A WIN-WIN SCENARIO FOR URBAN/RURAL WATER SUPPLIES [1)]

By
Bruce A. Lytle, P.E., President, Lytle Water Solutions, LLC
Neil Hansen, Ph.D., Associate Professor of Soil Science, Colorado State University
Frank P. Jaeger, District Manager, Parker Water and Sanitation District
Jim Nikkel, P.E., Assistant District Manager, Parker Water and Sanitation District

INTRODUCTION

Major areas of population along the Front Range of Colorado are primarily located in the South Platte River drainage basin (Denver metropolitan area to Fort Collins). The South Platte River basin downstream of Denver is also a major agricultural area, with approximately 1,000,000 acres (ac) currently in irrigated farming systems. The conflict between agricultural water use and municipal water demands is creating a dilemma which has state-wide implications. Most of Colorado's population lives in urban areas, while agricultural water use is approximately 85 percent of total water use in the state. Therefore, changes will be necessary between future allocations of current water uses based on expected future water demands.

The population in the South Platte River basin is expected to grow by 1.9 million by the year 2030, according to the Statewide Water Supply Initiative study (SWSI), completed in 2004. However, not included in the SWSI is the fact that the municipal water supply needs are even greater than this expected population growth. A substantial portion of the recent growth along the Front Range has developed on the non-renewable water resources of the Denver Basin, a large structural ground water basin which covers approximately 6,700 square miles and has as much as 200,000,000 acre-feet (ac-ft) of water in storage (Figure 1). However, development of the Denver Basin resources has not been uniform, with most of the development occurring in the greater Denver metropolitan area. While there is a large storage capacity in the Denver Basin aquifers, due to the density of development municipal water suppliers are experiencing significant water level declines in their production wells, with a resultant decrease in productivity. Therefore, municipal water suppliers are not only looking to the future to meet projected growth, they are also looking at replacement water supplies for existing demands.

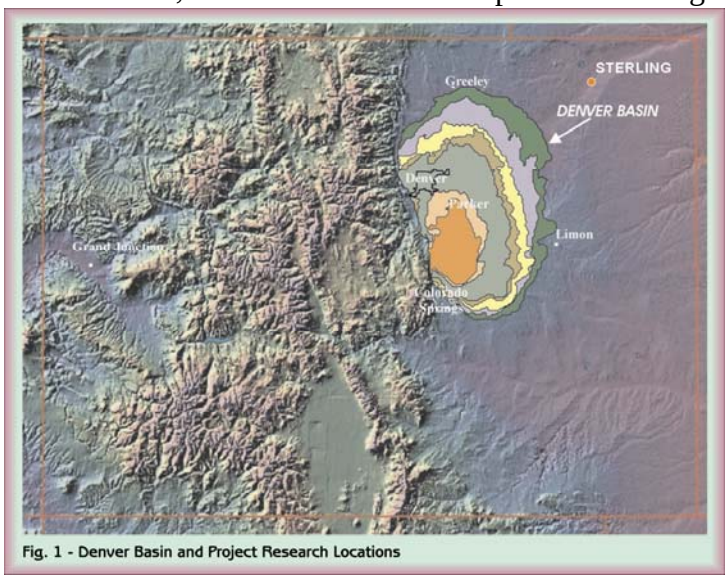


Fig. 1 - Denver Basin and Project Research Locations

1) Published in the February 2008 Edition of *The Water Report*, Issue #48.

SWSI also identified potential water supply shortfalls to the year 2030, based on its population growth projections. One of the alternatives identified by SWSI was the retirement of irrigated agricultural lands. In the South Platte River basin alone, SWSI estimated that approximately 130,000 to 260,000 acres of irrigated land would need to be retired to help meet projected water demands due to growth. This was based on the historic "buy and dry" concept, whereby municipalities would purchase the water from the agricultural lands and all farming would cease.

The Parker Water and Sanitation District (PWSD), one of the Denver metropolitan area water suppliers that is primarily dependent on Denver Basin aquifer water, approached Colorado State University (CSU), the agricultural land grant university in Colorado, to find out if there are more innovative approaches to agricultural dry-up that would benefit urban interests by providing much-needed water supplies while also maintaining the rural economies on the eastern plains of Colorado. The result of this collaborative effort is a three-year research program, the *Lower South Platte River Irrigation and Research Demonstration Project*, which commenced in 2007 and will continue through 2009 with current funding.

INNOVATIVE APPROACH TO AGRICULTURAL DRY-UP

The agricultural-to-municipal transfer has historically been modeled on the "buy and dry" concept. Generally, there are two principal reasons that the "buy and dry" concept has been utilized almost exclusively for agricultural-to-municipal transfers. First, farmers have been willing to sell all of the water rights used to irrigate their land and totally cease farming. Second, the dry-up of lands is the simplest way to administer a change in water rights, because state water rights administrators can simply observe that the land is no longer being irrigated and, therefore, this water is available for transfer to municipal interests. However, history has also shown that "buy and dry" creates environmental issues, e.g., proliferation of noxious weeds, erosion, and wind-blown sediments, as well as creating negative economic impacts to rural communities when large tracts of farmland are taken out of production. For example, there is the trickle-down effect associated with loss of business to implement dealers, seed dealers, fertilizer dealers, local businesses, etc. Because of these factors, PWSD and CSU began to collaboratively look at alternatives that would maintain farming interests and also protect rural economies.

Crop irrigation management and rotational fallowing are certainly not new concepts; however, the uniqueness of these strategies is the implementation of a research-oriented approach to optimize crop yields and, therefore, value, while also optimizing water savings. The other unique aspect of this study is to cooperate with the farmers themselves in conducting some of the research, so that the techniques developed are not only theoretically defensible, but also practically applicable. This study is investigating whether these concepts can be applied on a large-scale basis to help preserve agricultural lands and rural economies while also making water available for urban water suppliers. Three crop irrigation management techniques are being evaluated as part of this research, (a) limited irrigation, where irrigation is applied in lesser amounts than full evapotranspiration (ET) demand by timing irrigations to critical crop growth stages and managing crop water stress, (b) partial season irrigation, where perennial forage crops

receive a full water supply for part of the season, then irrigation ceases, and (c) rotational fallowing, whereby lands are alternatively taken out of, and then put into, production on either a 2-year or a 3-year rotation. In conjunction with the crop research, this study will seek to develop either administrative procedures which will allow this type of operation or legislative change to promote the win-win scenario for rural and urban interests. Therefore, there are two major components to this study, research related to crop irrigation management and institutional issues associated with developing a structure by which these types of crop irrigation management techniques can be employed within the Colorado water rights system.

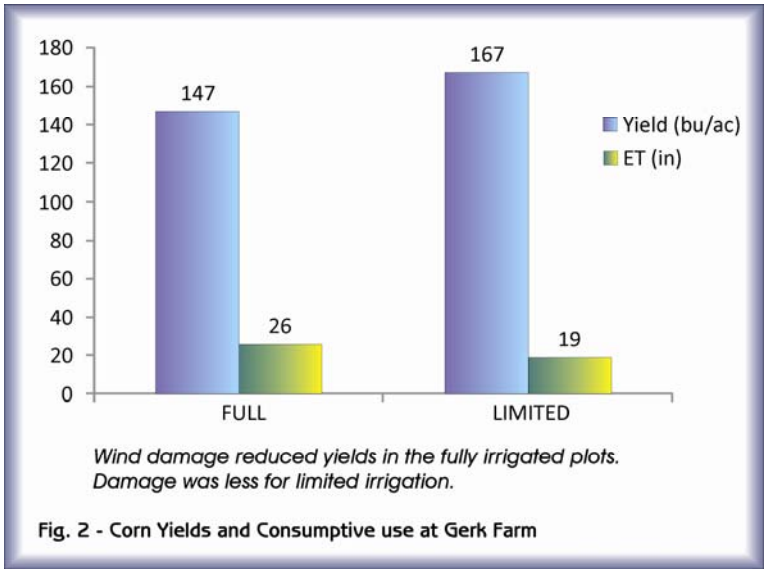
RESEARCH PROJECT

The first year of the three-year research project was completed during the 2007 irrigation season. There have been two distinct areas of research set up by CSU, three field scale on-farm demonstrations in cooperation with the farmers on these lands and a plot scale irrigation research farm, i.e., the farmland has been broken up into numerous small irrigation plots, which is completely operated by CSU personnel. It is important in this research that any of the techniques developed by CSU can be implemented by farmers on a large-scale basis. For this reason, the three on-farm demonstrations were designed so that, while CSU directed irrigation practices on these farms, the farmers actually implanted the techniques. It is important that any innovative crop irrigation management techniques be practical, in that the farmers can, and will, implement these techniques on a long-term basis. The three 2007 on-farm demonstrations are described below.

Rafaelli Farm--Gypsum amendments to soil to address salinity issues. As a result of high water tables and marginal irrigation water quality, some soils in the South Platte River basin are affected by soil salinity. Soil salinity reduces crop productivity and water use efficiency. Sodicity, i.e., the amount of sodium in the irrigation water, can also be a problem by reducing water infiltration and degrading soil structure. If salinity and sodicity issues can be minimized, crop yields and water use efficiency can be improved. A common method for reducing sodicity is applying gypsum to the soil in combination with leaching. The calcium cations from the gypsum replace sodium cations on the soil, which then need to be leached from the root zone. For this study, soils on the Rafaelli farm were tested and found to have a moderate salinity level (EC_s=3.8 dC m^{-1}) and a pH of 8.3, which is typical of a moderately sodium-affected soil. Two application rates of gypsum were added to the soils at the Rafaelli Farm to evaluate if gypsum was increasing the permeability of the soil and, therefore, reducing the effects of salinity. The preliminary results from the 2007 irrigation season indicate that crop yields were not materially affected by these gypsum amendments. It is expected that this study will continue in the 2008 irrigation season to assess the potential delayed effects of the gypsum amendments.

Gerk Farm--Limited irrigation on corn on a center pivot. The Gerk Farm operated a wiper pivot planted in corn as part of its normal operations. To evaluate the effects of limited irrigation, part of the pivot continued with full irrigation of the corn, while a portion of the pivot had water shut off during three irrigation events that occurred during vegetative corn growth periods prior to tasselling. Results from the 2007 irrigation

season were somewhat inconclusive, as significant windstorm damage just prior to harvest affected the yields on both the fully-irrigated corn and the limited-irrigation corn. Yields were actually higher on the limited-irrigation corn because the stalks were of lower stature and experienced less yield loss associated with the late season wind, as shown in Figure 2. However, visual estimates of yields suggest that the limited irrigation corn would yield competitively with a fully irrigated crop. The study evaluates crop consumptive use with a water balance method that accounts for differences in water used from the soil profile. The limited irrigation corn reduced ET by 7 acre-inches relative to the fully irrigated corn. CSU plans to continue the limited irrigation corn research on this field during the summer of 2008.



Wind damage reduced yields in the fully irrigated plots. Damage was less for limited irrigation.

Fig. 2 - Corn Yields and Consumptive use at Gerk Farm

Schuppe Farm--Partial season irrigation of alfalfa and native grass hay on a center pivot. Both alfalfa and native grass hay have historically been grown on the Schuppe Farm, and CSU wanted to evaluate the effect of partial season irrigation on these two crops. Therefore, there were areas of full irrigation of both the alfalfa and native grass hay, and also areas of partial season irrigation**.** For the partial irrigation season, CSU had the Schuppes fully irrigate all of the land through the first cutting of the alfalfa and then completely shut off irrigation to a portion of the alfalfa and native grass hay fields. While there was little loss in yield from the alfalfa with the partial season irrigation, there was a significant change in yield of native grass hay, which indicated that alfalfa may be amenable to partial season irrigation, but that native grass hay may not be amenable to partial season irrigation (Figure 3). Alfalfa is known to have drought tolerance traits that make it well suited for water savings. When under drought stress, alfalfa goes into dormancy. Although growth ceases, alfalfa stores energy in the crown and is capable of rapid re-growth when water is newly supplied. Alfalfa is

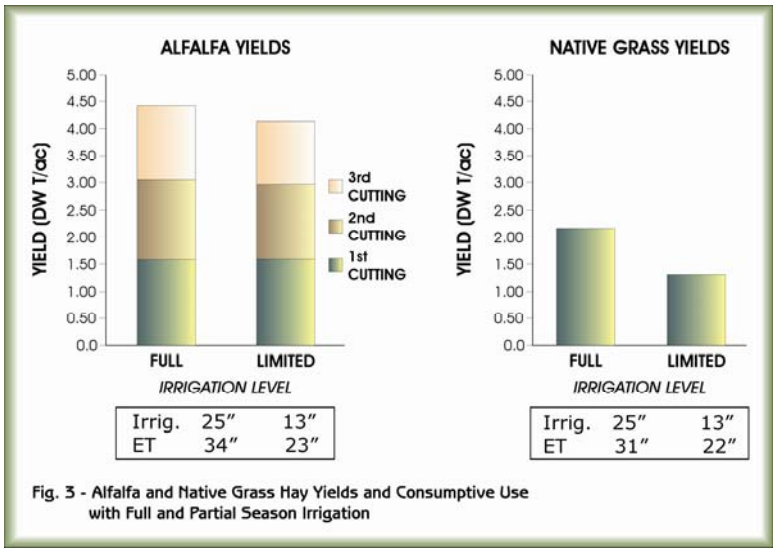


Fig. 3 - Alfalfa and Native Grass Hay Yields and Consumptive Use with Full and Partial Season Irrigation

also a good candidate for innovative water saving cropping systems because it is a large water user and is grown on a lot of land in Eastern Colorado.

Fig. 4 - Water Supply for Linear Sprinkler

Fig. 5 - Instrumented Sprinkler Nozzles

Fig. 6 - Linear Research Field Irrigation

In addition to the on-farm demonstrations, there was also a controlled research farm operated solely by CSU personnel. A research-grade linear sprinkler system was used to irrigate a 35-acre field that is divided into replicated and randomized research plots. The setup and operation of the linear sprinkler is shown in Figures 4 through 6. Figure 4 shows the water supply for the sprinkler, a linear ditch running parallel to the field on the north side and perpendicular to the linear sprinkler. Figure 5 shows the instrumented flow nozzles that are each individually metered to record precise irrigation rates to each section of the field. Figure 6 shows the operation of the linear sprinkler.

A linear sprinkler setup was used to facilitate the development of small plots to evaluate various crop irrigation management techniques. The linear sprinkler is fully instrumented with flow meters at each dropdown nozzle and a computer guidance system that can control the irrigation at each nozzle so that a full irrigation water supply can be applied to some plots, a limited irrigation supply to other plots, and no water supply to lands that are being fallowed during that year. The layout of the crop plots for the 2007 research season is shown in Figure 7.

The experimental treatments evaluated in 2007 include full and limited irrigation practices for different crops and crop rotations. Crops being tested include corn, winter wheat, sunflower, soybean, triticale, and winter canola. The plots

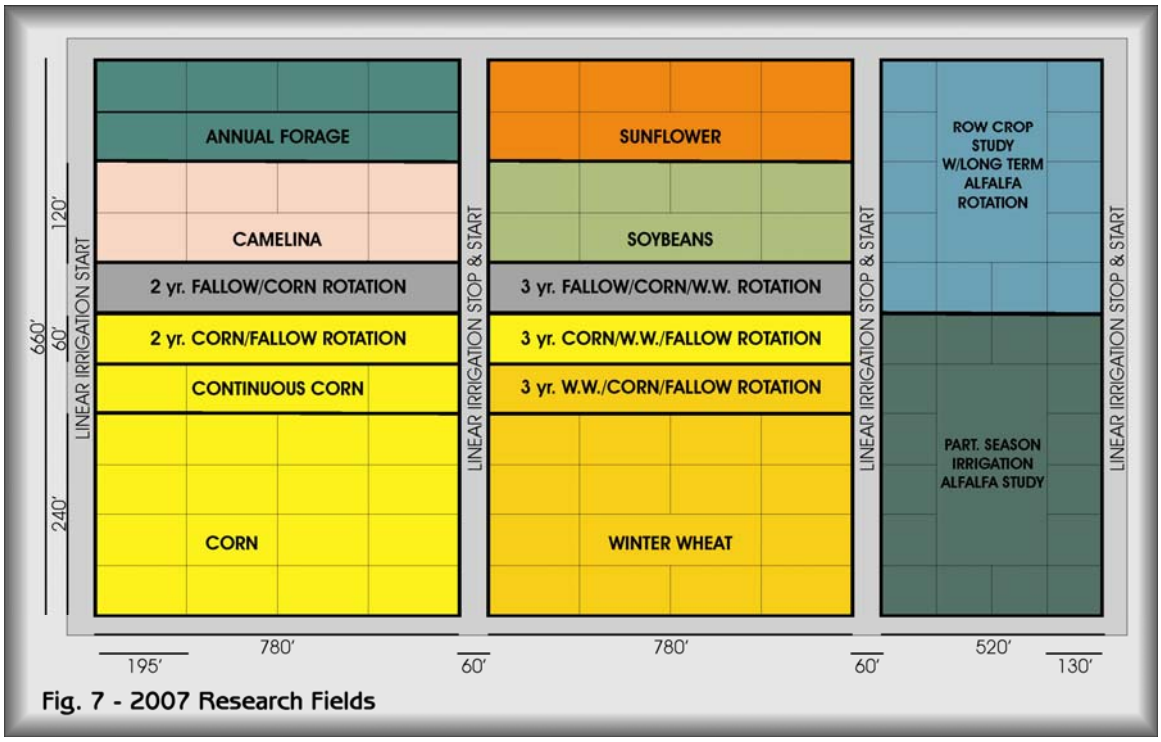


Fig. 7 - 2007 Research Fields

are designed to allow these crops to be combined in different rotations with each other and with fallow periods. Limited irrigation practices were found to have potential for corn, sunflower, and soybean crops. Corn yields under limited irrigation only reduced yields by 15 percent relative to a fully irrigated crop. Sunflower yields were reduced 25 percent under limited irrigation practices, with an ET savings of 4 inches compared to fully irrigated sunflower and a savings of 8 inches relative to fully irrigated corn (Figure 8). Soybean was well suited to limited irrigation practices, with increased yields with slightly lower irrigation (savings of 1.4 inches) (Figure 8). Because of the timing of irrigation, the limited irrigation approach resulted in slightly higher grain yield than the fully irrigated treatment, while saving 4 inches of ET relative to fully irrigated corn. Ongoing work will evaluate other crops and cropping practices for potential water savings. It is hoped that the amounts of saved ET will be higher in the 2008 season.

URBAN/RURAL ECONONOMICS

There has always been a potential synergy between urban and rural interests when it comes to water supplies, since urban interests are both willing and able to pay prices for water far in excess of the value of water to the farmers. However, this can be both a blessing and a curse, as it is what has fueled the “buy and dry” concept in agricultural-to-municipal water transfers. However, we believe a scenario presents itself where the disparate value in water for urban interests versus rural interests can be a blessing without the curse.

CSU has ongoing research at a site in the South Platte River Basin, where it is evaluating the effect of partial season irrigation of alfalfa. CSU has operated four plots, with one plot receiving a full water supply (approximately 27 inches) but the three other plots have received varying amounts of water in a partial season irrigation program, as

shown in Figure 9. These fields had four cuttings of hay with variable dry matter yields, as shown in Figure 9. CSU agricultural economists then compared the income derived from the yields of these fields to the cost to farm the land, and it can be seen that there can be significant water savings while, at the same time, seeing little decrease in farmer revenues. CSU economists evaluated the changes in return on the land for these varying irrigation techniques, as illustrated in Figure 10. Figure 10 shows the costs for farming the land per acre, the income obtained from the land per acre, and the difference in value under the varying irrigation techniques. By looking at the bar graph on the far left versus the bar graph second from the right indicates that water use was cut in half, yet the return on the crop only decreased $55 per acre (the actual value here is dependent upon the somewhat variable costs of inputs and the sale price for hay). If one ac-ft per acre of water could be removed from the land and still maintain production, in essence this would result in water which, at a minimum, would cost approximately $55 per ac-ft. This clearly illustrates the potential win-win scenario whereby farms keep farming and water is still made available to urban interests at a very reasonable rate. Whether these types of results can be replicated on a large scale and over a long period of time is one of the primary objectives of the ongoing research.

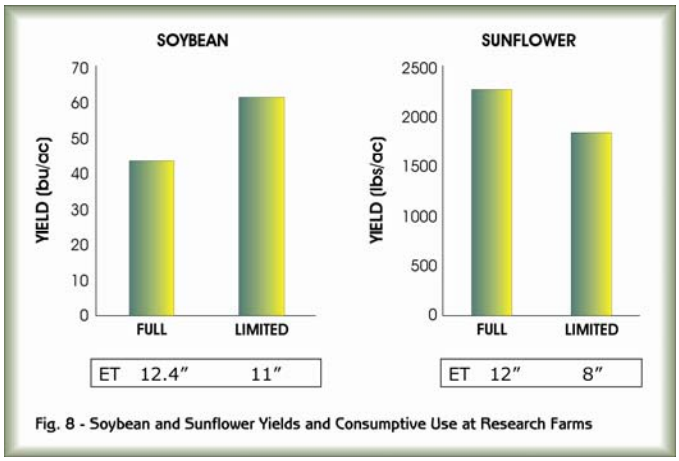


Fig. 8 - Soybean and Sunflower Yields and Consumptive Use at Research Farms

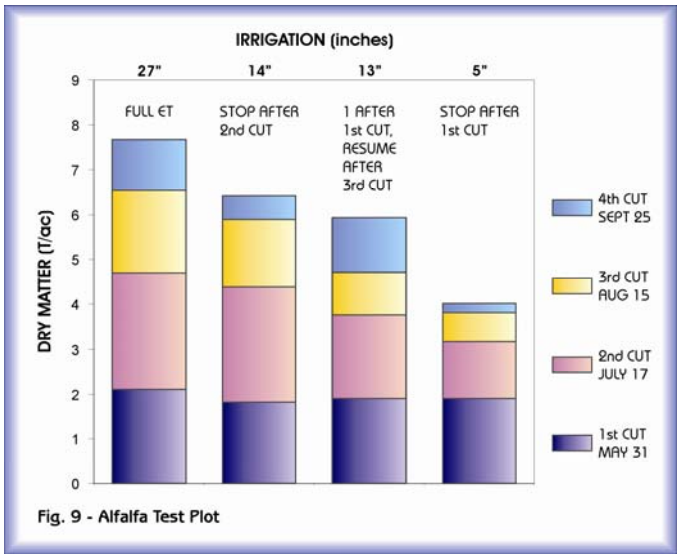


Fig. 9 - Alfalfa Test Plot

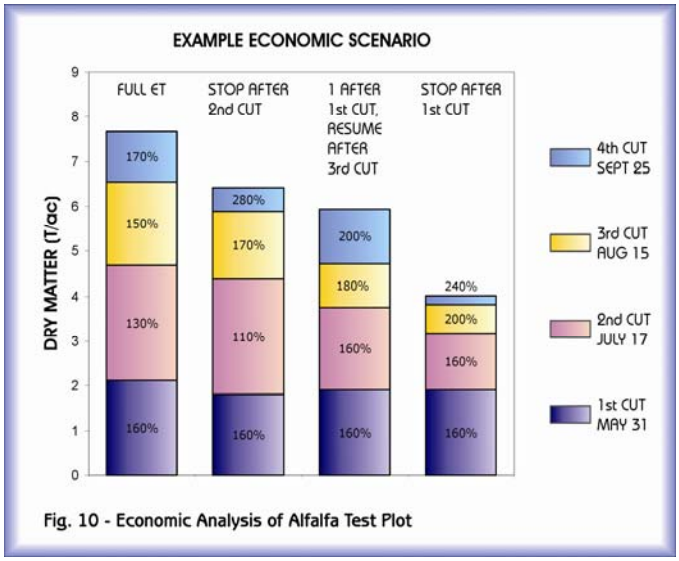


Fig. 10 - Economic Analysis of Alfalfa Test Plot

A recent survey of farmers in the South Platte River drainage basin conducted by CSU indicated that over 60 percent of the respondents would be willing to enter into long-term leases related to the crop irrigation management techniques being researched by CSU and that they would generally like to receive approximately $300 to $500 per acre for these leases. This would appear to more than offset any loss of yield on fields where either limited or partial irrigation techniques, or rotational fallowing, were being practiced. In addition, while there was only limited response to the survey (approximately 330 farmers), these responses indicated that they may have over 30,000 ac-ft of water that they would be willing to lease to urban interests. While obviously more work needs to be done relative to the research of implementable crop irrigation management techniques and to the economics associated with these techniques, the initial results from the first year of research project are encouraging.

WATER RIGHTS

All of the large senior water rights in the Lower South Platte River downstream of Denver are adjudicated for irrigation use only. Therefore, none of this water can be used for municipal purposes without a change of use proceeding in Colorado's Water Court. In a change of use proceeding, it is necessary to demonstrate the components of historic irrigation practices; i.e., the historic consumptive use of the crops grown on the land, the return flow pattern of the water applied in excess of the consumptive use requirement, and to demonstrate that these impacts on the stream system will not change (i.e., the pattern of depletions and accretions to the river). In a typical change of use proceeding, the lands are dried up and, therefore, the consumptive use associated with the land can be easily identified as transferable to a municipal entity. However, these new crop irrigation management techniques set up a new paradigm, whereby it is not clear-cut as to how the consumptive use of a specific crop, at a specific time, and at a specific location has been reduced to administratively demonstrate that this water is available for transfer.

One of the issues is sub-irrigation of lands that are providing some portion of the irrigation supply. Sub-irrigation is not a transferable water right, so quantification of the extent and location of sub-irrigation is very important. A network of monitoring wells throughout the research area has been set up and instrumented to monitor daily water levels in the alluvial aquifer. In addition, CSU has installed access tubes for routine assessment of soil moisture to a depth of 8 ft using a neutron attenuation method. All of these data will be used to evaluate sub-irrigation issues.

As part of this research project, CSU has set up an advisory committee to obtain input from local farmers, bankers, and state administrative officials. We are currently working with the State Engineer's Office (SEO) to evaluate if there are going to be administrative methods that will be acceptable to the SEO for crop irrigation methodologies that do not completely dry up lands if it can be shown that these crop irrigation management techniques are effective in reducing crop consumptive use while still maintaining farming operations. The two principal issues that we are facing from an administrative standpoint are (a) potential sub-irrigation in some areas near the ditch systems which could be affecting the crop consumptive use associated with irrigation and (b) definitively quantifying the amount of consumptive use reduction if either limited or partial season irrigation is used. These issues may be major hurdles to get over from an

administrative standpoint and may require legislative change if these techniques are to be employed. Alternatively, CSU is also evaluating rotational fallowing because this may be easier to deal with from an administrative standpoint, as specific fields would be dried in certain years and, therefore, it would be readily observable what historic consumptive use is being saved on the fields that are fallowed.

Clearly, consideration of administrative issues will be an extremely important adjunct to the research because, just like crop irrigation techniques must have a practical application on a large scale, the water rights have to be administrable from a practical standpoint. However, given the impending conflict between urban and rural water interests, a successful resolution to this dilemma is imperative.

PLANS FOR FUTURE RESEARCH

The crop irrigation management techniques being evaluated as part of this research study cannot be fully determined during one irrigation season. As such, it is expected that the CSU research will continue to focus on these crop irrigation management techniques and to further develop the techniques and crops which seem the best suited for creating a win-win scenario between farms and rural economies and urban interests for municipal water. The currently-funded study is set to run through the 2009 irrigation season; however, it is likely that additional studies will be required to fully develop both the most efficient irrigation methodologies and the procedures that will be necessary to convert available irrigation supplies to municipal use through Colorado's Water Court system. Alternatively, it may become apparent that legislative change is necessary, which likely will also require additional time beyond the scope of the 2009 horizon for the research project.

For Additional Information:

Bruce A. Lytle, Lytle Water Solutions, LLC, 303-350-4090 or email:
bruce@lytlewater.com; website: www.lytlewater.com

Neil Hansen, Ph.D., Colorado State University, 970-491-6804 or email:
Neil.Hansen@ColoState.edu

Frank P. Jaeger, Parker Water and Sanitation District, 303-841-4627 or email:
fjaeger@pwsd.org

Jim Nikkel, Parker Water and Sanitation District, 303-841-4627 or email:
jnikkel@pwsd.org