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THROUGH: Robert E. Mace, Deputy Executive Administrator, Water Science and Conservation
Kenneth L. Petersen, General Counsel

FROM: Bill Hutchison, Director, Groundwater Resources
Joe Reynolds, Attorney

DATE: February 10, 2010

SUBJECT: Report on Appeal of the Reasonableness of the Desired Future Conditions Adopted by the Groundwater Conservation Districts in Groundwater Management Area 1 for the Ogallala and Rita Blanca Aquifers

Preamble

This report and the attached technical analyses constitute the staff analysis associated with the Board's consideration of petitions filed by legally defined interests in groundwater in Groundwater Management Area 1 (GMA 1) that appeal the adoption of the desired future conditions (DFCs) for the Ogallala and Rita Blanca Aquifers. In addition, this report and technical analyses discuss whether the DFCs are unreasonable based on the evidence in the record. Staff recommends that the Board find that the DFCs adopted by the groundwater conservation districts (Districts) in GMA 1 are not unreasonable based on the analysis set out in this report.

Procedural History

The Districts in GMA 1[1] unanimously adopted DFCs for the Ogallala and Rita Blanca Aquifers on July 7, 2009, pursuant to Texas Water Code Section 36.108, specifically:

a. 40 percent volume in storage remaining in 50 years in Dallam, Sherman, Hartley, and Moore Counties;
b. 50 percent volume in storage remaining in 50 years in Hansford, Ochiltree, Lipscomb, Hutchinson, Roberts, Oldham, Potter, Carson, Gray, Wheeler, Randall, Armstrong, and Donley Counties; and
c. 80 percent volume in storage remaining in 50 years in Hemphill County.

[1] Hemphill County Underground Water Conservation District (Hemphill District), North Plains Groundwater Conservation District (North Plains District), High Plains Underground Water Conservation District No. 1 (High Plains District), and Panhandle Groundwater Conservation District (Panhandle District).

Administratively complete petitions were submitted by Mesa Water LP (Mesa) and G&J Ranch, Inc. (G&J) (collectively, the Petitioners) on August 19, 2009. Petitioners refer only to the Ogallala Aquifer in their petitions, testimony, and evidence. In fact, the only mention of the Rita Blanca Aquifer is in the resolution adopted by the Districts on July 7, 2009. Because of the nature of the two aquifers as explained in staff's technical analysis (Attachment A), the Ogallala and the Rita Blanca aquifers will be considered together for purposes of this report. All references to the Ogallala Aquifer will include the Rita Blanca Aquifer.

TWDB staff held a hearing on the petitions on November 11, 2009, in Amarillo, Texas to hear testimony and evidence from the Petitioners and the Districts. The record remained open until November 24, 2009, to receive additional evidence from other interested persons, as required by 31 Tex. Admin. Code § 356.44(f). TWDB staff received one additional statement from Petitioners and 76 additional comments from interested parties on behalf of the Districts.

Analysis

Attachment A is staff's technical analysis of certain issues raised by the Petitioners and the Districts. Attachment C is staff's analysis of regional economic impacts of alternative scenarios for the northwestern part of GMA 1.

The Petitioners seek to modify the DFCs adopted by the Districts to 50 percent volume in storage remaining in 50 years in all areas of GMA 1, based on a rationale that all areas should receive "equal treatment." Petitioners claim the DFCs adopted by the Districts are unreasonable because the DFCs are not based on science but solely on political subdivisions (counties and Districts in GMA 1). They claim that the approval of DFCs based purely on political subdivisions and not on hydrology, topography, geology, or definably distinct characteristics or use violates the statutes and raises several legal issues. Because the Districts failed to follow the statutes, the Petitioners claim, the DFCs adopted by the Districts are unreasonable as a matter of law.

To support their assertions, the Petitioners raise the following issues: (1) whether the Districts engaged in joint planning; (2) the impact on private property rights; (3) uses and conditions of the aquifer; (4) environmental impacts and spring flows; (5) development of the State's groundwater resources; (6) whether the DFCs are physically possible; and (7) the socio-economic impacts of the DFCs. Each of these issues is addressed below.

1. Joint Planning

Petitioners' Testimony

Petitioners assert that adoption of a DFC in the Hemphill District of 80 percent volume in storage remaining in 50 years amounts to a taking of Petitioners' private property and an unauthorized exercise of eminent domain. Petitioners point out that the Hemphill District does not have eminent domain power and, accordingly, has no legal right to take Petitioners' private property. Therefore, under Petitioners' argument, the Hemphill District's action is outside its statutory authority. Petitioners appear to be arguing that the Districts have acquiesced in a single District's allegedly illegal action rather than engaging in joint planning for the entire aquifer by agreeing to establish

DFCs that support Hemphill District's alleged taking. Therefore, they say, the DFCs are unreasonable as a matter of law.

Districts' Testimony

The Districts presented testimony and other evidence that chronicle numerous planning sessions attended by representatives of all four Districts. They also point to properly noticed open meetings held in each of the Districts in order to receive public input.

Staff Analysis

The Districts' testimony establishes that the Districts engaged in joint planning and exercised the local decision-making process envisioned by the statute. Whether the Hemphill District acted outside its statutory authority implicates a private property rights issue of law. As noted below, ("Private Property Rights"), this issue does not appear to have been settled in the courts, and staff believes the question is beyond the authority of the Board to decide. Whether the actions of the other Districts in confirming the DFC for the Hemphill District were outside the statutory authority of the Districts and whether such actions constitute a failure to engage in "joint planning" are issues premised on this question of law which is beyond the authority of the Board to decide.

2. Private Property Rights

Petitioners' Testimony

As an extension of certain legal assumptions concerning private property rights (essentially that a landowner owns *in situ* all the groundwater underlying his or her property without having to "capture" it), Petitioners assert that the DFCs adopted by the Districts are unreasonable because they violate constitutionally protected property rights. Petitioners discuss this point at length—in fact, it constitutes a major part of their petitions. For example, Mr. Steve Stevens, Vice President of Mesa Water, testified that the DFC for Hemphill County "makes the water in Hemphill County that we own worthless." Mr. Stevens testified that he acquired water rights "in reliance on the 50/50 standard", but that those water rights will be worthless under the DFC adopted for the Hemphill District. In support of his contention, Mr. Stevens presented a letter from the General Manager of the Canadian River Municipal Water Authority (Authority), in which the General Manager states that "the rules the [Hemphill District] is leaning toward will surely cause litigation for anyone wanting to develop water there." The letter states that the Authority is therefore interested in buying Petitioner's water interests except those in Hemphill County. Mr. Stevens concluded that the DFC is the cause of the Authority's concerns.

Another petitioner, Mr. George Arrington, a rancher and oil and gas operator in Hemphill County, testified that he could not use his groundwater for irrigation on his property and that the Hemphill County DFC "greatly affects the value of [his] property" for marketing because his "neighbor across the Roberts County line has the right to pump 50 percent—or to use 50 percent in 50 years and I have the right to 20 percent in 50 years [such that] my land will be drained." In essence, the

Petitioners appear to be arguing that the Hemphill County DFC imposes an unreasonable restriction on their use of propertied rights to engage in speculative export contracts.

Districts' Testimony

As the Districts point out, the Board has no jurisdiction to determine constitutional issues or takings claims. In addition, the nature of the absolute property right that Petitioners describe has yet to be clearly affirmed by the courts. The issue, in fact, is currently before the Texas Supreme Court, as noted by the Texas Attorney General: "No Texas court has directly addressed the question whether government limitations on groundwater production trigger liability under Art. I, §17, Tex. Const." (*See* Petition for Review of the Attorney General of Texas, *The Edwards Aquifer Authority and the State of Texas v. Burrell Day and Joel McDaniel*, Tex. Sup. Ct., No. 08-0964 (Feb. 2, 2009) at 7.)

Staff Analysis

To one degree or another, all DFCs adopted by groundwater conservation districts potentially impact the exercise of private property rights. This is recognized in Section 36.002, Water Code: "ownership and rights of the owners of the land . . . in groundwater are hereby recognized, and nothing in this code shall be construed as depriving or divesting the owners . . . of the ownership or rights, *except as those rights may be limited or altered by rules promulgated by a district.*" (Emphasis added.) Staff has seen no evidence that the Districts' DFCs prohibit someone from pumping their groundwater or prohibit a particular beneficial use.

The adverse impact to private real property rights asserted in these appeals appears to come down to a prospective limitation on maximum pumping from land in Hemphill County and the contracting opportunities that might result from such unconstrained production. The claim that water rights "will be" worthless under the DFC is given no basis in fact. The letter to which Petitioners refer expresses concern about rules adopted by the District and not the DFC itself. But rules based on the DFC have yet to be adopted. In addition, the statement that the rules "will surely cause litigation" is speculation.

Beyond outright prohibition, the impact on private property rights involves the balancing of competing interests. The claims by the Petitioners regarding future harm must be viewed against the real and present economic harm to the northwestern counties if the DFCs are set at 50 percent over the whole of GMA 1. This impact is discussed below in the section on socio-economic impacts. Additionally, the multiple affidavits produced by the Districts assert that the DFC adopted for Hemphill District serves to protect property rights in that it conserves current groundwater sufficiently, protects stream flow, and protects the existing users of their property and enhances their property values.

Staff is persuaded by the Districts' testimony and evidence that the Districts have considered the potential impact of their decision on all users and uses of groundwater in GMA 1 and have achieved a balance that for all sectors of the District, including the water marketers.

3. Uses and Conditions; Aquifer or Subdivision of an Aquifer; and Legitimate Support for the DFCs

Petitioners' Testimony

Petitioners' next three arguments arise from a common statutory principle stated in their petition and in testimony: in establishing different DFCs within GMA 1, the Districts must consider uses and conditions of the aquifer that differ substantially from one geographic area to another. Petitioners present evidence in an effort to show that the Ogallala Aquifer is essentially undifferentiated over the whole area based on hydrologic considerations; in addition, uses and conditions over the aquifer, while diverse, are still uniform. Thus, Petitioners assert, the Districts' DFCs are based on no statutorily legitimate rationale—instead, they are based solely on political subdivisions, which are not a valid basis under the statute.

Districts' Testimony

Districts contend that uses and conditions of the Aquifer and the surface above the Aquifer are not uniform. They point to a number of factors that suggest the various regions encompassed by the Districts are varied in ways that support the reasonableness of the adopted DFCs.

Staff' Analysis

Petitioners' argument hinges on two questions. First, are political subdivision boundaries included in the phrase "geographic areas" as a statutorily authorized basis for different DFCs? Second, did the Districts adequately consider different patterns of use and conditions existing over the aquifer?

Chapter 36, Water Code, allows multiple DFCs in a GMA based on different patterns of use and conditions within an aquifer. Staff's examination of Petitioners' own exhibits suggests significant differences from one part of GMA 1 to the other. For example, the map of spring flows proffered by Petitioners indicates that springs are more concentrated in the east. Regional recharge and natural discharge characteristics and spring locations appear to lie along certain distinct lines. Irrigation wells, public water supply wells, industrial wells, and stock wells appear to define areas of major and minor activity. The exhibits, taken as a whole, do not support the Petitioners' claim that uses are undifferentiated throughout GMA 1 and fail to establish that the different DFCs are unreasonable based on the statutory criteria.

Staff's technical analysis discusses historic pumping in GMA 1 (see Attachment A). Pumping in the four northwestern counties historically is significantly higher than pumping from the other counties. Likewise, pumping in Hemphill County historically is significantly lower than historic pumping in the other counties.

Political subdivisions are defined in Chapter 36, Water Code, and are common demarcations of geographic areas for purposes of describing uses and conditions of those areas. Given that uses and conditions can be distinguished in the various areas of GMA 1 and described conveniently by reference to the counties, it is not unreasonable to divide the geographic area along political boundaries. Such a division is consistent with the statute and useful to the Districts as they seek to fulfill their responsibilities. Staff therefore concludes that, based on the statutory language and the

historic patterns of pumping in GMA 1, the delineation along county boundaries as a basis for the DFCs is not unreasonable.

4. Environmental Impacts and Spring Flows

Petitioners' Testimony

Petitioners suggest that the Districts failed to consider environmental impacts and spring flows. Petitioners testify that spring flows are distributed throughout GMA 1. They further state that the DFCs do not offer equal protection for the spring flows in GMA 1. In fact, Petitioners assert, the DFCs offer radically different protections for the spring flows in ways that are unsupported by they natural regional recharge and discharge characteristics of the aquifer.

Districts' Testimony

The Districts observe that the different approaches taken to environmental issues and spring flow in the Hemphill and the North Plains districts coincide with different socio-economic concerns in the regions. Conservation is a primary objective in Hemphill County. Irrigation to sustain agribusiness is a major concern in the North Plains. The DFCs reflect these concerns and appear to be reasonable solutions that accommodate the needs and commitments of the residents in those areas.

The Districts' testimony is replete with statements regarding the desire to maintain the current elevation of water levels in Hemphill County in order to provide groundwater discharge to many of the streams, rivers, and springs within the county, keeping many of these flowing perennially, even in times of drought. The Districts testify that the aquifer is being depleted at different rates in different portions of GMA 1. Therefore, one of the primary objectives of the DFC is to maintain sustainable groundwater conditions for future generations. To that end, the Districts state that Hemphill District evaluated factors such as the desires of local constituents, physical characteristics of the Ogallala, estimated current and future demands, the effects of different DFCs on adjacent counties and districts, and four estimates of the resulting MAG amounts in determining the DFC for Hemphill District.

Staff's Analysis

Staff's analysis indicates that, under current conditions, groundwater flows laterally into Hemphill County from the north, west, and south (Lipscomb County, Roberts County, and Wheeler County, respectively), and flows laterally out of Hemphill County to the east (Oklahoma). If the pumping in Hemphill County were to be increased to 200,000 acre-feet per year, as is projected by staff using Petitioners' preferred scenario, there would be reductions in the managed available groundwater in adjacent counties, additional impacts to spring flow, elimination of groundwater discharge to surface water (base flow), and the beginning of surface water recharging groundwater in Hemphill County. Based on the Districts' stated desire to maintain spring flow and the impacts if pumping were increased to the level recommended by Petitioners, Staff finds the Districts have achieved a reasonable response to the issue.

5. Development of the State's Groundwater Resources

Petitioners' Testimony

Petitioners claim that the DFC of 80 percent volume in storage remaining in 50 years is not related to physical constraints of the aquifer, but instead is related to regulatory constraints by the Districts.

Districts' Testimony

The Districts' testimony suggests they gave reasonable consideration to potential future use of the aquifer and concluded:

"The 80/50 DFC is expected to result in a [managed available groundwater] amount for Hemphill County of approximately 55,000 acre-feet per year, substantially greater than the projected future demand of about 12,000 acre-feet per year. Accordingly, there will be a significant amount of groundwater available for development in Hemphill Co. above and beyond existing and expected future demand based on the 80/50 DFC."

Districts state that the MAG developed under the DFC adopted by the Districts will be well above current and projected demand. Therefore, they claim, it will allow for the reasonable and prudent development of groundwater resources with little or no interference with the rights of existing users. In support, the Districts provide testimony that the DFC adopted by the Districts is expected to result in a MAG amount for Hemphill County of approximately 55,000 acre-feet per year, substantially greater than the projected future demand of about 12,000 acre-feet per year from the State Water Plan. Accordingly, they assert that there will be a significant amount of groundwater available for development in Hemphill County above and beyond existing and expected future demand based on the DFC.

Staff' Analysis

The imposition of regulatory constraints is not unreasonable *per se*. The issue for the Districts appears to be how to balance competing concerns — environment, ecology, business, recreation, conservation, and development. DFCs represent a continuum of choices that try to balance these various concerns. The Districts present persuasive counter arguments that appear to balance the various uses, conditions, desires, and needs of all concerned in a manner that is not unreasonable.

6. Physically Possible

Petitioners' Testimony

Petitioners claim that MAG calculations that predict 40 percent water remaining in 50 years in the four northwestern counties are physically impossible. In addition, Petitioners assert that the MAG reported for Roberts County must come from Hemphill County and that amount of flow is dependent upon future pumpage, which cannot be predicted. As a precise amount of flow must occur for the DFCs to be physically possible, Petitioners conclude the DFCs are not physically possible.

Districts' Testimony

The Districts counter that groundwater availability modeling (GAM) runs have shown that the DFCs adopted by the Districts in GMA 1 are compatible with one another. They note that neither the petitions nor the Harden Affidavit assert that the DFCs are physically incompatible with one another. Rather, Districts state that, beginning in 2006, the Districts asked the TWDB to provide seven separate GAM runs. Two supplemental reports were issued. The last GAM run request, according to the Districts, indicated the DFCs were possible and compatible.

Staff Analysis

When staff assesses whether DFCs are physically possible, they assess whether there is any pumping scenario that would allow the DFCs to be achieved. If a scenario would allow the DFCs to be achieved, then the DFCs are considered physically possible. The models, as run by staff and as described in the Districts' testimony, demonstrate that the DFCs are physically possible.

7. Socio-economic Impacts

Petitioners' Testimony

Petitioners claim that the Districts did not quantify the socio-economic impacts of the DFCs.

Districts' Testimony

The Districts point out that water regulation involves the balancing of various and potentially diverging interests, uses, and potential uses, including municipal, agricultural, industrial, environmental, and recreational. They provide evidence in their testimony and the statements submitted after the hearing that the socio-economic impacts were a concern addressed in the decision to adopt DFCs that addressed the impacts in each area of the GMA.

Staff' Analysis

Neither the Water Code nor TWDB rules require Districts to quantify the socio-economic impacts of the Districts' DFCs. Failure to do so does not render the DFCs unreasonable. The burden is on the Petitioners to raise the issue in their claim that the DFCs are unreasonable.

Staff's analysis indicates that irrigated crop production accounts for 97 percent of the water use in the four northwestern counties. The average decrease in pumping necessary to achieve 50 percent volume in storage remaining in 50 years in those counties is approximately 130,000 acre-feet per year, compared to the pumping necessary to achieve 40 percent volume remaining in 50 years, which is a 50-year decrease of about 6.6 million acre-feet. Based on the attached economic analysis, the economic impact of this decrease is estimated to be $358 million.

Because the DFC based on 50 percent water remaining in 50 years is consistent with historic pumping in the 13 affected counties, no socio-economic impact is anticipated. In those 13 counties, pumping for irrigation and livestock is less than in the four northwestern counties and pumping is higher for municipal and manufacturing. The uses vary. But, given the nature of the use, these counties are not expected to experience major socio-economic changes.

Municipal use, irrigation, and livestock are the significant sectors in Hemphill County. The DFC for Hemphill County of 80 percent water remaining in 50 years allows for more than a ten-fold increase in pumping over current pumping, potentially benefiting all economic sectors of the county. Indeed, unless changes occur in the pumping patterns in Hemphill County compared to historic pumping, most of the available groundwater could be marketed, as Petitioners appear to want.

The Districts point out that water regulation involves the balancing of various and potentially diverging interests, uses, and potential uses, including municipal, agricultural, industrial, environmental, and recreational. Testimony presented by the Districts points to careful consideration of these interests, uses, and potential uses in the development and adoption of the DFCs. Staff's analysis confirms the Districts' assertions regarding consideration of socio-economic impacts. The Districts appear to have reasonably balanced the various interests, uses, and potential uses of all concerned.

Recommendation

Based on the foregoing analysis, staff recommends that the Board not find that the desired future conditions for the Ogallala and Rita Blanca aquifers adopted by the Districts in GMA 1 are unreasonable.

Attachment: A - Technical Analysis
B - Socio-economic Analysis – GMA 1

Technical Analysis

Background

The groundwater conservation districts in Groundwater Management Area 1 adopted desired future conditions for the Ogallala and Rita Blanca aquifers on July 7, 2009. The desired future conditions were adopted for three areas of Groundwater Management Area 1. Figure 1 depicts the location of Groundwater Management Area 1. Figure 2 depicts the groundwater conservation districts within Groundwater Management Area 1.

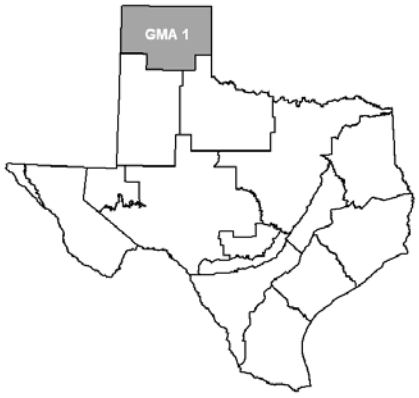


Figure 1. Location of Groundwater Management Area 1

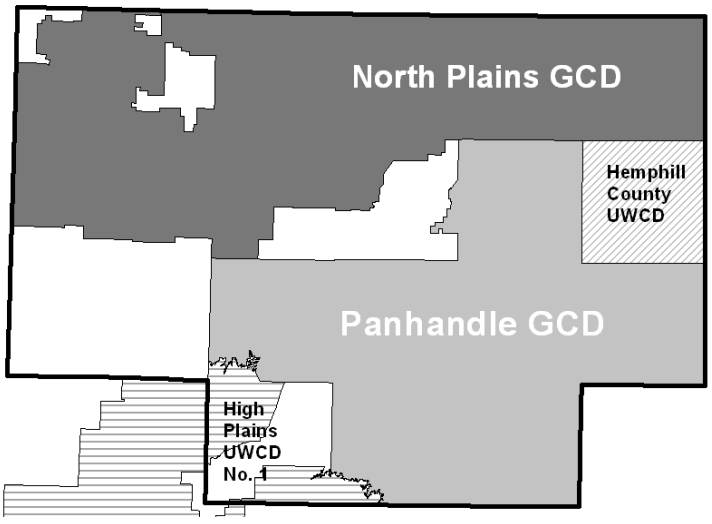


Figure 2. Groundwater conservation districts in Groundwater Management Area 1. Note that High Plains UWCD No. 1 also includes territory outside of Groundwater Management Area 1

Figure 3 depicts the counties in Groundwater Management Area 1 along with the coverage of the groundwater conservation districts. Figure 4 depicts the three areas described in the submitted desired future condition document and resolution along with the county boundaries.

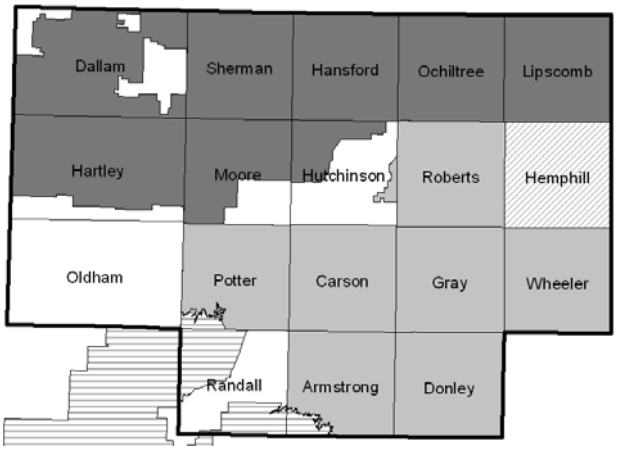


Figure 3. County boundaries and names and groundwater conservation district boundaries in Groundwater Management Area 1

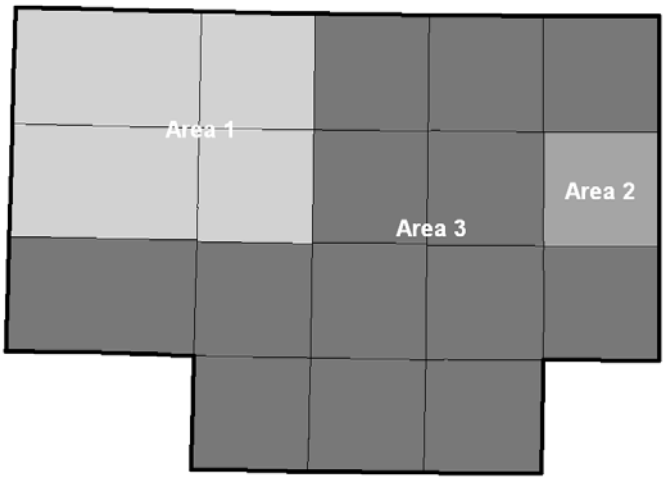


Figure 4. Areas of Groundwater Management Area 1 and county boundaries

Summary of Adopted Desired Future Conditions

The adopted desired future conditions were based on percentage of groundwater volume remaining after 50 years:

- Area 1: 40 percent volume remaining after 50 years
- Area 2: 80 percent volume remaining after 50 years
- Area 3: 50 percent volume remaining after 50 years

Table 1 lists the counties within each of the three delineated areas of Groundwater Management Area 1, summarizes the percent groundwater remaining in storage after 50 years for each county within the delineated areas of the groundwater management area. Table 1 also includes the percent groundwater remaining in storage for each of the delineated areas, and for the entire groundwater management area.

Table 1. Summary of groundwater storage remaining after 50 years by area, by county, and for the entire groundwater management area

Area	County	Percent Volume Remaining After 50 Years by County	Percent Volume Remaining After 50 Years by Area	Percent Volume Remaining After 50 Years in Groundwater Management Area 1
1	Dallam	23	40	49
	Hartley	40		
	Moore	41		
	Sherman	57		
2	Hemphill	80	80	
3	Armstrong	45	50	
	Carson	48		
	Donley	49		
	Gray	46		
	Hansford	52		
	Hutchinson	44		
	Lipscomb	57		
	Ochiltree	49		
	Oldham	57		
	Potter	45		
	Randall	74		
	Roberts	50		
	Wheeler	52		

The resolution that detailed the adoption of the desired future conditions for the Ogallala and Rita Blanca aquifers by the groundwater conservation districts in Groundwater Management Area 1 noted that a simulation with the groundwater availability model of the Ogallala and Rita Blanca aquifers was used. The referenced simulation was

documented in Smith (2009), and the groundwater availability model is documented in Dutton (2004). Both the groundwater availability model and the specific simulation used in the development of the desired future conditions were accepted and used in analyses completed by the expert witness retained by the petitioners, Bob Harden (p. 13, lines 1–25 of the hearing transcript). Data from the groundwater availability model (Dutton, 2004) and the simulation (Smith, 2009) were used in this technical analysis of the petitions.

The calculation of volume of groundwater remaining after 50 years was completed by calculating the volume of groundwater in each model grid cell (one square mile) at the beginning of the simulation (taken as 2006 conditions) and the volume of groundwater in each model grid cell for each of the years in the 50-year simulation. Volumetric totals can then be summed by county, by portions of counties (to account for areas inside and outside groundwater conservation district boundaries or within different river basins), by delineated areas within the groundwater management area, or as a single value for the entire groundwater management area. The appropriate totals are then used to develop an estimate of percent volume remaining by dividing the volume for the year of interest by the starting volume and multiplying the result by 100.

The groundwater conservation districts in Groundwater Management Area 1 chose to express the desired future condition in terms of the three delineated areas. However, the county-by-county values and the single value for the entire groundwater management area previously presented in Table 1 are simply different measures of the same set of assumptions relative to the adopted desired future conditions articulated by the groundwater conservation districts in Groundwater Management Area 1.

Summary of Petitions

On August 19, 2009 G&J Ranch, Inc. and Mesa Water LP filed petitions with the Texas Water Development Board appealing the desired future conditions adopted by the groundwater conservation districts in Groundwater Management Area 1. The petitions from the two parties assert that the desired future conditions are not reasonable. In summary, the petitioners seek to replace the three adopted desired future conditions with a single desired future condition of 50 percent groundwater volume remaining after 50 years. Specifically, the three major technical issues raised by the petitioners are:

- The delineated areas used by the groundwater conservation districts in Groundwater Management Area 1 are not based on hydrogeologic or geologic factors and are based on political boundaries.
- The desired future condition in area 1 should be 50 percent volume remaining after 50 years (instead of 40 percent volume remaining after 50 years).
- The desired future condition in area 2 should be 50 percent volume remaining after 50 years (instead of 80 percent volume remaining after 50 years).

This technical analysis includes: 1) a discussion of historic pumping in order to address the issue of how the groundwater conservations districts in Groundwater Management

Area 1 delineated the three areas, 2) a discussion of the impacts associated with changing the desired future condition in area 1 from 40 percent volume remaining after 50 years to 50 percent volume remaining after 50 years, and 3) a discussion of the impacts associated with changing the desired future condition in area 2 from 80 percent volume remaining after 50 years to 50 percent volume remaining after 50 years.

Historic Pumping and Delineation of Areas

Average historic groundwater pumping from 1950 to 2000 in Groundwater Management Area 1 from the Ogallala and Rita Blanca aquifers is summarized by county in Figure 5. Note that the summary is also organized to show the three areas designated by the groundwater conservation districts in Groundwater Management Area 1. Historic pumping in the four counties that comprise area 1 is significantly higher than historic pumping from the other two areas.

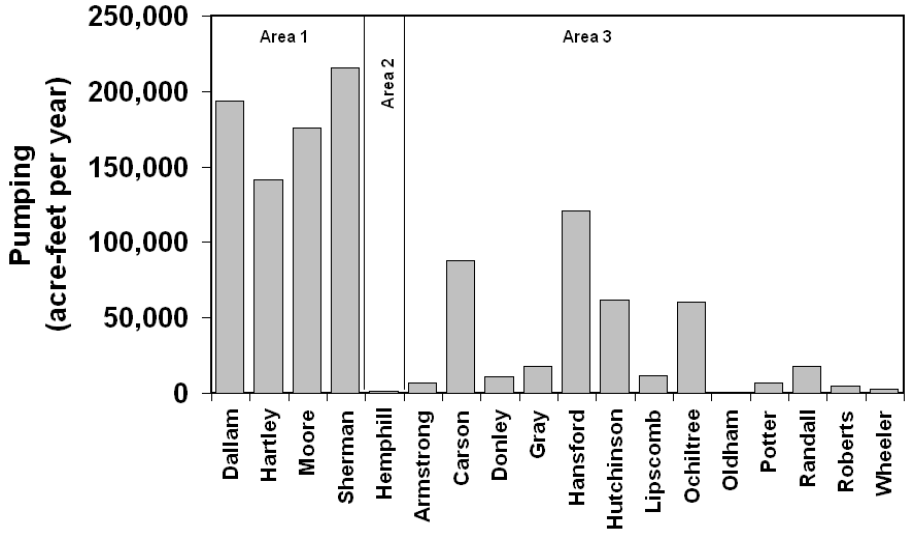


Figure 5. Average historic (1950–2000) groundwater pumping by county from the Ogallala and Rita Blanca aquifers in Groundwater Management Area 1

Because there are four counties in area 1, one county in area 2, and 13 counties in area 3, historic pumping was also summarized by area on a per-county basis. This summary is presented in Figure 6. Note that pumping in area 1 peaked in the 1980s at about 250,000 acre-feet per year per county. Pumping in area 3 peaked in the 1970s just below 50,000 acre-feet per year per county.

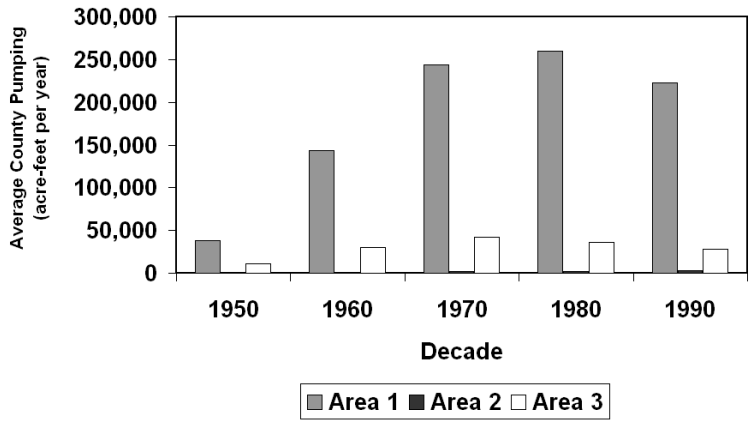


Figure 6. Summary of groundwater pumping by decade and by area on a per-county basis from the Ogallala and Rita Blanca aquifers in Groundwater Management Area 1

Area 1 Analysis

Area 1 of Groundwater Management Area 1 includes the four northwestern counties of Groundwater Management Area 1: Dallam, Hartley, Moore, and Sherman (previously shown in Figure 4). Groundwater pumping in area 1 is expected to decline in the future in response to decreasing groundwater levels. Based on the adopted desired future condition, the anticipated decline in area 1 is summarized in Figure 7.

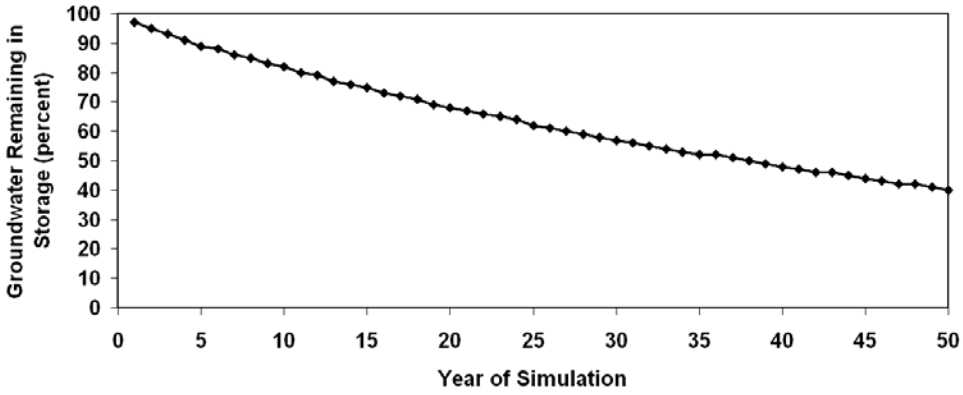


Figure 7. Annual groundwater storage in area 1 of Groundwater Management Area 1, Ogallala and Rita Blanca aquifers. Simulation documented in Smith (2009)

The petitioners seek to adjust the desired future condition in area 1 so that 50 percent of the groundwater in storage remains after 50 years. This would require a decrease in pumping. Annual pumping estimates to achieve the desired future condition and annual pumping estimates that would achieve petitioners' requested modification to the desired future condition are presented in Figure 8. The average decrease in pumping to achieve 50 percent volume remaining in 50 years is about 130,000 acre-feet per year as compared to the pumping to achieve 40 percent volume remaining in 50 years, or a 50-year

decrease of about 6.6 million acre-feet. Based on the attached economic analysis, the economic impact to this decrease is estimated to be $358 million.

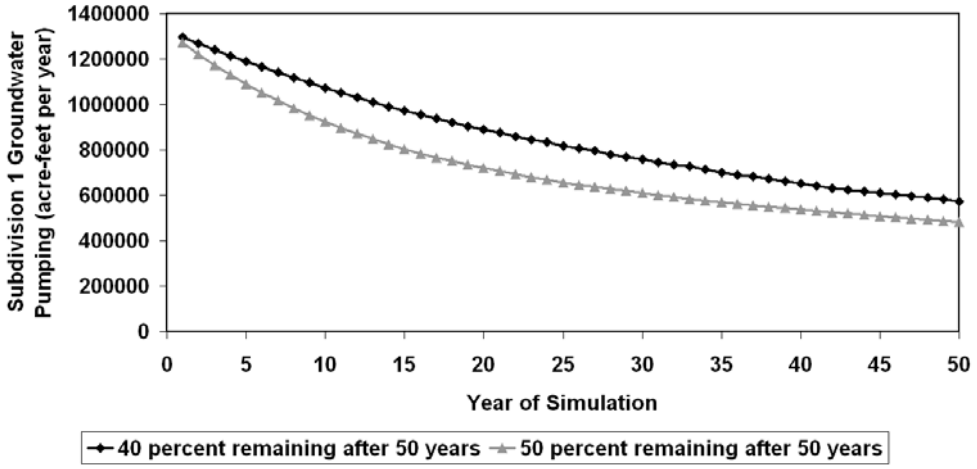


Figure 8. Annual groundwater pumping from the Ogallala and Rita Blanca aquifers in area 1 of Groundwater Management Area 1 to achieve alternative future conditions after 50 years

Area 2 Analysis

Area 2 of Groundwater Management Area 1 is coincident with Hemphill County. Historic groundwater pumping in Hemphill County has been less than 3,000 acre-feet per year since 1950. The 2007 State Water Plan estimated groundwater availability in Hemphill County to be 12,000 acre-feet per year. Under the adopted desired future condition, Hemphill County's estimated managed available groundwater would be 55,000 acre-feet per year. Thus, the estimated managed available groundwater to achieve the desired future condition of 80 percent volume remaining after 50 years is over 10 times the current use and over 4 times the groundwater availability estimated in the 2007 State Water Plan.

In order to analyze the petitioners' proposed modification of the adopted desired future condition from 80 percent volume remaining after 50 years to 50 percent volume remaining after 50 years, a series of simulations were completed using the groundwater availability model of the Ogallala Aquifer documented by Dutton (2004). The simulations used the same basic assumptions as used by Smith (2009) except for a series of alternative pumping assumptions. Pumping in areas 1 and 3 was assumed to be the same as that in Smith (2009) which results in 40 percent of the volume in area 1 to remain after 50 years, and 50 percent of the volume in area 3 to remain after 50 years. In order to investigate a range of conditions, seven scenarios were completed. The assumed pumping in Hemphill County and the resulting volume remaining in Hemphill County (area 2) after 50 years for the seven scenarios are summarized in Table 2.

Table 2. Summary of seven alternative pumping scenarios in Hemphill County

Scenario	Hemphill County Pumping (acre-feet per year)	Percent Volume Remaining After 50 Years in Hemphill County	Notes
1	12,000	90	1
2	55,000	80	2
3	75,000	76	
4	110,000	69	
5	150,000	61	
6	175,000	55	
7	200,000	50	3

1 Pumping equal to 2007 State Water Plan groundwater availability for Hemphill County
2 Estimated managed available groundwater for Hemphill County under adopted desired future condition
3 Estimated managed available groundwater for Hemphill County under petitioners' proposed modification to desired future condition

In addition to estimating the groundwater volume remaining in storage under each of the scenarios, other changes to the groundwater budget were estimated, including changes to lateral flow into and out of Hemphill County, changes to springflow and changes to river baseflow.

Lateral Groundwater Flow Impacts

Based on the groundwater availability model (Dutton, 2004), under current conditions, groundwater flows laterally into Hemphill County from the north, west and south (Lipscomb County, Roberts County, and Wheeler County, respectively). Under current conditions, groundwater flows laterally out of Hemphill County to the east (Oklahoma). This is consistent with the conceptual model that groundwater flow in the Ogallala Aquifer generally follows the trend of the Canadian River, flowing east and towards the Canadian River, which flows through Hemphill County. Figure 9 depicts the general lateral flow paths into and out of Hemphill County under current conditions.

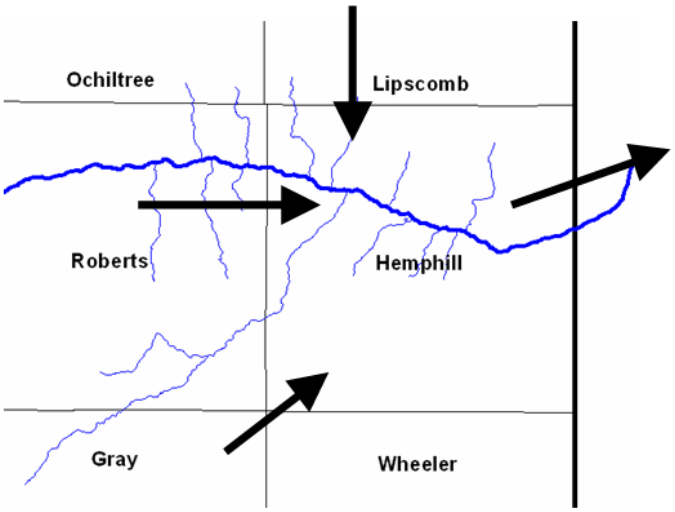


Figure 9. Generalized groundwater flow directions into and out of Hemphill County under current conditions

Under all the listed alternative scenarios, changes to the lateral flow will occur as a result of the continuation of declining groundwater levels associated with groundwater pumping. The lateral flow components under the adopted desired future conditions over the 50-year period are summarized in Figure 10.

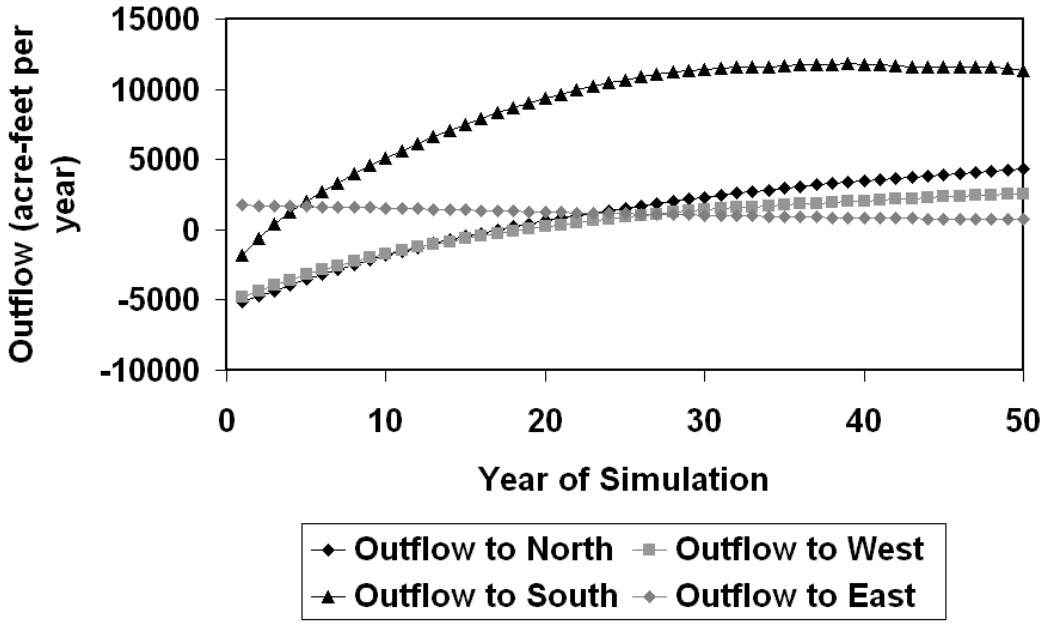


Figure 10. Lateral outflow from Hemphill County under the adopted desired future condition and the associated pumping of 55,000 acre-feet per year in Hemphill County. Negative values represent net inflow; positive values represent net outflow.

Note that the net inflow that currently occurs across the northern, western, and southern boundaries into Hemphill County will shift to a net outflow over the next 50 years under the adopted desired future condition. Total current net inflow from the north, west, and south is estimated to be about 14,000 acre-feet per year. Total net outflow after 50 years from the north, west, and south is estimated to be about 18,000 acre-feet per year. Thus, it can interpreted that the pumping in these three adjacent counties (Lipscomb, Roberts, and Wheeler), which is estimated to be about 520,000 acre-feet per year in the 50th year, would result in net impact to lateral flow of about 32,000 acre-feet per year (cutting off the inflow to Hemphill County and inducing an outflow from Hemphill County).

The lateral flow components under the proposed desired future condition by the petitioners over the 50-year period are summarized in Figure 11. Note under a scenario of higher pumping in Hemphill County (200,000 acre-feet per year versus 55,000 acre-feet per year) net inflow into Hemphill County from the north would continue during the 50-year period. Net inflow from the west would essentially be reduced to zero by the 50th year, and net inflow from the south would shift to a net outflow during the first decade. The reduction in net outflow from Hemphill County as compared to the desired future condition scenario previously depicted in Figure 10 would result in decreases in the managed available groundwater in Lipscomb, Roberts, and Wheeler counties (509,000 acre-feet per year vs. 520,000 acre-feet per year).

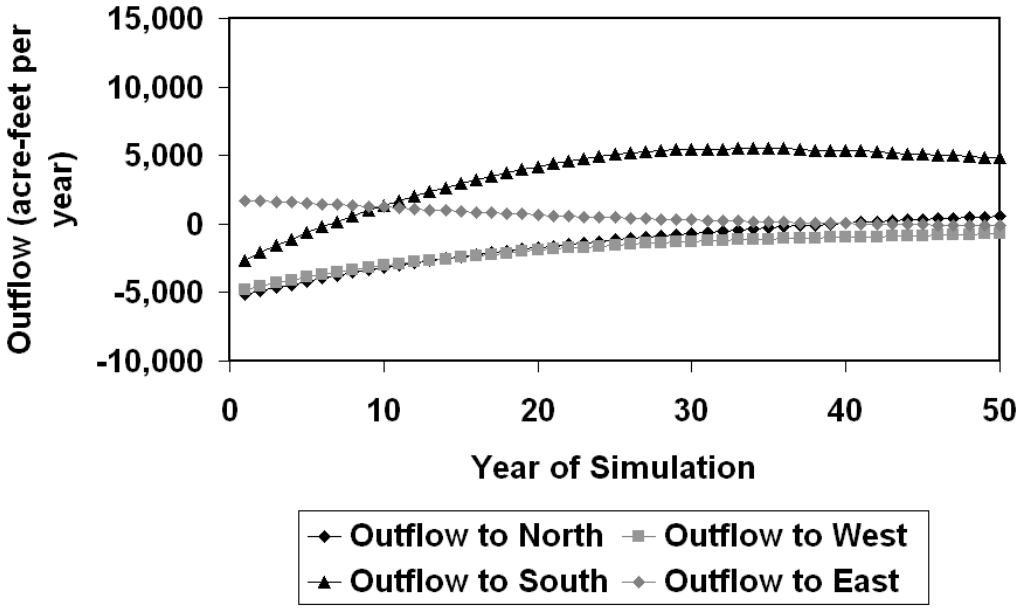


Figure 11. Lateral outflow from Hemphill County under the proposed desired future condition by the petitioners and the associated pumping of 200,000 acre-feet per year in Hemphill County. Negative values represent net inflow, positive values represent net outflow.

Impacts to Springflow and River Baseflow

Under current conditions, springflow in Hemphill County is estimated to be about 750 acre-feet per year, and baseflow contribution in Hemphill County is about 1,500 acre-feet per year. Impacts to springflow and baseflow under three alternative pumping scenarios in Hemphill County are summarized in Figures 12 and 13, respectively.

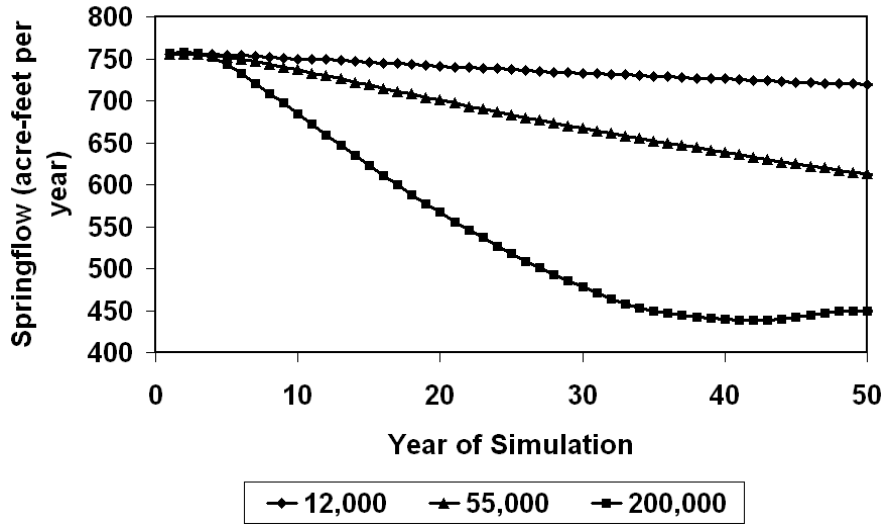


Figure 12. Estimated springflow in Hemphill County under alternative Hemphill County pumping scenarios

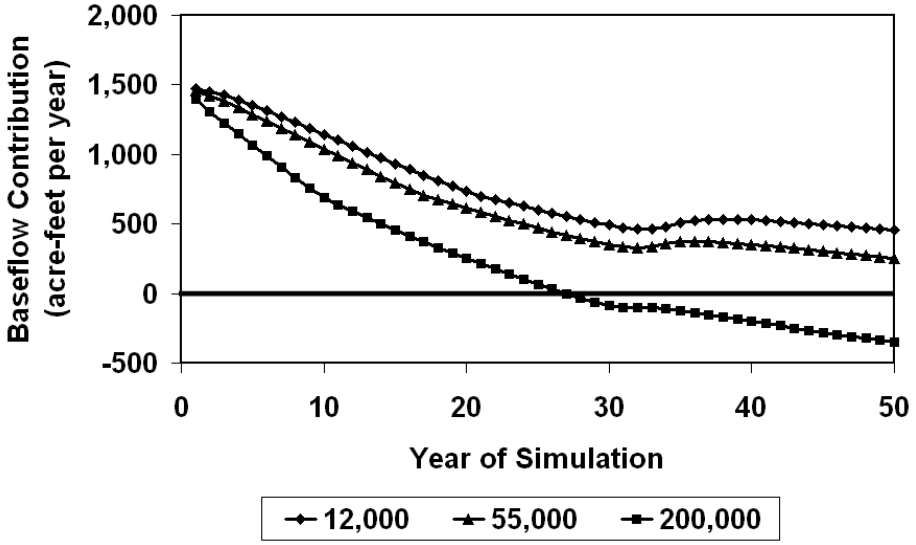


Figure 13. Estimated river baseflow in Hemphill County under alternative Hemphill County pumping scenarios. Positive values represent baseflow contributions; negative values represent stream recharge to the groundwater system.

Hemphill County pumping of 12,000 acre-feet per year represents the current state water plan estimate of groundwater availability. Hemphill County pumping of 55,000 acre-feet per year represents the estimated managed available groundwater pumping associated with the adopted desired future conditions. Hemphill County pumping of 200,000 acre-feet per year represents the staff's estimated managed available groundwater pumping associated with the proposed desired future conditions as outlined by the petitioners.

Under the state water plan assumed pumping (12,000 acre-feet per year) scenario, springflow is estimated to be reduced from about 750 acre-feet per year to about 720 acre-feet per year. Under the estimated managed available groundwater associated with the adopted desired future condition (55,000 acre-feet per year) scenario, springflow is estimated to be reduced from about 750 acre-feet per year to about 600 acre-feet per year. Finally, under the estimated managed available groundwater associated with the proposed desired future condition proposed by the petitioners (200,000 acre-feet per year) scenario, springflow is estimated to be reduced from about 750 acre-feet per year to about 450 acre-feet per year.

Under the state water plan assumed pumping (12,000 acre-feet per year) scenario, base flow is estimated to be reduced from about 1,500 acre-feet per year to about 450 acre-feet per year. Under the estimated managed available groundwater associated with the adopted desired future condition scenario (55,000 acre-feet per year), base flow is estimated to be reduced from about 1,500 acre-feet per year to about 250 acre-feet per year. Finally, under the estimated managed available groundwater associated with the proposed desired future condition proposed by the petitioners (200,000 acre-feet per year) scenario, base flow is expected to be reduced to zero, and, as a result of lowered groundwater levels, surface water will recharge the groundwater system at a rate of about 350 acre-feet per year.

Discussion

The adopted desired future conditions are based, in part, on the results of the groundwater availability model of the Ogallala Aquifer (Dutton, 2004) and a specific run of the model (Smith, 2009). In compiling the results, the groundwater management districts in Groundwater Management Area 1 developed averages of the volume remaining based on three delineated areas within Groundwater Management Area 1. Petitioners assert that the desired future condition should be the same across all of Groundwater Management Area 1. However, as this analysis has demonstrated, groundwater pumping varies across the region.

Based on this analysis, Hemphill County pumping under the adopted desired future condition (55,000 acre-feet per year) is over 10 times the current use (about 3,000 acre-feet per year) and over four times the use projected in the 2007 State Water Plan (12,000 acre-feet per year). The adopted desired future condition for Hemphill County provides for 43,000 acre-feet per year additional development of groundwater beyond that assumed in the State Water Plan. As discussed in this technical analysis, if the pumping

in Hemphill County were to be increased to 200,000 acre-feet per year, consistent with a 50-50 approach, there would be reductions in the management available groundwater in adjacent counties, additional impacts to springflow, and baseflow to surface water would be eliminated and surface water would recharge groundwater in Hemphill County.

References

Dutton, A., 2004. Adjustments to parameters to improve calibration of the Og-N model of the Ogallala aquifer, Panhandle Water Planning Area: Bureau of Economic Geology. The University of Texas at Austin, 9p.

Smith, R., 2009. GAM Run 09-001(Supplement). Texas Water Development Board, Groundwater Availability Modeling Section, February 26, 2009.

1. Overview of GMA1 Subdivision 1 Regional Economy and Water Use

In Subdivision 1 (Dallam, Hartley, Moore, and Sherman counties), oil and gas extraction, petroleum refining, and agriculture (irrigated crop production, livestock, and meat processing) are the primary base economic sectors[1] (Table 1). Irrigated crop production generates $174 million in gross regional product, and cattle ranching including feedlots produces $42 million per year.[2] Oil and gas mining and petroleum refining contribute another $255 million. Smaller or "secondary" base industries and non-basic sectors generate about $850 million. In terms of water requirements, irrigated crop production is by far the largest water consumer (97 percent) in the region.

Table 1: Gross regional product for Groundwater Management Area 1 Subdivision 1

Sector	Gross regional product ($millions)	Water use (acre-feet per year)	Average gross regional product per acre-foot
Primary base industries			
Irrigated crop production	$174 (12%)	1,231,340 (97%)	$141
Meat processing	$155 (11%)	2,380 (0.2%)	$65,320
Oil and gas extraction	$144 (10%)	670 (0.1%)	$214,179
Petroleum refineries	$111 (8%)	2,620 (0.2%)	$42,366
Cattle ranching and farming	$41 (3%)	23,170 (2%)	$1,778
Total primary base economic sectors	$625 (42%)	1,260,180 (99%)	$486
Other sectors (secondary basic and non-basic)	$850 (58%)	10,140 (1%)	$83,756
Total	$1,474 (100%)	1,270,320 (100%)	$1,151

Source: Based on data from IMPLAN Pro and TWDB.

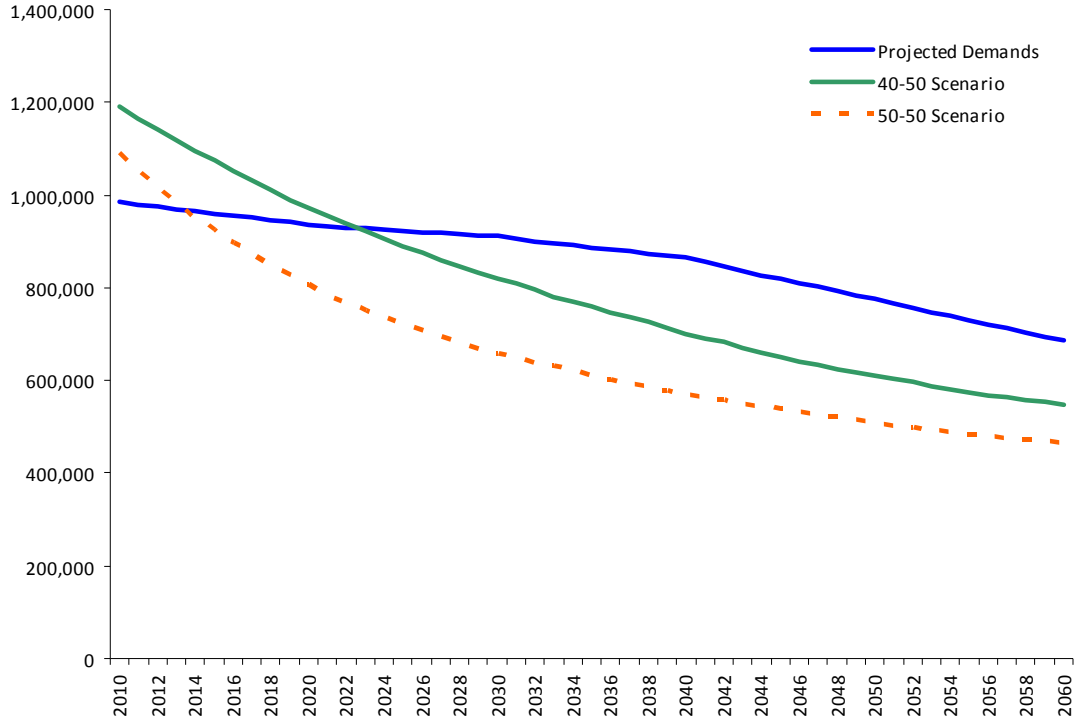
[1] In regional economics there are two primary classes of businesses. "Base" industries are the foundation of a community and generally produce goods and services that are sold outside of a region. Non-basic industries are supporting businesses that provide materials and labor for base industries and consumptive goods and services (retail goods, entertainment, medical service etc.) for the general public.

[2] Gross regional product consists of total payroll costs (wages and salaries plus benefits) paid by industries, corporate income, rental income, and interest payments. Basically, it is the amount of wealth created by businesses in a region that stays in the region and is equivalent to Gross Domestic Product (GDP) measured at a local rather than national level. Gross sales receipts are not a good measure of aggregate economic activity for a region.

2. Economic Impacts to the Subdivision 1 Regional Economy under Alternative Managed Available Groundwater Policies

Two alternative policy scenarios are under evaluation: the "50-50" option (50 percent of the water remaining in 50 years) and the "40-50" option (40 percent of the water remaining in 50 years). Both scenarios impose pumping limits on groundwater supplies in the region, which at various times in the future would require reductions in projected withdrawals. Based on a comparison of TWDB water demand projections and pumping limits, under the 50-50 option water consumers would need to reduce withdrawals beginning in about 2014 (Figure 1 and Table 4 at the end of this memorandum). The 40-50 scenario requires reductions beginning in 2023. By 2060, projected reductions total 223,000 acre-feet under the 50-50 scenario and 142,000 under the 40-50 alternative.

Figure 1: Projected Pumping Limits and Total Water Demands for GMA1 Subdivision 1 (acre-feet per year)



Reductions in available groundwater supplies mean that some water consumers in the region would have to reduce water use over time. Although some cutbacks could be met through improved efficiency in municipal and industrial uses, we assume that reductions in irrigation water demands would be the primary means of adapting to available groundwater supplies under each scenario.

Without irrigation water, producers will likely switch to dryland farming, which is less profitable. Cash receipts to farmers would decline which, in turn, would have negative economic consequences for the four-county region.

The following steps outline the basic process to estimate economic impacts:

1) calculate gross sales receipts for irrigated crops and corresponding contributions to gross regional product and, as an alternative, estimate the same figures assuming farmers resort to non-irrigated or "dryland" production (Table 2);

2) assume that irrigated acreage declines in proportion to reductions in groundwater availability; and

3) measure declines in irrigated economic output and offset by dryland revenues over the period of analysis (2010-2060) and estimate regional level economic impacts.[3]

A key assumption is that crop types, prices, and production technology remain constant based on historical averages over the period of analysis. This assumption makes long-term estimates (i.e., those beyond 10 to 15 years) less reliable. Crop types are not necessarily as much of an issue as are prices and technology, which is rapidly changing because of developments in biotechnology including genetically modified drought resistant crops. While, we cannot generate models that predict changes in technology and prices over the next 50 years with confidence, we can account for this uncertainty by weighting more distant values less than more current values. In other words, future values are discounted to present value.[4] This places a much greater emphasis on near-term values rather than longer-term less reliable estimates.

[3] Regional economic impacts are based on models generated developed by TWDB staff using proprietary data and software from by the Minnesota IMPLAN Group, Inc.

[4] The discount rate used in this analysis (4.4 percent) is based on interest rates for average market yields during fiscal year 2009 on interest-bearing marketable securities with 15 years or more remaining to maturity.

Table 2: Estimated annual gross sales receipts and gross regional product for irrigated and dryland crop production in Groundwater Management Area 1 Subdivision 1 ($millions).

		Irrigated		Dryland	
Crop category	Acres	Gross revenues	Gross regional product	Gross revenues	Gross regional product
Oilseed	19,420	$4.34	$2.35	$3.25	$1.76
Grains	685,420	$286.96	$137.12	$127.63	$60.99
Vegetable and melon*	5,870	$37.48	$24.49	$1.09	$0.52
Cotton	31,310	$14.27	$2.72	$6.58	$1.25
All other crops	33,600	$13.74	$6.98	$13.74	$3.49
Total	775,610	$356.78	$173.67	$188.68	$91.99

* Vegetable and melon acreage is converted to grain production under the dryland scenario. Data sources: Gross revenues are based on five-year average (2003-2007) values for prices and yields. Gross regional product estimates are based on models developed by TWDB staff using proprietary data and software from by the Minnesota IMPLAN Group, Inc.

Based on the analysis, reductions in gross regional product are significantly higher in the 50-50 scenario (Table 3 and Figure 2). For the period 2010–2020, the cost differential is $60 million, and this increases to $358 million if calculated over the entire period of analysis. Table 5 shows annual estimates (discounted and non-discounted).

Table 3: Estimated reductions in gross regional product under managed available groundwater scenarios for Groundwater Management Area 1 Subdivision 1 ($millions).

Period	40-50 scenario	50-50 scenario	Difference
2010-2020	$0	$60	$60
2010-2030	$25	$213	$188
2010-2040	$106	$391	$285
2010-2050	$175	$506	$331
2010-2060	$222	$580	$358

Figures are discounted to present value. Source: TWDB Water Resources Planning Division

Figure 2: Decreased gross regional product under alternative groundwater availability scenarios for Groundwater Management Area 1 Subdivision 1 ($millions)

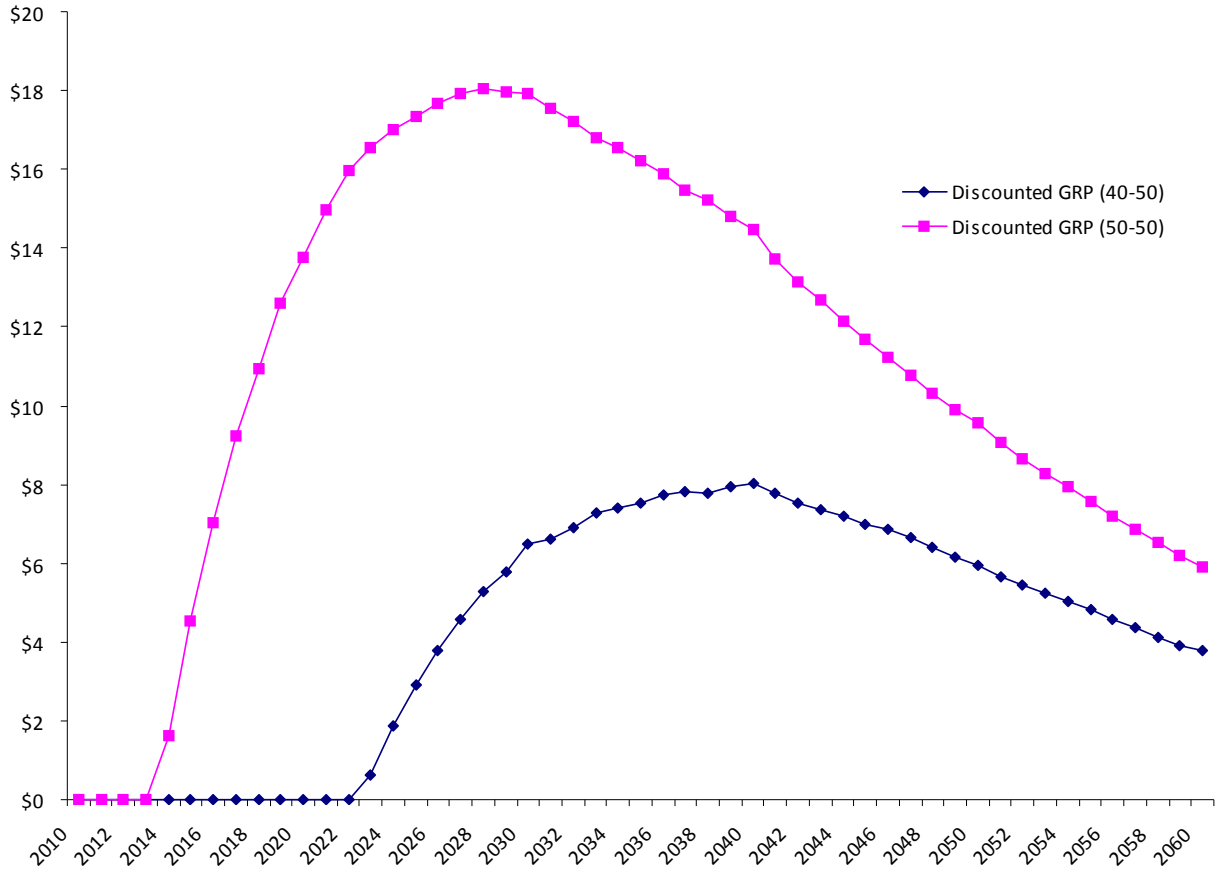


Table 4: Projected water demands and supplies for Subdivision 1 (Dallam, Hartley, Moore and Sherman counties) in Groundwater Management Area 1 under alternative water availability scenarios.

	Historic and projected water use (1000s of acre-feet)							Pumping limits and constrained irrigation water use (1000s of acre-feet)			
Year	Total Water Use	Municipal	Manufacturing	Steam-electric	Irrigation	Mining	Livestock	Pumping Limits (40-50)	Pumping Limits (50-50)	Surplus or Deficit (40-50)	Surplus or Deficit (50-50)
2005	1,471.5	9.7	8.3	0.1	1,436.7	0.3	23.6	1,327.4	1,327.4	(144,117)	(144,117)
2006	1,135.7	7.9	8.5	0.1	1,094.9	0.0	33.1	1,297.1	1,272.5	161,411	136,851
2007	1,196.4	7.5	7.2	0.1	1,162.3	0.0	27.2	1,268.4	1,220.8	72,032	24,427
2008	NA*	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2009	NA*	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2010	985.3	5.3	7.9	0.2	954.8	0.7	16.4	1,190.5	1,090.1	205.2	104.8
2011	980.2	5.3	7.9	0.2	949.2	0.7	16.8	1,165.3	1,052.0	185.1	71.8
2012	975.1	5.4	8.0	0.2	943.7	0.7	17.2	1,141.8	1,017.1	166.7	41.9
2013	970.1	5.4	8.1	0.2	938.2	0.7	17.6	1,117.7	983.7	147.6	13.5
2014	965.2	5.4	8.1	0.2	932.7	0.7	18.1	1,096.1	952.8	130.9	(12.4)
2015	960.2	5.4	8.2	0.2	927.2	0.7	18.5	1,073.5	924.0	113.3	(36.2)
2016	955.3	5.4	8.2	0.2	921.8	0.7	19.0	1,052.7	897.3	97.4	(58.0)
2017	950.5	5.4	8.3	0.2	916.4	0.7	19.4	1,030.5	871.2	80.0	(79.3)
2018	945.7	5.4	8.3	0.2	911.1	0.7	19.9	1,011.1	848.2	65.4	(97.5)
2019	941.0	5.4	8.4	0.2	905.8	0.7	20.4	989.9	824.8	49.0	(116.2)
2020	936.3	5.5	8.5	0.2	900.5	0.7	20.9	971.5	804.6	35.2	(131.7)
2021	933.0	5.3	7.9	0.2	897.7	0.7	21.1	955.8	784.2	22.8	(148.8)
2022	930.4	5.4	8.0	0.2	894.9	0.7	21.3	939.1	765.6	8.6	(164.9)
2023	927.9	5.4	8.1	0.2	892.1	0.7	21.4	921.1	750.0	(6.8)	(177.9)
2024	925.3	5.4	8.1	0.2	889.4	0.7	21.6	904.4	735.1	(21.0)	(190.3)
2025	922.8	5.4	8.2	0.2	886.6	0.7	21.7	889.0	720.9	(33.8)	(201.9)
2026	920.3	5.4	8.2	0.2	883.9	0.7	21.9	874.6	706.4	(45.7)	(213.9)
2027	917.8	5.4	8.3	0.2	881.1	0.7	22.1	860.2	692.2	(57.6)	(225.6)
2028	915.3	5.4	8.3	0.2	878.4	0.7	22.2	846.3	679.1	(69.0)	(236.2)
2029	912.8	5.4	8.4	0.2	875.7	0.7	22.4	834.1	668.0	(78.8)	(244.8)
2030	910.8	5.5	8.9	0.2	873.0	0.6	22.5	819.0	656.7	(91.8)	(254.1)
2031	905.0	5.3	7.9	0.2	868.1	0.7	22.7	808.1	646.2	(97.0)	(258.8)
2032	900.5	5.4	8.0	0.2	863.3	0.7	22.9	795.1	637.4	(105.3)	(263.1)
2033	895.9	5.4	8.1	0.2	858.5	0.7	23.1	781.0	629.3	(114.9)	(266.7)

Table 4: Projected water demands and supplies for Subdivision 1 (Dallam, Hartley, Moore and Sherman counties) in Groundwater Management Area 1 under alternative water availability scenarios.

2034	891.4	5.4	8.1	0.2	853.8	0.7	23.2	769.8	619.0	(121.6)	(272.4)
2035	886.9	5.4	8.2	0.2	849.0	0.7	23.4	758.9	609.7	(128.1)	(277.2)
2036	882.4	5.4	8.2	0.2	844.3	0.7	23.6	745.9	600.8	(136.6)	(281.6)
2037	878.0	5.4	8.3	0.2	839.6	0.7	23.8	735.2	593.6	(142.8)	(284.4)
2038	873.6	5.4	8.3	0.2	835.0	0.7	24.0	726.0	583.3	(147.6)	(290.3)
2039	869.2	5.4	8.4	0.2	830.3	0.7	24.1	712.8	575.8	(156.5)	(293.4)
2040	865.7	5.5	9.4	0.2	825.7	0.6	24.3	701.6	568.4	(164.1)	(297.3)
2041	854.9	5.3	7.9	0.2	816.2	0.7	24.5	690.7	562.2	(164.2)	(292.7)
2042	845.7	5.4	8.0	0.2	806.8	0.7	24.7	682.2	556.3	(163.6)	(289.4)
2043	836.7	5.4	8.1	0.2	797.4	0.7	24.9	671.2	548.9	(165.4)	(287.7)
2044	827.7	5.4	8.1	0.2	788.2	0.7	25.1	660.9	543.3	(166.8)	(284.4)
2045	818.9	5.4	8.2	0.2	779.1	0.7	25.3	651.8	536.5	(167.1)	(282.4)
2046	810.1	5.4	8.2	0.2	770.1	0.7	25.5	640.7	530.7	(169.4)	(279.5)
2047	801.5	5.4	8.3	0.2	761.2	0.7	25.7	632.2	524.8	(169.3)	(276.7)
2048	793.0	5.4	8.3	0.2	752.4	0.7	25.9	624.8	519.3	(168.2)	(273.7)
2049	784.5	5.4	8.4	0.2	743.7	0.7	26.1	617.9	513.7	(166.7)	(270.9)
2050	777.3	5.4	9.8	0.2	735.1	0.5	26.3	611.0	507.6	(166.3)	(269.7)
2051	766.1	5.3	7.9	0.2	725.4	0.7	26.5	603.9	502.4	(162.1)	(263.7)
2052	756.7	5.4	8.0	0.2	715.8	0.7	26.7	595.7	497.1	(161.1)	(259.6)
2053	747.5	5.4	8.1	0.2	706.3	0.7	26.9	588.3	491.8	(159.2)	(255.7)
2054	738.4	5.4	8.1	0.2	696.9	0.7	27.1	581.3	486.8	(157.1)	(251.6)
2055	729.4	5.4	8.2	0.2	687.7	0.7	27.3	574.1	482.4	(155.4)	(247.0)
2056	720.6	5.4	8.2	0.2	678.5	0.7	27.5	568.2	477.8	(152.4)	(242.8)
2057	711.9	5.4	8.3	0.2	669.5	0.7	27.8	562.5	474.7	(149.4)	(237.2)
2058	703.3	5.4	8.3	0.2	660.7	0.7	28.0	558.0	471.0	(145.3)	(232.3)
2059	694.8	5.4	8.4	0.2	651.9	0.7	28.2	553.0	467.6	(141.8)	(227.2)
2060	688.1	5.3	10.4	0.2	643.2	0.5	28.4	546.8	465.1	(141.3)	(223.0)

*NA = Not available. Historic estimates for 2008 are not yet published.

Table 5: Projected regional economic impacts for Subdivision 1 (Dallam, Hartley, Moore, and Sherman counties) in Groundwater Management Area 1 under alternative groundwater water availability scenarios ($millions).

Year	Decrease in gross regional product (40-50)	Decrease in gross regional product (50-50)	Decrease in gross regional product (40-50) discounted to present value	Decrease in gross regional product (50-50) discounted to present value
2010	$0.00	$0.00	$0.00	$0.00
2011	$0.00	$0.00	$0.00	$0.00
2012	$0.00	$0.00	$0.00	$0.00
2013	$0.00	$0.00	$0.00	$0.00
2014	$0.00	$1.91	$0.00	$1.61
2015	$0.00	$5.62	$0.00	$4.55
2016	$0.00	$9.06	$0.00	$7.02
2017	$0.00	$12.46	$0.00	$9.25
2018	$0.00	$15.40	$0.00	$10.95
2019	$0.00	$18.47	$0.00	$12.59
2020	$0.00	$21.05	$0.00	$13.75
2021	$0.00	$23.93	$0.00	$14.98
2022	$0.00	$26.59	$0.00	$15.95
2023	$1.10	$28.78	$0.63	$16.54
2024	$3.42	$30.88	$1.88	$17.01
2025	$5.52	$32.87	$2.91	$17.36
2026	$7.49	$34.94	$3.79	$17.68
2027	$9.46	$36.96	$4.59	$17.92
2028	$11.38	$38.82	$5.29	$18.04
2029	$13.02	$40.35	$5.80	$17.97
2030	$15.23	$42.02	$6.50	$17.93
2031	$16.17	$42.93	$6.61	$17.56
2032	$17.67	$43.88	$6.92	$17.20
2033	$19.38	$44.72	$7.28	$16.80
2034	$20.62	$45.94	$7.42	$16.53
2035	$21.84	$47.01	$7.53	$16.21
2036	$23.42	$48.02	$7.74	$15.87
2037	$24.62	$48.78	$7.80	$15.45
2038	$25.60	$50.07	$7.77	$15.20
2039	$27.29	$50.88	$7.94	$14.80
2040	$28.78	$51.84	$8.02	$14.45

Table 5: Projected regional economic impacts for Subdivision 1 (Dallam, Hartley, Moore, and Sherman counties) in Groundwater Management Area 1 under alternative groundwater water availability scenarios ($millions).

2041	$29.13	$51.32	$7.78	$13.71
2042	$29.36	$51.35	$7.52	$13.14
2043	$30.04	$51.64	$7.37	$12.67
2044	$30.64	$51.63	$7.20	$12.14
2045	$31.05	$51.87	$7.00	$11.69
2046	$31.86	$51.94	$6.88	$11.21
2047	$32.21	$52.02	$6.66	$10.76
2048	$32.36	$52.06	$6.42	$10.32
2049	$32.45	$52.13	$6.17	$9.90
2050	$32.75	$52.51	$5.96	$9.56
2051	$32.37	$51.94	$5.65	$9.06
2052	$32.58	$51.83	$5.45	$8.67
2053	$32.63	$51.72	$5.23	$8.29
2054	$32.65	$51.58	$5.01	$7.92
2055	$32.71	$51.32	$4.81	$7.55
2056	$32.53	$51.12	$4.59	$7.21
2057	$32.30	$50.61	$4.37	$6.84
2058	$31.85	$50.24	$4.13	$6.51
2059	$31.50	$49.80	$3.91	$6.18
2060	$31.80	$49.53	$3.78	$5.89