

**SOME ECONOMIC EFFECTS OF CHANGING AUGMENTATION  
RULES IN COLORADO'S LOWER SOUTH PLATTE BASIN:  
PRODUCER SURVEY AND REGIONAL ECONOMIC IMPACT  
ANALYSIS**

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Some Economic Effects of Changing Augmentation Rules

in

Colorado's Lower South Platte Basin:

Producer Survey and Regional Economic Impact Analysis

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## ABSTRACT

Many farmers who irrigate from wells within the South Platte River Basin draw water from underground aquifers that also feed the river. Recent changes to Colorado's well augmentation rules require ground water irrigators along the South Platte River to develop permanent augmentation plans to compensate for out-of-priority depletions. If a well-owner fails to file an approved augmentation plan, then the State Engineer is required to curtail out-of-priority pumping of non-augmented wells. Well-owners were granted a three-year window to develop and file well augmentation plans; this grace period ended in the Spring of 2005. The change in well regulations affirmed property rights for water right holders, which likely increased the value of those rights and improved the economic efficiency of water transactions.

Lower South Platte<sup>1</sup> farmers who were required to develop permanent augmentation plans altered their business practices in order to remain economically viable. Changes being made to business practices include establishment of approved augmentation plans by purchasing (rather than leasing) water rights, shifting crop rotation to less water-intensive crops, dryland cropping, and outright exit from farming. A notable impact of the rule changes is a net reduction in irrigated acres in the Lower South Platte (LSP). For rural communities, the impact of changing crop practices ripples through the entire economy as farmers alter input purchases and employee compensation.

Water is a resource with productive capacity, and the loss of its productive capacity affects more than just the agricultural producer—third parties such as local governments and businesses are affected as well (Pritchett, Frasier, and Schuck, 2003). State and regional planning bodies, researchers, and the public are very concerned about the adequacy of available water supplies to sustain Colorado's population and economic growth. Furthermore, agriculture is an important base industry for many rural communities, and a viable and healthy agriculture industry is essential to maintaining the economic, social, and cultural integrity of rural Colorado. Clearly, it is important to quantify and describe the economic impact of a reduction in irrigated agriculture, to disaggregate the impact among different industries in the region and among households, and to determine how government revenues might shrink. The magnitude of the total

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<sup>1</sup> The Lower South Platte Basin consists of Logan, Morgan, and Sedgwick counties.

economic impact depends on the basic demographics of the region, the diversity of the regional economy, the relative importance of irrigated agriculture in the regional economy, and the strength of the backward and forward linkages between irrigated agriculture and supplying and processing sectors.

The purposes of this study are three-fold: first, to describe the economic benefits of affirming the property rights which occurred as a result of the change in augmentation rules; second, to examine how affected farmers responded to the change in augmentation rules; and third, to quantify some of the economic impacts to the LSP as a result of the augmentation rule changes. As water continues to be transferred from agricultural to M&I<sup>2</sup>, recreational, and environmental uses, and with drought remaining a constant threat, further reductions in irrigated agriculture are sure to occur in the future. By estimating the size and scope of the economic impact of such acreage reductions, it is hoped that this study will help affected communities mitigate, prepare for, and adjust to such impacts.

In this study, the agricultural and economic demographics of the LSP are established and the IMPLAN software program is used to develop an input-output model for the area. A survey of agricultural producers in the region is used to estimate the change in cropping patterns stemming from the new well augmentation rules. In order to provide a range of impact values, two acreage change scenarios are analyzed. These include a maintained crop mix scenario, where high-value crops are removed according to the survey results, and alternative crop mix scenario, where high-value crops that were not planted by survey respondents were actually grown by farmers elsewhere in the basin. The changes in irrigated crop output are valued using 2004 prices for each crop (Colorado Agricultural Statistics Service) while the yield and production cost information are derived from the Agribusiness Management Association (CSU-CE) enterprise budgets. These changes in sales constitute the *direct* impact of the acreage changes and are used to "shock" the input-output model, thus generating the estimated *indirect* and *induced* impacts. The *total* economic impact is simply the sum of the direct, indirect, and induced impacts. This study finds that the net acreage loss, as estimated by the producer survey, results in a significant loss of economic activity in the Lower South Platte Basin.

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<sup>2</sup> Municipal and Industrial (M&I) demand is all of the water use of a typical municipal system, including residential, commercial, institutional and industrial uses.

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## INTRODUCTION AND BACKGROUND

### Problem Statement and Objectives

Recent changes to the administration of Colorado's well augmentation plans require ground water irrigators along the South Platte River to develop permanent augmentation plans to compensate for out-of-priority depletions. If a well-owner fails to file an approved augmentation plan, then the State Engineer is required to curtail out-of-priority pumping of non-augmented wells. Well-owners were granted a three-year window to develop and file well augmentation plans; this grace period ended in the Spring of 2005.

Developing a court approved augmentation plan, especially for those who do not already own surface or reservoir water rights, can be complex, time consuming and expensive. Indeed, not every irrigator can create an approved augmentation plan without significantly altering business practices. Changes being made to business practices include establishment of approved augmentation plans by purchasing (rather than leasing) water rights, shifting crop rotation to less water-intensive crops, shifting to dryland cropping, and outright exit from farming. A notable impact of the rule changes is a net reduction in irrigated acres in the Lower South Platte (LSP) counties, an area which has a significant number of groundwater wells requiring augmentation plans. For rural communities, the impact of changing crop practices ripples through the entire economy, as farmers alter input purchases and employee compensation.

The purposes of this study are to describe the economic benefits of affirming the property rights which occurred as a result of the change in augmentation rules, to examine how producers responded to the change in augmentation rules, and to quantify some of the economic impacts to the LSP as a result of the rule changes.

### Colorado Water Law Basics

As in most arid western states, the allocation of water in Colorado is governed by the doctrine of "prior appropriation". Under this doctrine, rights are granted upon the appropriation of a certain quantity of water for beneficial use<sup>3</sup>. The date of appropriation determines the priority of the water right, with the earliest appropriation establishing the most senior, or superior, right. Water rights are quantified based on consumptive use<sup>4</sup>. The appropriations system, in contrast to the older "riparian" system of water law of the eastern

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<sup>3</sup> Water in Colorado must be diverted for a purpose and used beneficially to get a water right. Beneficial use is the use of a reasonable amount of water necessary to accomplish the purpose of the appropriation, without waste. Some common types of beneficial use are: irrigation, municipal, wildlife, recreation, mining, household use.

<sup>4</sup> Consumptive use (CU) is that portion of water which is consumed completely and thus is not returned to the river system or underground aquifer.

U.S., treats the use of water as personal property separate from the land and subject to transfer or sale (Howe and Goemans, 2003).

The prior appropriation system in Colorado allows water rights to be transferred or changed in use, subject to the protection of other water right holders. Water right transfers or changes can be temporary or permanent and can involve changes in use, timing, amount, and location of diversion. Proposed changes in water use that deviate from the original water right decree require water court approval prior to implementation, to ensure that no other water user is adversely affected by the change. In Colorado, water rights are adjudicated<sup>5</sup> by a water courts system and administered (i.e., managed) by the State Engineer. Adjudicating a change of water rights can be time-consuming and costly (often requiring the services of lawyers, engineers, and other professionals), and formal notification is required by law.

When agricultural water rights are sold outside of the locale, the land that was formerly irrigated by that water is typically required to be dried up permanently. This is because only the consumptive use (CU) portion of a water right can be sold under Colorado law. Thus, if a farmer wanted to adopt a more technically efficient irrigation system with the goal of maintaining the same acreage and crop-mix while using less water, that farmer would not be able to sell the water savings. The increased efficiency allows the farmer to divert less water from the river but the CU remains the same because the crops are still consuming the same amount of water.

Making a new appropriation is another option for water planning, but this requires that there remain un-appropriated water in that river, which is not the case for the South Platte River, as it is already over-appropriated<sup>6</sup> (South Platte Research Team, 1987). No appropriation can be made when the proposed appropriation is based on the speculative sale or transfer of the appropriation rights. This anti-speculation doctrine prevents individuals or entities from acquiring water rights solely to sell to others.

Another option is an augmentation plan, which allows a water user to divert water out of priority from its decreed point of diversion so long as replacement water is provided to the stream from another source to make up for any deficit. Out-of-priority diversions can occur only when a replacement supply of water, suitable in quantity and quality, is made available to substitute for the otherwise diminished amount of water available to supply other water rights exercising their priorities. Depletions not adequately replaced shall result in curtailment of the out-of-priority diversions (Colorado Supreme Court, 1997). Augmentation plans are most common for ground water appropriators whose water source is "tributary" to appropriated surface water--that is, hydrologically connected to surface streams and thus administered according to the Doctrine of Prior Appropriation in the same general way as surface water.

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<sup>5</sup> To adjudicate is to award by judicial decision.

<sup>6</sup> A river is considered to be over-appropriated if water diversions and withdrawals from that river exceed the total amount of water available.



The need for an adjudicated augmentation plan arose from historical linking of tributary wells to surface water flows. In the 1960's, senior surface water right holders began voicing concern over the impact that well pumping was having on stream flow and water rights. In 1968, the Colorado Legislature authorized a study by consultants to determine the impact of groundwater wells. The study found that wells were reducing stream flows by pumping wells outside the priority system. Thus, in 1969, Colorado enacted the 1969 Water Rights Determination and Administration Act, requiring all tributary wells to file for adjudication and requiring the State Engineer to administer the wells once adjudicated in the priority system. Under this Act, tributary well must be managed according to the Prior Appropriation System. If wells take water away from or injure another water user, they must be curtailed or shut down. This law gave the State Engineer authority to allow wells to bypass the priority system as long as well users rented or leased surface water to offset pumping. The intent was to ensure surface rights holders with higher priorities weren't harmed but to allow for maximum beneficial use of the water. Substitute supply plans for renting, storing, or buying replacement water could be approved by the State Engineer for defined periods.

In the spring of 2002, the State Supreme Court essentially changed the well augmentation rules, limiting the ability of the State Engineer to approve these short-term substitute water supply plans, requiring in their place full-fledged augmentation plans--detailed, long-term plans that must be approved by a water court. The following section provides a brief overview of the important events leading up to the rule change, as well as the important events that have occurred since. The time-line is adapted from Simpson (2006) unless otherwise noted.

### **Recent Changes to Colorado's Water Law**

In the early 1970's, State Engineer Kuiper encouraged well-owners to form associations or conservancy districts to develop plans to replace well depletions that occurred where there was a call<sup>7</sup> on the South Platte River, which was historically just the months of July and August. Thus the Groundwater Appropriators of the South Platte (GASP) and the Central Colorado Water Conservancy District's Ground Water Management Sub-district (Central WCD) were formed. Both organizations operated under annual replacement plans, or substitute water supply plans (SWSP's) approved by the State Engineer.

This practice continued under State Engineer Danielson from 1980 to 1991, in which time Colorado received historically abundant precipitation. State Engineer Simpson continued this annual approval of SWSP's in 1992 with a strong warning in each letter of approval that both organizations needed to prepare for a drought condition and acquire more water. Central WCD did acquire more water using its tax base (a voter-approved property tax). GASP did not

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<sup>7</sup> A "call" occurs when a person with more-senior water rights exercises his/her rights of priority. After a call, all junior appropriators must stop use until the senior water user's right is satisfied.

have the ability to tax and relied on annual assessments to each well-owner based on acre-feet (AF) pumped.

In 2000, litigation was initiated in the Arkansas River Basin between Empire Lodge Homeowners Association and Moyers. This involved access issues, but a conflict over water also developed and the issue was the State Engineer's approval of a SWSP under CRS 37-80-120 that allowed a trout pond to be filled by exchange out of the Arkansas River up a small tributary. Judge Anderson ruled that, in his interpretation of the statutes, the legislature did not give the State Engineer authority to approve SWSP's. This ruling was appealed to the Colorado Supreme Court in 2001. The Supreme Court issued its opinion agreeing with the Water Court. This had a direct impact on the annual approval of SWSP's in the South Platte River Basin since the State Engineer no longer had the authority to approve the plans.

The worst drought in recorded history occurred in 2002 and the call by senior water rights began in June and stayed on the rest of the year. The calls in 2003 and 2004 were nearly for the entire year. This required considerably more augmentation water and GASP went out of business, while Central WCD's SWSP had to lease additional water to meet augmentation requirements.

In 2002, the Legislature passed HB 02-1414, allowing the State Engineer to approve a SWSP if an application for an augmentation plan was pending in Water Court. This bill also required, for the first time, notice to interested parties, and allowed a plan to be appealed to the Water Court. State Engineer Simpson filed new well use rules in May of 2002 that would have allowed the State Engineer to annually approve SWSP's that met the much more stringent standards proposed in the rules. These rules were challenged as unconstitutional by some objectors. Judge Klein ruled that annual approvals of replacement plans were not allowed by statute and this ruling was appealed to the Supreme Court in late 2002.

The Supreme Court in March of 2003 ruled in agreement with the Water Court that there is not statutory authority for the State Engineer to administer SWSPs for well administration and remanded the rules back to the Water Court for consideration of the portion of the rules that pertained to the South Platte River Compact. That same month, the Legislature approved SB 03-73, giving well organizations in the South Platte River Basin up to three years to file a plan for augmentation with the Water Court, and allowing the State Engineer to annually approve a SWSP after conducting a hearing.

The Colorado Supreme Court and Water Court Decisions in 2002 and 2004 did not constitute implementation of a new, stricter law, but rather enforcement of existing law (Ellinghouse). What did this mean to well-owners and what was their response? Under pressure to comply with the new regulations and in the midst of a serious drought, well-owners faced scrutiny from South Platte River surface water rights holders. Well owners needed to develop augmentation plans that were approved by water court. Surface right holders could file objections to those plans, and if the objections were upheld, the plan would

be rejected and a new plan must be submitted. The well users agreed to most of the required conditions. They also formed ground water sub-districts to address the substantial costs, bureaucracy, and complexity of getting these plans through water court.

In 2003, GASP filed a SWSP for approval, and although the plan to allow for replacement of ongoing stream depletions that resulted from past pumping was approved, no pumping was allowed. Also in 2003, the South Platte Well Users (a group composed of former GASP members) filed two augmentation plans and sought approval of a SWSP for 380 wells, which was approved.

In 2004, Central WCD established the Well Augmentation Sub-district (WAS), which included the above 380 wells and 61 additional wells. In 2004, a SWSP was approved for Central WAS, and in 2005, the Central WAS plan was approved for 445 wells. However, in May 2006, Judge Klein put forth an order stating that the member wells can not be pumped until the Water Court approves an augmentation plan, creating a major problem for Central WAS to pump in 2006.

The State Engineer's Office denied Central WAS' 2006 temporary plan because it lacked sufficient augmentation water, and about 440 wells in Central WAS were ordered shut down by the Water Court for failing to obtain a court-approved augmentation plan (Ellinghouse, 2006).

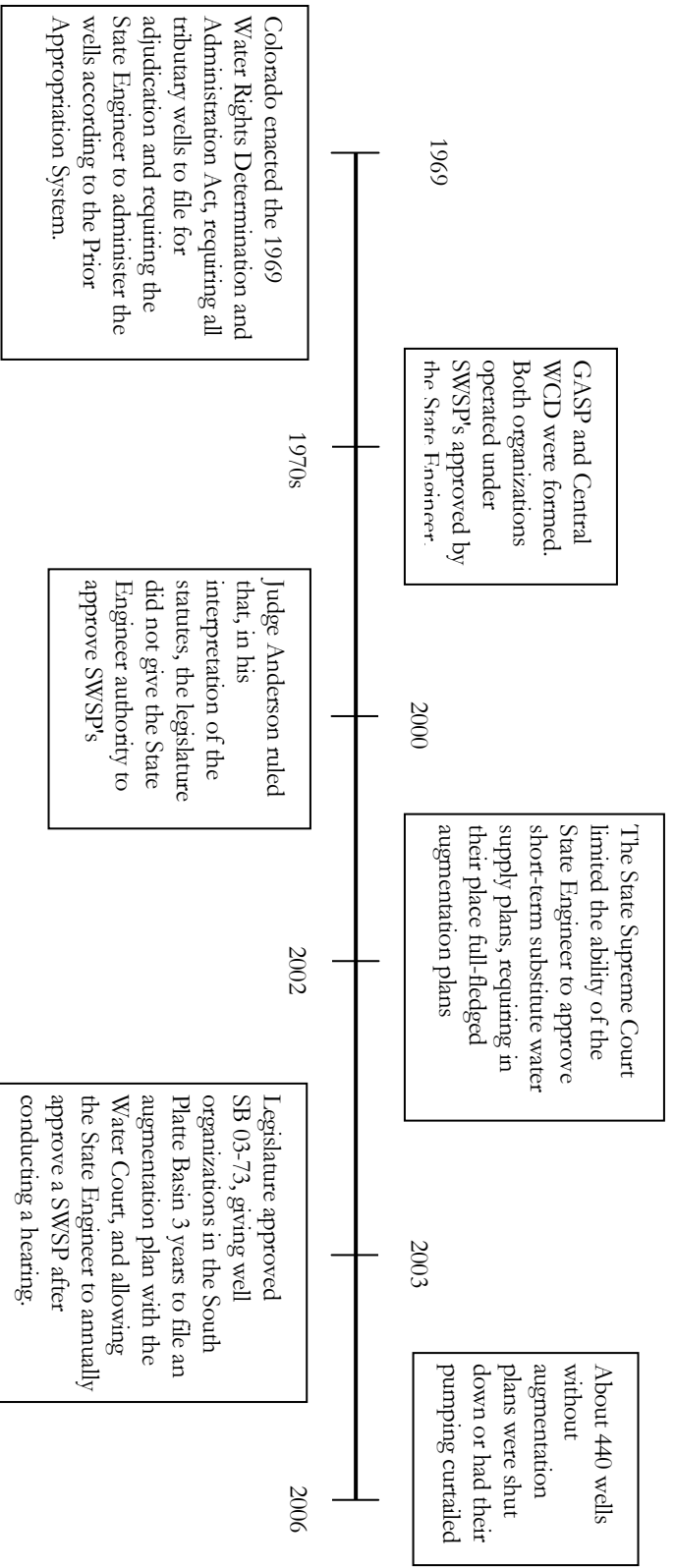


Figure 1: Augmentation Rule Time-line

## **The Economic Impacts of Recent Changes**

The previous discussion summarizes how the administration of augmentation plans has evolved since 1969. The more recent changes described in the previous section in water law have the effect of:

(a) protecting and “firming” the water rights of senior water right holders which include farmers and municipalities and

(b) requiring well owners to obtain court approved water augmentation plans. For some well owners, augmentation plans require the outright purchase of additional water rights to replenish out-of-priority depletions. In the absence of court approved water augmentation plans, groundwater pumping is curtailed and the associated farming operations alter business practices.

Firming senior water rights by curtailing out-of-priority depletions creates economic benefits. Senior water right values (e.g. dollars for a share) appreciate in value simply because they are more likely to be fulfilled when water supplies are scarce. The appreciation in water right value is spread throughout the South Platte Basin, but the appreciation is difficult to quantify until a sufficient number of water transactions have occurred. Likewise, irrigated cropland has increased in value so long as it has associated senior water rights or a court approved augmentation plan.

A more strictly enforced prior appropriations doctrine should increase the efficiency of water right transactions, and encourage more transactions over time. In this manner, water rights may be shifted to a higher valued use more readily resulting in an economic benefit, all things being equal.

For municipalities, the firming of senior water rights means they need to seek less water for a burgeoning population, and their water users will face fewer, less stringent restrictions in times of relative scarcity. For agricultural producers who rely on surface water rights, a longer irrigation season is more likely during drought thus improving crop yields and perhaps allowing these producers to plant crops that consume more water.

At the minimum, producers who filed augmentation plans incurred transactions costs (e.g., legal fees) and may have altered their business practices in order to fulfill the stipulations of their plan. That is, these well owners may have had to purchase water rights, improve their irrigation technology or changed crop rotations as a result of their court approved plan. Producers whose depletions were curtailed certainly altered business practices perhaps by irrigating less, changing their crop mix, adopting dryland cropping practices, etc. The purpose of this study is to better understand how these businesses practices changed.

As farmers, both senior water right holders and well owners, alter their business practices, it is expected that economic activity among support industries and rural communities will change as well. Colorado’s crop production has thrived with its water resources and, in turn, crop production has supported commercial livestock, meat-packing, and dairy industries. Each of these primary agricultural industries has encouraged economic development directly, through the purchase of inputs, and indirectly, through the wages and salaries of employees. Without other viable local base industries to generate revenues and provide employment, a reduction in the revenue generated in the agricultural sector will have adverse economic impacts throughout the regional economy (Pritchett, et al., 2005).

Water is a resource with productive capacity, and a loss of productive capacity affects more than just the agricultural producer—third parties such as local governments and businesses are affected as well. For example, there may be temporary or permanent income losses to factors of production in sectors with backward or forward linkages to irrigated agriculture. If persistently depressed economic conditions exist, factors of production (e.g., labor), agricultural supplying activities, and agricultural processing activities can be idled for long periods of time, leading to real efficiency losses. It will be easier to find alternative uses for some factors of agricultural production such as water and labor. Conversely, it would be more difficult to find alternative uses for other factors such as irrigation equipment and seed. Substantial economic and psychological costs are incurred even by those factors that successfully move to new occupations (Pritchett, Frasier, and Schuck, 2003).

Information relating Colorado's economy and agricultural water use is required by policy-makers as input for the decision-making process (Young, 1983), and understanding the impact of these changes on rural Colorado economies is a key challenge for all Coloradans. The total economic impact changing augmentation administration will include (but is not limited to):

1. Direct impacts: Changing production of irrigated crops resulting in decreased revenue flow from the sale of those crops.
2. Indirect impacts: As irrigated agriculture changes in size and scope, its demand for inputs provided by other industries, will also experience different revenue flows. For instance, if a farmer reduces his production of irrigated crops, he/she will demand less fertilizer, seed, etc. from the industries that supply those inputs.
3. Induced impacts: Changing crop production activity leads to altered demand for labor inputs. As an example, the income loss associated with decreased employment leads to a reduction in spending attributed to wages.

Impacts will be felt by businesses and by local governments whose property and sales tax base is eroded. Governments experience decreased tax revenues because the appraised value of irrigated land decreases as it is converted to dryland (Pritchett, Frasier, and Schuck, 2003). Local governments may experience increased costs if they assist displaced workers. Offsetting some of these losses might be a reduction in services that follows a shift from irrigated to dryland crops, because dryland farming generally requires fewer inputs and because it takes significantly more acres of dryland to support a household than does irrigated land (Pritchett, Frasier, and Schuck, 2003).

Fallowing the formerly-irrigated lands has generally produced short-term negative economic impacts on a regional or community basis for the following reasons:

1. Declining land values because of limited alternative land uses, greater potential for soil erosion, and unreliability of dryland cropping practices due to limited and variable natural precipitation (Smith, et al., 1996)
2. Reduced economic activity in the private sector because of the lower level of inputs used in dryland agriculture (Smith, 2005). Retiring irrigated land can lead to losses of

farm jobs, crop production, and farm income. Indirect impacts include losses of jobs, income and production in non-farm businesses that are linked to irrigated agriculture. Induced impacts include changes in population, employment and income in local businesses that are not linked to agriculture but that depend on the vitality of the local economy in general (Committee on Western Water Management, 1992).

Previous studies have considered the economic impacts of reduced irrigated acreage. Howe and Goemans (2003) used IMPLAN to estimate the economic losses from reductions in irrigated acreage resulting from water transfers in the Arkansas and South Platte Basins. The authors found that if the economic region is economically diversified and buoyant, alternative employment opportunities are close at hand and the selling farmer may be able to find local investment opportunities for his or her money. Furthermore, the negative indirect and induced effects in such a setting are likely to be short-lived. In contrast, in areas where the economy has historically been depressed, limited opportunity exists for the proceeds from the water sale to be invested in the local economy and most of the water sale proceeds are instead used to reduce farm debt. While the reduction in debt is a financial gain to the farmer, it creates no new jobs in the absence of local investment opportunities. The losses on a per capita basis are also much greater and are likely to persist over a longer time span. In such cases, the regional impacts of a permanent transfer of water rights can be quite severe. The authors conclude that agencies approving or modifying water allocations should consider the secondary economic and social costs imposed on the basin of origin, as is already the practice in Idaho, Utah, and Wyoming.

Naturally, the importance of these incurred costs depends on the accounting stance employed by the analyst. At the national level, where the agricultural losses can likely be made up by expanding production in other states, the losses in the area of origin may appear to be minor. At the state level, both direct and indirect losses of income and employment in the area of origin may be offset by gains in the importing areas. In the local region, however, these losses can be substantial and persistent (Howe, Lazo, and Weber, 1982).

The magnitude of economic impacts is important. The economy may be at a place where additional economic shocks will move it beyond a “tipping point” at which a critical mass of economic activity no longer exists and businesses are forced to relocate. Economic impacts also depend on the distribution of the losses, and “hot spots” of well closures may mean some rural communities bear more negative impacts than others. Thus, the true impacts will vary, based on the economic vitality of the area, the strength of the linkages between irrigated agriculture and other sectors in the economy, the number and magnitude of previous impacts the economy has already faced, and the distribution of the losses.

## SCOPE OF STUDY

Colorado is home to eight<sup>8</sup> major river divisions, as illustrated in Figure 2. This study focuses on the Lower South Platte Basin consisting of Logan, Morgan, and Sedgwick counties within Water Division 1. The Lower South Platte Basin has a population of 51,346 and comprises 3.5 percent of the state's total land area.

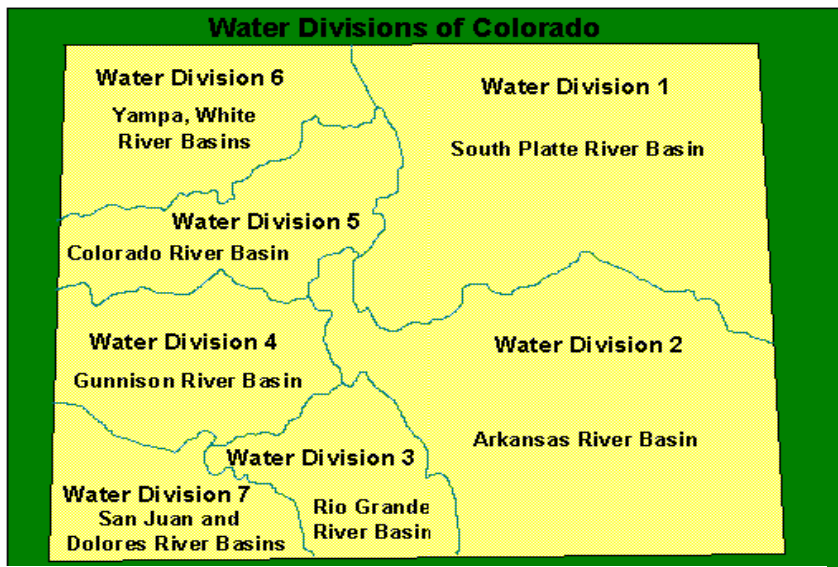


Figure 2: Colorado's Eight Water Divisions

### Economic Demographics

Annual value of sales and services of the Lower South Platte Basin is \$3,372 million, with all agriculture industries<sup>9</sup> together comprising 25 percent of this value. Table 1 shows the top 10 sectors in the basin, in terms of dollars of output. The Lower South Platte Basin accounts for approximately one percent of the state's employment. Employment and earnings are concentrated in agricultural and related industries. According to the U.S. Department of Labor's Bureau of Labor Statistics, the average unemployment rate in the Lower South Platte Basin in 2005 was 4.1 percent. There are relatively few economic alternatives to agriculture in the Lower South Platte Basin and the counties in this area are heavily dependant on agriculture

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<sup>8</sup> SWSI considers the Republican River Basin to be a sub-basin of the South Platte River Basin. Because the Republican River Basin has distinct cropping mixes and a greater level of ground water use, this study considers it separately from the South Platte Basin.

<sup>9</sup> In this context, agriculture industries are direct farm/ranch production and sales are quantified at the farm gate. Therefore, value-added processing such as cheese making and meatpacking are no included.



for their economic base. If the changing of water plan administration results less irrigated cropland in this basin, then non-trivial adjustments in economic activity are expected, due to the high percentage of the total value of sales coming from agriculture. Areas relying more exclusively on irrigated agriculture for economic activity, such as the Lower South Platte Basin, are likely to suffer greater impacts versus regions with a broader, more diverse economic base.

**Table 1: Economic Demographics for the 3 LSP Counties (2002<sup>10</sup>)**

<b>Industry</b>	<b>Output (Million \$)</b>	<b>Percent of Total Output</b>
Animal, except poultry, slaughtering	\$678	20%
Cattle ranching and farming	\$596	18%
Cheese manufacturing	\$213	6%
Irrigated Crops	\$151	5%
Owner-occupied dwellings	\$110	3%
State & Local Education	\$109	3%
Power generation and supply	\$90	3%
Wholesale trade	\$72	2%
Hospitals	\$65	2%
New residential 1-unit structures	\$64	2%
<b>Total Output</b>	<b>\$3,374</b>	<b>100%</b>

### **Agricultural Demographics**

Agriculture has been a major influence in almost every area of socioeconomic concern because the basin is located in one of the most agriculturally productive regions of the U.S. The basin's agricultural output has both regional and national significance (BOR, 1985). The total land area of the Lower South Platte Basin is 2,350,336 acres, with 91 percent of this land area dedicated to farming and ranching activities. Of the area in farm and ranch, 53 percent is cropland. Of the cropland, 14 percent is irrigated cropland and 86 percent is dryland (Figure 3). Grazing lands are utilized for beef cattle. The lands are irrigated by direct flow rights from canals, by storage from reservoirs, and by pumping from alluvial aquifers. The introduction of irrigation from both surface and ground water sources has diversified crops and increased livestock production. Corn (grain and silage), hay, and onions are the main irrigated crops grown today. Table 2 lists the value of sales by crop.

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<sup>10</sup> However, because 2002 was a drought year in Colorado, data from the year 2000 were used for the agricultural sectors in order to avoid underestimation of these figures (and thus overestimation of the impact).

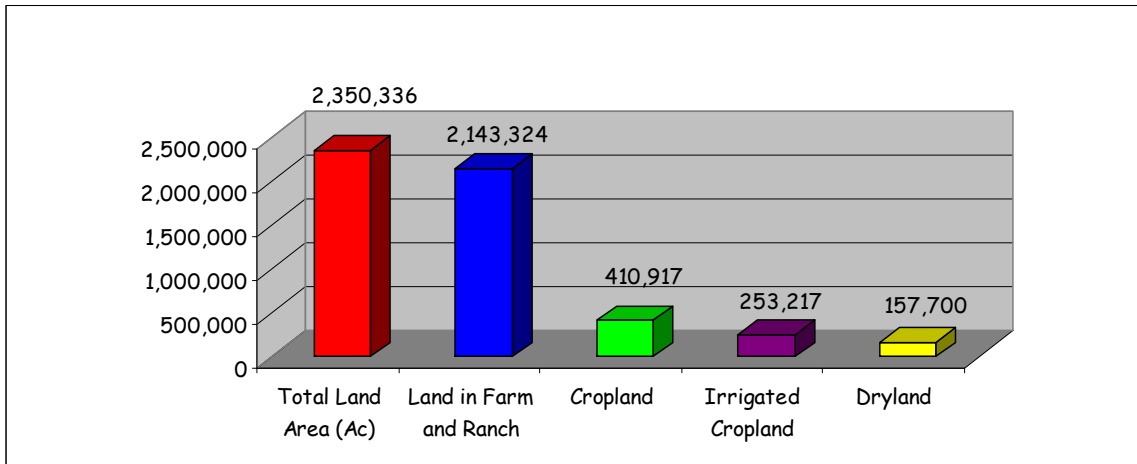


Figure 3: Lower South Platte Basin Land Disposition

Table 2: Value of Sales by Irrigated Crop for Lower South Platte River Basin Counties (2002)

<u>Crop</u>	<u>Acres Planted</u>	<u>Value of Crop Sales (million \$)</u>	<u>% of Total Irrigated Crop Sales</u>
Onions	1,357	\$6.62	5.9%
Corn Grain	172,086	\$54.54	48.7%
Dry Edible Beans	13,000	\$18.2	16.3%
Hay	33,500	\$11.8	10.5%
Corn Silage	20,000	\$10.6	9.5%
Potatoes	1,900	\$5.8	5.2%
Sugar Beets	2,681	\$2.4	2.1%
Wheat	3,000	\$1.03	0.9%
Oats	4,900	\$0.8	0.7%
Barley	700	\$0.2	0.2%
Sunflowers	93	\$0.02	0.02%
<b>Total</b>	<b>235,731</b>	<b>\$112.01</b>	<b>100%</b>

\*Here and throughout the entirety of this paper, “hay” refers to all hay types (e.g., alfalfa, clover, etc.)

\*\*Here and throughout the entirety of this paper, “wheat” refers to all wheat types (e.g., spring, winter, etc.)

\*\*\*Sunflower yields are for oil-type sunflowers only

## METHODOLOGY AND DATA

### Estimated Irrigated Acreage Losses in the Lower South Platte Basin

According to Mulligan and Gibson (1984), applied researchers are increasingly realizing that small-area impact models should be calibrated by survey-based data. As part of this study, 1,800 surveys were sent to producers with GASP wells<sup>11</sup>, with 210 usable surveys returned. More detail regarding the survey design and procedure utilized in the study can be found in the appendix.

Although these 210 surveys represented only 15 percent of all surveys mailed, they represented 20 percent of all irrigated acres in the Lower South Platte and 52 percent of all acres with GASP wells. Thus, acreage changes found in the survey were scaled up (i.e., multiplied) by a factor of 1.97 in order to represent all GASP acres. One exception to this is the survey acreage estimates for potatoes, which, when scaled up by 1.97, exceeded 100 percent of all potato acres planted in the basin. As a result, the lost potato acreage used in the impact analysis equaled all planted acres among survey respondents (1,900 acres). Net acreage gains among respondents include wheat, sunflowers, oats, and sorghum, while crops that experienced net acreage losses include corn (grain and silage), sugar beets, onions, dry beans, potatoes, barley, and alfalfa. The overall net acreage loss, after scaling, is 29,190 acres.

While the net acreage loss estimated by the survey is likely quite accurate, the total economic impact stemming from this lost acreage is likely an upper bound, because some high value crop acres (sugar beets, onions and potatoes) are likely to be replaced elsewhere in the Lower South Platte Basin by producers who have non-GASP sources of water. For this reason, an alternative scenario is considered whereby all lost onion, potato, and sugar beet acres are replaced at the expense of other, lower-valued crops. Even if the sole source of water for GASP farmers is their GASP wells, and these wells are all shut down, there are other producers in the Lower South Platte Basin who have *non-GASP* water and who could take over the production of those higher-valued crops. The full estimated acreage loss will indeed occur, but other, *non-GASP*, producers will likely replace some of their lower-value acreage with higher-value acreage. If this substitution occurs, the net loss of acreage will still be 29,100 acres, but the majority of this loss may be made up of lower-valued crops, thus tempering the economic impact somewhat. Thus, in the so-called "low-end" scenario, the same number of irrigated acres is taken out of production, but all of these lost acres are assumed to be crops other than onions, potatoes, or sugar beets. For consistency, the original scenario, which includes losses of onions, potatoes, and sugar beets, is termed the "high-end" scenario. Table 3 summarizes the acreage assumptions in the high end and low end scenarios.

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<sup>11</sup> Groundwater Appropriators of the South Platte

**Table 3: Estimated Acreage Changes for the High End and Low End Impact Scenarios**

<b>Irrigated Crop</b>	<b>Net Change (acres)</b>	<b>Change as % of 2002 Planted Acres</b>	<b>Alternative Scenario Net Change (acres)</b>
Corn Grain	- 26,225	- 17%	- 30,261
Hay	- 6,169	- 18%	- 7,118
Potatoes	- 1,900	- 100%	0
Sugar Beets	- 1,945	- 19%	0
Onions	- 1,357	-100%	0
Corn Silage	- 700	- 4%	- 808
Dry Beans	- 596	- 5%	- 688
Barley	- 114	- 16%	- 132
Wheat	+ 7,026	+ 234%	+ 7,026
Sunflowers	+ 1,113	+ 1,197%	+ 1,113
Oats	+ 1,020	+ 21%	+ 1,020
Sorghum	+ 657	+ 60%	+ 657
<b>Total</b>	<b>- 29,190</b>	<b>10 %</b>	<b>- 29,190</b>

Two overarching questions remain: what is irrigated agriculture’s contribution to the Lower South Platte economy and what is lost to the economy when the reductions listed in Table 3 come about? The answers to these questions are explored immediately follow the next section which outlines the data and procedures employed, as well as the assumptions made, in accomplishing the primary goal of this study.

### **Data, Methods and Assumptions**

Irrigated agriculture affects the local economy through several different channels: the sale of irrigated crops impacts the economy *directly*, through the purchases of goods and services locally, and *indirectly*, as those purchases in turn generate purchases of intermediate goods and services from other, related sectors of the economy. In addition, these direct and indirect effects increases employment and income, enhancing overall economy purchasing power, thereby *inducing* further spending on goods and services. This cycle continues until the spending eventually leaks out of the local economy as a result of taxes, savings, or purchases of non-locally produced goods and services.

Multipliers describe these ripple effects, with the notion of a multiplier resting upon the difference between the initial effect of a change in final demand and the total effects of that change. Multipliers break the effects of stimuli on economic activity down into three components (Anderson, Wengert, and Heil, 1976):

1. *Direct effects* represent the change in final demand for the industry impacted.
2. *Indirect effects* are the changes to inter-industry purchases as they respond to the new demands of the directly-affected industries.
3. *Induced effects* reflect changes in household spending as household income increases or decreases due to the change in production.

The *total effect* is the simply the sum of the direct, indirect and induced effects. Indirect and induced effects are an important part of an industry's contribution to the regional economy. Economic multipliers measure these secondary effects by quantifying the relationship between an initial change in an industry's output and the effect that this has on the sales of goods and services of all sectors within the region, as well as on regional household spending.

The greater the indirect and induced effects are, the greater the multiplier will be. Multipliers are useful for determining a sector's relative effectiveness to promote regional growth and for providing information to identify economic development opportunities for different geographic areas (Cox and Munn, 2001). The multiplier for the irrigated agriculture sector is among the highest of all economic sectors, such that each added dollar's worth of crop output generates more than a dollar's worth of economic activity. The size of the multiplier will depend on the basic demographics of the region, the diversity of the regional economy, the relative importance of irrigated agriculture in the regional economy, and the strength of the backward and forward linkages between irrigated agriculture and supplying and processing sectors.

### **Input-Output Models**

The economic modeling framework that captures these direct, indirect, and induced effects is called input-output (I-O) modeling. I-O models provide an empirical representation of the economy and its inter-sectoral relationships, keeping track of the purchases and sales of every sector. This enables the user to determine the economy-wide effect that results from a change in the production of one sector of that economy (irrigated agriculture in the present case).

In agriculture, crop enterprise budgets describe the proportion of each dollar spent by farmers on particular inputs to produce a particular crop. These enterprise budgets served two key purposes in this study. First, they were used to adjust the basic IMPLAN I-O model, which is derived from a national model, to make it specific to Colorado and its crops. The national model represents the "average" condition for a particular industry. Consequently, without adjustments for regional differences, the national production functions do not necessarily represent industries comprising the regional economy. Second, these enterprise budgets were used to create a new sector in IMPLAN for each irrigated crop in that region. Having a separate sector for each irrigated crop makes it possible to "shock" each of these sectors separately, according to how many acres of each crop are expected to be dried up, resulting in a more accurate calculation of the output multiplier, and thus a more accurate portrayal of the size and distribution of the impact of reduced irrigated acreage.

For this study, crop prices and enterprise budgets were provided by Colorado State University's Cooperative Extension, Agriculture and Business Management Section. When using enterprise budgets to create production functions for the newly-created agriculture sectors in IMPLAN, the enterprise budget for pinto beans was taken to be representative of

that for all dry edible beans. Crop yield data from the year 2001 were used if data from the year 2003 were not available.

The economic activity that is generated by an industry does not end simply at its direct economic contribution. In order to more fully describe the economic contributions of specific industries in a regional economy, the indirect and induced effects must also be explored. For example, if an analyst were to study the economy of a rural farming region and add only the direct impacts of each sector in the economy, they would get a vastly-skewed picture of that region. Farming in this region is not only responsible for generating direct revenues, it also is responsible for demanding fertilizer and seed from the local farm supply store, and tractors from the local dealer, all of which are indirect effects. The farmers also spend their income at the local diner and provide tax revenues to the local school district, which are induced effects. Therefore, a one-dollar decline in agriculture revenue would have a greater than one-dollar effect on the regional economy because of these linkages. This is the fundamental rationale behind looking at indirect and induced effects in addition to direct effects when conducting regional economic impact analysis (Watson and Winter, 2005). The total effect is the sum of the direct, indirect, and induced effects, and the multiplier is calculated by dividing the total effect by the direct effect.

IMPLAN is the I-O modeling system used in this study. IMPLAN (IMPact Analysis for PLANning) was originally developed by the USDA Forest Service in cooperation with the Federal Emergency Management Agency and the Bureau of Land Management to assist the Forest Service in land and resource management planning (MIG, Inc., 2002). It is now widely used by many state and federal agencies, universities and private consulting firms, and is the modeling system employed for this study. The following section describes how the IMPLAN software is used to create individualized I-O models and how impact analysis is then performed on those models.

The sectoring scheme used by the IMPLAN program has 509 sectors and very closely follows the 1997 Bureau of Economic Analysis (BEA) Benchmark Study for the United States sectoring. The IMPLAN sectoring scheme is based on national averages and thus needs to be calibrated to correspond better to Colorado data. According to Loveridge (2004), it is important for the analyst to double-check the validity of data in these models and make necessary adjustments, as they are often scaled down from national data sets under an assumption of fixed proportions, possibly resulting in the ‘creation’ of local sectors that in fact do not exist. The State Demographer’s List of Businesses was used for calibrating the model. This list is a record of all businesses that currently exist in each study area, with each business organized by type according to the NAICS<sup>12</sup> code. The list was used to verify whether or not each IMPLAN sector truly exists in each study area under consideration. These sectors’

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<sup>12</sup> The North American Industry Classification System (NAICS) was developed jointly by the U.S., Canada, and Mexico to provide new comparability in statistics about business activity across North America. NAICS replaces the 1987 Standard Industrial Classification (SIC).

NAICS codes were then aggregated and converted into to the appropriate IMPLAN sector codes. A more detailed discussion of IMPLAN and its role in economic impact analysis can be found in Colorado Water Resources Research Institute (CWRRRI) Completion Report No. 207.

## **Review of Methodology**

The IMPLAN system was used to construct an I-O model for the Lower South Platte Basin, and the model was calibrated to the most recently available data. Acreage data from Colorado Agricultural Statistical Services were used to disaggregate IMPLAN's default crop sectors into separate irrigated and dryland sectors for each crop. Enterprise budgets provided by Colorado State University's Cooperative Extension Agriculture and Business Management section were used to create a production function for each individual irrigated crop, linking the new irrigated crop sectors to other sectors in the economy. The I-O model was used to gauge irrigated agriculture's relative importance to the basin's economy and the spill-over effects that irrigated agriculture's sales create in the economy. At this point, the I-O model was ready to be "shocked".

The process of determining the size of the "shock" begins with quantifying the acreage changes for each crop. This was accomplished by conducting a survey of agricultural producers in the area, as described above. Prices from the year 2004 were used to determine the revenues that were gained or lost due to the estimated acreage changes. These values of lost sales constitute the direct effects of the impact and were used to "shock" the I-O model. The I-O model then determines the indirect and induced effects that ripple throughout the economy from this initial shock. As explained in more detail previously, the output multiplier is a good indicator of the size and extent of these ripple effects.

The most recent available IMPLAN data, which are from the year 2002, were used for the majority of this study. However, as footnoted previously, because 2002 was a drought year in Colorado, 2000 data were used for the industry output, employment, and income of the 18 agricultural sectors in order to avoid underestimation of these figures.

## **Assumptions and Notes**

Economic activity is a generic term that applies to economic transactions such as businesses producing goods, households buying goods, etc. Economic output (value of sales) as defined in the model is a measure of economic activity on the local level that is similar to the measure of the gross domestic product on the national level. This study estimates the lost economic activity due to a decrease in production; the study does not take into account the beneficial cost savings that would also be associated with a decrease in production, which may temper the revenue losses to some degree.

The term "agriculture" refers to a wide array of activities and sectors of the economy. For clarification, in this study the term "agriculture" refers to the following activities: irrigated crop farming; non-irrigated crop farming; greenhouse and nursery production; cattle ranching

and farming; poultry and egg production; all other animal production; and agriculture and forestry support activities. The following activities are not included in the category termed "agriculture": animal slaughtering; food manufacturing; repair and/or maintenance of farm equipment; and construction of farm structures.

If, in the regional economy, a business exists that provides an input needed by agricultural producers in that region, then it is assumed that those producers purchase that factor from the local provider rather than from an outside source.

Although the vast majority of producers with GASP wells are located within the Lower South Platte Basin, the survey was sent to all producers with GASP wells and thus the sample likely contains some producers who are located outside of the basin. At the same time, producers who are located within three-county region but are not on the GASP mailing list likely did not receive the survey. However, many Lower South Platte producers were aware of the on-going survey, through word of mouth and/or various presentations given by the study authors, and any interested party who requested a survey received one.

### **Limitations of Model**

This model is static rather than dynamic, meaning that substitution effects (i.e., adaptations) are not taken into account. Thus, multipliers are a snapshot of the basin's economic activity—neither new lines of business that could potentially be generated in response to reduced irrigated agriculture, nor migration of businesses and residences out of the dwindling economy, are taken into account. Consequently, these multipliers typically overstate the economic losses for large-scale events (Pritchett, Frasier, and Schuck, 2003). For example, if all the acres that are estimated to be taken out of irrigation are converted to grassland, the entire industry output would not be lost to the economy because many of the affected producers would substitute other money-earning activities. However, if those activities have lower RPCs<sup>13</sup> and provide lower-paying jobs, then there would indeed be a net loss to the regional economy from a reduction in the irrigated crops industry. Additionally, if producers of other commodities are dependent on farmers' goods as inputs to their production (e.g., corn silage for a dairy farm), these producers may be forced to purchase their inputs from farmers outside the region. This would represent a real loss of money to the local economy and would be considered an economic impact. The static nature of the model is also the reason that no discount rate was used in the analysis; thus, lost output is valued in 2002 dollars.

The model is linear and thus is valid for marginal (i.e., small) changes only. The true outcome of the impact also depends on what previous impacts the regional economy has experienced recently. We don't know the tipping point (i.e., the critical threshold) of business activity in the regional economy and thus cannot say with certainty how it will fare when faced with this new impact.

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<sup>13</sup> A regional purchase coefficient (RPC) represents the proportion of local demand for a good or service that is provided locally.



I-O models do not take into account forward linkages (effects to downstream industries who use the outputs of irrigated agriculture as inputs to their own production), such as a reduction in the supply of corn to feedlots, dairies, or ethanol plants; rather, they only address backward linkages (e.g., reductions in the demand for inputs to irrigated agriculture, such as seed, fertilizer, etc.). There has been much concern expressed over the fate of dairy and livestock farmers in the affected regions, particularly in the Lower South Platte Basin. This concern is certainly understandable and warrants consideration and comment. Colorado is a grain-deficit state, meaning that we already import grain (mainly for feedlots), so the reduction in irrigated acres will not require a substantial shift in grain flows to support these businesses. Colorado's corn production is small relative to national levels, so large corn price changes are not expected as corn acres are lost in Colorado. There likely will be some increased costs but these will not be of great magnitude, especially at the margin, which is what most production decisions are concerned with. Howe, Lazo, and Weber (1990) studied the economic impacts of agriculture-to-urban water transfers in the Arkansas River Basin and found no evidence that the phase-outs of feed grains, hay, and irrigated pasture held back the expansion of feedlots over the historical period from 1955 to 1985. Thus, forward linkages were judged to be absent during this historical period. The Texas Panhandle provides another example: a reduction in irrigated acreage has occurred in the area (also a net grain importer) in the recent past due to depletion of the Ogallala aquifer, yet fed cattle production has increased. These examples suggest that the livestock feeders and dairies will likely find other sources of grain rather than exiting the industry. That being said, these are merely examples of what has occurred in the past; results will certainly be somewhat different due to the different area under study and the different time frame. Thus, further study on these specific industries would be beneficial and is encouraged.

The model does not distinguish between local versus global effects. The severity of the effects could be very different if, for instance, the lost acres are clustered around an individual city or town. If the acreage losses occur in one or a few specific locations in the basin rather than being spread diffusely throughout the basin, the economic consequences will be highly concentrated in these "hot spots".

The model does not analyze distributional effects. Individuals with different characteristics are likely to be affected differently. For example, the owner of a farming enterprise may have additional skills that allow him or her to find other employment, or may have alternative sources of income, whereas a hired laborer on that same farm may not have either of these; thus, the impact will likely affect each one differently.

It should be noted that if the initial impact results in decreased demand for a particular good, the entire purchase price of that good is not lost to the regional economy if that good is not produced entirely in that region. If a good (a pesticide, for instance) is produced outside the region but sold by a local retailer (by an agricultural cooperative, for instance), only the

margin--the retailer's mark-up—rather than the entire purchase price, will be lost to the local economy.

## RESULTS

The model is “shocked” by the acreage reductions as estimated by the producer survey and as valued by 2004 crop prices. The total effects are presented and then broken down into the direct, indirect, induced effects.

### Output Impacts

Using the model and methods outlined in the previous section, a reduction in irrigated acreage was simulated and the resultant economic impacts estimated. Table 4 shows the irrigated acreage changes based on survey responses and on the alternative scenario described above.

**Table 4: Estimated Acreage Changes as Scaled Up from the producer survey.**

<u>Irrigated Crop</u>	<u>High End Scenario Acreage Change</u>	<u>High End Change as % of 2002 Planted Acres</u>	<u>Low End Scenario Acreage Change</u>
Corn Grain	- 26,225	- 17%	- 30,261
Hay	- 6,169	- 18%	- 7,118
Potatoes	- 1,900	- 100%	0
Sugar Beets	- 1,945	- 19%	0
Onions	- 1,357	- 100%	0
Corn Silage	- 700	- 4%	- 808
Dry Beans	- 596	- 5%	- 688
Barley	- 114	- 16%	- 132
Wheat	+ 7,026	+ 234%	+ 7,026
Sunflowers	+ 1,113	+ 1,197%	+ 1,113
Oats	+ 1,020	+ 21%	+ 1,020
Sorghum	+ 657	+ 60%	+ 657
<b>Total</b>	<b>- 29,190</b>	<b>10 %</b>	<b>- 29,190</b>

In Table 5, the total impact is broken down into its component parts, with the first column restating the net acreage reduction. The direct effects represent the lost irrigated crop sales and are shown in the second column of the table. The indirect and induced effects are an important part of an industry's contribution to the regional economy, and are shown in the third and fourth columns of the table, respectively. The indirect effects are the decreases in inter-industry purchases (fertilizer, seeds, etc.) in response to the decreased demands of irrigated agriculture. The induced effects reflect changes in household spending as household income decreases due to the decrease in production. The total effect is the sum of the direct, indirect and induced effects, and is shown in the fifth column of the table.

The basin's multiplier for irrigated agriculture is displayed in the final column of Table 5. Economic multipliers measure the ripple effects of an impact by quantifying the relationship between an initial change in an industry's final demand and the total effect that this change has on 1) the sales of goods and services of all sectors within the region and 2) regional household spending. The greater the indirect and induced effects are, the greater the multiplier will be.

**Table 5: Impact Components**

<b>Scenario</b>	<b>Direct</b>	<b>Indirect</b>	<b>Induced</b>	<b>Total</b>	<b>Output Multiplier</b>
High-End	-\$23,027,833	-\$2,124,979	-\$3,056,842	-\$28,209,654	1.23
Low-End	-\$10,752,816	-\$555,323	-\$1,483,309	-\$12,791,448	1.19

The output multiplier is a measure of economic inter-connectedness and it measures the degree to which a decrease in activity of a given local industry (irrigated agriculture in this case) causes a decrease in purchases from other local industries and local resource providers. A large multiplier indicates that that industry has many ties to the local economy (it does not necessarily indicate high output). For instance, the high-end Lower South Platte multiplier of 1.23 means that for every \$1 of irrigated agriculture sales that is lost, the total impact on the entire Lower South Platte region will be a loss of \$1.23 of economic activity. The output multiplier is thus a good indicator of the size and extent of the ripple effects and is intimately related to the proportion of inputs to irrigated agriculture that are purchased locally (i.e., within the study region). Multiple factors influence the size of the output multipliers, including:

1. Size and diversity of the regional economy:
  - a. Typically, the larger the economy, the more factors of production can be provided by local industries and thus the more economic activity is internalized. Money is thus used more times before it escapes from the economy, resulting in a larger multiplier. Conversely, the smaller the economy, the more dependent the area is on economic activity from other functional economies, and hence the more income that tends to leak outside the area as goods and services necessary for day-to-day commerce are imported from outside the area. Given the limited number of linkages that exist in these smaller economies, multipliers tend to be smaller, resulting in a smaller total effect for a given initial impact. However, because there are fewer businesses among which the losses can be spread, the losses could actually be more concentrated and severe in these areas.
  - b. In general, more diverse economies will have larger multipliers because more inputs will be provided locally. One indicator of the diversity of an economy is the Shannon-Weaver diversity index, which is calculated by IMPLAN. The Shannon-Weaver diversity index is determined by the number of industries in the region and how well-distributed employment is throughout all of those industries. Its values range from zero to one, with one being perfect diversity. Conversely, as employment and output become concentrated in fewer industries, the Shannon-Weaver index approaches zero. The Shannon-Weaver

diversity index for the Lower South Platte Basin is 0.64. For comparison purposes, the Shannon-Weaver diversity index for Colorado's economy as a whole is 0.77. In the South Platte Basin as a whole, where multiple alternatives to irrigated agriculture exist, displaced labor, capital, and land are likely to be reemployed in other productive activities within a relatively a relatively short period.

2. Number of production inputs: When a sector purchases a large number of inputs (especially high-cost inputs) from local industries, there are many ties to the local economy and less leakage, leading to a higher output multiplier. This can be evidenced by the lower LSP output multiplier (1.19) under the low-end scenario. The high-value and high-input-cost crops, which have more ties to the local economy and thus have a bigger impact when they are removed from the economy, are not included in the impact under the low-end scenario, resulting in a lower multiplier.

Table 6 compares the total impact in each scenario to the basin's total output and agricultural output levels. The first column restates the net acreage loss and the second column restates the total output impact in each scenario. The third column gives the impact as a proportion of the basin's total output, which is less than one percent in each scenario, suggesting that the impact of the well closures will not be detrimental to the Lower South Platte Basin economy as a whole. However, as displayed in the third column of the table, the impact of the well closures will make up a greater proportion of the region's total agricultural output (from 1.3 percent to 3.4 percent). Furthermore, as displayed in the fourth column of the table, the high-end impact will comprise a very significant proportion of total irrigated agricultural output (up to 25 percent), which could easily change the face of agriculture in the Lower South Platte region.

The last column of Table 6 shows the impact per acre lost, which can also be interpreted as the economic activity generated by one acre of irrigated crops. The economic activity generated per acre in the Lower South Platte Basin is high relative to other regions in Colorado (CWRRI Completion Report No. 207), which can be explained by a combination of factors. First, economic activity per acre tends to be higher when high value crops are being sold to areas outside of the local region (thus bringing new money into the region), resulting in a greater loss of economic activity in the local economy when those crops are reduced. Thus, the sale of onions, potatoes, and sugar beets (all high-value crops) outside of the region contributes to the high economic activity per acre seen here. Economic activity per acre also tends to be higher when local support industries use high amounts of local labor and inputs. For instance, onions, potatoes, and sugar beets are all major crops in the basin in terms of revenue and are all also high-input-cost crops, again contributing to the high amount of economic activity generated per acre in this basin.

**Table 6: Output Impacts Relative to Total Output and Agricultural Output**

<u>Scenario</u>	<u>Acreage Change</u>	<u>Total Impact</u>	<u>Impact as % of Total Output</u>	<u>Impact as % of Agriculture</u>	<u>Impact as % of Irrigated Crop Sales</u>	<u>Economic Activity Generated by Lost Acres</u>
High-End	-29,190	-\$28,209,654	0.8%	3.4%	25%	\$966.42 / ac.
Low-End	-29,190	-\$10,752,816	0.3%	1.3%	9.5%	\$368.37 / ac.

### Impacts per Capita

Howe and Goemans (2003) argue that the per capita losses are more relevant measures of the welfare impacts associated with a reduction in irrigated agriculture. This idea seems appropriate, especially given that the low population typical of rural areas means that the impacts per capita are likely to be higher than in urban areas. Even if the total impact to a region is relatively small, if the population density in that region is low, then the impact will be spread out over a relatively small number of people, resulting in a larger impact *per person*. The per capita impact is calculated by dividing the total impact by the total population in the region. In the Lower South Platte this impact is calculated to be -\$549.40 per person for the high end scenario.

### Impacts by Sector

The previous results examine the impact to the regional economy as a whole, but do not disaggregate the impact among different sectors. The distribution of the impact will be uneven among sectors, and this distribution is sure to be important to stakeholders. Table 7 shows the ten sectors which will experience the greatest total impact stemming from the reduction in irrigated acreage. Irrigated Crops is the sector most affected by the acreage reductions. This is not surprising, and can be explained by the fact that this sector is where all of the direct impacts occur. The impacts to all other sectors are a result of the indirect and induced effects, as defined earlier.

The Wholesale Trade sector also appears in the table. According to the NAICS definition, this sector comprises establishments engaged in wholesaling merchandise, generally without transformation, and rendering services incidental to the sale of merchandise. The merchandise described in this sector includes the outputs of agriculture, mining, manufacturing, and certain information industries, such as publishing.

The wholesaling process is an intermediate step in the distribution of merchandise. Wholesalers are organized to sell or arrange the purchase or sale of:

- a. goods for resale (i.e., goods sold to other wholesalers or retailers),
- b. capital or durable non-consumer goods, and
- c. raw and intermediate materials and supplies used in production.

This sector comprises two main types of wholesalers:

- a. merchant wholesalers, who sell goods on their own account and
- b. business-to-business electronic markets, agents, and brokers that arrange sales and purchases for others, generally for a commission or fee. Chemical dealers, fertilizer dealers, tractor dealers, etc., would likely fit into this category.

The Owner-Occupied Dwellings sector represents home-ownership. Home-ownership is treated like an industry—it purchases inputs and creates outputs for the economy (mostly property taxes), and households make payments to this sector as part of their consumption function (it is like home-owners paying a rent to themselves). The impact felt by this sector is due entirely to induced effects (those of reduced household spending due to decreased household income). The Cattle Ranching and Farming sector relies heavily upon crop farmers for cattle feed, and thus will be affected by a reduction in crop sales, as evidenced in the table.

The Monetary Authorities and Depository Credit sector also appears in the list of most-affected sectors, for which there are likely several contributing factors. Firstly, as farmers decrease the number of acres under irrigation, they will have fewer inputs to purchase and thus will likely take out fewer operating loans from local banks and other lending institutions. There will also likely be a decrease in real estate activity in the region, resulting in fewer mortgages and their associated fees. Finally, because banks and other financial institutions in this basin are more likely to be locally-owned, a larger portion of their revenues stay within the region, resulting in a larger ripple effect occurring in this sector.

**Table 7: Impact by Sector**

<b>Sector</b>	<b>Direct</b>	<b>Indirect</b>	<b>Induced</b>	<b>Total</b>
Irrigated Crops	-\$23,027,833	-\$406,086	-\$12,451	-\$23,446,370
Owner-occupied dwellings	0	0	-\$492,541	-\$492,541
Power generation and supply	0	-\$306,737	-\$114,953	-\$421,690
Wholesale trade	0	-\$188,676	-\$101,172	-\$289,848
Hospitals	0	0	-\$232,970	-\$232,970
Food services and drinking places	0	-\$14,539	-\$210,265	-\$224,804
Monetary authorities and depository credit	0	-\$64,012	-\$132,138	-\$196,149
Cattle ranching and farming	0	-\$127,629	-\$67,792	-\$195,421
Truck transportation	0	-\$127,696	-\$49,837	-\$177,533
Real estate	0	-\$99,980	-\$48,768	-\$148,748
<b>Total</b>	<b>-\$23,027,833</b>	<b>-\$2,124,979</b>	<b>-\$3,056,842</b>	<b>-\$28,209,654</b>

### Impacts by Crop

Each crop uses different proportions of crop inputs and thus is associated with slightly different economic activity (indirect and induced effects), giving way to varying magnitudes of the impact per acre. Table 8 lists the acreage reduction and economic activity loss for each crop, as well as the economic activity lost per acre lost for each crop (which can also be interpreted as the economic activity generated per acre of that crop). Because the total impact

is made up of the direct, indirect, and induced effects, a crop may experience a large total impact due a variety of factors. For instance, potatoes appear at the top of the list primarily due to their high price, and thus large direct impact. On the other hand corn grain appears near the top of the list due primarily to the large number of acres of that crop that are lost (and thus a large direct effect). Onions appear near the top of the list primarily because this crop requires relatively expensive quantities of inputs and labor, thus generating a large drop in economic activity per acre lost due to large indirect and induced effects in addition to the direct effects.

**Table 8: Impact and Economic Activity by Crop for the High End Scenario**

<u>Irrigated Crop</u>	<u>Acres Lost</u>	<u>Direct</u>	<u>Indirect</u>	<u>Induced</u>	<u>Total</u>	<u>Economic Activity per Acre</u>
Corn Grain	26,225	-\$8,457,563	-\$18,291	-\$6,447	-\$8,482,301	\$323
Onions	1,357	-\$6,622,160	-\$14,443	-\$640	-\$6,637,244	\$4,891
Potatoes	3,068	-\$5,759,375	-\$10	0	-\$5,759,385	\$1,877
Hay	6,169	-\$2,163,314	-\$66,788	-\$4,484	-\$2,234,586	\$362
Sugar Beets	1,945	-\$1,717,826	-\$233,444	-\$3	-\$1,951,273	\$1,003
Dry Edible Beans	596	-\$834,877	-\$16,090	-\$182	-\$851,149	\$1,428
Corn Silage	700	-\$369,600	-\$59,846	-\$1	-\$429,447	\$613
Barley	114	-\$29,728	0	-\$2	-\$29,730	\$261

## Employment Impact

Employment impacts obtained from IMPLAN are measured in annual average jobs. This includes wage, salary, and self-employed jobs, and both full-time and part-time work (MIG, Inc., 2002). Table 9 lists the ten sectors that experience the largest total employment impact. The table also breaks down the total employment impact into its component parts.

**Table 9: Employment Impacts by Sector (Measured in Jobs)**

<u>Sector</u>	<u>Direct</u>	<u>Indirect</u>	<u>Induced</u>	<u>Total</u>
Irrigated Crops	-211.50	-3.70	-0.27	-215.47
Food services and drinking places	0.00	-0.42	-6.10	-6.52
Agriculture and forestry support activities	0.00	-3.64	-0.02	-3.66
Wholesale trade	0.00	-2.22	-1.19	-3.41
Offices of physicians, dentists, etc.	0.00	0.00	-2.58	-2.58
Hospitals	0.00	0.00	-2.50	-2.50
Real estate	0.00	-1.31	-0.64	-1.95
Truck transportation	0.00	-1.23	-0.48	-1.71
Nursing and residential care facilities	0.00	0.00	-1.69	-1.69
General merchandise stores	0.00	-0.06	-1.58	-1.65
<b>Total</b>	<b>-211.50</b>	<b>-19.91</b>	<b>-38.07</b>	<b>-269.48*</b>

\*A total of 367.46 jobs were lost; however, 97.98 jobs were also created as a result of increased acreage of the crops mentioned previously, for a net loss of 269.48 jobs.

Table 10 displays the total employment impact alongside the unemployment rate in the region. The table also presents the total employment impact as a percentage of the total workforce and agricultural workforce in the basin. Dividing the net job loss by the net acreage loss gives us the number of jobs lost per acre lost, the inverse of which is the number of acres required to support one job in the basin, as displayed in the sixth column of the table. Finally, the employment multiplier is displayed in the last column of the table. The employment multiplier can be interpreted analogously to the output multiplier--for every one job lost in the irrigated crops sector, an additional 0.35 jobs are lost elsewhere in the economy.

**Table 10: Employment Impact Compared to the Entire Workforce and to the Agricultural Workforce**

<u>Unemployment Rate*</u>	<u>Net Jobs Lost**</u>	<u>Net Agriculture Jobs Lost</u>	<u>% of Total Workforce Lost**</u>	<u>% of Agriculture Jobs Lost</u>	<u>Acres that Support One Job</u>	<u>Employment Multiplier</u>
4.1	269.5	219.9	1.0%	6.6%	108.3	1.27

\*Unemployment rates are averages from the year 2005.

\*\*Job numbers in some industries were not disclosed; therefore, the actual workforce is likely to be somewhat higher, resulting in job loss percentages that are somewhat lower than what is shown here.

## Tax Impact

The reduction in economic activity, whether it takes place in the value of sales or wages, will adversely affect sales and tax revenues in the region. Table 11 shows the total tax impact and breaks it down into its component parts.

**Table 11: Tax Impacts (million \$)\***

<u>Employee Compensation</u>	<u>Proprietary Income</u>	<u>Household Expenditures</u>	<u>Enterprises (Corporations)</u>	<u>Indirect Business Taxes</u>	<u>Total</u>
-\$0.44	-\$0.16	-\$1.95	-\$0.91	-\$1.28	-\$4.74

\*Please note that these figures do not include any potential property tax impacts.

The survey estimates of reduced irrigated acreage, valued with 2004 prices, were used to “shock” the IMPLAN input-output model that had been built for the basin. This section presented the total economic impacts, as generated by IMPLAN. The total impact was then disaggregated into the direct, indirect, and induced effects. Impacts were also segregated by sector and by crop, and the output multiplier was displayed and discussed. Finally, the employment and tax impacts were displayed and briefly discussed.



## CONCLUSIONS

This study considers the economic impact of changing augmentation administration in the Lower South Platte. It contains an estimate of lost economic activity from predicted fallowing of irrigated cropland. These estimates are intended to help affected communities take steps to minimize and prepare for the resulting impacts. The study began by establishing demographics for the region and then provided general estimates of what the agricultural sector, and irrigated agriculture in particular, contributes to the regional economic activity of each region. An input-output model was tailored to the region, and then this I-O model was “shocked”, using estimates of future reductions in irrigated acreage (from the producer survey), with the final goal of providing preliminary estimates of what is likely to happen should the expected acreage reductions and crop-mix changes occur. This scenario involved the simplifying assumption that all of the value was instantly lost, rather than being lost gradually over time. In this context, the estimated impacts are permanent annual losses.

The benefits of the rule changes, which would offset some of these losses, have not been quantified in this study. These benefits include firming senior water rights, increased efficiency in water transactions and an increased productive capacity for agricultural producers.

Firming senior water rights by curtailing out-of-priority depletions creates economic benefits. As an example, senior water right values (e.g. dollars for a share) appreciate in value simply because they are more likely to be fulfilled when water supplies are scarce. The appreciation in water right value is spread throughout the South Platte Basin, but is difficult to quantify until a sufficient number of water transactions have occurred. Likewise, irrigated cropland has increased in value so long as it has associated senior water rights or a court approved augmentation plan.

A more strictly enforced prior appropriations doctrine should increase the efficiency of water right transactions and encourage more transactions over time. In this manner, water rights may be shifted to a higher valued use more readily resulting in an economic benefit, all things being equal.

For municipalities, the firming of senior water rights means they need to seek less water for a burgeoning population, and their water users will face fewer, less stringent restrictions in times of relative scarcity. For agricultural producers who rely on senior surface water rights, a longer irrigation season is more likely during drought thus improving crop yields and perhaps allowing these producers to plant crops that consumptively use more water.

Irrigated agriculture is an important base industry of the Lower South Platte region generating more than \$680 per acre of economic activity (Thorvaldson and Pritchett). According to our survey respondents, nearly 30,000 acres have been fallowed thus far as a result of changing augmentation rules. The overall estimated impact to the local economy depends importantly on if high value crops left the basin, or if these acres were replaced. It's clear that survey respondents reduced onion, sugar beet and potato acres, and if these crops left the basin the total economic impact totals more than \$28 million. If these acres were planted elsewhere in the Lower South Platte Basin, by farmers with non-GASP water supplies in lieu of lower-value crops, then the impact declines to nearly \$13 million.

Not only is the agricultural sector damaged, but also several other sectors of the economy are adversely affected by fallowing. Agricultural jobs and jobs in other sectors are eliminated. Income to both agricultural families and non-agricultural families is lost. Tax revenue losses are substantial--amounting to millions of dollars.

On one hand, the estimates of lost acreage may be conservative in that they do not capture the acreage that has already been lost due to farmers who have already quit the business and moved out of the region, and thus were not present to fill out the survey. Furthermore, the estimated acreage changes do not include all of the well shut-downs mandated in 2006, as enforcement occurred concurrently with the producer survey. Further reductions in irrigated acreage are likely to occur as additional wells are shut down and as additional farmers quit the business, in turn increasing the magnitude and scope of the impact. On the other hand, the estimates of lost acreage may be somewhat overstated, in that those farmers who were the most affected by the rule changes were also the most likely to fill out and return the survey, thus over-representing this group compared to those who experienced minimal losses due to the changing rules.

A similar phenomenon exists for the impact estimates. On one hand, the impact estimates may be conservative in that the model does not take into consideration any possible interactions with livestock production or food processing (forward linkages), nor the impact of unemployed people moving out of the region. On the other hand, the estimates could be somewhat overstated since they do not take into consideration any adaptive behavior aimed at lessening the losses, nor the potential re-employment of the unemployed people within some new business.

Also, I-O models are most suitably used for marginal (i.e., small) changes. The acreage changes considered here could suitably be considered marginal, as they comprise a maximum of 10 percent of all irrigated acreage. However, the output impact may not be marginal, as it comprises nearly 20 percent of irrigated agriculture sales under the high-end scenario.

Finally, as mentioned earlier, the direct impacts were based on the estimated ranges of reduced irrigated acres, as acquired from the producer survey and 2004 crop prices. Thus, it is important to note that the number of irrigated acres that will actually be lost, and their value, could be higher or lower. Many factors affect the magnitude of the initial impact and thus there are many reasons why the magnitude and extent of the actual impacts may differ somewhat from these initial estimates. This is, of course, the nature of all models—they are imperfect replicas of the real world.

The losses represent is what is likely to occur in the short run, when there is limited ability to react to the reduction in agricultural output. Over time, human resources and substitutable capital will migrate to other employment, although there will be less migration out of agriculture than would be the case with other sectors because of the culture of an agricultural way of life, the older average ages of farmers, and their more isolated locations (Howe and Goemans, 2003).

## APPENDIX: PRODUCER SURVEY

### Survey Methodology

The survey was targeted to well owners whose business practices may have been altered as result of changing augmentation rules. Consequently, a random draw from the mailing list of the now-defunct Groundwater Appropriators of the South Platte (GASP) was used. An initial mailing of 1,000 was made, but of these 108 could not be delivered. Two weeks after the initial mailing, a postcard reminder was sent. Two weeks following the reminder, a second survey was mailed to non-respondents. Nearly 20% of deliverable surveys were returned, however, a number of these were from producers who a) had already sold their farm and did not provide any acreage or irrigation information, b) were not applicable to the survey, such as greenhouses, or 3) did not fill out the survey and requested to be taken off the mailing list. Thus, the response rate of *usable* surveys was 14%.

Recognizing the large number of undeliverable addresses, a second mailing was made. In total, 676 surveys were mailed of which 80 were not deliverable. Two weeks later a postcard reminder was sent, and two weeks following the reminder a second survey was sent to non-respondents. There were 206 useable responses overall (from both mailings), a response rate of 15%. Importantly, respondents represented 58,702 irrigated acres, approximately 52% of the acreage believed to be irrigated within GASP.

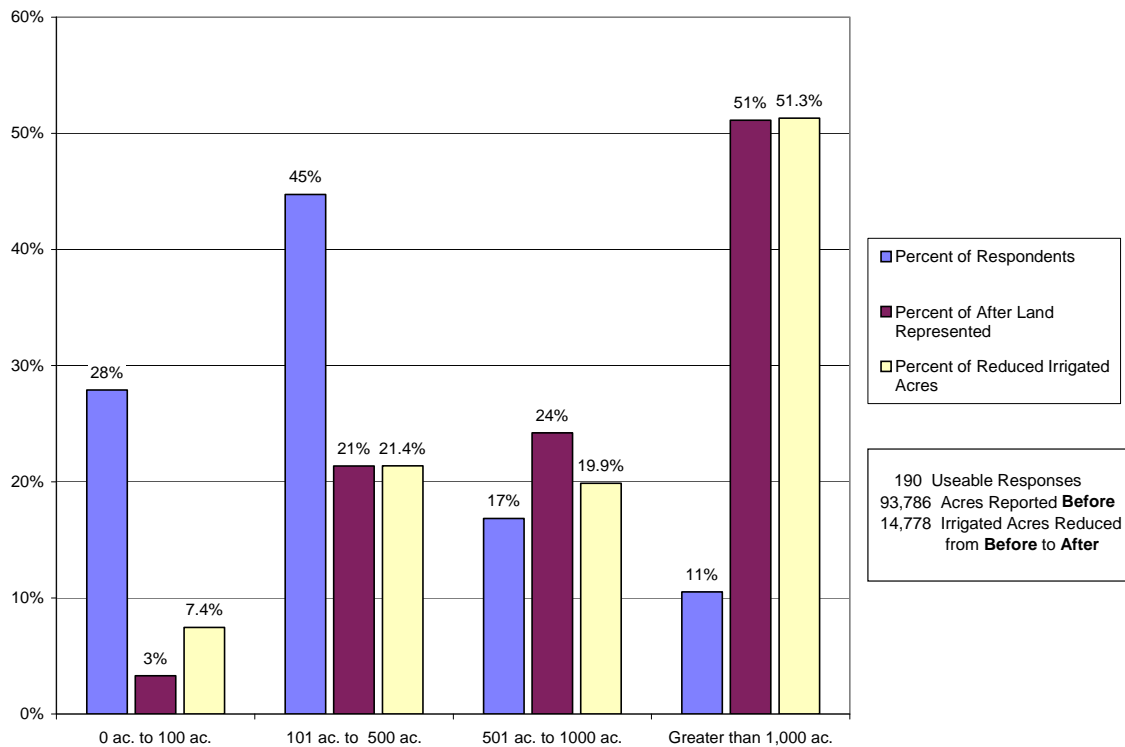
### Summary Results

The survey's first section of the survey establishes baseline farm demographics for respondents. This section is concerned with two points in time for the farm: a **BEFORE** time in which the farm operated prior to the change in the water augmentation rules, and the subsequent period (**AFTER**) in which the operation may have changed its business practices. A sample of the survey instrument is found at the close of the Appendix.

Respondents are first asked to provide the township and range of their operations. 198 survey respondents provided township and range information, which stretched along the South Platte River Basin from roughly I-25 at the westernmost edge to nearly Julesberg in the east. The overall concentration of respondents was in Morgan, Logan and Sedgwick counties as well as eastern edge of Weld County.

The subsequent questions sought to determine three descriptors for the operation's land base both **BEFORE** and **AFTER**: (a) the total land base, (b) the number or irrigated acres and (c) the number of irrigated acres owned by the respondent.

In total, 190 respondents provided acreage information, and the sum of their reported acres was 93,786 ac. in the **BEFORE** time period with an average respondent size of 494 acres. Of the total reported cropping acres, 61,057 (65%) were irrigated, and the respondents owned 81.5% of the irrigated acres.



**Figure A.1: Proportion of Respondents, AFTER Acreage and Lost Irrigated Base by Size of Farm**

As indicated in Figure A.1, smaller farmers dominated the number of survey responses, but their reported acreage was small relative to larger farms. In the figure, respondents are divided into four size categories. From left to right in the figure, groups are aggregated into those reporting 0 to 100 acres, respondents with 101 to 500 acres, respondents with 501 to 1000 acres and those respondents with more than 1000 acres. In each size category, three bars are shown. The first bar indicates the percent of surveys returned by the size class; the second bar indicates the percent of the total acreage that the size class reported, and the last bar shows the share of total reduced acres reported by the size class. The smallest size class (0 to 100 acres) represented 28 % of all of the useable responses, but only 3% of the total reported land base. Of the 14,778 acres reportedly fallowed, the smallest size had but 7.4%. In contrast, the largest size class (greater than 1,000 acres) represented 11% of survey responses but more than 50% of the total reported acreage. This size class also reported the largest share of fallowed acres – 51.3% of all fallowed acres. As mentioned previously, respondents were asked to list the number of irrigated acres within their operation **BEFORE**

and **AFTER**. Total irrigated acres **BEFORE** were 61,057 and total irrigated acres **AFTER** were 46,403 or a net loss of 14,778 irrigated acres.

Table A.1 summarizes specific circumstances of lost irrigated acres by size classification. The first row of Table 1 indicates the four size classifications. The next row lists the net irrigated acres lost followed by a row that indicates, on average, what proportion these lost acres made of the farm’s irrigated land base. Note that the largest number of lost irrigated acres is within the largest size category, but the smallest size categories lost a greater average percent of their irrigated land base. The final row of the table indicates the number of times that the respondent indicated a loss of 50% or more of their irrigated acres.

**Table A.1: Lost Irrigated Acres as Divided by Size Classification**

	0 acres to 100 acres.	101 acres to 500 acres.	501 acres to 1,000 acres.	Greater than 1,000 acres.
<b>Net Change in Irrigated Acres</b>	-1,101	-3,157	-2,937	-7,583
<b>Average percent of irrigated acres lost</b>	61.4%	49.9%	32.8%	34.5%
<b>No. of times a loss of greater than 50% of the irrigated base was reported</b>	18	15	2	2

The next section of the survey sought to describe the farm’s irrigated crop mix in the **BEFORE** and the **AFTER** time periods. Respondents were asked to indicate the acres **BEFORE** and **AFTER**, if less irrigation water was applied and an estimated decrease in yields for the following crops: corn grain, corn silage, alfalfa hay, sugar beets, dry beans, wheat and onions. Respondents were also give the opportunity to list additional crops that they might have irrigated in the **BEFORE** and **AFTER** periods.

**Table A.2: Crop Mix of Respondents BEFORE and AFTER**

<b>Irrigated Crop</b>	<b># Respondents with Crop BEFORE</b>	<b># Respondents with Crop AFTER</b>	<b># Acres Reported BEFORE</b>	<b># Acres Reported AFTER</b>	<b>Difference between BEFORE and AFTER</b>	<b>Instances with Less Water Applied</b>	<b>Avg Yield Reduction with Less Water</b>
Corn Grain	116	118	30,552	17,200	(13,352)	44	41%
Corn Silage	36	36	3,836	3,421	(415)	16	38%
Alfalfa	120	119	12,535	9,431	(3,104)	64	53%
Sugar Beets	22	21	2,735	1,709	(1,026)	12	51%
Dry Beans	19	22	1,297	1,009	(288)	14	35%
Onions	18	19	5,214	4,526	(688)	5	50%
Potatoes	5	5	1,890	335	(1,555)	2	25%
Barley	2	2	118	60	(58)	1	70%
Other	20	20	2,298	1,891	(407)	9	50%
Wheat	60	61	3,926	7,487	3,562	41	53%
Grass Hay	26	26	1,506	1,625	119	17	62%
Sorghum	14	14	322	655	333	8	31%
Sunflower	9	10	93	657	564	4	--
Oats	8	8	63	580	517		

As indicated in Table A.2, corn grain is the most popular crop grown by survey respondents in both the **BEFORE** and **AFTER** periods. However, the relative share that corn grain made of the overall crop mix declined from 46% share of crop mix **BEFORE** (30,552 ac.) to a smaller share of 34% (17,200 ac.). Corn grain bore the brunt of the overall reduction in acres by accounting for nearly 64% of all reduced acres.

A crop that maintained its share of the crop mix, but had an overall reduced acres was Alfalfa. In the **BEFORE** period, Alfalfa accounted for 12,535 of reported acres or 18.9% of the crop mix. Its share in the **AFTER** period was 18.6% of the overall crop mix or 9,431 acres.

Wheat is an interesting case for respondents. Overall acres of wheat grown increased by more than 90%, from 3,926 acres to 7,487 acres. However, a significant number of respondents (41) reported applying less water to wheat and receiving a reduced yield, on average, of 53%. We might expect that wheat was treated largely as a dryland or limited irrigated crop for these respondents.

Water availability changed for survey respondents, but the changes were not the same among all survey respondents. Different water sources (e.g., groundwater vs. surface water) may help explain the why some farms fared better than others. Consequently, respondents were asked to indicate the acreage that was irrigated: (a) solely with groundwater, (b) primarily by ditch or reservoir, but with groundwater as a supplemental source and (c) irrigated exclusively with ditch or reservoir water. Respondents were asked to list the acres in both the **BEFORE** and **AFTER** periods.

**Table A.3: Respondents' Irrigated Acres by Source in BEFORE and AFTER**

	Groundwater Exclusively		Surface Majority, Groundwater Supplemental		Surface Exclusively	
	BEFORE	AFTER	BEFORE	AFTER	BEFORE	AFTER
# Reporting the Source	131	81	95	84	65	64
Acres Irrigated by Source	37,570	23,640	21,775	17,655	10,673	10,634
Acreage Change		-13,930		-4,120		-39
% Acreage Change		-37.1%		-18.9%		-0.4%

The next section of the survey sought to uncover if producers managed their water differently once well augmentation rules changed. The respondents were given four alternatives: (a) purchase permanent water rights, (b) sold permanent water rights, (c) leased additional water rights and (d) leased seasonal water rights to another entity.

Of the 197 respondents to this section, 24% indicated that they performed one of the previously mentioned options. The majority sought to lease water from another (64%). Figure A.2 summarizes responses to the managing water section.

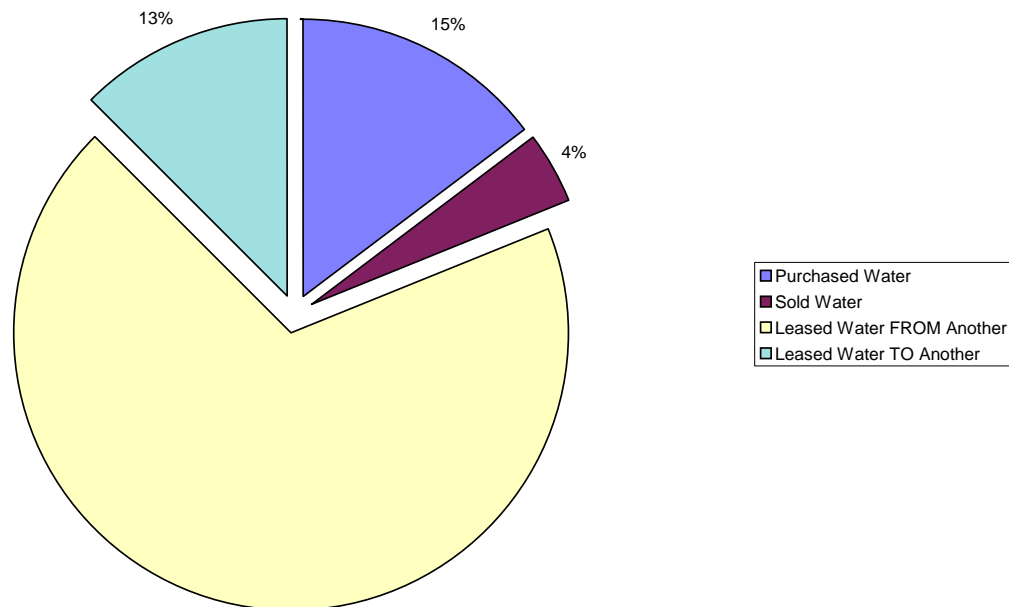


Figure A.2: Percent of Respondents Bought/Sold/Leased Water

In response to changing augmentation rules, producers might also have managed their non-water assets differently. As an example, farmers may change their irrigation system (buy, sell or improve); alter the land management (purchase land, sell land, lease land TO, or lease FROM, or idle land) and/or seek off farm employment.

Of the 205 respondents to this section, 177 instances of non-water asset management were indicated. The most popular management technique was to idle land (76 instances) and to add off farm employment (33 instances). Leasing land FROM another farmer was noted 16 times at an average cash lease of \$125 per acre, while some leased land TO another farmer (8 instances) at an average cash lease of \$81.25 per acre. In addition, 8 instances of selling land were noted at an average price of \$2,186 per acre.

Producers were asked to relate their financial standing in the last section of the survey. In this section, respondents were asked to indicate the interval which reflected the market value of their total assets. The intervals, and the proportion of respondents in each interval, are shown in Figure A.3. The largest proportion of respondents has assets totaling less than \$1 million (71%). Nearly one-quarter (24%) of respondents had less than \$100,000 in assets, and only 3% had more than \$5 million in assets.

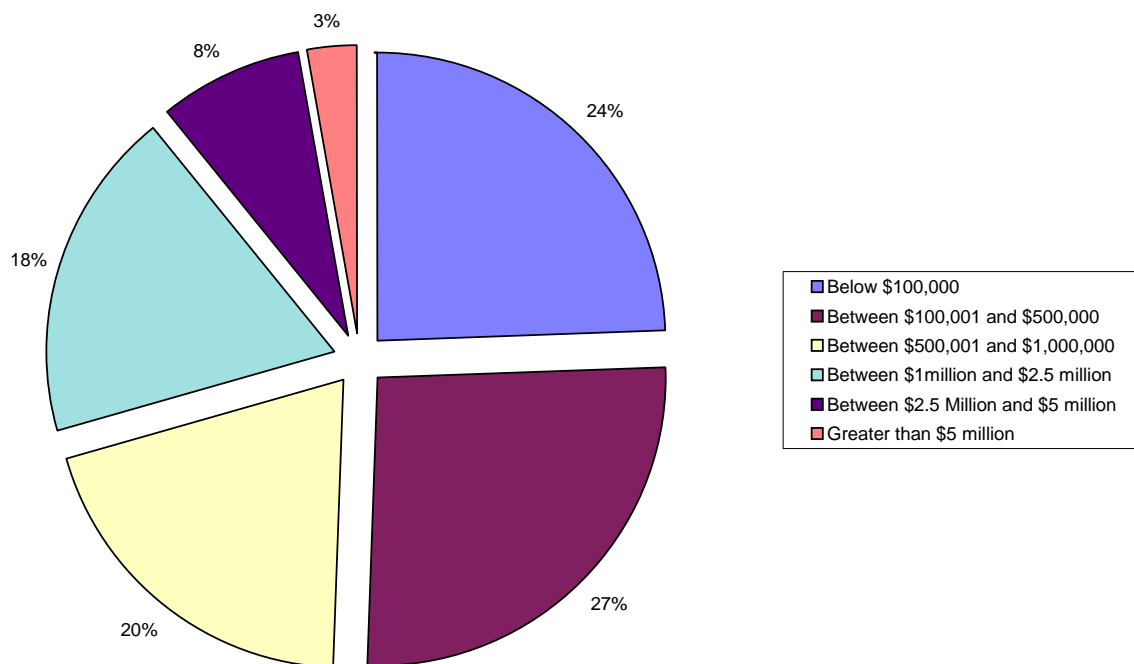


Figure A.3: Total Asset Base of Respondents

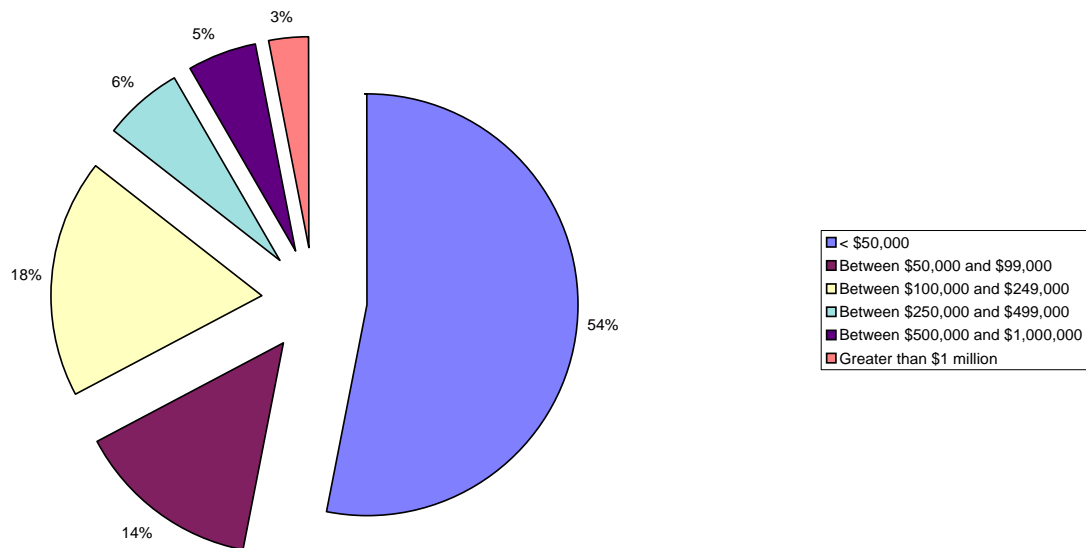


The relative proportion of debt to assets may have changed for respondents as a result of the shift in augmentation rules, perhaps negatively impacting the farms' solvency. To this end, farmers were asked to estimate their Debt-to-Asset Ratio both **BEFORE** and **AFTER**. As indicated by Table A.4, respondents had low debt to asset ratios both **BEFORE** and **AFTER**. However, debt levels did increase relative to assets during the time span.

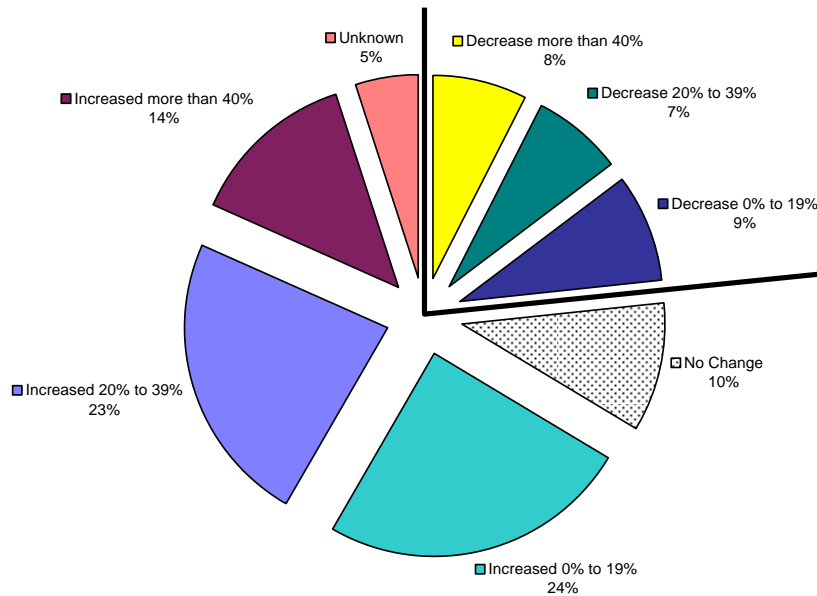
**Table A.4: Respondents' Debt-to-Asset Ratios in the BEFORE and AFTER**

<u>Debt Position</u>	<u>Number of Respondents BEFORE</u>	<u>Number of Respondents AFTER</u>
No Debt	68	64
Between 0.01 and 0.25	35	23
Between 0.26 and 0.50	16	20
Between 0.51 and 0.75	6	8
Between 0.76 and 1.00	1	6
Greater than 1.0	0	2
Don't Know	20	18
Prefer Not to Disclose	25	24

Gross revenues is a means of classifying the relative size of farming operations, and the US Department of Agriculture (USDA) considers farms with less than \$100,000 in gross sales annually to be small, farms with more than \$100,000 but less than \$250,000 in gross sales to be medium, and farms with that are greater than \$250,000 to be large. Respondents to this survey were asked to indicate the interval in which their annual gross revenues appear during a normal year, and the results are represented by Figure A.5. A majority of respondents (54%) have less than \$50,000 per year in gross revenues, and 68% of respondents fit in the "small" farm definition of USDA. Only 14% of respondents fall with the large farm classification.



**Figure A.5: Gross Revenues of Survey Respondents.**



**Figure A.6 Respondents' Estimate of Changing Costs Between the BEFORE and AFTER**

Respondents were asked to estimate the change in gross revenues between the **BEFORE** and the **AFTER** time period. As indicated in Figure A.6, 74% of respondents noted a decrease in gross revenues, with 41% of the respondents observing a decrease of more than 40%. In contrast, 4% of respondents felt revenue increased, while 16% noted no change.

Revenues are likely to decrease if producers shifted crop production from irrigated to dryland practices, or applied less water to their irrigated crops, or shifted to lower value, less water using crops. At the same time, the change in these cropping practices might also net less costs. With this in mind, respondents were asked to estimate the change in costs between the **BEFORE** and **AFTER** periods.

As might be anticipated, nearly one quarter of the respondents (24%) actually noted a decrease in costs between the **BEFORE** and **AFTER** periods. A larger share estimated an increase in costs (61%) with many writing that costs increased significantly as they joined conservancy districts or formed augmentation groups

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