GAM Run 09-014

by Mr. Wade Oliver

Texas Water Development Board
Groundwater Availability Modeling Section
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Cynthia K. Ridgeway is the Manager of the Groundwater Availability Modeling Section and is responsible for oversight of work performed by employees under her direct supervision. The seal appearing on this document was authorized by Cynthia K. Ridgeway, P.G. 471 on September 21, 2010.

EXECUTIVE SUMMARY:

The recently modified groundwater model for the Dockum Aquifer was used to estimate future pumping under a scenario where groundwater levels declined at a rate of one foot per year in Groundwater Management Area 1 between 2010 and 2060. Pumping required to achieve this constant rate of decline over the 51 year model simulation period was estimated to increase through time from approximately 13,000 acre-feet per year to over 107,000 acre-feet per year.

For comparison, an additional run was performed with pumping set at a constant rate to achieve a 51-foot decline over the 51 year simulation period. This run differs from the above run in that the drawdown rate – 1 foot per year – is not constant. The drawdown rate changes through time but still achieves the same average drawdown over Groundwater Management Area 1 by 2060. This run required a constant pumping rate of approximately 83,000 acre-feet per year.

The annual pumping in each of the above model runs was then adjusted up and down in order to provide insight into how the drawdown results change through time under different pumping scenarios.

REQUESTOR:

Mr. Steve Walthour of North Plains Groundwater Conservation District on behalf of Groundwater Management Area 1.

DESCRIPTION OF REQUEST:

Mr. Walthour requested a groundwater availability model run that results in a 1-foot decline in the average water level of the Dockum Aquifer per year in Groundwater Management Area 1 between 2010 and 2060. The Dockum Aquifer and nearby groundwater management areas are shown in Figure 1.

METHODS:

The recently modified groundwater model of the Dockum Aquifer (Oliver and Hutchison, 2010) was used in order to estimate the pumping required to achieve the requested rate of drawdown of one-foot per year in the Dockum Aquifer. This model is an modification of the groundwater availability model documented in Ewing and others (2008) and was completed in order to more effectively simulate predictive conditions. The pumping between 2010 and 2060 was determined iteratively by adjusting pumping in Groundwater Management Area 1 each year to obtain the requested decline. For this report, this model run will be referred to as “Scenario 1.”

For comparison purposes, an additional run was performed using pumping set at a constant rate between 2010 and 2060 to achieve 51-feet of drawdown – the same overall drawdown as the above request – but without the requirement of 1-foot of drawdown per year. This run is referred to in this report as “Scenario 2.”

Once the levels of pumping that met the above two scenarios were estimated, the pumping in each scenario was systematically adjusted up and down to show how drawdown through time changes under different pumping levels. More details on pumping in the model are given in the Pumping section below.

The historical-calibration period of the model ends in 1997 while the predictive simulation documented here begins in 2010. To determine the appropriate level of pumping between 1998 and 2009, the interim period leading up to the predictive simulation, a preliminary analysis of water levels in a few selected wells in Groundwater Management Area 1 was performed. As shown in Appendix A, these hydrographs do not indicate significant trends in water levels that indicate large changes in pumping during this time period. For this reason, we considered the pumping levels and distribution for the last year of the historical-calibration portion of the model to be appropriate for the interim period. Pumping was, therefore, held constant at 1997 levels between 1998 and 2009.

PARAMETERS AND ASSUMPTIONS:

The parameters and assumptions for the model run using the modified groundwater model for the Dockum Aquifer are described below:

- We used the modified version the groundwater model for the Dockum Aquifer described in Oliver and Hutchison (2008). This model is an update to the previously developed groundwater availability model for the Dockum Aquifer described in Ewing and others (2008) in order to more effectively simulate predictive conditions. See Oliver and Hutchison (2010) and Ewing and others (2008) for assumptions and limitations of the model.

- The model includes two active layers which represent the upper and lower portions of the Dockum Aquifer. Layer 2 represents the upper portion of the Dockum Aquifer. Layer 3 represents the lower portion of the Dockum Aquifer. Layer 1, which is active in version 1.01 of the model documented in Ewing and others (2008), was inactivated in the modified model as described in Oliver and Hutchison (2010).

- The mean absolute error (a measure of the difference between simulated and measured water levels during model calibration) for the lower portion of the Dockum Aquifer between 1980 and 1997 is 53 feet. This represents 2.5 percent of the hydraulic head drop across the model area.

- The MODFLOW General-Head Boundary package was used to simulate flow between the Dockum Aquifer and overlying aquifers. The water levels in the overlying aquifers were applied as described in Oliver and Hutchison (2010) using Groundwater Availability Model Run 09-001 (Smith, 2009) for the northern portion of the Ogallala Aquifer and Groundwater Availability Model Run 09-023 (Oliver, 2010a) for the southern portion of the Ogallala Aquifer.

- Cells were assigned to individual counties and groundwater conservation districts as shown in the September 14, 2009 version of the model grid for the Dockum Aquifer. Because this model grid predates development of the modified model, care was taken to ensure that only those fields in the model grid that were valid for the modified model were used for analysis of results.

- The recharge used for the model run represents average recharge as described in Ewing and others (2008).

- Pumping used for the predictive simulations was estimated iteratively to match the requested rate of water level decline by members of Groundwater Management Area 1. Details on this pumpage are given below.

Pumping

The pumping for Scenario 1 (the original request) in the model was determined using an iterative process. The pumping in the model for the year 1997 (the last year of the historical-calibration portion of the model) was held constant between 1998 and 2009. Beginning in 2010, this pumping was raised over Groundwater Management Area 1 as a whole and the decline in water levels each year between 2010 and 2060 was calculated. This decline was then compared against the request (1-foot per year) and pumping was adjusted to match the request. This process was repeated until the average water level decline in Groundwater Management Area 1 each year was 1 foot. In order to elevate the pumping to the specified level, the amount of pumping above the level for 1997 was uniformly increased over all model cells that contained pumping.

With the exception of Nolan and Mitchell counties in Groundwater Management Area 7, the pumping in areas outside Groundwater Management Area 1 was held constant at 1997 levels through the predictive period. Pumping in these counties was also adjusted, at the request of Groundwater Management Area 7, to values specified for these counties. Results for these areas are presented in GAM Run 10-001 (Oliver, 2010a).

As mentioned in the Methods section above, an additional run (Scenario 2) was also performed to estimate the constant pumping rate that achieves the same average drawdown over the 51-year predictive period as the requested run above (51 feet). The pumping for this run was determined using the same process as above except that the pumping input into MODFLOW did not vary through time between 2010 and 2060. Instead, this constant pumping was adjusted to achieve an average of 51 feet of drawdown in Groundwater Management Area 1 between 2010 and 2060.

The two pumping scenarios above were also adjusted up and down in order to provide insight into the relationship between pumping and drawdown in the Dockum Aquifer in Groundwater Management Area 1. The pumping input to the model was multiplied by factors to increase (factors of 1.3, 1.6 and 1.9) or decrease (factors of 0.8, 0.6, and 0.4) the pumping over the model as a whole. These values were chosen to provide a range of pumping values between roughly half and twice the "base" scenarios above. The relationships generated are presented in the Results section below.

RESULTS:

As described above, the pumping distribution for the last year of the historical-calibration portion of the model was held constant between 1998 and 2009 and then set to levels to meet the requirements of scenarios 1 and 2 between 2010 and 2060. The average drawdown for each decade for Scenario 1 is shown in tables 1 and 2 for each county, groundwater conservation district, and groundwater management for the upper and lower portions of the Dockum Aquifer, respectively. Table 2 also includes pumping output from the model which accounts for pumping lost due to cells going inactive. A model cell goes inactive when the water level in a cell drops below the bottom of the aquifer. In this situation, pumping can no longer occur. Table 1 does not include pumping because no pumping occurs in the upper portion of the Dockum Aquifer in the model. This same information for Scenario 2 is shown in tables 3 and 4.

As shown in Figure 1, the upper portion of the Dockum Aquifer within Groundwater Management Area 1 is limited to a small area in the southwest corner of Randall County. Drawdowns over the 51-year predictive period for this area are 19 and 20 feet for Scenarios 1 and 2, respectively (Tables 1 and 3). In Scenario 1, drawdown increases relatively steadily through the period. In Scenario 2, drawdown increases rapidly and then levels off.

Tables 2 and 4 present pumping and average drawdown for the lower portion of the Dockum Aquifer for Scenarios 1 and 2, respectively. For Scenario 1, drawdown in Groundwater Management Area 1 averages one foot per year. This rate is variable by county, however. For example, drawdown in Oldham County is only 4 feet after the 51-year period while drawdown is 111 feet in Sherman County by 2060. The primary reason for this difference is that the Dockum Aquifer outcrops over a large area of Oldham County while it does not in Sherman County. Where the aquifer outcrops, a decline in the water level requires that the aquifer actually be dewatered. This is in contrast to the subcrop, where a decline in water level is more easily achieved by reducing the confining pressure.

For Scenario 2, drawdown in Groundwater Management Area 1 increases rapidly and then begins to level off through the 51-year predictive period, achieving an average of 51 feet of drawdown by the end of 2060. As for Scenario 1 above, the rate of drawdown varies by county.

As described in the Pumping section above, the base pumping distribution for each of the above scenarios was adjusted up and down to provide insight into how the model responds under different levels of pumping. Tables similar to Tables 1 through 4, but showing pumping and drawdown results based on these pumping adjustments are shown in Appendix B. In addition, Figure 2 shows the drawdown in the lower portion of the Dockum Aquifer in Groundwater Management Area 1 through time for pumping Scenario 1. Runs with pumping equivalent to 40 percent of Scenario 1 (a decrease) and 190 percent of Scenario 1 (an increase) are also shown. Pumping for Scenario 1 must increase from about 13,400 acre-feet per year in 2010 to over 107,000 acre-feet per year in 2060 to achieve the requested 1 foot of drawdown per year for the “base” Scenario 1. For the model run with 40 percent of Scenario 1 pumping, pumping still increases through time, but from approximately 5,000 acre-feet per year to almost 43,000 acre-feet per year. For the model run with 190 percent of Scenario 1 pumping, pumping increases from 25,000 acre-feet per year to over 200,000 acre-feet per year. These runs result in drawdowns of 37 and 60 feet for the 40 percent and 190 percent runs, respectively.

Figure 3 shows the drawdown in Groundwater Management Area 1 through time for pumping Scenario 2. As for Figure 2 above, Figure 3 also contains the results of decreases and increases of the base pumping for Scenario 2. The shapes of the runs presented in Figure 3 are very different than Figure 2 because pumping is set at a constant rate through the predictive period in Scenario 2. At the low end, a constant pumping rate of 33,000 acre-feet per year (the 40 percent run) results in a drawdown of 36 feet after 51 years. At the high end, a constant pumping rate of 154,000 acre-feet per year (the 190 percent run) results in a drawdown of 62 feet after 51 years.

To better illustrate how the model responds through time during the “base” runs, Appendix C contains charts for each of the major water budget terms for each year of the predictive model runs for scenarios 1 and 2. Note that these charts only reflect the lower portion of the Dockum Aquifer within Groundwater Management Area 1. Appendix D contains water budget tables for each county, groundwater conservation district, and groundwater management area for the last stress period of the model run. The components of the water budget are described below:

- Recharge— areally distributed recharge due to precipitation falling on the outcrop areas of the aquifer. Recharge is always shown as “Inflow” into the water budget. Recharge is modeled using the MODFLOW Recharge package.

- Pumping—water produced from wells in the aquifer. This component is always shown as “Outflow” from the water budget. Pumping is modeled using the MODFLOW Well package.

- Change in Storage—changes in the water stored in the aquifer. This component of the budget is often seen as water both going into and out of the aquifer because water levels may decline in some areas (water is being removed from storage) and rise in others (water is being added to storage).

- Overlying Aquifers—water that flows into (or out of) the aquifer due to interaction with overlying units, primarily the Ogallala Aquifer. Interaction with overlying aquifers is modeled using the MODFLOW General-Head Boundary package. For areas overlain by the Ogallala Aquifer, the water level input to the general-head boundary package comes from predictive GAM runs 09-001 and 09-023 using the models for the northern and southern portions of the Ogallala Aquifer, respectively (Smith, 2009; Oliver, 2010a).

- Springs and Evapotranspiration—water that naturally discharges from the aquifer when water levels rise above the elevation of the spring or seep or when it is close enough to the surface to evaporate or be taken up by plants. This component is always shown as “Outflow,” or discharge, in the water budget. Spring and evapotranspiration outflows are simulated collectively in the model using the MODFLOW Drain package.

- Stream Interaction—water that flows between streams and the aquifer. The direction and amount of flow depends on the relationship between the water levels in the stream and the aquifer. Where the water level in the stream is higher than the water level in the aquifer, water flows into the aquifer and is shown as “Inflow” in the budget. Where the water level in the stream is lower than the water level in the aquifer, water flows out of the aquifer and is shown as “Outflow” in the budget. Streams are modeled using the MODFLOW Stream package.

- Lateral flow—describes lateral flow within the aquifer between one area and an adjacent area (for example, lateral flow into and out of a groundwater management area).

- Vertical flow or leakage (upper or lower)—describes the vertical flow, or leakage, between two aquifers, or, in the case of this model, between the upper and lower portions of the Dockum Aquifer. This flow is controlled by the water levels in each unit and aquifer properties that define the amount of leakage that can occur. “Upper” refers to interaction between an aquifer and the aquifer overlying it. “Lower” refers to interaction between an aquifer and the aquifer below it. For this model, vertical flow between the upper and lower portions of the Dockum Aquifer is reported separately from interaction of the Dockum Aquifer with the overlying aquifers described above (which is, strictly speaking, also vertical flow).

Figure C-1 in Appendix C shows the recharge through time for scenarios 1 and 2. Recharge is constant through time for both the historical period of the model to which it was calibrated (not shown) and the predictive period. Recharge to the Dockum Aquifer in Groundwater Management Area 1 is approximately 8,800 acre-feet per year.

Figure C-2 shows pumping through time for scenarios 1 and 2. This figure most clearly shows the differences in the way the two scenarios were set up. In Scenario 1, pumping gradually increases through time from approximately 13,400 acre-feet per year to over 107,000 acre-feet per year. In Scenario 2, pumping is set to a constant rate of approximately 83,000 acre-feet per year. While both scenarios achieve an average of 51-feet of drawdown over the 51-year period, the rate of pumping through time during the period is very different.

Figure C-3 shows the Net Change in Storage in the model. Note that in Scenario 2 the amount of water removed from storage increases dramatically in 2010 due to the abrupt increase in pumping shown in Figure C-2. While the increase in the rate of water removed from storage is smoother for Scenario 1, the rate at which water is removed from storage in 2060 is higher for Scenario 1 than at any point during the model run of Scenario 2.

Figure C-4 shows the net inflow from overlying aquifers (primarily the Ogallala Aquifer). This figure is similar in shape to Figure C-3 because the rapid decline in water levels in Scenario 2 induces an increase in the amount of water flowing into the Dockum Aquifer from the overlying Ogallala Aquifer. Note that the rate of inflow from overlying aquifers declines through time after approximately 2015 in Scenario 2. This is due to declining water levels in the overlying Ogallala Aquifer. As the water levels in the Ogallala decline, the gradient between the water level in the Dockum Aquifer and the water level in the Ogallala Aquifer is reduced. The amount of flow, therefore, is also reduced. In Scenario 1, however, the volume of flow from the Ogallala Aquifer increases, albeit slowly, through time. This is because the rate of drawdown in the Dockum Aquifer in this scenario is higher than the rate of drawdown in the overlying Ogallala Aquifer (in the areas where it overlies the Dockum Aquifer). This results in an increasing gradient between the two aquifers yielding an increase in the net inflow from the overlying aquifers.

Figure C-5 shows the outflow to springs and by evapotranspiration for scenarios 1 and 2. In both scenarios, outflows decline through time due to declining water levels in the Dockum Aquifer. Figure C-6, showing net outflow to streams, exhibits a very similar response as the springs and evapotranspiration shown in Figure C-5 for the same reason.

Figure C-7 shows the net lateral flow between Groundwater Management Area 1 and adjacent areas. Notice that throughout the predictive period flow is consistently toward Groundwater Management Area 1 and increases through time due to declining water levels.

Figure C-8 shows the magnitude and direction of vertical flow between the upper and lower portions of the Dockum Aquifer. Through the predictive period there is a net downward flow from the upper portion of the Dockum Aquifer to the lower portion. While the rate of this flow increases through time due to declining water levels, the magnitude is minor (less than 700 acre-feet per year) relative to the other water budget terms.

It is important to acknowledge the limitations of the precision of the sub-regional water budgets that is associated with the size of the model cells and the approach used to extract data from the model. To avoid double accounting, a model cell that straddles a political boundary (for example, a county) is assigned to one side of the boundary based on the location of the centroid of the model cell. For example, if a cell contains two counties, the cell is assigned to the county where the centroid of the cell is located.

REFERENCES AND ASSOCIATED MODEL RUNS:

Ewing, J.E., Jones, T.L., Yan, T., Vreugdenhil, A.M., Fryar, D.G., Pickens, J.F., Gordon, K., Nicot, J.P., Scanlon, B.R., Ashworth, J.B., Beach, J., 2008, Groundwater Availability Model for the Dockum Aquifer – Final Report: contract report to the Texas Water Development Board, 510 p.

Oliver, W., Hutchison, W.R., 2010, Modification and recalibration of the Groundwater Availability Model of the Dockum Aquifer: Texas Water Development Board, 114 p.

Oliver, W., 2010a, GAM Run 09-023: Texas Water Development Board, GAM Run 09-023 Draft Report, 30 p.

Oliver, W., 2010b, GAM Run 10-001: Texas Water Development Board, GAM Run 10-001 Draft Report, 35 p.

Smith, R., 2009, GAM Run 09-001: Texas Water Development Board, GAM Run 09-001 Draft Report, 28 p.

Table 1. Average drawdown for the upper portion of the Dockum Aquifer for Scenario 1 by decade for each county, groundwater conservation district (GCD), and groundwater management area (GMA). Drawdown is in feet. UWCD is the abbreviation for Underground Water Conservation District.

Scenario 1: Base Upper Dockum	Base Drawdown					
	2010	**2020**	**2030**	**2040**	**2050**	**2060**
County						
Randall	0	3	7	12	16	19
GCD						
High Plains UWCD No. 1	2	17	30	39	42	43
GMA						
Out-of-State	0	0	1	1	1	1
GMA 1	0	3	7	12	16	19
GMA 2	1	15	27	35	40	42
GMA 3	0	0	0	0	1	1
GMA 7	0	5	9	13	15	16

Table 2. Pumping and average drawdown for the lower portion of the Dockum Aquifer for Scenario 1 by decade for each county, groundwater conservation district (GCD), and groundwater management area (GMA). Pumping is in acre-feet per year. Drawdown is in feet. UWCD is the abbreviation for Underground Water Conservation District.

Scenario 1: Base Lower Dockum	Pumping						Average Drawdown					
	2010	**2020**	**2030**	**2040**	**2050**	**2060**	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**
County												
Armstrong	107	457	929	1,730	3,218	5,810	1	11	22	30	36	42
Carson	130	243	395	653	1,133	1,968	2	22	42	49	51	52
Dallam	2,826	3,717	4,918	6,954	10,739	17,331	2	19	36	52	67	81
Hartley	1,807	3,105	4,856	7,825	13,344	22,955	2	17	33	49	68	88
Moore	5,053	5,305	5,646	6,223	7,296	9,164	1	11	21	29	38	49
Oldham	1,169	2,500	4,294	7,336	12,991	22,839	0	0	1	1	2	4
Potter	819	1,455	2,312	3,764	6,465	11,169	0	4	8	12	17	21
Randall	1,018	1,830	2,926	4,783	8,235	14,248	0	7	15	26	35	43
Sherman	491	565	664	833	1,147	1,693	3	30	57	80	96	111
GCD												
High Plains UWCD No. 1	7,967	8,441	9,079	10,162	12,176	15,682	1	15	28	40	47	50
North Plains GCD	9,326	11,386	14,163	18,870	27,623	42,865	2	18	35	52	69	87
Panhandle GCD	888	1,883	3,224	5,498	9,725	17,086	1	9	17	23	27	32
GMA												
Out-of-State	7,793	7,793	7,793	7,793	7,793	7,793	0	1	1	2	2	3
GMA 1	13,419	19,177	26,940	40,099	64,566	107,175	1	11	21	31	41	51
GMA 2	9,598	9,598	9,598	9,598	9,598	9,598	1	10	20	29	34	37
GMA 3	4,231	4,231	4,231	4,231	4,231	4,231	0	0	0	0	0	0
GMA 6	69	69	69	69	69	69	0	1	2	2	3	4
GMA 7	23,802	23,802	23,802	23,802	23,802	23,802	1	2	3	4	5	5

Table 3. Average drawdown for the upper portion of the Dockum Aquifer for Scenario 2 by decade for each county, groundwater conservation district (GCD), and groundwater management area (GMA). Drawdown is in feet. UWCD is the abbreviation for Underground Water Conservation District.

Scenario 2: Upper Dockum	**Spread_Base**					
	2010	**2020**	**2030**	**2040**	**2050**	**2060**
County						
Randall	4	15	17	18	19	20
GCD						
High Plains UWCD No. 1	2	17	30	39	42	43
GMA						
Out-of-State	0	0	1	1	1	1
GMA 1	4	15	17	18	19	20
GMA 2	1	15	27	35	40	42
GMA 3	0	0	0	0	1	1
GMA 7	0	5	9	13	15	16

Table 4. Pumping and average drawdown for the lower portion of the Dockum Aquifer for Scenario 2 by decade for each county, groundwater conservation district (GCD), and groundwater management area (GMA). Pumping is in acre-feet per year. Drawdown is in feet. UWCD is the abbreviation for Underground Water Conservation District.

Scenario 2: Base Lower Dockum	**Pumping**						**Average Drawdown**					
	2010	**2020**	**2030**	**2040**	**2050**	**2060**	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**
County												
Armstrong	4,338	4,338	4,338	4,338	4,338	4,338	31	36	39	41	43	44
Carson	1,494	1,494	1,494	1,494	1,494	1,494	49	51	52	53	54	55
Dallam	13,586	13,586	13,586	13,586	13,586	13,586	36	66	71	74	77	80
Hartley	17,495	17,495	17,495	17,495	17,495	17,495	25	50	61	70	78	85
Moore	8,103	8,103	8,103	8,103	8,103	8,103	26	34	39	43	47	51
Oldham	17,245	17,245	17,245	17,245	17,245	17,245	1	2	3	4	5	6
Potter	8,486	8,486	8,486	8,486	8,486	8,486	11	15	17	19	21	22
Randall	10,832	10,832	10,832	10,832	10,832	10,832	13	33	37	39	42	43
Sherman	1,382	1,382	1,382	1,382	1,382	1,382	73	90	95	100	104	108
GCD												
High Plains UWCD No. 1	13,690	13,690	13,690	13,690	13,690	13,690	2	16	30	41	48	50
North Plains GCD	34,207	34,207	34,207	34,207	34,207	34,207	32	60	67	74	80	84
Panhandle GCD	12,894	12,894	12,894	12,894	12,894	12,894	23	27	29	30	32	33
GMA												
Out-of-State	7,793	7,793	7,793	7,793	7,793	7,793	0	1	2	2	3	3
GMA 1	82,961	82,961	82,961	82,961	82,961	82,961	21	36	41	45	48	51
GMA 2	9,598	9,598	9,598	9,598	9,598	9,598	1	11	21	29	35	38
GMA 3	4,231	4,231	4,231	4,231	4,231	4,231	0	0	0	0	0	0
GMA 6	69	69	69	69	69	69	0	1	2	2	3	4
GMA 7	23,802	23,802	23,802	23,802	23,802	23,802	1	2	3	4	5	5

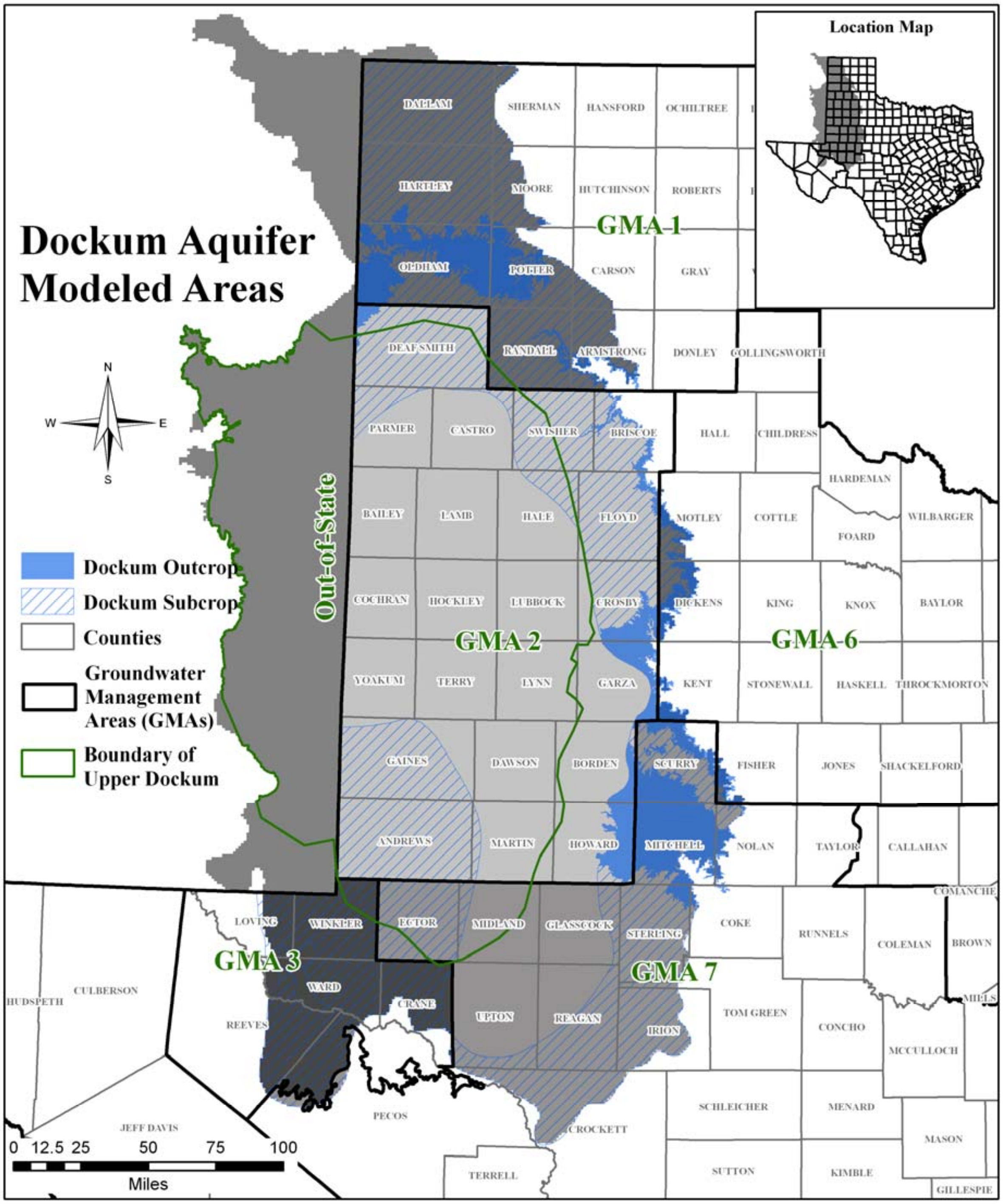

Figure 1. Location map showing model grid cells representing the Dockum Aquifer, groundwater management areas, the official Dockum Aquifer boundary, and the boundary of the upper portion of the Dockum Aquifer.

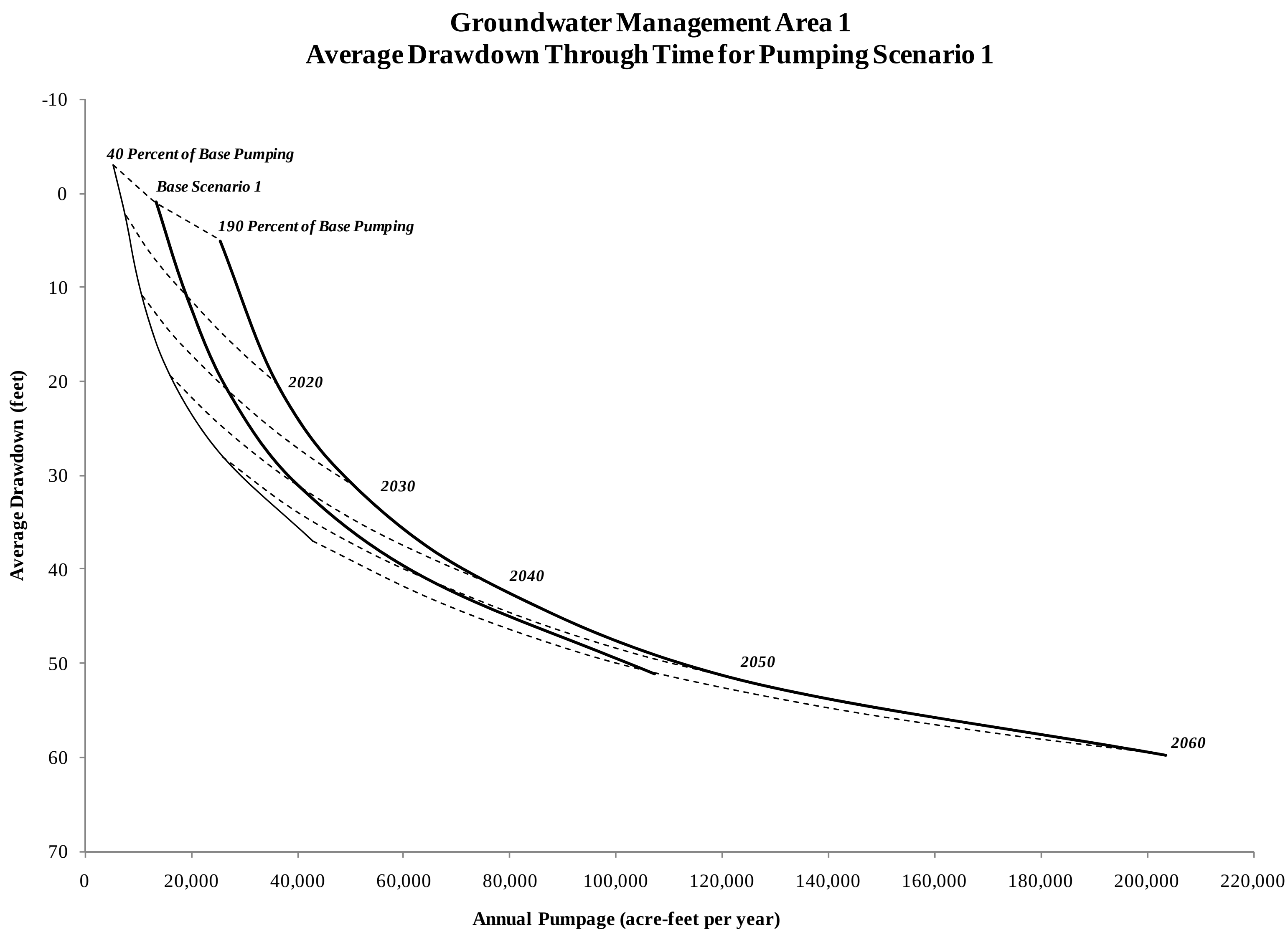

Figure 2. Average drawdown for the lower portion of the Dockum Aquifer in Groundwater Management Area 1 through time. Pumping was increased to 190 percent and decreased to 40 percent of the base pumping for Scenario 1.

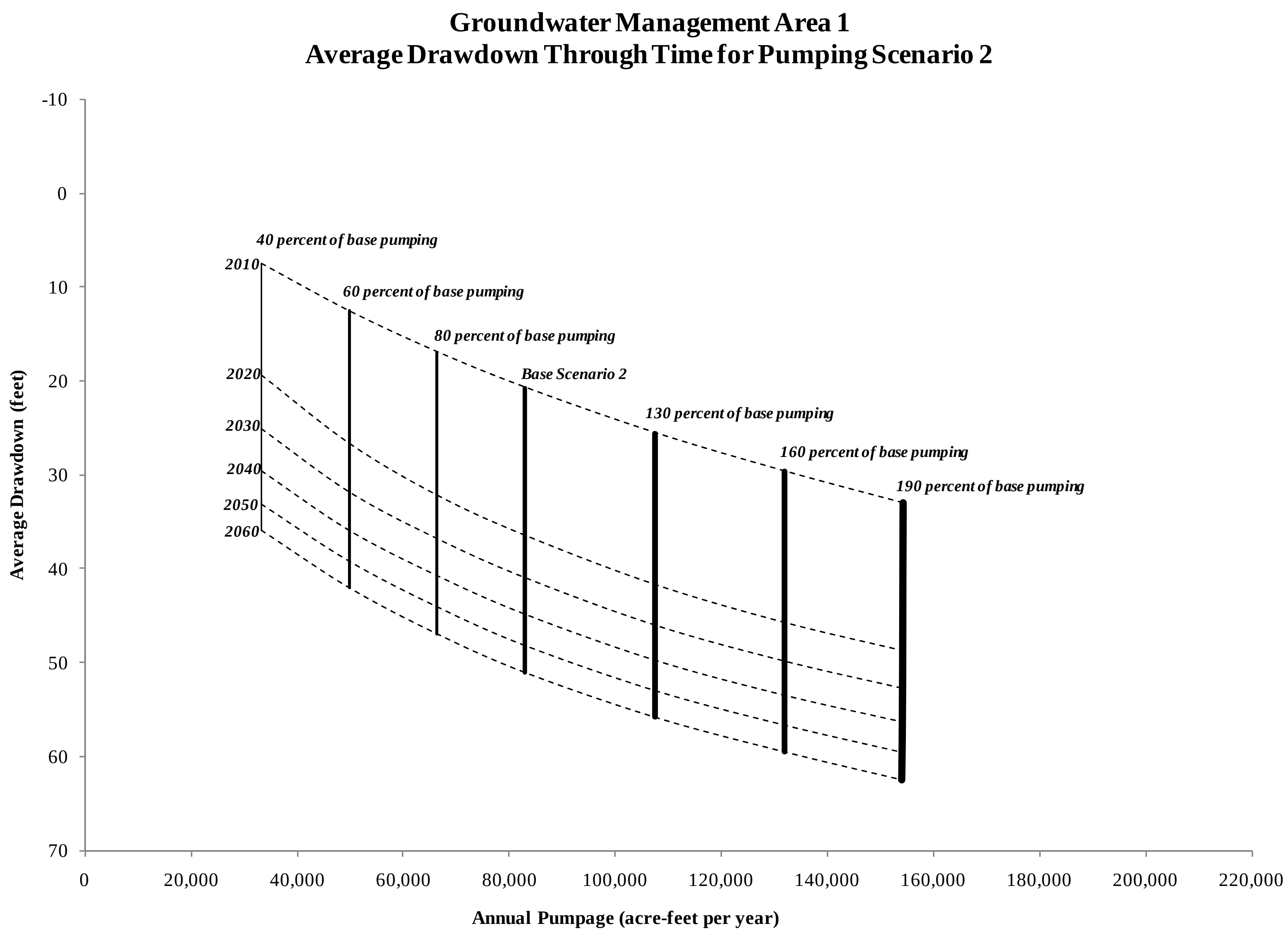

Figure 3. Average drawdown for the lower portion of the Dockum Aquifer in Groundwater Management Area 1 through time. Pumping was increased to 190 percent and decreased to 40 percent of the base pumping for Scenario 2.

Appendix A

Selected hydrographs between 1980 and 2009 for the Dockum Aquifer in Groundwater Management Area 1

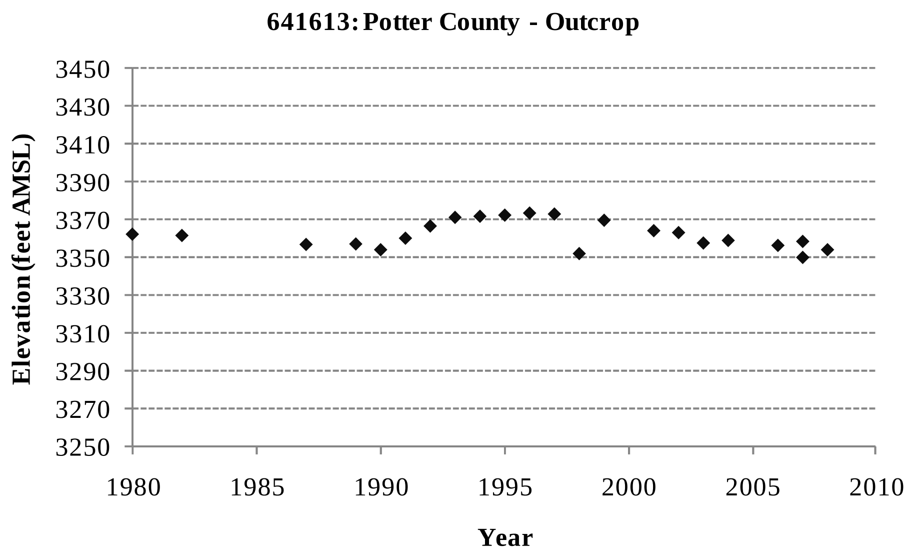

Figure A-1. Hydrograph of state well 641613 located in the outcrop portion of the Dockum Aquifer in Potter County.

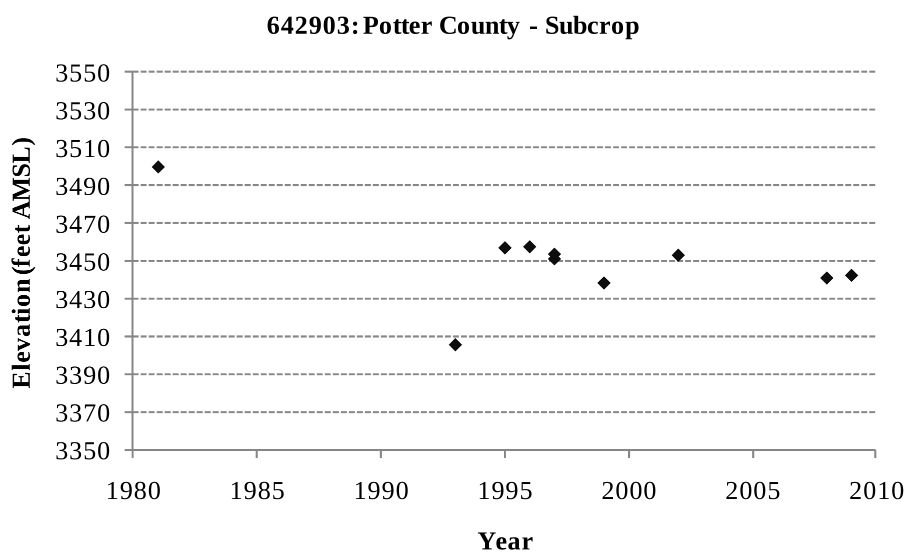

Figure A-2. Hydrograph of state well 642903 located in the subcrop portion of the Dockum Aquifer in Potter County.

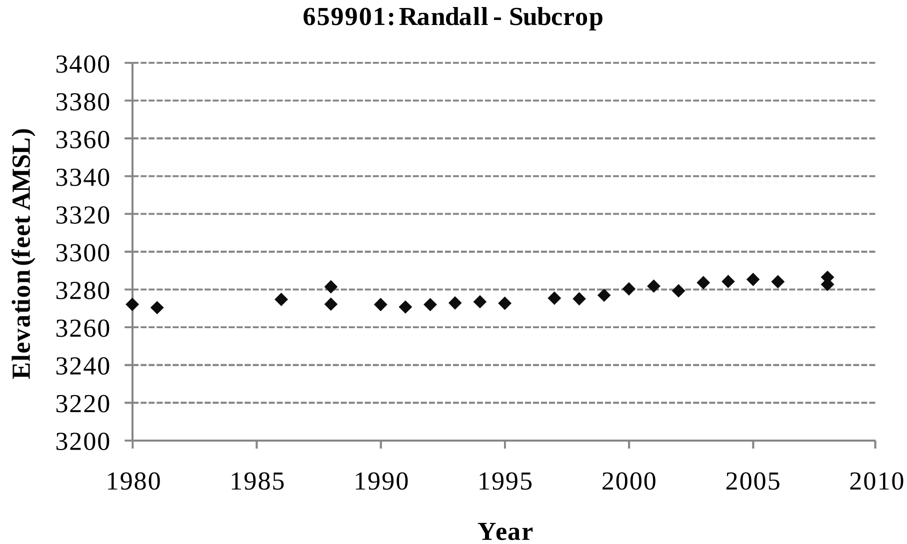

Figure A-3. Hydrograph of state well 659901 located in the subcrop portion of the Dockum Aquifer in Randall County.

Appendix B

Pumping and drawdown for each pumping scenario by decade

Table B-1. Average drawdown in the lower portion of the Dockum Aquifer resulting from pumping decreased to 40 percent of the base of Scenario 1 by decade by county, groundwater conservation district (GCD), and groundwater management area (GMA). Pumping is in acre-feet per year. Drawdown is in feet. UWCD is the abbreviation for Underground Water Conservation District. Negative values for average drawdown indicate an average rise in water levels.

Scenario 1: 40 Percent of Base	**Pumping**						**Average Drawdown**					
	2010	**2020**	**2030**	**2040**	**2050**	**2060**	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**
County												
Armstrong	33	47	66	267	862	1,899	0	4	8	15	25	32
Carson	50	72	101	181	373	708	-4	6	17	33	48	51
Dallam	1,141	1,631	2,292	3,233	4,747	7,384	-4	2	16	29	42	58
Hartley	706	1,009	1,417	2,400	4,607	8,452	-3	9	23	37	50	65
Moore	2,083	2,978	4,185	5,168	5,597	6,345	-23	-15	5	20	27	35
Oldham	441	630	885	1,776	4,038	7,977	0	0	0	1	1	2
Potter	318	455	640	1,109	2,190	4,071	-1	2	4	7	11	15
Randall	395	564	793	1,389	2,770	5,175	-1	3	8	13	21	30
Sherman	201	287	404	525	650	869	-22	-2	26	53	76	92
GCD												
High Plains UWCD No. 1	3,180	3,290	3,438	3,796	4,601	6,004	0	12	25	36	43	45
North Plains GCD	3,793	5,423	7,620	10,267	13,767	19,864	-7	2	18	33	47	63
Panhandle GCD	336	480	674	1,343	3,033	5,978	-1	3	7	13	20	25
GMA												
Out-of-State	3,117	3,117	3,117	3,117	3,117	3,117	-1	-2	-2	-2	-1	-1
GMA 1	5,368	7,673	10,782	16,048	25,835	42,878	-3	2	11	19	28	37
GMA 2	3,839	3,839	3,839	3,839	3,839	3,839	0	9	19	27	32	35
GMA 3	1,692	1,692	1,692	1,692	1,692	1,692	-1	-2	-2	-2	-2	-2
GMA 6	28	28	28	28	28	28	0	0	1	1	2	2
GMA 7	9,521	9,521	9,521	9,521	9,521	9,521	0	-3	-3	-3	-3	-3

Table B-2. Average drawdown in the lower portion of the Dockum Aquifer resulting from pumping decreased to 60 percent of the base of Scenario 1 by decade by county, groundwater conservation district (GCD), and groundwater management area (GMA). Pumping is in acre-feet per year. Drawdown is in feet. UWCD is the abbreviation for Underground Water Conservation District. Negative values for average drawdown indicate an average rise in water levels.

Scenario 1: 60 Percent of Base	Pumping						Average Drawdown					
	2010	**2020**	**2030**	**2040**	**2050**	**2060**	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**
County												
Armstrong	49	71	274	755	1,648	3,203	0	4	11	22	30	36
Carson	75	107	184	339	626	1,128	-2	9	25	44	50	51
Dallam	1,712	2,447	3,252	4,473	6,744	10,699	-2	9	24	38	53	69
Hartley	1,059	1,513	2,427	4,208	7,519	13,286	-1	12	27	41	57	74
Moore	3,125	4,467	5,174	5,520	6,164	7,284	-15	2	16	23	31	40
Oldham	661	945	1,805	3,629	7,022	12,931	0	0	1	1	2	2
Potter	478	683	1,123	1,994	3,615	6,437	-1	2	5	9	13	17
Randall	592	847	1,406	2,520	4,591	8,199	0	4	10	18	27	36
Sherman	301	431	526	628	816	1,143	-13	14	40	65	85	100
GCD												
High Plains UWCD No. 1	4,771	4,935	5,268	5,918	7,126	9,230	1	13	26	37	44	47
North Plains GCD	5,690	8,134	10,310	13,134	18,386	27,531	-4	10	25	40	56	73
Panhandle GCD	503	719	1,364	2,728	5,264	9,681	-1	4	10	18	23	28
GMA												
Out-of-State	4,676	4,676	4,676	4,676	4,676	4,676	0	-1	-1	0	0	0
GMA 1	8,052	11,510	16,169	24,065	38,745	64,311	-2	6	15	24	33	43
GMA 2	5,759	5,759	5,759	5,759	5,759	5,759	1	9	19	27	33	36
GMA 3	2,538	2,538	2,538	2,538	2,538	2,538	0	-1	-1	-1	-1	-1
GMA 6	41	41	41	41	41	41	0	0	1	2	2	3
GMA 7	14,281	14,281	14,281	14,281	14,281	14,281	0	-1	-1	-1	0	0

Table B-3. Average drawdown in the lower portion of the Dockum Aquifer resulting from pumping decreased to 80 percent of the base of Scenario 1 by decade by county, groundwater conservation district (GCD), and groundwater management area (GMA). Pumping is in acre-feet per year. Drawdown is in feet. UWCD is the abbreviation for Underground Water Conservation District. Negative values for average drawdown indicate an average rise in water levels.

Scenario 1: 80 Percent of Base	Pumping						Average Drawdown					
	2010	**2020**	**2030**	**2040**	**2050**	**2060**	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**
County												
Armstrong	66	224	602	1,242	2,433	4,507	0	7	17	27	33	39
Carson	100	168	289	496	880	1,548	0	15	35	48	51	52
Dallam	2,282	3,124	4,085	5,714	8,742	14,015	0	14	30	45	61	76
Hartley	1,411	2,241	3,642	6,016	10,431	18,120	0	15	30	45	62	82
Moore	4,167	5,137	5,410	5,871	6,730	8,224	-6	9	18	26	35	45
Oldham	882	1,614	3,049	5,483	10,006	17,885	0	0	1	1	2	3
Potter	637	1,032	1,717	2,879	5,040	8,803	0	3	7	11	15	19
Randall	790	1,289	2,166	3,651	6,413	11,223	0	5	13	22	32	40
Sherman	402	516	595	730	981	1,418	-5	24	49	74	91	106
GCD												
High Plains UWCD No. 1	6,361	6,663	7,174	8,040	9,651	12,456	1	14	27	38	46	49
North Plains GCD	7,587	10,015	12,236	16,002	23,004	35,198	-1	15	30	46	63	81
Panhandle GCD	671	1,221	2,294	4,113	7,494	13,384	0	6	14	21	26	30
GMA												
Out-of-State	6,234	6,234	6,234	6,234	6,234	6,234	0	0	0	1	1	2
GMA 1	10,735	15,344	21,555	32,082	51,655	85,743	0	9	18	28	38	48
GMA 2	7,678	7,678	7,678	7,678	7,678	7,678	1	10	20	28	34	37
GMA 3	3,385	3,385	3,385	3,385	3,385	3,385	0	0	-1	-1	-1	-1
GMA 6	55	55	55	55	55	55	0	1	1	2	3	3
GMA 7	19,042	19,042	19,042	19,042	19,042	19,042	0	0	1	1	2	2

Table B-4. Average drawdown in the lower portion of the Dockum Aquifer resulting from pumping increased to 130 percent of the base of Scenario 1 by decade by county, groundwater conservation district (GCD), and groundwater management area (GMA). Pumping is in acre-feet per year. Drawdown is in feet. UWCD is the abbreviation for Underground Water Conservation District.

Scenario 1: 130 Percent of Base	**Pumping**						**Average Drawdown**					
	2010	**2020**	**2030**	**2040**	**2050**	**2060**	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**
County												
Armstrong	352	807	1,421	2,462	4,396	7,766	4	17	26	33	39	46
Carson	209	356	553	889	1,513	2,599	7	33	47	50	52	53
Dallam	3,449	4,607	6,168	8,814	13,735	22,304	4	26	43	59	74	85
Hartley	2,714	4,402	6,679	10,537	17,712	30,207	3	20	37	55	75	96
Moore	5,229	5,558	6,000	6,750	8,145	10,574	3	15	23	32	42	55
Oldham	2,099	3,829	6,162	10,116	17,467	30,269	0	1	1	2	3	5
Potter	1,263	2,089	3,203	5,092	8,603	14,718	1	5	10	14	18	22
Randall	1,585	2,641	4,065	6,480	10,968	18,785	1	10	20	30	39	45
Sherman	543	639	768	987	1,395	2,105	8	40	68	87	102	118
GCD												
High Plains UWCD No. 1	10,223	10,839	11,669	13,077	15,694	20,253	1	16	30	42	49	52
North Plains GCD	10,765	13,442	17,053	23,172	34,550	54,366	4	23	41	58	77	94
Panhandle GCD	1,583	2,876	4,620	7,576	13,071	22,640	3	13	20	25	29	34
GMA												
Out-of-State	10,131	10,131	10,131	10,131	10,131	10,131	0	3	4	4	5	5
GMA 1	17,440	24,926	35,018	52,125	83,931	139,324	2	14	25	35	45	55
GMA 2	12,478	12,478	12,478	12,478	12,478	12,478	1	11	21	30	35	38
GMA 3	5,492	5,492	5,492	5,492	5,492	5,492	1	1	1	1	1	1
GMA 6	90	90	90	90	90	90	0	1	2	3	4	4
GMA 7	30,950	30,950	30,950	30,950	30,950	30,950	1	5	7	9	10	10

Table B-5. Average drawdown in the lower portion of the Dockum Aquifer resulting from pumping increased to 160 percent of the base of Scenario 1 by decade by county, groundwater conservation district (GCD), and groundwater management area (GMA). Pumping is in acre-feet per year. Drawdown is in feet. UWCD is the abbreviation for Underground Water Conservation District.

Scenario 1: 160 Percent of Base	Pumping						Average Drawdown					
	2010	**2020**	**2030**	**2040**	**2050**	**2060**	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**
County												
Armstrong	596	1,157	1,912	3,193	5,574	9,721	6	22	29	35	41	48
Carson	288	468	712	1,125	1,892	3,229	13	40	49	51	52	54
Dallam	4,071	5,496	7,417	10,675	16,731	27,277	6	32	50	65	79	86
Hartley	3,621	5,699	8,501	13,250	22,080	37,458	4	24	41	60	82	102
Moore	5,406	5,810	6,354	7,277	8,994	11,983	5	17	26	35	46	60
Oldham	3,029	5,158	8,029	12,895	21,943	37,700	0	1	1	2	4	6
Potter	1,707	2,724	4,095	6,419	10,741	18,267	2	7	11	16	20	24
Randall	2,153	3,453	5,205	8,177	13,701	23,321	2	13	24	34	42	47
Sherman	594	712	871	1,141	1,643	2,517	12	49	75	92	108	123
GCD												
High Plains UWCD No. 1	12,478	13,237	14,259	15,991	19,213	24,823	2	17	32	43	50	54
North Plains GCD	12,203	15,499	19,942	27,474	41,478	65,866	6	28	46	64	83	98
Panhandle GCD	2,278	3,870	6,016	9,653	16,416	28,195	5	16	22	27	31	35
GMA												
Out-of-State	12,468	12,468	12,468	12,468	12,468	12,468	1	5	6	7	8	8
GMA 1	21,462	30,675	43,096	64,151	103,297	171,472	4	18	28	39	49	58
GMA 2	15,358	15,358	15,358	15,358	15,358	15,358	1	12	22	31	36	39
GMA 3	6,754	6,754	6,754	6,754	6,754	6,754	1	2	2	2	3	3
GMA 6	110	110	110	110	110	110	0	2	3	3	4	5
GMA 7	38,097	38,097	38,097	38,097	38,097	38,097	2	9	12	14	15	16

Table B-6. Average drawdown in the lower portion of the Dockum Aquifer resulting from pumping increased to 190 percent of the base of Scenario 1 by decade by county, groundwater conservation district (GCD), and groundwater management area (GMA). Pumping is in acre-feet per year. Drawdown is in feet. UWCD is the abbreviation for Underground Water Conservation District.

Scenario 1: 190 Percent of Base	Pumping						Average Drawdown					
	2010	**2020**	**2030**	**2040**	**2050**	**2060**	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**
County												
Armstrong	841	1,506	2,404	3,925	6,752	11,677	9	25	32	37	44	51
Carson	366	581	870	1,360	2,272	3,859	18	44	50	51	53	55
Dallam	4,693	6,385	8,667	12,535	19,727	32,251	8	37	55	70	82	88
Hartley	4,528	6,996	10,323	15,963	26,448	44,710	6	27	45	65	88	107
Moore	5,582	6,062	6,708	7,805	9,843	13,393	7	20	29	38	50	65
Oldham	3,959	6,487	9,896	15,675	26,419	45,131	0	1	2	3	4	7
Potter	2,151	3,359	4,987	7,747	12,879	21,816	3	8	13	17	21	25
Randall	2,720	4,264	6,345	9,874	16,433	27,858	3	16	28	37	43	49
Sherman	646	786	975	1,295	1,891	2,929	17	58	81	96	112	127
GCD												
High Plains UWCD No. 1	14,734	15,635	16,848	18,906	22,731	29,393	2	18	33	45	52	55
North Plains GCD	13,642	17,556	22,832	31,776	48,406	77,366	7	33	51	69	88	102
Panhandle GCD	2,973	4,863	7,411	11,731	19,762	33,749	7	18	24	28	32	37
GMA												
Out-of-State	14,806	14,806	14,806	14,806	14,806	14,806	1	7	9	10	10	11
GMA 1	25,483	36,424	51,173	76,177	122,663	203,620	5	20	31	41	52	60
GMA 2	18,239	18,239	18,239	18,239	18,239	18,239	1	12	23	31	37	40
GMA 3	8,016	8,016	8,016	8,016	8,016	8,016	2	3	3	4	4	4
GMA 6	131	131	131	131	131	131	1	2	3	4	5	6
GMA 7	45,244	45,244	45,244	45,244	45,244	45,244	2	12	16	19	20	21

Table B-7. Average drawdown in the lower portion of the Dockum Aquifer resulting from pumping decreased to 40 percent of the base of Scenario 2 by decade by county, groundwater conservation district (GCD), and groundwater management area (GMA). Pumping is in acre-feet per year. Drawdown is in feet. UWCD is the abbreviation for Underground Water Conservation District. Negative values for average drawdown indicate an average rise in water levels.

Scenario 2: 40 Percent of Base	**Pumping**						**Average Drawdown**					
	2010	**2020**	**2030**	**2040**	**2050**	**2060**	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**
County												
Armstrong	1,310	1,310	1,310	1,310	1,310	1,310	15	24	26	28	30	32
Carson	518	518	518	518	518	518	28	43	46	48	50	51
Dallam	5,886	5,886	5,886	5,886	5,886	5,886	12	36	43	49	52	55
Hartley	6,268	6,268	6,268	6,268	6,268	6,268	9	25	37	47	55	62
Moore	5,920	5,920	5,920	5,920	5,920	5,920	10	19	23	28	31	35
Oldham	5,740	5,740	5,740	5,740	5,740	5,740	0	1	1	2	2	3
Potter	3,002	3,002	3,002	3,002	3,002	3,002	4	7	10	12	13	15
Randall	3,808	3,808	3,808	3,808	3,808	3,808	4	15	20	24	27	30
Sherman	745	745	745	745	745	745	27	53	66	75	82	88
GCD												
High Plains UWCD No. 1	5,207	5,207	5,207	5,207	5,207	5,207	1	13	26	36	43	45
North Plains GCD	16,401	16,401	16,401	16,401	16,401	16,401	11	31	41	49	55	60
Panhandle GCD	4,305	4,305	4,305	4,305	4,305	4,305	11	17	20	22	23	25
GMA												
Out-of-State	3,117	3,117	3,117	3,117	3,117	3,117	0	-1	-1	-1	-1	-1
GMA 1	33,197	33,197	33,197	33,197	33,197	33,197	8	19	25	30	33	36
GMA 2	3,839	3,839	3,839	3,839	3,839	3,839	0	9	19	27	32	35
GMA 3	1,692	1,692	1,692	1,692	1,692	1,692	-1	-2	-2	-2	-2	-2
GMA 6	28	28	28	28	28	28	0	0	1	1	2	2
GMA 7	9,521	9,521	9,521	9,521	9,521	9,521	0	-3	-3	-3	-3	-3

Table B-8. Average drawdown in the lower portion of the Dockum Aquifer resulting from pumping decreased to 60 percent of the base of Scenario 2 by decade by county, groundwater conservation district (GCD), and groundwater management area (GMA). Pumping is in acre-feet per year. Drawdown is in feet. UWCD is the abbreviation for Underground Water Conservation District. Negative values for average drawdown indicate an average rise in water levels.

Scenario 2: 60 Percent of Base	Pumping						Average Drawdown					
	2010	**2020**	**2030**	**2040**	**2050**	**2060**	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**
County												
Armstrong	2,319	2,319	2,319	2,319	2,319	2,319	23	30	32	34	35	37
Carson	843	843	843	843	843	843	43	49	50	51	52	52
Dallam	8,453	8,453	8,453	8,453	8,453	8,453	20	50	56	60	63	66
Hartley	10,010	10,010	10,010	10,010	10,010	10,010	14	34	45	55	63	71
Moore	6,648	6,648	6,648	6,648	6,648	6,648	17	25	29	33	37	40
Oldham	9,575	9,575	9,575	9,575	9,575	9,575	0	1	2	3	3	4
Potter	4,834	4,834	4,834	4,834	4,834	4,834	7	11	13	15	16	18
Randall	6,150	6,150	6,150	6,150	6,150	6,150	7	23	28	31	34	36
Sherman	957	957	957	957	957	957	47	72	80	86	91	96
GCD												
High Plains UWCD No. 1	8,035	8,035	8,035	8,035	8,035	8,035	1	14	27	38	45	47
North Plains GCD	22,336	22,336	22,336	22,336	22,336	22,336	19	43	52	59	65	70
Panhandle GCD	7,172	7,172	7,172	7,172	7,172	7,172	17	22	24	26	27	28
GMA												
Out-of-State	4,676	4,676	4,676	4,676	4,676	4,676	0	0	0	0	0	0
GMA 1	49,789	49,789	49,789	49,789	49,789	49,789	13	27	32	36	39	42
GMA 2	5,759	5,759	5,759	5,759	5,759	5,759	1	10	19	28	33	36
GMA 3	2,538	2,538	2,538	2,538	2,538	2,538	0	-1	-1	-1	-1	-1
GMA 6	41	41	41	41	41	41	0	0	1	2	2	3
GMA 7	14,281	14,281	14,281	14,281	14,281	14,281	0	-1	-1	-1	0	0

Table B-9. Average drawdown in the lower portion of the Dockum Aquifer resulting from pumping decreased to 80 percent of the base of Scenario 2 by decade by county, groundwater conservation district (GCD), and groundwater management area (GMA). Pumping is in acre-feet per year. Drawdown is in feet. UWCD is the abbreviation for Underground Water Conservation District. Negative values for average drawdown indicate an average rise in water levels.

Scenario 2: 80 Percent of Base	**Pumping**						**Average Drawdown**					
	2010	**2020**	**2030**	**2040**	**2050**	**2060**	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**
County												
Armstrong	3,329	3,329	3,329	3,329	3,329	3,329	28	34	36	38	39	41
Carson	1,168	1,168	1,168	1,168	1,168	1,168	48	50	51	52	53	54
Dallam	11,020	11,020	11,020	11,020	11,020	11,020	28	59	64	68	71	74
Hartley	13,753	13,753	13,753	13,753	13,753	13,753	20	43	53	63	71	78
Moore	7,375	7,375	7,375	7,375	7,375	7,375	22	30	34	38	42	46
Oldham	13,410	13,410	13,410	13,410	13,410	13,410	1	2	3	3	4	5
Potter	6,657	6,657	6,657	6,657	6,657	6,657	9	13	15	17	19	20
Randall	8,491	8,491	8,491	8,491	8,491	8,491	10	29	33	36	38	40
Sherman	1,170	1,170	1,170	1,170	1,170	1,170	63	83	89	94	98	103
GCD												
High Plains UWCD No. 1	10,862	10,862	10,862	10,862	10,862	10,862	1	15	29	39	46	49
North Plains GCD	28,272	28,272	28,272	28,272	28,272	28,272	26	52	60	67	73	78
Panhandle GCD	10,030	10,030	10,030	10,030	10,030	10,030	21	25	27	28	30	31
GMA												
Out-of-State	6,234	6,234	6,234	6,234	6,234	6,234	0	0	1	1	1	2
GMA 1	66,372	66,372	66,372	66,372	66,372	66,372	17	32	37	41	44	47
GMA 2	7,678	7,678	7,678	7,678	7,678	7,678	1	10	20	28	34	37
GMA 3	3,385	3,385	3,385	3,385	3,385	3,385	0	0	-1	-1	-1	-1
GMA 6	55	55	55	55	55	55	0	1	1	2	3	3
GMA 7	19,042	19,042	19,042	19,042	19,042	19,042	0	0	1	1	2	2

Table B-10. Average drawdown in the lower portion of the Dockum Aquifer resulting from pumping increased to 130 percent of the base of Scenario 2 by decade by county, groundwater conservation district (GCD), and groundwater management area (GMA). Pumping is in acre-feet per year. Drawdown is in feet. UWCD is the abbreviation for Underground Water Conservation District.

Scenario 2: 130 Percent of Base	**Pumping**						**Average Drawdown**					
	2010	**2020**	**2030**	**2040**	**2050**	**2060**	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**
County												
Armstrong	5,852	5,852	5,852	5,852	5,852	5,852	34	40	42	45	47	49
Carson	1,982	1,982	1,982	1,982	1,982	1,982	50	52	53	54	56	57
Dallam	17,436	17,436	17,436	17,436	17,436	17,436	45	74	78	81	83	86
Hartley	23,109	23,109	23,109	23,109	23,109	23,109	33	60	71	79	87	93
Moore	9,194	9,194	9,194	9,194	9,194	9,194	32	40	45	49	53	57
Oldham	22,997	22,997	22,997	22,997	22,997	22,982	1	3	4	5	7	8
Potter	11,215	11,215	11,215	11,215	11,215	11,215	14	17	20	21	23	25
Randall	14,344	14,344	14,344	14,344	14,344	14,344	17	38	41	43	45	47
Sherman	1,456	1,456	1,456	1,456	1,456	1,456	83	99	105	110	114	118
GCD												
High Plains UWCD No. 1	17,663	17,663	17,663	17,663	17,663	17,663	2	18	32	43	49	52
North Plains GCD	42,865	42,865	42,865	42,865	42,865	42,865	41	69	76	83	88	92
Panhandle GCD	17,175	17,175	17,175	17,175	17,175	17,175	26	29	31	33	35	36
GMA												
Out-of-State	10,131	10,131	10,131	10,131	10,131	10,131	1	4	4	5	5	6
GMA 1	107,584	107,584	107,584	107,584	107,584	107,570	26	42	46	50	53	56
GMA 2	12,478	12,478	12,478	12,478	12,478	12,478	1	11	22	30	36	39
GMA 3	5,492	5,492	5,492	5,492	5,492	5,492	1	1	1	1	1	1
GMA 6	90	90	90	90	90	90	0	1	2	3	4	4
GMA 7	30,950	30,950	30,950	30,950	30,950	30,950	1	5	7	9	10	10

Table B-11. Average drawdown in the lower portion of the Dockum Aquifer resulting from pumping increased to 160 percent of the base of Scenario 2 by decade by county, groundwater conservation district (GCD), and groundwater management area (GMA). Pumping is in acre-feet per year. Drawdown is in feet. UWCD is the abbreviation for Underground Water Conservation District.

Scenario 2: 160 Percent of Base	Pumping						Average Drawdown					
	2010	**2020**	**2030**	**2040**	**2050**	**2060**	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**
County												
Armstrong	7,366	7,366	7,366	7,366	7,366	7,366	36	42	45	48	51	53
Carson	2,332	2,332	2,332	2,332	2,332	2,332	51	52	54	56	57	59
Dallam	21,287	21,287	21,287	21,287	21,287	21,287	53	79	82	85	87	89
Hartley	28,723	28,723	28,723	28,723	28,723	28,723	40	70	79	88	94	100
Moore	10,285	10,285	10,285	10,285	10,285	10,285	36	45	50	55	59	63
Oldham	28,749	28,749	28,749	28,749	28,731	28,731	1	3	5	7	8	10
Potter	13,881	13,881	13,881	13,881	13,881	13,881	15	19	21	23	25	27
Randall	17,856	17,856	17,856	17,856	17,856	17,856	20	41	44	46	48	50
Sherman	1,301	1,301	1,301	1,301	1,301	1,301	88	109	116	121	126	130
GCD												
High Plains UWCD No. 1	21,636	21,636	21,636	21,636	21,636	21,636	3	19	33	44	51	54
North Plains GCD	51,294	51,294	51,294	51,294	51,294	51,294	48	76	83	89	94	98
Panhandle GCD	21,255	21,255	21,255	21,255	21,255	21,255	27	31	33	35	37	39
GMA												
Out-of-State	12,468	12,468	12,468	12,468	12,468	12,468	1	6	7	8	8	8
GMA 1	131,778	131,778	131,778	131,778	131,760	131,760	30	46	50	54	57	59
GMA 2	15,358	15,358	15,358	15,358	15,358	15,358	1	12	22	31	37	39
GMA 3	6,754	6,754	6,754	6,754	6,754	6,754	1	2	2	2	3	3
GMA 6	110	110	110	110	110	110	0	2	3	3	4	5
GMA 7	38,097	38,097	38,097	38,097	38,097	38,097	2	9	12	14	15	16

Table B-12. Average drawdown in the lower portion of the Dockum Aquifer resulting from pumping increased to 190 percent of the base of Scenario 2 by decade by county, groundwater conservation district (GCD), and groundwater management area (GMA). Pumping is in acre-feet per year. Drawdown is in feet. UWCD is the abbreviation for Underground Water Conservation District.

Scenario 2: 190 Percent of Base	**Pumping**						**Average Drawdown**					
	2010	**2020**	**2030**	**2040**	**2050**	**2060**	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**
County												
Armstrong	8,880	8,857	8,857	8,857	8,857	8,857	38	43	47	50	53	55
Carson	817	817	817	817	817	817	38	40	42	45	47	49
Dallam	25,113	25,113	25,113	25,113	25,113	25,113	59	82	85	87	89	91
Hartley	34,337	34,337	34,337	34,337	34,337	34,337	47	78	87	94	101	106
Moore	11,376	11,376	11,376	11,376	11,376	11,376	40	50	55	60	64	68
Oldham	34,502	34,502	34,502	34,479	34,479	34,457	1	4	6	8	10	12
Potter	16,421	16,421	16,421	16,421	16,421	16,421	16	20	22	24	26	28
Randall	21,368	21,368	21,368	21,368	21,368	21,368	24	43	46	48	50	52
Sherman	1,333	1,333	1,333	1,333	1,333	1,333	91	114	121	126	131	136
GCD												
High Plains UWCD No. 1	25,609	25,609	25,609	25,609	25,609	25,609	3	20	35	46	52	55
North Plains GCD	59,886	59,886	59,886	59,886	59,886	59,886	55	82	88	94	98	102
Panhandle GCD	23,345	23,322	23,322	23,322	23,322	23,322	26	30	32	35	37	39
GMA												
Out-of-State	14,806	14,806	14,806	14,806	14,806	14,806	2	8	9	10	11	11
GMA 1	154,145	154,123	154,123	154,101	154,101	154,078	33	49	53	56	60	62
GMA 2	18,239	18,239	18,239	18,239	18,239	18,239	1	13	23	32	37	40
GMA 3	8,016	8,016	8,016	8,016	8,016	8,016	2	3	3	4	4	4
GMA 6	131	131	131	131	131	131	1	2	3	4	5	6
GMA 7	45,244	45,244	45,244	45,244	45,244	45,244	2	12	16	19	20	21

Table B-13. Average drawdown in the upper portion of the Dockum Aquifer resulting from changes to the base pumping of Scenario 1. Results are shown by decade by county, groundwater conservation district (GCD), and groundwater management area (GMA). Note that pumping is not shown because all pumping occurs in the lower portion of the Dockum Aquifer in the model. Drawdown is in feet. UWCD is the abbreviation for Underground Water Conservation District. Negative values for average drawdown indicate an average rise in water levels.

Scenario 1: Upper Dockum	40 Percent of Base Pumping						60 Percent of Base Pumping						80 Percent of Base Pumping					
	2010	**2020**	**2030**	**2040**	**2050**	**2060**	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**
County																		
Randall	0	2	4	7	10	13	0	2	5	8	12	16	0	3	6	10	14	18
GCD																		
High Plains UWCD No. 1	1	16	29	37	41	41	1	17	30	38	41	42	1	17	30	38	42	42
GMA																		
Out-of-State	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1
GMA 1	0	2	4	7	10	13	0	2	5	8	12	16	0	3	6	10	14	18
GMA 2	1	15	26	34	39	40	1	15	27	35	39	41	1	15	27	35	39	41
GMA 3	0	-1	-1	-1	-1	-1	0	0	-1	-1	0	0	0	0	0	0	0	0
GMA 7	0	5	9	12	14	16	0	5	9	12	15	16	0	5	9	12	15	16

Table B-13. Continued.

Scenario 1: Upper Dockum	130 Percent of Base Pumping						160 Percent of Base Pumping						190 Percent of Base Pumping					
	2010	**2020**	**2030**	**2040**	**2050**	**2060**	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**
County																		
Randall	1	5	9	14	18	21	1	6	11	16	19	22	1	8	13	17	20	23
GCD																		
High Plains UWCD No. 1	2	17	31	39	43	44	2	18	31	40	44	45	2	18	32	40	44	46
GMA																		
Out-of-State	0	1	1	1	1	1	0	1	2	2	2	2	0	2	2	2	3	3
GMA 1	1	5	9	14	18	21	1	6	11	16	19	22	1	8	13	17	20	23
GMA 2	1	16	27	36	40	42	2	16	28	36	41	43	2	16	28	36	41	43
GMA 3	0	1	2	2	2	2	1	3	3	3	3	4	1	4	4	5	5	5
GMA 7	0	5	9	13	15	16	0	5	9	13	15	16	0	5	9	13	15	17

Table B-14. Average drawdown in the upper portion of the Dockum Aquifer resulting from changes to the base pumping of Scenario 2. Results are shown by decade by county, groundwater conservation district (GCD), and groundwater management area (GMA). Note that pumping is not shown because all pumping occurs in the lower portion of the Dockum Aquifer in the model. Drawdown is in feet. UWCD is the abbreviation for Underground Water Conservation District. Negative values for average drawdown indicate an average rise in water levels.

Scenario 2: Upper Dockum	40 Percent of Base Pumping						60 Percent of Base Pumping						80 percent of Base Pumping					
	2010	**2020**	**2030**	**2040**	**2050**	**2060**	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**
County																		
Randall	1	7	9	11	12	13	2	10	13	14	15	16	3	13	15	16	17	18
GCD																		
High Plains UWCD No. 1	1	16	29	37	41	41	1	17	30	38	41	42	1	17	30	38	42	42
GMA																		
Out-of-State	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1
GMA 1	1	7	9	11	12	13	2	10	13	14	15	16	3	13	15	16	17	18
GMA 2	1	15	27	35	39	40	1	15	27	35	39	41	1	15	27	35	39	41
GMA 3	0	-1	-1	-1	-1	-1	0	0	-1	-1	0	0	0	0	0	0	0	0
GMA 7	0	5	9	12	14	16	0	5	9	12	15	16	0	5	9	12	15	16

Table B-14. Continued.

Scenario 2: Upper Dockum	130 Percent of Base Pumping						160 Percent of Base Pumping						190 Percent of Base Pumping					
	2010	**2020**	**2030**	**2040**	**2050**	**2060**	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**
County																		
Randall	5	17	19	20	21	22	7	19	20	21	22	23	8	20	21	22	23	24
GCD																		
High Plains UWCD No. 1	2	17	31	39	43	44	2	18	31	40	44	45	2	18	32	40	44	46
GMA																		
Out-of-State	0	1	1	1	1	1	0	1	2	2	2	2	0	2	2	2	3	3
GMA 1	5	17	19	20	21	22	7	19	20	21	22	23	8	20	21	22	23	24
GMA 2	1	16	27	36	40	42	2	16	28	36	41	43	2	16	28	36	41	43
GMA 3	0	1	2	2	2	2	1	3	3	3	3	4	1	4	4	5	5	5
GMA 7	0	5	9	13	15	16	0	5	9	13	15	16	0	5	9	13	15	17

Appendix C

Water budgets for each stress period of the predictive model run

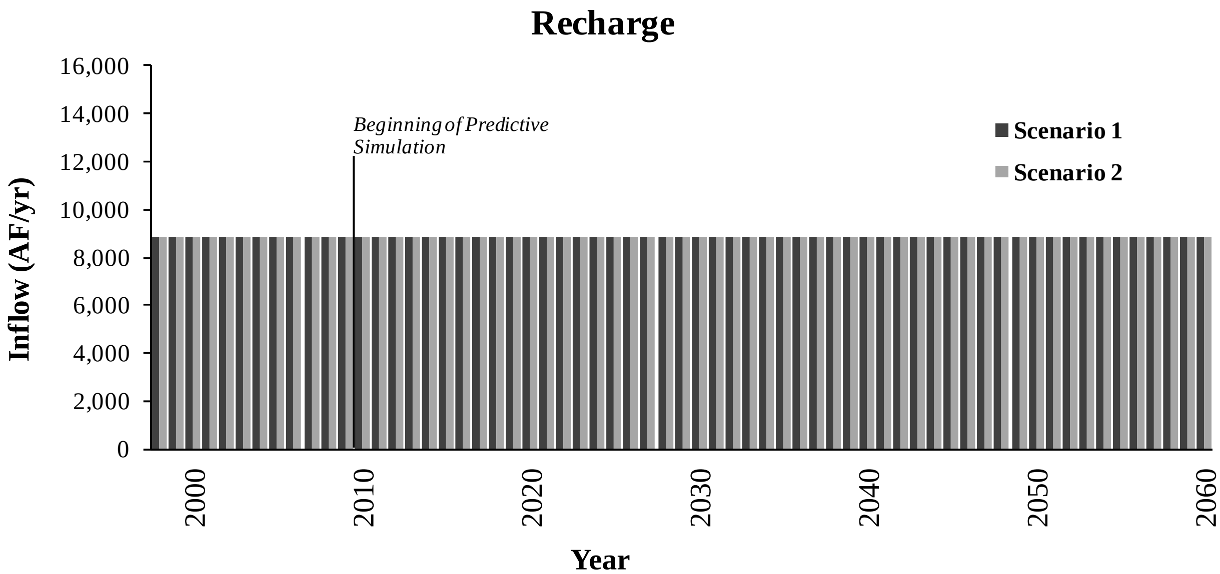

Figure C-1. Net recharge to the Dockum Aquifer by year in the groundwater model for Groundwater Management Area 1. AF/yr is acre-feet per year.

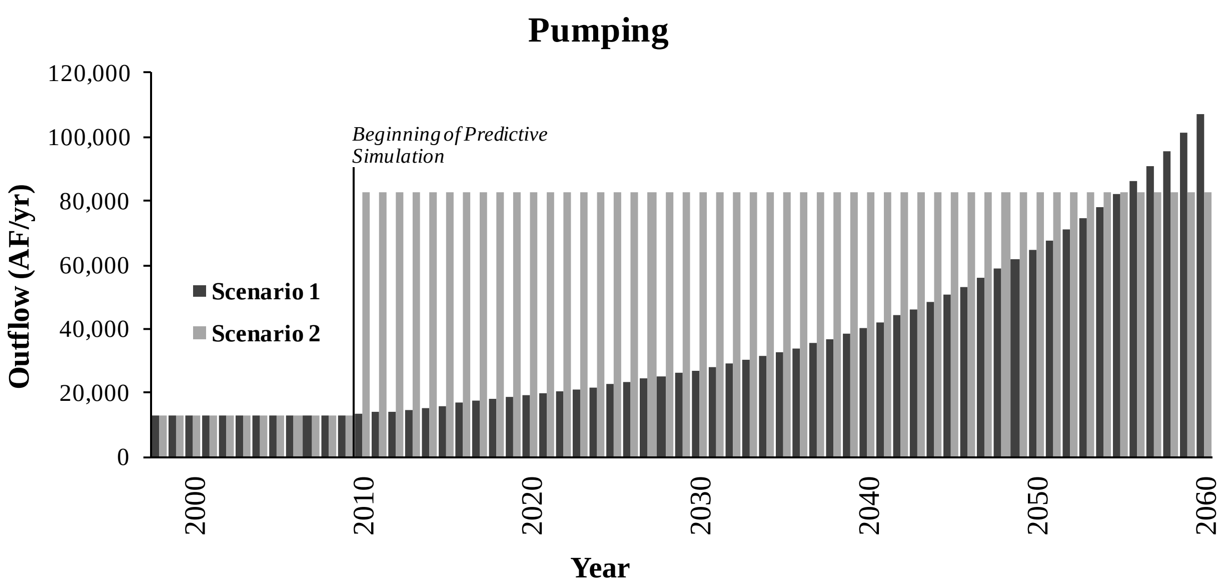

Figure C-2. Pumping output from the Dockum Aquifer by year in the groundwater model for Groundwater Management Area 1. AF/yr is acre-feet per year.

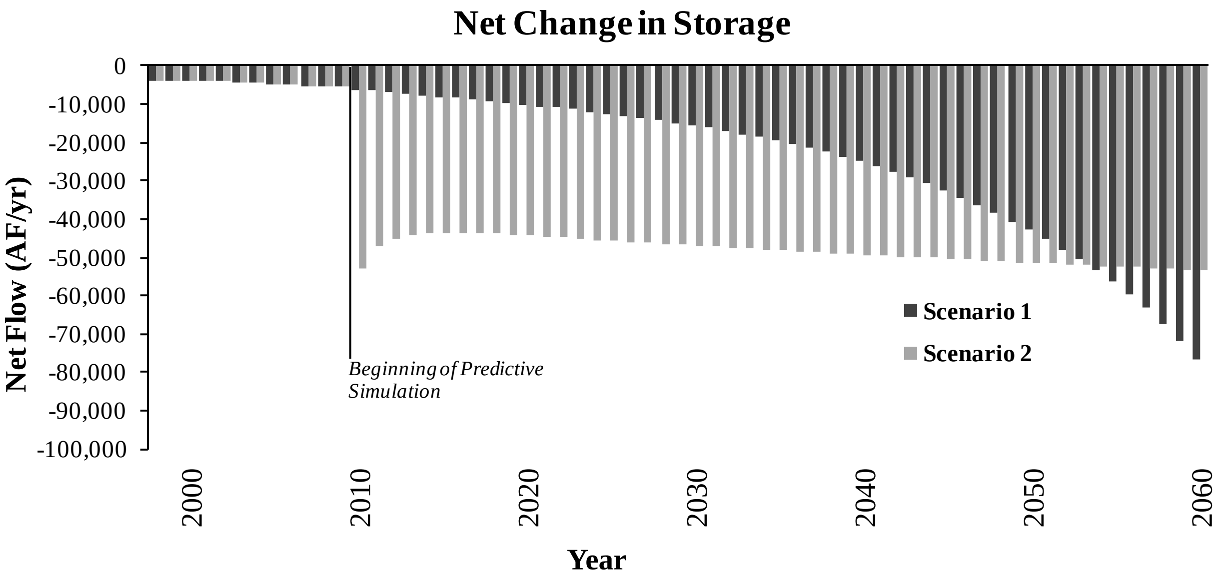

Figure C-3. Net change in storage (the volume of water stored in the aquifer) by year in the lower portion of the Dockum Aquifer for Groundwater Management Area 1. Negative values for the net change in storage indicate water level declines. AF/yr is acre-feet per year.

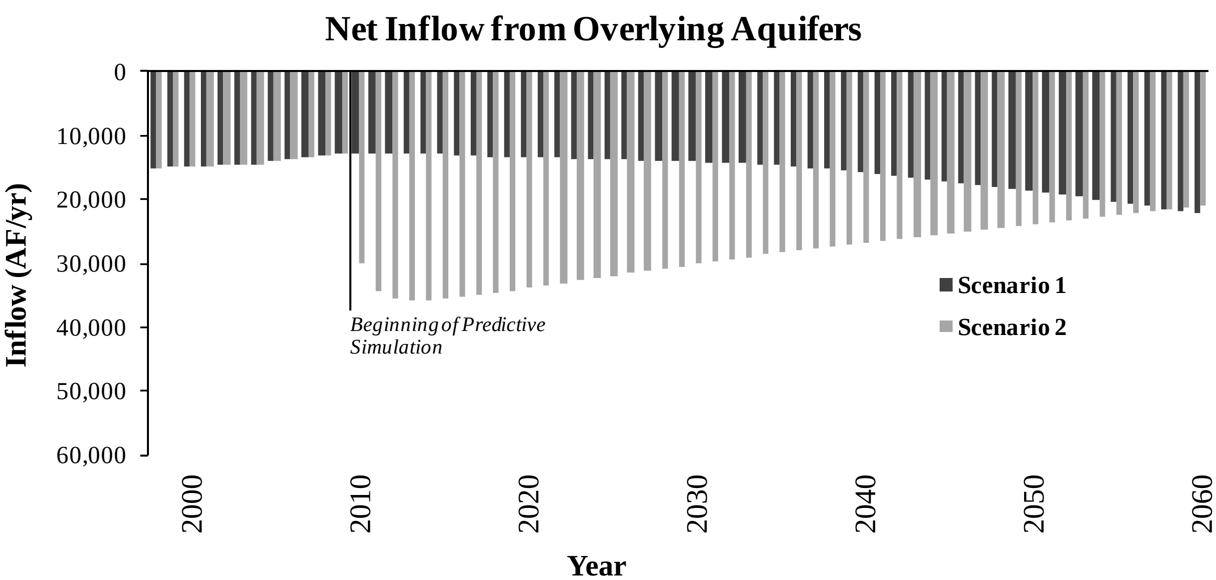

Figure C-4. Net inflow from overlying aquifers to the lower portion of the Dockum Aquifer in Groundwater Management Area 1. AF/yr is acre-feet per year.

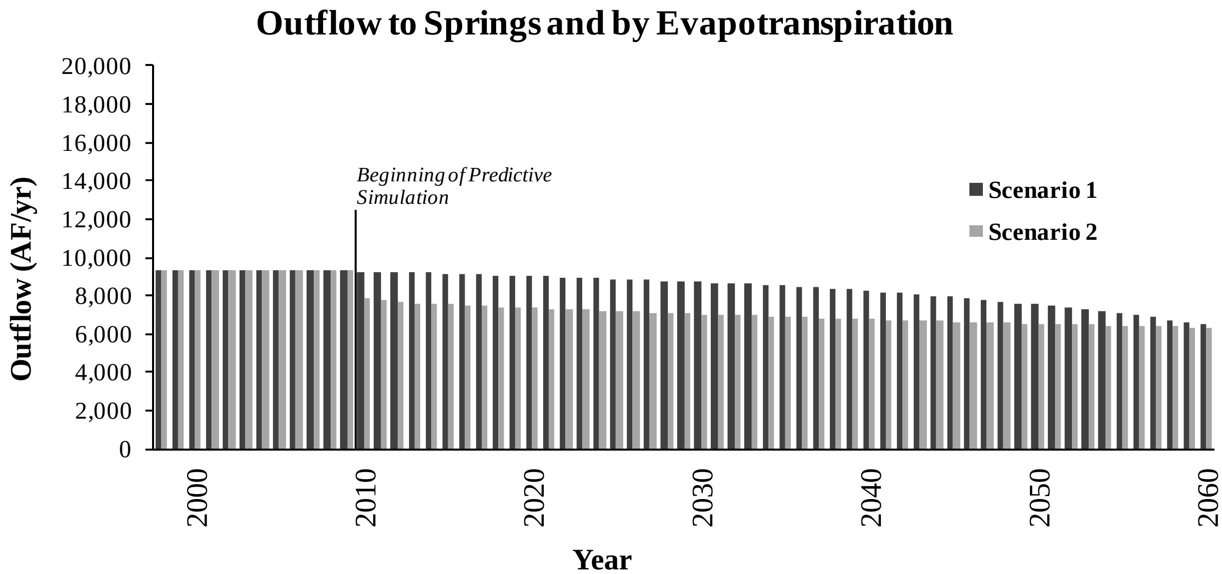

Figure C-5. Outflow from the Dockum Aquifer in Groundwater Management Area 1 to springs and by evapotranspiration. AF/yr is acre-feet per year.

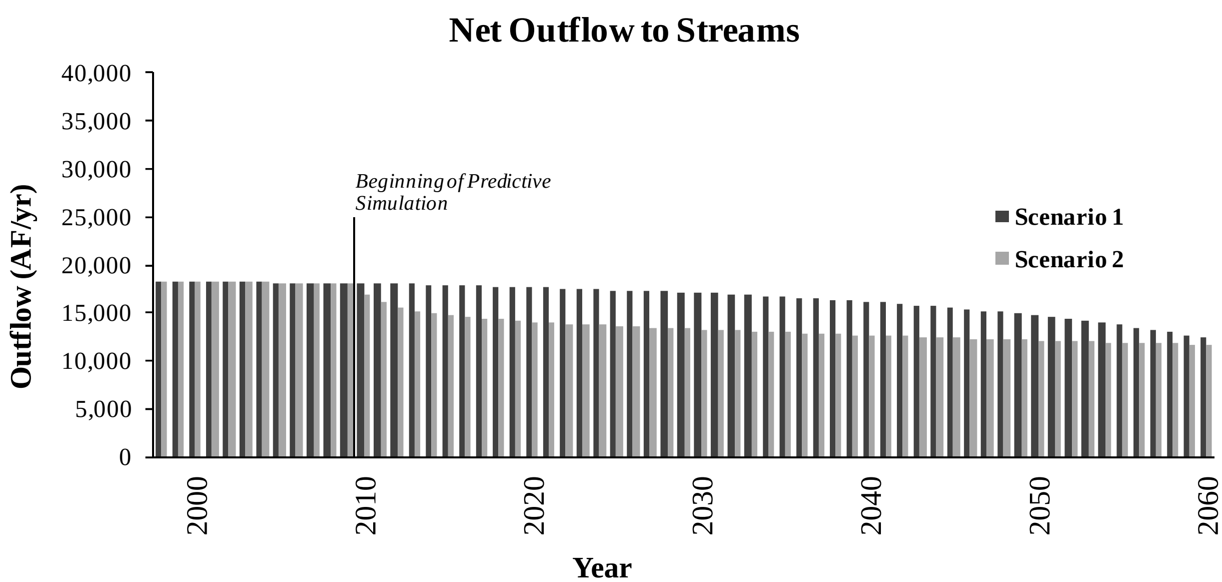

Figure C-6. Net outflow to streams from the Dockum Aquifer in Groundwater Management Area 1. AF/yr is acre-feet per year.

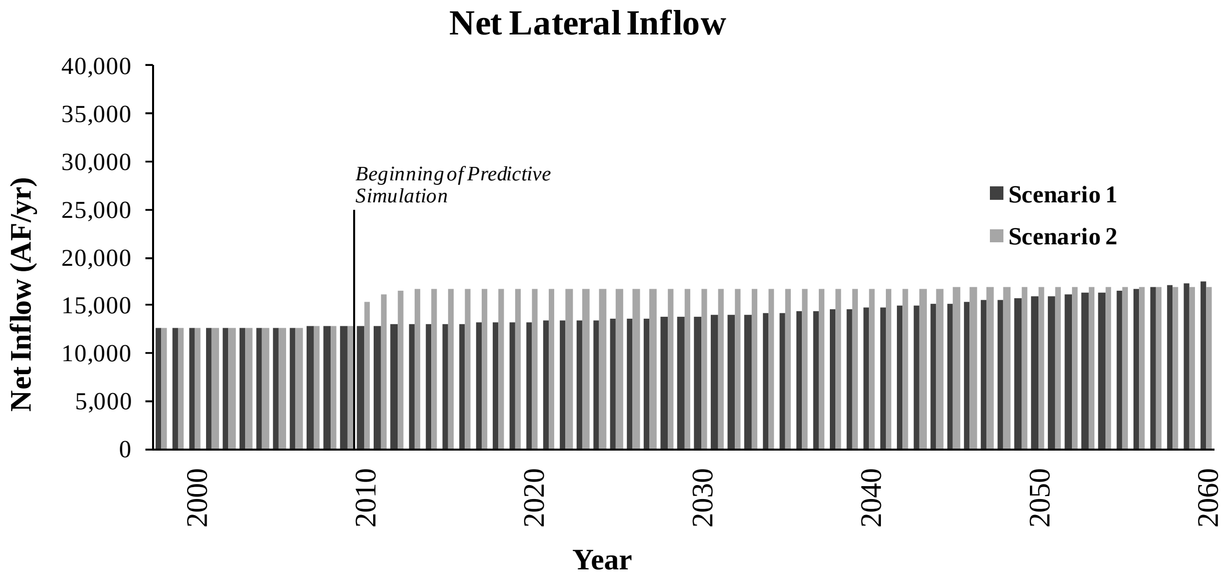

Figure C-7. Net lateral inflow to the Dockum Aquifer in Groundwater Management Area 1 from adjacent areas. AF/yr is acre-feet per year.

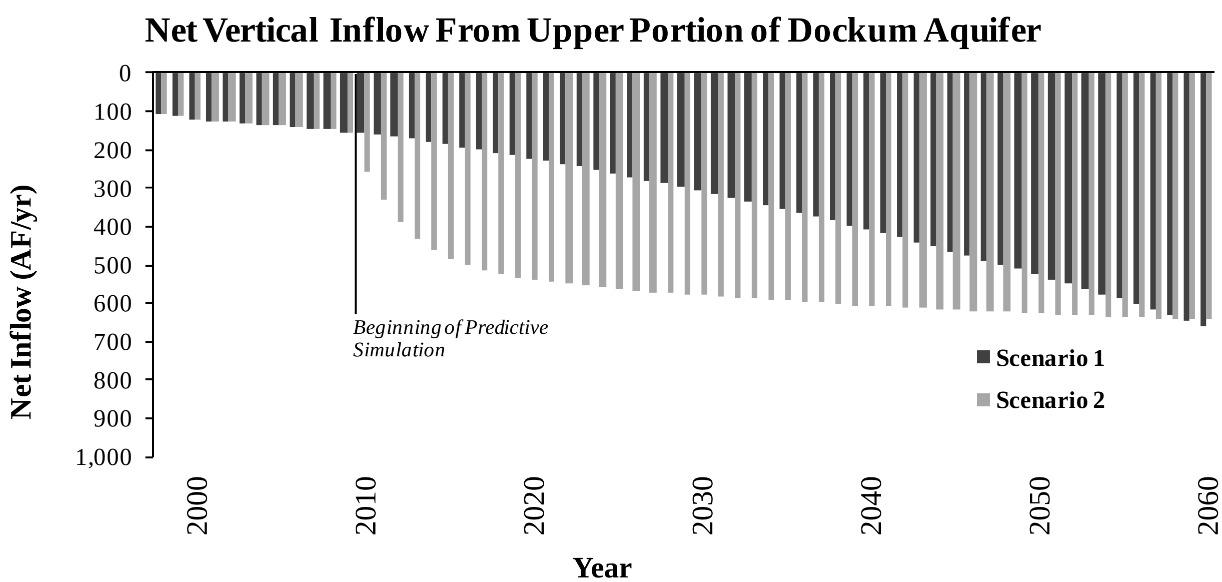

Figure C-8. Net vertical flow from the upper portion of the Dockum Aquifer to the lower portion of the Dockum Aquifer in Groundwater Management Area 1. AF/yr is acre-feet per year.

Appendix D

Water budget tables by county, groundwater conservation district, and groundwater management area for 2060 in the predictive model run

Table D-1. Water budgets by county in Groundwater Management Area 1 for the last stress period of the groundwater model run (2060) for Scenario 1. All values are reported in acre-feet per year.

	Armstrong		Carson		Dallam		Hartley		Moore		Oldham		Potter		Randall		Sherman	
	Upper	**Lower**	**Upper**	**Lower**	**Upper**	**Lower**	**Upper**	**Lower**	**Upper**	**Lower**	**Upper**	**Lower**	**Upper**	**Lower**	**Upper**	**Lower**	**Upper**	**Lower**
Inflow																		
Overlying Aquifers	0	716	0	232	0	2,213	0	7,079	0	1,996	0	4,931	0	2,088	510	5,838	0	710
Recharge	0	658	0	0	0	0	0	237	0	28	0	5,399	0	2,298	0	221	0	0
Stream Interaction	0	37	0	0	0	0	0	0	0	94	0	2,253	0	1,362	0	532	0	0
Vertical Leakage Upper	-	0	-	0	-	0	-	0	-	0	-	0	-	0	-	662	-	0
Vertical Leakage Lower	0	-	0	-	0	-	0	-	0	-	0	-	0	-	0	-	0	-
Lateral Flow	0	152	0	17	0	3,924	0	14,770	0	1,854	0	5,459	0	1,122	45	1,884	0	695
Total Inflow	*0*	*1,563*	*0*	*249*	*0*	*6,137*	*0*	*22,086*	*0*	*3,972*	*0*	*18,042*	*0*	*6,870*	*555*	*9,137*	*0*	*1,405*
Outflow																		
Wells	0	5,810	0	1,968	0	17,331	0	22,955	0	9,164	0	22,839	0	11,169	0	14,248	0	1,693
Springs and Evapotranspiration	0	517	0	0	0	0	0	1,119	0	0	0	3,247	0	763	0	844	0	0
Overlying Aquifers	0	62	0	0	0	74	0	3,160	0	95	0	29	0	60	6	65	0	0
Stream Interaction	0	245	0	0	0	0	0	968	0	581	0	10,176	0	1,936	0	2,724	0	0
Vertical Leakage Upper	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Vertical Leakage Lower	0	-	0	-	0	-	0	-	0	-	0	-	0	-	662	-	0	-
Lateral Flow	0	497	0	43	0	2,641	0	5,804	0	211	0	1,510	0	675	19	747	0	325
Total Outflow	*0*	*7,131*	*0*	*2,011*	*0*	*20,046*	*0*	*34,006*	*0*	*10,051*	*0*	*37,801*	*0*	*14,603*	*687*	*18,628*	*0*	*2,018*
Inflow - Outflow	**0**	**-5,568**	**0**	**-1,762**	**0**	**-13,909**	**0**	**-11,920**	**0**	**-6,079**	**0**	**-19,759**	**0**	**-7,733**	**-132**	**-9,491**	**0**	**-613**
Storage Change	**0**	**-5,566**	**0**	**-1,761**	**0**	**-13,903**	**0**	**-11,918**	**0**	**-6,077**	**0**	**-19,753**	**0**	**-7,733**	**-132**	**-9,487**	**0**	**-613**
Model Error	**0**	**-2**	**0**	**-1**	**0**	**-6**	**0**	**-2**	**0**	**-2**	**0**	**-6**	**0**	**0**	**0**	**-4**	**0**	**0**
Model Error (percent)	**0.00**	**0.03**	**0.00**	**0.05**	**0.00**	**0.03**	**0.00**	**0.01**	**0.00**	**0.02**	**0.00**	**0.02**	**0.00**	**0.00**	**0.00**	**0.02**	**0.00**	**0.00**

Table D-2. Water budgets by groundwater conservation district (GCD) in Groundwater Management Area 1 for the last stress period of the groundwater model run (2060) for Scenario 1. All values are reported in acre-feet per year. UWCD is Underground Water Conservation District.

	High Plains UWCD No. 1		**North Plains GCD**		**Panhandle GCD**	
	Upper	**Lower**	**Upper**	**Lower**	**Upper**	**Lower**
Inflow						
Overlying Aquifers	9,096	4,013	0	9,952	0	2,562
Recharge	1	423	0	59	0	2,663
Stream Interaction	0	459	0	0	0	1,293
Vertical Leakage Upper	-	10,395	-	0	-	0
Vertical Leakage Lower	4,199	-	0	-	0	-
Lateral Flow	2,872	9,249	0	18,106	0	1,780
Total Inflow	*16,168*	*24,539*	*0*	*28,117*	*0*	*8,298*
Outflow						
Wells	0	15,682	0	42,865	0	17,086
Springs and Evapotranspiration	0	2,385	0	0	0	1,229
Overlying Aquifers	9,135	1,171	0	3,312	0	116
Stream Interaction	0	205	0	0	0	2,181
Vertical Leakage Upper	0	4,199	0	0	0	0
Vertical Leakage Lower	10,395	-	0	-	0	-
Lateral Flow	1,120	12,349	0	3,180	0	1,267
Total Outflow	*20,650*	*35,991*	*0*	*49,357*	*0*	*21,879*
Inflow - Outflow	**-4,482**	**-11,452**	**0**	**-21,240**	**0**	**-13,581**
Storage Change	**-4,480**	**-11,447**	**0**	**-21,234**	**0**	**-13,579**
Model Error	**-2**	**-5**	**0**	**-6**	**0**	**-2**
Model Error (percent)	**0.01**	**0.01**	**0.00**	**0.01**	**0.00**	**0.01**

Table D-3. Water budgets by groundwater management area (GMA) for the last stress period of the groundwater model run (2060) for Scenario 1. All values are reported in acre-feet per year.

	Out-of-State		GMA 1		GMA 2		GMA 3		GMA 6		GMA 7	
	Upper	**Lower**	**Upper**	**Lower**	**Upper**	**Lower**	**Upper**	**Lower**	**Upper**	**Lower**	**Upper**	**Lower**
Inflow												
Overlying Aquifers	34,181	19,726	510	25,803	15,885	3,505	1,064	9,499	0	341	5,977	11,690
Recharge	44	1,142	0	8,834	26	21,783	0	0	0	7,974	0	47,369
Stream Interaction	0	78	0	4,279	535	20,406	0	0	0	1,022	0	10,776
Vertical Leakage Upper	-	14,768	-	662	-	20,597	-	1,268	-	0	-	5,965
Vertical Leakage Lower	4,434	-	0	-	8,187	-	280	-	0	-	908	-
Lateral Flow	23	1,032	45	18,898	2,329	13,025	153	7,900	0	2,983	106	15,532
Total Inflow	*38,682*	*36,746*	*555*	*58,476*	*26,962*	*79,316*	*1,497*	*18,667*	*0*	*12,320*	*6,991*	*91,332*
Outflow												
Wells	0	7,793	0	107,175	0	9,598	0	4,231	0	69	0	23,802
Springs and Evapotranspiration	0	2,107	0	6,491	0	26,506	0	0	0	3,541	0	19,166
Overlying Aquifers	21,994	5,473	6	3,544	17,505	1,269	324	12,883	0	27	1,269	1,128
Stream Interaction	0	1,941	0	16,628	0	40,262	0	0	0	7,248	0	37,498
Vertical Leakage Upper	0	4,434	0	0	0	8,187	0	280	0	0	0	908
Vertical Leakage Lower	14,768	-	662	-	20,597	-	1,268	-	0	-	5,965	-
Lateral Flow	2,292	20,258	19	1,464	251	17,003	0	1,505	0	1,925	95	17,215
Total Outflow	*39,054*	*42,006*	*687*	*135,302*	*38,353*	*102,825*	*1,592*	*18,899*	*0*	*12,810*	*7,329*	*99,717*
Inflow - Outflow	**-372**	**-5,260**	**-132**	**-76,826**	**-11,391**	**-23,509**	**-95**	**-232**	**0**	**-490**	**-338**	**-8,385**
Storage Change	**-363**	**-5,254**	**-132**	**-76,806**	**-11,386**	**-23,499**	**-95**	**-231**	**0**	**-491**	**-337**	**-8,385**
Model Error	**-9**	**-6**	**0**	**-20**	**-5**	**-10**	**0**	**-1**	**0**	**1**	**-1**	**0**
Model Error (percent)	**0.02**	**0.01**	**0.00**	**0.01**	**0.01**	**0.01**	**0.00**	**0.01**	**0.00**	**0.01**	**0.01**	**0.00**

Table D-4. Water budgets by county in Groundwater Management Area 1 for the last stress period of the groundwater model run (2060) for Scenario 2. All values are reported in acre-feet per year.

	Armstrong		Carson		Dallam		Hartley		Moore		Oldham		Potter		Randall		Sherman	
	Upper	**Lower**	**Upper**	**Lower**	**Upper**	**Lower**	**Upper**	**Lower**	**Upper**	**Lower**	**Upper**	**Lower**	**Upper**	**Lower**	**Upper**	**Lower**	**Upper**	**Lower**
Inflow																		
Overlying Aquifers	0	776	0	257	0	2,133	0	6,500	0	1,994	0	5,126	0	2,092	516	5,796	0	666
Recharge	0	658	0	0	0	0	0	237	0	28	0	5,399	0	2,294	0	221	0	0
Stream Interaction	0	48	0	0	0	0	0	0	0	97	0	2,311	0	1,315	0	527	0	0
Vertical Leakage Upper	-	0	-	0	-	0	-	0	-	0	-	0	-	0	-	642	-	0
Vertical Leakage Lower	0	-	0	-	0	-	0	-	0	-	0	-	0	-	0	-	0	-
Lateral Flow	0	164	0	17	0	3,872	0	14,061	0	2,169	0	5,435	0	1,064	43	1,737	0	670
Total Inflow	*0*	*1,646*	*0*	*274*	*0*	*6,005*	*0*	*20,798*	*0*	*4,288*	*0*	*18,271*	*0*	*6,765*	*559*	*8,923*	*0*	*1,336*
Outflow																		
Wells	0	4,338	0	1,494	0	13,586	0	17,495	0	8,103	0	17,245	0	8,486	0	10,832	0	1,382
Springs and Evapotranspiration	0	511	0	0	0	0	0	963	0	0	0	3,190	0	805	0	844	0	0
Overlying Aquifers	0	60	0	0	0	101	0	3,778	0	102	0	32	0	67	6	95	0	0
Stream Interaction	0	244	0	0	0	0	0	905	0	576	0	9,706	0	1,875	0	2,656	0	0
Vertical Leakage Upper	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Vertical Leakage Lower	0	-	0	-	0	-	0	-	0	-	0	-	0	-	642	-	0	-
Lateral Flow	0	479	0	43	0	2,393	0	6,077	0	183	0	1,424	0	603	17	673	0	349
Total Outflow	*0*	*5,632*	*0*	*1,537*	*0*	*16,080*	*0*	*29,218*	*0*	*8,964*	*0*	*31,597*	*0*	*11,836*	*665*	*15,100*	*0*	*1,731*
Inflow - Outflow	**0**	**-3,986**	**0**	**-1,263**	**0**	**-10,075**	**0**	**-8,420**	**0**	**-4,676**	**0**	**-13,326**	**0**	**-5,071**	**-106**	**-6,177**	**0**	**-395**
Storage Change	**0**	**-3,985**	**0**	**-1,262**	**0**	**-10,069**	**0**	**-8,418**	**0**	**-4,676**	**0**	**-13,319**	**0**	**-5,071**	**-107**	**-6,175**	**0**	**-395**
Model Error	**0**	**-1**	**0**	**-1**	**0**	**-6**	**0**	**-2**	**0**	**0**	**0**	**-7**	**0**	**0**	**1**	**-2**	**0**	**0**
Model Error (percent)	**0.00**	**0.02**	**0.00**	**0.07**	**0.00**	**0.04**	**0.00**	**0.01**	**0.00**	**0.00**	**0.00**	**0.02**	**0.00**	**0.00**	**0.15**	**0.01**	**0.00**	**0.00**

Table D-5. Water budgets by groundwater conservation district (GCD) in Groundwater Management Area 1 for the last stress period of the groundwater model run (2060) for Scenario 2. All values are reported in acre-feet per year. UWCD is Underground Water Conservation District.

	High Plains UWCD No. 1		North Plains GCD		Panhandle GCD	
	Upper	**Lower**	**Upper**	**Lower**	**Upper**	**Lower**
Inflow						
Overlying Aquifers	9,108	3,889	0	9,266	0	2,635
Recharge	1	423	0	59	0	2,659
Stream Interaction	0	459	0	0	0	1,257
Vertical Leakage Upper	-	10,413	-	0	-	0
Vertical Leakage Lower	4,189	-	0	-	0	-
Lateral Flow	2,870	8,992	0	17,404	0	1,692
Total Inflow	*16,168*	*24,176*	*0*	*26,729*	*0*	*8,243*
Outflow						
Wells	0	13,690	0	34,207	0	12,894
Springs and Evapotranspiration	0	2,381	0	0	0	1,268
Overlying Aquifers	9,123	1,203	0	3,964	0	124
Stream Interaction	0	191	0	0	0	2,119
Vertical Leakage Upper	0	4,189	0	0	0	0
Vertical Leakage Lower	10,413	-	0	-	0	-
Lateral Flow	1,122	12,346	0	3,221	0	1,126
Total Outflow	*20,658*	*34,000*	*0*	*41,392*	*0*	*17,531*
Inflow - Outflow	**-4,490**	**-9,824**	**0**	**-14,663**	**0**	**-9,288**
Storage Change	**-4,488**	**-9,821**	**0**	**-14,658**	**0**	**-9,285**
Model Error	**-2**	**-3**	**0**	**-5**	**0**	**-3**
Model Error (percent)	**0.01**	**0.01**	**0.00**	**0.01**	**0.00**	**0.02**

Table D-6. Water budgets by groundwater management area (GMA) for the last stress period of the groundwater model run (2060) for Scenario 2. All values are reported in acre-feet per year.

	Out-of-State		GMA 1		GMA 2		GMA 3		GMA 6		GMA 7	
	Upper	**Lower**	**Upper**	**Lower**	**Upper**	**Lower**	**Upper**	**Lower**	**Upper**	**Lower**	**Upper**	**Lower**
Inflow												
Overlying Aquifers	34,181	19,809	516	25,339	15,900	3,513	1,064	9,499	0	341	5,977	11,690
Recharge	44	1,142	0	8,830	26	21,783	0	0	0	7,974	0	47,369
Stream Interaction	0	78	0	4,297	535	20,408	0	0	0	1,022	0	10,776
Vertical Leakage Upper	-	14,768	-	642	-	20,614	-	1,267	-	0	-	5,965
Vertical Leakage Lower	4,434	-	0	-	8,171	-	280	-	0	-	908	-
Lateral Flow	23	1,021	43	18,322	2,328	12,917	153	7,900	0	2,983	106	15,532
Total Inflow	*38,682*	*36,818*	*559*	*57,430*	*26,960*	*79,235*	*1,497*	*18,666*	*0*	*12,320*	*6,991*	*91,332*
Outflow												
Wells	0	7,793	0	82,961	0	9,598	0	4,231	0	69	0	23,802
Springs and Evapotranspiration	0	2,107	0	6,313	0	26,506	0	0	0	3,541	0	19,166
Overlying Aquifers	21,994	5,473	6	4,235	17,487	1,269	324	12,883	0	27	1,269	1,128
Stream Interaction	0	1,931	0	15,962	0	40,257	0	0	0	7,248	0	37,498
Vertical Leakage Upper	0	4,434	0	0	0	8,171	0	280	0	0	0	908
Vertical Leakage Lower	14,768	-	642	-	20,614	-	1,267	-	0	-	5,965	-
Lateral Flow	2,292	19,699	17	1,346	250	16,986	0	1,505	0	1,925	95	17,215
Total Outflow	*39,054*	*41,437*	*665*	*110,817*	*38,351*	*102,787*	*1,591*	*18,899*	*0*	*12,810*	*7,329*	*99,717*
Inflow - Outflow	**-372**	**-4,619**	**-106**	**-53,387**	**-11,391**	**-23,552**	**-94**	**-233**	**0**	**-490**	**-338**	**-8,385**
Storage Change	**-363**	**-4,614**	**-107**	**-53,366**	**-11,386**	**-23,542**	**-95**	**-231**	**0**	**-491**	**-337**	**-8,385**
Model Error	**-9**	**-5**	**1**	**-21**	**-5**	**-10**	**1**	**-2**	**0**	**1**	**-1**	**0**
Model Error (percent)	**0.02**	**0.01**	**0.15**	**0.02**	**0.01**	**0.01**	**0.06**	**0.01**	**0.00**	**0.01**	**0.01**	**0.00**