

ON-FARM STRATEGIES FOR DEFICIT OR LIMITED IRRIGATION TO MAXIMIZE OPERATIONAL PROFIT POTENTIAL IN COLORADO'S SOUTH PLATTE BASIN

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ABSTRACT

Farming, in many ways, is more complex and technically demanding than ever before. Just one example of this complexity is related to the population growth along the Front Range of Colorado and within the South Platte Basin. Municipalities, desperate to identify and solidify their future water supplies that will sustain continued population growth and produce a “safe yield” of water are frequently looking toward agriculture as a water supply source. Often enough, farms are acquired outright and the water rights are parted off 100% to be changed over to municipal use. This is often referred to as “buy and dry.”

The purpose of this paper is to show that successful farming operations can be continued while benefiting from a proportional parting-off of the water right's established consumptive use (CU). The CU of a given water right is established through an engineering study which evaluates and details the historic use of the water right. Historic cropping patterns, acreages, and irrigation methods must be considered in the study. Once the CU is established and vetted through the Colorado Water Court, the CU for that water right becomes decreed – a known quantity. This then allows for more comprehensive consideration as to how that CU water might be used to economic advantage in the future. Specifically, a future water use might be to continue farming but to lease or sell a proportion of the CU to municipal interests. This same general idea might also apply to a ditch company getting involved in planning, controlling, and administering an overall service-area-wide program.

Once actual CU water quantification is fully understood, consideration can be given to a comprehensive package of farming practices which become the underpinning of future agriculture operations for farmers interested in availing themselves of such a change. Practices may include changes to cropping patterns, consideration of alternative crops, deficit irrigation, improved irrigation application efficiencies, and improved management and monitoring / control using the newest technologies. Optimization software is under development to assist farmers and ditch companies as they consider the viability of operational changes.

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INTRODUCTION

In 2003, the State of Colorado initiated a planning effort called the Statewide Water Supply Initiative (often termed “SWSI” and pronounced “swa - zy”) for the purpose of projecting water supply needs for each of Colorado’s river basins in 2025. For the South Platte Basin (Figure 1), the SWSI report forecast a population growth of 65% which equates to 2,000,000 people by 2025 and an associated water supply need of 400,000 acre feet. The South Platte is already over appropriated. Transbasin transfers and new storage are essentially no longer feasible because of permitting obstacles. The prevalent presumption is that the 400,000 acre feet will likely come from irrigated agriculture. This dynamic is also playing out in other states in the West and other basins in Colorado in the form of municipal acquisition of farms and water. The water is then 100% removed from the farm and the use of the water is changed to municipal and industrial (M&I) use. The farm is dried up into perpetuity. This process is often referred to as “buy and dry.” Even some of the municipalities who have availed themselves of this practice are saying publically that they do not want to continue with the practice because of the impact on the rural community and the cumulative negative push back from many sectors. Some municipalities are actively looking for alternatives to what has come to be called “buy and dry.”

South Platte River Basin

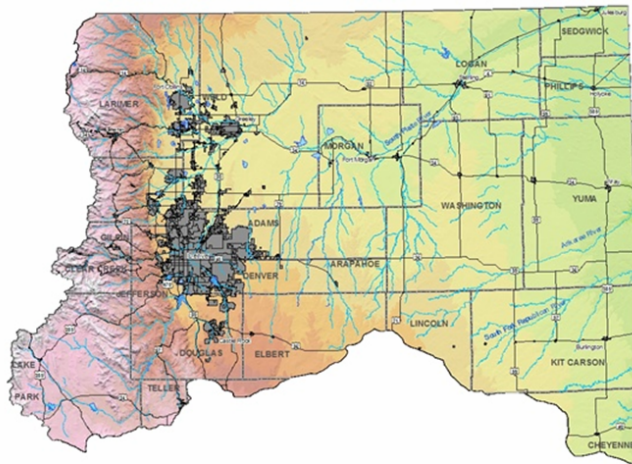


Figure 1. The South Platte River Basin in northeastern Colorado.

An alternative to buy and dry in the Arkansas Basin of southeastern Colorado is manifest in the form of the Super Ditch Company. The Super Ditch is a recent, for-profit farmer-managed entity that represents the collective interests of eight ditch companies by offering a rotational fallowing option to their constituent farmers. A municipality or water district may contract with The Super Ditch to deliver a prescribed amount of CU water over a specified period of time. The CU water is made available through rotational fallowing. Farmers can evaluate a number of options suitable to their specific circumstance and make it known to Super Ditch management that some proportion of their land is available to be fallowed. Some operational issues are still under

consideration, and as of now, no wet water has been delivered. However, a letter of intent to contract has been executed between Super Ditch and the Pikes Peak Regional Water Authority according to published newspaper reports in The Pueblo Chieftain.

A somewhat similar approach but differently organized is in the early stage of development and vetting in the South Platte Basin. With this program, farmers can initiate a desktop analysis of their farming operation, evaluate future “what if” operations, and consider the cumulative effect of changed practices. The analysis facilitates viewing their consumptive use (CU) water as a block from which they may evaluate an incremental parting off of some proportion of the CU. The ultimate goal, depending on several intertwined factors, may be to lease or sell a portion of their CU or to at least consider that option. The lease of a proportion of the CU could become a steady and predictable revenue stream for the farmer over the term of the lease. By evaluating alternatives which may include a full package of changed practices, the farmer can at least evaluate the potential for this change. Does it work for them or not? The answer to that question is an individual decision but at least the option can be fully evaluated using a decision support system and optimization. Changed farming practices represent a business decision, of necessity, but a decision underpinned by sound engineering and economics.

The relevant technical literature uses many terms for “limited irrigation” or “deficit irrigation.” The terms are often used interchangeably. It was noted at a recent deficit irrigation workshop that there is ambiguity in the terms but it was suggested that “deficit irrigation” may be preferred by many. Marshall English at Oregon State University has recently defined deficit irrigation as irrigation that allows stress in a significant fraction of a field at some times during the season. Freddie Lamb at Kansas State University notes that he defines deficit irrigation as an irrigation level under the expectation of reduced crop yield with economics justifying the deficit. The term “limited irrigation” herein will refer to a reduction of water applications through a combination of practices, one of which may be deficit irrigation.

The history of basic research in this area is long and dates back to the 1970s. Early work was primarily intended to show the basic potential for water conservation. The more recent work is driven by drought response demands, desire to predict climate change impacts on crop production, and the possibility of revamping individual farming operations for maximizing profit as opposed to maximizing yield.

The current definitive research in the western U.S. is being conducted by Derrel Martin and Ray Supalla at the University of Nebraska, Norm Klocke at Kansas State University, Tom Trout with the USDA-ARS Water Management Unit in Fort Collins, Colorado, and Marshall English at Oregon State University. Several of these research efforts have resulted in Excel-based optimization routines including the Water Optimizer program developed at the University of Nebraska and the Water Allocator program developed at Kansas State University.

THE SOUTH PLATTE BASIN CIRCUMSTANCE

The South Platte Basin has become a focus and “poster child” of many of the interrelated problems associated with population growth. Cities and towns along the Front Range have varying water portfolio amounts in what is referred to as “safe yield” water to serve growing populations. There is often a desperation mentality that makes the municipal water managers grasp at all alternatives – conservation, new storage, leak detection, fines for water wastage, water conservation programs, public information programs, and aggressive water acquisition. In the water acquisition realm, the City of Thornton clandestinely bought up Northeastern Colorado farms in 1986 with the explicit purpose to eventually dry up those farms and move water south to Thornton for future water supply needs. All of this creates a lot of angst, distrust, and uncertainty in the water community and the community at large. Periodic drought conditions and climate change discussions magnify all of this.

As noted in the 2004 SWSI report:

“Nearly two-thirds of the increase in the state gross demand by 2030, approximately 409,700 AF, will be in the South Platte Basin. Of the 409,700 AF of increased water demands in the South Platte Basin, the majority of the demand is proposed to be met through existing supplies and water rights and through the implementation of identified projects and processes. However, there are still some anticipated shortfalls expected in certain portions of the basin. The identified shortfalls will be the focus for supply alternatives developed for the basin.”

Todd Doherty with the Colorado Water Conservation Board noted in a recent Colorado Water Institute newsletter that “most of the (water for population growth) will be met through three main water supply strategies: conservation, agricultural transfers, and new water supply development.” He goes on to say “if these new water supply projects are not built, future water demands will have to be met mostly through a combination of agricultural transfers and conservation.

ESTABLISHMENT OF HISTORIC CONSUMPTIVE USE

There is no intent herein to fully describe the engineering or the legal process of formally establishing the consumptive use of a water right in Colorado. However, for the purpose of framing the change case effort which requires a study of historic CU, it is worthwhile to describe a few pertinent aspects of the process.

The need for establishing the CU of a water right must first exist. If farmers have beneficially used a water right decreed for irrigation for a long period, then they can continue to use the water right in that way indefinitely with no need to define or quantify CU. An evaluation of CU is generally driven by a change in the type of use, place of diversion, or the quantity of water diverted. Because the engineering study to establish historic consumptive use is costly, it is unlikely that anyone would take on the effort without justification. That said, it is important to note that someone else holding the same

water shares (i.e. same ditch company) can initiate a change case, establish CU through the court process, and Colorado's Water Court will likely view that change case as being a "ditch-wide" analysis and therefore affecting all the shareholders of that right whether they participated in the change case or not. This subtlety can be extremely important.

The historic water deliveries and season of use are easily found in the data base of the South Platte Decision Support System (<http://cdss.state.co.us/DNN/default.aspx>). Historic cropping data and irrigated areas are not so easily found. One must investigate vintage aerial photography from multiple sources, locate and check publically available Farm Service Agency documents and records, talk to landowners and irrigators, and otherwise undertake a time consuming effort to understand the past. Sometimes the ditch company's board members and board or annual meeting minutes can provide useful historic information. Historic irrigation practices, estimates of irrigation efficiency, and delivery efficiency (canal seepage) also come into play with the CU calculations and must be determined or estimated.

A water balance of the canal or the farm is a useful means of understanding the sources and the destinations of water. The Figure 2 one-line diagram shows how the water balance plays out from the river diversion and downstream to the on-farm distribution system and provides some context of common terms.

Basically, what this illustrative graphic shows is what happens to water once it is diverted into a ditch or canal for irrigation purposes. The character of some of the water changes as one moves downstream in the canal. Some would say colloquially that the "color" of the water changes, a reference to where the water came from, or where it is bound, or what is its decreed use.

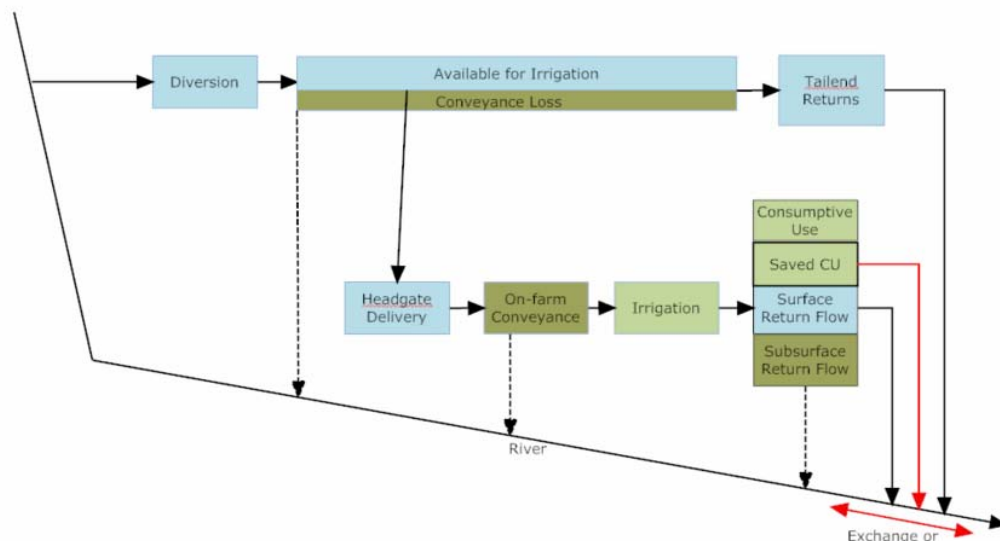


Figure 2. Depiction of the elements of surface water delivered to the farm via canal.

After diversion into an earthen canal, the diverted flow immediately begins to diminish because of conveyance losses, the most notable of which is seepage. Other losses are attributable to phreatophytes and evaporation. Seepage can be quite significant especially over the full length of the canal and is likely the highest loss in earthen canals. Seepage returns to the river as subsurface flows and the time it takes to actually arrive at the river is a function of distance from the river and characteristics of the alluvium and this can vary over the length of the canal as well. With a water right change case, this historic return flow pattern must be maintained into the future.

As we move downstream through the canal, some water returns to the river via the end of the canal as wastage or operational spill. Some canals have historically diverted a generous amount of water to assist with canal operations. It is easier to deliver equitable flows to canal headgates, especially those at the end of the canal, if the canal is flowing nicely with excess water that can be returned to the river for other downstream users.²

Continuing to refer to Figure 2, a headgate delivery to the farm has similar water balance characteristics as with the main canal but the headgate delivery likely represents the point at which the company's delivery responsibility ends and the individual farmer's responsibility begins. Downstream of the headgate, there are often on-farm conveyances from which there are losses, and again, those losses are most notably seepage. Once we deliver water to on-farm irrigated fields, and the associated irrigation systems, the key elements of irrigation water can be identified as consumptive use, the surface return flow, and the subsurface return flow. Within the consumptive use amount, there is a proportion of that consumptive use that may be appropriately termed "conserved" or "saved" or "set-aside" CU and this amount is the water that might be considered for its higher economic value.

In Figure 3, the average historically diverted water to the farm is characterized as consumptive use, surface return flow, and subsurface return flow. Crop consumptive water use is the amount of water transpired during plant growth plus what evaporates from the soil surface and foliage in the crop area. The portion of water consumed in crop production depends on many factors including whether or not water availability is limiting evapotranspiration plus soil texture, crop varieties, and so on.

² This practice is becoming less common as canals come under scrutiny for "sweeping the river" and taking the full flow of the river even if they are decreed to do so.

Historic Crop Water Allocation

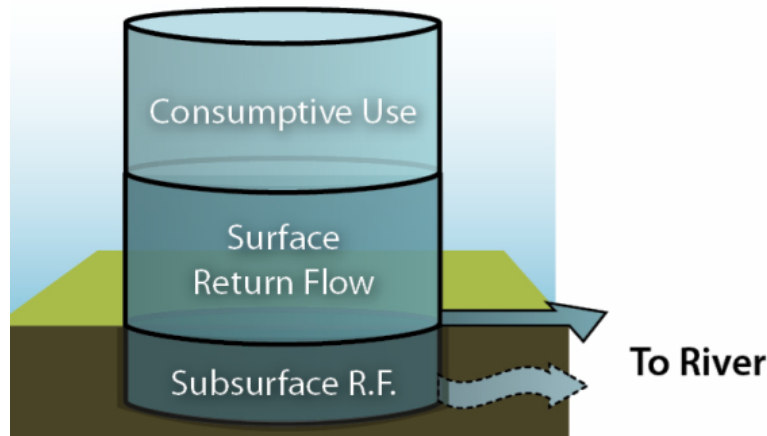


Figure 3. Depiction of the primary named use of water delivered to the farm.

Once an estimated or a fully decreed consumptive use (CU) is known for a given water right, it opens up potential to consider options for how the CU might be utilized differently in the future. The consumptive use can be allocated to new use priority or some balance between old and new priorities. The consumptive use can now be viewed in terms of an on-farm CU water budget. A new use of the CU might be to part off a portion of the water to a municipal or environmental water user.

As an example, consider a farming operation that is typified as follows:

- 150 acres irrigated.
- Surface water supply is owned to include 10 shares in a ditch company that, on average, delivers 30 acre feet per share or 300 acre feet total.
- The CU has been established via a ditch-wide analysis of the shares and the right. The decreed CU is 10 acre feet per share.
- A local municipality is offering \$500 per acre foot of CU water on a long-term lease arrangement.

In this example, the farmer has 10 shares times 10 acre feet per share or 100 acre feet of CU water available in an average year. Maybe the farmer wants to consider parting off half of that water, or 50 acre feet of CU water. A lease of the water to a municipality would provide a low risk revenue option and a predictable revenue stream (\$25,000 / year) into the farming operation.

Planning for the use of the remaining 50 acre feet of CU water can now be considered by management. Planning must include appropriate consideration to each component of the water right. Historic return flows must be maintained and this applies to the full water

right just as if no CU water had been parted out. So, farms can be operationally changed in a significant way or crops may be converted to dryland crops or fields fallowed to reduce the amount of CU water that is used. Monitoring and reporting of operational changes is likely to be precisely mandated in any change case decree. The State of Colorado has become much more stringent in the last decade and requiring of more data and more timely, even real time, data.

It is important to note that a lease to a municipality probably includes a guarantee for delivery of a certain amount of water each year. This would be defined in contractual terms but would probably be a commitment to deliver an agreed upon amount of water regardless of the impact on the farming operation in that year. In other words, the farmer will be required, under contract, to take the shortage in any given year. A drought year or years could result in the necessity for the farmer to deliver the agreed upon amount of water regardless of the impact to the farm. Severe drought conditions may result in curtailed farming during drought years so as to meet the obligation to the municipality.

A somewhat bigger picture view of this circumstance is shown in Figure 4 which indicates surface irrigated fields and again identifying colored water. Downstream of the river diversion the canal seepage contributes to return flows to the river. After water is diverted at the farm headgate, water flows down furrows and the portion that does not infiltrate to the soil becomes tailwater and returns to the river as surface return flows. Deep percolation below the crop root zone is subsurface return flow.

Flow measurements are indicated in Figure 4 at the river diversion, downstream of the farm headgate, and on the tailwater return ditch. In the past some or all of these flow measurements were not necessary and not undertaken due to hydraulic structure and data collection costs. In the future, and under a substitute water supply plan or a water right change decree, all of these flow measurements will be mandated along with the reporting.

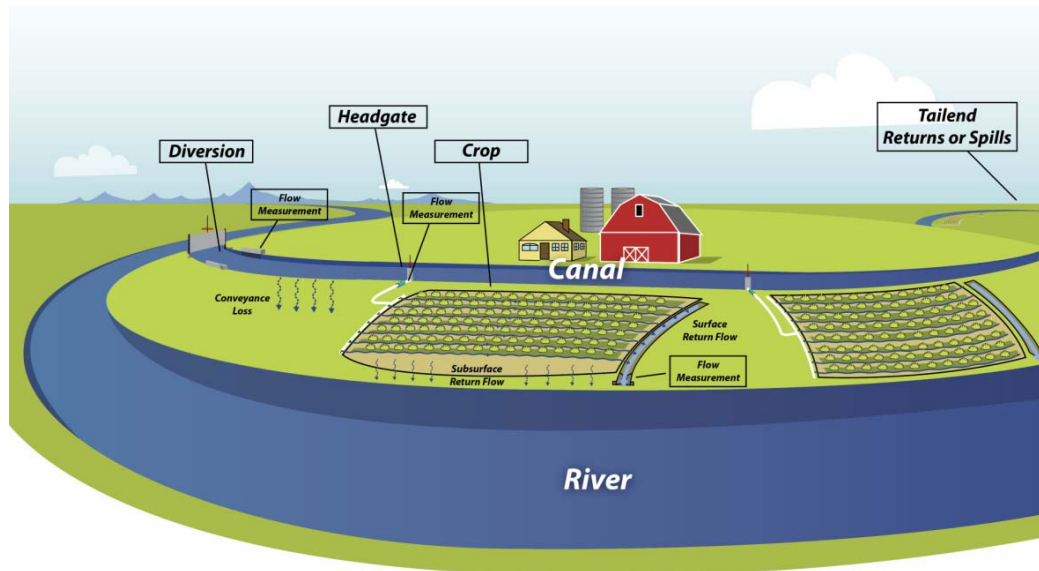


Figure 4. A graphic depiction of a river diversion, canal, and elements of on-farm water delivery. In the future, flow measurements at the points noted will likely be required in a water court change decree and the State Engineer will monitor real time data and monthly reports which collectively will indicate conformance with a decree.

POTENTIAL FOR CHANGING FARMING PRACTICES AND MONITORING USING A DECISION SUPPORT SYSTEM

Once a farmer or group of farmers (possibly a farmer cooperative) understands the amount of consumptive use water that is available to them through their water rights, consideration can be given to a new mix of water uses for the remaining portion. These uses can be evaluated within a CU water budget which can be optimized for a given year. This water budget would logically have basic characteristics as follows:

- Monthly and annual time basis and potentially covering multiple years.
- Recognition of multiple water sources and their respective season of use.
- Water allocations by fields and crops.
- Consumptive use allocation.
- Approach to return flow replacements at the river.

In many instances, the water right was historically used to grow the crops that were prevalent in the area. On the South Platte, the predominant crops are corn, wheat, dry beans, grass hay, alfalfa hay, and truck crops. Consideration can be given to the practices, or more likely the combinations of practices, that adhere to an annual CU water budget. In any given year, practices may include:

- Deficit irrigation.
- Crop rotations and introduction of new crops.
- Permanent or rotational fallowing.
- Dryland farming.
- Continued full irrigation of selected crops.
- Combinations or permutations of the above.

A new decision support system is under development by a team lead by Regenesi Management Group located in Denver, Colorado. This program is contained within an internet-delivered software package known as Sustainable Water & Innovative Irrigation ManagementTM or SWIIMTM. SWIIMTM is intended to be used for farmer-considered planning but also as a monitoring and reporting system into the future should practice changes be implemented.

SWIIMTM is a tool for farmers to use in evaluating potential operational changes to conserve CU. More specifically, SWIIMTM is:

- A package of technologies under one umbrella software program.
- A decision support system (DSS).
- A farm operations simulation.
- An optimization program for evaluating alternative farm operational strategies.
- A database, monitoring, and reporting system following implementation of a strategy or strategies.

Primary planning and modeling features of SWIIMTM are:

- GIS-created user inputs of all inputs such as field configurations that are geographic in nature.
- Prompting for inputs for past operational costs.
- An underlying database containing all planning level data.
- Optimization routines (non-linear programming) to evaluate alternatives.
- Reports to assist in considering a package of changed practices to compare future practices with the historic past and with one another.

Primary implementation, monitoring, and reporting features of SWIIMTM are:

- On-farm monitoring of soil moisture and other site specific parameters such as wind speed and precipitation.
- Integration with weather station networks and existing SCADA systems.
- Reports to management.

- Reports to the State Engineer's Office (SEO) to meet their regulatory requirements for timely and a suitable amount of confirming data.
- Field confirmation of changed irrigation practices.
- Aerial (low level periodic flights) confirmation of changed irrigation practices and evapotranspiration rates.
- Satellite (LandSat) confirmation of farm level, ditch-wide, and regional evapotranspiration rates and monitoring or affirmation of deficit conditions on larger fields.

SUMMARY

Agriculture to urban water transfers can be affected in various ways. Alternatives to “buy and dry” appear to have validity and are under development. The Super Ditch Company in the Arkansas Valley of southeastern Colorado was formed to offer farmers land fallowing options. It is intended that a collection of consumptive use water sources can to be leased to needful municipal interests. In the South Platte Basin of northeastern Colorado, research is being conducted and optimization and planning software is under development to assist farmers in considering technology and changed farming practices also intended to provide options. Farmers interested in continued farming operations while availing themselves of a new predictable revenue stream are considering these options. With consumptive use water is parted out, historic return flows to the river must be maintained. None of these technology options have been decreed by the Colorado Water Court system and it will likely be several years before a change case with high technology features receives its day in court.

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