Evaluation of Changing Land Use and Potential Water Conservation Strategies:

North Plains Groundwater Conservation District

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Introduction

The North Plains Groundwater Conservation District (NPGCD) is facing critical decisions regarding potential water conservation policies. It has been projected through the planning efforts set forth in Senate Bills 1, 2, 3 and 4 that the four western counties of the district will have difficulty in meeting the Desired Future Condition (DFC) of having 40% of the groundwater remaining in 50 years. Evaluation of the economic implications from changing land use, alternative water conservation strategies being considered, and/or the impacts of potential water policies originating from the state or federal government can aid the district in making important policy decisions.

The objective of this study is to evaluate the short and long-term implications of changing land use and alternative water conservation strategies being considered by the NPGCD. Specifically, changing land use and water conservation strategies identified by the district will be evaluated using computer models that project saturated thickness, producer gross margin, and impacts on the regional economy. The results of different scenarios are compared to a *status quo* baseline scenario to evaluate their impacts. A total of four policy alternatives identified by the NPGCD will be evaluated relative to the baseline with the first two being completed in the fall of 2011 (Phase One), and the remaining two scenarios completed by October 2013 or earlier (Phase Two).

The baseline scenario (Phase One) assumes no water conserving policy is included, no projected changes in irrigated acreage occur, and producers operate in an unregulated profit maximizing manner. The baseline projections developed in the previous contract with the district were updated with respect to input parameters. Two scenarios identified in the June 7, 2011 NPGCD Board meeting were evaluated in Phase One related to potential changing land use within the district: an increase in irrigated acreage in the western four counties and an increase in irrigated acreage in the eastern four counties. In both scenarios, a sensitivity analysis on the number of irrigated acres added was performed to provide a broader picture of potential impacts. An additional scenario was analyzed to evaluate the impact of varying discount rates on the value of future agricultural production.

Study Area

The study area is the region overlying the Ogallala Aquifer in the NPGCD. The specific counties included in the analysis are Dallam, Hartley, Moore, and Sherman Counties in the western portion of the district and Hansford, Hutchinson, Ochiltree, and Lipscomb Counties in the eastern portion, Figure 1.

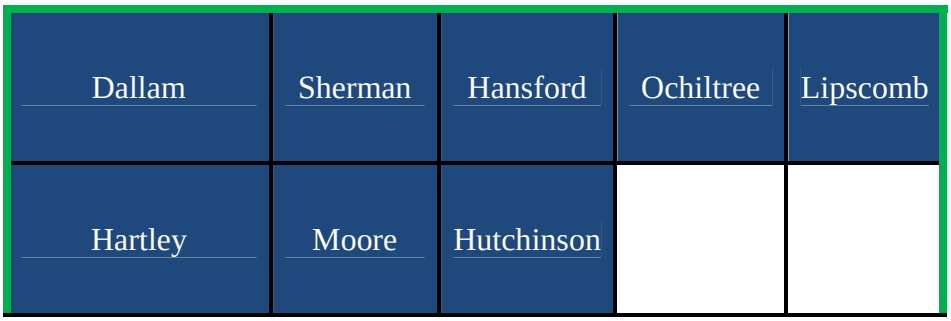

Figure 1. North Plains Groundwater Conservation District

Phase One: Data and Methods

There are two types of economic models that were used in the policy analyses. Economic optimization models (Brooke et al., 1998) for each of the eight counties in the study area were used to estimate changes in the aquifer and producer gross margin over a 50-year planning period. Socioeconomic models were used to evaluate changes in the regional economy and regional employment based on the aggregate results from the county optimization models (MIG, 2009).

The county optimization models begin with the initial county values for crop acreage, irrigated acreage, average saturated thickness, and depth to water. Given the initial conditions, the models estimate the level of crop production and water use that optimize gross margin over a 50-year planning period. Gross margin is defined as the total of revenue less cash expenses. Gross margin differs from net returns in that it does not include fixed expenses. The results of the model include changes in crop acres, irrigated acres, and gross margin over the planning horizon.

The underlying assumptions for the model include county, aquifer, and crop parameters. The parameters for each county include the number of acres planted in each crop, the number of irrigated acres (Farm Service Agency, 2008-2010), and the percentage of the county overlying the Ogallala Aquifer. The aquifer characteristics for each county include the average saturated thickness, depth to water, specific yield, and recharge. Initial saturated thickness estimates were provided by the NPGCD (2011) while a slight modification was made to Moore County saturated thickness (from 196 feet to 167 feet) using Texas Tech Universities' Center for Geospatial Technology (2011) estimates. It was felt that this value more accurately reflects the saturated material which exists for irrigation purposes.

The crop parameters for each crop include crop price, cost of production, and crop yield. Texas AgriLife Extension Service (2010) crop budgets were utilized to obtain three-year average crop prices and costs of production. Crop yield was determined by a production function which estimates yield as a response to applied water. Each crop in each county has a unique production function. As available water decreases, the crop yield decreases in response to reduced irrigation. The production functions were estimated with the aid of Leon New (2010) and are based on field-level observations of the relationships between crop yield and irrigation water applied. Cost of pumping was calculated using the energy price and energy requirement due to the changing depth to water over the planning period. One of the unique aspects of this model is that

water demand incorporates costs of pumping, changes in depth to water, changing crop yields, and potential changes to crop mix as they respond to changing water availability over time.

The results of the county optimization models were aggregated into sub-regional results for the socioeconomic analyses to forecast the effects of the policies on overall economic activity in the NPGCD study area. These models capture the often-cited "spillover effects" of changes in water availability on other economic sectors linked directly and indirectly to irrigated crop production. Models to evaluate the baseline socioeconomic impacts on the overall study area and impacts of the alternative scenarios analyzed used the input-output model, IMpact analysis for PLANning (IMPLAN). Input-output modeling is a method used to understand the linkages between elements of an economy and estimate the impacts of changes in the economy.

To measure impacts, the IMPLAN model produces multipliers which estimate the total economic impact of expenditures within an economy. These impacts are referred to as direct, indirect, and induced effects. An example of these effects is when a producer pays to have his crop custom harvested (direct effect). Then, the custom harvester purchases additional equipment (indirect effect). As a result of profits received, the producer and the custom harvester can spend money at the local grocery store (induced effect). The IMPLAN model contains comprehensive and detailed data coverage of the entire U.S. by county and the ability to incorporate user-supplied data at each stage of the model building process. In addition, particular crop production costs for each crop were input into the model to get more detailed and region-specific results. These models generated the impact projections of employment, regional income, and industry output for the study area.

Modeling Modifications from Recent Reports

Several updates/changes were made to the models used in the analysis compared to the previous study. Frist, the projected planning horizon was reduced from 60 years to 50 years to be consistent with the length of time established to reach a specified DFC. Second, crop acreage data was updated through 2010 utilizing Farm Service Agency (2008-2010) records. Previously, a five year average of crop acreage data was used in the models. In the current study, three year averages of crop acreages were utilized to be more responsive to recent changes in acreage. Maximum Allowable Groundwater (MAG) estimates provided by the Texas Water Development Board were replaced by a three year average of water use provided by the district (North Plains Groundwater Conservation District, 2011). Finally, the data in the IMPLAN model for the region was updated and the analysis expanded to include forward linked sectors in addition to the traditional backward linked sectors to reflect more accurately the total impact on the regional economy.

Phase One Results

Current commodity prices in conjunction with technological advancements throughout the farm structure could allow landowners in the NPGCD to expand their current irrigated acreage. In this study, the objective was to evaluate the potential impacts to the aquifer and the regional economy from irrigated acreage increasing throughout the district. The first step in the analysis was to estimate a *status quo* baseline over a 50-year time horizon in which no water

conserving policy is included, no projected changes in irrigated acreage are assumed, and producers operate in an unregulated profit maximizing manner. Then, three separate scenarios were evaluated. The first estimated the impacts of increasing irrigated acreage by 20% and 40% over the baseline values for the four western counties within the NPGCD. A second scenario evaluated the impacts of increasing irrigated acreage by 20% and 40% in the eastern four counties of the NPGCD. For these scenarios, county optimization models projected saturated thickness, irrigated acreage, and gross margin per acre over a 50-year planning horizon while the input-output model (IMPLAN) estimated the impact on the regional economy in terms of output, value added production, and employment. Finally, a third scenario was added to illustrate how the magnitude of these impacts changes with the discount rate chosen.

The baseline scenario established the *status quo* projections by which the 20% and 40% increase in irrigated acres scenarios were compared. Saturated thickness of the western counties started with an average saturated thickness of 156 feet which declined to 64 feet by year 50. As saturated thickness declined, the number of irrigated acres also decreased from a total of 196,642 irrigated acres in year one of the analysis to 130,826 by the end of the planning horizon. Gross margin also declined from $318.59 per acre year one to $218.67 by year 50. Agricultural production under the baseline in the western counties generates impacts to the NPGCD Region of $49.4 billion in output, $17.4 billion in value added, and an annual average of almost 5,000 jobs. The eastern counties of the district started with an average saturated thickness of 201 feet, 86,945 irrigated acres, and gross margin of $141.18 per acre which ended at 183 feet, 69,297 acres, and $236.58 per acre by year 50, respectively. Agricultural production under the baseline in the eastern counties generates impacts to the NPGCD Region of $23.3 billion in output, $7.8 billion in value added, and an annual average of more than 2,400 jobs.

The results of the first scenario indicate that the western counties within the NPGCD will be affected by a 20% and 40% increase in irrigated acreage. The additional burden placed upon the aquifer caused by an increase of 20% in the initial irrigated land draws down the ending saturated thickness an additional 18.7% compared to the baseline, leading to a weighted average of 52 feet by year 50 of the time horizon. The additional 12 foot drop in saturated thickness from depletion of the water resource causes a further reduction in irrigated acreage of 7.6%. Early in the planning horizon, gross margin increased, however, the rapid drawdown in water availability and decreasing irrigated acreage caused gross margin per acre to decline 45.5% by year 50. The scenario with a 40% increase in irrigated acreage magnified the outcomes. Saturated thickness dropped 30.1%, irrigated acreage declined 8.6% and gross margin per acre declined 72.3% compared to the baseline by the end of the planning horizon. Overall, these scenarios resulted in a positive impact to the region's economy over the planning horizon. Industry output and value added rose 15% and 17%, respectively, under the 20% increase scenario with annual average employment increasing 15% relative to the baseline. The 40% scenario results in industry output, value added, and employment increasing 21%, 23%, and 21%, respectively. However, the benefits to the regional economy occur early in the time horizon. Industry output, value added, and employment are less than the baseline in the latter years of the planning horizon.

The second scenario evaluated how a 20% and 40% increase in irrigated land area would impact the eastern counties within the NPGCD. The results of this scenario are much different than Scenario I in that the eastern counties of the district can sustain and thrive from these

increases and still meet the specified DFC. This is due to the smaller amount of irrigated acres (compared to the western counties) relative to the availability of underground water reserves within the four eastern counties. This region of the NPGCD does not exhibit the high rates of decline for the aquifer as observed in the western counties. The weighted average of saturated thickness for these counties only declines by an additional 3.6% and 7.7% compared to the baseline by year 50 when the irrigated land is increased 20% and 40%, respectively. The region was able to sustain the increase in irrigated acreage through the entire planning horizon at either level of irrigated acreage increase. The increase in irrigated acreage improved gross margin per acre 6.3% and 12.9% for the 20% and 40% scenarios, respectively. Additional irrigated acreage has a positive impact on the eastern region's economy. Industry output, value added, and average annual employment increase 10%, 11%, and 10% under the 20% scenario and 22%, 23%, and 21% with the 40% scenario, respectively. Overall, the results of these scenarios prove to be an economic benefit to the eastern counties of the NPGCD despite some loss in saturated thickness.

The third scenario illustrates the impact of alternative discount rates by comparing the baseline to the 20% increase in irrigated acreage scenario for the western counties utilizing discount rates of 3%, 0%, and -3%. Discounting allows the future impacts to the economy to be converted to present day dollars. The analysis within this paper, as well as previous studies, assumed a discount rate of 3%, which is typically an acceptable real rate of return on an asset. The district may want to consider an alternative rate such as 0% meaning that current and future consumption are valued equally or -3% which reflects that future consumption is worth more than current consumption. Results indicate that as the discount rate moves from 3% to -3%, the magnitude of the difference between the baseline and the 20% increase in irrigated acres scenario becomes more prevalent, especially in the latter years of the time horizon.

Given the current economic environment, there exist incentives for landowners to either convert existing dryland acres or break out new rangeland for irrigated purposes. It can be concluded from this analysis that a 20% or a 40% increase in irrigated land in the western four counties of the NPGCD will make it extremely difficult to reach the DFC. While the increase in economic activity will benefit the regional economy as a result of greater farmland returns, this will only be short lived as the aquifer will deplete at a much faster rate, causing large and rapid conversions to dryland and decreasing the profit potential of farmland acres. Conversely, the eastern four counties of the NPGCD appear to be able to sustain either a 20% or 40% increase in irrigated land and still meet the DFC. Increases in irrigated acreage in the eastern counties will increase aquifer depletion somewhat but do lead to gains in the region's economy. It should be noted that any increase in irrigated acreage should to be closely monitored because of potential impact regardless of where it occurs in the NPGCD. The discount rate used in any analysis affects the results and the board needs to evaluate the appropriate rate to be used for the NPGCD considering the organization's own beliefs and goals.

Phase Two

Two additional scenarios were identified by NPGCD in August, 2013 for analysis in Phase II of the project. The first scenario involves estimating the impacts on saturated thickness, producer income and the regional economy over a 50-year time horizon assuming no constraints on water use are imposed. In scenario two, water use is limited in each county where necessary

to meet the DFC for the individual counties and the east and west sub-regions as a whole. A comparison of the unconstrained scenario and the constrained water use scenario results is conducted to evaluate the resultant impacts on saturated thickness, producer income and the regional economy over a 50-year time horizon. It should be noted that the regional economic analysis not only includes the backward linked sectors (traditionally done in the IMPLAN model) but the impacts of the next level of forward-linked sectors such as livestock production, milk production, elevators, etc. to more closely capture the full effect on the regional economy. A final scenario was added by the project team which entailed conducting a sensitivity analysis of the amount of irrigated acreage that could be either added to counties projected not to be constrained by the DFC or subtracted to counties projected to not meet their DFC. A more detailed description of the alternative scenarios identified by the District and the project team to be included in the analysis is given below:

1) **Unconstrained Model:** The unconstrained model is analogous to the baseline model developed in Phase One. The unconstrained model scenario assumes no water conserving policy is included, no projected changes in irrigated acreage occur, and producers operate in an unregulated profit maximizing manner. *Rationale:* Several conditions have changed since the development of the baseline model used in Phase One that could impact projections made with the original baseline model. These changes that were made to the unconstrained model included: updating the irrigated acreage by county; updating the relative crop production costs and utilization of the new GAM projections.

2) **Desired Future Conditions:** The implementation of conservation measures for the NPGCD including two separate Desired Future Conditions (DFC). *Rationale:* Two DFC's are analyzed due to substantial differences in water uses and aquifer conditions between the four western counties and the four eastern counties in the District. Specifically, the four western counties must achieve at least 40% of the current aquifer storage remaining in 50 years while the eastern counties must have at least 50% of aquifer storage remaining in 50 years. In the first DFC scenario, the impacts of each county within the two sub-regions meeting the DFC were evaluated. The second DFC scenario evaluated the effects of the sub-region as *a whole* meeting the requirements.

3) **Acreage Sensitivity Analysis:** Determine the amount of irrigated acreage that can be added to counties and still meet the DFC. *Rationale:* The western counties of the NPGCD have seen a significant expansion in irrigated acreage in recent years due to higher commodity prices and increases in local demand. As depletion in these counties occurs, it is probable that irrigation demand will expand in the remaining counties of the NPGCD resulting in increases in irrigated acreage in these counties. This scenario provides an estimate of the amount of irrigated acreage increase that could be withstood and still meet the DFC in those counties. In counties that were not able to meet the DFC, the reduction in irrigated acreage required to meet the DFC was estimated. It is assumed in this scenario that all new irrigated acreage is introduced in 2014.

Phase Two: Modifications to Phase One Data and Methods

The same basic methodology used in Phase One for constructing and analyzing scenarios was utilized in Phase Two (described above). Changing conditions warranted updating the data used in developing the models to analyze the scenarios in Phase Two. First and foremost, irrigated acreage was changed by county to reflect what is being used in the 2016 Region A water planning effort. In this effort, it was determined that irrigated acreage in Region A had increased 132,278 acres with virtually all of the increase occurring in the NPGWD (mainly in Dallam and Hartley counties). Of the 132,278 acres, 83,000 acres existed in production but was not reported in Farm Service Agency data and the remainder was considered "new" irrigated acreage (Marek et al., 2012). Costs were also updated in the models using the Texas A&M AgriLife Extension Service (2013) crop budgets to obtain three-year average crop prices and costs of production. Finally, the maximum water use in any given year was set based on the average water use in the district for the 2008 – 2012 time periods (North Plains Groundwater Conservation District, 2013). This was done to negate the impacts of volatility in weather and crop mix.

Phase Two Results:

Unconstrained

The unconstrained county level results established the *status quo* projections for the desired future conditions (DFC). Under the unconstrained scenario, no water conserving policy is included, no projected changes in irrigated acreage are assumed, and producers operate in an unregulated profit maximizing manner. The initial values for each county include the allowable annual pumping, average acreage estimates, and other economic variables as indicated in the methods section.

The aquifer drawdown of the western counties of the district was significant under the unconstrained scenario as illustrated in Table 1. Saturated thickness begins at 147 feet, 145 feet, 167 feet, and 173 feet and declines to 47 feet, 50 feet, 73 feet, and 76 feet by year 50 in Dallam, Hartley, Moore, and Sherman Counties, respectively, due to continued aquifer depletion. This loss in saturated thickness translates into a percentage decline of 68% and 66% in Dallam and Hartley Counties, respectively, and 56% in both Moore and Sherman Counties. Dallam and Hartley Counties are projected to have the largest change in saturated thickness, declining 100 and 95 feet over the 50-year horizon, respectively. The eastern counties of the district have relatively less irrigated land which results in a slower rate of aquifer decline over the planning horizon. Saturated thickness begins at 189 and 154 feet in Hansford and Hutchinson Counties with drawdowns of 39 and 37 feet. Lipscomb and Ochiltree Counties are dryland intensive and show very little change in the aquifer over the planning horizon with a beginning saturated thickness of 215 and 214 and drawdowns of 12 and 10 feet, respectively. The percentage decline in saturated thickness is no greater than 24% in any eastern county over the 50-year period.

The western counties, which exhibit the largest decreases in saturated thickness, also have the largest declines in gross margin per acre (Table 2). Dallam County begins with a gross margin of $243.41 per acre in year one which decreases to $128.78 by year 50. Hartley and

Sherman Counties have gross margins of $459.65 and $376.61 in year one which decline to $137.99 and $315.39 by year 50, respectively. On the other hand, gross margin per acre increases in Moore County and the eastern counties over the time period. The increase in profitability through time in these counties is due to the optimization process within the model choosing the crop mix which maximizes profit over the 50-year planning horizon. Given that these counties can reasonably sustain irrigated land over the time horizon, the model converts existing irrigated crop mixes to a more profitable crop mix. In Moore County, gross margin begins at $296.58 per acre, increases over time to $435.57 and then decreases to $347.70 by year 50 with further depletion of the aquifer. This increase in gross margin is possible even as the saturated thickness declines. It should be noted that these changes in crop mix are highly dependent upon the assumptions made within the model. The focus of the model remains upon the marginal difference between the unconstrained results and the alternative scenarios evaluated. Detailed county results of saturated thickness, gross margin and year are located in Appendix A.

The cumulative net present values of regional economic impacts over the 50-year time horizon are shown in Table 3. The IMPLAN analysis captures the impact on the regional economy of changes in crop production in the western and eastern counties of the NPGCD. The value of irrigated and dryland crops through backward and forward linkages in the economy is estimated at $59 billion in industry output, $24 billion in value added, and the support of an annual average of 6,400 jobs over the 50-year time period under the unconstrained scenario for the western counties. The eastern counties do not have the magnitude of impacts to the economy as the western counties as the value of agricultural crop production is less than half at $23 billion in industry output, $9 billion in value added, and an annual average of 2,400 jobs.

Table 1. NPGCD Unconstrained County Saturated Thickness (feet)[1] for Selected Years of the Time Horizon

County	Year 1	Year 10	Year 20	Year 30	Year 40	Year 50
West						
Dallam	147.00	125.75	102.13	78.52	58.71	46.84
Hartley	145.00	121.97	96.38	73.66	59.36	49.75
Moore	167.00	149.48	130.02	110.56	91.10	73.24
Sherman	173.00	154.40	133.73	113.07	92.48	76.40
West Average	**155.75**	**135.16**	**112.27**	**90.32**	**72.18**	**59.07**
East						
Hansford	189.00	181.86	173.93	166.00	158.07	150.14
Hutchinson	154.00	147.13	139.49	131.85	124.21	116.57
Lipscomb	215.00	212.78	210.30	207.83	205.36	202.89
Ochiltree	214.00	212.23	210.26	208.29	206.32	204.36
East Average	**201.47**	**197.49**	**193.06**	**188.64**	**184.21**	**179.79**

[1] West and East averages are weighted by the area overlying the aquifer in each county.

Table 2. NPGCD Unconstrained Gross Margin ($/acre)[1] by County for Selected Years of the Time Horizon

County	Year 1	Year 10	Year 20	Year 30	Year 40	Year 50
West						
Dallam	$243.41	$302.86	$343.74	$364.06	$224.13	$128.78
Hartley	$459.65	$507.25	$529.80	$361.51	$216.65	$137.99
Moore	$296.58	$340.69	$379.98	$411.51	$435.57	$347.70
Sherman	$376.61	$427.08	$464.58	$489.18	$462.38	$315.39
West Average	**$342.57**	**$393.81**	**$428.78**	**$403.06**	**$320.72**	**$218.50**
East						
Hansford	$192.04	$230.95	$257.86	$276.45	$291.50	$303.64
Hutchinson	$189.70	$230.78	$261.83	$282.45	$299.03	$312.42
Lipscomb	$239.38	$274.17	$295.88	$313.05	$327.02	$338.38
Ochiltree	$163.02	$192.13	$215.20	$233.80	$248.97	$261.35
East Average	**$186.03**	**$221.40**	**$247.00**	**$265.72**	**$280.91**	**$293.22**

[1] West and East averages are based on the total irrigated and dryland gross margin (at time t) divided by total irrigated and dryland cropland acres.

Table 3. NPGCD Unconstrained 50-Year Regional Economic Impacts[1] by West and East Regions

	Direct	Indirect	Induced	Total
West				
Output[2]	$36,625	$19,054	$2,871	$58,550
Value Added[2]	$15,971	$6,430	$1,706	$24,108
Employment[3]	3,297	2,516	548	6,360
East				
Output[2]	$14,521	$6,814	$1,186	$22,521
Value Added[2]	$5,753	$2,505	$706	$8,963
Employment[3]	1,195	976	225	2,395

[1] Impacts include both forward-linked and backward-linked effects.
[2] Millions of dollars – discounted at 3% over the 50-year time horizon.
[3] Average annual employment.

Desired Future Conditions (DFC)

The DFC scenario included a 40/50 policy in the West Counties of Dallam, Hartley, Moore and Sherman, and a 50/50 policy in the East Counties of Hansford, Hutchinson, Lipscomb, and Ochiltree. The DFC scenario establishes a restriction on pumping so that at least 40% of the saturated thickness will be remaining in 50 years in the West and 50% in 50 years in the East.

Two different DFC Scenarios were analyzed. In the unconstrained scenario for Moore, Sherman, Hansford, Hutchinson, Lipscomb, and Ochiltree Counties, saturated thickness at the end of the time horizon was greater than the DFC target. Therefore, applying the DFC policy left these counties unaffected. Dallam and Hartley were the only counties affected by the DFC

restriction. Thus, under the first DFC scenario "County Weighted DFC", the DFC was analyzed for Dallam and Hartley Counties individually. Then, a weighted average for the west region was calculated. The second DFC scenario, "Regional DFC" analyzed the DFC for the entire western region as a whole and provides a better representation of actual management which is occurring on a regional basis rather than on a county basis. The eastern region of the NPGCD is unaffected by the DFC and thus, only a comparison between the unconstrained scenario and the DFC scenarios for the western portion of the District is shown in Tables 4-6.

The County Weighted DFC policy constrained saturated thickness to be 58.8 feet in Dallam County and 58.0 feet in Hartley County by year 50 of the analysis. Saturated thickness in Dallam and Hartley Counties started at 147 feet and 145 feet and declined 60% to reach their respective targets. This resulted in a savings of 12 feet of saturated thickness in Dallam County and 8.25 feet in Hartley County. The increase in saturated thickness at the end of the time horizon had noticeable effects on producer gross margin. Gross margins were reduced in both counties when restricted by the County DFC. Under this scenario, gross margin in Dallam County dropped from $217.51 to $18.70 per acre by year 50. Gross margin decreased 86% from the unconstrained projections. In Hartley County, gross margin under the DFC scenario fell from $459.62 to $54.92 per acre, resulting in a decrease of 60% compared to the unconstrained scenario. The county-level effects resulted in an overall weighted average for the western region of 65 feet in saturated thickness and $163.35 per acre in producer gross margin by year 50.

The Regional DFC policy constrained saturated thickness to be 62.3 feet in the western region by year 50 of the analysis. Saturated thickness started at an average of 156 feet and declined 60% to reach the target, resulting in a savings of three feet of saturated thickness when compared to the unconstrained scenario. Gross margins were reduced in as a result of the Regional DFC, but not by as much as in the County DFC scenario. Gross margin fell from $337.54 to $213.79 per acre, resulting in a decrease of 2.2% compared to the unconstrained scenario.

The regional economy was also affected by the DFC, as indicated in Table 8. The net impact to regional economic output and employment fell by as much as 6% under the County DFC scenario. Industry output, value added, and employment decreased by $3.5 billion, $1.5 billion, and 239 jobs, respectively, over the 50-year time horizon. The impacts of the Regional DFC to the economy are less pronounced with a decline of 4% compared to the unconstrained scenario. Under the Regional DFC, industry output, value added, and employment declined by $2.2 billion, $958 million, and 151 jobs, respectively, over the 50-year time period. These impacts are illustrated in Figure 2 where the regional economic impacts under the unconstrained scenario are represented with solid lines while the DFC is depicted by the dashed lines. In addition, two alternative discount rates were compared to detect the differences in regional economic impacts from agricultural crop production under both scenarios. The 0% discount rate (shown in red) suggests that current and future consumption are valued equally while the 3% discount rate (shown in blue) indicates that future consumption is worth more than current consumption. Typically, a 3% discount rate is used in economic studies to convert future returns to present day values. However, the choice of a discount rate depends on many factors including a person's or organization's own beliefs, goals, or age.

Although the eastern NPGCD was unaffected by the DFC scenario, the regional economic results are presented in Table 7 and Figure 3. Detailed county and regional results of saturated thickness and gross margin under the DFC scenarios are presented in Appendix B.

Table 4. NPGCD DFC Saturated Thickness (feet) for Dallam County, Hartley County, and the West Region for Selected Years of the Time Horizon

County	Year 1	Year 10	Year 20	Year 30	Year 40	Year 50
Dallam						
Unconstrained	147.00	125.75	102.13	78.52	58.71	46.84
DFC	147.00	125.93	103.92	85.37	70.14	58.80
Change from Unconstrained	*0.0%*	*0.1%*	*1.8%*	*8.7%*	*19.5%*	*25.5%*
Hartley						
Unconstrained	145.00	121.97	96.38	73.66	59.36	49.75
DFC	145.00	123.17	102.58	85.21	70.47	58.00
Change from Unconstrained	*0.0%*	*1.0%*	*6.4%*	*15.7%*	*18.7%*	*16.6%*
West Average						
Unconstrained[1]	155.75	135.16	112.27	90.32	72.18	59.07
County Weighted DFC[1]	155.75	135.60	114.78	95.97	78.94	65.05
Change from Unconstrained	*0.0%*	*0.3%*	*2.2%*	*6.3%*	*9.4%*	*10.1%*
Regional DFC[2]	155.75	135.58	113.17	91.21	74.02	62.30
Change from Unconstrained	*0.0%*	*0.3%*	*0.8%*	*1.0%*	*2.5%*	*5.5%*

[1] West average weighted by the area overlying the aquifer in each county.
[2] Four counties in the West analyzed as a single region.

Table 5. NPGCD DFC Gross Margin ($/acre) for Dallam County, Hartley County, and the West Region for Selected Years of the Time Horizon

County	Year 1	Year 10	Year 20	Year 30	Year 40	Year 50
Dallam						
Unconstrained	$243.41	$302.86	$343.74	$364.06	$224.13	$128.78
DFC	$217.51	$163.23	$111.99	$73.88	$45.73	$18.70
Change from Unconstrained	*-10.6%*	*-46.1%*	*-67.4%*	*-79.7%*	*-79.6%*	*-85.5%*
Hartley						
Unconstrained	$459.65	$507.25	$529.80	$361.51	$216.65	$137.99
DFC	$459.62	$313.23	$202.72	$132.77	$88.01	$54.92
Change from Unconstrained	*0.0%*	*-38.2%*	*-61.7%*	*-63.3%*	*-59.4%*	*-60.2%*
West Average						
Unconstrained[1]	$342.57	$393.81	$428.78	$403.06	$320.72	$218.50
County Weighted DFC[1]	$334.69	$300.73	$272.96	$255.13	$232.91	$163.35
Change from Unconstrained	*-2.3%*	*-23.6%*	*-36.3%*	*-36.7%*	*-27.4%*	*-25.2%*
Regional DFC[2]	$337.54	$338.21	$335.78	$327.82	$260.72	$213.79
Change from Unconstrained	*-1.5%*	*-14.1%*	*-21.7%*	*-18.7%*	*-18.7%*	*-2.2%*

[1] West average is based on the total irrigated and dryland gross margin (at time t) divided by total irrigated and dryland cropland acres.
[2] Four counties in the West analyzed as a single region.

Table 6. NPCGD West Region 50-Year Regional Economic Impacts[1]

	Direct	Indirect	Induced	Total	Change From Uncon-strained	% Change From Uncon-strained
Unconstrained						
Output[2]	$36,625	$19,054	$2,871	$58,550		
Value Added[2]	$15,971	$6,430	$1,706	$24,108		
Employment[3]	3,297	2,516	548	6,360		
County Weighted DFC						
Output[2]	$34,669	$17,678	$2,675	$55,022	-$3,528	-6%
Value Added[2]	$15,063	$5,945	$1,590	$22,598	-$1,510	-6%
Employment[3]	3,297	2,313	511	6,122	-239	-4%
Regional DFC						
Output[2]	$35,391	$18,180	$2,746	$56,317	-$2,233	-4%
Value Added[2]	$15,396	$6,122	$1,632	$23,150	-$958	-4%
Employment[3]	3,298	2,387	525	6,209	-151	-2%

[1] Impacts include both forward-linked and backward-linked effects.
[2] Millions of dollars – discounted at 3% over the 50-year time horizon.
[3] Average annual employment.

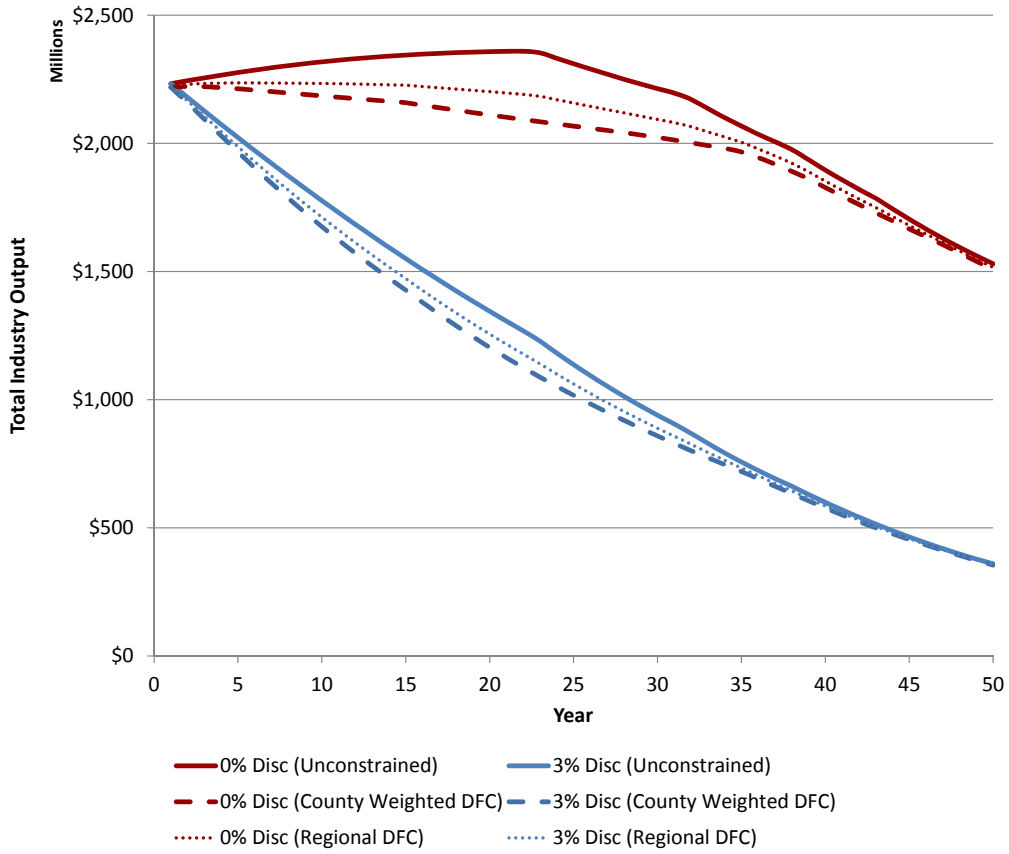

Figure 2. NPCGD West Region Total Industry Output Impacts for a 50-year Planning Horizon Utilizing Alternative Discount Rates of 0% and 3%

Table 7. NPCGD East Region 50-Year Regional Economic Impacts[1]

	Direct	Indirect	Induced	Total	Change From Uncon-strained	% Change From Uncon-strained
Unconstrained						
Output[2]	$14,521	$6,814	$1,186	$22,521		
Value Added[2]	$5,753	$2,505	$706	$8,963		
Employment[3]	1,195	976	225	2,395		
DFC						
Output[2]	$14,521	$6,814	$1,186	$22,521	$0	0%
Value Added[2]	$5,753	$2,505	$706	$8,963	$0	0%
Employment[3]	1,195	976	225	2,395	0	0%

[1] Impacts include both forward-linked and backward-linked effects.
[2] Millions of dollars – discounted at 3% over the 50-year time horizon.
[3] Average annual employment.

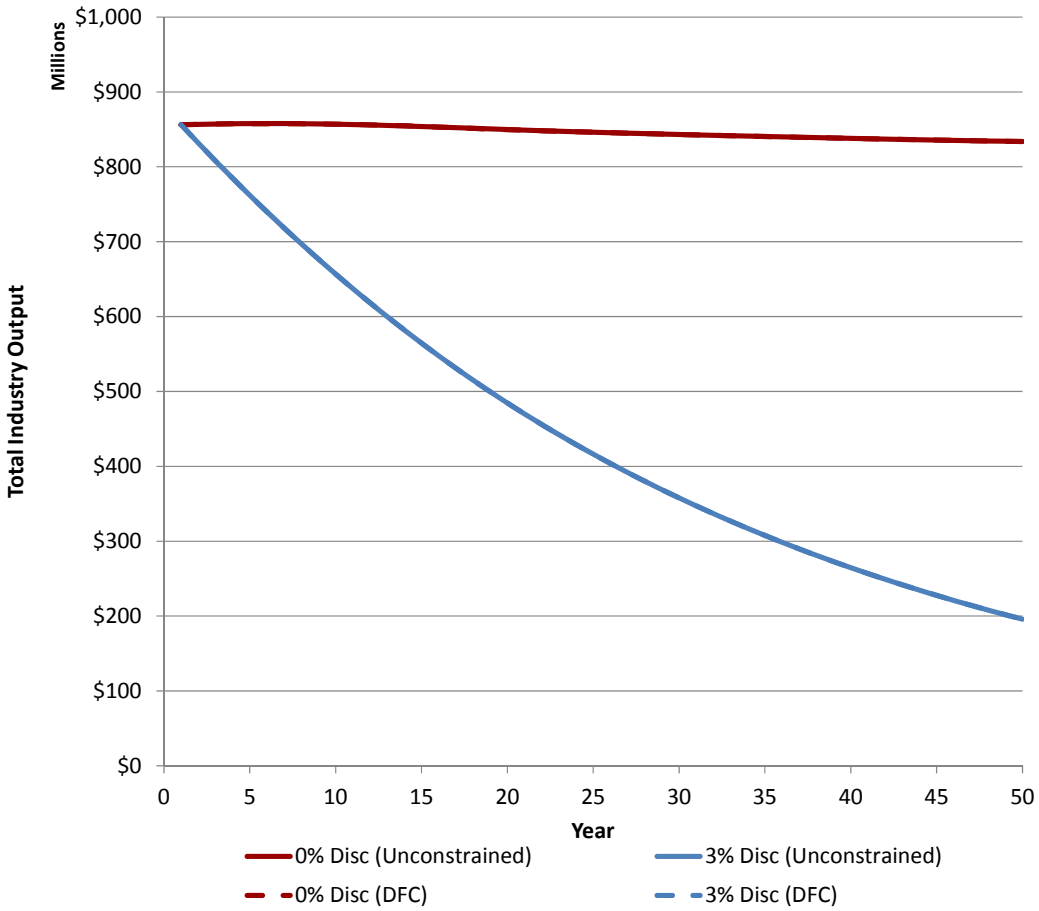

Figure 3. NPCGD East Region Total Industry Output Impacts for a 50-year Planning Horizon Utilizing Alternative Discount Rates of 0% and 3%

Acreage Sensitivity Analysis

The western counties of the NPGCD have seen a significant expansion in irrigated acreage in recent years due to higher commodity prices and increases in local demand. In particular, Dallam and Hartley Counties have experienced substantial increases in irrigated acreage and are not projected to meet their DFC in the absence of water use restrictions. The decrease in irrigated acreage that would be necessary for these counties to be able to meet their DFC was estimated to be 20% (Table 10). Irrigated acreage would need to decline to 235,602 acres in Dallam County and 204,498 acres in Hartley County.

As depletion in these two counties occurs, it is probable that irrigation demand will expand in the remaining counties of the NPGCD resulting in increases in irrigated acreage in these counties. The increase in irrigated acreage that could be sustained while still meeting the DFC was estimated for the remaining six counties in the NPGCD. The percentage increase in irrigated acreage that could be allowed while still meeting the DFC ranged from 5% in Moore County to 500% in Lipscomb County. The eastern counties, in particular, are able to withstand a substantial increase in irrigated acreage and still meet their DFC in year 50 of the analysis. Currently, Lipscomb has only 61,706 acres of cropland and Ochiltree has 231,001 acres of total

cropland. Thus, in these counties, the estimated maximum increase in acreage to occur while still meeting the DFC would have to come from the break-out of new irrigated cropland.

Table 10. Irrigated Acreage Decrease or Increase to Meet a County DFC.

County	Average Acreage (2006-2010)	Acreage to Meet the DFC	Percent Change
West			
Dallam	294,502	235,602	-20%
Hartley	255,623	204,498	-20%
Moore	142,470	149,594	5%
Sherman	184,844	203,328	10%
East			
Hansford	132,913	245,889	85%
Hutchinson	35,520	56,832	60%
Lipscomb	36,416	218,496	500%
Ochiltree	59,634	268,353	350%

Summary and Conclusions

Two scenarios were identified by the NPGCD for analysis in Phase II of this project. The first scenario involved estimating the impacts on saturated thickness, producer income and the regional economy over a 50-year time horizon assuming no constraints on water use are imposed (unconstrained scenario). Changing conditions warranted updating the data used in developing the models to analyze the scenarios in Phase Two. Increases in local demand, rising commodity prices, and technological advancements have influenced the expansion of irrigated acres in the western portion of the NPGCD. Saturated thickness of the western counties started with an average saturated thickness of 156 feet which declined to 59 feet by year 50. As saturated thickness declined, gross margin also declined from $342.57 per acre in year one to $218.50 by year 50. Agricultural production under the unconstrained scenario in the western counties generates impacts to the NPGCD Region of $59 billion in output and $24 billion in value added over the 50-year time horizon, and an annual average of approximately 6,400 jobs. The average initial saturated thickness in the eastern counties of the district started at 201 feet with an average gross margin of $186.03 per acre. Ending average saturated thickness was 180 feet with an average gross margin of $293.22 per acre by year 50. Agricultural production under the unconstrained scenario in the eastern counties generates impacts to the NPGCD Region of approximately $23 billion in output, $9 billion in value added, and an annual average of 2,400 jobs.

In scenario 2 (the DFC scenario), water use was limited in each county where necessary to meet the DFC for the individual counties and the district as a whole. A comparison of the unconstrained scenario and the constrained water use scenario results was conducted to evaluate the resultant impacts on saturated thickness, producer income and the regional economy over a 50-year time horizon. The DFC only resulted in restricted water use in Dallam and Hartley Counties. Under this scenario, average saturated thickness for the western portion of the NPGCD decreased to 65.05 feet by year 50 which is 10% higher than the unconstrained scenario. Reduced yields resulted in a reduced average gross margin for the western portion of $163.35 per

acre which is 25% lower than the unconstrained scenario. In addition, economic activity in the sub-region was reduced 3.5 billion dollars over the 50 years and an annual average of 239 jobs was lost compared to the unconstrained model.

Evaluating the impacts of imposing a regional DFC rather than a county specific DFC in the western counties helped lessen the overall negative economic impacts. Ending gross margin was estimated to be $50 per acre higher, economic activity over the 50-year time line was 1.3 billion more and annual employment averaged 87 more than the county specific DFC. However, region-wide saturated thickness did decline an additional 2.75 feet.

A final scenario was added by the project team in which a sensitivity analysis was conducted for the amount of irrigated acreage that could be added to counties projected not to be constrained by the DFC. Results indicated that Dallam and Hartley Counties would both need to reduce irrigated acreage by 20% in order to meet the DFC while the remaining counties in the district could actually increase irrigated acreage in a range from 5% in Moore County to 500% in Lipscomb County.

Given the current economic environment, there exist incentives for landowners to either convert existing dryland acres or break out rangeland for irrigated purposes. It can be concluded from this analysis that Dallam and Hartley Counties cannot sustain further increases in irrigated acreage. In fact, either a decrease in irrigated acreage or a lower application of irrigation per acre will need to occur in order for these counties to meet their target DFC. However, the eastern counties of the district could actually increase irrigated acreage substantially and still be able to meet their DFC. Increasing irrigated acreage in these counties could be one way to offset some of the economic losses that will occur in the western counties as the aquifer declines. Further research should be conducted to determine the feasibility as well as the costs and benefits associated with any increases in irrigated acreage in these counties.

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Appendix A:

Estimated Saturated Thickness and Gross Margin for the Unconstrained Scenario by County and Year

SATURATED THICKNESS (FEET)								
Year	**Dallam**	**Hartley**	**Moore**	**Sherman**	**Hansford**	**Hutchinson**	**Lipscomb**	**Ochiltree**
2014	147.00	145.00	167.00	173.00	189.00	154.00	215.00	214.00
2015	144.64	142.44	165.05	170.93	188.21	153.24	214.75	213.80
2016	142.28	139.88	163.11	168.87	187.41	152.47	214.51	213.61
2017	139.92	137.32	161.16	166.80	186.62	151.71	214.26	213.41
2018	137.55	134.76	159.22	164.73	185.83	150.94	214.01	213.21
2019	135.19	132.20	157.27	162.67	185.03	150.18	213.76	213.02
2020	132.83	129.65	155.32	160.60	184.24	149.42	213.52	212.82
2021	130.47	127.09	153.38	158.53	183.45	148.65	213.27	212.62
2022	128.11	124.53	151.43	156.47	182.65	147.89	213.02	212.43
2023	125.75	121.97	149.48	154.40	181.86	147.13	212.78	212.23
2024	123.39	119.41	147.54	152.33	181.07	146.36	212.53	212.03
2025	121.02	116.85	145.59	150.27	180.28	145.60	212.28	211.84
2026	118.66	114.29	143.65	148.20	179.48	144.83	212.03	211.64
2027	116.30	111.73	141.70	146.13	178.69	144.07	211.79	211.44
2028	113.94	109.17	139.75	144.07	177.90	143.31	211.54	211.24
2029	111.58	106.61	137.81	142.00	177.10	142.54	211.29	211.05
2030	109.22	104.05	135.86	139.93	176.31	141.78	211.05	210.85
2031	106.86	101.50	133.91	137.87	175.52	141.02	210.80	210.65
2032	104.49	98.94	131.97	135.80	174.72	140.25	210.55	210.46
2033	102.13	96.38	130.02	133.73	173.93	139.49	210.30	210.26
2034	99.77	93.82	128.08	131.67	173.14	138.72	210.06	210.06
2035	97.41	91.26	126.13	129.60	172.34	137.96	209.81	209.87
2036	95.05	88.70	124.18	127.53	171.55	137.20	209.56	209.67
2037	92.69	86.18	122.24	125.47	170.76	136.43	209.32	209.47
2038	90.32	83.80	120.29	123.40	169.96	135.67	209.07	209.28
2039	87.96	81.55	118.34	121.33	169.17	134.91	208.82	209.08
2040	85.60	79.42	116.40	119.27	168.38	134.14	208.57	208.88
2041	83.24	77.40	114.45	117.20	167.59	133.38	208.33	208.69
2042	80.88	75.48	112.51	115.13	166.79	132.61	208.08	208.49
2043	78.52	73.66	110.56	113.07	166.00	131.85	207.83	208.29
2044	76.16	71.92	108.61	111.00	165.21	131.09	207.59	208.10
2045	73.79	70.27	106.67	108.93	164.41	130.32	207.34	207.90
2046	71.49	68.69	104.72	106.87	163.62	129.56	207.09	207.70
2047	69.33	67.18	102.77	104.80	162.83	128.79	206.84	207.51
2048	67.30	65.73	100.83	102.74	162.03	128.03	206.60	207.31
2049	65.38	64.35	98.88	100.67	161.24	127.27	206.35	207.11
2050	63.58	63.02	96.94	98.60	160.45	126.50	206.10	206.91
2051	61.87	61.75	94.99	96.54	159.65	125.74	205.86	206.72
2052	60.25	60.53	93.04	94.47	158.86	124.98	205.61	206.52
2053	58.71	59.36	91.10	92.48	158.07	124.21	205.36	206.32
2054	57.26	58.23	89.15	90.57	157.27	123.45	205.11	206.13
2055	55.87	57.15	87.20	88.74	156.48	122.68	204.87	205.93
2056	54.55	56.11	85.26	86.98	155.69	121.92	204.62	205.73
2057	53.30	55.10	83.31	85.29	154.90	121.16	204.37	205.54
2058	52.10	54.13	81.44	83.67	154.10	120.39	204.13	205.34
2059	50.95	53.19	79.66	82.10	153.31	119.63	203.88	205.14
2060	49.86	52.29	77.95	80.60	152.52	118.87	203.63	204.95
2061	48.81	51.41	76.31	79.15	151.72	118.10	203.38	204.75
2062	47.80	50.57	74.75	77.75	150.93	117.34	203.14	204.55
2063	46.84	49.75	73.24	76.40	150.14	116.57	202.89	204.36
% at 50	31.86%	34.31%	43.86%	44.16%	79.44%	75.70%	94.37%	95.49%

GROSS MARGIN ($/ACRE)								
Year	**Dallam**	**Hartley**	**Moore**	**Sherman**	**Hansford**	**Hutchinson**	**Lipscomb**	**Ochiltree**
2014	243.41	459.65	296.58	376.61	192.04	189.70	239.38	163.02
2015	251.74	465.91	302.19	383.21	197.16	195.02	244.36	166.78
2016	259.54	471.90	307.55	389.54	202.07	200.13	248.99	170.40
2017	266.86	477.64	312.68	395.61	206.77	205.05	253.28	173.88
2018	273.73	483.13	317.61	401.42	211.26	209.78	257.33	177.23
2019	280.25	488.38	322.43	407.00	215.56	214.32	261.15	180.45
2020	286.42	493.42	327.14	412.34	219.68	218.69	264.75	183.54
2021	292.24	498.23	331.76	417.46	223.61	222.88	268.11	186.52
2022	297.72	502.84	336.27	422.37	227.36	226.91	271.25	189.38
2023	302.86	507.25	340.69	427.08	230.95	230.78	274.17	192.13
2024	307.65	511.46	345.02	431.59	234.37	234.50	276.86	194.77
2025	312.11	515.46	349.25	435.91	237.63	238.07	279.33	197.30
2026	316.38	519.01	353.39	440.06	240.74	241.50	281.59	199.74
2027	320.55	522.05	357.44	444.03	243.70	244.79	283.76	202.08
2028	324.63	524.59	361.41	447.83	246.51	247.94	285.88	204.38
2029	328.63	526.63	365.29	451.47	249.09	250.97	287.97	206.63
2030	332.53	528.17	369.08	454.96	251.46	253.88	290.01	208.84
2031	336.35	529.21	372.79	458.31	253.65	256.67	292.00	211.00
2032	340.09	529.76	376.43	461.51	255.77	259.32	293.96	213.12
2033	343.74	529.80	379.98	464.58	257.86	261.83	295.88	215.20
2034	347.26	529.36	383.46	467.51	259.90	264.19	297.76	217.23
2035	350.45	528.41	386.86	470.33	261.90	266.42	299.60	219.23
2036	353.31	520.65	390.18	473.02	263.85	268.58	301.41	221.18
2037	355.83	495.21	393.44	475.59	265.77	270.69	303.17	223.09
2038	358.03	470.48	396.62	478.06	267.64	272.75	304.90	224.97
2039	359.89	446.63	399.73	480.42	269.48	274.77	306.60	226.81
2040	361.42	423.77	402.77	482.69	271.28	276.75	308.26	228.61
2041	362.63	401.94	405.75	484.90	273.04	278.69	309.89	230.37
2042	363.51	381.19	408.66	487.06	274.76	280.59	311.48	232.10
2043	364.06	361.51	411.51	489.18	276.45	282.45	313.05	233.80
2044	364.29	342.90	414.29	491.24	278.10	284.27	314.58	235.46
2045	356.60	325.33	417.01	493.25	279.72	286.05	316.08	237.08
2046	337.07	308.78	419.67	495.00	281.31	287.80	317.54	238.68
2047	318.25	293.19	422.27	496.35	282.86	289.50	318.98	240.24
2048	300.27	278.52	424.81	497.30	284.37	291.18	320.39	241.77
2049	283.18	264.67	427.30	497.83	285.86	292.81	321.77	243.27
2050	267.03	251.59	429.73	497.97	287.31	294.42	323.12	244.74
2051	251.82	239.25	432.03	497.70	288.74	295.99	324.45	246.18
2052	237.53	227.61	433.98	481.23	290.13	297.52	325.75	247.59
2053	224.13	216.65	435.57	462.38	291.50	299.03	327.02	248.97
2054	211.60	206.33	436.80	444.33	292.83	300.50	328.26	250.33
2055	199.90	196.64	437.67	427.08	294.14	301.94	329.48	251.66
2056	188.93	187.53	438.18	410.60	295.42	303.35	330.68	252.96
2057	178.61	178.99	425.16	394.90	296.67	304.73	331.85	254.23
2058	168.89	170.98	410.76	379.93	297.89	306.08	332.99	255.48
2059	159.77	163.47	396.95	365.69	299.09	307.41	334.12	256.70
2060	151.23	156.45	383.74	352.14	300.27	308.70	335.22	257.90
2061	143.23	149.87	371.13	339.26	301.42	309.97	336.29	259.08
2062	135.75	143.73	359.12	327.02	302.54	311.21	337.35	260.23
2063	128.78	137.99	347.70	315.39	303.64	312.42	338.38	261.35

Appendix B:

Estimated Saturated Thickness and Gross Margin for the Desired Future Conditions (DFC) Scenarios by County or Region and Year

SATURATED THICKNESS (FEET)								
Year	**Dallam**	**Hartley**	**Moore**	**Sherman**	**Hansford**	**Hutchinson**	**Lipscomb**	**Ochiltree**
2014	147.00	145.00	167.00	173.00	189.00	154.00	215.00	214.00
2015	144.64	142.44	165.05	170.93	188.21	153.24	214.75	213.80
2016	142.28	139.89	163.11	168.87	187.41	152.47	214.51	213.61
2017	139.92	137.38	161.16	166.80	186.62	151.71	214.26	213.41
2018	137.56	134.90	159.22	164.73	185.83	150.94	214.01	213.21
2019	135.21	132.47	157.27	162.67	185.03	150.18	213.76	213.02
2020	132.87	130.09	155.32	160.60	184.24	149.42	213.52	212.82
2021	130.54	127.74	153.38	158.53	183.45	148.65	213.27	212.62
2022	128.23	125.44	151.43	156.47	182.65	147.89	213.02	212.43
2023	125.93	123.17	149.48	154.40	181.86	147.13	212.78	212.23
2024	123.64	120.95	147.54	152.33	181.07	146.36	212.53	212.03
2025	121.37	118.76	145.59	150.27	180.28	145.60	212.28	211.84
2026	119.11	116.62	143.65	148.20	179.48	144.83	212.03	211.64
2027	116.86	114.51	141.70	146.13	178.69	144.07	211.79	211.44
2028	114.62	112.43	139.75	144.07	177.90	143.31	211.54	211.24
2029	112.40	110.39	137.81	142.00	177.10	142.54	211.29	211.05
2030	110.22	108.39	135.86	139.93	176.31	141.78	211.05	210.85
2031	108.08	106.42	133.91	137.87	175.52	141.02	210.80	210.65
2032	105.98	104.48	131.97	135.80	174.72	140.25	210.55	210.46
2033	103.92	102.58	130.02	133.73	173.93	139.49	210.30	210.26
2034	101.90	100.71	128.08	131.67	173.14	138.72	210.06	210.06
2035	99.92	98.87	126.13	129.60	172.34	137.96	209.81	209.87
2036	97.98	97.06	124.18	127.53	171.55	137.20	209.56	209.67
2037	96.07	95.28	122.24	125.47	170.76	136.43	209.32	209.47
2038	94.20	93.53	120.29	123.40	169.96	135.67	209.07	209.28
2039	92.37	91.81	118.34	121.33	169.17	134.91	208.82	209.08
2040	90.57	90.12	116.40	119.27	168.38	134.14	208.57	208.88
2041	88.80	88.45	114.45	117.20	167.59	133.38	208.33	208.69
2042	87.07	86.82	112.51	115.13	166.79	132.61	208.08	208.49
2043	85.37	85.21	110.56	113.07	166.00	131.85	207.83	208.29
2044	83.71	83.62	108.61	111.00	165.21	131.09	207.59	208.10
2045	82.08	82.07	106.67	108.93	164.41	130.32	207.34	207.90
2046	80.48	80.53	104.72	106.87	163.62	129.56	207.09	207.70
2047	78.91	79.03	102.77	104.80	162.83	128.79	206.84	207.51
2048	77.37	77.54	100.83	102.74	162.03	128.03	206.60	207.31
2049	75.87	76.08	98.88	100.67	161.24	127.27	206.35	207.11
2050	74.39	74.65	96.94	98.60	160.45	126.50	206.10	206.91
2051	72.94	73.23	94.99	96.54	159.65	125.74	205.86	206.72
2052	71.53	71.84	93.04	94.47	158.86	124.98	205.61	206.52
2053	70.14	70.47	91.10	92.48	158.07	124.21	205.36	206.32
2054	68.81	69.12	89.15	90.57	157.27	123.45	205.11	206.13
2055	67.53	67.80	87.20	88.74	156.48	122.68	204.87	205.93
2056	66.30	66.49	85.26	86.98	155.69	121.92	204.62	205.73
2057	65.11	65.20	83.31	85.29	154.90	121.16	204.37	205.54
2058	63.97	63.94	81.44	83.67	154.10	120.39	204.13	205.34
2059	62.86	62.70	79.66	82.10	153.31	119.63	203.88	205.14
2060	61.79	61.48	77.95	80.60	152.52	118.87	203.63	204.95
2061	60.76	60.28	76.31	79.15	151.72	118.10	203.38	204.75
2062	59.76	59.12	74.75	77.75	150.93	117.34	203.14	204.55
2063	58.80	58.00	73.24	76.40	150.14	116.57	202.89	204.36
% at 50	40.00%	40.00%	43.86%	44.16%	79.44%	75.70%	94.37%	95.49%

GROSS MARGIN ($/ACRE)								
Year	**Dallam**	**Hartley**	**Moore**	**Sherman**	**Hansford**	**Hutchinson**	**Lipscomb**	**Ochiltree**
2014	217.51	459.62	296.58	376.61	192.04	189.70	239.38	163.02
2015	210.97	445.08	302.19	383.21	197.16	195.02	244.36	166.78
2016	204.63	427.78	307.55	389.54	202.07	200.13	248.99	170.40
2017	198.48	409.01	312.68	395.61	206.77	205.05	253.28	173.88
2018	192.50	391.10	317.61	401.42	211.26	209.78	257.33	177.23
2019	186.24	374.03	322.43	407.00	215.56	214.32	261.15	180.45
2020	180.18	357.74	327.14	412.34	219.68	218.69	264.75	183.54
2021	174.34	342.20	331.76	417.46	223.61	222.88	268.11	186.52
2022	168.69	327.38	336.27	422.37	227.36	226.91	271.25	189.38
2023	163.23	313.23	340.69	427.08	230.95	230.78	274.17	192.13
2024	157.96	299.73	345.02	431.59	234.37	234.50	276.86	194.77
2025	152.86	286.85	349.25	435.91	237.63	238.07	279.33	197.30
2026	147.94	274.55	353.39	440.06	240.74	241.50	281.59	199.74
2027	143.18	262.82	357.44	444.03	243.70	244.79	283.76	202.08
2028	138.46	251.61	361.41	447.83	246.51	247.94	285.88	204.38
2029	132.67	240.91	365.29	451.47	249.09	250.97	287.97	206.63
2030	127.14	230.69	369.08	454.96	251.46	253.88	290.01	208.84
2031	121.86	220.94	372.79	458.31	253.65	256.67	292.00	211.00
2032	116.81	211.62	376.43	461.51	255.77	259.32	293.96	213.12
2033	111.99	202.72	379.98	464.58	257.86	261.83	295.88	215.20
2034	107.39	194.21	383.46	467.51	259.90	264.19	297.76	217.23
2035	102.99	186.09	386.86	470.33	261.90	266.42	299.60	219.23
2036	98.78	178.32	390.18	473.02	263.85	268.58	301.41	221.18
2037	94.76	170.90	393.44	475.59	265.77	270.69	303.17	223.09
2038	90.92	163.81	396.62	478.06	267.64	272.75	304.90	224.97
2039	87.24	157.04	399.73	480.42	269.48	274.77	306.60	226.81
2040	83.67	150.56	402.77	482.69	271.28	276.75	308.26	228.61
2041	80.26	144.36	405.75	484.90	273.04	278.69	309.89	230.37
2042	77.00	138.44	408.66	487.06	274.76	280.59	311.48	232.10
2043	73.88	132.77	411.51	489.18	276.45	282.45	313.05	233.80
2044	70.90	127.36	414.29	491.24	278.10	284.27	314.58	235.46
2045	67.96	122.17	417.01	493.25	279.72	286.05	316.08	237.08
2046	65.15	117.22	419.67	495.00	281.31	287.80	317.54	238.68
2047	62.47	112.47	422.27	496.35	282.86	289.50	318.98	240.24
2048	59.91	107.94	424.81	497.30	284.37	291.18	320.39	241.77
2049	57.46	103.59	427.30	497.83	285.86	292.81	321.77	243.27
2050	55.11	99.44	429.73	497.97	287.31	294.42	323.12	244.74
2051	52.87	95.46	432.03	497.70	288.74	295.99	324.45	246.18
2052	50.23	91.65	433.98	481.23	290.13	297.52	325.75	247.59
2053	45.73	88.01	435.57	462.38	291.50	299.03	327.02	248.97
2054	41.66	84.52	436.80	444.33	292.83	300.50	328.26	250.33
2055	37.96	81.17	437.67	427.08	294.14	301.94	329.48	251.66
2056	34.62	77.97	438.18	410.60	295.42	303.35	330.68	252.96
2057	31.60	74.79	425.16	394.90	296.67	304.73	331.85	254.23
2058	28.87	71.70	410.76	379.93	297.89	306.08	332.99	255.48
2059	26.40	68.75	396.95	365.69	299.09	307.41	334.12	256.70
2060	24.17	65.93	383.74	352.14	300.27	308.70	335.22	257.90
2061	22.16	62.43	371.13	339.26	301.42	309.97	336.29	259.08
2062	20.34	58.56	359.12	327.02	302.54	311.21	337.35	260.23
2063	18.70	54.92	347.70	315.39	303.64	312.42	338.38	261.35

West Average						
	Saturated Thickness (Feet)			Gross Margin ($/Acre)		
Year	Unconstrained	County Weighted DFC	Regional DFC	Unconstrained	County Weighted DFC	Regional DFC
2014	155.75	155.75	155.75	342.57	334.69	337.54
2015	153.47	153.47	153.51	349.42	331.59	337.85
2016	151.18	151.18	151.27	355.92	327.71	338.09
2017	148.89	148.91	149.03	362.10	323.40	338.26
2018	146.60	146.65	146.78	367.99	319.27	338.37
2019	144.31	144.40	144.54	373.62	315.19	338.42
2020	142.02	142.18	142.30	379.02	311.31	338.43
2021	139.74	139.97	140.06	384.17	307.61	338.39
2022	137.45	137.78	137.82	389.10	304.08	338.32
2023	135.16	135.60	135.58	393.81	300.73	338.21
2024	132.87	133.44	133.34	398.29	297.53	338.06
2025	130.58	131.30	131.10	402.56	294.48	337.89
2026	128.29	129.17	128.85	406.58	291.57	337.69
2027	126.00	127.06	126.61	410.39	288.81	337.47
2028	123.72	124.96	124.37	413.97	286.13	337.23
2029	121.43	122.88	122.13	417.35	283.21	336.97
2030	119.14	120.82	119.89	420.52	280.44	336.70
2031	116.85	118.79	117.65	423.47	277.81	336.40
2032	114.56	116.77	115.41	426.23	275.32	336.10
2033	112.27	114.78	113.17	428.78	272.96	335.78
2034	109.99	112.81	110.92	431.11	270.72	335.45
2035	107.70	110.86	108.68	433.17	268.59	335.11
2036	105.41	108.93	106.44	433.30	266.58	334.97
2037	103.13	107.02	104.21	428.68	264.67	334.81
2038	100.90	105.13	101.98	424.10	262.86	334.62
2039	98.72	103.26	99.77	419.62	261.15	334.41
2040	96.57	101.41	97.56	415.25	259.50	332.81
2041	94.45	99.58	95.39	411.03	257.96	330.99
2042	92.37	97.76	93.28	406.97	256.50	329.33
2043	90.32	95.97	91.21	403.06	255.13	327.82
2044	88.30	94.19	89.18	399.30	253.85	326.22
2045	86.31	92.43	87.19	393.39	252.61	317.36
2046	84.35	90.68	85.29	384.06	251.40	308.96
2047	82.46	88.95	83.47	375.10	250.17	300.99
2048	80.63	87.24	81.73	366.52	248.92	293.43
2049	78.84	85.55	80.06	358.32	247.65	286.24
2050	77.11	83.87	78.46	350.49	246.35	279.39
2051	75.42	82.20	76.92	343.01	245.00	272.87
2052	73.77	80.56	75.44	331.97	239.54	266.65
2053	72.18	78.94	74.02	320.72	232.91	260.72
2054	70.64	77.37	72.65	310.03	226.57	255.05
2055	69.16	75.83	71.33	299.88	220.51	249.63
2056	67.72	74.34	70.06	290.23	214.72	244.45
2057	66.33	72.88	68.83	278.54	206.65	239.49
2058	65.00	71.46	67.65	267.10	198.61	234.74
2059	63.72	70.09	66.51	256.25	190.98	230.19
2060	62.49	68.77	65.40	245.99	183.74	225.83
2061	61.31	67.48	64.33	236.29	176.66	221.65
2062	60.17	66.25	63.30	227.13	169.82	217.64
2063	59.07	65.05	62.30	218.50	163.35	213.79