canal or Prewitt Inlet. Oftentimes, the amount of free river available at the Pawnee Ditch headgate and the minimum South Platte River flow rate between the Cache la Poudre River and the North Sterling Canal or Prewitt inlet exceeded the capacity of the various pumping stations included in the analysis. As a result, a relatively small percentage of available District 64 free river could have been exchanged. Storage or recharge downstream of the North Sterling Canal or Prewitt Inlet could be useful in capturing and retiming District 64 free river so that it could be exchanged on a more regular basis. Nonetheless, the analysis showed that there is potential to exchange District 64 free river to locations upstream of the North Sterling Canal or Prewitt Inlet.

5.2.5 Administrative and Legal Issues

This demonstration project focused on methods of water marketing and delivery that are institutionally and legally available to the potential Lower South Platte Water Cooperative. Potential participants in the cooperative stated strongly that the cooperative should work within the framework of the water rights system so that senior water rights are not injured. Comments and conclusions regarding institutional and legal issues that were discussed by the Project Team during this demonstration project are summarized below:

- Water Court approval of the cooperative should be obtained. Though exchanges could operate administratively, the cooperative would want to adjudicate exchanges and obtain a priority date.

- The cooperative should examine whether the individual decrees for augmentation plans and associated recharge projects limit transfers of excesses to other users. Some of the decrees associated with these plans may have limitations on how and when excess recharge credits could be transferred.
- Administration would likely be a joint effort between the individual recharge credit providers, the cooperative, and the end users. For example:
  - The individual recharge credit providers would manage their individual recharge activities and provide accounting to the cooperative.
  - The cooperative would manage group accounting, direct re-diversion and re-timing, and manage deliveries to end users at specified locations.
  - The end users would be responsible for administration from the point of delivery to the point of use.
- Tools for the State Engineer are being developed to allow Water Commissioners to make real time determinations of exchange capacity and the amount of excess recharge credit available for exchange. Physical exchange capacity and river calls vary on a day-to-day basis. The cooperative will likely need timely information on exchange capacity and available recharge credits in order to effectively deliver, store, or retime supplies. Likewise, the State Engineer will need this same information in order to administer exchanges needed by the cooperative.
- The initial and administrative costs for the cooperative are unknown at this time. However, these costs could be shared among a number of participants, and once established, the resulting project has the potential to provide water on a semi-permanent to permanent basis to end users. Exchanges and methods of enhancing exchange and delivery (if needed) will require funding for planning; legal, engineering and other professional expertise; infrastructure installation (if necessary); and support from the cooperative participants. Loans or grants may be available for up-front planning, and both up-front costs and operating costs could be designed into exchange and leasing programs. It should be noted that funding the cooperative will be the subject of future work. Funding alternatives will depend on the organizational structure of the cooperative and operational strategies used to deliver water to end users.

5.2.6 Summary

The results of this demonstration project show that there is potential for the Lower South Platte Water Cooperative to facilitate opportunities for augmentation plans to market excess recharge credits. Likewise, the Lower South Platte Water Cooperative could provide the framework for facilitating alternative transfers. The demonstration project results are summarized below:

- A significant amount of exchange capacity exists between the Cache la Poudre River and the North Sterling Canal. This capacity could be used to exchange both excess recharge credits and water transferred through alternative methods such as rotational fallowing or interruptible supply. Water exchanged to the mouth of the Cache la Poudre River could potentially be marketed to several augmentation plans or water providers.
- Pumping stations could potentially be used as a tool to enhance exchange capacity through exchange bottlenecks.
- In recent years, there have been a significant periods of free river in the lower South Platte River. The location of free river occurrence and the annual amounts have varied significantly.
- Free river in District 64 could potentially be exchanged to locations upstream of the North Sterling Canal or Prewitt Inlet exchange bottleneck through the use of pumping stations.

- The ability to exchange excess recharge credits to the mouth of the Cache la Poudre varied by year and by "exchange from" location. Facilities for capturing and/or retiming excess recharge credits would be helpful in enhancing the ability to deliver water upstream when exchange potential is available.
- The Lower South Platte Water Cooperative has a number of options for facilitating the management and exchange of available supplies in the South Platte River. Specific exchanges, methods of enhancing exchange, and strategic locations for storage and recharge should be evaluated collectively in an effort to develop an operating plan for the cooperative.
- The cooperative could provide an important function in aggregating or pooling the water resources of individual or small groups of water users who are interested in alternative water transfers but who do not have the means to conduct these transfers individually.

5.2.7 Future Work

From January through April, 2010, representatives of the steering committee met with numerous ditch and reservoir companies, irrigation districts, augmentation groups, and water conservancy districts to discuss whether there was sufficient interest in organizing the cooperative. During these meetings, the results of this demonstration project were described and future work was discussed. The response was sufficiently positive that the steering committee became optimistic that the cooperative could be established. In order to research the cooperative and the issues that were raised during meetings, the steering committee prepared a work plan to outline a course of action. The primary goals of the work plan were to:

- Research and develop potential organizational structures for the cooperative
- Develop a detailed draft operational plan
- Request necessary funding to accomplish this work

Based on feedback from the initial round of meetings with water users made it clear that the success of the cooperative will be directly related to two key issues:

- The organizational structure chosen to govern and operate the cooperative must be fair, open and transparent.
- The operational plan for the 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 steering committee has begun work to address the goals of the work plan described above. The committee recently applied for and was awarded a grant through the Water Supply Reserve Account to research an organizational structure for the cooperative. In addition, a grant was recently awarded from the CWCB's Alternative Transfer Methods grant program to fund work focused primarily on developing an operations plan for the cooperative.

5.3 DT Ranch/Town of Wiggins (Interruptible Water Supply Agreement)

5.3.1 Introduction

This demonstration project was focused on the establishment of an IWSA between a relatively small municipal water provider and a nearby water right owner. The focus for alternative transfers often centers on obtaining water for Front Range municipal providers. However, there are also unmet water needs along the South Platte River downstream of the Denver metropolitan area. In addition, water right owners downstream of Denver may not be able to directly market their water if they do not possess a large quantity of water or if there is not an available marketing mechanism or a way to convey that water to Front Range water providers. This demonstration project presents a case study on how water could be transferred using alternative methods to meet local needs along the South Platte River in District 1.

This demonstration project focuses on the implementation of an IWSA between the DT Ranch and the Town of Wiggins (Wiggins). The demonstration project was pursued for several reasons:

- As shown on Figure 5-7, DT Ranch and Wiggins are located relatively close to one another in that Wiggins is approximately 10 miles upstream of DT Ranch. Because of this, the distance required to exchange water transferred via the IWSA between DT Ranch to Wiggins is relatively short, minimizing the potential for an interruption in delivery due to calls on the river.
- Figures 4-2 and 4-3 show that the average 2002-2008 exchange capacity in the South Platte River between the two water users ranges from 100 to 300 KAF per year, providing a significant amount of exchange capacity in a given year.
- The two points of diversion in the exchange reach are the Fort Morgan Canal and the Weldon Valley Ditch. The Fort Morgan Canal is the source of the DT Ranch surface water right available for the IWSA, and the Weldon Valley Ditch is the source of augmentation supplies for Wiggins. As described later in this section, Wiggins owns shares in the Weldon Valley Ditch and a recharge site along the ditch. Water from the IWSA could be readily exchanged and delivered to Wiggins' recharge facility.

As described in Section 2 of this report, an IWSA is an arrangement whereby irrigation is temporarily suspended so that the agricultural water may be temporarily transferred to a different use. For example, a municipal water provider who is party to an IWSA with an agricultural water right holder may, in a particular year, exercise the IWSA and use the agricultural water for municipal storage, augmentation associated with pumping of municipal wells, or other uses. IWSAs typically require that irrigation not be suspended for more than three out of ten consecutive years. Although the legal framework for IWSAs currently exists in Colorado under §37-92-309 C.R.S., their implementation has not been widespread. Implementation requires an application to the State Engineer's Office along with information describing the historical use of the water right. For example, transferrable amounts (historical consumptive use) and provision for the maintenance of historical return flows need to accompany the application. To implement an IWSA, the State Engineer's Office needs to be notified by March 1 of a year in which the IWSA transfer is to be conducted. One objective of this demonstration project is to provide specific information regarding the feasibility of successfully implementing an IWSA between DT Ranch and Wiggins with respect to technical, administrative, and legal components.

5.3.1.1 Overview of Proposed Operation

Wiggins is in the process of constructing a new water supply system consisting of an alluvial wellfield along the South Platte River and a pipeline to deliver the pumped water to the town's treatment and distribution systems. The town owns shares in the Weldon Valley Ditch that will be used to augment stream flow depletions associated with the pumping of their alluvial wells. Wiggins intends to deliver their Weldon Valley shares to recharge facilities located on the farm where those shares were historically used for irrigation. The alluvial wellfield, pipeline, and the location of Wiggins' recharge facilities are shown in Figure 5-7.

During a year when Wiggins needs water, the town and DT Ranch would implement the IWSA, and DT Ranch would temporarily suspend irrigation associated with a portion of their shares so that the water could be transferred to Wiggins for use as part of their supply. There are several options for providing water to Wiggins. The consumptive use portion of shares included in the IWSA could be delivered directly to the South Platte River and exchanged upstream to the point of depletion of the wellfield or into the Weldon Valley Ditch for delivery to Wiggins' recharge facilities. Alternatively, the transferred water could be delivered to a recharge facility, and Wiggins could claim the recharge credits reaching the South Platte River as part of the augmentation plan for their wells. This strategy could be useful to the town, because the transferred water could be retimed and delivered during times when Wiggins' other water supplies may not be plentiful. The recharge facility used for the purpose of the IWSA will likely be located on DT Ranch property in the form of a wetland area constructed in cooperation with DU. Wiggins' recharge facility and several of the DT Ranch recharge facilities are relatively close to the river and would provide recharge credits at the river relatively quickly, as described in more detail in Section 5.3.4. DT Ranch has several recharge facilities on or near their irrigated lands and would be useful for maintaining return flows from historically irrigated areas on DT Ranch were irrigation has been temporarily suspended for the IWSA. In years where Wiggins does not require implementation of the IWSA, irrigated agriculture would continue on DT Ranch.

5.3.2 Description of Facilities Associated with DT Ranch

5.3.2.1 Fort Morgan Canal

DT Ranch receives its irrigation supplies primarily from the Fort Morgan Canal. The Fort Morgan Canal is operated by FMRICO and serves approximately 11,000 acres of crop land located primarily in Morgan County, Colorado. FMRICO is a mutual ditch company with 2,839 outstanding shares. The headgate is located along the South Platte River in the southeast quarter of Section 31, Township 5 North, Range 59 West of the 6th Principal Meridian. The primary direct flow right associated with FMRICO is for 323 cubic feet per second (cfs) with a priority date of October 18, 1882. FMRICO also owns 1,030 shares of the Jackson Lake Reservoir Company and distributes those shares to FMRICO water users on a contract basis.

On an annual basis, FMRICO diverts an average of 30,000 acre-feet of water. A Parshall Flume is located immediately downstream of the Fort Morgan Canal headgate and is used as the main measurement point for ditch diversions. An analysis of monthly and annual Fort Morgan Canal diversions over the period of 1950 to 2009 shows that the minimum annual diversion was approximately 9,300 acre-feet, and the maximum annual diversion was over 57,000 acre-feet. A statistical analysis of annual diversions shows that in 50 percent of past years, diversions were greater than 30,000 acre-feet. Overall, FMRICO annual diversions have varied in volume (depending on irrigation demands, calls, etc.), but they have been consistent in that they diverted every year from 1950 to 2009. As a result, it appears that DT Ranch's shares in FMRICO are well suited for use in the proposed demonstration project.

The primary direct flow right owned by FMRICO has a priority date of October 18, 1882. A review of call records maintained by the State Engineer's Office over the last 61 years (1950-2010) shows that FMRICO was subject to call an average of 30 days per year during the irrigation season. However, in 24 of the years reviewed there were no calls issued that were senior to FMRICO. When FMRICO is out of priority, deliveries to project participants could be reduced or curtailed completely.

FMRICO is also the calling right on an occasional basis. During these periods, deliveries might initially be short to project participants as the call takes effect and more water is made available to FMRICO to divert. In recent years, the FMRICO calls have occurred in the early to mid irrigation season.

5.3.2.2 DT Ranch

The DT Ranch encompasses approximately 2,039 acres and is located along the south bank of the South Platte River in Morgan County, Colorado, and is immediately downstream of the FMRICO diversion.

DT Ranch is a farming operation and water fowl hunting club. As such, there are multiple uses of irrigation water at the ranch. DT Ranch irrigates their fields with FMRICO shares. Beneficial uses of irrigation water have been for wildlife habitat preservation and for crop production. Historically, DT Ranch has irrigated approximately 200 acres of corn, beans, and sorghum and meadow grass. Occasionally, some of the fields not used for crop production are irrigated but are not harvested in an effort to provide foraging for water fowl. Additionally, seasonal irrigation patterns are often modified to allow for a later harvest and to provide for wildlife foraging. The locations of the DT Ranch, Fort Morgan Canal and headgate, and irrigated fields on the DT Ranch are shown on Figure 5-8.

In addition to the cultivated fields, DT Ranch also operates several recharge sites adjacent to the river that provide recharge credits for augmentation as well as wildlife habitat. These recharge sites could potentially be utilized in an alternative transfer to provide recharge credit for other users or to maintain the timing of historical return flows.

DT Ranch has four turnouts from the Fort Morgan Canal and several laterals that deliver irrigation water to cultivated fields and that can be used to deliver water to several wetlands and recharge facilities.

5.3.3 Historical Water Use at DT Ranch

5.3.3.1 Historical Use Analysis

To assess the feasibility of the proposed demonstration project and the amounts of transferrable consumptive use and return flows, a general understanding of quantities of water applied to the crops was required. One method of estimating consumptive use and return flows is to review previous quantifications in the same region/ditch service area. The primary parameters that are used to calculate consumptive use are cropping patterns and climate data. Oftentimes, cropping patterns are similar across ditch systems as well as climate data, which allows for extrapolation to individual farms. A comprehensive quantification of consumptive use associated with DT Ranch's FMRICO shares was not performed. Rather, ditchwide analyses were relied upon for general estimates of consumptive use and return flows associated with DT Ranch's shares.

Total water use of a crop is typically defined as the total amount of water a particular crop consumes in order to fully mature. The sources of the water can include precipitation, sub-irrigation from high groundwater tables, residual soil moisture, and manual irrigation via sprinklers or flood methods. Irrigation water requirement (IWR) is the amount of water, in addition to precipitation, that is required by a crop to reach full maturity and to produce full yield and is usually the amount of transferrable water associated with changed shares. In ditch systems that cannot provide for the full IWR, transferrable amounts may be less than what is needed for full yield of a crop. IWR can fluctuate on a yearly basis due to temperature and the amounts of precipitation that occur during the growing seasons. For the purposes of this report, historical average annual amounts of irrigation water consumed by crops was the basis of quantifying transferrable consumptive use and will be referred to as the consumptive use associated with DT Ranch's FMRICO shares. Return flows are the amount of water applied for irrigation that was not consumed by crops. This amount was also quantified and is described in the next section.

To develop an estimate of historical consumptive use and return flows associated with DT Ranch's FMRICO shares, the Project Team reviewed an engineering report produced by HRS Water Consultants Inc. (HRS) for the FMRICO Plan for Augmentation (Water Court Case No. W-2692). Based on the data in this report, the average annual ditch-wide historical consumptive use of FMRICO shares was 15,849 acre-feet/year. With 2,839 total outstanding shares in FMRICO, the per-share consumptive use was estimated by the Project Team to be approximately 5.6 acre-feet/year.

Based on the ditch-wide determination of historical consumptive use and DT Ranch's ownership of 31.5 shares in FMRICO, the estimated annual transferrable consumptive use for DT Ranch's FMRICO would be approximately 175 acre-feet/year. This assumes that the cropping patterns on DT Ranch are similar to the ditch-wide patterns. It should be noted that the HRS analysis was based on climate and FMRICO delivery data from 1960 through 1980. An expanded study period and a specific analysis of DT Ranch historical cropping patterns, soil types, etc. would result in different estimates of transferrable consumptive use.

5.3.3.2 Return Flows

Downstream water rights depend on return flows that have historically accrued to the South Platte River from irrigation. Return flows associated with transferred shares need to be maintained in location, timing, and amount in order to successfully conduct a water transfer without injuring senior downstream water rights.

Return flows can occur as end-of-field runoff from irrigation and water that percolates through the root zone of crops and that recharges the alluvial aquifer. Water that recharges the alluvial aquifer eventually accrues to the river as stream flow. For the purposes of this demonstration project, it was assumed that 40 percent of return flows occur as surface runoff, and 60 percent of return flows occur as deep percolation. Return flows occurring as runoff are generally considered to reach the receiving stream very soon after they are generated. Deep percolation, however, takes more time to accrue to the river via the alluvial aquifer.

As described above, the historical use analysis performed by HRS for FMRICO estimated that on a per-share basis, the long-term average historical consumptive use was approximately 5.6 acre-feet/year. In HRS's report, on-farm irrigation efficiency was assumed to be 65 percent. However, that efficiency represents a mix of flood and sprinkler irrigation use throughout the ditch service area. DT Ranch relies only on flood irrigation. For flood irrigated fields, a typical estimate of farm efficiency is 50 percent. Therefore, using an efficiency of 50 percent and the historical consumptive use, the Project Team estimated that the average annual historic return flow volume for the DT

Ranch on a per share basis was approximately 5.6 acre-feet/year. Given that DT Ranch owns 31.5 FMRICO shares, their total annual return flow volume would be approximately 175 acre-feet/year.

5.3.4 Rates of Groundwater Return at DT Ranch

To develop a strategy for recharge and retiming the delivery of transferrable consumptive use to Wiggins when it is needed, it is important to understand the length of time needed for recharged water to return to the river. Groundwater return rates were calculated using the AWAS model. As described in Section 5.1.5, AWAS is an analytical modeling program developed by Colorado State University that utilizes a modified Glover Equation to estimate the transient effects of pumping or injection wells (or sources of alluvial aquifer recharge) on a nearby river. In this model several parameters are considered, including aquifer boundary conditions, transmissivity, specific yield, and physical distance between a well and river. While originally designed to estimate depletion rates from pumping, AWAS can be used to estimate return flow timing by simply inputting positive pumping (i.e. injection or alluvial aquifer recharge).

The transmissivity of the aquifer at each site was determined using a GIS data set developed by the IDS group at CSU. The GIS data set consists of a 200 meter by 200 meter grid of points that cover the entire South Platte alluvium. Each grid point contains aquifer data such as transmissivity, harmonic average transmissivity, distance from the point to the river, and width of the alluvial aquifer. The harmonic transmissivity represents the harmonic mean of all transmissivities along a line between the point and the main channel of the South Platte. For input into AWAS, the harmonic transmissivity was used. The specific yield for all sites was assumed to be 0.2. The value for specific yield was based on a study by Gehman, et al. (2009).

AWAS will produce several time-series data sets including cumulative returns from recharge, returns during each discrete time interval, and the rate of return for each time step. The Project Team analyzed cumulative recharge returns over time to evaluate the return flow lag characteristics. The amount of time required for all recharge water to return to the river can, in some situations, be attenuated over a long period of time, with the last portions occurring in very small increments over many months. To simplify the assessment of returns, the Project Team quantified recharge returns based on the streamflow accrual of 50 percent of the original recharge amount.

At DT Ranch, a total of eleven recharge sites were identified and analyzed. These sites are distributed across DT Ranch. The majority of the sites analyzed represent agricultural fields where recharge facilities either have been or could be easily developed, but two are potential recharge wetlands located on a bluff to the southwest of the Fort Morgan Canal. Transmissivity for each site was determined using the GIS data set described above. For the groundwater return rate assessment, unit responses were developed for each of the sites that were analyzed. To develop unit responses, it was assumed that recharge occurred for one week and at a rate of 1000 gpm. Table 5-10 shows the resulting return rate for each site analyzed at DT Ranch.

Table 5-10. Unit lagging responses for various recharge sites at DT Ranch

Well Name	Transmissivity (gpd/ft)	Aquifer Width (ft)	Distance to Well (ft)	Return Rate (Weeks)	Return Rate (Days)
Field 1	189,200	59,780	1,795	5	35
Field 2	189,000	62,328	2,006	3	21
Field 3	189,000	61,987	686	1	7
Field 4	187,000	34,030	1,636	2	14
Field 5	188,900	64,697	1,584	2	14
Field 6	189,500	41,639	1,912	2	14
Field 7	180,600	61,653	2,107	4	28
Field 8	179,000	40,119	1,930	3	21
Field 9	149,900	66,272	1,214	3	21
Recharge1	128,000	50,138	4,100	17	119
Recharge2	190,700	63,650	3,100	14	98

The results of the above lagging analysis were used to develop strategies for operating the IWSA and for delivering water when needed by Wiggins (see Section 5.3.5).

5.3.4.1 Analytical Modeling Assumptions

AWAS contains many assumptions in order to simplify the very complex groundwater systems it simulates. The degree of validity of these assumptions can have a significant impact on the accuracy of results. Assumptions inherent in AWAS are primarily related to aquifer geometry, physical aquifer parameters, and river geometry. Assumptions pertaining to the aquifer are that it is isotropic, homogenous, is of uniform thickness, and extends infinitely in the lateral directions. Assumptions regarding the river are that it is straight, infinite in length, and fully penetrates the aquifer. While these assumptions may or may not be applicable to sites such as DT Ranch, the AWAS method is commonly used to estimate return flow and recharge timing in water rights cases in the South Platte River basin. A more rigorous and precise analysis of return flow/recharge timing using heterogeneous aquifer conditions and other site-specific considerations could be conducted using numerical models such as MODFLOW. However, implementation of more precise tools can be time consuming and costly. For the purposes of this demonstration project, use of the AWAS model is appropriate.

5.3.5 Proposed IWSA Operation

5.3.5.1 Town of Wiggins

Wiggins, the end user partner for DT Ranch water, operates a relatively small water system for its residents and is located a few miles to the southwest of DT Ranch. Their primary source of water for Wiggins is Kiowa-Bijou designated basin ground water. Pending the results of upcoming Water Court actions, the Kiowa-Bijou water will be supplemented by South Platte River alluvial wells (see Figure 5-7).

Wiggins' alluvial wellfield has junior water rights, and the operation of the alluvial wells will deplete stream flow in the South Platte River. When there is a senior, downstream call, the depletions associated with these wells will need to be augmented in time, location, and amount. To help meet their augmentation obligations, Wiggins purchased shares in the Weldon Valley Ditch and the associated irrigated farm. The town will construct a recharge facility on the farm and will deliver their Weldon Valley shares to the recharge facility and recharge the alluvium. Ideally the accrual of recharge credits to the South Platte River would be similar to the timing of their wellfield depletions. Through an engineering analysis, Wiggins found that the return flow timing from the farm was shorter than the well depletion timing. During the typical irrigation season, April 1 though October 31, Weldon Valley Ditch shares should be sufficient to augment the lagged well depletions. However, the majority of the peak summer-time pumping depletions will impact river flows nearly six months after pumping, and there will potentially be a need for recharge credits in January and February in a typical year. In certain times of a typical year, the amount of return flow credits available to Wiggins is projected to be greater than lagged well depletions. Wiggins intends to exchange excess recharge credit upstream to the Weldon Valley Ditch and deliver excess supplies back into their recharge facility. The reported timing of the well depletions and recharge is based on conversations with the water resources engineer for Wiggins. Water from the DT Ranch, strategically retimed, could be used as an alternative or supplement to Wiggins' existing augmentation supplies during January and February.

With the cooperation of DT Ranch and FMRICO, Wiggins could divert their excess augmentation supplies into the Fort Morgan Canal and deliver the water to recharge facilities on DT Ranch instead of exchanging their excess credits back to Weldon Valley Ditch headgate. This could be mutually beneficial for both DT Ranch and Wiggins. Wiggins could take advantage the recharge facilities on DT Ranch that provide longer lag times and thus better match the depletions from their alluvial wells, and DT Ranch would have more water available for their wetland/recharge areas and provide benefits to wildlife habitat.

This agreement would operate separately from the IWSA and would require detailed engineering and approval from the SEO and FMRICO. However, in conjunction with the demonstration project, it could help optimize Wiggins' use of recharge credits.

In addition to delivering water for recharge, the transferred water from DT Ranch could potentially be delivered directly to the South Platte River for Wiggins' use in times during the irrigation season if Wiggins' other supplies are inadequate to fully augment their wellfield depletions. As stated above, Wiggins' augmentation supplies are adequate during the irrigation season, so direct delivery of DT Ranch's shares would probably only be useful if future wellfield depletions increase due to increased municipal water use in Wiggins or if delivery of Weldon Valley shares are curtailed.

5.3.5.2 DT Ranch Operation

Under the IWSA between DT Ranch and the Wiggins, the town can take delivery of Fort Morgan Canal water for up three years over the ten-year agreement. When Wiggins requests the water, all or portions of DT Ranch crops would need to be fallowed in order to deliver the agricultural water for municipal use. Although the deadline to notify the State Engineer's Office is March 1 in a given year, DT Ranch would likely want notification from Wiggins before March 1 for agricultural planning purposes. The amount of irrigated area that would have to be fallowed would depend on the quantity of water or number of shares that Wiggins would request to use. The Project Team anticipates that only a portion of DT Ranch's 31.5 Fort Morgan Canal shares would be needed. A more rigorous analysis of DT Ranch irrigation and consumptive use would be required determine the appropriate amount of fallowing at the time when water would be used.

As described previously, there are several options for delivering water to Wiggins under the IWSA. The method that is most likely to meet Wiggins' needs would be to retime deliveries of water so that they accrue to the South Platte River during the winter. The agricultural water to be used by Wiggins would therefore need to be delivered to recharge facilities so that the associated recharge accretions are useful in offsetting winter depletions from the town's wellfield.

There are currently several locations on DT Ranch that are being used for recharge purposes. The recharge ponds are located between the South Platte River and the Fort Morgan Canal. The decreed return flow timing for those locations is 75 days. The Project Team's assessment of return flow lagging using AWAS is similar to this timing (see Table 5-10 above). The DT Ranch recharge facilities between the South Platte River and the Fort Morgan Canal have short return times and are best suited to provide recharge credits to meet depletions with short lag times. However, Wiggins' alluvial wells have lagged depletions that accrue to the river six months following pumping. As a result, recharge facilities on DT Ranch with longer lag times were investigated.

The portion of the Fort Morgan Canal that runs adjacent to DT Ranch flows in a southeasterly direction. Directly to the southwest of the canal there is a bluff that rises approximately 60 feet above the elevation of the canal. DT Ranch owns portions of un-irrigated areas along the edge of the bluff. These locations could be potential sites for recharge wetlands (see Figure 5-8). The Project Team analyzed these sites using AWAS and found that the lag time to return 50 percent of recharge from these proposed sites ranged from approximately 100 to 200 days. If transferrable water from the IWSA were delivered to recharge facilities on the bluff in the late irrigation season, recharge credits would accrue during the winter months and would be available to Wiggins during times when other augmentation supplies may not be plentiful.

If transferrable water were delivered to recharge facilities that have both short and long return times, then deliveries of water to Wiggins could be regulated to meet a variety of timing requirements. A delivery scenario was developed and assessed to illustrate how this could be done.

Fort Morgan Canal diversion records were used to develop the timing and amount of deliveries to recharge facilities. The Project Team does not know how many of DT Ranch's 31.5 FMRICO shares would be included in a transfer (this would be negotiated between DT Ranch and Wiggins), so the recharge timing assessment was conducted on a per share basis. In other words, the recharge assessment assumed that one share would be delivered to recharge. The results of the assessment can be scaled based on the number of shares included in a potential IWSA. Based on the temporary transfer of 1 share, a pro-rated farm delivery schedule was developed based on the average daily diversion rate of the Fort Morgan Canal from 2005 through 2009. During the first two months of the irrigation season, April and May, the share was delivered to the recharge sites that are located on the bluff south of the canal and have long return times. During the middle portion of the irrigation season, June and July, deliveries were split between the facilities on the bluff and the facilities on the lower portion of the ranch adjacent to the South Platte River. Finally, for the last two months of the irrigation season, August and September, the share was again delivered to the facilities with long lag times located on the bluff. Because the availability of return flow credits in the winter months is a priority for Wiggins, delivering water at the end of the irrigation season to recharge facilities on the bluff will maximize the recharge credits that are available during the portions of the year when the canal is not diverting.

The return timing of deliveries to various recharge facilities was assessed using AWAS. The results of the AWAS assessment showed the cumulative timing of stream flow accruals resulting from recharge at facilities with both short and long lag times throughout a typical irrigation season when a transfer is conducted. Figure 5-9 shows the cumulative return flow credits available throughout the year using this strategy for delivering water to various DT Ranch recharge facilities. As the figure shows, there is a significant difference in lag times seen between the lower areas of DT Ranch adjacent to the river and the potential recharge locations on the bluff. The graph also shows that the timing difference can be used to manage the amount of recharge credits accruing to the South Platte River at various time of the year. Given the conditions of the scenario described above, there are still recharge credits available during the months of December and January.

An additional recharge scenario was developed assuming that the share is delivered to the potential recharge facility on the bluff throughout the irrigation season. Figure 5-10 shows the accrual of stream flow at the South Platte River resulting from deliveries of recharge to the potential recharge facility on the bluff. The figure shows that recharge credit availability would peak in September, and recharge credits would be available in December and January. The figure also shows that slightly more recharge credits would be available under this scenario in December and January as opposed to the first scenario where deliveries of recharge were split between the facilities close to the river and the potential facility on the bluff.

DT Ranch will need to maintain the amount, timing, and location of historical return flows from irrigation during years when the IWSA is executed. Given the number of potential recharge locations and laterals available to DT Ranch, it should be relatively simple to manage the timing and location of return flows. Prior to implementing the IWSA, DT Ranch should quantify the historical amount, location, and timing of return flows resulting from both on-farm runoff and deep percolation. Once this is quantified, DT Ranch could develop a strategy for delivering return flows to the South Platte River.

Surface water return flows could be provided by diverting an appropriate proportion of the transferred shares into a lateral and conveying the water directly to the South Platte River. The delivery of surface return flows should occur at times when transferrable consumptive use is being delivered for recharge or for direct delivery to the river. Surface return flows delivered to the South Platte River will need to be measured and reported to the State Engineer's Office with the water accounting that will be conducted for the IWSA.

It is likely that the most efficient way to provide subsurface return flows (return flows resulting from on-farm deep percolation) will be to deliver the return flows to recharge facilities that are very near or on the fields that are fallowed in years when the IWSA is executed. As with surface return flows, the amount of water delivered to recharge to maintain subsurface return flows will need to be measured and reported to the State Engineer.

5.3.6 New Infrastructure Necessary for the Transfer

It is anticipated that the amount of infrastructure necessary to conduct this IWSA would be similar to that needed to conduct a traditional, buy-and-dry transfer. Other than the proposed recharge wetlands on the bluff south of the South Platte River, it is anticipated that DT Ranch could use their existing recharge facilities to manage transferrable consumptive use and subsurface return flow obligations. Existing laterals could be used to deliver surface return flow obligations to the South Platte River. Additional measuring devices (flumes) may be needed to measure flows returned to the South Platte River or to recharge facilities.

The recharge wetlands at the top of the bluff south of the river will be the most significant infrastructure need for this project. In addition to constructing the wetland, a pumping station and pipeline will be necessary to deliver water from the Fort Morgan Canal to the wetlands on top of the bluff. Costs for pumping stations generally range from $50,000 to $200,000 per cfs of pumping capacity depending on the complexity of the structure. The Project Team anticipates that the pumping station would not be complex and costs would fall into the lower end of the estimate.

Pipelines generally cost around $8 per inch of diameter per linear foot of pipe. The pipeline should be sized such that the flow velocity ranges from 4 to 6 feet per second (fps).

Based on analysis of the FMRICO diversion records and the anticipated deliveries for this demonstration project, the maximum pro-rated flow through the pump station and pipeline was estimated to be 2 cfs. To convey 2 cfs at a velocity of approximately 6 fps, the pipe diameter would need to be approximately 8 inches. Based on aerial mapping of the DT Ranch, it is assumed that 1,500 feet of pipeline would be required to deliver FMRICO water to the wetland, resulting in an estimated installed pipeline cost of $96,000. Combined pump station and pipeline costs could reach $200,000. However, depending on site conditions (i.e. availability of power, configuration and necessity of an intake structure, etc.), the cost could rise to $300,000 or more. It should be noted that these costs are based on general “rules of thumb” for pumping stations and pipelines, and they should be reassessed in the future if DT Ranch and Wiggins further explore the IWSA described in this demonstration project.

The potential cost of the pumping station and pipeline could be offset by identifying partners. For example, if the recharge facility is a constructed wetland, it is possible that funds could be raised from sources that aim to further the creation of wetland habitat. In addition, if the recharge facilities could be useful to entities like augmentation plans, water markets, etc., it is possible that these entities may either help to fund construction or pay a fee for the future usage of the pumping station and pipeline.

5.3.7 Other Operational Activities

Interruptible supply agreements must contain provisions to prevent erosion and blowing soils in years when the option to transfer water is exercised. In addition, the agreement must also provide a description of compliance with local county noxious weed regulations and other land use provisions. In years when water is temporarily transferred from DT Ranch to Wiggins, a cover crop or other temporary vegetation will need to be established if necessary to prevent erosion. DT Ranch managers will also need to control noxious weeds in fields that are fallowed.

5.3.8 Administrative Considerations

The enabling legislation for IWSAs includes several items related to administrative considerations and the process of establishing an IWSA. Prior to establishing an IWSA, the parties to the agreement will need to submit an application to the State Engineer. The application will need to include a written report prepared by a registered engineer that quantifies the historical consumptive use and return flows and that describes the potential to injure senior water rights as a result of operation of the IWSA. The application also needs to include provisions for preventing injury to senior water rights.

Once the application is mailed, other water right holders will have 30 days to review the application and file comments on the IWSA. Upon review of comments, the State Engineer will determine whether the IWSA will cause injury to other water rights. The State Engineer may also provide terms and conditions for the IWSA that will prevent injury to other water rights. The State Engineer has the option of approving the IWSA with or without a public hearing. However, if other water right holders have significant issues with the proposed IWSA, a formal hearing may be held to address the issues. Once the IWSA is approved by the State Engineer, no additional approvals are necessary for the duration of the IWSA.

In a year when the IWSA is to be exercised, notice must be provided to the State Engineer by March 1. As stated earlier in this report, it is likely that DT Ranch will desire earlier notice from Wiggins if DT Ranch's shares are needed. Earlier notice may be provided if the parties agree to this in the IWSA.

On years when the IWSA is to be exercised, DT Ranch will need to fallow an amount of land commensurate with the historical irrigated acreage associated with the number of shares being transferred. The legislation for IWSAs provides no guidance regarding the type of monumenting that would be required in order for the State Engineer to verify dry-up in years when the IWSA is exercised, beyond general statements that any plan should prevent erosion and blowing soils and should mandate compliance with county weed regulations. Based upon experience in Water Court change of use cases, the notification will need to include at a minimum the legal location of lands to be fallowed, a map identifying the dry-up, and a demonstration that the lands will not receive water from the shares being delivered under the IWSA. These lands will likely be inspected and the dry-up approved by the water commissioner on an annual basis to confirm compliance with dry-up conditions.

5.3.9 Contractual Issues

DT Ranch and the Town of Wiggins would need to enter into an interruptible water supply agreement. State statute requires the agreement to address:

- A quantification of the historical consumptive use of the water right;
- An accurate description of the location the water is decreed for use;
- A plan to prevent erosion and blowing soils; and
- A description of compliance with local county noxious weed regulations and other land use provisions

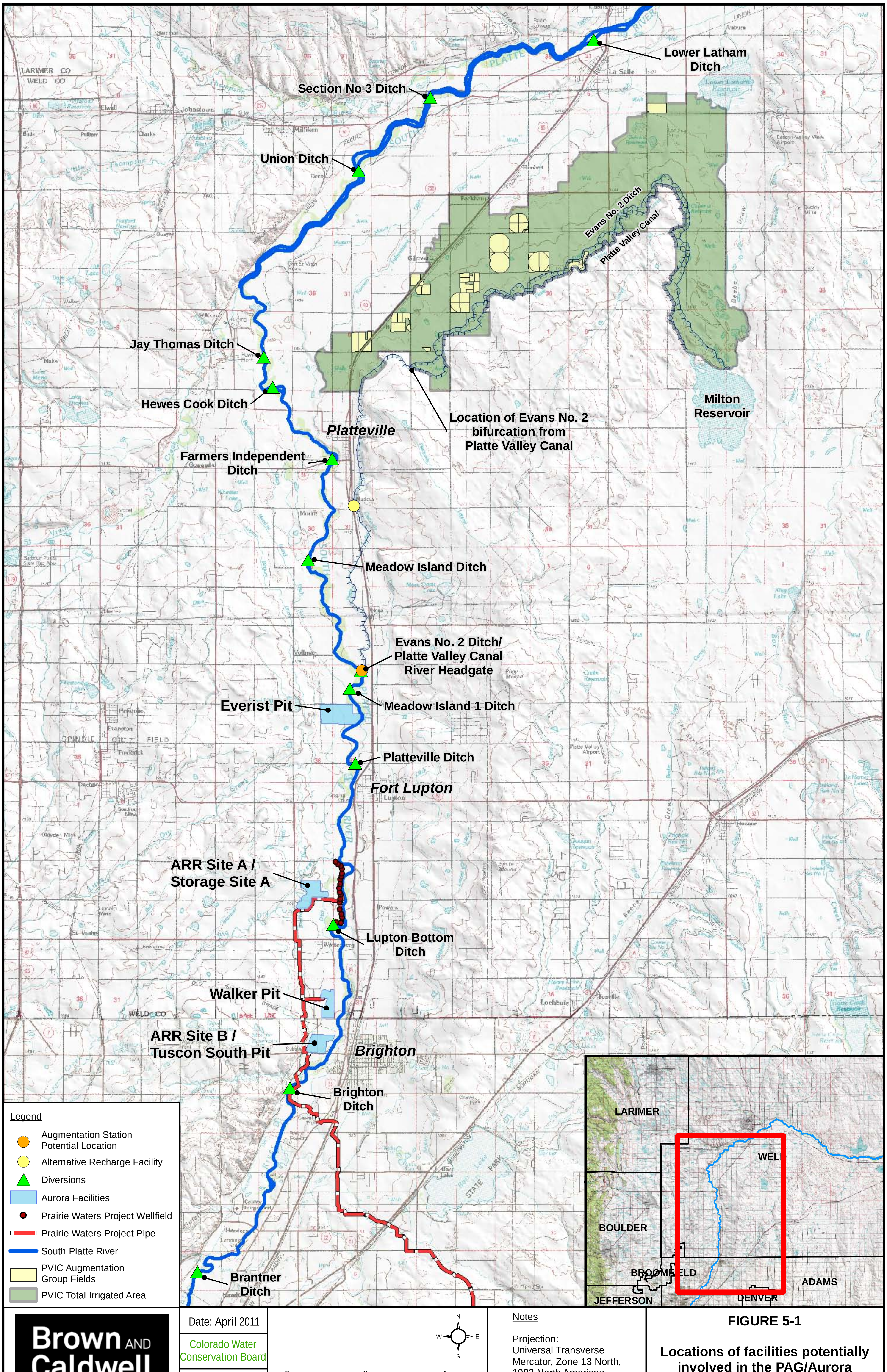
Under the statute (§37-92-309(3)(b), C.R.S.), the agreement may be exercised only three years out of a ten year period. In addition to the term, the agreement should also address, without limitation, the compensation to be paid; the construction of necessary infrastructure including location, costs, and easements; notice provisions; the responsibility for taking measurements and providing accounting to the water commissioner and division engineer; and cost sharing arrangement between the parties for legal and engineering costs. The agreement should be reviewed by qualified water counsel for both parties to ensure that it complies with §37-92-309 and adequately protects the interests of the parties.

5.3.10 Conclusions and Recommendations for Future Work

DT Ranch is in an ideal location to enter into an IWSA with the Town of Wiggins. Water from DT Ranch could be readily exchanged to a variety of locations that are useful for augmenting depletions associated with Wiggins' wellfield. Using the recharge facilities on DT Ranch, water temporarily transferred to Wiggins could be retimed in order to better meet Wiggins' seasonal needs for augmentation supplies. Historical return flows can be managed with relative ease given the variety of recharge facilities on the DT Ranch property and the laterals the can deliver surface flows directly to the South Platte River. This demonstration project may serve as a good example for smaller water suppliers and water right holders as a means to conduct alternative transfers in the lower South Platte River, downstream of the Denver metropolitan area.

The Project Team recommends several future tasks if this demonstration project is to go forward:

- Wiggins and DT Ranch should meet to discuss the project, review potential operational goals of the two parties, and refine the operational characteristics of the IWSA as presented in this report.
- DT Ranch should conduct a study of the historical consumptive use and return flows associated with their FMRICO shares. DT Ranch should also develop erosion and weed control plans for years when the IWSA is executed.
- The parties should negotiate terms of the IWSA including:
  - Rates of compensation for water during years when the IWSA is executed.
  - Rates of compensation (if any) for water during years when the IWSA is not executed.
  - Dates by which Wiggins will notify DT Ranch that they intend to exercise the IWSA.
  - Responsibilities for accounting and other reporting.



ilheritier

April 29, 2011

P:\Data\GEN\Colorado Corn Growers Ass'n\Alternative Ag Water Transfers\GIS\PVIC\Fig_Overview PAG-Aurora facilities.mxd

Brown AND Caldwell	Date: April 2011 Colorado Water Conservation Board Project: 137559	Notes Projection: Universal Transverse Mercator, Zone 13 North, 1983 North American Datum (meters).	FIGURE 5-1 Locations of facilities potentially involved in the PAG/Aurora demonstration project

Figure 5-2. Return flow response from deliveries to potential short term recharge facility along the Platte Valley Canal

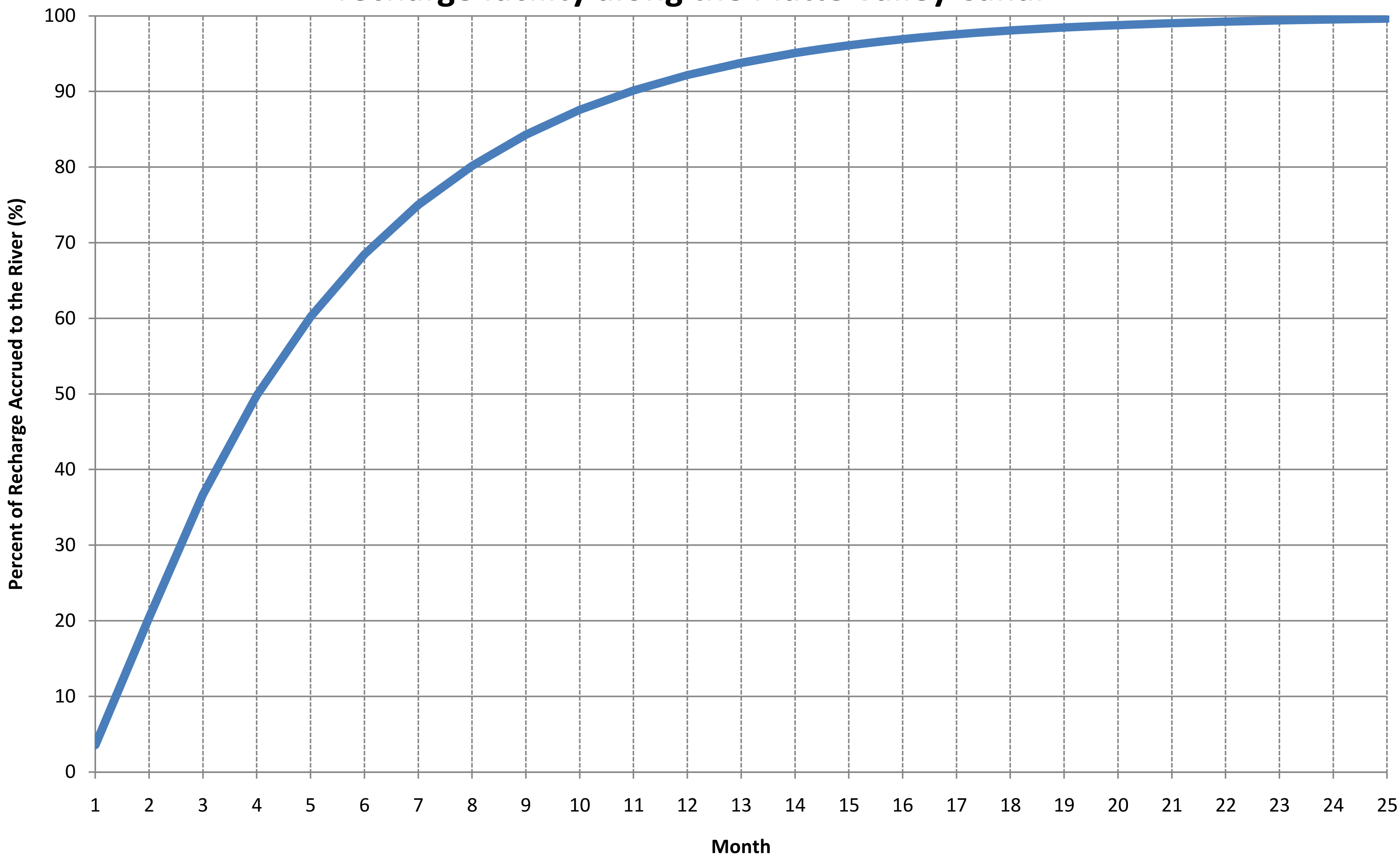


Figure 5-3. Percentage of excess recharge accretions accruing between Prewitt Inlet and Sterling #1 that could be exchanged (when exchange is necessary) to the Cache la Poudre River with various sizes of pumping stations at the North Sterling/Prewitt Inlet

(Exchangeable flows based on adjusted net effects)

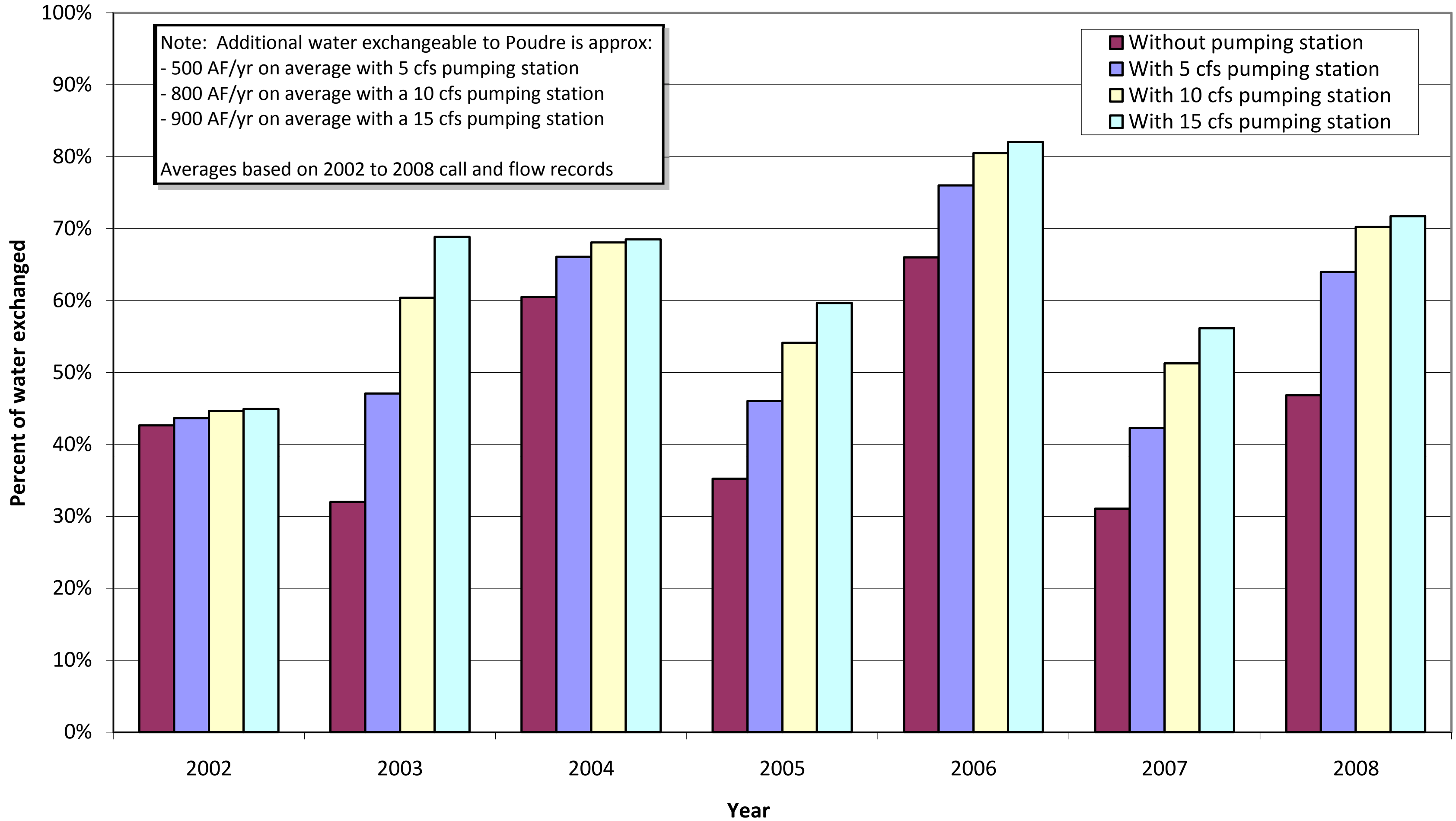
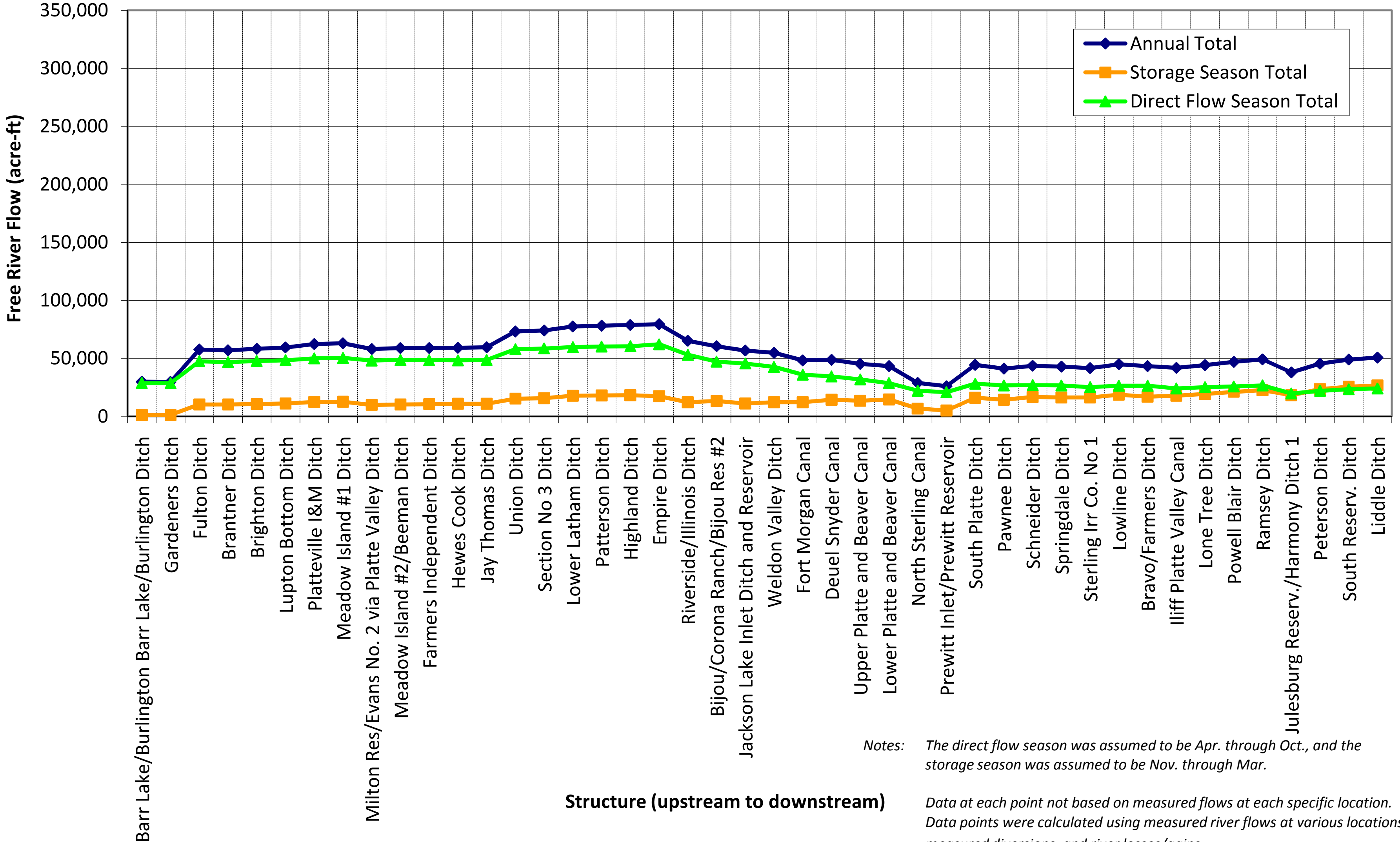
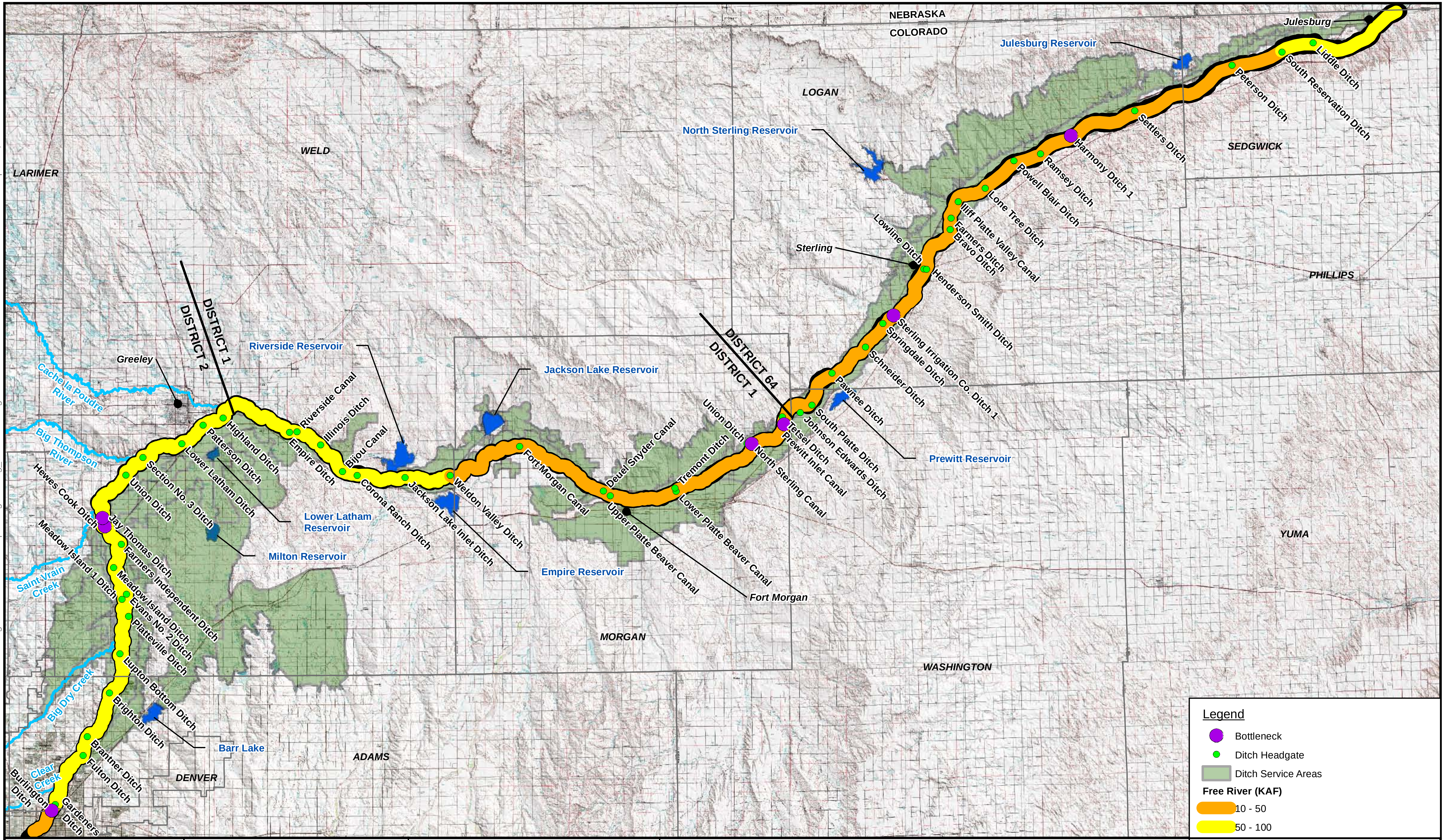


Figure 5-4. Variation in the average annual volume of free river flow passing various points along the South Platte River for water years 2002 - 2008



Notes: The direct flow season was assumed to be Apr. through Oct., and the storage season was assumed to be Nov. through Mar.

Data at each point not based on measured flows at each specific location. Data points were calculated using measured river flows at various locations, measured diversions, and river losses/gains.



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Colorado Water Conservation Board

Project: 137559

1 in = 10 miles

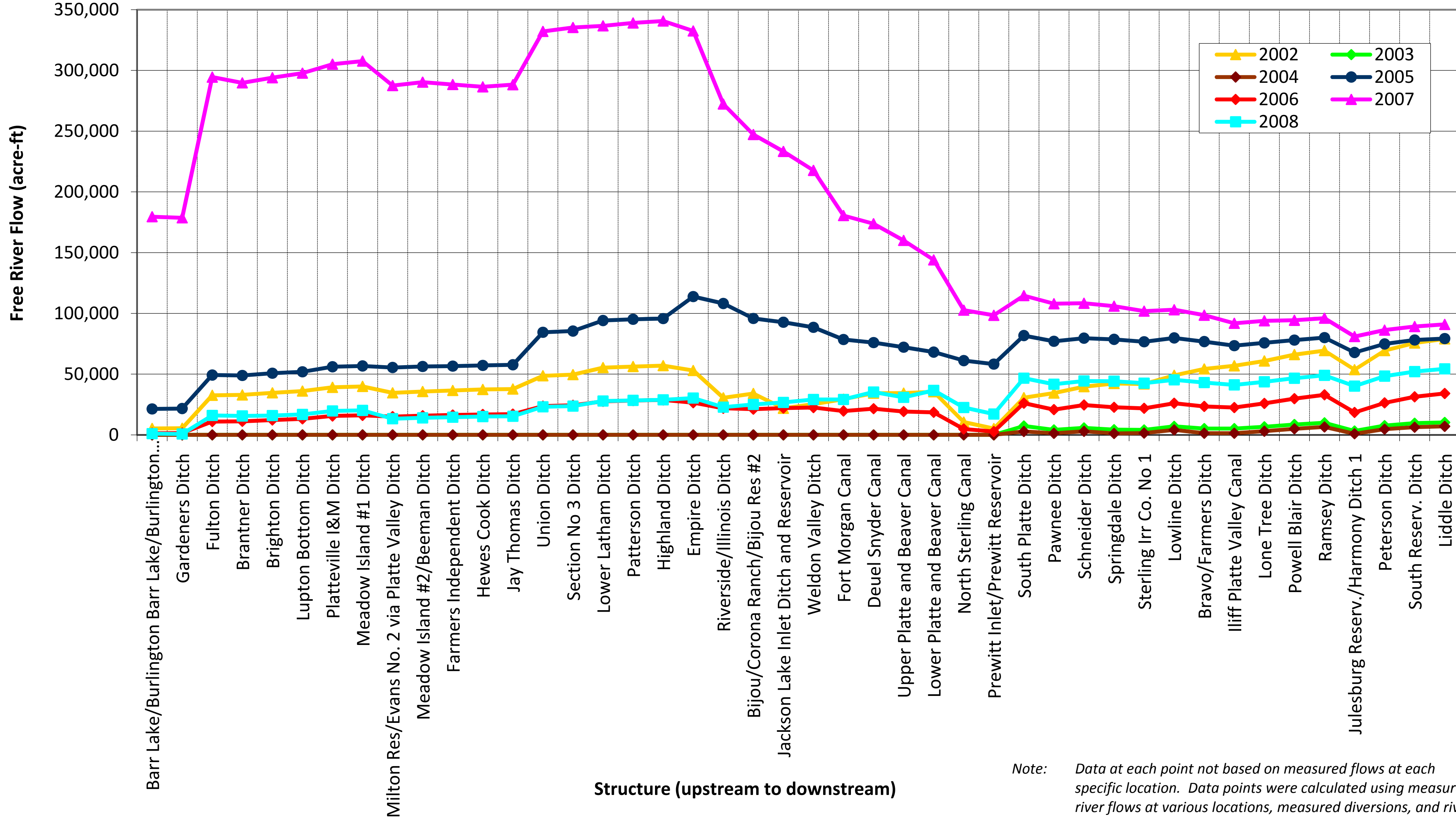
Notes

Projection: Universal Transverse Mercator, Zone 13 North, 1983 North American Datum (meters).

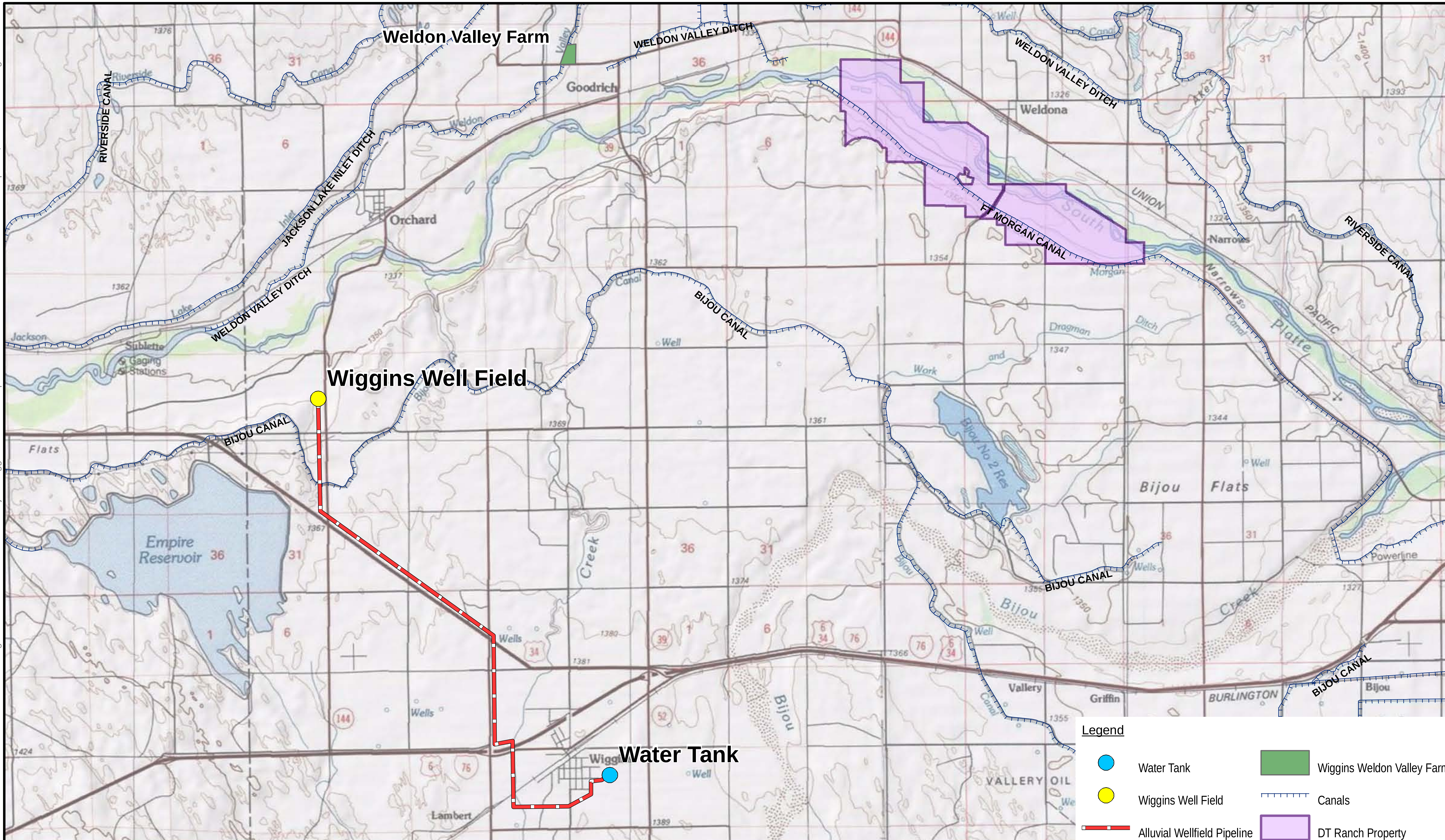
Locations of ditch headgates from South Platte Decision Support System

FIGURE 5-5
Average annual free river occurrence (2002 through 2008) and exchange bottlenecks along the South Platte River in Districts 1, 2, and 64

Figure 5-6. Variation in the annual volume of free river flow passing various points along the South Platte River for water years 2002 through 2008



Note: *Data at each point not based on measured flows at each specific location. Data points were calculated using measured river flows at various locations, measured diversions, and river losses/gains.*



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Date: April 2011

Colorado Water Conservation Board

Project: 137559

N W E S

0 6,000 12,000 Feet

Notes

Projection: Universal Transverse Mercator, Zone 13 North, 1983 North American Datum (meters).

FIGURE 5-7

Location of DT Ranch and Town of Wiggins Water Supply Facilities

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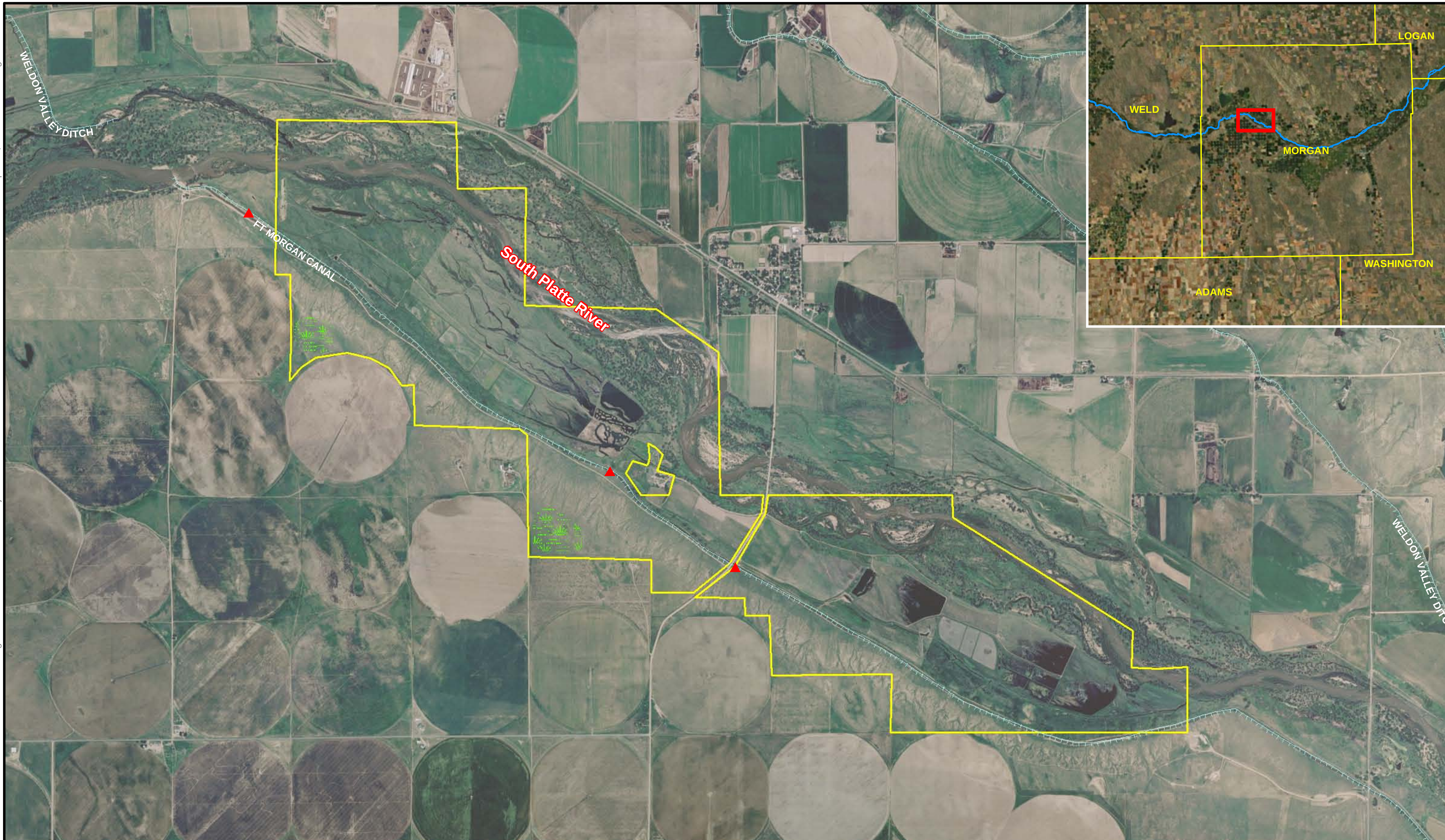

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Brown AND Caldwell

Date: April 2011

Colorado Water Conservation Board

Project: 137559

Legend

- DT Ranch Farm Headgates
- Potential Recharge Sites
- Canals
- DT Ranch Boundary

Notes

Projection: Universal Transverse Mercator, Zone 13 North, 1983 North American Datum (meters).

FIGURE 5-8

Overview of DT Ranch

Figure 5-9. Return flow response from deliveries to short and long term recharge facilities on the DT Ranch

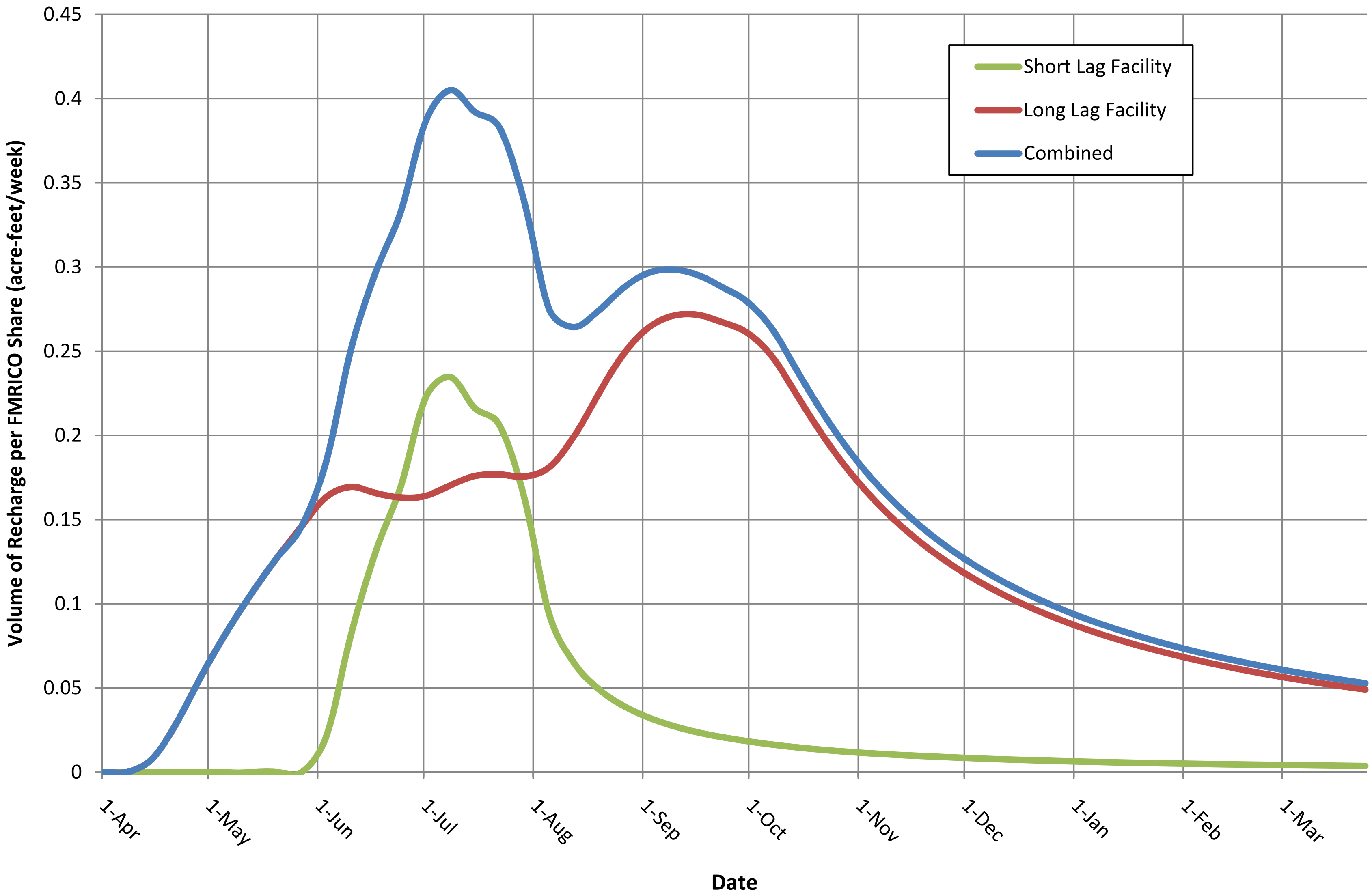
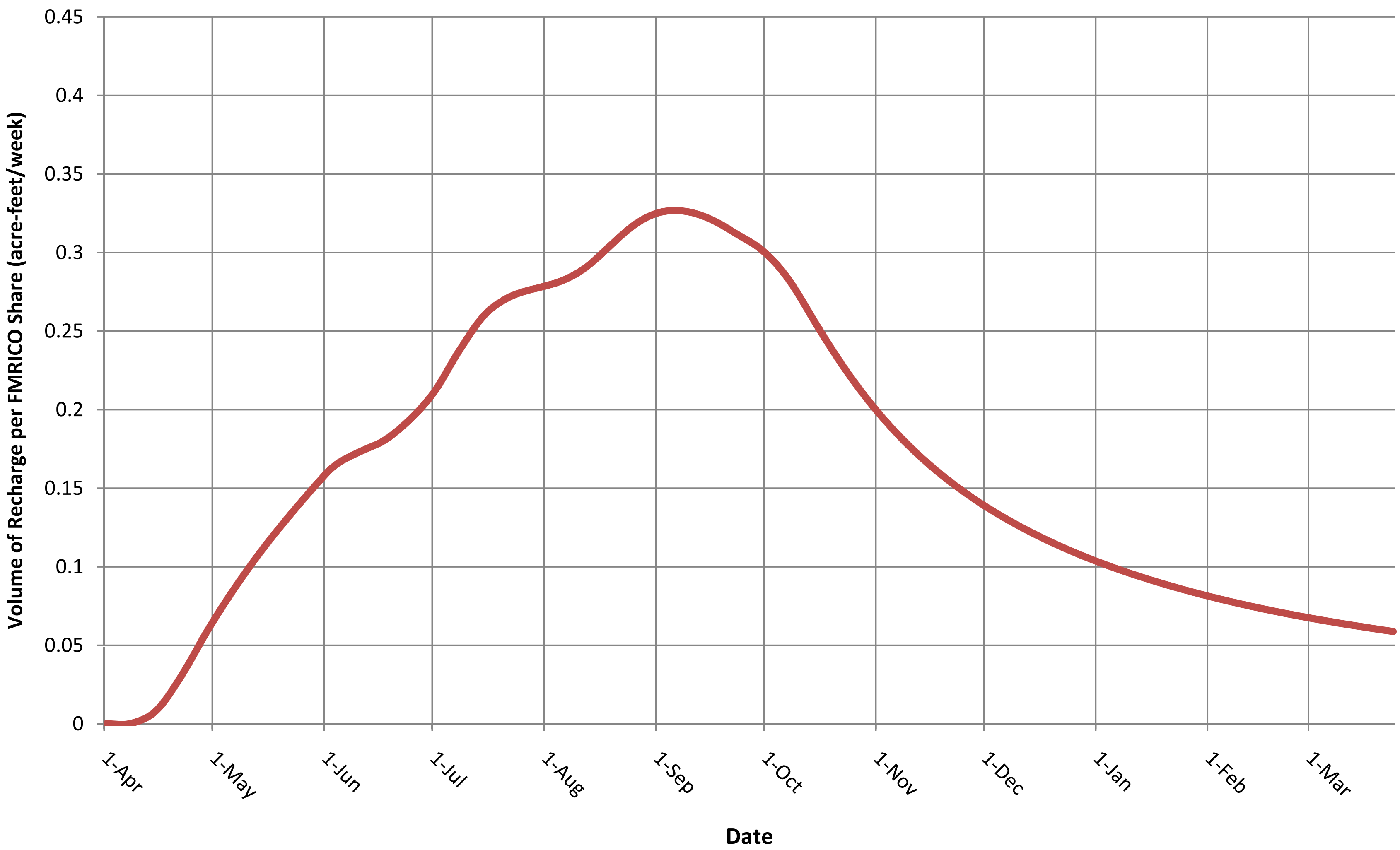


Figure 5-10. Return flow response from deliveries to long term recharge facilities on the DT Ranch



Section 6

Conclusions

The Project Team has been encouraged by the interest that water users, the CWCB, and others have shown in the demonstration projects and concepts developed under this ATM grant. Each of the demonstration projects will be explored in greater detail after the ATM grant funding expires. The "next steps" for each of the demonstration projects are described in the sections below:

6.1 PVIC Augmentation Group/City of Aurora

The Flex Market concept will be further assessed by the Project Team through a new ATM grant from the CWCB. The objectives of the upcoming study are as follows:

- Develop a Flex Market contract template.
- Develop model decree terms and conditions for the Flex Market and for alternative transfers that would potentially be conducted within the market.
- Conduct a survey level engineering analysis of three major ditch companies in Division One, focusing on District 2 (Denver to Greeley), but extending to Districts 1 and 64 to the extent entities in these Districts desire to participate, summarizing potential CU available to ATM projects and assessing the potential for delivery of CU from these companies to major metro M&I 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. As described in Section 2.6.3 the Flex Market contemplates the establishment of a long term, sustainable contractual partnership between agricultural water users, M&I users, and environmental interests. The Project Team will expand the review of the Flex Market to a broad 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 to develop model decree terms and conditions for alternative transfers. One of the major issues that has restrained the implementation of alternative transfer methods 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 Court. The Project Team will 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 Project Team understands that each case is unique, and that one size does not fit all. However, the Project Team believes 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 engineering analysis will likely focus on ditch companies with senior rights, a consistent history of large diversions, and the potential to supply large amounts of CU. An exchange analysis will be conducted to assess the potential for delivering CU from the headgates of these ditch companies to major M&I users. A summary of current opportunities and suggestions regarding infrastructure improvements necessary to improve reliability will be included. Additionally, if an alternative transfer is included in a long term lease, the study will explore how a municipality might view a lease in the context of their firm yield and portfolio of owned water.

6.2 The Lower South Platte Water Cooperative

The potential Lower South Platte Water Cooperative will be studied in greater detail in the coming year. Potential organizational structures and operational strategies will be researched in the coming year with a goal of implementing the cooperative in the near future. The initial formation of a new organization would likely include water users in Water Districts 1 and 64 (Kersey to the Colorado/Nebraska state line).

The organizational analysis will research, analyze and formulate best-fit alternatives for the organizational structure of the cooperative in the area of the lower South Platte River. The work will include analysis and determination of water law and water rights issues related to the cooperative to identify and prevent injury to other water rights within the basin. This project will also research and determine the best fit for operational planning for the cooperative. The results of the research will be used to develop guidelines and an overall summary of potential options for the organizational structure of a new water cooperative. Water users and other interested parties will be provided with best fit alternatives that summarize estimated costs, benefits, impacts, risks and other issues associated with each alternative. Meetings will be held with interested water users to discuss and evaluate alternatives. Draft organizational documents will be prepared for evaluation by water users to the point of potential initiation of such an organization.

In addition to an organizational analysis, operational strategies for the cooperative will be studied. An operations plan will be developed that identifies water supplies (including direct flow and/or storage water transferred through alternative methods, excess recharge credits, new junior water rights, etc.), demands, and the means and necessary infrastructure to provide water when and where it is needed. Additional objectives of the operational study are as follows:

- 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.

During the development of the operational plan, an economic analysis will be conducted to explore the economic attractiveness of alternative transfers among ditch companies along the lower South Platte River. A group of ditch company shareholders will input their farm-specific economic information into AgLET in an effort to derive economically attractive levels of compensation for alternative transfers on a farm-by-farm basis. Results of individual analyses will be anonymously compiled and assessed.

In addition, small groups of shareholders will be engaged to study farming input costs and operational strategies during an alternative transfer. The AgLET tool may be updated at the conclusion of this study depending on the results of this analysis.

6.3 DT Ranch/Town of Wiggins IWSA

The results of the analyses conducted for this demonstration project were shared with Town of Wiggins, DT Ranch, and DU staff. The parties are interested in this potential alternative transfer and look forward to future collaboration. Discussions with the parties suggest that other alternative methods besides IWSA, such as rotational fallowing, may be of interest as well.

Section 7

Limitations

This document was prepared solely for the Colorado Corn Growers Association in accordance with professional standards at the time the services were performed and in accordance with the contract between Colorado Corn Growers Association and Brown and Caldwell dated May 5, 2009. This document is governed by the specific scope of work authorized by the Colorado Corn Growers Association; it is not intended to be relied upon by any other party except for regulatory authorities contemplated by the scope of work. We have relied on information or instructions provided by the Colorado Corn Growers Association and other parties and, unless otherwise expressly indicated, have made no independent investigation as to the validity, completeness, or accuracy of such information.

Further, Brown and Caldwell makes no warranties, express or implied, with respect to this document, except for those, if any, contained in the agreement pursuant to which the document was prepared. All data, drawings, documents, or information contained this report have been prepared exclusively for the person or entity to whom it was addressed and may not be relied upon by any other person or entity without the prior written consent of Brown and Caldwell unless otherwise provided by the Agreement pursuant to which these services were provided.

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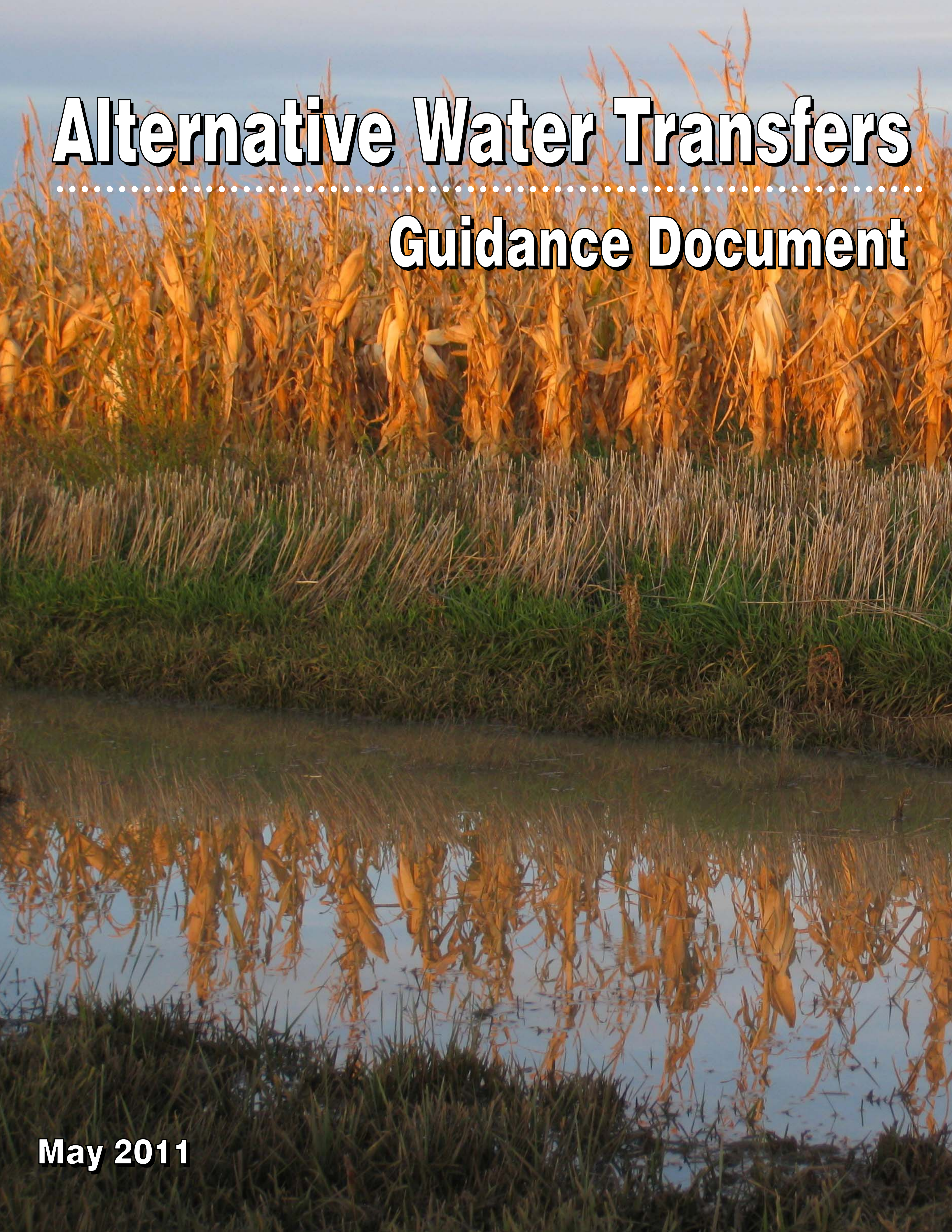
Appendix A: Guidelines for Agricultural Producers in Implementing Alternative Transfers

Alternative Water Transfers

Guidance Document



May 2011

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The Colorado Water Resources Research Institute
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Disclaimer

This document is intended to provide general guidelines and information for parties interested in alternative agricultural water transfers in Colorado. The information in this document is based upon information available as of 2011 to the extent known by the authors. The guidelines and information are specific to Colorado. The information provided is meant to be broad and not specific to any single water transfer prospect; nor to be relied upon in the development or execution of any specific transfer. Each water transfer will have unique features that deserve consideration before proceeding with that transfer. Users of these guidelines should contact the Colorado Department of Water Resources, Colorado State University Extension, and qualified water counsel regarding current legislation, policies, and practices before participating in any alternative transfer.

Contents

Introduction

Historically, Colorado agricultural producers have had three choices with regard to using the water rights that support their agricultural operation:

1. Continue to farm using the water rights
2. Sell the water rights to another agricultural user
3. Sell the rights to a municipal and industrial (M&I) user under a "buy-and-dry" arrangement

There is a fourth option that has been used by some agricultural producers and has been gaining interest in Colorado and in other parts of the United States. This option can be described as:

4. Continuing with irrigated crop production but leasing or selling part of their water right to an M&I user.

This fourth option, known as an "alternative agricultural water transfer" or "alternative transfer," is the subject of this document.

Purpose of this Document

Focus:
Alternative transfer methods that are currently well accepted from a legal and administrative point of view

This document is meant to provide agricultural producers and others with a general understanding of what alternative transfers are and why they might be beneficial. In addition, the document will describe different types of alternative transfers and provide a checklist of legal, administrative, engineering and economic issues that should be considered in a typical transfer.

It should be noted that there are several potential methods for doing an alternative transfer. Some have been used in Colorado and some have not. The focus of this document is to provide guidelines and information on alternative transfer methods that are currently accepted from a legal and administrative point of view. Other methods have potential and interest, but they have not been tested in Colorado Water Court. These are also briefly described, but no specific guidelines for carrying out these transfer methods are provided.

Definition of Alternative Water Transfers

Definition:
Water is transferred out of agriculture to another use but the ownership of the water remains all or in part with the agricultural producer

Alternative transfers can be defined as a process in which water is transferred out of agriculture to another use for a short or long time period, but the ownership of the water remains all or in part with the agricultural producer.

The length of alternative transfer is negotiable and is dependent on water owner and intended water user needs. Alternative Transfers can be short term, mid term, or long term in duration:

- Short Term

  Example - The City of Aurora entered into a three-year interruptible supply contract with shareholders on the Highline Canal in the Arkansas River basin. The water resulting from this deal was used to boost Aurora's depleted storage supplies after the drought of the early 2000s.

- Mid-Term

  Example - An agricultural producer might enter into a 10-year interruptible supply agreement in which their water could be used by an industrial user in 3 of 10 years. This sort of arrangement might be useful for lowering the water supply risk of drought.

- Long-Term

  Example - a group of shareholders on a ditch might enter into a long term agreement with a municipality to provide a regular supply of water through a long term rotational fallowing program.

A Note on Permanent, Buy-and-Dry Transfers

Water rights are property rights

Water rights are property rights in Colorado. This document was not written to undermine an agricultural producer's ability to sell his or her water rights in favor of alternative agricultural water transfers. Alternative transfers are meant to be just that – *alternatives* to permanent, buy-and-dry transfers.

It is anticipated that permanent transfers will continue into the future. Permanent transfers make the most sense in some situations:

> Example - An agricultural producer is retiring and his or her kids do not have an interest in maintaining the family business. In this case a permanent transfer is a reasonable option to consider.

On the other hand, for another agricultural producer, alternative transfers may make good sense:

> Example - An agricultural producer who would like to farm well into the future may want to diversify his or her business model or stabilize income. In this case, a long term rotational fallowing program may be attractive.

Why Should an Agricultural Producer Consider Alternative Water Transfers?

A viable alternative transfer needs to be economically beneficial to both parties

Alternative transfers can be an economically beneficial tool for both agricultural producers and municipalities and industry. In fact, for an alternative transfer to be viable, it needs to be economically beneficial to both parties. The following are examples of the potential benefits to agricultural producers and municipalities and industry alike.

- Benefits to the agricultural producer
  - Can lower risk by providing a source of stable revenues and profit
  - Diversifies business – in essence, treating water as a cash crop
  - Can help sustain the farming enterprise over the long term
  - Can result in subsidized or free infrastructure or improvements to water delivery system

- Benefits to municipalities or industry
  - Avoids the larger expense of an outright purchase
  - Focuses on only the asset of interest (water when needed) while avoiding the management burden of assets which might not be useful to municipalities or industry (land)

    - Win-win water transfers cast municipalities in a more positive light than buy-and-drys

- Benefits to local economy
    - Helps keep agriculture in business, maintaining a basic economic mainstay of certain rural areas
    - Avoid further erosion of business base for rural communities that support farming
    - Helps maintain the property tax base
    - Helps maintain a market for businesses that supply agriculture

Examples from Colorado and other Western States

Colorado

While very few alternative water transfers have been conducted in Colorado, there are a few examples of alternative transfers that have occurred in the recent past. They are described below.

The City of Aurora and the Rocky Ford High Line Canal Company entered into a three year lease agreement to transfer 37 percent of the shares in the canal company. Under this agreement, shareholders were allowed to conduct rotational fallowing to produce the water available for transfer. Individual irrigators were responsible for the temporary fallowing of lands included in the alternative transfer program. The State Engineer performed periodic inspections of fallowed lands to ensure that no irrigation was occurring. In the last two years of the agreement, approximately 10,000 acre-feet of water was transferred by fallowing between 8,200 and 8,300 acres of irrigated land.

A pilot water banking program was established in 2001 for storage rights in the Arkansas basin. The program allowed owners of storage water to temporarily lease their water to other water users. By 2005, the pilot project was canceled due to lack of interest and participation. The lack of interest may have been due to restrictions that were put on the water bank such as limitations on exporting the water out of the Arkansas basin and the prohibition of marketing direct flow rights through the water bank (the bank was limited to storage rights only). In addition, the short duration of the pilot water bank likely discouraged the establishment of long term leases that would provide the supply security that municipalities or industry frequently need.

Purchase and leaseback programs have been developed between several agricultural and M&I water users. For example, Xcel Energy has purchased water rights in the Arkansas basin. However, Xcel does not have an immediate need for the water and has been leasing the water back to irrigators. Denver Water purchased water rights on the Williams Fork River in the 1960s. When Denver Water does not need the water, it is used for irrigation. However, in 2002 through 2004, Denver Water exercised their option to use the water for their own purposes.

California

The state of California has implemented a number of alternative transfer methods to provide water to municipal users when needed. The examples described below may or may not be possible in Colorado given differences in legal obligations and constraints between California and Colorado water law.

The Metropolitan Water District (MWD) has an agreement with users in Sacramento Valley to transfer water from agricultural use down to southern California for municipal use when needed. Farmers in the Sacramento Valley who provide the transferred water are required to fallow their land in order to transfer water that would have been used for irrigation down to the southern part of the state for use by MWD.

The Palo Verde Irrigation District also provides alternative transfer water to MWD by implementing a long-term rotational fallowing program. In both cases, the required infrastructure already exists to transfer the agricultural water made available from idling/fallowing from one part of the state to another.

California has also implemented a drought water bank in certain years; the first year was in 1991. Much of the water supply for the water bank comes from farmers who fallow their land, providing water that would have been used for irrigation to municipal users in need of a water supply during drought years.

Transfer Techniques

In an alternative transfer (or any transfer, for that matter), the amount of water that can be transferred is based on the amount that was historically consumed by agricultural crops. The amount of water historically applied to a field that was not consumed by crops (end of field runoff or deep percolation of water below the crop root zone) is considered return flow because this water eventually returned to the river. The return flows are used by irrigators or other water users downstream and are not available to transfer to other users.

All alternative transfer methods depend upon the ability to:

- Quantify historical consumptive use and return flows
- Write decree terms and conditions to govern the transfer
- Verify…
    - The amount of water transferred
    - That return flows were provided in correct amount, timing, and location

<u>"Feasibility"</u>

For this manual, refers the ability of a transfer method to be implemented quickly under Colorado water law and to be administered by DWR

Some alternative transfer techniques have been used in Colorado, while others are being contemplated and aggressively researched. All of these are technically feasible methods. However, methods that have been legally tested through Colorado Water Courts and that are easily verifiable are better candidates for immediate implementation. For the purposes of this document, the "feasibility" of a method refers to its ability to be implemented relatively quickly under Colorado water law and to readily be administered by Colorado's Department of Water Resources (DWR) under currently accepted standards and processes.

As time goes on, methods that are now experimental will likely be tested in the Colorado Water Courts and gain acceptance, increasing the range of options to parties seeking to implement alternative transfers.

Existing Techniques

Alternative transfers involving temporary or rotational fallowing have been successfully implemented in Colorado and in other areas of the United States. Temporary fallowing is generally implemented in the form of interruptible water supply agreements, in which the agricultural producer agrees to cease irrigation and provide water to an M&I user on an intermittent basis. Rotational fallowing involves a commitment by the agricultural user to provide water each year, supported by dry-up of agricultural lands, chosen at the discretion of the agricultural user. These techniques have been the subject of substantial research at the academic level, and have been applied in Colorado and other western states. Though each alternative transfer has unique facts and no proposal is guaranteed approval in a Water Court or administrative context, alternative transfers involving fallowing enjoy the highest level of acceptance in the water community as viable means to implement an alternative transfer.

Purchase and leaseback is another method that has been conducted in Colorado. While this method involves a permanent transfer of water ownership, it does keep the water in agriculture on a temporary or periodic basis.

Rotational Fallowing

Rotational fallowing is an alternative transfer method where an agricultural user would agree to either not irrigate for certain years out of a set period of years, or not irrigate a certain portion of land out of the total amount of irrigated land. In a typical application of rotational fallowing, the lands dedicated to dry-up change from year to year. In other words, during each year of a rotational fallowing program, a different field or set of fields are not irrigated. The water that would have otherwise been consumed as a result of irrigation would be quantified; this amount is the transferrable amount of water that becomes available to a different end user. This alternative transfer method allows most of the agricultural land to remain in production, while at the same time providing a transferrable water supply for another user.

Rotational fallowing could be applied on a smaller scale by one agricultural user, or could also be implemented on a larger scale if applied to an entire ditch/canal company. The degree to which the agricultural producer is responsible for delivery of water and historical return flows likely depends on the scale of the rotational fallowing program. For example, if a group of ditch company shareholders participates in a rotational fallowing program, it is possible that the ditch company or the shareholder group would manage delivery of transferrable water and return flows. In this case, individual agricultural producers may simply be responsible for determining the fields to be fallowed. If a single agricultural producer is conducting the rotational fallowing program, that producer may be responsible for most aspects of water delivery, return flow maintenance, accounting, etc. Responsibilities for various aspects of the rotational fallowing program will likely be a matter of contract negotiation between the agricultural producer(s) and the end user.

Interruptible Water Supply Agreements

Interruptible water supply agreements (IWSA) provide for temporarily suspending irrigation in order to transfer water to a different user. This alternative transfer method is typically implemented on an as-needed basis. For example, during drought conditions a municipal user may call on a farmer under their IWSA agreement to provide water. The amount of water that would have been consumed from irrigation that year would be quantified and represents the transferrable amount. In a year when the IWSA is implemented, typically the agricultural user is notified before the irrigation season. This alternative transfer method also allows for agricultural land to remain in production in most years, since irrigation is temporarily suspended only in years when the water is needed by the other user and limited as to frequency of the transfer. Like rotational fallowing, the degree to which an agricultural producer is responsible for delivery of transferrable water, return flow maintenance, accounting, etc. likely depends on the scale of the interruptible supply program and results of contract negotiations with the end user.

These agreements may be temporary or long-term; however, current Colorado law limits implementation to no more than three years in a ten year period without having to go through Water Court.

Purchase and Leaseback

A purchase and leaseback arrangement occurs when a non-agricultural water user, for example a municipality, purchases an agricultural water right with the agreement that the water will be leased back to the agricultural producer (or ditch system) during certain years, usually during normal or wet years. This type of arrangement allows for the land to remain in agricultural production when the water is leased back to the producer and the purchaser does not need the additional supply. It also provides the purchaser with additional supply during dry years when it is needed. This type of arrangement is similar to an IWSA, except that in a purchase and leaseback agreement the purchaser is the new owner of the water right, rather than the agricultural producer.

Emerging Techniques

There are other methods that have potential to be used in the future. These methods have not been used in the past because they are relatively untested in Colorado Water Court and it is uncertain how DWR would administer them. However, these methods are being researched and are likely to be implemented in the coming years as pressure to meet the State's growing water demand increases.

Deficit or Limited Irrigation

Deficit or limited irrigation involves limiting irrigation at specific times during the crop growth cycle to minimize water use while still producing crops (at potentially lower yield). Since less water is consumed by the crop during the times of limited irrigation, the amount of water that would have historically been consumed becomes available for transfer to another user. This alternative transfer method also allows for agricultural land to remain in production, while still providing a transferrable amount of consumable water.

Deficit irrigation could provide many opportunities for alternative transfers. There are several benefits and challenges associated with this method of transfer. They are described below:

Benefits

- All of the irrigated land that an agricultural producer owns could still be farmed.
- Farming input costs could be reduced.
- Impacts to the local economy are minimized, because there is still a demand for farming inputs.
- The farming business would gain more diversity of income while still raising crops.
- Because the land continues to be irrigated, the land holds its value, which benefits the farmer and the county (assessed land values stay the same).

Challenges

- Crop yields may be less than under full irrigation. Compensation for transferred water would need to make up for lost revenues from lower yields.
- It is unclear how the state would administer the transfer. There are efforts underway to quantify saved consumptive use accurately and in a way that could be used by DWR for

verification. Some of these efforts are being funded by the CWCB grant program that funded this guidance document.

- A deficit irrigation transfer would need to go through Colorado Water Court. Because deficit irrigation transfers are not yet commonplace, it is possible that the first deficit irrigation Water Court cases will have many issues to work out.
- Additional costs may be incurred by agricultural producers to purchase equipment or other technologies to monitor or quantify transferrable consumptive use and to demonstrate that historical return flows are being provided in the correct timing and amount.
- It may be necessary to cooperate with several other agricultural producers to accumulate enough transferrable water that it would be attractive to a municipality or industry.

Alternative Cropping

Alternative cropping involves changing the crop type from the historically grown crops to an alternative crop with a lower annual consumptive use (CU). These crop substitutions may occur either on a short-term or a more permanent basis. Water that would have been consumed by the higher CU crop that is no longer required by the new crop represents the amount of water transferrable to a different user. This alternative transfer method allows for the agricultural land to remain in production, while still providing a transferrable amount of water.

Like deficit irrigation, alternative cropping is an attractive but untested transfer method. Benefits and challenges associated with this method are listed below. Many of these are the same as deficit irrigation.

Benefits

- All of the benefits of deficit irrigation are applicable to alternative cropping.
- A rotation of lower water use crops may fit easily into an agricultural producer's operations.

Challenges

- An alternative cropping transfer program would need to go through a Water Court proceeding and would face many of the same challenges as Deficit Irrigation.
- Methods for verifying the amount of transferrable consumptive use would need to be developed.

- The market for lower water use crops may not be as strong as for higher water use crops.
- Some lower water use crops may require different equipment or inputs than higher water use crops.

Water Banks

Water banks are organizational frameworks for marketing water that have been authorized by the Colorado Legislature. They are intended to provide a mechanism for transferring water from agricultural users who may have an excess amount in a given year to other water users who may have a need for water that same year. A water bank is often in the form of water stored in a reservoir, where agricultural users (sellers) contribute excess water they do not need that year to the water bank while other water users (buyers) use the amount they require from the water bank that same year. Transactions can occur either through a third party managing the water bank (where the seller and buyer do not interact directly) or directly (where the seller and buyer carry out the transaction directly with each other). Water banks must be formed by a governmental agency, such as a water conservancy district or a water conservation district.

Water banks have not been widely implemented in Colorado. As described earlier in this document, a water banking pilot project was implemented in the Arkansas River basin in 2001 but was cancelled in 2005. Even though the pilot water bank was not as successful as desired, water banks are still an option for marketing alternative transfers of water. They can provide a transparent means for marketing water and can help potentially avoid the time delays and expense of Water Court.

Flex Water Market

The "Flex Water Market" is a concept developed in CWCB funded studies to encourage alternative transfers. Flex water markets involving a combination of both permanent and temporary transfers are currently being studied in the South Platte River basin. No flex water markets have been established as of the publication of this document. However, from the studies that have been conducted to date, it appears that this concept is readily implementable under Colorado's current water law. A description of the flex water market is provided below.

The flex water market concept combines elements of long term rotational fallowing, reduced consumptive use, purchase, leasing and interruptible supply. The flex water market is a Water Court approved contractual relationship between one or more M&I users and one or more agricultural suppliers. The agricultural user provides two types of water to the M&I user, referred to as "Base Consumptive Use" (Base CU) and "Flex Consumptive Use" (Flex CU). Base CU is a small portion of the consumptive use associated with the agricultural user's shares (10% is a suggested number, but it would be a point of contract negotiation) that is permanently sold to the M&I user. Flex CU is the remaining 90% of the consumptive use, which remains under the ownership of the agricultural user, and can be leased to the M&I user on terms agreed upon between the agricultural user and the M&I user. These leases could be for short terms, longer terms or interruptible supply.

The agricultural user manages his or her land through rotational fallowing or other means to produce the Base and Flex CU for the M&I user each year. Recharge sites could be installed to help provide for the delivery of consumptive use and return flows.

The Flex CU can be sold by the agricultural user at any time, whether to the M&I partner or to another water user, subject to a right of first refusal for the M&I user partner. The agricultural user and M&I user cooperate in a Water Court application to seek approval of a change in use of 100% of the agricultural user's water, to establish terms under which the delivery of Base and Flex CU will be administered.

The program is intended to establish a mutually beneficial partnership between the M&I user and agricultural user that supplies additional water for M&I needs while creating conditions conducive to maintaining a healthy agricultural economy within the ditch system.

Because this manual is directed at methods that are currently implementable by Colorado irrigators, more implementation guidance is provided for some of the above methods than others. Specifically, this manual provides more detailed descriptions of rotational fallowing and interruptible supply agreements in later sections of the manual.

Important Technical Issues

Transferrable Amounts

The amount of irrigation water available for transfer is based on the amount historically consumed by crops

The amount of water that is available for transfer is based on the consumption of irrigation water applied to crops grown by the agricultural producer. This amount of water, often referred to as "consumptive use" or "CU," is the valuable portion of a water right because it is the portion that can be applied to new uses. Water provided by precipitation and consumed by crops is not available for transfer. Also, water that runs off the end of irrigated fields or that percolates through the soil and into the groundwater aquifer cannot be transferred.

The amount of consumptive use available for transfer is dependent on several factors, which are listed below:

- **Crops grown.** Different crops consume different amounts of water. The historical mix of crops grown on a farm is considered when quantifying the amount of irrigation water available for transfer.
- **Location, Climate and Precipitation.** Precipitation, temperature, relative humidity, and other environmental factors impact the amount of irrigation water that a crop consumes. Elevation plays a role as well.
- **Priority of water right.** The historical amount of irrigation water that was available to apply to a crop may have been impacted by the priority of the irrigation water right. For example, a relatively junior water right may have been curtailed from time to time, lessening the amount of water that was historically applied for irrigation and consumed by the crop.
- **Legality of diversions for irrigation.** In some recent Water Court cases involving permanent transfers of irrigation water, it was found that some of the water historically used for irrigation was applied to lands that were outside of the original service area of the ditch. Historical consumptive use from these lands was not included in legally transferrable amounts of water.
- **Other legal uses of water besides irrigation**. In some recent Water Court cases, uses of water other than for irrigation purposes were included in the calculation of historical consumptive use. For example, if an agricultural producer has leased his or her ditch shares to another producer or to a municipality, that water usage can be counted in the overall quantification of historical consumptive use.

Historical Return Flows

Return flows must be protected in timing, location, and amount

The irrigation water that was applied to the field but was not used by the crop is assumed to have returned to the river either by running in surface drainages or by percolating below the ground surface through the aquifer. This water is considered to be return flows.

Return flows must be protected because downstream water users depend on them as a part of their water supply. When conducting an alternative transfer, the amount of water historically returned to the river must be quantified. It must be provided to the river using the same timing and in the same location as happened historically.

Conveyance Losses

When water is diverted for irrigation, part of that water is lost through ditch seepage between the river headgate and the farm turnout. This water is considered to be a conveyance loss, and it is not transferrable. It needs to be protected like historical return flows.

Conveyance losses are important to both downstream water users other shareholders on a ditch

Other water users on the ditch system depend on the maintenance of conveyance losses. If all or part of the conveyance loss were transferred, then it would be difficult, if not impossible, to deliver water to the lower ends of the ditch.

Downstream water users also depend on the maintenance of conveyance losses. The water that seeps from the ditch enters the aquifer and eventually returns to the river as streamflow. Like historical return flows, the conveyance loss that returns to the stream is part of downstream users' water supply.

Ability to Administer

An important consideration in alternative transfers is the DWR's ability to administer the transfer. Staff from DWR need to be confident that:

- The new user diverts and consumes no more than the historical CU amount established by the Water Court or the State Engineer
- Historical return flows are being maintained in terms of timing, location, and amount

Documentation submitted to DWR must allow for efficient evaluation. The staff of DWR have many transfers to administer, and their time is limited. Clear documentation of transfer amounts and historical return flows must be provided to DWR so that they can efficiently oversee the transfer.

A few examples may be useful to highlight examples of transfers that are administrable and not easily administrable.

Administrable

An agricultural producer enters into a rotational fallowing program. In each year of the program, the producer provides information to DWR describing the locations of the fields to be fallowed. The producer either monuments fallowed areas (places signs in the fields along the borders of fallowed areas) or submits current satellite imagery documenting that no crops were grown on the field. Staff from DWR can either visit the field in person to verify that no crops were grown or they could rely on the satellite imagery. The producer also submits daily accounting showing the amounts transferred and historical return flows.

Not Easily Administrable at the Current Time

An agricultural producer enters into a deficit irrigation program with the intent of transferring the reduced consumptive use from the crop. New technologies are currently being developed to quantify the saved consumptive use, but they are untested for DWR administration purposes. As a result, it is currently difficult for the producer to quantify, and for DWR staff to verify, the amount of water that is being saved and that is available for transfer. It is also currently difficult to quantify the amount of return flow that the producer needs to provide to the river.

Financial Considerations

The economic implications of a potential alternative transfer are very important. If the conditions of the transfer are not economically beneficial to both parties, then it should not occur.

Both parties must understand terms and price ranges which might be acceptable to them. They should consider how transfer fits economically into the larger financial setting of their respective operations.

Financial considerations of alternative transfers are very important and should be understood by both parties

Certain considerations are identified below that are relevant to negotiating the terms of an alternative transfer. Of course, each alternative transfer will have its own, specific considerations which deserve close attention.

Considerations for Municipal or Industrial Users

- The initial and on-going cost obligations under an agreement
- The ability to exchange water to a place where it can be conveyed or used
- The costs of conveying water to treatment plants
- Quality of the water and ability to treat with existing systems
- The cost of other water supplies that could be used instead
- The ability to efficiently gain the support of agricultural producers
- The ability to gain other public and institutional support for the transfer
- The transaction costs, including engineering, of adjudicating the transfer in Water Court, etc.

Considerations for Agricultural Water Users

- Understanding the terms and full ramifications of the proposed transfer
- Lost revenue from crop production due to the water transfer
- Lower input costs due to fewer acres of crop production
- Benefits of new revenue streams
- Reduced risk associated with revenue diversification
- Cash flow changes in different types of crop years

- Labor and fixed asset utilization
- Costs for weed control
- Costs associated with putting fallowed land back into crop production
- Risks associated with increasing/decreasing commodity prices or increasing/decreasing input costs. Is the agricultural producer better off or worse off under various alternative future scenarios?
- The cost of adjudicating the transfer in Water Court

AgLET is a free computer program for evaluating financial considerations of alternative transfers

The Agricultural Lease Evaluation Tool (or AgLET) is a free computer application developed with funding from the CWCB, to help agricultural producers evaluate the above listed factors and the proposed price and terms of a potential water transfer. The program allows the agricultural user to input the details of his or her agricultural operation and the proposed terms of a water lease, and helps calculate the "bottom line." The AgLET tool is available through Colorado State University Extension at the address and phone number at the end of this document.

Colorado State University Extension is currently studying the costs of bringing irrigated fields back into production after fallowing. More information on this study can be obtained by contacting the individuals listed at that end of this manual.

The timing for negotiating the terms of a potential alternative transfer will vary from deal to deal. However, it is likely that the historical use, return flows, and operational plan will need to be understood before the alternative transfer can reach the final negotiation stage.

Water Court Approval

Most transfers will need to go through Water Court and obtain a decree (an Interruptible Water Supply Agreement is an exception). The Water Court process allows other water users to review the plan for the transfer and to object if they feel that their water rights might be injured. There are benefits and challenges with the Water Court process:

Most alternative transfer methods will need Water Court approval

Benefits

- The Water Court process and resulting decree protect the parties conducting the transfer by providing certainty regarding the ability to operate the proposed plan.
- Other water users on the river are protected by giving them the chance to weigh in on the conditions of the transfer.
- It provides a forum for dispute resolution.

Challenges

- The Water Court process is costly and time consuming.
- It can be risky to bring a transfer (or "change in use") case to Water Court because the water right is subjected to increased scrutiny, requantification, and limits on future use. For example, if the irrigated lands involved in the transfer were not a part of the original plan for irrigation on the ditch, the CU may be reduced and the water right prohibited from irrigating those acres in the future.

Before entering into an alternative transfer agreement, both parties should carefully consider the relative costs and benefits of the Water Court process, and develop a strategy to share the costs, risks and benefits of the process.

Cooperative Strategies

Many agricultural producers interested in alternative transfer agreements are recognizing the potential benefits of banding together to spread the costs and risks. This section describes several strategies that apply the "strength in numbers" approach, and the benefits and challenges of each.

> Example - The costly nature of Water Court could be lessened by forming a group of agricultural producers who are interested in an alternative transfer program. The costs for Water Court could be shared among the producers and with the municipality or industry that would use the water.

Developing Larger Deals

There are a number of costs associated with conducting alternative transfers. Water Court procedures can be very expensive and time consuming. Also, costs for water measurement structures, recharge basins, accounting, etc. can be significant.

Working with other water users who are interested in doing alternative water transfers can be an effective means to lessen the costs to individual agricultural producers in conducting alternative transfers. Costs for Water Court and technical analyses can be spread over more shares and among more parties. A natural fit might be to organize shareholders within the same ditch system who are interested in conducting an alternative water transfer. Organizing groups of water users offers several benefits, but also some potential challenges:

Benefits

- By organizing a group of shareholders, the amount of water available for transfer increases. This would likely be more attractive to a municipal water provider. It would also allow shareholders to spread the costs associated with technical analysis and Water Court or administrative approval over more shares.
- Groups of shareholders could share the cost of installing the necessary infrastructure to conduct a transfer.
- Standardized contracts could be developed. This is attractive to municipal water providers. It is a disincentive to a municipal water provider to do

alternative transfers if the provider needs to establish individual contracts with many agricultural producers.

- A ditch wide analysis of historical consumptive use and return flows could be conducted. Ditch wide analyses offer the advantage of establishing uniform amounts of transferrable consumptive use per share. The establishment of per-share standards also allows for more efficient and less costly expansion of an alternative transfer program.

Challenges

By participating in a larger alternative transfers, water users can spread the costs of conducting transfers

- Loss of control. The larger the group, the less control you will have over the decisions made by the group. You may not agree with some decisions made by the group.
- Loss of flexibility. As the size of group grows, and its methods become standardized, there is less opportunity to accommodate unique circumstances.
- Increased transaction and administrative costs. As an alternative plan becomes larger and more complex, Water Court and administrative costs increase. A smaller, less complex plan can be easier to adjudicate and administer
- Potential increased liability. Actions of the group or group members may affect you in negative ways. For example, if the group fails to properly administer the plan, you may suffer increased assessment or dues for penalties or remediation, even if you committed no specific violation.

Many of the benefits of entering into larger deals can also be challenges if the plan is not well thought out or administered properly. It is important to have competent technical and legal counsel when considering involvement in a large water transaction. Be sure the group is well represented, and do not hesitate to contact your own water counsel (separate from the group counsel) to advise you on the benefits and challenges of the proposed deal.

Water Banks and Cooperatives

Water banks and cooperatives could help reduce transaction costs by providing an established marketing mechanism for water from alternative transfers. Examples of these entities include the Arkansas River "Super Ditch" and the developing "Lower South Platte Water Cooperative."

Cooperative entities could provide an institutional framework for water transfers that extends beyond temporary alternative arrangements. For example, in the Lower

South Platte River and in other areas of the state, well augmentation plans use intentional recharge as a source of augmentation water supply. From time to time, the need for augmentation supply is less than the supply itself, resulting in an excess of supply. This excess supply, if it is properly accounted for, can be leased to other water users who do not have enough supply. The leasing of excess recharge credits has become relatively commonplace in the Lower South Platte River.

The proposed Lower South Platte Water Cooperative could act as a "middle man" in matching those with excess water with those in need of water. In addition to the marketing of excess recharge supplies, this organization could, in the future, potentially market water from rotational fallowing, interruptible supply, deficit irrigation, and other alternative transfer programs.

Some of the cost-saving benefits of water banks and cooperatives were described earlier in this manual. These benefits include establishment of standard contracts, cost sharing for Water Court applications, and sharing of infrastructure for delivering water for transfer or return flows. Additional benefits and challenges of participating in these entities are similar to those described for "Developing Larger Deals" above.

Cost Sharing Between Parties

If two parties agree to an alternative transfer (regardless of whether the transfer takes place within or outside of a water bank or cooperative), costs associated with alternative transfers could be shared between the parties. Water Court proceedings, water measuring structures, recharge facilities, water accounting, etc. are all costs that could be shared by the parties.

Long Term Deals

If the costs to establish an alternative transfer are anticipated to be large, it would likely be advantageous to develop longer term water deals. The longer the term of the water transfer, the lower the costs to establish the transfer will be when considered on an annual basis.

Checklist for an Alternative Transfer

Locating Opportunities

While some alternative transfers have been conducted in Colorado, they are not commonplace. Because of this, it is possible that an agricultural producer who is interested in an alternative transfer may need to do some investigation to identify opportunities for conducting transfers. As time goes on and as alternative transfers become more common, more opportunities to conduct transfers will likely be available to producers. Individuals or organizations that may have knowledge of potential alternative transfer opportunities include:

- ❑ Other shareholders in a ditch company
- ❑ Ditch company board members and staff
- ❑ Water conservancy district staff
- ❑ Staff/management of organizations such as the Super Ditch or the Lower South Platte Water Cooperative
- ❑ Water commissioner and other DWR staff
- ❑ Water attorneys and engineers
- ❑ The "Round Table" for the water basin

Calculating Historical Consumptive Use and Return Flows

A technical analysis will need to be conducted in order to quantify the amount of transferrable water associated with the water rights that will be included in an alternative transfer. In addition, an assessment will need to be conducted to quantify the amount, timing, and location of return flows that historically occurred. These activities are necessary for all methods of permanent and alternative transfers.

There are a number of qualified engineers who have conducted these sorts of analyses. If the alternative transfer needs to be decreed through Water Court, it is likely that a qualified engineer will need to provide an expert report or expert testimony. It is advisable to consult with a water attorney at this stage, who can perform an initial feasibility assessment and recommend a qualified engineer. Many ditch companies work with qualified engineers and can also provide a recommendation for an engineer who is familiar with your ditch system. A summary of the typical steps in this process are below.

- ❑ Check to see if a ditch-wide analysis of historical consumptive use and return flows has been conducted

  Several ditch companies have conducted ditch-wide analyses of historical consumptive use and return flows. These analyses result in estimates of historical consumptive use and return flows on a per-share basis and can likely be used for conducting an alternative transfer. It is possible that the ditch company board will require the use of the ditch-wide study for permanent and alternative transfers.

- ❑ Hire an engineer if needed

  If a ditchwide analysis exists and the ditch company would like to use it as the standard method of quantifying historical consumptive use and return flows, then it is possible that an attorney could use this information to develop the paperwork to implement the alternative transfer.

  If a ditchwide analysis does not exist or is not useful, a qualified engineer should be hired to quantify historical consumptive use and return flows. In addition, an engineer may be required if a Water Court proceeding is necessary.

  The steps that an engineer will take in conducting the analysis are summarized below.

  Data assembly

  - *Historical acreage and types of crops*. If actual records of this information exist, it is best to use it. Oftentimes, these records do not exist, and the historical acreage and types of crops grown through the years is developed from the memory of farm operators.
  - *Ditch conveyance losses*. Ditch conveyance loss estimates are oftentimes provided by ditch riders. In some cases, ditch loss studies may have been conducted previously and can be used.
  - *Historical water deliveries*. Records of historical water deliveries to a farm do not normally exist. Therefore, they are estimated using records of headgate deliveries and subtracting

ditch conveyance losses. Headgate diversion records from DWR are normally available for this calculation.

- *Historical methods of irrigation and application efficiency.* The method of irrigation historically used is normally provided by the shareholder. Records of irrigation application efficiency rarely exist. Irrigation efficiency is normally estimated using standard methods or rules-of-thumb.
- *Historical climate data.* This data is readily available through a variety of outlets including the Colorado Decision Support System, the High Plains Regional Climate Center, the Northern Colorado Water Conservancy District, and others.
- *Location of the farm and aquifer properties.* The properties of the alluvial aquifer determine the amount of time it took for historical, subsurface return flows to reach a stream. Aquifer properties have been mapped in most cases, and the location of the farm is needed in order to determine the conditions of the aquifer in the specific location of the farm.
- *Historical deliveries, historical consumptive use, method of irrigation, and irrigation efficiency.* Basically, the quantity of historical return flow that occurred at a farm is equal to the amount of water applied for irrigation minus the amount that was consumed by crops. The types of information listed under this item are all a part of, or a result of, the quantification of historical consumptive use.
- *An estimate of the proportion of deep percolation and runoff.* Understanding the quantity of return flow that returns to a stream via overland and via subsurface flow is important in order to properly mimic the historical timing of return flows (return flows that make their way back to a river via surface waterways tend to enter the river much more quickly than return flows that migrate towards the stream through an underground aquifer). If any data exists that describes the proportion of subsurface (deep percolation) and surface (end of field runoff), it would be useful. That said, it is uncommon to have this data, and estimates are usually made based on the distance from the stream and the proximity of local drainageways.

Estimation of historical consumptive use

Once the necessary data is assembled, historical consumptive use can be estimated using computer models. The most commonly used computer models are available from the Colorado Decision Support System (the StateCU model) or the Integrated Decision Support Group at Colorado State University (the IDSCU model). These tools are routinely used in Colorado water rights cases. A qualified engineer familiar with Colorado water rights will be able to use these models in a manner that is acceptable for a Water Court proceeding.

Estimation of the amount of return flows

Normally, the amount of historical return flow that occurred at a particular field is calculated along with the historical consumptive use. Once the amounts are calculated, the timing of their return to a stream needs to be estimated.

Estimation of the timing and location of return flows

Once historical return flows at a farm are quantified, the amount of time it takes for those return flows to return to the stream is estimated. This can be done using several computer models. Some of these models are quite complicated. The complexity of the timing analysis oftentimes drives the choice of model. A qualified engineer familiar with Colorado water rights will be able to provide advice on the necessary analyses and models and can apply these models in a manner that is acceptable for a Water Court proceeding. In addition, the engineer can also provide estimates of the location of return flows based on drainage patterns (for surface return flows) and the general direction of groundwater flow (for subsurface return flows).

Developing an Operational Plan

A plan for delivering transferable water (historical consumptive use) and return flows will need to be developed. This plan (or components of it) could be incorporated into the terms and conditions associated with a Water Court decree and/or the contract for the transfer. The plan should describe how transferrable consumptive use will be delivered to a stream or to an end user, how historical return flows will be provided, limitations on the amount of water to be delivered under the transfer agreement, etc. Potential components of the plan are described below.

- [ ] Delivery of historical consumptive use

Oftentimes, water to be transferred is diverted from a stream and immediately returned to the stream through an augmentation station with a flow measurement structure. The transferred water can then either be delivered downstream or exchanged upstream to a storage, pumping, or diversion facility. Water could also be delivered to a recharge facility or wetland. Water delivered in this manner would not be immediately available for another user, but would eventually re-emerge as streamflow, which could be delivered to other users. The operational plan should identify existing or proposed conveyance and measuring structures and/or recharge facilities that will be used to deliver the water to be transferred.

- [ ] Delivery of historical return flows

Historical return flows could be delivered through an augmentation station. This works well during the irrigation season. However, it can be difficult in the winter because diversions are not occurring. Alternatively, historical return flows could be delivered to a recharge pond or recharge wetland. If the timing and location are similar to the historical place of use, this water will emerge at the proper time and location to replicate historical patterns. This method offers an advantage because in some situations, historical return flows might not need to be delivered to the river for a few years after their original diversion from the river. If a short term transfer is conducted, an agricultural producer or municipality might not want to be liable for delivering historical return flows for several years after the transfer is concluded. Recharging the return flows into a facility with the right lagging characteristics helps to address this problem. The operational plan should identify existing or proposed conveyance and measuring structures and/or recharge facilities that will be used to deliver the water to meet historical return flow requirements.

- [ ] Limitations on transferrable consumptive use amounts

The amount of water available for transfer is limited to historical average amounts of consumptive use. However, the amount of consumptive use or irrigation water that occurred on a yearly or monthly basis varied over the historical period of record. Likewise, the amount of transferrable consumptive use will likely vary based on the amount of water that was diverted from the river when the transfer is being operated. Therefore, limitations are necessary to prevent the amount of water transferred from exceeding historical maximum monthly or annual amounts of consumptive use. These amounts are normally derived in the quantification of historical consumptive use.

- ❑ Accounting

  Daily accounting will need to be developed in a format prescribed by DWR that documents the daily amount of water transferred and the daily provision of historical return flows. Accounting data needs to be reported to DWR on a monthly basis.

- ❑ Monumenting

  The fields that are the subject of an alternative transfer will need to be monumented. Monumenting can be done by either erecting physical markers in a field denoting areas that are subject to the transfer (i.e. fallowed areas) or by providing GPS coordinates of field corners to the DWR. Monumenting is necessary so that staff from DWR can clearly identify and physically verify fields that are subject to the transfer.

- ❑ Erosion and weed control

  A plan for controlling erosion and blowing soils should be developed for lands that are fallowed. In addition a plan for controlling weeds should be developed to ensure that noxious weeds or other nuisance vegetation do not develop on fallowed lands.

Obtaining Court/Administrative Approval

Water Court or administrative approval is necessary prior to conducting an alternative transfer. A water rights attorney will need to be consulted regardless of the method of transfer chosen. Water rights attorneys will advise an agricultural producer regarding Water Court procedures and issues, make the necessary Water Court or administrative filings, develop or review contracts for the transfer, and will advise engineers regarding legal considerations in the technical analysis and operations plan.

Processes for obtaining Water Court or administrative approval can differ depending on the method of transfer chosen. Below are descriptions of steps and processes that need to be taken depending on the method of transfer.

Rotational Fallowing

The following are activities that are specific to a rotational fallowing program:

- ❑ Submit an application to Water Court

  An application to conduct a rotational fallowing program will need to be submitted to Water Court that describes the applicant(s), the source of the water, the location of diversion, the amounts of water to be transferred, and a description of the proposed use of the water.

- ❑ Submit a Substitute Water Supply Plan to the State Engineer

  Once the application has been accepted, a Substitute Water Supply Plan (SWSP) needs to be filed with the State Engineer's Office (SEO), if the parties want to operate the plan while the Water Court application is pending. An SWSP is a one-year authorization to operate the program described in the Water Court application. SWSPs will need to be filed on an annual basis until a Water Court decree is issued (typically 2-3 years). It describes amounts of water to be transferred; the timing, location, and amount of historical return flows; the operational plan; and accounting that will need to be performed. An SWSP can be reviewed by objectors, and objectors can provide comments on the SWSP prior to its approval by the State Engineer.

- ❑ Begin the rotational fallowing program

  Once the necessary legal paperwork has been filed, and approval to operate under an SWSP is granted by the SEO, the rotational fallowing program can begin. The program should follow the steps and processes outlined in the Operational Plan.

Interruptible Water Supply Agreements

The following are activities that are specific to an IWSA (see §37-92-309, Colorado Revised Statutes for more information).

DWR has developed detailed Rules and Regulations for Submittal and Evaluation of Interruptible Water Supply Agreements, which can be obtained at the following web address:

http://water.state.co.us/DWRIPub/Documents/IWSARules.PDF

The following is a summary of the Rules and Regulations for IWSAs. The reader should obtain and reference the Rules and Regulations when developing and requesting approval of an IWSA. The reader should work with their water rights attorney prior to developing an IWSA and check for updates to the Rules and Regulations.

- ❑ Submit an application to the State Engineer's Office

  The State of Colorado allows the operation of interruptible supply programs for a maximum of 10 years without the need to go through Water Court. An application for an interruptible supply program needs to be submitted to the SEO in order to start the approval process. The application needs to include a description of the water rights involved in the IWSA, copies of IWSA agreements, an engineering report that documents the historical consumptive use and return flows, an erosion and noxious weed control plan, a proposed accounting form, and a description of how water deliveries will be measured. The applicant will need to pay a fee to cover publishing and administrative costs.

- ❑ Potentially participate in a hearing to approve the interruptible supply program application

  The State Engineer has the option of conducting a hearing prior to approving the application for the interruptible supply program. The issues involved would likely be similar to those in a Water Court proceeding—quantification of historical consumptive use and return flows, assessment of operational plan, and terms and conditions governing administration of the plan.

- ❑ Begin the interruptible supply program

  Once the necessary legal paperwork has been filed, and approval to operate is granted by the SEO, the IWSA can begin. The IWSA can only be conducted in three of ten years. Notice should be provided by March 1st of a year when the IWSA is to be conducted. The program should follow the steps and processes outlined in the Operational Plan.

References for More Information

The following reports and contacts can provide more information on alternative agricultural water transfers:

- Chapter 3 of *Colorado's Water Supply Future, Statewide Water Supply Initiative - Phase 2* contains a review of various methods of alternative transfer. It is available for download at: http://cwcb.state.co.us.

- Reports and information resulting from work conducted under the CWCB's Alternative Transfer Methods grant program. More information can be found at the following website: http://cwcb.state.co.us/LoansGrants/alternative-agricultural-water-transfer-methods-grants/Pages/main.aspx

- The Colorado Department of Water Resources

  http://water.state.co.us/Home/Pages/default.aspx

- Colorado State University Extension. Contacts include:

  Dr. James Pritchett
  (970) 491-5496
  or
  Dr. Perry Cabot
  (719) 549-2045

- For more information about the Lower South Platte Water Cooperative, contact:

  Mr. Joe Frank
  Lower South Platte Water Conservancy District
  (970) 522-1378