Potential Economic Impact of Water Use Changes in Northwest Kansas

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TABLE OF CONTENTS

Executive Summary

Current levels of groundwater consumption in northwest Kansas raise concerns relative to the long-term feasibility of irrigated agriculture in the area. In order to extend the economic life of the aquifer and maintain the economic base of the region, water conservation alternatives need to be evaluated. The purpose of this research is to estimate the likely economic impacts to producers and the regional economy and hydrologic impacts to the Ogallala aquifer associated with a variety of water conservation policies.

This research focuses on 98,143 irrigated acres in six subareas located in Cheyenne, Thomas, Sheridan, and Sherman counties within the jurisdiction of Groundwater Management District number four. Three policy scenarios were evaluated: a status-quo scenario where water-use continues at current levels; an immediate conversion to nonirrigated production where all water-use for irrigation is immediately stopped, and; a 30% reduction in groundwater withdrawals relative to the status-quo scenario. Three options for achieving a 30% reduction were considered: an immediate shift to a limited irrigation management strategy; a water rights buyout program, and; a Conservation Reserve Enhancement Program. The impact of policy alternatives were measured relative to the status-quo scenario.

Economic models of production and temporal allocation were developed and used to estimate producer and hydrologic impacts over a 60 year time horizon. A nine-county, 140-sector IMPLAN model was developed and used to estimate the regional economic impacts to value-added. Value-added is closely related to the sum of proprietary and property income, employee wages, and indirect business taxes.

The IMPLAN model is a static model that provides probable instantaneous impacts. The literature suggests that after an economic shock regional economies recover in a dynamic fashion. In the absence of empirical information, a consensus forecast was generated by the research team which was used to parameterize an ad hoc decay function that diminished the IMPLAN forecast over time. Net present values were calculated for the 60 year forecast period based on a 5% discount rate.

Results suggest that from the regional economy perspective: if 98,143 irrigated acres were converted to nonirrigated production the net present value of lost value-added would be $172,381,183; if 98,143 irrigated acres shifted from fully irrigated production to limited irrigation production the net present value of lost value-added would be $28,214,016; if 29,443 irrigated acres were converted to nonirrigated production via a water rights buyout program the net present value of lost value-added would be $24,208,710, and ; if 29,443 irrigated acres were enrolled in a Conservation Reserve Enhancement Program the net present value of lost value-added would be $66,132,000. This implies that the water rights buyout program may be the least cost method of conserving groundwater. The water rights buyout has the least impact on value-added because of the relatively high payments producers received for the water rights. The Conservation Reserve Enhancement Program has a relatively high cost because enrolled acreage is prohibited from producing nonirrigated crops during the first 15 years.

Expressing impacts as net present values can sometimes be misleading. As an example, few laymen can readily place the $28 million dollar lost value-added associated with a shift to limited irrigation production in a relative perspective. The regional economy generates a total annual value-added of approximately $973,387,000. The $28 million dollar lost value-added associated with a shift to limited irrigation production is the 60 year cumulative loss after the annual values have been discounted by 5% annually and diminished by the decay function. The cumulative lost value-added represents 2.8% of a single year's total regional value-added. In the first year, a conversion to limited irrigation would result in a lost value-added of $3,569,328 or 0.37% of the total annual regional value-added. The first year's lost value-added is assumed to diminish over time.

From a producer's perspective the water rights buyout is also the preferred policy option. It has the least impact on gross profits because of the relatively high payments producers received for the water right and nonirrigated production is allowed on the enrolled acreage. Additionally, a producer might oppose a shift to limited irrigation because of the unknown risk associated with production and the lack of incentive payments.

From an input supplier's perspective, a shift from fully irrigated production to limited irrigation production is the preferred policy option as it has the least negative impact on his annual value-added ($869,391). An input supplier may oppose a Conservation Reserve Enhancement Program because it generates relatively large reductions in the sector's annual value-added ($2,838,582) because crop inputs are not required on the enrolled acreage.

From the state's perspective a Conservation Reserve Enhancement Program is attractive because the majority of monies required for incentive payments are provided by the federal government. The water rights buyout program, on a scale this large, may be unattractive as funding would have to be raised within the state. A shift to limited irrigation, which could be viewed as a mandatory water-use restriction, may require changes in current statutes to modify water allocations.

All water conservation policies extend the usable life of the Ogallala aquifer. As an example, a shift to limited irrigation extends the time that producer revenues are stable by 24 years to more than 49 years, depending on the subarea. Since the benefits of water conservation depend, to an extent, on current hydrologic conditions that vary across subareas, targeting available funding to specific subareas will maximize benefits. While all policies considered extend the economic life of the aquifer, no policy stabilizes the aquifer at current levels.

This research estimates measures of producer gross profits and regional value-added in an endeavor to define the least costly water conservation policy. While individual policy alternatives have been compared to a 'Status Quo' scenario, this research does not attempt to place a monetary value on the saved water or place monetary value on other benefits of water conservation and should not be viewed as a cost-benefit analysis of water conservation.

Potential Economic Impact of Water Use Changes in Northwest Kansas

I. Study Objectives

Current levels of groundwater consumption in northwest Kansas raise concerns relative to the long-term feasibility of irrigated agriculture in the area. In order to extend the economic life of the aquifer and maintain the economic base of the region both voluntary and mandated policy intervention may need to be considered.

The purpose of this report is to provide the methods, assumptions, and estimates of the likely economic impacts associated with a variety of groundwater conservation policies aimed at extending the economic life of the Ogallala aquifer in northwest Kansas. This research considers three policy scenarios for six subareas located in Cheyenne, Thomas, Sheridan, and Sherman counties. These counties are located in northwest Kansas, as illustrated in Figure 1, within the jurisdiction of Groundwater Management District number four. The three policy scenarios include 1) a status-quo scenario where water-use continues at current levels, 2) an immediate conversion to nonirrigated production where all water-use for irrigation is immediately stopped, and 3) a 30% reduction in groundwater withdrawals relative to the status-quo scenario. The impact of the two policy alternatives will be measured relative to the baseline (status-quo) scenario.

II. Model Overview

In order to accomplish the goals of this research a variety of economic and hydrological models will be required. The study will require the development of three broad classes of economic models. For simplicity, they will be referred to as models of 'production', models of 'temporal allocation', and models of 'regional economic impact'. The models of production are necessary to provide the required input for the model of temporal allocation. The models of temporal allocation will provide the required time series forecast on water-use, irrigated acreage, and economic productivity for the baseline and alternative scenarios. The models of regional economic impact will utilize the output from the temporal allocation models to predict the baseline economic scenario and the economic impacts associated with the policy options. The models will be discussed in more detail below.

The development of economic models that predict the future are, by their very nature, subject to error, and the results are most appropriately viewed as a 'best guess'. From a policy analysis perspective, it is not imperative that the predictions be perfectly accurate. It is important to focus on the 'difference' between scenarios and not the scenario itself. So long as consistency is maintained between methodology and assumptions, and all stakeholders are comfortable with the methodology and assumptions, comparisons of different scenarios are appropriate to evaluate water management options.

Models of Production

Past research has shown that irrigated agriculture is best viewed in a dynamic framework. As an example, choices of technology, crop choice, crop yields, and water-use per acre may change over time. Future trends in these variables will impact the status quo and alternative scenarios. Data from the Kansas Agricultural Statistics Service (KASS), the Water Right Information System (WRIS), Extension and water management professionals, and other stakeholders will be used to quantify these trends.

Each factor associated with these models will be discussed in detail in the 'Data and Assumptions' section of this report.[1]

Models of Temporal Allocation

The models of temporal allocation will provide a 60-year time-series representation of water-use, aquifer levels, irrigated acreage, and economic productivity. For a unconfined aquifer, the economic community typically uses the concept of a 'single cell aquifer' as the hydrological model that is incorporated into the temporal allocation model. Within this framework, the aquifer is viewed as being strictly homogeneous on the spatial scale being analyzed. In other words, if analysis is performed on a subarea level then the aquifer is assumed to be uniform across that subarea.

There are two methods of generating the temporal allocation solution 1) the competitive market solution and 2) the optimal temporal allocation solution.[2] Gisser and Mercado (1973) were among the first to integrate economic theory and the hydrological theory of groundwater flow into a single model. They conceptualized the single cell aquifer, defined the appropriate equations of motion, and provided the theoretical basis for evaluating the competitive market solution. Within the competitive market framework, a producer maximizes profit by choosing the optimal allocation of water on an annual basis. While a producer may realize that the choice of water-use today impacts the aquifer decline and thus the future value of water, this factor is not taken into consideration due to the common property characteristic of the aquifer. Typically, the producer's decisions are simulated on a yearly basis without regard for the future. Comparable models have been developed and applied to groundwater policy management scenarios by Gisser and Sanchez (1980), Gisser (1983), Ding (2005), and Feinerman and Knapp (1983).

Within the optimal temporal allocation framework, a single 'social planner' determines both current and future water-use. The social planner is forward-looking and chooses the optimal time path of water-use based on the discounted value of future profits considering the marginal benefit of future water consumption. The optimal temporal allocation solution yields an optimal time path for water-use. Burt (1967) is often credited with developing the decision rules for the optimal temporal allocation of groundwater stocks. Comparable models have been developed and applied to groundwater policy management scenarios by Gisser and Sanchez (1980), Gisser (1983), Wheeler (2005), and Johnson (2003 & 2005).

Gisser and Sanchez (1980), Gisser (1983), Feinerman and Knapp (1983), and Nieswiadomy (1985) evaluated both models and suggest there is very little difference between the competitive market solution and the optimal temporal allocation solution. As such, the competitive market framework, based on its intuitive appeal and ability to mimic real-world water allocations, is used in this study. The model will mimic the crop choice, land allocation and water-use decisions of a typical producer in northwest Kansas.

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[1] The WRIS database is maintained by the Kansas Department of Agriculture's Division of Water Resources (DWR).

[2] The competitive market solution is often referred to as the no-control solution in the economic literature. The optimal temporal allocation solution is often referred to as the social planner's solution, the optimal control solution, or the dynamic optimization solution in the economic literature.

Models of Regional Economic Impact

When agricultural water-use is restricted, crop production will, in all likelihood, be reduced in the near term and producers and local communities will incur negative economic impacts. These direct economic impacts will ripple through the economy, creating additional indirect and induced impacts. The short-term magnitude of these impacts will depend upon the magnitude of the water-use reductions and the relative economic importance of agriculture to the affected communities. The results of the temporal allocation models, for various scenarios, will be used as input for the regional economic impact models. Impact Analysis for Planning (IMPLAN) software will be used for these models.

III. Models of Production and Temporal Allocation

Definition of Economic Impact

A reduction in agricultural output results in a direct negative economic impact to the regional economy. For this analysis, the magnitude of the reduction in agricultural gross profits defines the farm-level economic impact (EI) and is simply the difference between the gross profits that are calculated for the status-quo scenario (GP_S) and the gross profits that are calculated for an alternative scenario (GP_A). Gross profit (GP) is defined as returns to land, management, and equipment, and calculated as the difference between crop revenue and variable expenses. The economic impact (EI) can be defined as

$$EI = GP_A - GP_S .$$

The magnitude of the economic impact, depends on several factors: 1) the magnitude of the water-use reduction; 2) the current level of water-use efficiency in the production process; 3) the number of acres involved; 4) the crop mix for the area; 5) crop yields that depend on the shape of the crop-specific production functions which are impacted by localized growing season characteristics such as precipitation and temperature; and 6) prices and costs. The data and assumptions associated with these factors, as well as their impact on the final estimate, are documented in the 'Data and Assumptions' section of this report.

Data and Assumptions

A. Subareas

This research considers six subareas located in Cheyenne, Thomas, Sheridan, and Sherman counties as reported in Table 1. The subarea acreage was determined based on ARCGIS data provided by the Kansas Water Office (KWO). The number of points of diversion, average annual water-use, and the irrigated acreage are based on 1996 to 2005 averages derived from WRIS data and are consistent with values used in the Republican River Compact Administration (RRCA) model.

B. Assumptions on Hydrology

The Kansas Geological Survey High Plains Aquifer Section-Level Database, accessed through the WIZARD system, was used to obtain the saturated thickness information. The recharge, hydraulic conductivity, specific yield, and average decline in saturated thickness are consistent with the RRCA model. These data are used to estimate the current average well capacity as well as provide the parameter estimates for the single cell aquifer model. Mathematical functions relating well capacity to saturated thickness were derived based on Hecox, Macfarland, and Wilson (2002).[3] These data are reported in Table 2.

C. Assumptions on Irrigated Crop Production

1. Crop Mix

The irrigated crop mix in a subarea impacts two factors. First, the choice of the irrigated crop mix determines the annual water-use and thus the rate at which the aquifer declines. The assumed crop mix also determines the annual gross profits derived from irrigated production. Table 3 reports the irrigated crop mix used in this study. These data are consistent with the 1999 to 2006 average of WRIS data. Within the WRIS data some acres are reported as a mixture of the major crops in the area. As a result these 'mixed' acres were prorated among the major crops. One of the goals of this project is to maintain consistency between the economic/hydrological model and the RRCA hydrological model. To insure that the initial total water-use balanced between the two models, minor adjustments were made to the initial crop mix derived from the WRIS data. The crop mix data are reported in Table 3. These data are applied to the total irrigated acres reported in Table 1, to determine the initial acres irrigated of each crop.

Predicting future crop mix is difficult because it requires predicting future technology and other market impacts (two examples of recent such impacts are Roundup Ready soybeans, and the ethanol industry affecting crop prices and acreages). As a result a producer's crop choice is assumed fixed for this analysis and changes only as water availability limits the production of individual crops and those acres convert to nonirrigated production.

2. Yield-Water Relationship with Full Irrigation

A production function is a mathematical equation that relates the quantity of output produced to the quantity of inputs used in the production process. As an example, the production function for irrigated corn would quantify the relationship between the bushels of corn produced per acre to the acre-inches of irrigation water applied. There is extensive literature on the shape of crop production functions. Research by Frank, Beattie, and Embleton (1990), Paris (1992), Moore, Gollehon and Negri (1992), Llewelyn and Featherstone (1997), and Kastens, Schmidt, and Dhuyvetter (2003) suggest that crop production functions are curvilinear in nature As a result, most economic research assumes a polynomial or other curvilinear functional form. The relevance of the shape of production functions is that curvilinear production functions imply diminishing marginal returns to the quantity of irrigation water applied. Simply stated, the yield increase per acre-inch of water applied diminishes as the amount of water applied increases.

This report applies production functions developed by Stone et al. (2006).[4] Average annual (1996 to 2005) water-use was derived for the major crops from the WRIS data. These data represent gross water-use for the technology mix (flood and center pivot) in the subarea. Based on the technology mix and assumed irrigation efficiencies (discussed at a later point in this report) the crop specific gross water-use data were converted to net water-use requirements. Given the net water-use, irrigated crop yields were estimated from the production function. One of the goals of this project is to

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[3] A detailed explanation of the single cell aquifer as well as the derivation of the mathematical functions relating well capacity to saturated thickness is available upon request.

[4] These production functions were reported for unit increments of annual precipitation. The production functions were adjusted to reflect an average annual rainfall of 19.5 inches by interpolating between the 19 inch function and the 20 inch function.

maintain consistency between the economic/hydrological model and the RRCA hydrological model. To insure that the initial total water-use balanced between the two models, minor adjustments were made to the water-use data derived from the WRIS data. Table 4 reports the net water-use requirements used in this report. Table 5 reports the estimated crop yield. The temporal allocation model assumes that technological advances in crop yield and water-use efficiency remain constant during the simulation period.

3. Yield-Water Relationship with Limited Irrigation

One of the scenarios to be considered is a 30% reduction in groundwater withdrawals based on the status-quo scenario. This scenario can be generated under several assumptions. One possibility is that crop mix and total irrigated acreage stay fixed and producers adopt a limited irrigation strategy and reduce gross water by 30%. Table 6 represents a 30% reduction in net water requirements relative to the data presented in Table 4. Table 7 provides the corresponding yield expectations.

4. Irrigation Efficiency

Rogers et al. (1997) defines irrigation efficiency (E_I) as the percent of water pumped that is used beneficially in crop production. Irrigation efficiency (E_I) can be defined as

$$E_C = 100(W_B / W_P),$$

where W_P is the gross groundwater withdrawal, and W_B is the amount of irrigation water that is beneficially used in crop production. Season-long irrigation efficiency depends upon the coefficient of uniformity, application rate, system capacity and length, sprinkler package, soil type, field slope, irrigation timing, and individual management practices. Due to the variability in observed irrigation efficiencies, ranges of efficiencies are often reported. Several ranges are presented in Table 8.

For this report it is assumed that flood irrigation technology has a season-long irrigation efficiency of 70%. It is assumed that center pivot technology has a season-long irrigation efficiency of 95%. The temporal allocation model assumes that season-long irrigation efficiency remain constant during the simulation period.

5. Technology Mix

Center pivot technology has a higher irrigation efficiency than flood technology. As such, an acre-inch of water-used in the production of an irrigated crop may have a higher value when applied with center pivot technology as compared to application with flood technology. Based on 2005 WRISS data, Table 9 reports the current technology mix for the subareas. Over time, this technology mix has shifted from flood technology to center pivot technology. While there is little flood technology left in the area, these acres need to be accounted for. The model requires that we make assumptions as to the rate at which the remaining acres irrigated with flood technology will be converted to center pivot technology. For the purpose of this report, it is assumed that 15% of the remaining flood irrigated acres will be converted to center pivot technology on an annual basis.

6. Revenue, Costs, and Returns

The magnitude of economic impacts associated with a conversion from irrigated production to dryland production will be determined, to an extent, by the associated revenue and profit differentials. Table 10 reports the prices, and costs used in this analysis. These data represent a modification to the 2006 Cost-Return Budgets published by the Kansas State University Agricultural Experiment Station and Cooperative Extension Service. The budgets have been modified to reflect long-run average returns to land, management, and equipment. Revenues used in this analysis are based on the prices reported in Table 10, and yields reported in Table 5 and Table 10. Scenarios that simulate a limited irrigation strategy both reduce gross water-use by 30% as well as reduce yields. As yield changes, fertilizer, repairs and maintenance, and fuel expenses are adjusted appropriately.

Once the producer has made the choice of what crop to produce he is faced with the choice of how much irrigation water to use in the production process. Production theory implies that a profit maximizing producer will use water to the point where the value marginal product of water, which is the additional revenue generated by the use of one more unit of water, is equal to the marginal cost of the additional unit of water. As a result, the demand curve for irrigation water is downward sloping, indicating that, as the price of water (which is positively correlated with fuel price and the depth to water) increases, the amount of irrigation water-used in crop production decreases. Extensive economic research has focused on the demand for irrigation water. Allen and Gisser (1984); Nieswiadomy (1985); Kim, Hanchar, and Moore (1987); Ogg and Gollehon (1989); Moore and Negri (1992); Moore, Gollehon, and Carey (1994); Schaible (1997); Peterson and Ding (2005); and Golden (2005) have all estimated the demand for irrigation water. The research consensus is that the demand is highly price inelastic, meaning that the quantity demanded is relatively unresponsive to price. The implication is that, once the crop choice is made, producers essentially apply water based on a fixed land-water ratio. Based on past research, the temporal allocation model implicitly assumes that irrigation fuel prices do not impact the quantity of water applied during the simulation period.

7. Producer Reaction to Diminishing Water Supplies

When water-use is restricted irrigated producers develop and implement strategies to mitigate potential revenue losses. Buller (1988) and Wu, Bernardo, and Mapp (1996) suggest that producers will change crop mix by shifting from high water-use crops, such as corn, into crops with lower consumptive use. Burness and Brill (2001) and Williams et al. (1996) suggest that in such cases producers will adopt more efficient irrigation technology. Harris and Mapp (1986) and Klocke (2004) suggest that computer-aided technologies and improved irrigation scheduling might provide a solution. Schlegel, Stone, and Dumler (2005) report significant water savings with the adoption of limited irrigation management strategy.

In order to develop a temporal allocation model the producer's reaction to diminishing water supplies needs to be defined. It should be mentioned that each of the possible reactions noted in the preceding paragraph lead to different time paths of water-use, crop choices, and economic impacts. For this study it is assumed that 1) a typical producer maintains the current crop choice (typically corn), 2) maintains the current water-use preferences, which is necessary to achieve optimal yields, and 3) converts irrigated acres to dryland acres as water availability becomes a limiting factor.

The assumed producer reaction to diminishing water supplies is based on stakeholder input. Economists would characterize this mode of operation as 'yield maximizing' behavior. An alternative to this assumption would be to assume 'profit maximizing' behavior. Under the profit maximizing assumption a producer might find it more profitable to reduce per acre water-use, obtain lower yields, and maintain irrigation on all acres as opposed to reducing acres and maximizing yield on the remaining acres. Assuming profit maximizing behavior implicitly assumes producers are 'risk neutral', while a yield maximizing behavior may implicitly assume 'risk aversion'.[5]

In order to parameterize the behavioral assumption it is necessary to develop 'trigger-points' for each crop that define when water availability becomes a limiting factor. For informational purposes Table 11 provides data on gross daily application rates for various well capacities.

The 'trigger-points' or the required minimum daily application rate necessary to maintain 100% of the crop acres are reported in Table 12. As an example, if declining saturated thickness results in a well capacity of 475 gallons per minute and the trigger-point for corn is set at 0.20 inches per acre per day, then the typical producer is capable of watering 100% of his corn acreage. If the well capacity diminishes to 450 gallons per minute then the producer can only irrigate 95.5% of his acreage, and maintain a 0.20 inches per acre per day gross daily application rate, and the remaining 4.5% of the acres would be converted to dryland production. An individual producer may not strictly adhere to fractionally reducing irrigated acres in a continuous manner; rather he might reduce acres in larger increments creating a 'stair-step' decline. However, when considering that all producers will not make the acreage reduction at the same point in time, the resulting aggregate average acre reduction for the subarea will reflect a smooth continuous decline.

D. Assumptions on Nonirrigated Crop Production

1. Crop Mix

The model assumes that as saturated thickness declines, well capacity diminishes and irrigated acres are converted to dryland production. The assumed nonirrigated crop mix determines the annual revenue and profits derived from dryland production. Table 13 reports the nonirrigated crop mix used in this study. These data are based on the 1999 to 2006 average of county level KASS data.

2. Crop Yield

The assumed nonirrigated crop yield determines the annual revenue and profits derived from dryland production. Table 14 reports the nonirrigated crop yield used in this study. These data are based on the 1999 to 2006 average of county level KASS data.

3. Revenue, Costs, and Returns

The magnitude of economic impacts associated with a conversion from irrigated production to dryland production will be determined, to an extent, by the associated revenue and profit differentials. Table 15 reports the prices and costs used in this analysis. These data represent a modification to the 2006 Cost-Return Budgets published by the Kansas State University Agricultural Experiment Station and Cooperative Extension Service. The budgets have been modified to reflect long-run average returns to land, management, and equipment. Nonirrigated revenues used in this analysis are based on the prices illustrated in Table 15 and yields reported in Table

[5] Given all assumptions, there is less than a 1.5% difference in acre allocation between the two behavioral assumptions. A more detailed discussion and comparison of the two behavioral assumptions is available upon request.

14 and the crop mix reported in Table 13. Implicitly, the temporal allocation model assumes that nonirrigated crop yield, crop mix and crop price remain constant during the simulation period.

Model Details: Temporal Allocation Models

The temporal allocation model, based on the competitive market framework, has been discussed in broad generalities and a great deal of data and assumptions have been presented. To insure that stakeholders understand the relevance of the data and assumptions as well as their impact on model output, in this section the model will be discussed in more detail. As an aid to understanding, this discussion will be based on the policy scenarios for subarea number six in Sheridan County.[6]

A. Scenario 1: Status Quo

The output of a temporal allocation model is a time series representation (also referred to as a time path) of the aquifer hydrology, crop mix, water-use, and economic output. Table 16 illustrates this time path for the hydrology, crop mix, and water-use portions of the model. Due to size constraints, the only crop reported in this table is corn.

In time period one, the aquifer has a saturated thickness (ST) of 89.8 feet (Table 2). Based on the saturated thickness and hydraulic conductivity (Table 2) the estimated well capacity was 587 gallons per minute, which has a gross daily application rate (GDAR) of 0.25 inches per day per acre. Table 1 indicates that there are 24,855.0 irrigated acres in subarea six, of which 71.3% are corn acres (Table 3) and 90.6% are irrigated with center pivot technology (Table 9). Assuming equal distribution, this implies that there are 16,062 acres irrigated with center pivot technology and 1667 acres irrigated with flood technology.[7] Table 4 suggests that the net water requirement for corn is 12.7 inches per year. We also have assumed that flood irrigation is 70% efficient and center pivots are 95% efficient. Taken together, these assumptions imply a gross annual water-use (GWU) on the 1667 flood irrigated acres of 28,220 inches and on the 16,062 center pivot irrigated acres of 214,728 inches. Total water-use (TWU) for the year is 26,723.6 acre-feet, which also includes the water-use on other irrigated crop acres. This compares rather well to the average observed water-use of 26,595 acre-feet listed in Table 1. Across all irrigated crop acres, the average acre-foot water usage (AAFWU) was estimated as 1.08 acre-feet during the time period. This is within a small tolerance of the average acre-foot listed in Table 1 of 1.07 acre feet per acre. Based on the hydrological parameters presented in Table 2 the model predicts that the total water-use during the period resulted in a 1.15 foot change in the saturated thickness (ΔST). This compares to the average decline rate of 1.15 feet listed in Table 2.

In time period two, the saturated thickness declines to 88.6 feet ($ST_{T=2} = ST_{T=1} - \Delta ST_{T=1}$). The model then makes comparable calculations to those discussed in the preceding paragraph. Of interest during this time period is the change in the quantity of flood and center pivot irrigated acres. It has been assumed that 15 % of the flood acres are converted to center pivot technology each period. In the second time period 250 (15% of 1667) acres irrigated with flood technology are converted to center pivot technology (ConvCP).[8] As a result of this calculation flood irrigated acreage declines to 1417 acres

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[6] An EXCEL spreadsheet with model results for all subareas is available upon request.

[7] The tabular data has been rounded off and mathematical calculations based on the rounded data will not match the results displayed.

[8] To avoid confusion the ConvCP column in Table 15 represents the total cumulative acres converted to center pivot technology and not the annual amount.

and center pivot irrigated acres increase to 16312. Since center pivot technology has higher application efficiency, total water usage (TWU) declines slightly.

A trigger-point is reached in time period 12, based on our assumptions regarding a producer's reaction to diminishing water supplies. In time period 12, saturated thickness has been reduced and well capacity diminished so that the gross daily application rate (GDAR) is slightly below 0.197 inches per day per acre. Since this is lower than the required minimum daily application rate of 0.20 inches per day per acre, as reported in Table 12, producers are forced to reduce irrigated acres. Irrigated acres are reduced, and converted to dryland production (ConvDL), by 279 acres (approximately 1.6%) so that a 464 gallon per minute irrigation well is capable of meeting the 0.20 inches per day per acre minimum requirement on the remaining acres. While this reduction in total irrigated acres reduces total water usage (TWU) it does not change the average acre-foot water usage (AAFWU) for center pivots because our assumption is that a producer may reduce acres but will maintain the per acre water-use necessary to achieve optimal yields on the remaining acres. The reduction in AAFWU is the result of converting flood irrigated acreage to center pivot technology.

By time period 60, saturated thickness has declined to 40 feet, well capacity has diminished to 219.2 gallons per minute, all flood irrigated acres have been converted to center pivot irrigation, and 11,954 acres (approximately 48.1% of the starting irrigated acres) have been converted to dryland production.

Figure 2 illustrates the time path for saturated thickness and well capacity. These curves are a function of hydrological, crop mix, crop acre, and water-use assumptions and the equations of motion that have been previously discussed. Different assumptions on hydrological, crop mix, crop acre, and water-use will lead to different time paths. Figure 3 illustrates the time path for irrigated corn acres. The shape of this curve is determined by the relationship between well capacity and saturated thickness and the assumed producer reaction to diminishing water supplies. The 'kinked' convex nature of the curve is the result of the implicit assumption that producers 'follow' the well capacity curve by reducing acres. Different assumptions regarding a producer's reaction to diminishing water supplies will lead to different shapes and time paths. Figure 4 illustrates the time path for total irrigated and nonirrigated acres. The slope of the total irrigated acreage curve is less severe than the irrigate corn acreage curve illustrated in Figure 3. This is the result of different trigger-point for different crops as reported in Table 12. Essentially, irrigated crops with different water requirements convert to nonirrigated production at different points in time.

The time path for the economic portions of the temporal allocation model is reported in Table 17. In time period number one the model predicts that irrigated corn generates total gross profits of $4,003,719. The revenue portion of this number is calculated by multiplying the crop price of $2.99 per bushel (Table 10), by a crop yield of 198.2 bushels per acre (Table 5), by a crop mix percentage of 71.3% (Table 3), by the irrigated acres in the subarea of 24,855 (Table 1).[9] The base variable costs are reported in Table 15. The gross profits for alfalfa, sorghum, soybeans, sunflowers, and wheat are calculated in a similar manner.

[9] The tabular data has been rounded off and mathematical calculations based on the rounded data will not match the results displayed.

In time period 12 irrigated alfalfa and corn gross profits start to diminish as irrigated acres are converted due to a lack of well capacity. Nonirrigated crop revenue is calculated based on a weighted average per acre revenue calculated from crop price (Table 15), nonirrigated crop mix (Table 13), and nonirrigated crop yields (Table 14). The weighted average per acre revenue is then multiplied by the number of acres converted to dryland production.

In time period 22, irrigated sorghum, soybean, and sunflower gross profit start to diminish. At this point well capacity has diminished to the point that not all soybean acres can be fully irrigated and producers are forced to reduce irrigated acres, based on our assumptions regarding a producer's reaction to diminishing water supplies. Notice that gross profits generated from irrigated wheat production never decline. This is because well capacity never diminishes to the point that gross daily application rate (GDAR) is below the required minimum daily application rate reported in Table 12.

By time period 60, total irrigated acreage declined from 24,855 acres to 12,901. The remaining 11,954 acres have been converted to dryland production, as illustrated in Figure 4. As reported in Table 12, total gross profits have declined from approximately $5.28 million to approximately $4.0 million.

B. Scenario 2: Immediate Conversion to Dryland Production

If the 24,855 irrigated acres in subarea six were immediately converted to dryland production, there would be no water-use on those acres and those acres would generate revenues based on nonirrigated production. Nonirrigated crop gross profit is calculated base on a weighted average per acre gross profit calculated from crop price and costs (Table 15), nonirrigated crop mix (Table 13), and nonirrigated crop yields (Table 14). The weighted average per acre revenue for subarea six in Sheridan County is $112.23 per acre. As a result, total annual gross profits for the subarea are projected at $2,789,420. The gross profit estimate is constant over the time horizon.

C. Scenario 3: 30% Reduction in Groundwater Withdrawals

A 30% reduction in groundwater withdrawals can be achieved in several ways. While all methods have similar impacts on the aquifer, the impacts on the economy are significantly different. This report will analyze three methods to achieve a 30% reduction in groundwater withdrawals: 1) a limited irrigation scenario where all producers, regardless of crop choice, reduce groundwater consumption by 30%, 2) a water right buy-out program impacting 30% of the crop acreage (equally distributed across crop choices) where producers are allowed to immediately produce nonirrigated crops, and 3) a Conservation Reserve Enhancement Program (CREP) impacting 30% of the crop acreage (equally distributed across crop choices) where producers are required to fallow the impacted acres and allowed to resume production of nonirrigated crops in 15 years.

Scenario 3a, the 'Limited Irrigation, scenario, evaluates a limited irrigation scenario where all producers, regardless of crop choice, reduce groundwater consumption by 30%. Crop water-use parameters are reported in Table 6 and crop yield expectations are reported in Table 7. All other parameters and assumptions are the same as the status quo scenario. Table 18 illustrates this time path for the hydrology, crop mix, and water-use portions of the model. Due to size constraints, the only crop reported in this table is corn.

In this scenario aquifer decline rates are reduced to approximately 0.61 feet per year which slows the decline in well capacity. As a result irrigated corn and alfalfa acres start declining in time period 37, as opposed to time period 12 for the status quo scenario. Sorghum and soybean acres start to decline in time period 55 and sunflower and wheat acres never reach the threshold that requires a reduction in irrigated acres.

Table 19 reports the impacts on gross revenues. In time period one, gross revenues are reduced by approximately 10.7% relative to the status quo scenario. The reduction in gross revenue is less than the reduction in groundwater consumption due to the curvilinear nature of the assumed production functions.

Scenario 3b, the 'Water Rights Buyout' scenario evaluates a water right buy-out program impacting 30% of the crop acreage (equally distributed across crop choices) where producers are allowed to immediately produce nonirrigated crops. The reduction in acreage occurs over 6 years (5% per year) and producers receive $800 per acre for their water right. All other parameters and assumptions are the same as the status quo scenario. The initial total irrigated acres are 5% less than those used in the status quo scenario and total irrigated acres declines by 5% through the sixth year. Additionally, landowners receive revenues during the first six years as compensation for their water right. Table 20 illustrates this time path for the hydrology, crop mix, and water-use portions of the model. Due to size constraints, the only crop reported in this table is corn. Table 21 reports the impacts on gross revenues

Scenario 3c, the 'CREP' scenario, evaluates a CREP impacting 30% of the crop acreage (equally distributed across crop choices) where producers must wait till year 15 to resume production of nonirrigated crops. All acreage is enrolled the first year and producers receive an annual payment of $112 per acre for 15 years. All other parameters and assumptions are the same as the status quo scenario except that the nonirrigated crop revenues for the 30% impacted acres do not start until year 15. Table 22 illustrates this time path for the hydrology, crop mix, and water-use portions of the model. Due to size constraints, the only crop reported in this table is corn. Table 23 reports the impacts on gross revenues.

Analysis of the Net Present Value of Gross Profit

The time paths for gross profits for all scenarios are illustrated in Figure 5. The net present values of gross revenue for the different scenarios are reported in Table 24. The difference in net present values, by scenario 2 and scenario 3, relative to the status quo scenario are reported in Table 25.

Net present value comparison is a standard method used to compare long-term projects. The calculation discounts future cash flows to present values and sums the resulting income stream. The use of net present value is a reasonable method for long-lived entities to use when comparing investments and/or project costs. However, it often has been argued that measures welfare based on the discounted value of the future benefit stream, are inappropriate.[10] Ferejohn and Page (1978) argued that the use of the discounted present value metric is inappropriate when dealing with welfare maximization over an infinite horizon because it implies that the underlying social preference ranking remains constant over time. Gisser (1983) indicates that there is a philosophical

[10] In economics, welfare is a synonym for the overall well being of an individual or society. Welfare is often measured in monetary terms.

problem of the inappropriateness of welfare maximization over an infinite horizon. He argues that the only justification for the application of net present value theory is the assumption that the present generation feels altruistic toward future generations and will represent their best interest.

An additional concern raised by the economic literature is the reliance on net present value as a metric of comparison, and the failure to include measures of social welfare loss in analyses. There probably is no justification for excluding social welfare losses due to the social cost of water in economic analysis. The existence value which society places on the remaining stock of water in the Ogallala should not be neglected. [11]

Net present value calculations require a 'discount rate' that transforms future values into present values. The use of a positive discount rate would imply the conventional view that profits today are more valuable than profits in the future. A positive discount rate might be chosen by a producer that focuses on the near term cash flows necessary to meet current obligations such as land and equipment payments. A zero percent discount rate would imply neutrality as to the timing of cash flows. The use of a negative discount rate would imply that profits, and by extension water, is valued more highly in the future than it is today. Such a stance might be taken by a producer that wants to insure that water resources are conserved today so that his children might enjoy the stability of irrigated production in the future.

For this research, it is appropriate to use net present value analysis to compare and choose between policy alternatives, since all polices were developed to yield similar short-run water savings. Amosson et al. (2006) suggests that the cost of generating water savings must be weighed against the benefit of doing so and to accomplish this, a 'price tag' needs to be given to the water that is conserved. Since this research does not attempt to place a value on the conserved water, it is not appropriate to use net present value analysis to make the decision on whether or not water-use restrictions should be implemented.

Analysis of Water Savings

The time paths for saturated thickness and total water used, for all scenarios, are illustrated in Figure 6 and Figure 7, respectively. While economists have the tools and ability to conduct the net present value analysis on the future revenue streams generated by different scenarios, we are probably no better than anyone else at placing a value on the water conserved by the different scenarios. Total water-use is reported in Table 26. The amounts of water conserved by scenario 2 and scenario 3, relative to the status quo scenario are reported in Table 27.

IV. Models of Regional Economic Impact

Background

Input-output (I-O) analysis is often used to estimate the impacts that changes in policy have on regional economies. Given estimates of direct economic impacts, software

[11] Existence value can be an important component of non-market value associated with nature. Sources of non-market or non-use values might include the existence of rare or diverse species of animals, unique natural environments, or even a way of life, such as family farms. These values are less tangible and thus more difficult to quantify because they are derived from the satisfaction an individual gets from knowing that such aspects of nature exist, and/or will continue to exist, without actually experiencing them and/or intending to experience them.

such as Impact Analysis for Planning (IMPLAN) estimates endogenous linkages between production, labor and capital income, trade, and household expenditures providing estimated effects on sector output, value-added, household income, and employment (MIG, 1999). The process captures not only the direct and indirect effects in production, but induced effects, as well. Direct effects represent the initial impacts of an outside shock on a particular sector. Indirect effects refer to the economic impacts on a particular sector's demands for intermediate goods. Induced effects refer to changes in those demands for goods and services made by households spending their altered income.

IMPLAN is often used to analyze water-use impacts on agriculture. Pritchett et al. (2005) used IMPLAN to model the economic impacts of reduced irrigation water-use in the Republican River Basin of Colorado. Leatherman et al. (2006) evaluated the proposed CREP program in southwest Kansas with input-output analysis and IMPLAN software. Lamphear (2005) applied IMPLAN analysis to valuing the importance of irrigated agriculture to the Nebraska economy. Supalla, Buell, and McMullen (2006) applied multipliers developed by Lamphear (2005) in their evaluation of economic impacts associated with various policy scenarios aimed at reducing consumptive use of irrigation water in the Platte and Republican Basins of Nebraska.

I-O impact analysis is a valuable tool for evaluating the economic consequences of policy decisions. The method provides a static snap-shot in time of probable impacts, but does not estimate the dynamic adjustment process. However, implicit in economic theory is the notion that policy implementation influences individual and market behavior creating dynamic reactions. Recognizing this factor, several researchers have applied ad-hoc (best guess for the case at hand) correction factors to conventional I-O impact analysis. Pritchett et al (2005) applied impact analysis to the case of water rights retirement in Colorado. He noted that this type of analysis has limitations; in particular, the analysis does not capture the dynamic adjustments of businesses that pursue new activities in lieu of the business traditionally used to support irrigated cropping. He suggested that, in spite of this limitation, the analysis does provide a basis for policy discussion. Supalla, Buell, and McMullen (2006) applied I-O analysis to various water conservation policy scenarios in Nebraska. Recognizing that rural economies make dynamic adjustments, the authors diminished a portion of the economic impacts in an ad-hoc linear fashion over 10 years. Leatherman et al. (2006) evaluated the proposed CREP program in southwest Kansas with I-O analysis. The research team assumed that people generally are innovative in their response to economic change, and that an economy is never static in the way it responds to change. They suggested that it is likely that the negative impacts associated with the program would in fact diminish over time and developed an ad-hoc non-linear response function.

The Descriptive Model

I-O model development is often conceptualized as having two components; the descriptive model and the predictive model. The descriptive model contains the social accounts and I-O accounts and describes the transfer of money between industries and institutions (MIG, 1999). The descriptive model is for a specified geographic area for a selected time period. Multipliers, which will be discussed later, generate the predictive model.

IMPLAN analysis uses published government economic data to account for financial transactions which occur in a region at a specific point in time. The method generates multipliers that reflect how industry sectors, households, and other institutions are financially linked one to another and to the overall economy, and how they are impacted by an exogenous economic shock. These multipliers can be used to determine the size and direction of the secondary economic impacts.

The appropriate geographic scope used in the analysis should reflect the researcher's belief in where the reduction in agricultural output, associated with reduced water-use, impacts the economy. The intent of this analysis is to identify those impacts that affect market participants and households within that area. It is assumed that stakeholders are not concerned with economic impacts that may affect the state or US economy. MIG (1999) suggest the use of the concept of a 'functional economic area' to define the study area. This area is semi self-sufficient economic unit that includes the places where people live, work, and shop, and accounts for the locations of buyers and sellers of goods and services important to the analysis. According to the Thorvaldson and Prichett (2007) in order to isolate the effects of an economic impact it is desirable to make the study area as small as possible while still including areas necessary to capture all important effects. While the six subareas are located in Cheyenne, Thomas, Sheridan, and Sherman counties, the I-O study area includes Cheyenne, Thomas, Sheridan, Sherman, Decatur, Gove, Logan, Rawlins, and Wallace Counties. Table 28 reports the basic demographic information for the study region. Within the study region there are 143 industries. Table 29 reports economic demographic information on select industries.

This research uses 2004 data (the most recent data available) obtained from MIG. IMPLAN uses a single year's data to create the structural matrices, production functions, and multipliers that describe the regional economy. Thorvaldson and Prichett (2007) suggest that it is important to select the appropriate annual IMPLAN dataset to ensure that anomalies do not exist. By selecting 2004 data, this research assumes that the overall structure of the economy, industry linkages, and multipliers that described the 2004 regional economy are reasonable approximations for the 2007 regional economy. All results are reported in 2007 dollars.

Types of Economic Impacts

Purchases for final use (final demand), for an industry, drive an I-O model. Changes in final demand represent a direct economic impact to the affected industry. 'Direct effects' are the changes in the industries to which the final demand change was made (MIG, 1999). For our case, the direct impacts are those that directly impact the producer's revenues and impact the grain farming sector.

Accurately identifying and quantifying the direct economic impact is critical to I-O analysis. The researcher defines the magnitude of the direct economic impact and typically, IMPLAN then estimates the indirect and induced impacts. If the direct impacts are erroneous then the indirect and induced impacts will also be erroneous. When water resources are shifted from agricultural production a variety of direct economic impacts may occur. Reduced revenues from irrigated crop production will negatively impact the community through both backwards and forwards industry linkage. In most cases, the lost revenues from irrigated crop production will be offset, to some extent, by the increased revenues generated from dryland crop production. In some cases, previously irrigated cropland may be converted to a permanent pasture which might enhance revenues from haying, grazing, and recreation. Many of the water right transfer policies compensate the landowner which in turn generates a positive direct economic impact.

This research considers four policy alternatives/scenarios. Table 30 reports the type of direct impacts associated with each scenario. As in the previous section, this discussion will be based on subarea number six in Sheridan County. Since the CREP scenario involves all the types of direct impacts it will serve as the example scenario.[12]
In all likelihood, an industry that experiences a direct economic impact, purchases goods and services from other industries which may indirectly experience economic impacts. 'Indirect effects' are the changes in inter-industry purchases as they respond to the new demands of the directly affected industries (MIG, 1999). When irrigated land is retired, the demand for goods and services will diminish. Major inputs for agricultural production (equipment, replacement parts, fuel, seed, fertilizer, herbicides, and insecticides) are purchased from local suppliers. The reduction in demand experienced by these local suppliers is referred to as the first-round indirect impacts. The firms that experience first-round indirect impacts will in-turn reduce their demand for goods and services which will create subsequent rounds of indirect impacts.

As the direct and indirect economic impacts ripple through the economy household consumer income may be affected. 'Induced effects' typically reflect changes in spending from households as income increases or decreases due to the changes in industry production (MIG, 1999), resulting from the direct and indirect impacts. Indirect and induced effects are often referenced in the literature as secondary impacts and/or third party costs.

Types of Multipliers
Given a direct economic impact, the goal of I-O analysis is to estimate the indirect and induced effects so that total effects (total economic impact) can be determined. The total impact can be expressed as a multiplier which is defined as

$$Multiplier = \frac{Total\ Impacts}{Direct\ Impacts}.$$

A multiplier is simply the ratio of total impacts to direct impacts and will always be expressed as a number greater than one.

I-O multipliers measure the strength of backward linkages; that is the financial impact that an increase or decrease in output by given local industry causes to its input supply chain. This financial impact is the result of changes in purchases from local industries and local resource providers (Hughes, 2003).

Final demand changes in one industry (direct impacts) creates final demand changes in related industries (indirect impacts), which in turn may generate a second round of final demand changes, and so forth. The combined effects of these multiple iterations are described by multipliers. There are three types of multipliers developed for predictive modeling: the Type I, the Type II, and the Type SAM (MIG, 1999). The 'Type I multiplier' measures the direct and indirect effects of the change in economic activity. It captures only the inter-industry effects (MIG, 1999). The 'Type II multiplier' captures the effects of direct and indirect impacts as well as the induced impacts on household incomes and expenditure (MIG, 1999).

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[12] An EXCEL spreadsheet with model results for all subareas is available upon request.

Traditionally, I-O analysis has focused on impacts to industries and households. By adding social accounting data researchers can examine non-industrial transactions such as payment of taxes by business and households and other institutional transactions. These institutional transactions are accounted for when social accounting matrices (SAMs) are included in the analysis. The 'Type SAM multiplier' captures the effect of direct, indirect, and induced impacts on industries, households, and institutions (MIG, 1999). Many researchers have used SAM type multipliers; however, Thorvaldson and Prichett (2007) used Type II multipliers as they felt the focus should be on industries and not on institutions. They suggest that while Type SAM multipliers can result in more information and detail the additional information is often more complicated and harder to interpret and explain. This research will be based on Type SAM multipliers.[13]

Reporting Economic Impacts

The IMPLAN software generates several types of outputs that quantify the total economic impact (all of which are broken down into the direct, indirect, and induced effects). 'Total Industry Output' (TIO) is the total value of industry output for a given time frame (MIG, 1999). It can be loosely interpreted as the value of sales. Norvell and Kluge (2005) suggest that TIO is not a good measurement of economic impacts as it double count sales to other industries. As an example, within the study region there is a manufacturer of phosphate fertilizer that may sell his output to a fertilizer mixer. The fertilizer mixer in-turn may sell his output to a local cooperative, which then sells the blended fertilizer to the producer. If, as the result of retiring irrigated farm land, a producer reduces his phosphate fertilizer demand, then the measure of TIO would count the manufacturer's sale three times and the mixer's margin twice. To be consistent with the literature, this study will report TIO but the metric will not be used in policy comparison.

A more accurate measure of the local economic impact may be 'Value-added' (VA). VA consist of four components: 1) employment compensation (wage, salary, and benefits paid by the employers), 2) proprietor income (payments received by self-employed individuals as income), 3) other property income (payments to individuals in the form of rents), and 4) indirect business taxes (basically all taxes with the exception of income tax). Thorvaldson and Prichett (2007) and BBC Research & Consulting et al. (1996) suggest that VA is the most appropriate measure of community economic impact. This research reports the measure of VA and uses the metric to compare policy options.

Researchers often report 'Employment' impacts generated by IMPLAN. Thorvaldson and Prichett (2007), (Hughes, 2003), and Norvell and Kluge (2005) suggest that IMPLAN may over estimate employment impacts. There are several reasons why IMPLAN may overstate employment impacts associated with agricultural production: 1) the employment calculation counts both full and part time workers as employees. Part time workers, necessary during peak labor periods such as harvesting and planting may not be eliminated in reality, even though IMPLAN will predict such a change. 2) IMPLAN assumes fixed proportion production. While this is a reasonable assumption for most inputs, it is probably not a reasonable assumption for labor and capital expenditures. Mann (2002) suggest that if farmers expect to continue farming in the future they maintain machinery, other capital expenditures, and that labor expenses are maintained because experienced labor is scarce and a skilled person might not be available in the future. Norvell and Kluge (2005) suggest that employers may not lay off workers given

[13] Based on a discussion with Doug Olson from the Minnesota IMPLAN Group.

that experienced labor is sometime scarce and not readily available and lost jobs might find employment in other sectors. 3) As much as 69% of agriculture labor, both paid and unpaid, is provided by family members.[14] It may be unlikely that family members would be impacted by land retirement programs. Additional research is needed to quantify the impact of land retirement programs have on family labor in northwest Kansas.

IMPLAN uses the concept of 'sales-per-worker' to estimate employment impacts; where sales and total industry output are equivalent. For the nine county study area, IMPLAN estimates that the grain farming sector (#2) has a total industry output of $265 million and an employment of 2,663 workers, which equates to $99,566 in sales-per-worker. Under the assumption of a linear production function, this implies that a reduction in the sale of agricultural commodities totaling $99,566 would result in one lost job. As will be discussed later, an average irrigated acre generates approximately $563 in sales, which implies one job will be lost for every 177 acres of irrigated land retired. A review of Langemeier and Dhuyvetter (2005) and an informal survey of extension professionals suggests a better estimate might be that one job will be lost for every 2000 acres or $1,126,000 in sales. This sales-per-worker estimate will be used in calculating the employment change resulting form the direct economic impact associated with lost agriculture revenues. This implies that the employment impacts reported in this research are approximately 8.8% of the employment impacts initially generated by IMPLAN. In the absence of better information, the indirect employment changes (associated with input suppliers) will also be based on the 8.8% factor.[15] This study will report employment impacts but the metric will not be used in policy comparison.

A final note on reporting economic impacts; while total industry output, value-added, and employment impacts are reported, the reader is cautioned that the impacts are not additive. The wages associated with any employment change are included in the estimated value-added, which is itself a portion of the total industry output.

Modeling Economic Impacts Using Analysis by Parts

The reduced revenues from irrigated production are often difficult to conceptualize, estimate, and model. There are four areas that need attention: first, which irrigated crop acres are retired; second, which backward linked industries are affected; third, of the crop revenues paid to backward linked industries, what percent is purchased from local suppliers; and fourth, of crop revenues paid to backward linked industries in the region, what proportion (wholesaler margin) remains in the regional economy.

Many researchers assume that the crops grown on retired irrigated acres have cropping patterns similar to the regional average. Thorvaldson and Prichett (2007), BBC Research & Consulting et al. (1996), and Norvell and Kluge (2005) applied this technique. However, BOR (1999) suggest that in a willing-seller market, water would tend to be purchased in locations with crop patterns that cost the least, in terms of foregone crop revenue; Thorvaldson and Prichett (2007) suggest that while their study assumed that crops were taken out of production in proportion to the observed crop mix, it was more likely that some crops would be taken out of production in greater proportion than others based on relative profitability; Taylor and Young (1995), BBC Research &

[14] Source: http://www.usda.gov/news/pubs/fbook98/ch3a.htm
[15] The change in the sales-per-worker factor only affects the reported employment impacts. It does not affect calculations for TIO or VA.

Consulting et al. (1996) suggest that lower valued crops on marginal land will be the first to be retired; based on crop profitability, soil characteristics, and aquifer profiles; Leatherman et al (2006) developed a model to predict which acreage would be retired first. Since the crop mix in the subareas is predominantly corn, and to maintain consistency with the temporal allocation model, this study assumes that crop acreage is taken out of production in proportion to the observed crop mix in the subarea, as reported in Table 3.

I-O analysis is a means of examining relationships within an economy both between businesses and between businesses and final consumers. It captures all monetary market transactions for consumption in a given time period (MIG, 1999). The method generates mathematical formulas (also referred to as production functions) that can be used to estimate how changes in the final demand for one industry affect both other industries and consumers. The technical coefficients (also called multipliers) on these production functions are based on national averages, and should be modified if they are not representative of the region (MIG, 1999). Norvell and Kluge (2005) suggest that since the national average for agricultural production is an aggregation of irrigated and dryland production and also includes crops that and may not be present in the region, modification of the production functions may be appropriate. BBC Research & Consulting et al. (1996), Thorvaldson and Prichett (2007), and Mann (2002) also suggest the national production functions may not naturally reflect local production methods and may need to be adjusted. Thorvaldson and Prichett (2007) suggest that state extension crop budgets, which describe how producers allocate monies to various crop inputs, can be used to develop appropriate IMPLAN production function. Crop budgets, reported in Table 10, and cash flow budgets developed by the Kansas Farm Management Association are the basis for the crop specific production functions used in this analysis. These production functions also define the backward linked industries that are affected in the first-round of indirect impacts.

The concept of a functional economic area has been previously discussed, however the notion of keeping a study region relatively small while at the same time defining an area sufficiently large enough to capture all industry linkages is problematic for agriculture. Some of the inputs necessary for agricultural production will be purchased from suppliers that are not in the defined area. Additionally, a portion of household income may be spent in adjoining states. Regional Purchase Coefficients (RPC) are calculated by IMPLAN and used to correct for these issues. A RPC is the estimated fraction of the region's commodity demand met by using locally produced commodities. It is the result of an econometric equation which predicts local purchases based on the regions characteristics (MIG, 1999).

Agricultural production can be characterized as generating large input demands and subsequent cash flows, much of which flows outside of the regional economies. The major inputs for agricultural production (equipment, replacement parts, fuel, seed, fertilizer, herbicides, and insecticides), while purchased locally on a retail basis and may have a 100% RPC, are produced by major manufacturers, and sold to local suppliers on a wholesale basis. These major manufacturers are typically not located within the study region. The value-added to these inputs by these local merchandising activities is typically only a small fraction of total purchase costs. If these out-of-region cash flows are not appropriately accounted for, I-O analysis may significantly overestimate regional economic impacts. Thorvaldson and Prichett (2007) suggest that I-O analysis may overstate indirect impacts because if the direct impact results in a demand change for a particular good the entire purchase price of that good is counted as an indirect impact. If the good is produced outside the region, but sold through a local retailer only the retailer markup, as opposed the full purchase price, will be lost to the local economy. Only if the good is produced entirely in the local economy will the entire purchase price be lost to that local economy. If an industry within an area purchases goods or services from an industry outside of the area it would be necessary to include both areas in the study region to capture the effects of all linkage (MIG, 1999). To correct for this factor, margins derived by IMPLAN and from informal surveys of extension professionals will be incorporated into the analysis. Margins define the difference between what an input supplier pays for an item and what he sells it for.

Typically, a researcher defines the magnitude of a direct impact and the sector which is impacted (referred to as an 'event' in IMPLAN). As an example, if we anticipate the retirement of 7,456.5 irrigated acres (30% of the 24,855 irrigated acres in subarea 6) with average revenue of $563.73 per acre, then the direct impact would be $4,203,453. We might specify the grain farming sector (#2) as the impacted sector. IMPLAN then uses the sector's production function to define the magnitude of the indirect impact and the distribution of the indirect impact across the supply chain. As has been previously noted, production functions based on the national average may not be appropriate. Researchers at Minnesota IMPLAN Group have developed a protocol, referred to as Analysis By Parts (ABP), to accommodate this situation and tailor I-O modeling to local conditions.

ABP is an IMPLAN protocol that allows a researcher to incorporate project-specific information into the analysis. It is accomplished by dividing the direct economic impact into the two parts: 1) the indirect impacts to the supply chain and 2) the direct impact to the payroll sector (which also is equivalent to the direct impact on VA). When using ABP the researcher manually calculates the direct impacts on Total Industry Output, Value-added, and Employment and actually models the first-round indirect impacts. Two caveats need to be noted when using ABP: first, since the indirect impacts are being modeled the IMPLAN generated output listing direct, indirect, and induced impacts are mislabeled and need to be re-aggregated; and second, since margins and RPC are incorporated the IMPLAN generated output includes impacts on domestic and foreign trade which need to be removed from the totals.[16]

The literature suggests that IMPLAN production functions, based on national averages, may not be appropriate. Additionally, MIG (1999) suggests that since their agriculture data is entirely derived, researchers with better data should incorporate it when building their IMPLAN models. ABP is a means of incorporating local information by creating a production function that specifies the first-round indirect impacts and is used in this research.

Modeling the Impact of Irrigated Crop Revenue

Since IMPLAN is driven by cash flow accounting, the KSU budgets, used in the temporal allocation model, are not entirely suitable for our purposes and were supplemented with information from cash flow budgets developed by the Kansas Farm Management

[16] For a more detailed explanation of required modifications when using ABP, the reader is refereed to IMPLANS protocol documentation.

Association.[17] These crop specific budgets were then weighted by the irrigated crop mix reported in Table 3. Table 31 reports the IMPLAN coding and impacts to the different sectors. These data suggest that the total direct impact on total industry output resulting from the retirement of 7,456.5 irrigated acres (30% of the 24,855 irrigated acres in subarea 6) is $4,203,455. The total direct impact to value-added is $1,561,891. The total first-round indirect impact is $2,641,564. However, this is the total indirect impact to all areas of the country and includes both domestic and foreign trade. That is, it does not account for local input supplier's margins or the RPC. Table 32 reports the first-round indirect impact to local suppliers as $762,261 or approximately 28.8% of the total. Based on these data, Table 33 reports the impacts on total industry output, value-added, and employment due to revenue losses associated with a reduction in irrigated crop acreage.

Stakeholders are often concerned about the magnitude of land payments and USDA farm program payments that leave the regional economy. ERS (2004) suggests that approximately 23% of USDA farm program payments, associated with farm production in northwest Kansas, may be paid to absentee landowners outside the region. Event 10 in Table 32 reflects that 23% of the estimated farmland rental and lease value leave the local economy and have a zero percent effective local impact.

Modeling the Impact of Nonirrigated Crop Revenue

As with the previous analysis, the KSU budgets were supplemented with information from cash flow budgets developed by the Kansas Farm Management Association. These crop specific budgets were then weighted by the nonirrigated crop mix reported in Table 13.[18] Table 34 reports the IMPLAN coding and impacts to the different sectors. These data suggest that the total direct impact on total industry output resulting from an increase of 7,456.5 nonirrigated acres (30% of the 24,855 irrigated acres in subarea 6) is $1,696,637. The total direct impact to value-added is $843,636. The total first-round indirect impact is $853,000. However, this is the total indirect impact to all areas of the country and includes both domestic and foreign trade. That is, it does not account for the local input supplier's margins or the RPC. Table 35 reports the first-round indirect impact to local suppliers as $261,782 or approximately 30.7% of the total. Based on these data, Table 36 reports the impacts on total industry output, value-added, and employment due to revenue gains associated with an increase in nonirrigated crop acreage.

When landowners enroll in the CREP, they are allowed the option of enrolling the corners associated with center pivot irrigation and receiving a payment for those acres based on nonirrigated rental rates. These corners are currently producing a combination of nonirrigated crops and pasture, or are being fallowed. It is assumed that for every irrigated acre enrolled in the CREP that 0.231 acres of nonirrigated crop land will be retired at an average CREP rate of $40 per acre.

Modeling the Impact of Haying, Grazing, and Recreation Revenues

The CREP program requires landowners to idle their land for 15 years. A portion of the idled land enrolled in the CREP would be eligible to be used for haying and grazing. Up

[17] In the section titled 'Models of Production and Temporal Allocation' producer gross profit was the metric of comparison as the focus was on producer impacts. In this section value-added is the metric of comparison as the focus is on community impacts. Producer gross profits will generally be larger than value-added.

[18] Weighting the revenues by the nonirrigated crop mix implicitly assumes that all retired irrigated land resumes production of nonirrigated crops.

to one-third of the acreage could be used for haying and grazing on a rotational basis each year. Dhuyvetter and Kastens (2006), suggest that the cash rent per acre for pasture land in the Northwest Kansas was $9.60, which is used as a proxy for the value of haying and grazing. The annual contribution to the local economy is estimated as $3.20 (one third of $9.60) per acre, of which 23% is estimated to be paid to absentee landowners as reported in Table 36.

The land idled by the CREP program may increase local recreation opportunities and generate additional economic activity. ERS (2004) estimated the national value of recreation benefits associated with CRP. Leatherman et al. (2006), based on ERS (2004), estimated that each acre of CRP land annually generates $1.20 of access lease income for the landowner and $2.85 additional economic activity for the local community.[19] It is assumed that 100% of the land lease income stays in the local economy (since the absentee landowner's portion may be accounted for as haying and grazing rental) and the additional economic activity ($2.85 per acre) is distributed as reported in Table 37.

Based on these data, Table 38 reports the impacts on total industry output, value-added, and employment due to revenue gains associated with an increase in haying, grazing and recreational activity.

Modeling the Impact of Program Payments

Landowner participation in the CREP (or water rights buyout program) generates incentive payments to the landowner. A landowner participating in the CREP is assumed to receive $112 per enrolled irrigated acre. It is assumed that 23% of these payments are made to absentee landowners.

Based on these data, Table 39 reports the IMPLAN coding and Table 40 reports the impacts on value-added, and employment due to revenue gains associated with the CREP incentive payments.

One caveat, to maintain consistency between scenarios and between the individual types of impacts within a scenario, it is assumed that 23% of proprietary income associated with land is paid to absentee landowners and 100% of the remainder is spent locally. BBC Research & Consulting et al. (1996) suggests that whether or not compensation received by the farmers are reinvested in the local community will have an important influence on nature magnitude is secondary impacts.

Impacts Not Modeled with IMPLAN

IMPLAN multipliers only trace backward linkages and do not capture the impacts on forward linked industries (MIG, 1999). Industries such as fuel, machinery, and fertilizer provide inputs to the irrigated crop sectors. These industries are referred to as backward linked industries or upstream industries. Other industries in the region use irrigated crops as an input to their production process. These industries are often referred to as forward linked industries or downstream industries. For our case, feedlots, dairies, and ethanol plants represent the forward linked industries of interest.

[19] Leatherman et al. (2006) focused in southwest Kansas, it is assumed that these data are a proxy for northwest Kansas.

BBC Research & Consulting et al. (1996) suggest that the downstream impacts of a water-use change in the Edwards aquifer region of Texas would be severe. This is due to the fact that the region produces vegetables and other high-value crops that are further process in the region. Howe et al. (1990) suggested that water-use changes in southern Colorado did not appear to impact the expansion of feed lots, and that high valued vegetable and specialty crops moved to new irrigated lands so there was no impact on processors. Thorvaldson and Prichett (2007) suggested that since Colorado is a grain-deficit state (net importer of grain), a reduction in irrigated acres would not require a substantial shift in grain flows and thus have little downstream impact. Additionally, Thorvaldson and Prichett (2007) suggested that since Colorado's corn production is small relative to national levels, large price changes were not expected.

The economic 'Law of One Price' suggests that in an efficient market all identical goods must have only one price. This suggests that in an efficient market the factor price of corn (as an industry input) will be the same for corn purchased locally and corn imported. Since northwest Kansas is already a net corn importer and since local production is small relative to national levels, this research assumes that there will be no downstream impacts or price effects.

When irrigated cropland is converted to nonirrigated cropland there will be a change in land values which may in turn impact local property tax revenues and/or personal income tax. This research does not estimate the impacts to the landowner resulting from a reduction in his asset valuation. It is assumed that a producer would not participate in a voluntary water rights retirement program if the benefits did not equal or exceed the costs. This research does not address personal income tax issues.

This research does not provide a separate analysis of the institutional impacts generated from changes in local property tax revenues. However, the IMPLAN model implicitly captures this impact. By using the ABP methodology, applying SAM type multipliers, and incorporating cash flow budgets from KFMA, the change in indirect business taxes (IMPLAN sector 8001) is captured. Referencing the difference in values reported in Table 31 and Table 34, a change of $2.86 per acre has been included in the impact analysis.

Farmers adopted irrigation technology to enhance profits and reduce risk relative to nonirrigated production. There is little research that focuses on the increased risk associated with such practices as limited irrigation. This research quantifies the impacts on profits but does not address the impacts of increased production risk.

Duration of the Economic Impacts

The most difficult aspect of a regional economic impact analysis is estimating the duration of the impacts. All policy scenarios, relative to the status quo scenario, reduce producer output, input usage, revenues, and profits and as such have negative direct, indirect, and induced impacts. When faced with declining incomes producers develop strategies (adopt new technology, shift cropping patterns, increase inputs on the remaining acreage, etc.) to reduce the loss and return to previous income levels. Similarly, when faced with negative impacts local businesses develop strategies to reduce the impact. As time passes, the direct, indirect and induced negative impacts diminish and the economy recovers.

ERS (2004) suggested that I-O models are useful for predicting the local economic response to policy shocks ex ante (before the fact), but they do not reflect actual ex post (after the fact) adjustments. Supalla (2006) suggested that the secondary impacts are transitory in nature because the resources involved eventually find alternative employment. He noted that principles and guidelines used by federal agencies for evaluating water projects do not allow project applications to include secondary costs (US Water Resource Council, 1983) based on the assumption that labor and other resources which become unemployed move on to alternative employment and earn as much or more than they earned before the policy. Anderson and Settle (1977) suggests that secondary costs should be ignored in economic analysis because they are both transitory and difficult to estimate. Adams (2004) suggests that the CRP program negatively impacted elevator merchandising margins, but the elevators adjusted rather quickly, making most of the adjustment within one year. Pritchett et al (2005) applied impact analysis to the case of water rights retirement in Colorado. He noted that this type of analysis has limitations; in particular, the analysis does not capture the dynamic adjustments of businesses that pursue new activities in lieu of the business traditionally used to support irrigated cropping. He suggested that, in spite of this limitation, the analysis does provide a basis for policy discussion. Bangsund et al. (2002) performed an ex post analysis of the CRP program in North Dakota and suggested that the net economic effects in several areas of the state were not as economically severe as previous research had suggested. In summary, based on the literature, past research, and empirical evidence, an IMPLAN analysis is a short-run static analysis, which implicitly assumes that the impacted firms do not react. As such it is inappropriate to project the impacts generated with IMPLAN analysis into the future without accounting for the dynamic adjustment process. Unfortunately, there is little empirical research on the dynamic adjustment process.

Several ad-hoc methods have been applied to dynamically adjust estimates of direct and indirect impacts. Supalla, Buell, and McMullen (2006) applied I-O analysis to various water conservation policy scenarios in Nebraska. Recognizing that rural economies make dynamic adjustments, the authors diminished a portion of the economic impacts in an ad-hoc linear fashion over 10 years. Leatherman et al. (2006) evaluated the proposed CREP program in southwest Kansas with I-O analysis. The team assumed that people generally are innovative in their response to economic change, and that an economy is never static in the way it responds to change. They suggested that it is likely that the negative impacts associated with the program would in fact diminish over time and developed an ad-hoc non-linear response function. Similar to Leatherman et al. (2006) this research applies an ad-hoc non-linear 'S-curve' response function to estimate the duration of impacts. [20]

Once the duration of the impacts are estimated, net present values can be calculated as a metric of comparison. As discussed in Section II net present value analysis can be ambiguous. For this research, it is appropriate to use net present value analysis to compare and choose between policy alternatives, since all polices were developed to yield similar water savings. However, Amosson et al. (2006) suggests that the cost of generating water savings must be weighed against the benefit of doing so. In order to accomplish this, a 'price tag' needs to be given to the water that is conserved. Since this research does not attempt to place a value on the conserved water, it is not appropriate

[20] Reference Leatherman et al. (2006) for a complete description of the S-curve used in this analysis.

to use this net present value analysis to make the decision on whether or not water-use restrictions should be implemented.

Economic Impacts of a Conversion to Dryland Production

The 'Immediate Conversion to Dryland Production Scenario' (scenario 2) assumes all irrigated production is immediately converted to dryland production, and producers are not compensated for the change. Subarea 6 in Sheridan County has 24,855 irrigated acres, as reported in Table 1. Table 31 indicates that the average irrigated acre contributes $209.47 in direct value-added, which accrues primarily to the benefit of the landowner, operator, and hired labor. Table 33 reports a value-added multiplier of 1.64, implying that each irrigated acre contributes $343.53 in total value-added to the community. The 24,855 irrigated acres is estimated to contribute $8,538,438 in total value-added to the regional economy.

Table 34 suggests that the average nonirrigated acre contributes $113.14 in direct value-added and has a value-added multiplier of 1.51, implying that each nonirrigated acre contributes $170.84 in total value-added to the community. If the entire 24,855 irrigated acres were converted to nonirrigated production they would generate $4,246,228 in total value-added to the regional economy. The total loss in value-added for the first year would be $4,292,201.

Figure 8 illustrates the time path for value-added for this scenario. The data series labeled 'Status Quo' projects the time path of the value-added to the regional economy from irrigated production. In year 11 the value-added contribution begins to decline as aquifer depletion forces some irrigated acreage to convert to nonirrigated production. The data series labeled 'Conversion to Dryland' projects the time path of the value-added to the regional economy from dryland production. The data series labeled 'Difference' represents the difference between the 'Status Quo' scenario and the 'Conversion to Dryland' scenario. For convenience and figure clarity the difference is illustrated as positive value, even though it represents a negative impact. Over time producers and input suppliers develop strategies to mitigate the negative impact and this impact diminishes. Cash flows that occur in the future may need to be discounted to reflect current values. The data series labeled 'Diminished and Discounted Difference' represents the 'Difference' curve after it has been diminished by the previously discussed S-curve and discounted based on a 5% annual discount rate. Based on these adjustments, the net present value, over the 60 year planning horizon, of the lost value-added is $43,815,439.

Economic Impacts of a Shift to Limited Irrigation

The 'Immediate Shift to Limited Irrigation Scenario' (scenario 3a) assumes all producers of irrigated crops immediately adopt a limited irrigation management strategy. A 30% reduction in water-use is achieved and producers are not compensated for the change. Subarea 6 in Sheridan County has 24,855 irrigated acres, as reported in Table 1. Table 31 indicates that the average irrigated acre contributes $209.47 in direct value-added, which accrues primarily to the benefit of the landowner, operator, and hired labor. Table 33 reports a value-added multiplier of 1.64, implying that each irrigated acre contributes $343.53 in total value-added to the community. The 24,855 irrigated acres is estimated to contribute $8,538,438 in total value-added to the regional economy.

The average limited irrigated acre contributes $183.12 in direct value-added and has a value-added multiplier of 1.64, implying that each limited irrigated acre contributes

$300.31 in total value-added to the community. If the entire 24,855 irrigated acres were converted to limited irrigated production they would generate $7,464,205 in total value-added to the regional economy. The total loss in value-added, for the first year, would be $1,074,233.

Figure 9 illustrates the time path for value-added for this scenario. The data series labeled 'Status Quo' projects the time path of the value-added to the regional economy from irrigated production. In year 11 the value-added contribution begins to decline as aquifer depletion forces some irrigated acreage to convert to nonirrigated production. The data series labeled 'Conversion to Limited Irrigation' projects the time path of the value-added to the regional economy from limited irrigation production. Under this scenario the value-added from limited irrigation does not start to diminish until year 37. The data series labeled 'Difference' represents the difference between the 'Status Quo' scenario and the 'Conversion to Dryland' scenario. For convenience and figure clarity the difference is illustrated as positive values, even though it represents a negative impact. Over time producers and input suppliers develop strategies to mitigate the negative impact and this impact diminishes. Cash flows that occur in the future may need to be discounted to reflect current values. The data series labeled 'Diminished and Discounted Difference' represents the 'Difference' curve after it has been diminished by the previously discussed S-curve and discounted based on a 5% annual discount rate. Based on these adjustments, the net present value, over the 60 year planning horizon, of the lost value-added is $7,943,605.

Economic Impacts of a Water Rights Buyout Program

The 'Water Rights Buyout Scenario' (scenario 3b) assumes that water rights are purchased and permanently retired. A 30% reduction in water-use is achieved, participating producers can immediately start producing nonirrigated crops, and producers are compensated at a rate of $800 per acre. The water rights would be purchased over a 6 year period. Subarea 6 in Sheridan County has 24,855 irrigated acres that currently contribute $8,538,438 in total value-added to the regional economy.

In this scenario 5% of the irrigated acreage (1243 acres) would be converted to dryland production in the first year. These dryland acres would yield a total value-added of $170.84 per acre, or $212,354 in total. The remaining 23612 irrigated acres would generate $343.53 per acre, or $8,111,430 in total value-added. The landowner would receive $800 per acre, of which 23% stays in the local economy, with a value-added multiplier of 1.29 (Table 39). These producer payments would yield $987,773 in total value-added to the regional economy, and would continue for six years. The cumulative value-added under this scenario is $9,311,557. Since the value-added gained from the landowner payments exceeds the reduction in value-added due to converting irrigated land to dryland this scenario increases regional total value-added in the first year. The total gain in value-added, for the first year, would be $773,119.

Figure 10 illustrates the time path for value-added for this scenario. The data series labeled 'Status Quo' projects the time path of the value-added to the regional economy from irrigated production. In year 11 the value-added contribution begins to decline as aquifer depletion forces some irrigated acreage to convert to nonirrigated production. The data series labeled 'Water Rights Buyout' projects the time path of the value-added to the regional economy. The data series labeled 'Difference' represents the difference between the 'Status Quo' scenario and the 'Water Rights Buyout' scenario. The data series labeled 'Diminished and Discounted Difference' represents the 'Difference' curve after it has been diminished by the previously discussed S-curve and discounted based on a 5% annual discount rate. Based on these adjustments, the net present value, over the 60 year planning horizon, of the lost value-added is $5,080,542.

Economic Impacts of a CREP Program

The 'CREP' (scenario 3c) assumes that water rights are purchased and permanently retired. A 30% reduction in water-use is achieved, participating producers cannot start producing nonirrigated crops until year 15, and producers are compensated at a rate of $112 per acre per year for the 15 year enrollment period. Subarea 6 in Sheridan County has 24,855 irrigated acres that currently contribute $8,538,438 in total value-added to the regional economy.

In this scenario 30% of the irrigated acreage (7456.5 acres) would be idled in the first year. Table 38 suggests that the haying, grazing, and recreational benefits from these acres would yield a total value-added to the regional economy of $51,862 ($6.96 per acre). The remaining 17398.5 irrigated acres would generate $343.53 per acre, or $5,976,907 in total value-added. The landowner would receive $112 per acre, of which 23% stays in the local economy, with a value-added multiplier of 1.29 (Table 40). These producer payments would yield $832,501 in total value-added to the regional economy, and would continue for 15 years.

The cumulative value-added, thus far, under this scenario is $6,858,301. Since the value-added gained from the landowner payments plus the haying, grazing, and recreation income does not exceed the reduction in value-added due to idling previously irrigated land this scenario decreases regional total value-added in the first year. The total loss in value-added (due to the retirement of irrigated cropland), for the first year, would be $1,680,137.

In addition to this amount, there will be a loss in value-added associated with the enrollment of the center pivot corners in the CRP program. It is estimated that 1721 acres (23.1% of 7456.5 acres) of nonirrigated cropland will be enrolled. These acres will cause a reduction in value-added of $294,016 (1721 acres X $170.84), which will be offset by $88,805 (1721 acres X $40 X 1.29) in value-added gained from the CRP payments and $11,978 (1721 acres X $6.96) in value-added gained from haying, grazing, and recreation. The total loss in value-added (due to the retirement of nonirrigated cropland), for the first year, would be $193,233. The total loss in value-added, for the first year, would be $1,873,370.

Figure 11 illustrates the time path for value-added for this scenario. The data series labeled 'Status Quo' projects the time path of the value-added to the regional economy from irrigated production. In year 11 the value-added contribution begins to decline as aquifer depletion forces some irrigated acreage to convert to nonirrigated production. The data series labeled 'CREP' projects the time path of the value-added to the regional economy. The data series labeled 'Difference' represents the difference between the 'Status Quo' scenario and the 'CREP' scenario. The data series labeled 'Diminished and Discounted Difference' represents the 'Difference' curve after it has been diminished by the previously discussed S-curve and discounted based on a 5% annual discount rate. Based on these adjustments, the net present value, over the 60 year planning horizon, of the lost value-added is $17,182,693.

V. Summary

The previous sections have concentrated on subarea number 6 in Sheridan County. In This section, the most relevant results for all subareas will be discussed.[21] In some cases, making direct comparisons across subareas is problematic since the magnitude of irrigated acres varies considerably. Indexed values will be used to make relative comparisons. When applied to a time series, indexed values are obtained by dividing each annual value by the starting value. When multiplied by 100, an indexed value represents the percent of staring values that occurs in each year.

Based on the 'Status Quo' scenario, Figure 12 illustrates the relative time trends in gross profit (associated with the acreage that was initially irrigated) for all subareas. All subareas start the series with 100% of the acreage irrigated. As water resources are diminished irrigated acreage is converted to nonirrigated production, gross profits diminish, and the indexed values start to decline. As an example, irrigated acres start to decline and gross profits diminish in year 11 in subarea number 6, in year 19 in subarea number 3, and in year 1 in subarea number 4. By year 60, revenues in subarea number 6 are reduced to approximately 76% of the initial value, revenues in subarea number 3 are reduced to approximately 84% of the initial value, and revenues in subarea number 4 are reduced to approximately 82% of the initial value. The shapes of these curves are dependent upon the subarea specific hydrological parameter, crop mix and water-use. In the absence of groundwater conservation programs, if water-use continues at current levels the model predicts that subarea numbers 2 and 4 will experience reduced gross revenues in the next few years. On the other hand, subarea number 3 will not experience gross revenue losses in the near term.

Based on the 'Limited Irrigation' scenario, Figure 13 illustrates the relative time trends in gross profit for all subareas. If producers reduce current groundwater consumption by 30%, irrigated acres and gross profits do not decline over the 60 year planning period in subareas number 3 and 6. The remaining subareas are capable of maintain their current irrigated acres in production for approximately 30 to 35 years before they start to decline. The shapes of these curves are also dependent upon the subarea specific hydrological parameter, crop mix and water-use.

Relative to the 'Status Quo' scenario, Table 41 reports the total net present value of lost producer gross profits associated with each policy option. Table 42 reports the per acre net present value of lost producer gross profits associated with each policy option. Both tables are based on a 5% discount rate. A 5% discount rate assumes current losses are worth more than future gains. As an example, a 5% discount rate implies that a dollar received or lost 60 years from now is only worth $0.05. The use of a 5% discount rate can be useful in determining the relative short-run costs borne by the producers. Table 41 and Table 42 suggest that the 'Water Rights Buyout' scenario is the least-cost method of conserving groundwater, while the 'CREP' scenario is the most expensive.[22] A CREP program tends to be more expensive because the enrolled acreage does not produce crop revenues for the first 15 years. Table 42 suggests that the short-run costs are most severe for subarea 3 in Cheyenne County. Referencing Figure 12, subarea 3

[21] An EXCEL spreadsheet with additional summary tables and figures including all subareas is available upon request.

[22] The 'Immediate Conversion to Dryland' scenario is not considered in this discussion. It is important to note that the 'Water Rights Buyout' scenario is superior to the 'Limited Irrigation' scenario because of the payments to producers.

in Cheyenne County has the 'best' water and is not expected to experience irrigated acreage reductions within the next 20 years.[23]

Relative to the 'Status Quo' scenario, Table 43 reports the total net present value of lost producer gross profits associated with each policy option. Table 44 reports the per acre net present value of lost producer gross profits associated with each policy option. Both tables are based on a -5% discount rate. A -5% discount rate assumes current losses are worth less than future gains. As an example, a -5% discount rate implies that a dollar received 60 years from now is worth $21.71 in today's value. The use of a -5% discount rate can be useful in determining the relative producer long-run gains of water conservation today. Table 43 and Table 44 suggest that the 'Limited Irrigation' scenario generates the largest future gains to conserving groundwater, while the 'Water Rights Buyout' scenario is the most expensive.[24] Table 44 suggests that subarea 3 in Cheyenne County has the least the long-run benefits. Referencing Figure 12, subarea 3 in Cheyenne County has the 'best' water and thus derives fewer benefits from conservation.

Figure 14 and Figure 15 illustrate the relative temporal changes in saturated thickness for the 'Limited Irrigation' and 'Status Quo' scenario. Of particular interest is the difference in these two graphs, as illustrated in Figure 16, which depicts to some extent the impact of water conservation on the aquifer and by extension gross profits. If subarea 3 in Cheyenne County can be categorized as having the 'best' water then subarea 2 in Sherman County and subarea 4 in Thomas County might be categorized as having the 'worst' water.[25] Notice that, in the first 20 years, there is little difference in impacts between subareas with the 'best' water and subareas with the 'worst' water. At the extremes this can be generalized as: if water resources are stable there is little economic need for water conservation and after the well has run dry water conservation can not restore the water resource. On the other hand, Figure 16 illustrate that subarea 1 in Sherman County and subarea 6 in Sherman County receive the greatest short-run benefits of water conservation. These subareas currently have sufficient saturated thickness to maintain status quo irrigation practices but can be expected to experience difficulties maintaining revenues from irrigated production in the short run. This implies that in the presence of scarce financial resources necessary to fund water conservation, economic benefits may be maximized by targeting subarea 1 in Sherman County and subarea 6 in Sherman County. Additional research is needed to quantify the relationship between the temporal changes in saturated thickness and the optimal targeting of water conservation funds across subareas.

Relative to the 'Status Quo' scenario, Table 45 reports the net present value of lost value-added to the regional economy. These data have been discounted and diminished as previously discussed. This analysis is based on a 5% discount rate. While landowners may value future profits more than current profits, and consider negative discount rates, it may be unlikely that input suppliers will feel altruistic toward future generations. These data suggest that the 'Water Rights Buyout' scenario is the

[23] In so far as the largest saturated thickness typically implies the largest well capacity, which implies the largest revenues, then 'best' can be used as a qualitative descriptor.
[24] Relative to the 'CREP' scenario, the 'Water Rights Buyout' scenario reduces water-use over a 6 year period so there is relatively less water available for future use. The 'Immediate Conversion to Dryland' scenario is not considered in this discussion.
[25] The model implies that subarea 2 in Sherman County and subarea 4 in Thomas County currently have diminishing well capacity that is reducing revenues from irrigated production.

least-cost method of conserving groundwater, while the 'CREP' scenario is the most expensive.[26] A CREP program tends to be more expensive because the enrolled acreage does not produce crop revenues for the first 15 years.

When a researcher expresses costs as net present value the numbers can become staggering. As an example, few laymen can readily place the $66 million dollar lost value-added associated with a CREP program, as reported in Table 45, in a relevant context. Howe and Goemans (2003) suggest reporting impacts on a per capita basis. Leatherman et al. (2006) reported impacts as a percent of total regional values. Table 46 reports the first year impacts, relative to the 'Status Quo' scenario, on both a per capita and percent basis. During the first year, the 'Water Rights Buyout' scenario generates positive values due to landowner payments. The 'CREP' scenario is the most costly. Based on previously discussed assumptions, these impacts would be expected to diminish over time.

Prichett et al. (2003), Howe and Goemans (2003), and Wahl (1993) suggest, that while landowners may benefits by selling their water, third party costs are generally not fully accounted for. However, Wahl (1993) points out that this cost is simply one price that society incurs for changes in water-use and that a similar impact occurs when industries of other types relocate. The IMPLAN ABP protocol allows us to partially disaggregate impacts and approximate third party costs. More precisely, ABP allows the estimation of indirect and induced impacts to the input suppliers. Induced impacts resulting from changes in proprietary income, property income, employee compensation, and indirect business taxes are not accounted for. Table 47 reports estimates of lost value-added to input supplier sectors. Comparing Table 46 and Table 47: the 'Limited Irrigation' scenario reflects modest impacts on input suppliers, approximately 24% of the total, implying that producers bear the majority of the costs associated with the policy; the 'Water Rights Buyout' scenario has a negative impact on input suppliers indicating that the positive first year impact reported in Table 46 is the result of the relatively large payments made to landowners and; the 'CREP' scenario is the most costly to input suppliers as there is no crop production on the enrolled acreage.

VI. Conclusions

The purpose of this research was to provide input into the water planning process for relatively small sub-basins in northwest Kansas. The study considered a variety of water conservation policies aimed at achieving a 30% reduction in current groundwater consumption levels. Stakeholder input suggests that a reduction in water-use is desirable in order to preserve the Ogallala aquifer and extend its economic contribution to both the producer and the regional economy. This research estimates measures of producer gross profits and regional value-added in an endeavor to define the least costly water conservation policy. While individual policy alternatives have been compared to a 'Status Quo' scenario, this research does not attempt to place a monetary value on the saved water or place monetary value on other benefits of water conservation and should not be viewed as a cost-benefit analysis of water conservation,

[26] The 'Immediate Conversion to Dryland' scenario is not considered in this discussion. It is important to note that the 'Water Rights Buyout' scenario is superior to the 'Limited Irrigation' scenario because of the payments to producers.

In order to accomplish the goals of this research, models of ‘production’, models of ‘temporal allocation’, and models of ‘regional economic impact’ were developed and used to estimate impacts over a 60 year time horizon. The development of economic models that predict the future are, by their very nature, subject to error, and the results are most appropriately viewed as a ‘best guess’. The estimated impacts were based on a variety of assumptions. A different set of assumptions will alter the magnitude of impacts. So long as consistency of assumptions is maintained across policy options, different assumptions may not impact the relative order of policy choices.

Of the policy options considered, the Conservation Reserve Enhancement Program is the most costly method of conserving water. While producers are compensated, based on a fair market value of land rent, this payment does not fully compensate the average producer for current losses in gross profit or the value-added contribution of crop production to the regional economy. This scenario also has the largest impact to the input supply sectors. The magnitude of these losses is the result of the programs requirement that enrolled irrigated acreage be idled, and also the assumption that additional nonirrigated acreage will be enrolled and idled. The CREP program may be the easiest water conservation policy to implement. The program has wide spread support of environmental groups and will generate additional recreational benefits. Importantly, the majority of monies necessary to fund this program will come from the federal government as opposed to Kansas taxpayers.

The Water Rights Buyout Program has short-run positive impacts and long run-negative impacts to the producer and regional economy as a whole. The program has both short-run and long-run negative impacts to the input supply sectors. While input suppliers have negative impacts, they are not as severe as those that occur with the CREP program as enrolled acreage maintains nonirrigated production. The Water Rights Buyout Program may be the most difficult water conservation policy to implement. The majority of monies necessary to fund this program will come from Kansas taxpayers.

Of the policy options considered, the ‘Limited Irrigation’ scenario is the least costly method of conserving water. All irrigated cropland remains in production so the impact to the input supply sector is minimized. The annual negative impact on value-added for the input supply sector was estimated as 0.09% of the total value-added for regional economy ($869,391). Producers will also incur losses as crop output will decline and producers will not be compensated. The total annual negative impact on value-added was estimated as 0.37% of the regional economy ($3,569,328). The ‘Limited Irrigation’ scenario may be a difficult water conservation policy to implement. While no monies will be necessary from Kansas taxpayers, producers may hesitate to voluntarily assume the risk of limited irrigation without compensation. Additional research is required to quantify this risk. Additionally, changes in current statutes may be required to modify water allocations.

The analysis was conducted based on an either-or assumption (either policy A or policy B is implemented) and the assumption that implementation is rapid. In all reality, a combination of these policies may be required to achieve the goal of a 30% reduction in groundwater consumption and it may take more time than assumed to reach the goal. If timing or funding becomes an issue, this research suggests that economic benefits may be maximized by targeting subarea 1 in Sherman County and subarea 6 in Sheridan County. This is not to imply that the other subareas do not receive economic benefits from water conservation.

The adoption of a water conservation policy, similar to the technology adoption process, may reduce groundwater consumption in the short-run but will not reduce groundwater consumption over an infinite horizon. The water saved today will eventually be used and the water resource exhausted. This research suggests that a 30% reduction in groundwater consumption is not sufficient to stabilize the groundwater resource.

The reported water savings are potential water savings. The study area was chosen because of current concerns over aquifer decline rates and diminishing well capacities. Average well capacity and average water-use were the basis for this analysis. Undoubtedly, there are producers in the area that are currently incapable of fully irrigated production. If the aquifer is stabilized their water-use could increase. From an equitability and administrative standpoint, Kansas water appropriation regulations may need to be modified to ensure that water-use is constrained.

It should be noted that the long-run impact estimates of value-added are subject to a degree of uncertainty. While they have been calculated based on the stated assumptions and reported accurately, they are based on an ad hoc decay function that has not been substantiated by empirical research. However, the notion that these impacts diminish over time is firmly established by the literature. The estimates of long-run impacts to value-added should be considered tentative and subject to change based on additional empirical evidence. While the exact magnitude may be in question, since all scenarios apply the same decay function policy comparison is appropriate.

Producers in the semi-arid region of northwest Kansas adopted irrigation technologies to increase profits and reduce risk. This research estimates the impact on profits associated with the adoption of a limited irrigation management practice, but does not address the potential for increased risk exposure. Local producers have suggested that increased risk exposure is their primary concern associated with the adoption of a limited irrigation. Additional research is needed to identify and quantify the risks associated with limited irrigation.

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Tables

Table 1. Subarea Designations and Size

Item	Subarea Number 1	2	3	4	5	6
State Name	Kansas	Kansas	Kansas	Kansas	Kansas	Kansas
County Name	Sherman	Sherman	Cheyenne	Thomas	Thomas	Sheridan
Average Annual Water Use (acre feet)	23593.0	9684.0	7008.0	1054.0	35766.0	26595.0
Total Irrigated Acres	21888.0	8775.0	6211.0	1202.0	35212.0	24855.0
Average Water Use per Acre	1.08	1.10	1.13	0.88	1.02	1.07

These data are based on 1996 – 2005 averages and are consistent with the Water Rights Information System (WRIS) and data used in the Republican River Compact Administration (RRCA) model.

Table 2. Subarea Hydrological Parameters

Item	Subarea Number 1	2	3	4	5	6
Recharge (inches/year) (RRCA 1996 – 2005)	1.01	0.96	0.71	0.62	0.76	1.20
Depth to Water (feet)	162.8	167.5	208.0	159.6	146.3	164.7
Saturated Thickness (feet) (KGS)	105.5	107.4	116.1	93.3	73.3	89.8
Hydraulic Conductivity (ft/day)	25.1	20.4	23.0	27.6	46.7	40.4
Specific Yield (RRCA)	0.175	0.175	0.175	0.175	0.175	0.175
Average Well Capacity (gallons per minute)	531	473	593	461	480	587
Average Decline in Saturated Thickness (feet)	1.08	0.83	0.79	0.60	0.76	1.15

These data are consistent with the Republican River Compact Administration (RRCA) model. Average well capacity has been calculated based on methods described in Appendix 1.

Table 3. Subarea Irrigated Crop Mix

Subarea	County	Alfalfa	Corn	Sorghum	Crop Soybeans	Sunflowers	Wheat
1	Sherman	4.5%	60.0%	4.0%	7.6%	9.1%	14.8%
2	Sherman	2.3%	63.9%	4.9%	7.3%	5.5%	16.1%
3	Cheyenne	0.1%	65.4%	2.2%	18.8%	4.1%	9.5%
4	Thomas	3.7%	64.1%	5.7%	11.0%	6.7%	8.8%
5	Thomas	2.4%	60.6%	3.0%	22.0%	4.7%	7.3%
6	Sheridan	1.1%	71.3%	3.5%	16.0%	3.8%	4.2%

Table 4. Subarea Net Water Requirements Assuming Full Irrigation (inches)

		Crop					
Subarea	County	Alfalfa	Corn	Sorghum	Soybeans	Sunflowers	Wheat
1	Sherman	15.5	14.3	9.9	12.5	6.7	6.9
2	Sherman	15.9	14.4	9.8	12.3	6.4	6.7
3	Cheyenne	14.1	13.9	10.3	12.5	6.4	7.2
4	Thomas	11.9	11.9	7.5	11.7	6.1	6.7
5	Thomas	12.8	12.6	9.2	11.9	6.1	6.8
6	Sheridan	13.8	12.7	7.8	12.1	6.3	6.9

Table 5. Subarea Crop Yields Assuming Full Irrigation

		Crop					
Subarea	County	Alfalfa	Corn	Sorghum	Soybeans	Sunflowers	Wheat
1	Sherman	9.0	204.1	145.7	64.3	94.9	64.2
2	Sherman	9.1	204.3	145.3	63.9	93.5	63.7
3	Cheyenne	8.7	202.9	147.4	64.3	93.0	65.1
4	Thomas	8.1	194.1	133.5	62.8	91.6	63.6
5	Thomas	8.3	197.7	142.6	63.2	91.8	64.0
6	Sheridan	8.6	198.2	135.3	63.5	92.7	64.2

All yields are in bushel except alfalfa which is in tons.

Table 6. Subarea Net Water Requirements Assuming Limited Irrigation (inches)

		Crop					
Subarea	County	Alfalfa	Corn	Sorghum	Soybeans	Sunflowers	Wheat
1	Sherman	10.9	10.0	6.9	8.8	4.7	4.8
2	Sherman	11.1	10.1	6.9	8.6	4.5	4.7
3	Cheyenne	9.9	9.7	7.2	8.8	4.5	5.0
4	Thomas	8.3	8.3	5.3	8.2	4.3	4.7
5	Thomas	9.0	8.8	6.4	8.3	4.3	4.8
6	Sheridan	9.7	8.9	5.5	8.5	4.4	4.8

Table 7. Subarea Crop Yields Assuming Limited Irrigation

		Crop					
Subarea	County	Alfalfa	Corn	Sorghum	Soybeans	Sunflowers	Wheat
1	Sherman	6.7	187.7	134.0	59.1	87.3	59.1
2	Sherman	6.8	188.0	133.7	58.8	86.0	58.6
3	Cheyenne	6.5	186.7	135.6	59.1	85.6	59.9
4	Thomas	6.1	178.5	122.8	57.8	84.3	58.5
5	Thomas	6.2	181.9	131.2	58.1	84.4	58.9
6	Sheridan	6.5	182.4	124.5	58.5	85.3	59.1

All yields are in bushel except alfalfa which is in tons.

Table 8. Ranges of Irrigation Efficiency for Center Pivot and Flood Technology.

	Irrigation Efficiency		
Source	Flood	Center Pivot	SDI
Rogers et al. (1997)	50% - 90%	70% - 95%	70% - 95%
KSU - CWA	50% - 80%	85% - 90%	95%
UNL - WO	50% - 75%	70% - 80%	NR

KSU - CWA: Kansas State University's Crop Water Allocator
UNL – WO: University of Nebraska at Lincoln's Water Optimizer
SDI: Subsurface Drip Irrigation
NR: Not reported

Table 9. Subarea Percent of Acres Irrigated with Center Pivot Technology

Subarea Number					
1	2	3	4	5	6
Sherman	Sherman	Cheyenne	Thomas	Thomas	Sheridan
97.9%	92.7%	89.6%	100.0%	98.2%	90.6%

These data are based on 2005 WRISS data. Due to comparable efficiencies, these percentages include acres irrigated with center pivots, center pivots with drops, and subsurface drip irrigation technology.

Table 10. Example of a Crop Budget for Irrigated Production in Northwest Kansas

	Crop					
	Alfalfa	Corn	Sorghum	Soybeans	Sunflowers	Wheat
Income per Acre						
A. Yield per acre	7.5	215	120	65	2,800	75
B. Price per unit	$101.00	$2.99	$2.65	$5.68	$11.82	$4.33
C. Net government payment	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
D. Indemnity payments	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
E. Miscellaneous income	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
F. Revenue per Acre	$757.50	$642.85	$318.00	$369.20	$330.96	$324.75
Costs per Acre						
1. Seed	$10.17	$57.46	$17.75	$33.00	$17.32	$13.20
2. Herbicide	$16.20	$30.96	$28.04	$13.44	$20.42	$4.60
3. Insecticide / Fungicide	$9.06	$37.43	$0.00	$0.00	$15.10	$0.00
4. Fertilizer and Lime	$32.38	$100.39	$53.33	$14.50	$50.17	$45.46
5. Crop Consulting	$6.50	$6.50	$6.25	$6.25	$6.50	$6.00
6. Crop Insurance	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
7. Drying	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
8. Miscellaneous	$10.00	$10.00	$10.00	$10.00	$10.00	$10.00
9. Custom Hire / Machinery Expense	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
10. Non-machinery Labor	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
11. Irrigation						
a. Labor	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
b. Fuel and Oil	$97.73	$81.44	$65.15	$73.30	$48.86	$40.72
c. Repairs and Maintenance	$7.92	$6.60	$5.28	$5.94	$3.96	$3.30
d. Depreciation on Equipment and Well	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
e. Interest on Equipment	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
12. Land Charge / Rent	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
13. Interest	$5.70	$9.92	$5.57	$4.69	$5.17	$3.70
H. Total Cost per Acre	$195.65	$340.70	$191.37	$161.12	$177.50	$126.98
I. Returns per Acre	$561.85	$302.15	$126.63	$208.08	$153.46	$197.77

Table 11. Gross Daily Application Rates at Various Well Capacities

Well Capacity (gallons per minute)	Acres	Gross Daily Application Rate (inches per day per acre)
1200	125	0.51
1150	125	0.49
1100	125	0.47
1050	125	0.45
1000	125	0.42
950	125	0.40
900	125	0.38
850	125	0.36
800	125	0.34
750	125	0.32
700	125	0.30
650	125	0.28
600	125	0.25
550	125	0.23
500	125	0.21
475	125	0.20
450	125	0.19
400	125	0.17
350	125	0.15

Table 12. Required Minimum Daily Application Rate (inches per acre per day)

Alfalfa	Corn	Sorghum	Soybeans	Sunflowers	Wheat
0.2	0.2	0.16	0.16	0.12	0.08

These data are reduced by 20% for the limited irrigation scenarios.

Table 13. Subarea Non-Irrigated Crop Mix

					Crop		
Subarea	County	Alfalfa	Corn	Sorghum	Soybeans	Sunflowers	Wheat
1	Sherman	0.0%	10.9%	7.2%	0.0%	12.9%	69.0%
2	Sherman	0.0%	10.9%	7.2%	0.0%	12.9%	69.0%
3	Cheyenne	0.0%	0.0%	3.9%	0.0%	0.0%	96.1%
4	Thomas	0.0%	14.4%	14.8%	0.0%	0.0%	70.8%
5	Thomas	0.0%	14.4%	14.8%	0.0%	0.0%	70.8%
6	Sheridan	0.0%	20.1%	17.5%	0.0%	0.0%	62.4%

These data are based on the average of KASS annual data, where a crop with an annual percentage less than 5% removed and the remaining percentages normalized to 100%

Table 14. Subarea Non-Irrigated Crop Yield

Subarea	County	Alfalfa	Corn	Sorghum	Crop Soybeans	Sunflowers	Wheat
1	Sherman	NA	46.4	40.2	NA	36.3	29.6
2	Sherman	NA	46.4	40.2	NA	36.3	29.6
3	Cheyenne	NA	44.2	31.1	NA	NA	29.2
4	Thomas	NA	55.8	51.3	NA	NA	32.6
5	Thomas	NA	55.8	51.3	NA	NA	32.6
6	Sheridan	NA	63.8	55.9	NA	NA	36.9

NA: not applicable since the crop mix reported in Table 13 is zero.

Table 15. Crop Budgets for Non-Irrigated Production in Northwest Kansas

	Crop					
	Alfalfa	Corn	Sorghum	Soybeans	Sunflowers	Wheat
Income per Acre						
A. Yield per acre	5.5	95	85	35	1,800	50
B. Price per unit	$101.00	$2.99	$2.65	$5.68	$11.82	$4.33
C. Net government payment	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
D. Indemnity payments	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
E. Miscellaneous income	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
F. Revenue per Acre	$555.50	$284.05	$225.25	$198.80	$212.76	$216.50
Costs per Acre						
1. Seed	$10.17	$33.80	$7.92	$26.40	$14.80	$8.80
2. Herbicide	$3.03	$34.38	$34.38	$24.40	$37.10	$9.48
3. Insecticide / Fungicide	$10.02	$1.00	$0.00	$0.00	$15.10	$0.00
4. Fertilizer and Lime	$22.13	$55.80	$47.52	$8.03	$40.32	$30.48
5. Crop Consulting	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
6. Crop Insurance	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
7. Drying	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
8. Miscellaneous	$5.50	$5.50	$5.50	$5.50	$5.50	$5.50
9. Custom Hire / Machinery Expense	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
10. Non-machinery Labor	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
11. Irrigation						
a. Labor	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
b. Fuel and Oil	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
c. Repairs and Maintenance	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
d. Depreciation on Equipment and Well	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
e. Interest on Equipment	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
12. Land Charge / Rent	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
13. Interest	$1.53	$3.91	$2.86	$1.93	$3.38	$1.63
H. Total Cost per Acre	$52.38	$134.40	$98.18	$66.26	$116.21	$55.90
I. Returns per Acre	$503.12	$149.65	$127.07	$132.54	$96.55	$160.60

Table 16. Status Quo Projected Impacts on Future Hydrology, Crop Mix, and Water-Use in Subarea 6 of Sheridan County

							Corn					
		Hydrology			Flood Technology			Center Pivot Technology			Total	
Time	ST	GPM	GDAR	Acres	ConvCP	GWU	Acres	ConvDL	GWU	TWU	AAFWU	∆ST
1	89.8	587.4	0.249	1667	0	28220	16062	0	214728	26723.6	1.08	1.15
2	88.6	575.4	0.244	1417	250	23987	16312	0	218070	26474.1	1.07	1.14
3	87.5	563.7	0.239	1204	462	20389	16525	0	220910	26406.1	1.06	1.13
4	86.4	552.1	0.234	1023	643	17330	16705	0	223325	26348.3	1.06	1.13
5	85.2	540.6	0.229	870	797	14731	16859	0	225377	26299.2	1.06	1.13
6	84.1	529.3	0.225	739	927	12521	16989	0	227121	26257.5	1.06	1.12
7	83.0	518.1	0.220	629	1038	10643	17100	0	228604	26222.0	1.06	1.12
8	81.9	507.1	0.215	534	1132	9047	17195	0	229864	26191.9	1.06	1.12
9	80.7	496.1	0.210	454	1212	7690	17275	0	230936	26166.2	1.06	1.12
10	79.6	485.2	0.206	386	1281	6536	17343	0	231846	26144.4	1.05	1.12
11	78.5	474.5	0.201	328	1338	5556	17401	0	232620	26125.9	1.05	1.12
12	77.4	463.9	0.197	274	1392	4647	17175	279	229603	25792.1	1.05	1.09
13	76.3	453.5	0.192	228	1438	3862	16837	664	225079	25341.2	1.05	1.07
14	75.2	443.5	0.188	190	1477	3210	16502	1037	220608	24906.2	1.05	1.04
15	74.2	433.9	0.184	158	1509	2669	16173	1398	216207	24486.7	1.05	1.01
16	73.2	424.6	0.180	131	1535	2220	15850	1748	211888	24081.9	1.05	0.98
17	72.2	415.6	0.176	109	1557	1847	15534	2086	207659	23691.3	1.05	0.96
18	71.2	406.9	0.173	91	1576	1537	15224	2414	203526	23314.3	1.04	0.93
19	70.3	398.5	0.169	76	1591	1280	14923	2731	199494	22950.2	1.04	0.91
20	69.4	390.4	0.166	63	1604	1066	14629	3037	195563	22598.5	1.04	0.89
21	68.5	382.5	0.162	52	1614	887	14342	3334	191734	22258.6	1.04	0.87
22	67.6	374.9	0.159	44	1623	739	14064	3622	188009	21901.2	1.04	0.84
23	66.8	367.5	0.156	36	1630	616	13793	3899	184393	21490.1	1.04	0.82
24	66.0	360.4	0.153	30	1636	514	13532	4166	180904	21095.1	1.04	0.79
25	65.2	353.6	0.150	25	1641	428	13280	4423	177537	20715.2	1.04	0.77
26	64.4	347.1	0.147	21	1645	357	13037	4670	174288	20349.8	1.04	0.74
27	63.7	340.8	0.145	18	1649	298	12803	4908	171154	19998.2	1.04	0.72
28	63.0	334.7	0.142	15	1652	249	12577	5138	168129	19659.8	1.03	0.70
29	62.3	328.8	0.140	12	1654	208	12358	5358	165210	19333.8	1.03	0.68
30	61.6	323.2	0.137	10	1656	174	12148	5571	162393	19019.7	1.03	0.66
31	60.9	317.7	0.135	9	1658	145	11944	5776	159674	18717.0	1.03	0.64
32	60.3	312.5	0.133	7	1659	121	11748	5974	157049	18425.2	1.03	0.62
33	59.7	307.4	0.130	6	1661	101	11558	6165	154514	18143.6	1.03	0.60
34	59.1	302.5	0.128	5	1661	85	11375	6349	152065	17872.0	1.03	0.58
35	58.5	297.8	0.126	4	1662	71	11198	6527	149700	17609.8	1.03	0.57
36	57.9	293.3	0.124	4	1663	59	11027	6698	147414	17356.7	1.03	0.55
37	57.4	288.9	0.123	3	1664	50	10862	6864	145205	17112.1	1.03	0.53
38	56.8	284.6	0.121	2	1664	42	10702	7024	143070	16875.9	1.03	0.52
39	56.3	280.5	0.119	2	1664	35	10548	7179	141005	16643.7	1.03	0.50
41	55.3	272.7	0.116	1	1665	25	10254	7473	137081	16196.8	1.03	0.47
43	54.4	265.4	0.113	1	1665	17	9980	7748	133413	15779.5	1.02	0.45
45	53.5	258.5	0.110	1	1666	12	9723	8005	129983	15389.4	1.02	0.42
47	52.7	252.1	0.107	1	1666	9	9483	8245	126771	15024.3	1.02	0.40
49	51.9	246.2	0.104	0	1666	6	9258	8471	123762	14682.2	1.02	0.38
51	51.1	240.5	0.102	0	1666	4	9047	8682	120940	14361.6	1.02	0.36
52	50.8	237.9	0.101	0	1666	4	8946	8783	119595	14208.7	1.02	0.35
53	50.4	235.3	0.100	0	1666	3	8849	8880	118292	14060.7	1.02	0.34
54	50.1	232.8	0.099	0	1666	3	8754	8975	117029	13917.2	1.02	0.33
55	49.8	230.3	0.098	0	1666	2	8663	9066	115805	13778.1	1.02	0.32
56	49.5	228.0	0.097	0	1666	2	8574	9155	114618	13643.3	1.02	0.31
57	49.1	225.7	0.096	0	1666	2	8488	9241	113467	13512.6	1.02	0.30
58	48.8	223.5	0.095	0	1666	1	8404	9325	112351	13385.8	1.02	0.29
59	48.6	221.3	0.094	0	1666	1	8323	9405	111269	13262.9	1.02	0.29
60	48.3	219.2	0.093	0	1666	1	8245	9484	110219	13143.6	1.02	0.28

Time is time measured in years; ST is saturated thickness measured in feet; GPM is gallons per minute; GDAR is the gross daily application of the well measured in inches; ConvCP is the number of flood irrigated acreage converted to center pivot technology; GWU is the gross water use measured in inches for corn; ConvDL is the number of center pivot acres converted to dryland production; TWU is the total water use measured in acre-feet for all crops; AAFWU is the average acre foot water usage per acre measured in feet; ∆ST is the change in saturated thickness measured in feet..

Table 17. Status Quo Projected Impacts on Future Gross Profits in Subarea 6 of Sheridan County

Time	Alfalfa	Corn	Sorghum	Soybeans	Sunflowers	Wheat	Non Irrigated	Program Payments	Total
1	$168,344	$4,003,719	$137,510	$720,320	$109,884	$140,051	$0	$0	$5,279,829
2	$168,344	$4,003,719	$137,510	$720,320	$109,884	$140,051	$0	$0	$5,279,829
3	$168,344	$4,003,719	$137,510	$720,320	$108,335	$140,051	$1,497	$0	$5,279,776
4	$168,344	$4,003,719	$137,510	$720,320	$107,018	$140,051	$2,769	$0	$5,279,731
5	$168,344	$4,003,719	$137,510	$720,320	$105,899	$140,051	$3,850	$0	$5,279,693
6	$168,344	$4,003,719	$137,510	$720,320	$104,947	$140,051	$4,769	$0	$5,279,661
7	$168,344	$4,003,719	$137,510	$720,320	$104,138	$140,051	$5,550	$0	$5,279,633
8	$168,344	$4,003,719	$137,510	$720,320	$103,451	$140,051	$6,214	$0	$5,279,610
9	$168,344	$4,003,719	$137,510	$720,320	$102,867	$140,051	$6,779	$0	$5,279,590
10	$168,344	$4,003,719	$137,510	$720,320	$102,370	$140,051	$7,258	$0	$5,279,573
11	$168,344	$4,003,719	$137,510	$720,320	$101,948	$140,051	$7,666	$0	$5,279,558
12	$165,691	$3,940,626	$137,510	$720,320	$101,589	$140,051	$39,872	$0	$5,245,659
13	$162,038	$3,853,729	$137,510	$720,320	$101,284	$140,051	$84,046	$0	$5,198,977
14	$158,497	$3,769,517	$137,510	$720,320	$101,024	$140,051	$126,819	$0	$5,153,738
15	$155,067	$3,687,960	$137,510	$720,320	$100,804	$140,051	$168,214	$0	$5,109,927
16	$151,748	$3,609,008	$137,510	$720,320	$100,617	$140,051	$208,262	$0	$5,067,516
17	$148,535	$3,532,596	$137,510	$720,320	$100,458	$140,051	$247,001	$0	$5,026,470
18	$145,426	$3,458,648	$137,510	$720,320	$100,322	$140,051	$284,471	$0	$4,986,749
19	$142,417	$3,387,085	$137,510	$720,320	$100,207	$140,051	$320,718	$0	$4,948,309
20	$139,504	$3,317,824	$137,510	$720,320	$100,109	$140,051	$355,786	$0	$4,911,105
21	$136,685	$3,250,781	$137,510	$720,320	$100,026	$140,051	$389,720	$0	$4,875,094
22	$133,956	$3,185,871	$136,691	$716,033	$99,956	$140,051	$425,812	$0	$4,838,370
23	$131,319	$3,123,149	$134,014	$702,008	$99,896	$140,051	$468,164	$0	$4,798,600
24	$128,783	$3,062,837	$131,437	$688,510	$99,845	$140,051	$508,891	$0	$4,760,354
25	$126,344	$3,004,822	$128,957	$675,517	$99,801	$140,051	$548,069	$0	$4,723,560
26	$123,996	$2,948,996	$126,568	$663,005	$99,764	$140,051	$585,770	$0	$4,688,151
27	$121,737	$2,895,256	$124,268	$650,955	$99,733	$140,051	$622,063	$0	$4,654,062
28	$119,561	$2,843,505	$122,052	$639,346	$99,706	$140,051	$657,013	$0	$4,621,233
29	$117,464	$2,793,651	$119,916	$628,158	$99,684	$140,051	$690,682	$0	$4,589,606
30	$115,444	$2,745,606	$117,857	$617,373	$99,664	$140,051	$723,130	$0	$4,559,125
31	$113,497	$2,699,290	$115,872	$606,973	$99,648	$140,051	$754,410	$0	$4,529,740
32	$111,619	$2,654,623	$113,957	$596,940	$99,634	$140,051	$784,576	$0	$4,501,400
33	$109,807	$2,611,532	$112,109	$587,260	$99,622	$140,051	$813,678	$0	$4,474,059
34	$108,058	$2,569,948	$110,325	$577,917	$99,612	$140,051	$841,761	$0	$4,447,674
35	$106,371	$2,529,806	$108,603	$568,897	$99,604	$140,051	$868,872	$0	$4,422,203
36	$104,741	$2,491,042	$106,940	$560,185	$99,596	$140,051	$895,051	$0	$4,397,606
37	$103,166	$2,453,599	$105,333	$551,769	$99,590	$140,051	$920,338	$0	$4,373,847
38	$101,645	$2,417,420	$103,781	$543,637	$99,585	$140,051	$944,771	$0	$4,350,890
39	$100,175	$2,382,453	$102,280	$535,777	$98,753	$140,051	$969,185	$0	$4,328,673
40	$98,754	$2,348,664	$100,830	$528,180	$97,350	$140,051	$993,355	$0	$4,307,184
41	$97,381	$2,316,017	$99,429	$520,841	$95,994	$140,051	$1,016,708	$0	$4,286,422
42	$96,055	$2,284,465	$98,075	$513,747	$94,685	$140,051	$1,039,278	$0	$4,266,356
43	$94,772	$2,253,964	$96,766	$506,889	$93,419	$140,051	$1,061,096	$0	$4,246,957
44	$93,532	$2,224,470	$95,500	$500,257	$92,195	$140,051	$1,082,194	$0	$4,228,200
45	$92,333	$2,195,944	$94,275	$493,843	$91,012	$140,051	$1,102,599	$0	$4,210,057
46	$91,172	$2,168,347	$93,091	$487,638	$89,867	$140,051	$1,122,340	$0	$4,192,506
47	$90,050	$2,141,643	$91,944	$481,633	$88,760	$140,051	$1,141,442	$0	$4,175,522
48	$88,963	$2,115,796	$90,835	$475,821	$87,688	$140,051	$1,159,931	$0	$4,159,084
49	$87,911	$2,090,774	$89,761	$470,194	$86,650	$140,051	$1,177,830	$0	$4,143,170
50	$86,892	$2,066,546	$88,720	$464,746	$85,646	$140,051	$1,195,160	$0	$4,127,761
51	$85,905	$2,043,081	$87,713	$459,469	$84,673	$140,051	$1,211,945	$0	$4,112,838
52	$84,950	$2,020,351	$86,737	$454,357	$83,731	$140,051	$1,228,204	$0	$4,098,381
53	$84,024	$1,998,329	$85,792	$449,405	$82,818	$140,051	$1,243,957	$0	$4,084,375
54	$83,126	$1,976,987	$84,876	$444,606	$81,933	$140,051	$1,259,223	$0	$4,070,802
55	$82,257	$1,956,303	$83,988	$439,954	$81,076	$140,051	$1,274,019	$0	$4,057,647
56	$81,413	$1,936,251	$83,127	$435,445	$80,244	$140,051	$1,288,362	$0	$4,044,894
57	$80,596	$1,916,809	$82,292	$431,073	$79,439	$140,051	$1,302,269	$0	$4,032,529
58	$79,803	$1,897,956	$81,483	$426,833	$78,657	$140,051	$1,315,755	$0	$4,020,538
59	$79,034	$1,879,670	$80,698	$422,720	$77,899	$140,051	$1,328,835	$0	$4,008,908
60	$78,289	$1,861,932	$79,936	$418,731	$77,164	$140,051	$1,341,524	$0	$3,997,627

Table 18. Impacts on Future Hydrology, Crop Mix, and Water-Use in Subarea 6 of Sheridan County, Based on a Limited Irrigation Scenario.

						Corn						
	Hydrology			Flood Technology			Center Pivot Technology				Total	
Time	ST	GPM	GDAR	Acres	ConvCP	GWU	Acres	ConvDL	GWU	TWU	AAFWU	ΔST
1	89.8	587.4	0.249	1667	0	19754	16062	0	150310	18706.5	0.75	0.64
2	89.2	580.8	0.246	1417	250	16791	16312	0	152649	18531.8	0.75	0.63
3	88.5	574.3	0.244	1204	462	14272	16525	0	154637	18484.3	0.74	0.62
4	87.9	567.9	0.241	1023	643	12131	16705	0	156327	18443.8	0.74	0.62
5	87.3	561.5	0.238	870	797	10312	16859	0	157764	18409.5	0.74	0.62
6	86.7	555.2	0.236	739	927	8765	16989	0	158985	18380.2	0.74	0.62
7	86.1	548.9	0.233	629	1038	7450	17100	0	160023	18355.4	0.74	0.61
8	85.4	542.7	0.230	534	1132	6333	17195	0	160905	18334.3	0.74	0.61
9	84.8	536.5	0.228	454	1212	5383	17275	0	161655	18316.4	0.74	0.61
10	84.2	530.4	0.225	386	1281	4575	17343	0	162292	18301.1	0.74	0.61
11	83.6	524.3	0.222	328	1338	3889	17401	0	162834	18288.1	0.74	0.61
12	83.0	518.2	0.220	279	1388	3306	17450	0	163295	18277.1	0.74	0.61
13	82.4	512.2	0.217	237	1429	2810	17492	0	163686	18267.8	0.74	0.61
14	81.8	506.2	0.215	201	1465	2388	17527	0	164019	18259.8	0.74	0.61
15	81.2	500.3	0.212	171	1495	2030	17558	0	164302	18253.0	0.74	0.61
16	80.6	494.3	0.210	146	1521	1726	17583	0	164542	18247.3	0.74	0.61
17	80.0	488.4	0.207	124	1543	1467	17605	0	164747	18242.4	0.74	0.61
18	79.4	482.6	0.205	105	1561	1247	17624	0	164920	18238.2	0.74	0.61
19	78.7	476.7	0.202	89	1577	1060	17639	0	165068	18234.7	0.74	0.61
20	78.1	470.9	0.200	76	1591	901	17653	0	165193	18231.7	0.74	0.61
21	77.5	465.2	0.197	65	1602	766	17664	0	165300	18229.1	0.74	0.61
22	76.9	459.4	0.195	55	1612	651	17674	0	165391	18227.0	0.74	0.61
23	76.3	453.7	0.192	47	1620	553	17682	0	165468	18225.1	0.74	0.61
24	75.7	448.0	0.190	40	1627	470	17689	0	165533	18223.6	0.74	0.61
25	75.1	442.3	0.188	34	1633	400	17695	0	165589	18222.2	0.74	0.61
26	74.5	436.7	0.185	29	1638	340	17700	0	165636	18221.1	0.74	0.61
27	73.9	431.1	0.183	24	1642	289	17704	0	165677	18220.1	0.74	0.61
28	73.3	425.5	0.181	21	1646	245	17708	0	165711	18219.3	0.74	0.61
29	72.7	420.0	0.178	18	1649	209	17711	0	165740	18218.6	0.74	0.61
30	72.1	414.5	0.176	15	1652	177	17714	0	165765	18218.0	0.74	0.61
31	71.5	409.0	0.174	13	1654	151	17716	0	165786	18217.5	0.74	0.61
32	70.9	403.5	0.171	11	1656	128	17718	0	165803	18217.1	0.74	0.61
33	70.3	398.1	0.169	9	1657	109	17720	0	165819	18216.7	0.74	0.61
34	69.7	392.7	0.167	8	1659	93	17721	0	165831	18216.4	0.74	0.61
35	69.1	387.3	0.164	7	1660	79	17722	0	165842	18216.2	0.74	0.61
36	68.4	381.9	0.162	6	1661	67	17723	0	165852	18215.9	0.74	0.61
37	67.8	376.6	0.160	5	1662	57	17700	24	165634	18196.6	0.74	0.60
38	67.2	371.3	0.158	4	1662	48	17452	273	163316	17999.3	0.73	0.59
39	66.6	366.2	0.155	3	1663	40	17211	515	161057	17807.1	0.73	0.58
41	65.5	356.3	0.151	2	1664	28	16746	980	156711	17437.5	0.73	0.56
43	64.4	346.9	0.147	2	1665	20	16305	1422	152582	17086.7	0.73	0.53
45	63.4	337.9	0.143	1	1665	14	15886	1842	148656	16753.3	0.73	0.51
47	62.3	329.4	0.140	1	1666	10	15487	2241	144922	16436.3	0.73	0.49
49	61.4	321.4	0.136	1	1666	7	15107	2621	141368	16134.7	0.73	0.47
51	60.4	313.7	0.133	0	1666	5	14745	2983	137984	15847.6	0.73	0.45
52	60.0	309.9	0.132	0	1666	4	14571	3158	136352	15709.2	0.73	0.44
53	59.5	306.3	0.130	0	1666	3	14401	3328	134759	15574.0	0.73	0.43
54	59.1	302.8	0.128	0	1666	3	14234	3494	133204	15442.1	0.73	0.43
55	58.7	299.3	0.127	0	1666	2	14072	3657	131685	15286.9	0.73	0.42
56	58.3	296.0	0.126	0	1666	2	13914	3814	130207	15124.0	0.73	0.41
57	57.9	292.7	0.124	0	1666	2	13761	3968	128773	14965.8	0.73	0.40
58	57.5	289.5	0.123	0	1666	1	13612	4117	127379	14812.2	0.73	0.39
59	57.1	286.5	0.122	0	1666	1	13467	4261	126026	14662.9	0.73	0.38
60	56.7	283.5	0.120	0	1666	1	13327	4402	124711	14518.0	0.73	0.37

Time is time measured in years; ST is saturated thickness measured in feet; GPM is gallons per minute; GDAR is the gross daily application of the well measured in inches; ConvCP is the number of flood irrigated acreage converted to center pivot technology; GWU is the gross water use measured in inches for corn; ConvDL is the number of center pivot acres converted to dryland production; TWU is the total water use measured in acre-feet for all crops; AAFWU is the average acre foot water usage per acre measured in feet; ΔST is the change in saturated thickness measured in feet.

Table 19. Impacts on Future on Crop Revenues in Subarea 6 of Sheridan County, Based on a Limited Irrigation Scenario

Time	Alfalfa	Corn	Sorghum	Soybeans	Sunflowers	Wheat	Non Irrigated	Program Payments	Total
1	$124,402	$3,583,519	$124,473	$658,287	$98,325	$128,455	$0	$0	$4,717,461
2	$124,402	$3,583,519	$124,473	$658,287	$98,325	$128,455	$0	$0	$4,717,461
3	$124,402	$3,583,519	$124,473	$658,287	$96,939	$128,455	$1,497	$0	$4,717,571
4	$124,402	$3,583,519	$124,473	$658,287	$95,760	$128,455	$2,769	$0	$4,717,665
5	$124,402	$3,583,519	$124,473	$658,287	$94,759	$128,455	$3,850	$0	$4,717,745
6	$124,402	$3,583,519	$124,473	$658,287	$93,907	$128,455	$4,769	$0	$4,717,812
7	$124,402	$3,583,519	$124,473	$658,287	$93,184	$128,455	$5,550	$0	$4,717,870
8	$124,402	$3,583,519	$124,473	$658,287	$92,569	$128,455	$6,214	$0	$4,717,919
9	$124,402	$3,583,519	$124,473	$658,287	$92,046	$128,455	$6,779	$0	$4,717,960
10	$124,402	$3,583,519	$124,473	$658,287	$91,601	$128,455	$7,258	$0	$4,717,996
11	$124,402	$3,583,519	$124,473	$658,287	$91,223	$128,455	$7,666	$0	$4,718,026
12	$124,402	$3,583,519	$124,473	$658,287	$90,902	$128,455	$8,013	$0	$4,718,051
13	$124,402	$3,583,519	$124,473	$658,287	$90,629	$128,455	$8,308	$0	$4,718,073
14	$124,402	$3,583,519	$124,473	$658,287	$90,397	$128,455	$8,558	$0	$4,718,091
15	$124,402	$3,583,519	$124,473	$658,287	$90,200	$128,455	$8,771	$0	$4,718,107
16	$124,402	$3,583,519	$124,473	$658,287	$90,033	$128,455	$8,952	$0	$4,718,120
17	$124,402	$3,583,519	$124,473	$658,287	$89,890	$128,455	$9,106	$0	$4,718,132
18	$124,402	$3,583,519	$124,473	$658,287	$89,769	$128,455	$9,236	$0	$4,718,141
19	$124,402	$3,583,519	$124,473	$658,287	$89,666	$128,455	$9,347	$0	$4,718,149
20	$124,402	$3,583,519	$124,473	$658,287	$89,579	$128,455	$9,442	$0	$4,718,156
21	$124,402	$3,583,519	$124,473	$658,287	$89,504	$128,455	$9,522	$0	$4,718,162
22	$124,402	$3,583,519	$124,473	$658,287	$89,441	$128,455	$9,590	$0	$4,718,167
23	$124,402	$3,583,519	$124,473	$658,287	$89,387	$128,455	$9,648	$0	$4,718,172
24	$124,402	$3,583,519	$124,473	$658,287	$89,342	$128,455	$9,698	$0	$4,718,175
25	$124,402	$3,583,519	$124,473	$658,287	$89,303	$128,455	$9,740	$0	$4,718,178
26	$124,402	$3,583,519	$124,473	$658,287	$89,270	$128,455	$9,775	$0	$4,718,181
27	$124,402	$3,583,519	$124,473	$658,287	$89,242	$128,455	$9,806	$0	$4,718,183
28	$124,402	$3,583,519	$124,473	$658,287	$89,218	$128,455	$9,831	$0	$4,718,185
29	$124,402	$3,583,519	$124,473	$658,287	$89,198	$128,455	$9,853	$0	$4,718,187
30	$124,402	$3,583,519	$124,473	$658,287	$89,180	$128,455	$9,872	$0	$4,718,188
31	$124,402	$3,583,519	$124,473	$658,287	$89,166	$128,455	$9,888	$0	$4,718,189
32	$124,402	$3,583,519	$124,473	$658,287	$89,153	$128,455	$9,901	$0	$4,718,190
33	$124,402	$3,583,519	$124,473	$658,287	$89,143	$128,455	$9,912	$0	$4,718,191
34	$124,402	$3,583,519	$124,473	$658,287	$89,134	$128,455	$9,922	$0	$4,718,192
35	$124,402	$3,583,519	$124,473	$658,287	$89,126	$128,455	$9,930	$0	$4,718,192
36	$124,402	$3,583,519	$124,473	$658,287	$89,120	$128,455	$9,937	$0	$4,718,193
37	$124,233	$3,578,647	$124,473	$658,287	$89,114	$128,455	$12,692	$0	$4,715,901
38	$122,489	$3,528,420	$124,473	$658,287	$89,109	$128,455	$41,033	$0	$4,692,267
39	$120,791	$3,479,501	$124,473	$658,287	$89,105	$128,455	$68,636	$0	$4,669,248
40	$119,137	$3,431,847	$124,473	$658,287	$89,102	$128,455	$95,524	$0	$4,646,825
41	$117,525	$3,385,419	$124,473	$658,287	$89,099	$128,455	$121,720	$0	$4,624,978
42	$115,955	$3,340,175	$124,473	$658,287	$89,097	$128,455	$147,247	$0	$4,603,689
43	$114,424	$3,296,079	$124,473	$658,287	$89,094	$128,455	$172,127	$0	$4,582,940
44	$112,932	$3,253,094	$124,473	$658,287	$89,093	$128,455	$196,379	$0	$4,562,713
45	$111,477	$3,211,185	$124,473	$658,287	$89,091	$128,455	$220,025	$0	$4,542,993
46	$110,058	$3,170,318	$124,473	$658,287	$89,090	$128,455	$243,082	$0	$4,523,763
47	$108,674	$3,130,460	$124,473	$658,287	$89,089	$128,455	$265,569	$0	$4,505,008
48	$107,325	$3,091,580	$124,473	$658,287	$89,088	$128,455	$287,505	$0	$4,486,713
49	$106,008	$3,053,648	$124,473	$658,287	$89,087	$128,455	$308,906	$0	$4,468,864
50	$104,723	$3,016,636	$124,473	$658,287	$89,086	$128,455	$329,787	$0	$4,451,447
51	$103,469	$2,980,514	$124,473	$658,287	$89,086	$128,455	$350,167	$0	$4,434,450
52	$102,245	$2,945,257	$124,473	$658,287	$89,085	$128,455	$370,058	$0	$4,417,860
53	$101,050	$2,910,838	$124,473	$658,287	$89,085	$128,455	$389,476	$0	$4,401,664
54	$99,883	$2,877,233	$124,473	$658,287	$89,085	$128,455	$408,435	$0	$4,385,851
55	$98,744	$2,844,417	$123,501	$653,142	$89,084	$128,455	$431,213	$0	$4,368,556
56	$97,636	$2,812,499	$122,115	$645,813	$89,084	$128,455	$455,294	$0	$4,350,896
57	$96,560	$2,781,506	$120,769	$638,697	$89,084	$128,455	$478,677	$0	$4,333,748
58	$95,515	$2,751,407	$119,462	$631,785	$89,084	$128,455	$501,386	$0	$4,317,094
59	$94,500	$2,722,170	$118,193	$625,072	$89,084	$128,455	$523,444	$0	$4,300,918
60	$93,514	$2,693,766	$116,960	$618,550	$89,083	$128,455	$544,874	$0	$4,285,202

Table 20. Impacts on Future Hydrology, and Water-Use in Subarea 6 of Sheridan County, Based on a Water Rights Buyout Scenario.

						Corn						
	Hydrology			Flood Technology			Center Pivot Technology				Total	
Time	ST	GPM	GDAR	Acres	ConvCP	GWU	Acres	ConvDL	GWU	TWU	AAFWU	ΔST
1	89.8	587.4	0.25	1667	0	28220	15176	886	202878	25420.1	1.1	1.07
2	88.7	576.3	0.24	1417	250	23987	14539	1773	194369	23867.1	1.1	0.97
3	87.8	566.3	0.24	1204	212	20389	13865	2659	185359	22503.0	1.1	0.88
4	86.9	557.2	0.24	1023	181	17330	13160	3546	175923	21147.9	1.1	0.79
5	86.1	549.1	0.23	870	154	14731	12427	4432	166125	19800.7	1.1	0.71
6	85.4	542.0	0.23	739	130	12521	11671	5319	156019	18459.9	1.1	0.62
7	84.8	535.7	0.23	629	111	10643	11782	5319	157502	18428.3	1.1	0.62
8	84.1	529.5	0.22	534	94	9047	11876	5319	158763	18401.4	1.1	0.62
9	83.5	523.4	0.22	454	80	7690	11956	5319	159834	18378.6	1.1	0.62
10	82.9	517.3	0.22	386	68	6536	12024	5319	160744	18359.1	1.1	0.61
11	82.3	511.2	0.22	328	58	5556	12082	5319	161518	18342.6	1.1	0.61
12	81.7	505.1	0.21	279	49	4722	12131	5319	162176	18328.6	1.1	0.61
13	81.1	499.1	0.21	237	42	4014	12173	5319	162736	18316.7	1.1	0.61
14	80.4	493.2	0.21	201	36	3412	12209	5319	163211	18306.5	1.1	0.61
15	79.8	487.3	0.21	171	30	2900	12239	5319	163615	18297.9	1.1	0.61
16	79.2	481.4	0.20	146	26	2465	12265	5319	163958	18290.6	1.1	0.61
17	78.6	475.5	0.20	124	22	2095	12286	5319	164250	18284.4	1.1	0.61
18	78.0	469.7	0.20	105	19	1775	12260	5364	163902	18227.9	1.1	0.61
19	77.4	463.9	0.20	88	17	1490	12126	5514	162110	18052.1	1.0	0.59
20	76.8	458.3	0.19	74	14	1251	11993	5662	160325	17880.8	1.0	0.58
21	76.2	452.8	0.19	62	12	1051	11860	5807	158552	17713.6	1.0	0.57
22	75.7	447.4	0.19	52	10	882	11729	5948	156796	17550.6	1.0	0.56
23	75.1	442.1	0.19	44	8	741	11599	6086	155060	17391.6	1.0	0.55
24	74.5	437.0	0.19	37	7	623	11471	6221	153346	17236.3	1.0	0.54
25	74.0	432.0	0.18	31	6	523	11344	6353	151657	17084.8	1.0	0.53
26	73.5	427.1	0.18	26	5	440	11220	6483	149995	16936.8	1.0	0.52
27	72.9	422.3	0.18	22	4	370	11098	6609	148360	16792.3	1.0	0.51
28	72.4	417.6	0.18	18	3	311	10978	6733	146752	16651.1	1.0	0.50
29	71.9	413.0	0.18	15	3	261	10859	6854	145174	16513.1	1.0	0.50
30	71.4	408.5	0.17	13	2	220	10744	6972	143624	16378.2	1.0	0.49
31	70.9	404.1	0.17	11	2	185	10630	7088	142104	16246.4	1.0	0.48
32	70.5	399.8	0.17	9	2	155	10518	7201	140612	16117.4	1.0	0.47
33	70.0	395.6	0.17	8	1	131	10409	7312	139149	15991.3	1.0	0.46
34	69.5	391.5	0.17	6	1	110	10301	7421	137714	15867.9	1.0	0.45
35	69.1	387.5	0.16	5	1	92	10196	7527	136308	15747.2	1.0	0.45
36	68.6	383.5	0.16	5	1	78	10093	7631	134929	15629.0	1.0	0.44
37	68.2	379.7	0.16	4	1	65	9992	7733	133577	15513.4	1.0	0.43
38	67.8	375.9	0.16	3	1	55	9893	7833	132252	15389.0	1.0	0.42
39	67.3	372.2	0.16	3	1	46	9796	7930	130955	15245.2	1.0	0.41
41	66.5	365.1	0.15	2	0	33	9609	8118	128458	14968.6	1.0	0.40
43	65.7	358.3	0.15	1	0	23	9431	8296	126083	14705.7	1.0	0.38
45	65.0	351.9	0.15	1	0	17	9262	8466	123822	14455.9	1.0	0.36
47	64.3	345.7	0.15	1	0	12	9101	8627	121671	14218.3	1.0	0.35
49	63.6	339.9	0.14	0	0	8	8948	8780	119623	13992.1	1.0	0.33
51	62.9	334.4	0.14	0	0	6	8802	8926	117671	13776.8	1.0	0.32
52	62.6	331.7	0.14	0	0	5	8732	8997	116731	13672.9	1.0	0.31
53	62.3	329.1	0.14	0	0	4	8663	9065	115812	13571.6	1.0	0.31
54	62.0	326.5	0.14	0	0	4	8596	9133	114915	13472.7	1.0	0.30
55	61.7	324.0	0.14	0	0	3	8531	9198	114039	13376.1	1.0	0.29
56	61.4	321.6	0.14	0	0	3	8467	9262	113184	13281.7	1.0	0.29
57	61.1	319.2	0.14	0	0	2	8404	9325	112349	13189.6	1.0	0.28
58	60.8	316.9	0.13	0	0	2	8343	9386	111533	13099.7	1.0	0.27
59	60.6	314.6	0.13	0	0	2	8283	9445	110736	13011.8	1.0	0.27
60	60.3	312.4	0.13	0	0	1	8225	9504	109957	12925.9	1.0	0.26

Time is time measured in years; ST is saturated thickness measured in feet; GPM is gallons per minute; GDAR is the gross daily application of the well measured in inches; ConvCP is the number of flood irrigated acreage converted to center pivot technology; GWU is the gross water use measured in inches for corn; ConvDL is the number of center pivot acres converted to dryland production; TWU is the total water use measured in acre-feet for all crops; AAFWU is the average acre foot water usage per acre measured in feet; ∆ST is the change in saturated thickness measured in feet.

Table 21. Impacts on Future on Crop Revenues in Subarea 6 of Sheridan County, Based on a Water Rights Buyout Scenario

Time	Alfalfa	Corn	Sorghum	Soybeans	Sunflowers	Wheat	Non Irrigated	Program Payments	Total
1	$159,927	$3,803,533	$130,634	$684,304	$104,390	$133,048	$139,471	$994,200	$6,149,508
2	$151,510	$3,603,347	$123,759	$648,288	$98,896	$126,046	$278,942	$994,200	$6,024,988
3	$143,093	$3,403,161	$116,883	$612,272	$93,402	$119,043	$418,413	$994,200	$5,900,468
4	$134,675	$3,202,975	$110,008	$576,256	$87,908	$112,041	$557,884	$994,200	$5,775,947
5	$126,258	$3,002,789	$103,132	$540,240	$82,413	$105,038	$697,355	$994,200	$5,651,427
6	$117,841	$2,802,603	$96,257	$504,224	$76,919	$98,036	$836,826	$994,200	$5,526,906
7	$117,841	$2,802,603	$96,257	$504,224	$76,919	$98,036	$836,826	$0	$4,532,706
8	$117,841	$2,802,603	$96,257	$504,224	$76,919	$98,036	$836,826	$0	$4,532,706
9	$117,841	$2,802,603	$96,257	$504,224	$76,919	$98,036	$836,826	$0	$4,532,706
10	$117,841	$2,802,603	$96,257	$504,224	$76,919	$98,036	$836,826	$0	$4,532,706
11	$117,841	$2,802,603	$96,257	$504,224	$76,919	$98,036	$836,826	$0	$4,532,706
12	$117,841	$2,802,603	$96,257	$504,224	$76,919	$98,036	$836,826	$0	$4,532,706
13	$117,841	$2,802,603	$96,257	$504,224	$76,919	$98,036	$836,826	$0	$4,532,706
14	$117,841	$2,802,603	$96,257	$504,224	$76,919	$98,036	$836,826	$0	$4,532,706
15	$117,841	$2,802,603	$96,257	$504,224	$76,919	$98,036	$836,826	$0	$4,532,706
16	$117,841	$2,802,603	$96,257	$504,224	$76,919	$98,036	$836,826	$0	$4,532,706
17	$117,841	$2,802,603	$96,257	$504,224	$76,919	$98,036	$836,826	$0	$4,532,706
18	$117,413	$2,792,436	$96,257	$504,224	$76,919	$98,036	$841,960	$0	$4,527,245
19	$115,981	$2,758,376	$96,257	$504,224	$76,919	$98,036	$859,159	$0	$4,508,952
20	$114,579	$2,725,037	$96,257	$504,224	$76,919	$98,036	$875,993	$0	$4,491,046
21	$113,208	$2,692,416	$96,257	$504,224	$76,919	$98,036	$892,466	$0	$4,473,525
22	$111,866	$2,660,503	$96,257	$504,224	$76,919	$98,036	$908,580	$0	$4,456,385
23	$110,554	$2,629,289	$96,257	$504,224	$76,919	$98,036	$924,341	$0	$4,439,620
24	$109,270	$2,598,761	$96,257	$504,224	$76,919	$98,036	$939,757	$0	$4,423,224
25	$108,015	$2,568,905	$96,257	$504,224	$76,919	$98,036	$954,833	$0	$4,407,188
26	$106,787	$2,539,705	$96,257	$504,224	$76,919	$98,036	$969,577	$0	$4,391,505
27	$105,586	$2,511,147	$96,257	$504,224	$76,919	$98,036	$983,998	$0	$4,376,166
28	$104,412	$2,483,213	$96,257	$504,224	$76,919	$98,036	$998,103	$0	$4,361,164
29	$103,263	$2,455,889	$96,257	$504,224	$76,919	$98,036	$1,011,901	$0	$4,346,488
30	$102,139	$2,429,158	$96,257	$504,224	$76,919	$98,036	$1,025,399	$0	$4,332,131
31	$101,039	$2,403,004	$96,257	$504,224	$76,919	$98,036	$1,038,605	$0	$4,318,084
32	$99,963	$2,377,413	$96,257	$504,224	$76,919	$98,036	$1,051,527	$0	$4,304,339
33	$98,910	$2,352,368	$96,257	$504,224	$76,919	$98,036	$1,064,173	$0	$4,290,888
34	$97,879	$2,327,856	$96,257	$504,224	$76,919	$98,036	$1,076,551	$0	$4,277,722
35	$96,870	$2,303,862	$96,257	$504,224	$76,919	$98,036	$1,088,667	$0	$4,264,835
36	$95,883	$2,280,372	$96,257	$504,224	$76,919	$98,036	$1,100,528	$0	$4,252,219
37	$94,916	$2,257,373	$96,257	$504,224	$76,919	$98,036	$1,112,142	$0	$4,239,866
38	$93,969	$2,234,851	$95,940	$502,565	$76,919	$98,036	$1,124,771	$0	$4,227,050
39	$93,043	$2,212,832	$94,996	$497,618	$76,919	$98,036	$1,139,636	$0	$4,213,079
40	$92,141	$2,191,375	$94,076	$492,798	$76,919	$98,036	$1,154,122	$0	$4,199,465
41	$91,261	$2,170,462	$93,179	$488,098	$76,919	$98,036	$1,168,241	$0	$4,186,196
42	$90,404	$2,150,078	$92,304	$483,517	$76,919	$98,036	$1,182,003	$0	$4,173,262
43	$89,569	$2,130,206	$91,451	$479,051	$76,919	$98,036	$1,195,421	$0	$4,160,652
44	$88,754	$2,110,830	$90,620	$474,695	$76,919	$98,036	$1,208,504	$0	$4,148,357
45	$87,959	$2,091,934	$89,809	$470,448	$76,919	$98,036	$1,221,262	$0	$4,136,367
46	$87,185	$2,073,505	$89,018	$466,305	$76,919	$98,036	$1,233,705	$0	$4,124,673
47	$86,429	$2,055,529	$88,247	$462,263	$76,919	$98,036	$1,245,843	$0	$4,113,266
48	$85,691	$2,037,992	$87,494	$458,321	$76,919	$98,036	$1,257,685	$0	$4,102,137
49	$84,972	$2,020,880	$86,759	$454,473	$76,919	$98,036	$1,269,239	$0	$4,091,279
50	$84,270	$2,004,183	$86,043	$450,719	$76,919	$98,036	$1,280,514	$0	$4,080,683
51	$83,585	$1,987,887	$85,343	$447,055	$76,919	$98,036	$1,291,518	$0	$4,070,342
52	$82,916	$1,971,981	$84,660	$443,478	$76,919	$98,036	$1,302,259	$0	$4,060,249
53	$82,263	$1,956,454	$83,994	$439,987	$76,919	$98,036	$1,312,744	$0	$4,050,396
54	$81,626	$1,941,295	$83,343	$436,578	$76,919	$98,036	$1,322,980	$0	$4,040,776
55	$81,003	$1,926,494	$82,708	$433,250	$76,919	$98,036	$1,332,975	$0	$4,031,384
56	$80,395	$1,912,040	$82,087	$429,999	$76,919	$98,036	$1,342,735	$0	$4,022,212
57	$79,802	$1,897,925	$81,481	$426,825	$76,919	$98,036	$1,352,266	$0	$4,013,254
58	$79,222	$1,884,138	$80,890	$423,725	$76,919	$98,036	$1,361,576	$0	$4,004,505
59	$78,656	$1,870,671	$80,311	$420,696	$76,919	$98,036	$1,370,670	$0	$3,995,959
60	$78,103	$1,857,514	$79,747	$417,738	$76,919	$98,036	$1,379,555	$0	$3,987,610

Table 22. Impacts on Future Hydrology, Crop Mix, and Water-Use in Subarea 6 of Sheridan County, Based on a CREP Scenario.

	Corn												
	Hydrology			Flood Technology			Center Pivot Technology			Total			
Time	ST	GPM	GDAR	Acres	ConvCP	GWU	Acres	ConvDL	GWU	TWU	AAFWU	∆ST
1	89.8	587.4	0.249	1167	0	19754	11244	0	150310	18706.5	1.08	0.64
2	89.2	580.8	0.246	992	175	16791	11419	0	152649	18531.8	1.07	0.63
3	88.5	574.3	0.244	843	324	14272	11567	0	154637	18484.3	1.06	0.62
4	87.9	567.9	0.241	716	450	12131	11694	0	156327	18443.8	1.06	0.62
5	87.3	561.5	0.238	609	558	10312	11801	0	157764	18409.5	1.06	0.62
6	86.7	555.2	0.236	518	649	8765	11893	0	158985	18380.2	1.06	0.62
7	86.1	548.9	0.233	440	727	7450	11970	0	160023	18355.4	1.06	0.61
8	85.4	542.7	0.230	374	793	6333	12036	0	160905	18334.3	1.06	0.61
9	84.8	536.5	0.228	318	849	5383	12092	0	161655	18316.4	1.06	0.61
10	84.2	530.4	0.225	270	896	4575	12140	0	162292	18301.1	1.05	0.61
11	83.6	524.3	0.222	230	937	3889	12181	0	162834	18288.1	1.05	0.61
12	83.0	518.2	0.220	195	971	3306	12215	0	163295	18277.1	1.05	0.61
13	82.4	512.2	0.217	166	1001	2810	12244	0	163686	18267.8	1.05	0.61
14	81.8	506.2	0.215	141	1026	2388	12269	0	164019	18259.8	1.05	0.61
15	81.2	500.3	0.212	120	1047	2030	12290	0	164302	18253.0	1.05	0.61
16	80.6	494.3	0.210	102	1065	1726	12308	0	164542	18247.3	1.05	0.61
17	80.0	488.4	0.207	87	1080	1467	12324	0	164747	18242.4	1.05	0.61
18	79.4	482.6	0.205	74	1093	1247	12337	0	164920	18238.2	1.05	0.61
19	78.7	476.7	0.202	63	1104	1060	12348	0	165068	18234.7	1.05	0.61
20	78.1	470.9	0.200	53	1113	900	12345	12	165031	18217.9	1.05	0.61
21	77.5	465.2	0.197	45	1122	756	12202	163	163123	18043.6	1.05	0.59
22	76.9	459.5	0.195	37	1129	634	12061	311	161240	17873.7	1.05	0.58
23	76.4	454.0	0.193	31	1135	533	11923	456	159386	17707.7	1.05	0.57
24	75.8	448.6	0.190	26	1140	448	11786	598	157563	17545.8	1.05	0.56
25	75.2	443.4	0.188	22	1144	376	11652	736	155770	17387.7	1.05	0.55
26	74.7	438.3	0.186	19	1148	316	11520	871	154010	17233.2	1.05	0.54
27	74.1	433.2	0.184	16	1151	265	11391	1003	152282	17082.4	1.05	0.53
28	73.6	428.3	0.182	13	1153	223	11264	1133	150586	16935.0	1.05	0.52
29	73.1	423.5	0.180	11	1155	187	11140	1259	148923	16790.9	1.05	0.51
30	72.6	418.8	0.178	9	1157	158	11018	1383	147293	16650.1	1.05	0.50
31	72.1	414.2	0.176	8	1159	132	10898	1504	145695	16512.4	1.04	0.50
32	71.6	409.7	0.174	7	1160	111	10781	1622	144129	16377.8	1.04	0.49
33	71.1	405.3	0.172	6	1161	94	10667	1738	142594	16246.2	1.04	0.48
34	70.6	401.0	0.170	5	1162	79	10554	1852	141091	16117.4	1.04	0.47
35	70.1	396.8	0.168	4	1163	66	10444	1962	139617	15991.4	1.04	0.46
36	69.7	392.7	0.167	3	1163	56	10336	2071	138174	15868.1	1.04	0.45
37	69.2	388.7	0.165	3	1164	47	10230	2177	136760	15747.4	1.04	0.45
38	68.8	384.7	0.163	2	1164	39	10126	2281	135374	15629.3	1.04	0.44
39	68.3	380.9	0.162	2	1165	33	10025	2383	134017	15513.7	1.04	0.43
41	67.5	373.4	0.158	1	1165	24	9828	2581	131384	15255.8	1.04	0.41
43	66.7	366.2	0.155	1	1166	17	9640	2769	128875	14978.6	1.04	0.40
45	65.9	359.4	0.152	1	1166	12	9462	2948	126490	14715.1	1.04	0.38
47	65.1	353.0	0.150	0	1166	8	9292	3118	124221	14464.7	1.04	0.36
49	64.4	346.8	0.147	0	1166	6	9131	3279	122063	14226.5	1.04	0.35
51	63.7	341.0	0.145	0	1166	4	8977	3433	120008	13999.8	1.04	0.33
52	63.4	338.2	0.143	0	1166	4	8903	3507	119017	13890.5	1.03	0.33
53	63.1	335.4	0.142	0	1166	3	8831	3579	118051	13783.9	1.03	0.32
54	62.7	332.7	0.141	0	1166	3	8760	3650	117107	13679.8	1.03	0.31
55	62.4	330.1	0.140	0	1166	2	8691	3719	116186	13578.2	1.03	0.31
56	62.1	327.6	0.139	0	1166	2	8624	3786	115287	13479.1	1.03	0.30
57	61.8	325.1	0.138	0	1166	2	8558	3852	114409	13382.2	1.03	0.29
58	61.5	322.6	0.137	0	1166	1	8494	3916	113551	13287.7	1.03	0.29
59	61.2	320.3	0.136	0	1166	1	8431	3979	112714	13195.3	1.03	0.28
60	61.0	317.9	0.135	0	1167	1	8370	4040	111896	13105.2	1.03	0.28

Time is time measured in years; ST is saturated thickness measured in feet; GPM is gallons per minute; GDAR is the gross daily application of the well measured in inches; ConvCP is the number of flood irrigated acreage converted to center pivot technology; GWU is the gross water use measured in inches for corn; ConvDL is the number of center pivot acres converted to dryland production; TWU is the total water use measured in acre-feet for all crops; AAFWU is the average acre foot water usage per acre measured in feet; ∆ST is the change in saturated thickness measured in feet.

Table 23. Impacts on Future on Crop Revenues in Subarea 6 of Sheridan County, Based on a CREP Scenario

Time	Alfalfa	Corn	Sorghum	Soybeans	Sunflowers	Wheat	Non Irrigated	Program Payments	Total
1	$117,841	$2,802,603	$96,257	$504,224	$76,919	$98,036	$0	$835,128	$4,531,008
2	$117,841	$2,802,603	$96,257	$504,224	$76,919	$98,036	$0	$835,128	$4,531,008
3	$117,841	$2,802,603	$96,257	$504,224	$75,835	$98,036	$1,048	$835,128	$4,530,971
4	$117,841	$2,802,603	$96,257	$504,224	$74,913	$98,036	$1,938	$835,128	$4,530,940
5	$117,841	$2,802,603	$96,257	$504,224	$74,129	$98,036	$2,695	$835,128	$4,530,913
6	$117,841	$2,802,603	$96,257	$504,224	$73,463	$98,036	$3,338	$835,128	$4,530,890
7	$117,841	$2,802,603	$96,257	$504,224	$72,897	$98,036	$3,885	$835,128	$4,530,871
8	$117,841	$2,802,603	$96,257	$504,224	$72,416	$98,036	$4,350	$835,128	$4,530,855
9	$117,841	$2,802,603	$96,257	$504,224	$72,007	$98,036	$4,745	$835,128	$4,530,841
10	$117,841	$2,802,603	$96,257	$504,224	$71,659	$98,036	$5,081	$835,128	$4,530,829
11	$117,841	$2,802,603	$96,257	$504,224	$71,363	$98,036	$5,366	$835,128	$4,530,819
12	$117,841	$2,802,603	$96,257	$504,224	$71,112	$98,036	$5,609	$835,128	$4,530,810
13	$117,841	$2,802,603	$96,257	$504,224	$70,899	$98,036	$5,815	$835,128	$4,530,803
14	$117,841	$2,802,603	$96,257	$504,224	$70,717	$98,036	$5,991	$835,128	$4,530,797
15	$117,841	$2,802,603	$96,257	$504,224	$70,563	$98,036	$6,140	$835,128	$4,530,792
16	$117,841	$2,802,603	$96,257	$504,224	$70,432	$98,036	$843,092	$0	$4,532,485
17	$117,841	$2,802,603	$96,257	$504,224	$70,320	$98,036	$843,200	$0	$4,532,481
18	$117,841	$2,802,603	$96,257	$504,224	$70,226	$98,036	$843,292	$0	$4,532,478
19	$117,841	$2,802,603	$96,257	$504,224	$70,145	$98,036	$843,369	$0	$4,532,476
20	$117,725	$2,799,850	$96,257	$504,224	$70,077	$98,036	$844,826	$0	$4,530,994
21	$116,289	$2,765,683	$96,257	$504,224	$70,018	$98,036	$862,135	$0	$4,512,642
22	$114,884	$2,732,271	$96,257	$504,224	$69,969	$98,036	$879,054	$0	$4,494,694
23	$113,510	$2,699,600	$96,257	$504,224	$69,927	$98,036	$895,592	$0	$4,477,146
24	$112,167	$2,667,655	$96,257	$504,224	$69,891	$98,036	$911,757	$0	$4,459,987
25	$110,853	$2,636,421	$96,257	$504,224	$69,861	$98,036	$927,558	$0	$4,443,210
26	$109,569	$2,605,879	$96,257	$504,224	$69,835	$98,036	$943,005	$0	$4,426,806
27	$108,314	$2,576,014	$96,257	$504,224	$69,813	$98,036	$958,107	$0	$4,410,765
28	$107,086	$2,546,809	$96,257	$504,224	$69,794	$98,036	$972,872	$0	$4,395,078
29	$105,885	$2,518,245	$96,257	$504,224	$69,779	$98,036	$987,311	$0	$4,379,736
30	$104,710	$2,490,306	$96,257	$504,224	$69,765	$98,036	$1,001,432	$0	$4,364,730
31	$103,561	$2,462,976	$96,257	$504,224	$69,754	$98,036	$1,015,243	$0	$4,350,050
32	$102,436	$2,436,238	$96,257	$504,224	$69,744	$98,036	$1,028,754	$0	$4,335,689
33	$101,336	$2,410,077	$96,257	$504,224	$69,736	$98,036	$1,041,972	$0	$4,321,638
34	$100,260	$2,384,476	$96,257	$504,224	$69,729	$98,036	$1,054,906	$0	$4,307,887
35	$99,206	$2,359,420	$96,257	$504,224	$69,723	$98,036	$1,067,564	$0	$4,294,430
36	$98,175	$2,334,896	$96,257	$504,224	$69,717	$98,036	$1,079,952	$0	$4,281,258
37	$97,166	$2,310,889	$96,257	$504,224	$69,713	$98,036	$1,092,079	$0	$4,268,363
38	$96,178	$2,287,384	$96,257	$504,224	$69,709	$98,036	$1,103,951	$0	$4,255,739
39	$95,210	$2,264,369	$96,257	$504,224	$69,706	$98,036	$1,115,576	$0	$4,243,378
40	$94,262	$2,241,831	$96,243	$504,151	$69,704	$98,036	$1,127,015	$0	$4,231,241
41	$93,334	$2,219,759	$95,296	$499,190	$69,701	$98,036	$1,141,920	$0	$4,217,235
42	$92,430	$2,198,250	$94,373	$494,355	$69,700	$98,036	$1,156,444	$0	$4,203,587
43	$91,548	$2,177,286	$93,473	$489,642	$69,698	$98,036	$1,170,601	$0	$4,190,284
44	$90,689	$2,156,852	$92,596	$485,049	$69,697	$98,036	$1,184,400	$0	$4,177,318
45	$89,851	$2,136,930	$91,741	$480,570	$69,695	$98,036	$1,197,852	$0	$4,164,676
46	$89,035	$2,117,506	$90,908	$476,202	$69,694	$98,036	$1,210,970	$0	$4,152,350
47	$88,238	$2,098,563	$90,094	$471,943	$69,693	$98,036	$1,223,761	$0	$4,140,330
48	$87,461	$2,080,088	$89,301	$467,789	$69,693	$98,036	$1,236,237	$0	$4,128,606
49	$86,704	$2,062,066	$88,528	$463,737	$69,692	$98,036	$1,248,407	$0	$4,117,170
50	$85,964	$2,044,485	$87,773	$459,784	$69,692	$98,036	$1,260,280	$0	$4,106,013
51	$85,243	$2,027,331	$87,037	$455,926	$69,691	$98,036	$1,271,863	$0	$4,095,127
52	$84,539	$2,010,592	$86,318	$452,162	$69,691	$98,036	$1,283,167	$0	$4,084,505
53	$83,852	$1,994,255	$85,617	$448,488	$69,690	$98,036	$1,294,199	$0	$4,074,138
54	$83,182	$1,978,310	$84,932	$444,903	$69,690	$98,036	$1,304,967	$0	$4,064,019
55	$82,527	$1,962,744	$84,264	$441,402	$69,690	$98,036	$1,315,478	$0	$4,054,142
56	$81,888	$1,947,548	$83,612	$437,985	$69,690	$98,036	$1,325,740	$0	$4,044,498
57	$81,265	$1,932,711	$82,975	$434,648	$69,690	$98,036	$1,335,759	$0	$4,035,083
58	$80,655	$1,918,222	$82,353	$431,390	$69,689	$98,036	$1,345,543	$0	$4,025,888
59	$80,060	$1,904,072	$81,745	$428,208	$69,689	$98,036	$1,355,098	$0	$4,016,909
60	$79,479	$1,890,252	$81,152	$425,100	$69,689	$98,036	$1,364,431	$0	$4,008,139

Table 24. Net Present Value of All Scenarios for Subarea 6 of Sheridan County

Discount	Scenario				
Rate	Status Quo	Conversion to Dryland	Limited Irrigation	Water Rights Buyout	CREP
-5.0%	$1,776,655,690	$1,155,165,605	$1,868,000,813	$1,742,659,126	$1,732,817,846
-2.5%	$633,322,787	$398,102,515	$651,905,014	$617,034,606	$606,997,137
0.0%	$277,433,415	$167,365,224	$277,417,462	$269,097,175	$259,924,585
2.5%	$148,725,231	$86,217,237	$144,246,112	$144,385,706	$136,125,050
5.0%	$93,979,870	$52,801,746	$88,840,809	$91,836,868	$84,362,187

Table 25. Difference in Net Present Value Relative to the Status Quo Scenario for Subarea 6 of Sheridan County

Discount	Scenario			
Rate	Conversion to Dryland	Limited Irrigation	Water Rights Buyout	CREP
-5.0%	-$621,490,085	$91,345,123	-$33,996,564	-$43,837,844
-2.5%	-$235,220,272	$18,582,227	-$16,288,181	-$26,325,650
0.0%	-$110,068,191	-$15,953	-$8,336,240	-$17,508,829
2.5%	-$62,507,995	-$4,479,119	-$4,339,526	-$12,600,182
5.0%	-$41,178,124	-$5,139,062	-$2,143,003	-$9,617,683

Table 26. Total Water Use for All Scenarios for Subarea 6 of Sheridan County (acre-feet)

Scenario				
Status Quo	Conversion to Dryland	Limited Irrigation	Water Rights Buyout	CREP
1,179,241	0.0	1,050,008	1,021,174	982,605

Table 27. Water Conserved Relative to the Status Quo Scenario for Subarea 6 of Sheridan County (acre-feet)

Scenario			
Conversion to Dryland	Limited Irrigation	Water Rights Buyout	CREP
1,179,241	129,233	158,067	196,636

Table 28. Input-Output Study Region: Basic Demographics

County	Area (square miles)	Population	Households	Household Income	Average Household Income
Cheyenne	1,020	2,979	1,386	$51,887,000	$37,434
Decatur	894	3,274	1,518	$74,763,000	$49,247
Gove	1,072	2,845	1,282	$66,671,000	$52,002
Logan	1,073	2,827	1,243	$61,213,000	$49,243
Rawlins	1,070	2,765	1,315	$61,863,000	$47,041
Sheridan	896	2,614	1,171	$87,008,000	$74,297
Sherman	1,056	6,218	2,826	$150,256,992	$53,166
Thomas	1,075	7,801	3,245	$198,064,992	$61,032
Wallace	914	1,579	694	$38,720,000	$55,788
Total	9,069	32,902	14,681	$790,446,984	$53,841

Based on 2004 IMPLAN Data

Table 29. Input-Output Study Region: Select Industry Economic Demographics

Sector	Sector Description	Industry Output*	Employment	Value Added*
11	Cattle ranching and farming	$422.542	2,110	$70.037
52	Soybean processing	$270.354	106	$7.561
2	Grain farming	$265.105	2,663	$164.330
390	Wholesale trade	$106.332	1,052	$72.684
503	State & Local Education	$81.972	2,875	$81.972
509	Owner-occupied dwellings	$78.249	0	$64.205
430	Monetary authorities and depository credit in	$63.157	427	$48.281
394	Truck transportation	$48.522	469	$19.716
18	Agriculture and forestry support activities	$42.009	1,101	$27.485
481	Food services and drinking places	$40.727	1,098	$15.535
468	Nursing and residential care facilities	$40.370	1,190	$20.114
504	State & Local Non-Education	$38.134	1,271	$38.134
483	Automotive repair and maintenance- except car	$34.685	594	$16.469
13	Animal production- except cattle and poultry	$28.229	464	$3.810
422	Telecommunications	$28.164	111	$12.356
465	Offices of physicians- dentists- and other he	$27.000	460	$18.203
30	Power generation and supply	$23.748	71	$16.095
10	All other crop farming	$23.070	61	$14.277
1	Oilseed farming	$22.654	108	$16.056
467	Hospitals	$21.385	269	$8.573
401	Motor vehicle and parts dealers	$21.065	292	$12.214
19	Oil and gas extraction	$19.982	105	$11.215
428	Insurance agencies- brokerages- and related	$19.850	366	$15.132
499	Other State and local government enterprises	$18.806	124	$6.266
407	Gasoline stations	$18.712	278	$12.217
405	Food and beverage stores	$17.537	351	$10.275
410	General merchandise stores	$17.518	364	$9.892
47	Other animal food manufacturing	$16.906	26	$0.679
67	Animal- except poultry- slaughtering	$16.217	45	$1.849
33	New residential 1-unit structures- all	$16.043	151	$5.097
257	Farm machinery and equipment manufacturing	$14.213	49	$2.196
431	Real estate	$11.747	138	$8.223
157	Phosphate fertilizer manufacturing	$9.567	11	$1.117
485	Commercial machinery repair and maintenance	$4.875	102	$3.013
142	Petroleum refineries	$0.000	0	$0.000
156	Nitrogenous fertilizer manufacturing	$0.000	0	$0.000
159	Pesticide and other agricultural chemical man	$0.000	0	$0.000
	All Other	$287.185	5901	$138.107
	Total	$2,216.630	24,804	$973.387

* Millions of dollars
Based on 2004 IMPLAN Data

Table 30. Types of Direct Economic Impacts Included in Analysis

Direct Impact	Scenario Conversion to Dryland	Limited Irrigation	Water Rights Buyout	CREP
Loss of Irrigated Crop Revenue	Yes	Yes	Yes	Yes
Gain of Non-Irrigated Crop Revenue	Yes	No	Yes	Yes
Gain in Haying, Grazing, and Recreational Revenues	No	No	No	Yes
Gain Due to Producer Compensation	No	No	Yes	Yes

Table 31. IMPLAN Coding for the Revenues Lost Due to a Reduction in Irrigated Crop Acreage and Total Sector Impacts

Event	IMPLAN Sector[6]	Sector Name	Input	Impact Per Acre	Impact Total[7]
1	2	Grain Farming	Seed[1]	$48.22	$359,581
2	159	Pesticide & chemical manufacturing	Herbicide & insecticide[1]	$53.76	$400,853
3	156	Nitrogen fertilizer manufacturing	Nitrogen fertilizer[1]	$62.39	$465,230
4	157	Phosphate fertilizer manufacturing	Phosphate fertilizer[1]	$17.60	$131,219
5	428	Insurance agencies, brokerages, & related	Crop & other insurance[2]	$17.00	$126,737
6	142	Petroleum refineries	Fuel & oil[2]	$72.60	$541,327
7	390	Farm machinery wholesalers	Parts[2]	$11.47	$85,544
8	485	Farm machinery repair and maintenance	Repairs[2]	$11.47	$85,544
9	430	Commercial Banking	Interest[2]	$23.08	$172,101
10	431	Farmland rental or leasing (absentee owner)	Land Charge[2]	$11.28	$84,114
11	390	Farm machinery wholesalers	Equipment payments[2]	$25.39	$189,315
		Total Indirect Impact (all regions)		**$354.26**	**$2,641,564**
12	5001	Employee compensation	Labor[3]	$30.21	$225,284
13	7001	Other property income	Land Charge[2]	$37.77	$281,598
14	8001	Indirect business taxes	Taxes[2]	$6.64	$49,505
15	6001	Proprietary income	Profits[4]	$134.85	$1,005,503
		Total Direct Impact on Payroll Sectors[5]		**$209.47**	**$1,561,891**
		Total Direct Impact		**$563.73**	**$4,203,455**

1: The total weighted average expense is based on KSU extension budgets.
2: The total weighted average expense is based on KFMA budgets
3: The total weighted average expense is based on KSU and KFMA budgets. The number 1ncludes labor, consulting, and machine hire.
4: Proprietary income is the remainder after all other categories have been deducted from gross revenues.
5: This is equivalent to the total direct impact on Value Added
6: The IMPLAN sectors were chosen based on local ES-202 data. ES-202 data is based on annual county-level establishment data from the U.S. Department of Labor, Bureau of Labor Statistics' Quarterly Census of Employment and Wages program. These data tracks all employers with employees who are eligible for unemployment compensation insurance. The North American Industry Classification System (NAICS) codes for local input suppliers were obtained from the ES-202 data. IMPLAN's cross reference guide was then used to match NAICS codes to the correct IMPLAN sector.
7: Based on the retirement of 7,456.5 irrigated acres (30% of the 24,855 irrigated acres in subarea 6) with a weighted average revenue of $563.73 per acre.

Table 32. IMPLAN Coding for the Revenues Lost Due to a Reduction in Irrigated Crop Acreage and Regional Sector Impacts

Event	IMPLAN Sector	Sector Name	Input	Effective Local Impact (%)[3]	Impact Local
1	2	Grain Farming	Seed	14.2%	$51,060
2	159	Pesticide & chemical manufacturing	Herbicide & insecticide	19.5%	$78,166
3	156	Nitrogen fertilizer manufacturing	Nitrogen fertilizer	15.4%	$71,645
4	157	Phosphate fertilizer manufacturing	Phosphate fertilizer	45.2%[1]	$59,311
5	428	Insurance agencies, brokerages, & related	Crop & other insurance	55.9%	$70,846
6	142	Petroleum refineries	Fuel & oil	20.5%	$110,972
7	390	Farm machinery wholesalers	Parts	40.0%	$34,218
8	485	Farm machinery repair and maintenance	Repairs	100.0%	$85,544
9	430	Commercial Banking	Interest	100.0%	$172,101
10	431	Farmland rental or leasing (absentee owner)	Land Charge	0.0%[2]	$0
11	390	Farm machinery wholesalers	Equipment payments	15.0%	$28,397
		Total Indirect Impact (Local region)			**$762,261**
12	5001	Employee compensation	Labor	100.0%	$225,284
13	7001	Other property income	Land Charge	100.0%	$281,598
14	8001	Indirect business taxes	Taxes	100.0%	$49,505
15	6001	Proprietary income	Profits	100.0%	$1,005,503
		Total Direct Impact on Payroll Sectors[5]			**$1,561,891**

1: IMPLAN assumes that 100% of local demand is met by a local supplier, if there is a supplier in the region. The IMPLAN data suggests that there is a phosphate fertilizer manufacturer in the region. The margin includes the manufacturer's margin as well as the local wholesaler's margin. In the absence of better information, IMPLAN's suggested impacts were used. This may overstate the local impact due to the reduced demand for phosphate fertilizer.
2: ERS (2004) suggests that approximately 23% of USDA farm program payments may be made to individuals outside the target region. It is assumed that 23% of payments that accrue to land also are made to individuals outside the target region and have no regional impact. The remaining 77% of payments that accrue to land are included in value added.
3: The effective local impact was derived by modeling each event separately. The effective local impact percent captures the combined affect of input supplier margins and the RPC.

Table 33. Total Impacts Due to Revenues Losses from a Reduction in Irrigated Crop Acreage

Metric	Direct	Indirect	Induced	Total	Multiplier
Total Industry Output	$4,203,455	$866,240[1]	$777,043	$5,846,738	1.39
Value Added	$1,561,891	$542,849	$453,784	$2,558,524[3]	1.64
Employment[2]	3.7	0.8	0.5	5.0	1.36

1: The indirect impacts to total industry output includes the first-round impact of $762,261 reported in Table 30 plus indirect impacts generated by subsequent rounds of input supplier spending.
2: These data represent 8.8% of the employment impacts calculated by IMPLAN.
3: Based on the retirement of 7,456.5 irrigated acres (30% of the 24,855 irrigated acres in subarea 6).

Table 34. IMPLAN Coding for the Revenues Gained Due to an Increase in Nonirrigated Crop Acreage and Total Sector Impacts

Event	IMPLAN Sector[6]	Sector Name	Input	Impact Per Acre	Impact Total[7]
1	2	Grain Farming	Seed[1]	$12.28	$91,542
2	159	Pesticide & chemical manufacturing	Herbicide & insecticide[1]	$16.90	$125,984
3	156	Nitrogen fertilizer manufacturing	Nitrogen fertilizer[1]	$28.59	$213,176
4	157	Phosphate fertilizer manufacturing	Phosphate fertilizer[1]	$8.06	$60,126
5	428	Insurance agencies, brokerages, & related	Crop & other insurance[2]	$7.56	$56,406
6	142	Petroleum refineries	Fuel & oil[2]	$8.09	$60,357
7	390	Farm machinery wholesalers	Parts[2]	$5.05	$37,672
8	485	Farm machinery repair and maintenance	Repairs[2]	$5.05	$37,672
9	430	Commercial Banking	Interest[2]	$7.19	$53,626
10	431	Farmland rental or leasing (absentee owner)	Land Charge[2]	$3.15	$23,510
11	390	Farm machinery wholesalers	Equipment payments[2]	$12.46	$92,930
		Total Indirect Impact (all regions)		**$114.40**	**$853,000**
12	5001	Employee compensation	Labor[3]	$13.60	$101,439
13	7001	Other property income	Land Charge[2]	$10.56	$78,709
14	8001	Indirect business taxes	Taxes[2]	$3.78	$28,155
15	6001	Proprietary income	Profits[4]	$85.21	$635,334
		Total Direct Impact on Payroll Sectors[5]		**$113.14**	**$843,636**
		Total Direct Impact		**$227.54**	**$1,696,637**

1: The total weighted average expense is based on KSU extension budgets.
2: The total weighted average expense is based on KFMA budgets
3: The total weighted average expense is based on KSU and KFMA budgets. The number 1ncludes labor, consulting, and machine hire.
4: Proprietary income is the remainder after all other categories have been deducted from gross revenues.
5: This is equivalent to the total direct impact on Value Added
6: The IMPLAN sectors were chosen based on local ES-202 data. ES-202 data is based on annual county-level establishment data from the U.S. Department of Labor, Bureau of Labor Statistics' Quarterly Census of Employment and Wages program. These data tracks all employers with employees who are eligible for unemployment compensation insurance. The North American Industry Classification System (NAICS) codes for local input suppliers were obtained from the ES-202 data. IMPLAN's cross reference guide was then used to match NAICS codes to the correct IMPLAN sector.
7: Based on the retirement of 7,456.5 irrigated acres (30% of the 24,855 irrigated acres in subarea 6) with average revenue of $563.73 per acre.

Table 35. IMPLAN Coding for the Revenues Gained Due to an Increase in Nonirrigated Crop Acreage and Regional Sector Impacts

Event	IMPLAN Sector	Sector Name	Input	Effective Local Impact (%)[3]	Impact Local
1	2	Grain Farming	Seed	14.2%	$12,999
2	159	Pesticide & chemical manufacturing	Herbicide & insecticide	19.5%	$24,567
3	156	Nitrogen fertilizer manufacturing	Nitrogen fertilizer	15.4%	$32,829
4	157	Phosphate fertilizer manufacturing	Phosphate fertilizer	45.2%[1]	$27,177
5	428	Insurance agencies, brokerages, & related	Crop & other insurance	55.9%	$31,531
6	142	Petroleum refineries	Fuel & oil	20.5%	$12,373
7	390	Farm machinery wholesalers	Parts	40.0%	$15,069
8	485	Farm machinery repair and maintenance	Repairs	100.0%	$37,672
9	430	Commercial Banking	Interest	100.0%	$53,626
10	431	Farmland rental or leasing (absentee owner)	Land Charge	0.0%[2]	$0
11	390	Farm machinery wholesalers	Equipment payments	15.0%	$13,939
		Total Indirect Impact (Local region)			**$261,782**
12	5001	Employee compensation	Labor	100.0%	$101,439
13	7001	Other property income	Land Charge	100.0%	$78,709
14	8001	Indirect business taxes	Taxes	100.0%	$28,155
15	6001	Proprietary income	Profits	100.0%	$635,334
		Total Direct Impact on Payroll Sectors[5]			**$843,636**

1: IMPLAN assumes that 100% of local demand is met by a local supplier, if there is a supplier in the region. The IMPLAN data suggests that there is a phosphate fertilizer manufacturer in the region. The margin includes the manufacturer's margin as well as the local wholesaler's margin. In the absence of better information, IMPLAN's suggested impacts were used. This may overstate the local impact due to the demand change for phosphate fertilizer.
2: ERS (2004) suggests that approximately 23% of USDA farm program payments may be made to individuals outside the target region. It is assumed that 23% of payments that accrue to land also are made to individuals outside the target region and have no regional impact. The remaining 77% of payments that accrue to land are included in value added.
3: The effective local impact was derived by modeling each event separately. The effective local impact percent captures the combined affect of input supplier margins and the RPC.

Table 36. Total Impacts Due to Revenues Gained from an Increase in Nonirrigated Crop Acreage

Metric	Direct	Indirect	Induced	Total	Multiplier
Total Industry Output	$1,696,637	$297,875[1]	$422,176	$2,416,688	1.42
Value Added	$843,636	$183,449	$246,569	$1,273,654	1.51
Employment[2]	1.5	0.3	0.2	2.0	1.36

1: The indirect impacts to total industry output includes the first-round impact of $261,782 reported in Table 34 plus indirect impacts generated by subsequent rounds of input supplier spending.
2: These data represent 8.8% of the employment impacts calculated by IMPLAN.
Based on the retirement of 7,456.5 irrigated acres (30% of the 24,855 irrigated acres in subarea 6).

Table 37. IMPLAN Coding for the Revenues Gained Due to an Increase in Haying, Grazing, and Recreation and Sector Impacts

Event	IMPLAN Sector[6]	Sector Name	Impact Per Acre	Impact Total	RPC
1	405	Food and beverage stores	$0.27	$2,036	100.0%
2	407	Gasoline stations	$0.30	$2,269	100.0%
3	409	Sporting goods stores	$1.28	$9,565	100.0%
4	410	General merchandise stores	$0.07	$488	100.0%
5	411	Miscellaneous retail stores	$0.07	$551	100.0%
6	432	Automotive rental and leasing	$0.30	$2,269	100.0%
7	479	Hotels and motels	$0.27	$2,036	100.0%
8	481	Food services and drinking places	$0.27	$2,036	100.0%
		Total Direct Recreational Impact	**$2.85**	**$21,251.03**	**100.0%**
9	6001	Proprietary income (Recreation)[3]	$1.20	$8,947.80	100.0%
10	6001	Proprietary income (Haying & Grazing -Absentee)[1]	$0.74	$5,487.98	0.0%
11	6001	Proprietary income (Haying & Grazing -Local)[1]	$2.46	$18,372.82	100.0%
		Total Direct Impact on Payroll Sectors [2]	**$9.36**	**$69,822.67**	**100.00%**

1: The total annual proprietary income from haying and grazing is estimated as $3.20 per acre, of which 23% ($0.74) is estimated to be paid to absentee landowners.
2: The proprietary income associated with absentee landowners has been removed from the total.
3: All proprietary income associated with recreation is assumed to be paid to the local operator.
Based on the retirement of 7,456.5 irrigated acres (30% of the 24,855 irrigated acres in subarea 6).

Table 38. Total Impacts Due to Revenues Gained from an Increase in Haying, Grazing and Recreational Activities

Metric	Direct	Indirect	Induced	Total	Multiplier
Total Industry Output	$48,571	$19,376	$6,035	$73,982	1.52
Value Added	$39,668	$1,582	$10,612	$51,862	1.31
Employment[1]	0.1	0.0	0.0	0.1	1.11

1: These data represent 8.8% of the employment impacts calculated by IMPLAN.
Based on the retirement of 7,456.5 irrigated acres (30% of the 24,855 irrigated acres in subarea 6).

Table 39. IMPLAN Coding for the CREP Incentives Paid to Landowners and Sector Impacts

Event	IMPLAN Sector[6]	Sector Name	Impact Per Acre	Impact Total	RPC
1	6001	Proprietary income (Incentive -Absentee)	$25.76	$192,079	0.00%
2	6001	Proprietary income (Incentive -Local)	$86.24	$643,049	100.00%
		Total Direct Impact on Payroll Sectors[1]	**$86.24**	**$643,049**	

1: The proprietary income associated with absentee landowners has been removed from the total. These data are based on a $112 per acre incentive paid to landowners.
Based on the retirement of 7,456.5 irrigated acres (30% of the 24,855 irrigated acres in subarea 6).

Table 40. Total Impacts Due to CREP Incentives Paid to Landowners

Metric	Direct	Indirect	Induced	Total	Multiplier
Total Industry Output	NA	NA	NA	NA	NA
Value Added	$643,049	$0	$189,452	$832,501	1.29
Employment[1]	0.3	0.0	0.1	0.4	1.31

1: These data represent 8.8% of the employment impacts calculated by IMPLAN.
NA: Not Applicable; payroll sector impacts have only a value added impact.
Based on the retirement of 7,456.5 irrigated acres (30% of the 24,855 irrigated acres in subarea 6).

Table 41. Total Net Present Value of Producer Gross Profits, at a 5% Discount Rate

		Scenario			
Subarea	County	Conversion to Dryland	Limited Irrigation	Water Rights Buyout	CREP
1	Sherman	-$40,598,443	-$5,044,516	-$5,811,092	-$9,298,043
2	Sherman	-$15,152,883	-$1,395,309	-$2,865,160	-$3,558,114
3	Cheyenne	-$11,398,450	-$1,877,773	-$1,561,732	-$2,997,437
4	Thomas	-$1,917,431	-$253,201	-$311,225	-$486,814
5	Thomas	-$54,788,294	-$5,472,980	-$5,829,657	-$12,817,581
6	Sheridan	-$41,178,124	-$5,139,062	-$2,143,003	-$9,617,683
	Total	-165,033,625	-19,182,841	-18,521,869	-38,775,671

All impacts are measured relative to the 'Status Quo' scenario.
These data are based on a total retirement of 30% of the 98,143 irrigated acres in the six subareas.

Table 42. Per Acre Net Present Value of Producer Gross Profits, at a 5% Discount Rate

		Scenario			
Subarea	County	Conversion to Dryland	Limited Irrigation	Water Rights Buyout	CREP
1	Sherman	-$1,855	-$230	-$265	-$425
2	Sherman	-$1,727	-$159	-$327	-$405
3	Cheyenne	-$1,835	-$302	-$251	-$483
4	Thomas	-$1,595	-$211	-$259	-$405
5	Thomas	-$1,556	-$155	-$166	-$364
6	Sheridan	-$1,657	-$207	-$86	-$387
	Average	-$1,682	-$195	-$189	-$395

All impacts are measured relative to the 'Status Quo' scenario.
These data are based on a total retirement of 30% of the 98,143 irrigated acres in the six subareas.

Table 43. Total Net Present Value of Impacts on Producer Gross Profits, at a -5% Discount Rate

		Scenario			
Subarea	County	Conversion to Dryland	Limited Irrigation	Water Rights Buyout	CREP
1	Sherman	-$637,347,240	$56,619,633	-$109,641,180	-$74,540,292
2	Sherman	-$258,433,163	$17,733,301	-$65,178,654	-$39,650,466
3	Cheyenne	-$204,041,718	$4,253,400	-$35,802,255	-$33,705,710
4	Thomas	-$33,814,427	$295,755	-$8,605,519	-$6,093,770
5	Thomas	-$871,556,743	$73,900,115	-$133,143,973	-$104,743,324
6	Sheridan	-$621,490,085	$91,345,123	-$33,996,564	-$43,837,844
	Total	-$2,626,683,377	$244,147,327	-$386,368,144	-$302,571,405

All impacts are measured relative to the 'Status Quo' scenario.
These data are based on a total retirement of 30% of the 98,143 irrigated acres in the six subareas.

Table 44. Per Acre Net Present Value of Impacts on Producer Gross Profits, at a -5% Discount Rate

		Scenario			
Subarea	County	Conversion to Dryland	Limited Irrigation	Water Rights Buyout	CREP
1	Sherman	-$29,119	$2,587	-$5,009	-$3,406
2	Sherman	-$29,451	$2,021	-$7,428	-$4,519
3	Cheyenne	-$32,852	$685	-$5,764	-$5,427
4	Thomas	-$28,132	$246	-$7,159	-$5,070
5	Thomas	-$24,752	$2,099	-$3,781	-$2,975
6	Sheridan	-$25,005	$3,675	-$1,368	-$1,764
	Average	-$26,764	$2,488	-$3,937	-$3,083

All impacts are measured relative to the 'Status Quo' scenario.
These data are based on a total retirement of 98,143 irrigated acres in the six subareas.

Table 45. Total Net Present Value of Impacts on Regional Value Added, at a 5% Discount Rate

		Scenario			
Subarea	County	Conversion to Dryland	Limited Irrigation	Water Rights Buyout	CREP
1	Sherman	-$41,631,687	-$7,191,179	-$6,918,724	-$15,205,286
2	Sherman	-$15,901,577	-$2,121,068	-$3,257,611	-$5,896,617
3	Cheyenne	-$11,821,392	-$2,222,283	-$1,853,606	-$4,603,317
4	Thomas	-$1,915,764	-$317,538	-$326,013	-$776,064
5	Thomas	-$57,295,324	-$8,418,343	-$7,742,513	-$22,468,024
6	Sheridan	-$43,815,439	-$7,943,605	-$4,110,243	-$17,182,693
	Total	-172,381,183	-28,214,016	-24,208,710	-66,132,000

All impacts are measured relative to the 'Status Quo' scenario.
These data are based on a total retirement of 98,143 irrigated acres in the six subareas.

Table 46. First Year Economic Impact on Total Value Added on a Per Capita basis and as a Percent of Total Regional Value Added

	Scenario			
Item	Conversion to Dryland	Limited Irrigation	Water Rights Buyout	CREP
First Year Lost Value Added	-$16,509,509	-$3,569,328	$2,751,298	-$7,117,582
Impact per Capita	-$502	-$108	$84	-$216
Percent Impact	-1.70%	-0.37%	0.28%	-0.73%

All impacts are measured relative to the 'Status Quo' scenario.
These data are based on a total retirement of 98,143 irrigated acres in the six subareas.
As reported in Table 28, the nine-county regional economy produces $973,387,000 in value added annually.
As reported in Table 27, the nine-county region has a population of 32,902.

Table 47. First Year Economic Impact on Input Suppliers Value added on a Per Capita basis and as a Percent of Total Regional Value Added

Item	Conversion to Dryland	Limited Irrigation	Water Rights Buyout	CREP
	Scenario			
First Year Lost Value Added	-$5,398,503	-$869,391	-$1,619,551	-$2,383,582
Impact per Capita	-$164	-$26	-$49	-$72
Percent Impact	-0.55%	-0.09%	-0.17%	-0.24%

All impacts are measured relative to the ‘Status Quo’ scenario.
These data do not include impacts associated with producer proprietary income, employee compensation, producer property income, or indirect business tax.
These data are based on a total retirement of 98,143 irrigated acres in the six subareas.
As reported in Table 28, the nine-county regional economy produces $973,387,000 in value added annually.
As reported in Table 27, the nine-county region has a population of 32,902.

Figures

Figure 1. Subareas in Cheyenne, Sheridan, and Sherman Counties

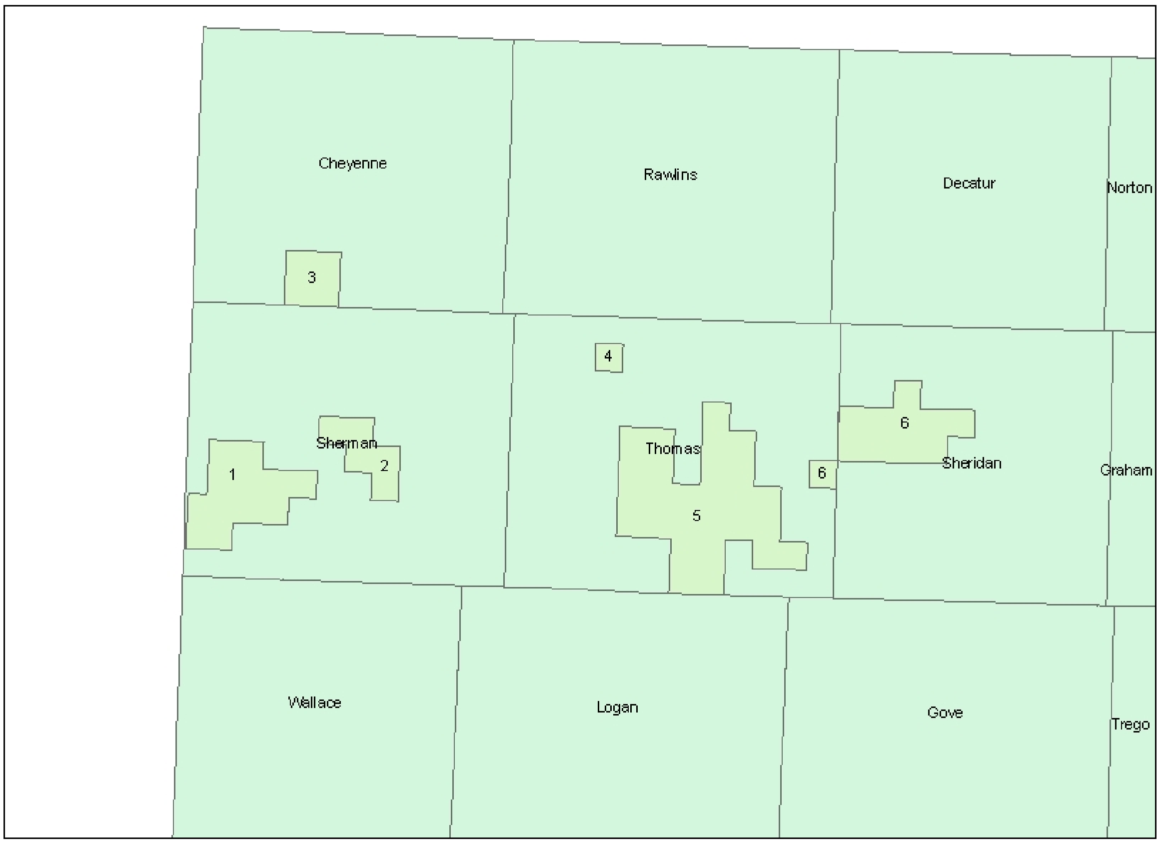

Figure 2. Scenario 1: Status Quo Projected Time Path for Saturated Thickness and Well Capacity in Subarea 6 of Sheridan County

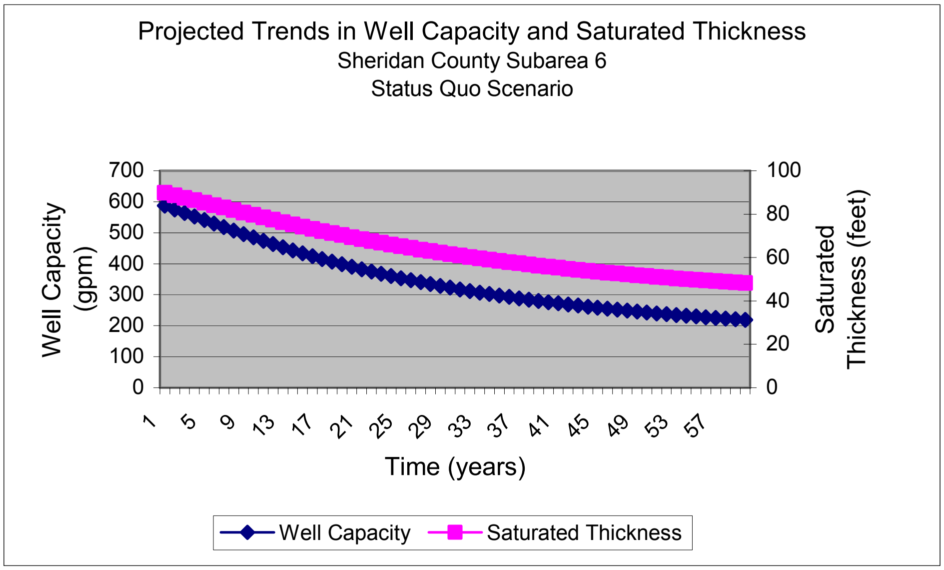

Figure 3. Scenario 1: Status Quo Projected Time Path for Irrigated Corn Acreage in Subarea 6 of Sheridan County

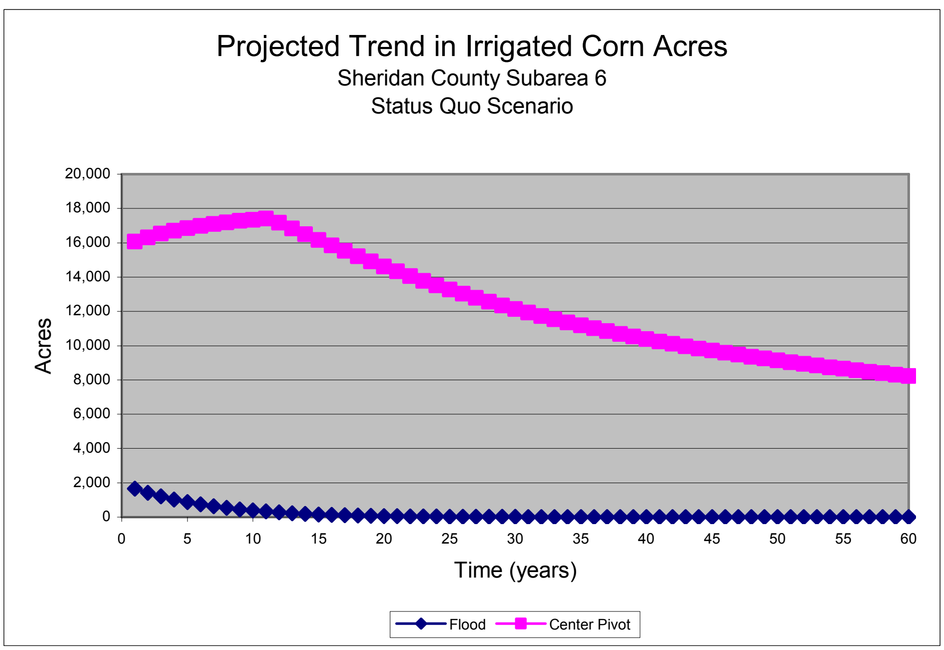

Figure 4. Scenario 1: Status Quo Projected Time Path for Total Irrigated and Non-Irrigated Acreage in Subarea 6 of Sheridan County

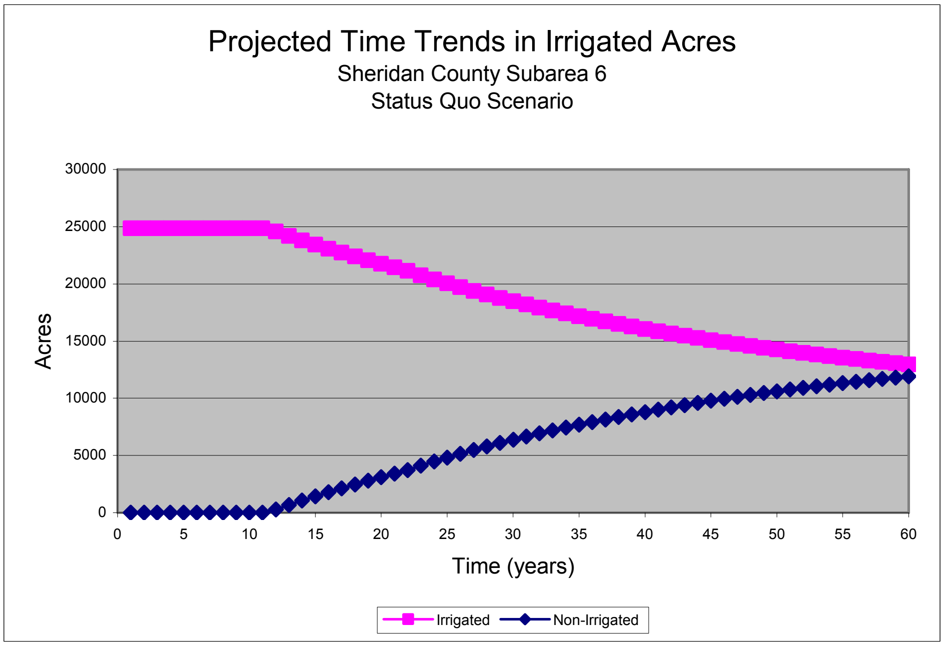

Figure 5. Time Path for Gross Profits in Subarea 6 of Sheridan County for all Scenarios.

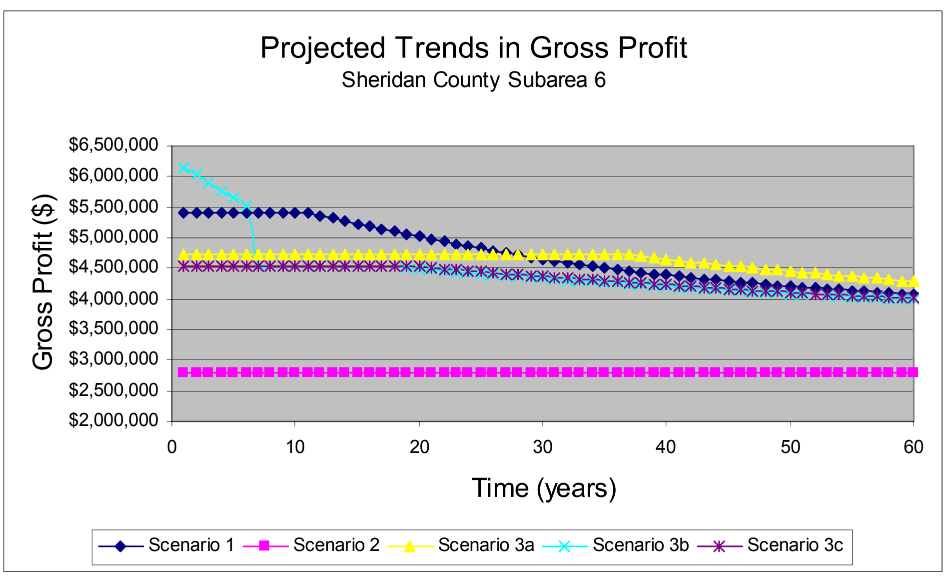

Figure 6. Time Path for Saturated Thickness in Subarea 6 of Sheridan County for all Scenarios

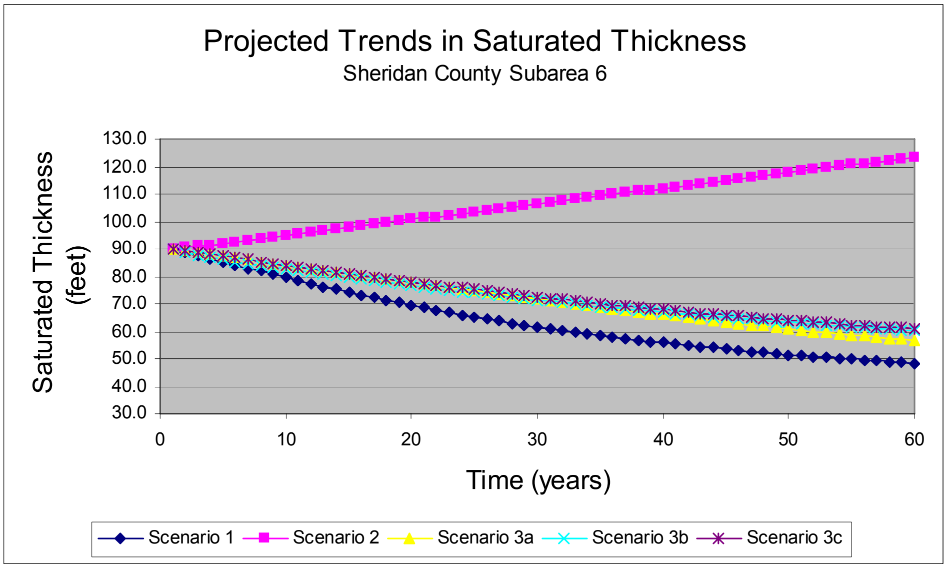

Figure 7. Time Path for Gross Water Used in Subarea 6 of Sheridan County for all Scenarios

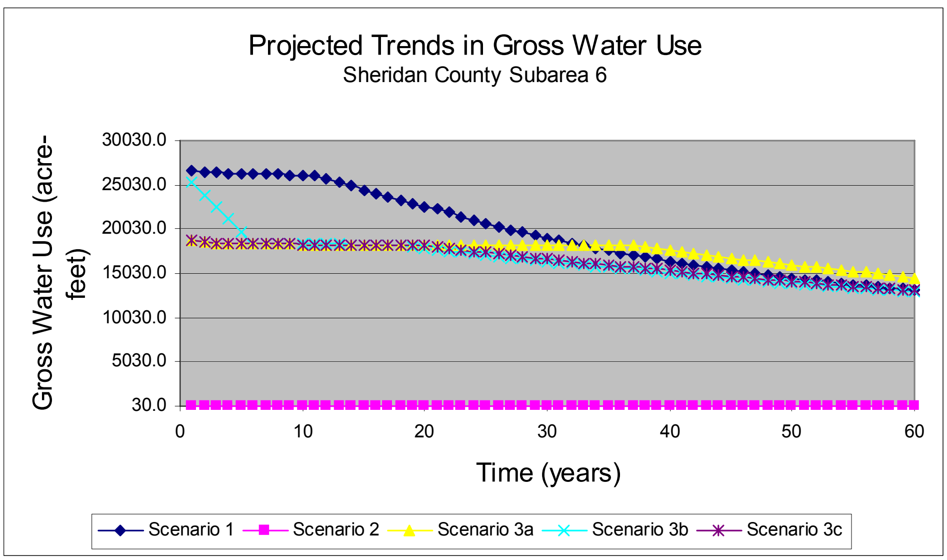

Figure 8. Time Path for Total Value Added for the Immediate Conversion to Dryland Scenario for Subarea 6 of Sheridan County

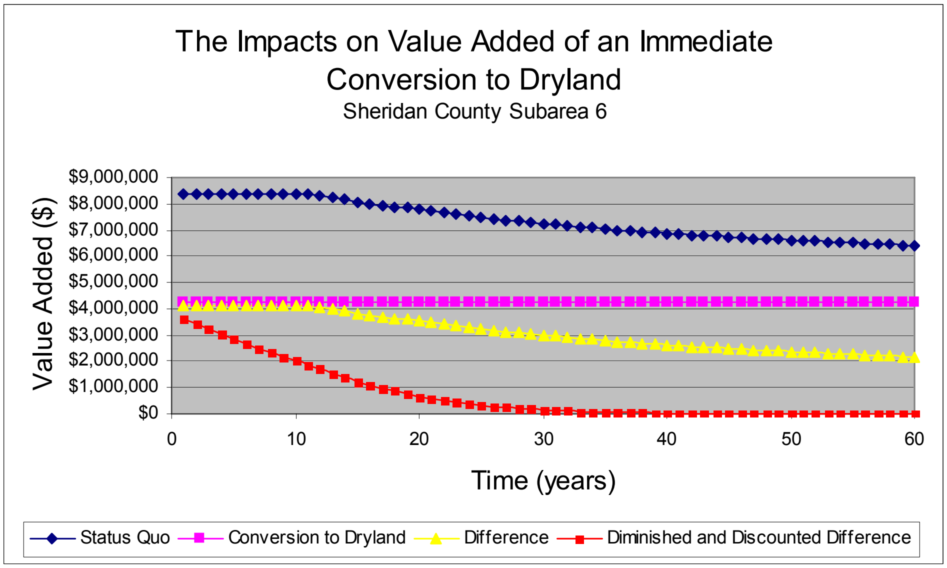

Figure 9. Time Path for Total Value Added for the Immediate Conversion to Limited Irrigation Scenario for Subarea 6 of Sheridan County

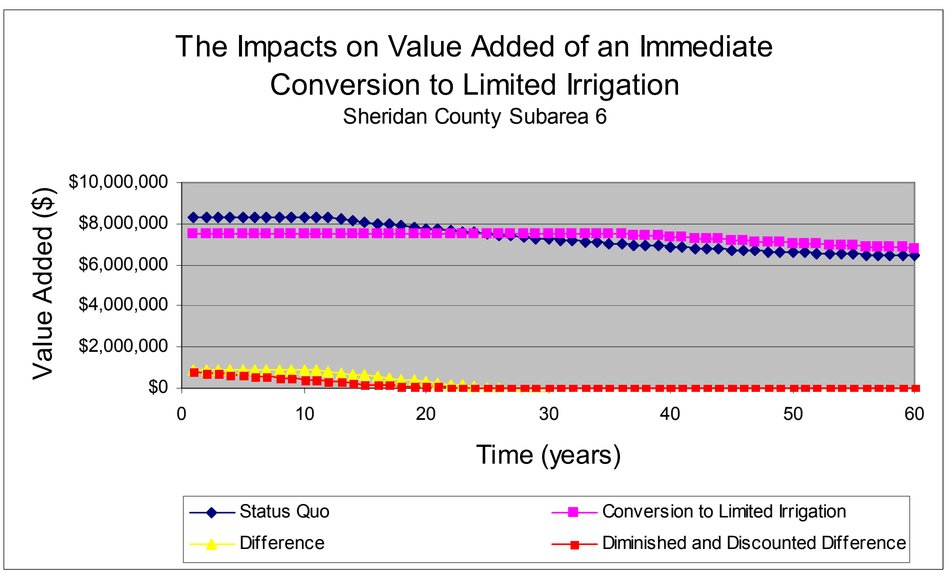

Figure 10. Time Path for Total Value Added for a Water Rights Buyout Scenario for Subarea 6 of Sheridan County

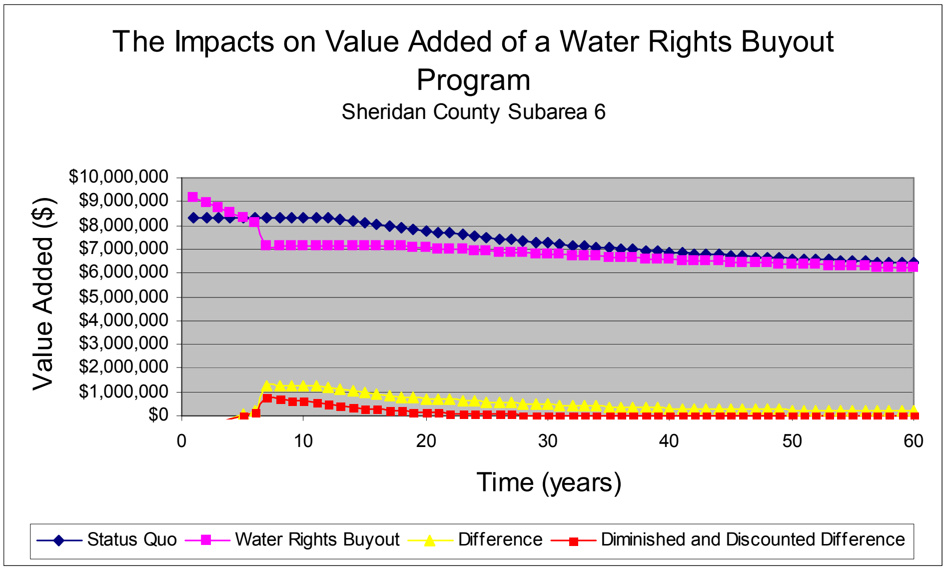

Figure 11. Time Path for Total Value Added for a CREP Scenario for Subarea 6 of Sheridan County

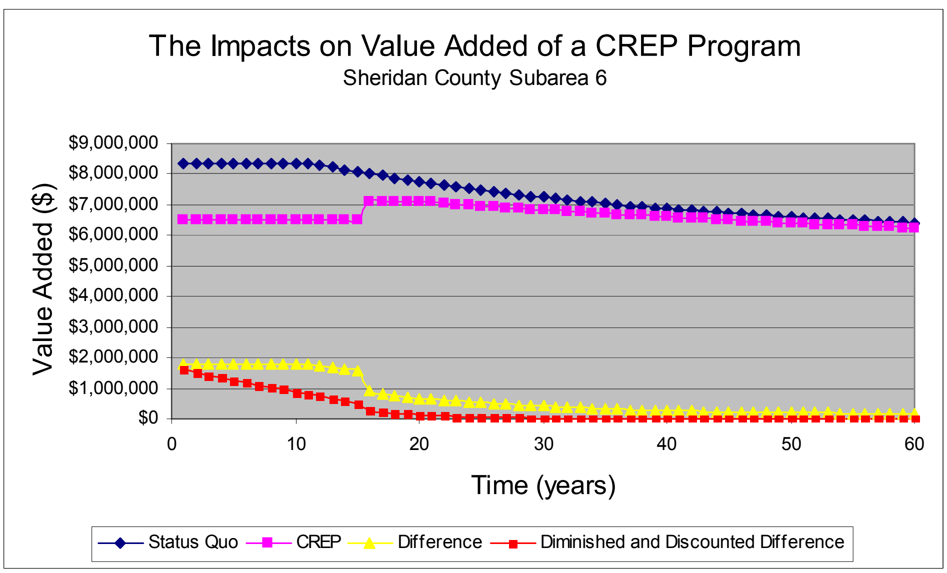

Figure 12. Relative Time Trends in Gross Profit for the Status Quo Scenario

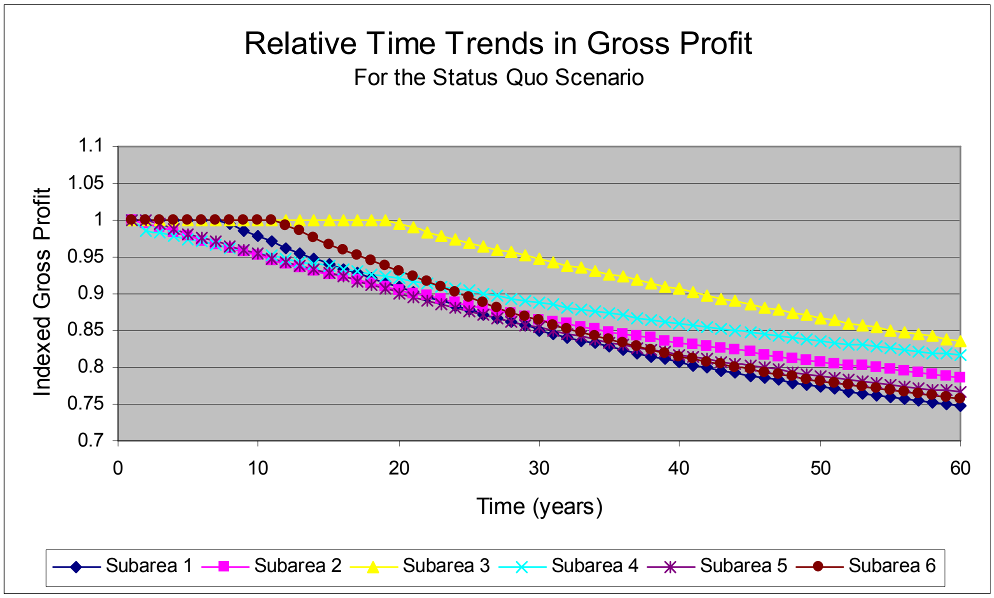

Figure 13. Relative Time Trends in Gross Profit for the Limited Irrigation Scenario

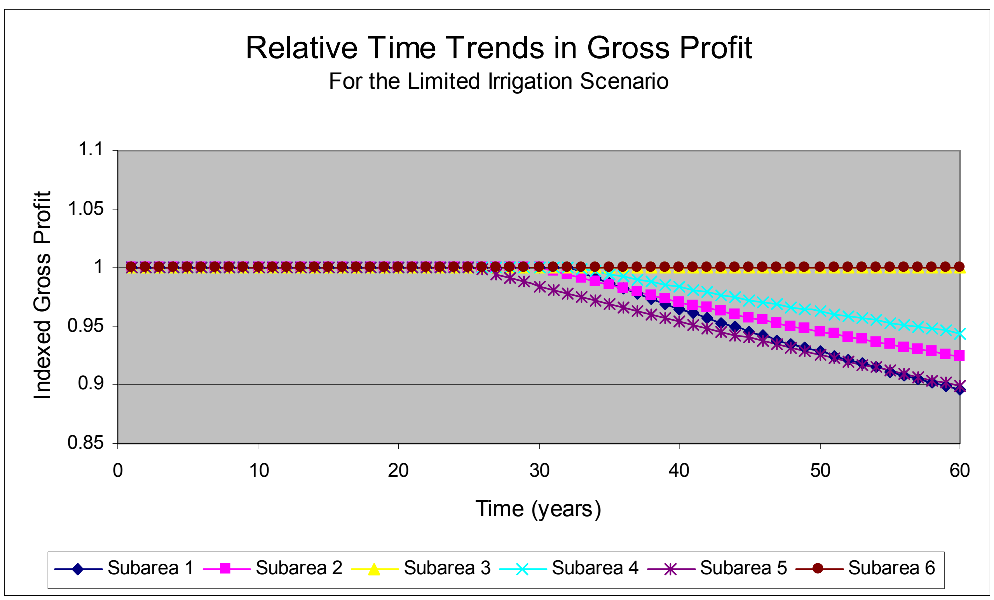

Figure 14. Relative Time Trends in Saturated Thickness for the Status Quo Scenario

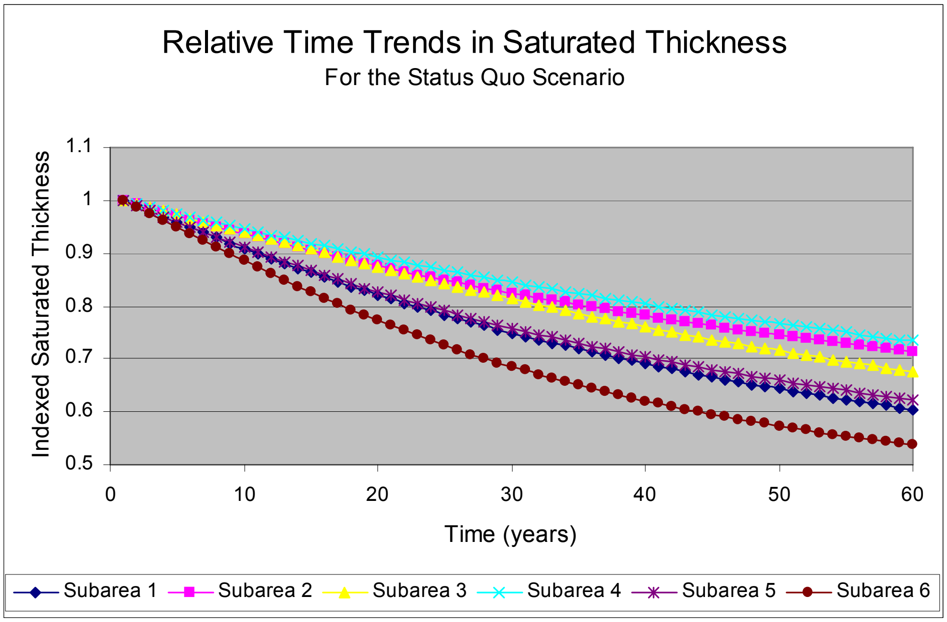

Figure 15. Relative Time Trends in Saturated Thickness for the Limited Irrigation Scenario

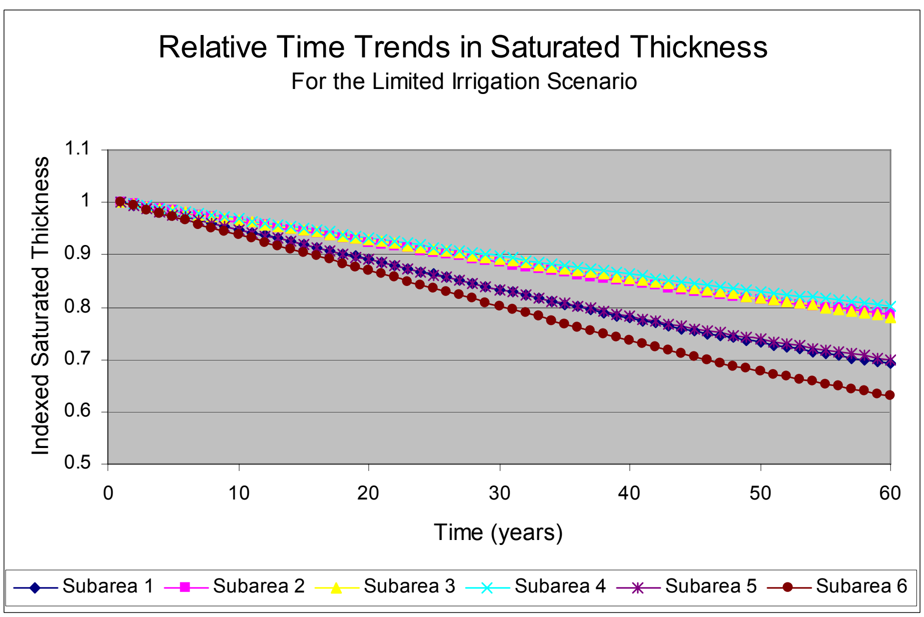

Figure 16. Relative Difference Time Trends in Saturated Thickness between the Limited Irrigation and Status Quo Scenario