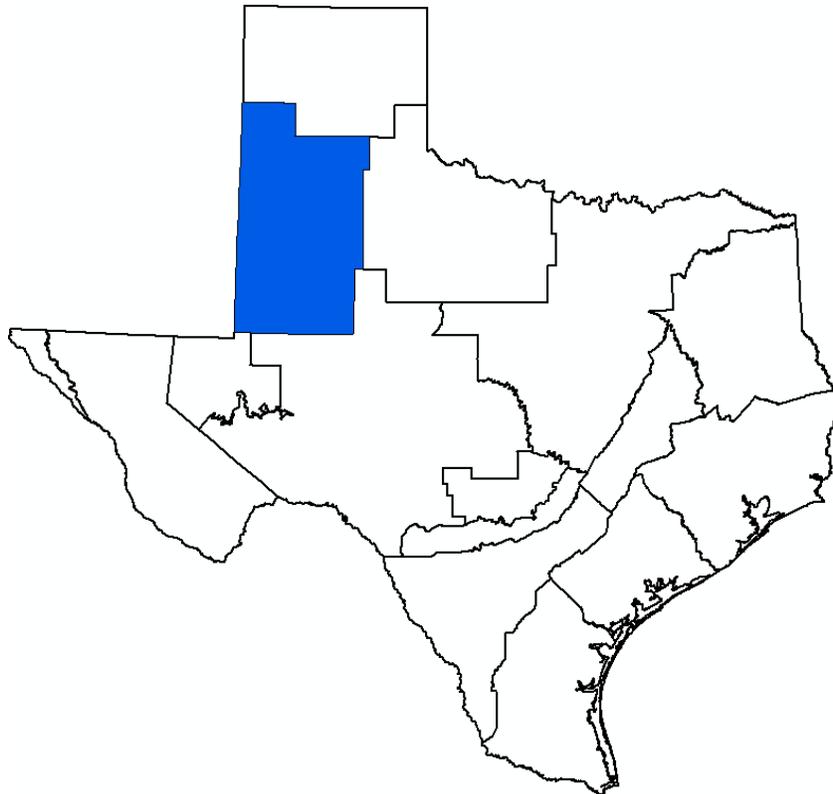


GMA 2 Technical Memorandum 20-01 (Final)

**Joint Planning Simulations with the High Plains Aquifer System
Groundwater Availability Model:
Updated Dockum Aquifer Pumping (Scenarios 16 to 21)**



Prepared for:
Groundwater Management Area 2

Prepared by:
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August 26, 2021

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Geoscientist and Engineering Seal

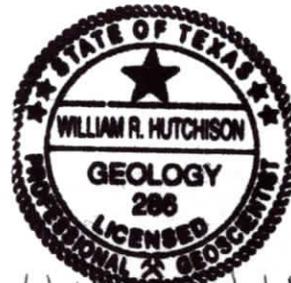
This report documents the work and supervision of work of the following licensed Texas Professional Geoscientist and licensed Texas Professional Engineers:

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Dr. Hutchison completed the analyses and model simulations described in this report, and was the principal author of the final report.



William R Hutchison
8/26/2021



William R Hutchison
8/26/2021

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Appendices

A – Source Code for *CombineDockumWells.exe*

B – Source Code for *ScenWEL.exe*

C – Source Code for *getdd.exe*

D – Source Code for *getpump.exe*

E – Decadal Summaries of Average Drawdown and Pumping - Ogallala-ETHP Aquifers (County)

F – Decadal Summaries of Average Drawdown and Pumping - Dockum Aquifer (County)

G – Decadal Summaries of Average Drawdown and Pumping - Ogallala-ETHP Aquifers (GCD)

H – Decadal Summaries of Average Drawdown and Pumping - Dockum Aquifer (GCD)

1.0 Introduction and Background

In 2016, the groundwater conservation districts in Groundwater Management Area 2 adopted desired future conditions (DFCs) that were based, in part, on a predictive simulation using the High Plains Aquifer System (HPAS) Groundwater Availability Model (GAM). The HPAS model is documented in Deeds and Jigmond (2015). Specifically, the simulation known as Scenario 16, documented in Hutchison (2016), was used to quantify future drawdowns (which were the bases for the DFCs) and future groundwater pumping. The pumping from the simulation were the bases for the Modeled Available Groundwater (MAG) calculated by the Texas Water Development Board (TWDB). Based on guidance from TWDB at the time, the simulation period of Scenario 16 was 2013 to 2070.

On May 19, 2020, the groundwater conservation districts in Groundwater Management Area 2 reviewed an updated simulation based on Scenario 16 that was extended to include the years 2071 to 2080 to conform with updated guidance from TWDB. Thus, the updated simulation period was 2013 to 2080.

The updated simulation was necessary because, as discussed in Hutchison (2016), as groundwater elevations declines in the Ogallala Aquifer, saturated thickness is reduced, and pumping rates in wells will be reduced. The HPAS GAM simulates this reduction in pumping rates due to the physics of groundwater flow to wells as documented in Niswonger and others (2011). Thus, the amount of pumping in the input file can be considered a “request” and the actual final pumping for each well is an output of the model simulation. Because the simulation period was extended ten years, it was not necessary to make any modifications to the input pumping of the Ogallala and Edwards-Trinity (High Plains) which are simulated in layers 1 and 2 of the model. The only modifications to the input files were related to the specifications of the simulation period.

During the May 19, 2020 GMA 2 meeting, representatives from some districts requested additional simulations where the Dockum Aquifer pumping in specific counties was increased. This required the modification of the input pumping to layers 3 and 4 of the model in those counties. Well data and pumping modifications were provided by Amy Bush of RMBJ Geo, a consultant for several of the groundwater conservation district in GMA 2, and by Jacob Hernandez, General Manager for Mesa UWCD.

This Technical Memorandum documents the extended Scenario 16 simulation and the updated simulations (named Scenarios 17 to 21), including the alternative modifications to the Dockum Aquifer pumping. The modifications to the WEL input file are documented, and the results to the extended simulation for all aquifers are documented.

2.0 Additions to the 2016 Scenario 16 WEL File Cells

The objective of this section of the Technical Memorandum is to document the pumping cells already in the 2016 Scenario 16 WEL file in Dawson, Gaines, Howard, and Martin counties and document the additional wells identified by district-provided data. Ultimately, to the extent that the district-provided wells are already accounted for in the HPAS file, they should not be duplicated in an updated simulation.

2.1 2016 Scenario 16 WEL File

The pumping input file from Scenario 16 (Hutchison, 2016) is named *scen16.wel* with a file date of 2/28/2016. It specifies pumping from 94,822 wells as follows:

- Layer 1 (Ogallala Aquifer): 92,727 wells
- Layer 2 (Edwards-Trinity (High Plains) Aquifer): 849 wells
- Layer 3 (Upper Dockum Aquifer): 53 wells
- Layer 4 (Lower Dockum): 1,193 wells

The Scenario 16 included specification of pumping for these wells for the first stress period. Pumping for stress periods 2 to 58 was specified with a -1 for each subsequent stress period, which means that the pumping from stress period 1 was unchanged.

2.2 Extended Scenario 16 Simulation Modifications

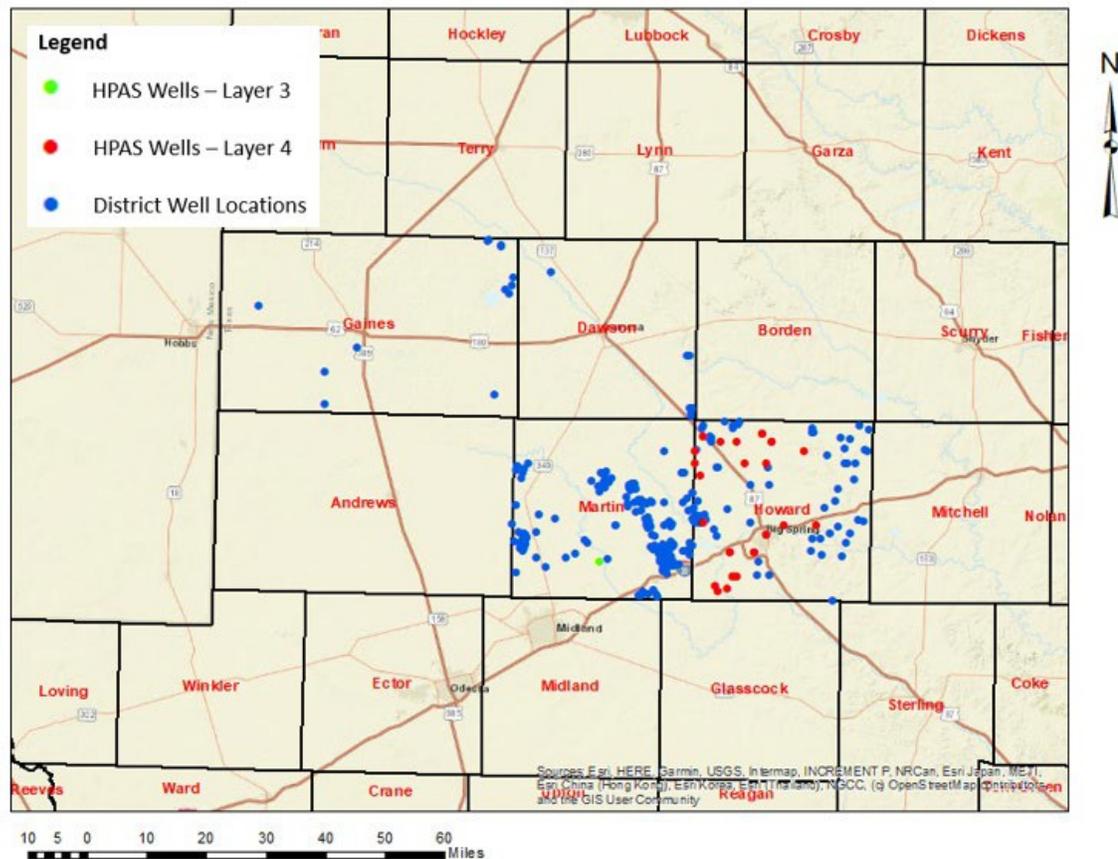
Because the preliminary simulation extended the 2016 Scenario 16 simulation an additional 10 years, the only modification was to add additional years (i.e. 10 entries of “-1”) at the end of the input file. The modified file was named *scen16-2080.wel*, with a file date of May 6, 2020.

2.3 Removal of Wells with Zero Pumping

The WEL input file from Scenario 16 was exported into an Excel spreadsheet named *AllLayers.xlsx*. The wells were sorted by layer. Wells in layers 1 and 2 were saved to the file *Layers1and2.csv*. Wells with zero pumping (762) were deleted, which left a total of 93,449 wells in the upper two layers. Wells in layers 3 and 4 were saved to the file *Layers3and4.csv*. Wells with zero pumping (654) were deleted, which left a total of 1,137 wells in the lower two layers.

2.4 Comparison of Dockum Wells – 2016 WEL File and District-Provided Data

Data on additional Dockum Aquifer wells were received from Llano Estacado UWCD (Gaines County), Mesa UWCD (Dawson County), and Permian Basin UWCD (Howard and Martin counties). Figure 1 presents the locations of the wells specified in the 2016 WEL file from the HPAS GAM (designated by layer) for these four counties and the locations of the wells provided by the districts.



**Figure 1. Dockum Aquifer Well Locations
 HPAS Wells and District Data - Dawson, Gaines, Howard, and Martin Counties**

Please note that there are no Dockum Aquifer wells in the HPAS GAM in Dawson and Gaines counties. There are 29 wells specified in the HPAS GAM in Howard County (all in layer 4). However, there are duplicate wells in seven model cells, so there are only 22 model cells with Dockum Aquifer wells in Howard County. In Martin County, there is a single Dockum Aquifer well specified in layer 3. The details of the HPAS wells in the four counties are saved in *HPASPermianUWCD.csv*, which is included in the package of files associated with this Technical Memorandum.

In contrast, the district has provided data for 253 wells in these four counties as follows:

- Dawson County – 6 production wells and 2 injection wells
- Gaines County – 13 wells
- Howard County – 71 wells
- Martin County – 161 wells

For purposes of these simulations, the locations of the production and injection wells in Dawson County were treated as production wells.

2.5 Combined List and Location of Wells for Updated Simulation

For Dawson and Gaines counties, the district provided well locations were added as provided since the HPAS GAM has no specified Dockum Aquifer wells.

For Howard and Martin counties, the FORTRAN pre-processor *CombineDockumWells.exe* was written to assign model row and column locations to each of the well locations provided by the Permian Basin UWCD. Source code for the pre-processor is presented in Appendix A. The pre-processor also reads the HPAS GAM wells in Howard and Martin counties.

One output from this pre-processor is the file *distwellxyrc.dat* that writes the results of the row and column assignments for each well in the input file, including the distance between the well and the center of the cell.

Output from this pre-processor also includes the file *districtwellcells.dat* that summarizes the row and column for the district-provided Dockum Aquifer wells, the number of district-provided Dockum Aquifer wells in each cell, and the HPAS GAM pumping in layer 3 and layer 4 of each of these cells. Please note that there are only two instances of overlap (both wells are in Howard County):

- In Row 688, Column 293, the HPAS specified pumping of about 484 AF/yr
- In Row 712, Column 296, the HPAS specified pumping of about 43 AF/yr

The final output is the file *combinedwellcell.dat* that lists both HPAS-specified and district-provided well cells. The specified pumping from the HPAS is listed for those cells that have HPAS specified pumping. Otherwise, a place holder value (-999999) is written that signifies that the pumping from a district-provided well will need to be specified.

2.6 Modified HPAS file for Layers 3 and 4

Because the district-provided data covered Dawson, Gaines, Howard, and Martin counties, the HPAS-based file for layers 3 and 4 (*Layers3and4.csv*) was modified to remove wells in Howard and Martin counties (since there were no Dockum Aquifer wells in Dawson and Gaines counties). This updated file was named *Layers3and4noPB.csv*.

3.0 Pumping Specifications

3.1 HPAS Pumping

Pumping from the Dockum Aquifer was specified as follows in the Scenario 16 file of the HPAS simulation:

- Howard County: 1,809 AF/yr
- Martin County: 9 AF/yr

As discussed above, Scenario 16 of the HPAS simulation assumed zero pumping from the Dockum Aquifer in Dawson and Gaines counties.

3.2 Model Cells by County

A summary of the pumping cells from the file *CombinedDockumWells.dat*, documented above, is presented in Table 1.

Table 1. Summary of WEL Cells from HPAS and District-Provided Data

County	HPAS Well Cells	District-Provided Well Cells
Dawson	0	8
Gaines	0	11
Howard	22	62
Martin	1	143

3.3 Pumping Rates

Based on district-supplied information, Dockum Aquifer well pumping rates are generally between 40 and 160 gallons per minute (gpm). Table 2 summarizes the conversion calculations for 40 gpm, 160 gpm, and the midpoint between these limits (100 gpm).

Table 2. Pumping Rate Conversion Summary

Gallons Per Minute (gpm)	Gallons per Day (gpd)	Cubic Feet per Day (cfd)	Acre-Feet per Day (AF/d)	Acre-Feet per Year (AF/yr)
40	57,600	7,700	0.176767	839
100	144,000	19,250	0.441917	2,097
160	230,400	30,800	0.707067	3,355

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If all 143 wells in Martin County were operated 100 percent of the time at the lowest pumping rate (40 gpm), a total pumping rate for Martin County would be almost 120,000 AF/yr. However, in the HPAS well file, the 22 wells in Howard County pump a total of 1,809 AF/yr, or an average of about 82 AF/yr. If this per well rate were applied to the 143 wells in Martin County, the total pumping would be 11,726 AF/yr, and represent about a 10 percent operation rate.

For purposes of the updated simulations, a range of pumping rates was simulated for the district-provided wells:

- Scenario 17: 60 AF/yr/well
- Scenario 18: 70 AF/yr/well
- Scenario 19: 80 AF/yr/well
- Scenario 20: 90 AF/yr/well
- Scenario 21: 100 AF/yr/well

The resulting total pumping for each scenario (HPAS pumping plus pumping from locations provided by the districts) is summarized in Table 3.

Table 3. Scenario Pumping Sources and Totals

County, Source, or District	Number of District Provided Wells	Scenario Pumping (AF/yr)				
		Scenario 17:	Scenario 18:	Scenario 19:	Scenario 20:	Scenario 21:
		60 AF/yr/well	70 AF/yr/well	80 AF/yr/well	90 AF/yr/well	100 AF/yr/well
Dawson (Dist)	8	480	560	640	720	800
Dawson (HPAS)		0	0	0	0	0
Dawson (Total)		480	560	640	720	800
Mesa UWCD (Total)		480	560	640	720	800
Gaines (Dist)	11	660	770	880	990	1,100
Gaines (HPAS)		0	0	0	0	0
Gaines (Total)		660	770	880	990	1,100
Llano Estacado (UWCD) Total		660	770	880	990	1,100
Howard (Dist)	62	3,720	4,340	4,960	5,580	6,200
Howard (HPAS)		1,809	1,809	1,809	1,809	1,809
Howard (Total)		5,529	6,149	6,769	7,389	8,009
Martin (Dist)	143	8,580	10,010	11,440	12,870	14,300
Martin (HPAS)		9	9	9	9	9
Martin (Total)		8,589	10,019	11,449	12,879	14,309
PBUWCD (Total)	205	14,118	16,168	18,218	20,268	22,318

Table 4 summarizes the per well pumping rates for each scenario and the various conversions that are useful.

Table 4. Per Well Pumping Rates for Scenarios 17 to 21

Scenario	Gallons Per Minute (gpm)	Gallons per Day (gpd)	Cubic Feet per Data (cfd)	Acre-Feet per Day (AF/d)	Acre-Feet per Year (AF/yr)
17	32	53,565	7,161	0.1644	60
18	38	62,492	8,355	0.1918	70
19	43	71,420	9,548	0.2192	80
20	49	80,347	10,742	0.2466	90
21	54	89,275	11,935	0.2740	100

4.0 Scenario 17 to 21 WEL Files

The FORTRAN pre-processor *ScenWEL.exe* was developed for this effort to write the WEL files for Scenarios 17 to 21. The source code for *ScenWEL.exe* is presented in Appendix B.

The pre-processor:

- Reads the grid file
- Reads HPAS pumping for layers 1 and 2 and fills the pumping array
- Reads unchanged HPAS pumping for layers 3 and 4 and fills the pumping arrays
- Reads HPAS pumping from Howard and Martin counties and fills the pumping arrays
- Reads a list of district-provided well locations in Dawson, Gaines, Howard, and Martin counties
- Assigns alternative pumping for each scenario for these district-provided locations and fills pumping arrays
- Sums pumping by county and district based on IB and AQ (active model cells and official aquifer boundary cells)
- Writes summary totals
- Writes WEL files for each scenario

5.0 Scenario 17 to 21 Model Runs

The model execution for each scenario was specified with a name file (NAM):

- Scenario 17: *scen17.nam*
- Scenario 18: *scen18.nam*
- Scenario 19: *scen19.nam*
- Scenario 20: *scen20.nam*
- Scenario 21: *scen21.nam*

The input and output files used for Scenarios 17 to 21 are listed in Table 5.

Table 5. Scenario 17 to 21 Model Files

Input Files			
Package	FORTRAN Unit Number	File Name	Comments
DIS	11	hpas_pred_2013_2080.dis	Discretization Package
BAS6	13	hpas_pred_2013_2080.bas	Basic Package
UPW	14	hpas_pred_2013_2080.upw	Upstream Weighting Package
RCH	15	hpas_pred_2013_2080.rch	Recharge Package
RIV	16	hpas_pred_2013_2080.riv	River Package
DRN	17	hpas_pred_2013_2080.drn	Drain Package
NWT	18	hpas_pred_2013_2080.nwt	Newton Solver Package
OC	19	hpas_pred_2013_2080.oc	Output Control Package
EVT	22	hpas_pred_2013_2080.evt	Evapotranspiration Package
WEL	21	scenXX.wel	Well Pumping Package

Output Files			
Package	FORTRAN Unit Number	File Name	Comments
LIST	2	scenXX.lst	Standard Output
DATA(BINARY)	50	scenXX.cbb	Cell-by-cell flow output
DATA(BINARY)	30	scenXX.hds	Head output
DATA	60	scenXX.specify	Pumping reduction data

Note: XX represents a scenario number (i.e. 17, 18, 19, 20, or 21)

In addition, Table 6 lists the files (common to all scenarios) for starting heads, horizontal and vertical hydraulic conductivity, specific storage, and specific yield. The table is organized by model layer.

Table 6. Layer-Specific Starting Head and Aquifer Parameter Input Files

Parameter	File Names			
	Layer 1	Layer 2	Layer 3	Layer 4
Starting Heads	newshed1.dat	newshed2.dat	newshed3.dat	newshed4.dat
Horizontal Hydraulic Conductivity	Kh1.ref	Kh2.ref	Kh3.ref	Kh4.ref
Vertical Hydraulic Conductivity	Kv1.ref	Kv2.ref	Kv3.ref	Kv4.ref
Specific Storage	Ss1.ref	Ss2.ref	Ss3.ref	Ss4.ref
Specific Yield	Sy1.ref	Sy2.ref	Sy3.ref	Sy4.ref

The MODFLOW executable is named *mfnwt-hpas_x64.exe* (dated March 26, 2015) and is a modified version of the USGS executable as documented in Deeds and Jigmond (2015).

6.0 Post-Processing Scenario Results

6.1 Drawdown

The FORTRAN post-processor *getdd.exe* was developed for this effort to read simulation head results and calculate drawdowns. The source code for *getdd.exe* is presented in Appendix C.

The post-processor:

- Reads the grid file
- Reads the list of counties
- Reads the list of groundwater conservation districts
- Sums the total cells in GMA 2 by IB (active cells) and by AQ (official aquifer cells)
- Writes summary tables of cell counts (total, active, and official aquifer)
- Reads the starting heads (end of 2012)
- Reads simulation heads (2013 to 2080)
- For each county:
 - Sums drawdown in IB cells (active model cells)
 - Sums drawdowns in AQ cells (official aquifer cells)
 - Corrects cell counts for dry cells
- For each groundwater conservation district
 - Sums drawdown in IB cells (active model cells)
 - Sums drawdowns in AQ cells (official aquifer cells)
 - Corrects cell counts for dry cells
- Calculates average drawdown for the Ogallala-ETHP (layers 1 and 2) based on IB and AQ for each county and groundwater conservation district
- Calculates average drawdown for the Dockum Aquifer (layers 3 and 4) based on IB and AQ for each county and groundwater conservation district

- Writes summary output files and individual output files for each county and groundwater conservation district

6.2 Pumping

The FORTRAN post-processor *getpump.exe* was developed for this effort to read output pumping. The source code for *getpump.exe* is presented in Appendix D.

The post-processor:

- Reads the grid file
- Reads the list of counties
- Reads the list of groundwater conservation districts
- Reads the simulation cell-by-cell file (cbb file)
- Sums pumping by county and groundwater conservation district by IB (active model cells) and AQ (official aquifer cells)
- Sums pumping for the Ogallala-RTHP (layers 1 and 2) and for the Dockum Aquifer (layers 3 and 4) by IB (active model cells) and AQ (official aquifer cells)
- Writes summary output files and individual output files for each county and groundwater conservation district

7.0 Discussion of Results

The discussion of the results is limited to specific items for purposes of the upcoming GMA 2 meeting in January 2021. Future versions of this Technical Memorandum will include additional discussion of results as warranted.

7.1 Active Model Cells (IB) vs. Official Aquifer Boundary (AQ)

Figure 2 is a GCD-based comparison of active model cells and official aquifer cells for the Ogallala-ETHP aquifers (layers 1 and 2 of the HPAS). Please note that the model covers areas outside the official aquifer boundary.

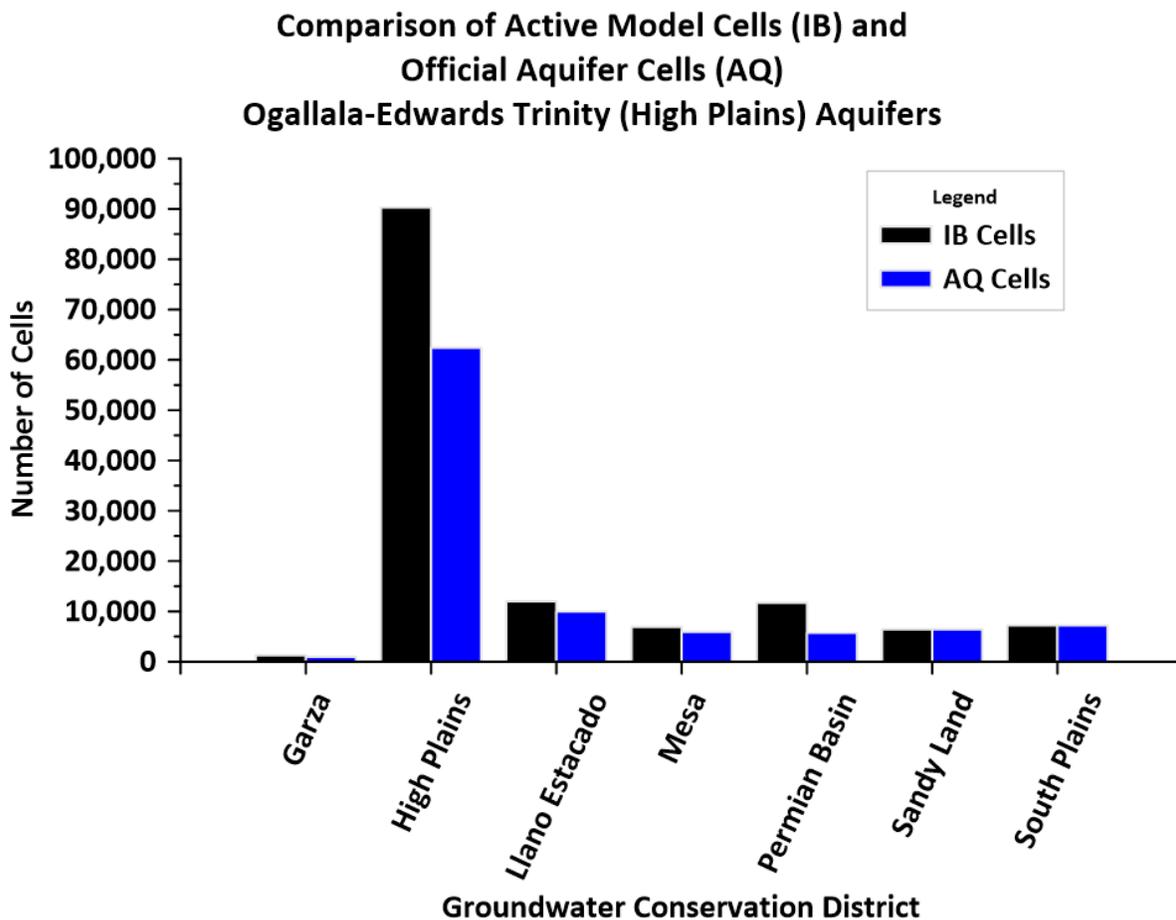


Figure 2. IB vs. AQ Cells - Ogallala-ETHP Aquifers

Figure 3 is a GCD-based comparison of active model cells and official aquifer cells for the Dockum Aquifer (layers 3 and 4 of the HPAS). Please note that the model covers areas outside the official aquifer boundary.

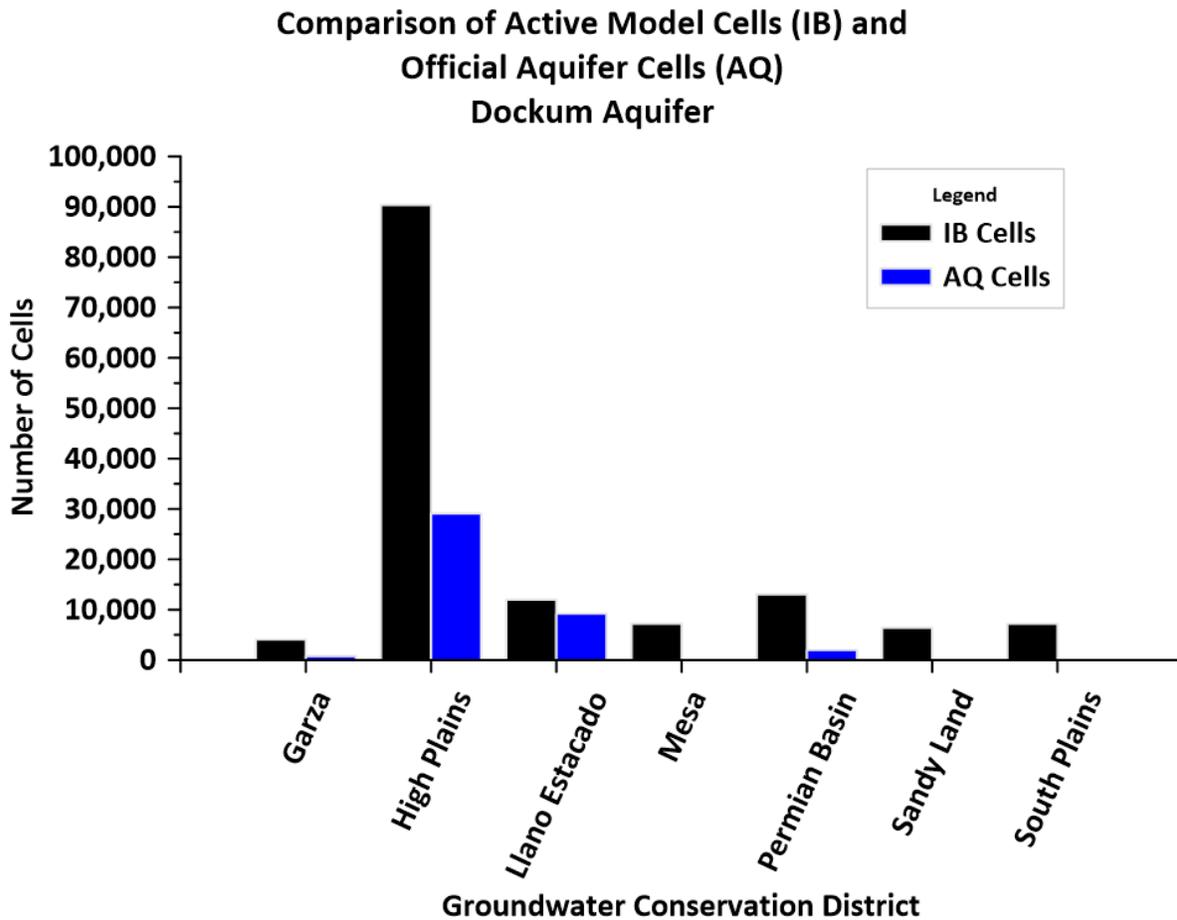


Figure 3. IB vs. AQ Cells - Dockum Aquifer

The official extent of the Dockum Aquifer as defined by the Texas Water Development Board is shown in Figure 4 along with the location of HPAS and district-provided wells that are classified as Dockum Aquifer wells. Please note that TWDB generally limits aquifer boundaries to exclude areas with poor groundwater quality (i.e., total dissolved solids greater than 3,000 mg/l). For the counties of interest in these simulations, it can be seen that:

- Dawson County has no official Dockum Aquifer
- Some areas of Gaines County is outside the official boundary of the Dockum Aquifer, but some well locations provided are classified as Dockum wells
- The official part of the Dockum Aquifer in Howard County is limited to a relatively narrow strip in the eastern part of the county
- The official part of the Dockum Aquifer in Martin County is limited to a narrow strip along the western part of the county.

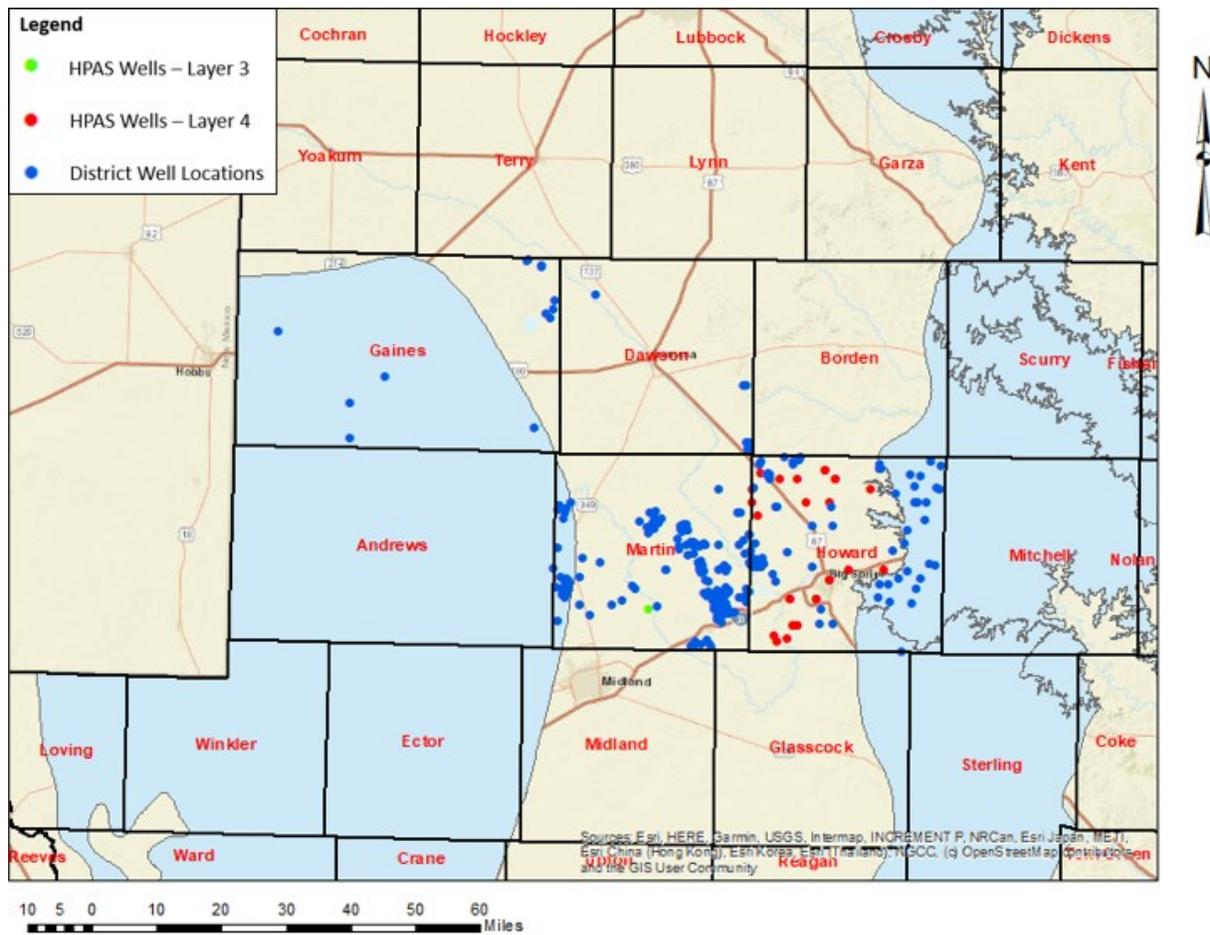


Figure 4. HPAS and District-Provided Wells and Official Dockum Aquifer Boundary

Average drawdown calculations involve summing the drawdowns in all cells in an identified unit (e.g. county or GCD) and dividing the sum by the number of cells. Calculated average drawdowns based on the active model cells (IB) can be different than the calculated average drawdowns based on the official aquifer boundary cells (AQ).

Because the GCDs in GMA 2 are actively managing groundwater with total dissolved solids greater than 3,000 mg/l, the use of the IB cell-based drawdowns and pumping are recommended. To clearly communicate this to TWDB for their modeled available groundwater (MAG) calculations, the desired future condition resolution and the explanatory report should include an explicit statement that the desired future condition is based on all active cells in the HPAS.

7.2 Comparison Dawson, Gaines, Howard, and Martin County Results

The desired future condition adopted by the groundwater conservation districts in Groundwater Management Area 2 on October 16, 2016 was based, in part, on results from Scenario 16 as documented by Hutchison (2016). The simulation period of Scenario 16 was 2013 to 2070. As part of the current round of joint planning, the simulation period for Scenario 16 was extended to also include 2071 to 2080.

As developed in this Technical Memorandum, Scenarios 17 to 21 were developed to evaluate alternative pumping in the Dockum Aquifer in Dawson, Gaines, Howard, and Martin counties. All pumping in the Ogallala Aquifer and the Edwards-Trinity (High Plains) Aquifer for Scenarios 17 to 21 was set equal to the pumping in Scenario 16. All pumping in the Dockum Aquifer outside of Dawson, Gaines, Howard, and Martin counties in Scenarios 17 to 21 was set equal to Scenario 16.

Table 7 summarizes the pumping in Dawson, Gaines, Howard, and Martin counties for Scenarios 16 to 21. These results were extracted from the model output, and, except for rounding errors, are the same as the input values previously presented in Table 3. Please note that the pumping is calculated for all active cells in the HPAS.

Table 7. Output Dockum Aquifer Pumping for Scenarios 16 to 21 - Four Counties

Scenario	Dawson	Gaines	Howard	Martin
Scen 16	0	0	1,809	9
Scen 17	480	660	5,530	8,589
Scen 18	560	770	6,150	10,020
Scen 19	640	880	6,770	11,449
Scen 20	720	990	7,390	12,880
Scen 21	800	1,100	8,010	14,310

Figure 5 summarizes the average drawdown in Dawson, Gaines, Howard, and Martin counties for Scenarios 16 to 21 for the period 2013 to 2080. Please note that these drawdowns are calculated for all active cells in the HPAS.

Please note that the relatively minor increase in pumping in Scenarios 17 to 21 (as compared to Scenario 16) in Dawson and Gaines counties results in relatively small increases in average drawdown. However, relatively large increases in pumping in Scenarios 17 to 21 (as compared to Scenario 16) in Howard and Martin counties results in relatively large increases in average drawdown.

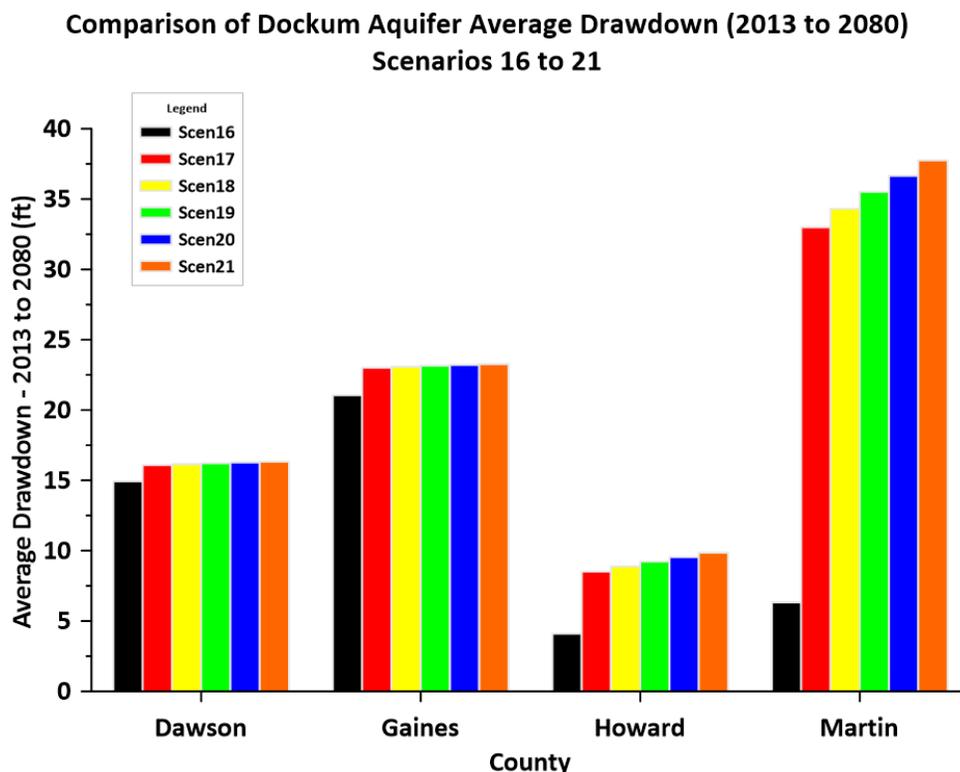


Figure 5. Average Drawdown in Dockum Aquifer for Scenarios 16 to 21 -Four Counties

7.3 Comparison of 2080 Average Drawdown for All Scenarios

The average drawdown calculations for 2080 (with 2013 starting conditions) are summarized for all active model cells as follows:

- Table 8 – Ogallala-ETHP aquifers (County)
- Table 9 – Ogallala-ETHP aquifers (GCD)
- Table 10 – Dockum Aquifer (County)
- Table 11 – Dockum Aquifer (GCD)

At the end of each table is a calculated average drawdown for all of GMA 2. Please note that the values in the county tables (Tables 8 and 10) are for the entire active model of GMA 2. In contrast, the values in the GCD tables (Tables 9 and 11) are only for the GCD areas of GMA 2. The differences are minor, but any desired future condition statement based on a GMA 2-wide average should use the values in Tables 8 and 10.

Table 8. Average Drawdown (ft, 2013-2080), Ogallala-ETHP Aquifers (County)

County	Scen16	Scen17	Scen18	Scen19	Scen20	Scen21
Andrews	4	4	4	4	4	4
Bailey	19	19	19	19	19	19
Borden	6	6	6	6	6	6
Briscoe	14	14	14	14	14	14
Castro	68	68	68	68	68	68
Cochran	22	22	22	22	22	22
Crosby	60	60	60	60	60	60
Dawson	35	35	35	35	35	35
Deaf Smith	30	30	30	30	30	30
Floyd	51	51	51	51	51	51
Gaines	26	26	26	26	26	26
Garza	12	12	12	12	12	12
Hale	46	46	46	46	46	46
Hockley	22	22	22	22	22	22
Howard	0	0	0	0	0	0
Lamb	35	35	35	35	35	35
Lubbock	19	19	19	19	19	19
Lynn	15	15	15	15	15	15
Martin	13	14	14	14	14	14
Parmer	35	35	35	35	35	35
Swisher	30	30	30	30	30	30
Terry	22	22	22	22	22	22
Yoakum	24	24	24	24	24	24
GMA2	28	28	28	28	28	28

Table 9. Average Drawdown (ft, 2013-2080), Ogallala-ETHP Aquifers (GCD)

GCD	Scen16	Scen17	Scen18	Scen19	Scen20	Scen21
Garza	12	12	12	12	12	12
High Plains	35	35	35	35	35	35
Llano Estacado	26	26	26	26	26	26
Mesa	35	35	35	35	35	35
Permian Basin	8	9	9	9	9	9
Sandy Land	24	24	24	24	24	24
South Plains	23	23	23	23	23	23
GMA2 (GCD Area Only)	26	27	27	27	27	27

Table 10. Average Drawdown (ft, 2013-2080), Dockum Aquifer (County)

County	Scen16	Scen17	Scen18	Scen19	Scen20	Scen21
Andrews	7	7	7	7	7	7
Bailey	24	24	24	24	24	24
Borden	5	5	5	5	5	5
Briscoe	9	9	9	9	9	9
Castro	73	73	73	73	73	73
Cochran	17	17	17	17	17	17
Crosby	45	45	45	45	45	45
Dawson	15	16	16	16	16	16
Deaf Smith	40	40	40	40	40	40
Floyd	54	54	54	54	54	54
Gaines	21	23	23	23	23	23
Garza	1	1	1	1	1	1
Hale	75	75	75	75	75	75
Hockley	20	20	20	20	20	20
Howard	4	9	9	9	10	10
Lamb	49	49	49	49	49	49
Lubbock	37	37	37	37	37	37
Lynn	16	16	16	16	16	16
Martin	6	33	34	36	37	38
Parmer	75	75	75	75	75	75
Swisher	39	39	39	39	39	39
Terry	8	8	8	9	9	9
Yoakum	8	8	8	8	8	8
GMA2	30	31	31	31	32	32

Table 11. Average Drawdown (ft, 2013-2080), Dockum Aquifer (GCD)

GCD	Scen16	Scen17	Scen18	Scen19	Scen20	Scen21
Garza	1	1	1	1	1	1
High Plains	46	46	46	46	46	46
Llano Estacado	21	23	23	23	23	23
Mesa	15	16	16	16	16	16
Permian Basin	5	22	23	24	25	26
Sandy Land	8	8	8	8	8	8
South Plains	8	8	8	9	9	9
GMA2 (GCD Area Only)	28	30	30	30	30	30

Please note that Martin County and Permian Basin UWCD are the only instances where average drawdown in the Ogallala-ETHP aquifers in Scenarios 17 to 21 is higher than Scenario 16. The one-foot increase is not considered to be significant.

In the Dockum Aquifer, the increases in average drawdown in Dawson, Gaines, Howard, and Martin counties were discussed in the previous section of this Technical Memorandum. Tables 10 and 11 results show that outside of the four counties where simulated pumping was increased, the only other increase is in Terry County (South Plains UWCD), and the increase is only one foot, which is not considered significant.

7.4 Decadal Summaries of Average Drawdown and Pumping

Decadal summaries of average drawdown and pumping for all scenarios are presented as follows:

- Appendix E – Ogallala-ETHP Aquifers (County)
- Appendix F – Dockum Aquifer (County)
- Appendix G – Ogallala-ETHP Aquifers (GCD)
- Appendix H – Dockum Aquifer (GCD)

8.0 References

Deeds, N.E. and Jigmond, M., 2015. Numerical Model Report for the High Plains Aquifer System Groundwater Availability Model. Prepared by INTERA Incorporated for Texas Water Development Board, 640p.

Hutchison, W.R., 2016. Predictive Simulation of the Ogallala, Edwards-Trinity (High Plains) and Dockum Aquifers: Scenario 16. GMA 2 Technical Memorandum 16-01. Prepared for Groundwater Management Area 2, November 1, 2016, 78p.

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Appendix A

Source Code for *CombinedDockumWells.exe*

```

1  ! CombineDockumWells.exe
2
3  ! Reads grid file
4  ! Reads HPAS wells in four counties (Dawson, Gaines, Howard, Martin)
5  ! Reads District-provided well locations
6  ! Finds model row and column for district-provided wells
7  ! writes list of wells and source of data
8
9  ! Declare arrays
10
11 dimension ib(4,932,580),iaq(4,932,580),icounty(932,580),xc(932,580),yc(932,580)
12 dimension q(4,932,580),q2(4,932,580),idw(932,580)
13 dimension dwxc(253),dwyc(253),idwr(253),idwc(253),dist(253)
14 character*30 text
15
16 ! read grid file
17
18 open (1,file='rcxy.csv')
19 read (1,*) text
20 do 100 k=1,540560
21 read (1,*) ir,ic,(ib(il,ir,ic),il=1,4),icounty(ir,ic),(iaq(il,ir,ic),il=1,4),xc(ir,ic),yc(ir,ic)
22 100 continue
23
24 ! initialize q array
25
26 do 200 il=1,4
27 do 201 ir=1,932
28 do 202 ic=1,580
29 q(il,ir,ic)=0
30 q2(il,ir,ic)=0
31 202 continue
32 201 continue
33 200 continue
34
35 ! read HPAS wells and increment q array
36
37 qmax=0
38 open (3,file='HPASPermianUWCD.csv')
39 read (3,*) text
40 do 300 k=1,30
41 read (3,*) il,ir,ic,qt
42 q(il,ir,ic)=q(il,ir,ic)+qt
43 q2(il,ir,ic)=q2(il,ir,ic)+qt
44 if (q2(il,ir,ic).lt.qmax) qmax=q2(il,ir,ic)
45 300 continue
46

```

```

47 write (*,310) qmax
48 310 format ('Highest Q',f10.2)
49
50 ! read District wells
51
52 open (4,file='DistrictDockumWells.csv')
53 read (4,*) text
54 do 400 k=1,253
55 read (4,*) xlat,xlong,dwxc(k),dwyc(k)
56 400 continue
57
58 ! calculate distance to all active cells, find closest, write selected cell and distance
59
60 do 500 k=1,253
61 dist(k)= 99999
62 idwr(k)=0
63 idwc(k)=0
64 do 501 ir=1,932
65 do 502 ic=1,580
66 if (ib(3,ir,ic).gt.0.or.ib(4,ir,ic).gt.0) then
67 dt1=dwxc(k)-xc(ir,ic)
68 dt2=dt1*dt1
69 dt3=dwyc(k)-yc(ir,ic)
70 dt4=dt3*dt3
71 dt5=dt2+dt4
72 dt6=sqrt(dt5)
73 dt7=dt6
74 if (dt7.lt.dist(k)) then
75 idwr(k)=ir
76 idwc(k)=ic
77 dist(k)=dt7
78 end if
79 end if
80 502 continue
81 501 continue
82 500 continue
83
84 ! initialize district model array
85
86 do 600 ir=1,932
87 do 601 ic=1,580
88 idw(ir,ic)=0
89 601 continue
90 600 continue
91
92 ! write district well row and column

```

```

93
94 open (7,file='distwellxyc.dat')
95 do 700 k=1,253
96 write (7,710) k,idwr(k),idwc(k),dist(k),icounty(idwr(k),idwc(k)),dwxc(k),dwyc(k)
97 710 format (3i10,f10.0,i10,2f15.0)
98 700 continue
99
100 ! Increment model cells with district wells
101
102 do 800 k=1,253
103 idw(idwr(k),idwc(k))=idw(idwr(k),idwc(k))+1
104 800 continue
105
106 ! write list of district well cells and pumping from HPAS wells
107
108 open (9,file='districtwellcells.dat')
109 do 900 ir=1,932
110 do 901 ic=1,580
111 if (idw(ir,ic).gt.0) then
112 write (9,910) ir,ic,idw(ir,ic),q(3,ir,ic),q(4,ir,ic),icounty(ir,ic)
113 910 format (3i10,2f10.2,i10)
114 if (q(3,ir,ic).lt.0) then
115 q2(3,ir,ic)=q(3,ir,ic)
116 else
117 q2(3,ir,ic)=-999999
118 end if
119 if (q(4,ir,ic).lt.0) then
120 q2(4,ir,ic)=q(4,ir,ic)
121 else
122 q2(4,ir,ic)=-999999
123 end if
124 end if
125 901 continue
126 900 continue
127
128 ! write combined list of HPAS and District Dockum well cells
129
130 open (10,file='combinedwellcell.dat')
131 do 1000 ir=1,932
132 do 1001 ic=1,580
133 if (q2(3,ir,ic).lt.0.or.q2(4,ir,ic).lt.0) then
134 write (10,1010) ir,ic,icounty(ir,ic),q2(3,ir,ic),q2(4,ir,ic)
135 1010 format (3i10,2f15.2)
136 end if
137 1001 continue
138 1000 continue

```

139
140 stop
141 end

Appendix B

Source Code for *ScenWEL.exe*

```

1  ! ScenWEL.exe
2  !
3  ! Reads grid file
4  ! Reads HPAS pumping for Layers 1 and 2, fills pumping arrays
5  ! Reads unchanged HPAS pumping for Layers 3 and 4, fills pumping arrays
6  ! Reads HPAS pumping from Howard and Martin counties, fills pumping arrays
7  ! Reads list of well locations in four counties from districts
8  ! Assigns alternative pumping for each scenario for these locatios, fills pumping arrays
9  ! Sums pumping by county and district based on IB and IAQ
10 ! Writes summary totals
11 ! Writes WEL files for each scenario
12
13 ! Declare Arrays
14
15 dimension icounty(932,580),ib(4,932,580),iaq(4,932,580)
16 dimension q(5,4,932,580),qscen(5)
17 dimension sp(3,5,26,4),idc(26),kcount(5)
18 character*30 text,cn(26),pumpfn(26),specify
19
20 ! initialize sumpump arrays
21
22 do 10 iscen=1,5
23 do 11 icty=1,26
24 do 12 il=1,4
25 sp(1,iscen,icty,il)=0
26 sp(2,iscen,icty,il)=0
27 sp(3,iscen,icty,il)=0
28 12 continue
29 11 continue
30 10 continue
31
32 ! initialize WEL counts
33
34 do 20 k=1,5
35 kcount(k)=0
36 20 continue
37
38 ! initialize q array
39
40 do 30 iscen=1,5
41 do 31 il=1,4
42 do 32 ir=1,932
43 do 33 ic=1,580
44 q(iscen,il,ir,ic)=0
45 33 continue
46 32 continue

```

```

47 31 continue
48 30 continue
49
50 ! read grid file
51
52 open (1,file='rcxy.csv')
53 read (1,*) text
54 do 100 k=1,540560
55 read (1,*) ir,ic,(ib(il,ir,ic),il=1,4),icounty(ir,ic),(iaq(il,ir,ic),il=1,4)
56 100 continue
57
58 ! read layers 1 and 2 HPAS pumping
59
60 open (2,file='Layers1and2.csv')
61 do 200 k=1,93449
62 read (2,*) il,ir,ic,qt
63 do 201 iscen=1,5
64 q(iscen,il,ir,ic)=q(iscen,il,ir,ic)+qt
65 201 continue
66 200 continue
67
68 ! read unchanged layer 3 and 4 pumping
69
70 open (3,file='Layers3and4noPB.csv')
71 do 300 k=1,1107
72 read (3,*) il,ir,ic,qt
73 do 301 iscen=1,5
74 q(iscen,il,ir,ic)=q(iscen,il,ir,ic)+qt
75 301 continue
76 300 continue
77
78 ! read HPAS Dockum pumping in Howard and Martin counties
79
80 open (4,file='HowardMartinHPAS.csv')
81 read (4,*) text
82 do 400 k=1,23
83 read (4,*) ir,ic,ic2,qt3,qt4
84 do 401 iscen=1,5
85 q(iscen,3,ir,ic)=q(iscen,3,ir,ic)+qt3
86 q(iscen,4,ir,ic)=q(iscen,4,ir,ic)+qt4
87 401 continue
88 400 continue
89
90 ! read locations of district provided wells and assign pumping for each scenario
91
92 qscen(1)=-7161

```

```

93  qscen(2)=-8355
94  qscen(3)=-9548
95  qscen(4)=-10742
96  qscen(5)=-11935
97
98  open (5,file='FourCountyDistWellRC.csv')
99  read (5,*) text
100 do 500 k=1,224
101 read (5,*) ir,ic,ic2
102 do 501 iscen=1,5
103 q(iscen,4,ir,ic)=qscen(iscen)
104 501 continue
105 500 continue
106
107 ! read county list
108
109 open (6,file='countylist.dat')
110 do 600 k=1,26
111 read (6,*) cn(k),idc(k),pumpfn(k)
112 600 continue
113
114
115 ! increment pumping and well count totals
116 ! also don't count pumping outside of IB > 0
117
118 do 700 iscen=1,5
119 do 701 il=1,4
120 do 702 ir=1,932
121 do 703 ic=1,580
122
123 if (q(iscen,il,ir,ic).lt.0) then
124 qaf=-q(iscen,il,ir,ic)*365/43560
125 if (ib(il,ir,ic).gt.0) kcount(iscen)=kcount(iscen)+1
126
127 do 704 icty=1,26
128 if (icounty(ir,ic).eq.idc(icty)) then
129 sp(1,iscen,icty,il)=sp(1,iscen,icty,il)+qaf
130 if (ib(il,ir,ic).gt.0) sp(2,iscen,icty,il)=sp(2,iscen,icty,il)+qaf
131 if (iaq(il,ir,ic).gt.0) sp(3,iscen,icty,il)=sp(3,iscen,icty,il)+qaf
132 end if
133 704 continue
134
135 end if
136
137 703 continue
138 702 continue

```

```

139 701 continue
140 700 continue
141
142 ! compare tot,ib,and iaq totals and write any differences to file
143
144 open (7,file='sumdiff.dat')
145
146 do 711 iscen=1,5
147 do 712 ic2=1,26
148 do 713 il=1,4
149 if (sp(1,iscen,ic2,il).ne.sp(2,iscen,ic2,il)) write (7,720)
150 iscen,ic2,cn(ic2),il,sp(1,iscen,ic2,il),sp(2,iscen,ic2,il)
151 720 format ('Tot vs IB',2x,2i10,1x,a15,1x,i10,2f10.0)
152 if (sp(2,iscen,ic2,il).ne.sp(3,iscen,ic2,il)) write (7,730)
153 iscen,ic2,cn(ic2),il,sp(2,iscen,ic2,il),sp(3,iscen,ic2,il)
154 730 format ('IB vs IAQ',2x,2i10,1x,a15,1x,i10,2f10.0)
155 713 continue
156 712 continue
157 711 continue
158
159 ! write summary files by layer (1 to 4)
160
161 open (8,file='CountySum1.dat')
162 open (9,file='CountySum2.dat')
163 open (10,file='CountySum3.dat')
164 open (11,file='CountySum4.dat')
165 do 800 ic2=1,26
166 do 801 il=1,4
167 write (il+7,810)
168 idc(ic2),cn(ic2),(sp(1,iscen,ic2,il),iscen=1,5),(sp(2,iscen,ic2,il),iscen=1,5),(sp(3,iscen,ic2,
169 il),iscen=1,5)
170 810 format (i10,1x,a12,1x,15f10.0)
171 801 continue
172 800 continue
173
174 ! write WEL files
175
176 specify='SPECIFY'
177 i50=50
178 i30=30
179 i60=60
180 in1=-1
181
182 open (21,file='Scen17.wel')
183 open (22,file='scen18.wel')
184 open (23,file='scen19.wel')

```

```

185 open (24,file='scen20.wel')
186 open (25,file='scen21.wel')
187
188 ! headers
189
190 do 2000 iscen=1,5
191 write (iscen+20,2010) kcount(iscen),i50
192 write (iscen+20,2011) specify,i30,i60
193 write (iscen+20,2012) kcount(iscen)
194 2010 format (2i10)
195 2011 format (a7,1x,2i5)
196 2012 format (i10)
197
198 ! sp 1 wells
199
200 do 2001 il=1,4
201 do 2002 ir=1,932
202 do 2003 ic=1,580
203 if (q(iscen,il,ir,ic).lt.0.and.ib(il,ir,ic).gt.0) write (iscen+20,2013) il,ir,ic,q(iscen,il,ir,ic)
204 2013 format (3i10,f15.2)
205 2003 continue
206 2002 continue
207 2001 continue
208
209 ! sp 2 to 68 wells (negative 1)
210
211 do 2004 isp=2,68
212 write (iscen+20,2014) in1
213 2014 format (i10)
214 2004 continue
215
216 2000 continue
217
218
219 stop
220 end

```

Appendix C

Source Code for *getdd.exe*

```

1  ! getdd.exe
2  !
3  ! reads grid file
4  ! reads county list
5  ! reads gcd list
6  ! sums total cells by ib (active model cells) and aq (official aquifer cells)
7  ! write cell totals
8
9  ! reads starting heads (end of 2012)
10 ! read simulation heads (2013 to 2080)
11
12 ! For each county:
13 ! sums drawdowns in ib cells
14 ! sums drawdowns in aq cells
15
16 ! for each GCD:
17 ! sums drawdowns in ib cells
18 ! sums drawdowns in aq cells
19
20 ! for each county:
21
22 ! calculates average drawdown in ib cells for Ogallala-ETHP (layers 1 and 2)
23 ! calculates average drawdown in aq cells for Ogallala-ETHP (layers 1 and 2)
24 ! calculates average drawdown in ib cells for Dockum (layers 3 and 4)
25 ! calculates average drawodwn in aq cells for Dockum (layers 3 and 4)
26 ! writes files for drawdown by layer and summaries
27
28 ! for each GCD:
29
30 ! calculates average drawdown in ib cells for Ogallala-ETHP (layers 1 and 2)
31 ! calculates average drawdown in aq cells for Ogallala-ETHP (layers 1 and 2)
32 ! calculates average drawdown in ib cells for Dockum (layers 3 and 4)
33 ! calculates average drawodwn in aq cells for Dockum (layers 3 and 4)
34 ! writes files for drawdown by layer and summaries
35
36 ! declare arrays
37
38 dimension icounty(932,580),xc(932,580),yc(932,580),igma(932,580),igcd(932,580)
39 dimension ib(4,932,580),iaq(4,932,580)
40 dimension iclist(27),igcdlist(8)
41 dimension ctytot(4,27),ctyib(4,27),ctyaq(4,27)
42 dimension gcdtot(4,8),gcdib(4,8),gcdaq(4,8)
43 dimension shed(4,932,580),hed(68,4,580,932),dd(68,4,932,580)
44 dimension dcctyib(4,68,27),dcctyaq(4,68,27),dcgcdib(4,68,8),dgcgdaq(4,68,8)
45 dimension sumddcib(4,68,27),sumddcaq(4,68,27),sumddgib(4,68,8),sumddgaq(4,68,8)
46 dimension addcib(2,68,27),addcaq(2,68,27),addgib(2,68,8),addgaq(2,68,8)

```

```

47 character*30 text,county(27),gcd(8),avgddcfn(27),avgddgfn(8),simhedfn
48 character*4 txtid
49 dimension txtid(4)
50
51 ! read grid file
52
53 open (1,file='hpas_grid_poly082615.csv')
54 read (1,*) text
55 do 100 k=1,540560
56 read (1,*)
57 ir,ic,(ib(il,ir,ic),il=1,4),x1,text,icounty(ir,ic),text,igcd(ir,ic),text,i1,igma(ir,ic),text,text,text,i1,(
58 iaq(il,ir,ic),il=1,4),xc(ir,ic),yc(ir,ic),i1,i2,i3
59 100 continue
60
61 ! read county list and output file names
62
63 open (2,file='countylist.dat')
64 do 200 k=1,27
65 read (2,*) county(k),iclist(k),avgddcfn(k)
66 200 continue
67
68 open (3,file='gcdlist.dat')
69 do 300 k=1,8
70 read (3,*) gcd(k),igcdlist(k),avgddgfn(k)
71 300 continue
72
73 ! count cell - county (total, ib, and aq) in GMA 2
74
75 do 400 ir=1,932
76 do 401 ic=1,580
77
78 ! count county cells
79
80 do 402 k=1,26
81 if (igma(ir,ic).eq.2.and.icounty(ir,ic).eq.iclist(k)) then
82 do 403 il=1,4
83 ctytot(il,k)=ctytot(il,k)+1
84 if (ib(il,ir,ic).gt.0) ctyib(il,k)=ctyib(il,k)+1
85 if (iaq(il,ir,ic).gt.0) ctyaq(il,k)=ctyaq(il,k)+1
86 403 continue
87 end if
88 402 continue
89
90 ! count GMA 2 cells
91
92 if (igma(ir,ic).eq.2) then

```

```

93  do 404 il=1,4
94  ctytot(il,27)=ctytot(il,27)+1
95  if (ib(il,ir,ic).gt.0) ctyib(il,27)=ctyib(il,27)+1
96  if (iaq(il,ir,ic).gt.0) ctyaq(il,27)=ctyaq(il,27)+1
97  404 continue
98  end if
99
100 401 continue
101 400 continue
102
103 ! write county-based cell sums (total, ib, aq) in GMA 2
104
105 open (41,file='celltot-county.dat')
106 open (42,file='cellib-county.dat')
107 open (43,file='cellaq-county.dat')
108 do 410 k=1,27
109 write (41,411) county(k),iclist(k),(ctytot(il,k),il=1,4)
110 write (42,411) county(k),iclist(k),(ctyib(il,k),il=1,4)
111 write (43,411) county(k),iclist(k),(ctyaq(il,k),il=1,4)
112 411 format (a15,1x,i10,4f10.0)
113 410 continue
114
115 ! count cell - gcd (total, ib, and aq) in GMA 2
116
117 do 500 ir=1,932
118 do 501 ic=1,580
119
120 ! count gcd cells
121
122 do 502 k=1,7
123 if (igma(ir,ic).eq.2.and.igcd(ir,ic).eq.igcdlist(k)) then
124 do 503 il=1,4
125 gcdtot(il,k)=gcdtot(il,k)+1
126 if (ib(il,ir,ic).gt.0) gcdib(il,k)=gcdib(il,k)+1
127 if (iaq(il,ir,ic).gt.0) gcdaq(il,k)=gcdaq(il,k)+1
128 503 continue
129 end if
130 502 continue
131
132 ! count GMA 2 cells
133
134 if (igma(ir,ic).eq.2) then
135 do 504 il=1,4
136 gcdtot(il,8)=gcdtot(il,8)+1
137 if (ib(il,ir,ic).gt.0) gcdib(il,8)=gcdib(il,8)+1
138 if (iaq(il,ir,ic).gt.0) gcdaq(il,8)=gcdaq(il,8)+1

```

```

139 504 continue
140 end if
141
142 501 continue
143 500 continue
144
145 ! write county-based cell sums (total, ib, aq) in GMA 2
146
147 open (51,file='celltot-gcd.dat')
148 open (52,file='cellib-gcd.dat')
149 open (53,file='cellaq-gcd.dat')
150 do 510 k=1,8
151 write (51,511) gcd(k),igcdlist(k),(gcdtot(il,k),il=1,4)
152 write (52,511) gcd(k),igcdlist(k),(gcdib(il,k),il=1,4)
153 write (53,511) gcd(k),igcdlist(k),(gcdaq(il,k),il=1,4)
154 511 format (a15,1x,i10,4f10.0)
155 510 continue
156
157 ! read starting heads
158
159 open (61,file='newshed1.dat')
160 open (62,file='newshed2.dat')
161 open (63,file='newshed3.dat')
162 open (64,file='newshed4.dat')
163
164 do 600 ir=1,932
165 read (61,*) (shed(1,ir,ic),ic=1,580)
166 read (62,*) (shed(2,ir,ic),ic=1,580)
167 read (63,*) (shed(3,ir,ic),ic=1,580)
168 read (64,*) (shed(4,ir,ic),ic=1,580)
169 600 continue
170
171 ! read simulation hds file
172
173 open (71,file='simhedfn.dat')
174 read (71,*) simhedfn
175 open (72,file=simhedfn,form='binary')
176 do 700 isp=1,68
177 write (*,710) isp
178 710 format ('+', 'SP', 1x, i3)
179 do 701 il=1,4
180 read (72) kstp,kper,pertim,totim,txtd,ncol,nrow,ilay
181 read (72) ((hed(isp,il,ic,ir),ic=1,ncol),ir=1,nrow)
182 701 continue
183 700 continue
184

```

```

185 ! calculate cell by cell drawdown
186
187 do 800 isp=1,68
188 do 801 il=1,4
189 do 802 ir=1,932
190 do 803 ic=1,580
191
192 dd(isp,il,ir,ic)=0
193
194 if (shed(il,ir,ic).ne.99999.and.igma(ir,ic).eq.2) then
195 if (hed(isp,il,ic,ir).ne.99999) dd(isp,il,ir,ic)=shed(il,ir,ic)-hed(isp,il,ic,ir)
196 end if
197
198 ! sum by county (count dry cells too)
199
200 ! ib cells
201
202 do 804 k=1,26
203 if (icounty(ir,ic).eq.iclist(k)) then
204 if (ib(il,ir,ic).gt.0) then
205 if (hed(isp,il,ic,ir).eq.99999) then
206 dcctyib(il,isp,k)=dcctyib(il,isp,k)+1
207 dcctyib(il,isp,27)=dcctyib(il,isp,27)+1
208 end if
209 if (hed(isp,il,ic,ir).ne.99999) then
210 sumddcib(il,isp,k)=sumddcib(il,isp,k)+dd(isp,il,ir,ic)
211 sumddcib(il,isp,27)=sumddcib(il,isp,27)+dd(isp,il,ir,ic)
212 end if
213 end if
214 end if
215 804 continue
216
217 ! aq cells
218
219 do 805 k=1,26
220 if (icounty(ir,ic).eq.iclist(k)) then
221 if (iaq(il,ir,ic).gt.0) then
222 if (hed(isp,il,ic,ir).eq.99999) then
223 dcctyaq(il,isp,k)=dcctyaq(il,isp,k)+1
224 dcctyaq(il,isp,27)=dcctyaq(il,isp,27)+1
225 end if
226 if (hed(isp,il,ic,ir).ne.99999) then
227 sumddcaq(il,isp,k)=sumddcaq(il,isp,k)+dd(isp,il,ir,ic)
228 sumddcaq(il,isp,27)=sumddcaq(il,isp,27)+dd(isp,il,ir,ic)
229 end if
230 end if

```

```

231  end if
232  805 continue
233
234  ! sum by gcd (count dry cells too)
235
236  ! ib cells
237
238  do 806 k=1,7
239  if (igcd(ir,ic).eq.igcdlist(k)) then
240  if (ib(il,ir,ic).gt.0) then
241  if (hed(isp,il,ic,ir).eq.99999) then
242  dcgcdib(il,isp,k)=dcgcdib(il,isp,k)+1
243  dcgcdib(il,isp,8)=dcgcdib(il,isp,8)+1
244  end if
245  if (hed(isp,il,ic,ir).ne.99999) then
246  sumddgib(il,isp,k)=sumddgib(il,isp,k)+dd(isp,il,ir,ic)
247  sumddgib(il,isp,8)=sumddgib(il,isp,8)+dd(isp,il,ir,ic)
248  end if
249  end if
250  end if
251  806 continue
252
253  ! aq cells
254
255  do 807 k=1,7
256  if (igcd(ir,ic).eq.igcdlist(k)) then
257  if (iaq(il,ir,ic).gt.0) then
258  if (hed(isp,il,ic,ir).eq.99999) then
259  dcgcdaq(il,isp,k)=dcgcdaq(il,isp,k)+1
260  dcgcdaq(il,isp,8)=dcgcdaq(il,isp,8)+1
261  end if
262  if (hed(isp,il,ic,ir).ne.99999) then
263  sumddgaq(il,isp,k)=sumddgaq(il,isp,k)+dd(isp,il,ir,ic)
264  sumddgaq(il,isp,8)=sumddgaq(il,isp,8)+dd(isp,il,ir,ic)
265  end if
266  end if
267  end if
268  807 continue
269
270
271  803 continue
272  802 continue
273  801 continue
274  800 continue
275
276

```

```

277 ! calculate average drawdown (ib and aq, county and gcd)
278
279 do 900 isp=1,68
280
281 ! county-based
282
283 do 901 k=1,27
284
285 ! layers 1 and 2 combined for Ogallala-ETHP
286
287 ! ib-based
288
289 cb1=sumddcib(1,isp,k)+sumddcib(2,isp,k)
290 cb2=ctyib(1,k)+ctyib(2,k)
291 cb3=dcctyib(1,isp,k)+dcctyib(2,isp,k)
292 cb4=cb2-cb3
293 if (cb4.gt.0) addcib(1,isp,k)=cb1/cb4
294
295 ! aq-based
296
297 cq1=sumddcaq(1,isp,k)+sumddcaq(2,isp,k)
298 cq2=ctyaq(1,k)+ctyaq(2,k)
299 cq3=dcctyaq(1,isp,k)+dcctyaq(2,isp,k)
300 cq4=cq2-cq3
301 if (cq4.gt.0) addcaq(1,isp,k)=cq1/cq4
302
303 ! layers 3 and 4 combined for Dockum
304
305 ! ib-based
306
307 cb5=sumddcib(3,isp,k)+sumddcib(4,isp,k)
308 cb6=ctyib(3,k)+ctyib(4,k)
309 cb7=dcctyib(3,isp,k)+dcctyib(4,isp,k)
310 cb8=cb6-cb7
311 if (cb8.gt.0) addcib(2,isp,k)=cb5/cb8
312
313 ! aq-based
314
315 cq5=sumddcaq(3,isp,k)+sumddcaq(4,isp,k)
316 cq6=ctyaq(3,k)+ctyaq(4,k)
317 cq7=dcctyaq(3,isp,k)+dcctyaq(4,isp,k)
318 cq8=cq6-cq7
319 if (cq8.gt.0) addcaq(2,isp,k)=cq5/cq8
320
321
322 901 continue

```

```

323
324 ! gcd-based
325
326 do 902 k=1,8
327
328 ! layers 1 and 2 combined for Ogallala-ETHP
329
330 ! ib-based
331
332 gb1=sumddgib(1,isp,k)+sumddgib(2,isp,k)
333 gb2=gcdib(1,k)+gcdib(2,k)
334 gb3=dcgcdib(1,isp,k)+dcgcdib(2,isp,k)
335 gb4=gb2-gb3
336 if (gb4.gt.0) addgib(1,isp,k)=gb1/gb4
337
338 ! aq-based
339
340 gq1=sumddgaq(1,isp,k)+sumddgaq(2,isp,k)
341 gq2=gcdaq(1,k)+gcdaq(2,k)
342 gq3=dcgcaq(1,isp,k)+dcgcaq(2,isp,k)
343 gq4=gq2-gq3
344 if (gq4.gt.0) addgaq(1,isp,k)=gq1/gq4
345
346 ! layers 3 and 4 combined for Dockum
347
348 ! ib-based
349
350 gb5=sumddgib(3,isp,k)+sumddgib(4,isp,k)
351 gb6=gcdib(3,k)+gcdib(4,k)
352 gb7=dcgcdib(3,isp,k)+dcgcdib(4,isp,k)
353 gb8=gb6-gb7
354 if (gb8.gt.0) addgib(2,isp,k)=gb5/gb8
355
356 ! aq-based
357
358 gq5=sumddgaq(3,isp,k)+sumddgaq(4,isp,k)
359 gq6=gcdaq(3,k)+gcdaq(4,k)
360 gq7=dcgcaq(3,isp,k)+dcgcaq(4,isp,k)
361 gq8=gq6-gq7
362 if (gq8.gt.0) addgaq(2,isp,k)=gq5/gq8
363
364
365 902 continue
366
367 900 continue
368

```

```

369 ! write summary files of 2080 drawdown
370
371 ! county-based
372
373 open (10,file='sumcountydd2080.dat')
374 do 1000 k=1,27
375 write (10,1010)
376 k,county(k),iclist(k),addcib(1,68,k),addcaq(1,68,k),addcib(2,68,k),addcaq(2,68,k)
377 1010 format (i10,1x,a15,1x,i10,4f10.2)
378 1000 continue
379
380 ! gcd-based
381
382 open (11,file='sumgcd2080.dat')
383 do 1001 k=1,8
384 write (11,1010)
385 k,gcd(k),igcdlist(k),addgib(1,68,k),addgaq(1,68,k),addgib(2,68,k),addgaq(2,68,k)
386 1001 continue
387
388 ! write county and gcd based files for all stress periods
389
390 ! county based
391
392 do 1100 k=1,27
393 open (11,file=avgddcfk(k))
394 write (11,1110) k,county(k),iclist(k)
395 1110 format (i10,1x,a15,1x,i10)
396 do 1101 isp=1,68
397 write (11,1111)
398 isp,isp+2012,addcib(1,isp,k),addcaq(1,isp,k),addcib(2,isp,k),addcaq(2,isp,k)
399 1111 format (2i10,4f10.2)
400 1101 continue
401 close (11)
402 1100 continue
403
404 ! gcd based
405
406 do 1200 k=1,8
407 open (12,file=avgddgfk(k))
408 write (12,1210) k,gcd(k),igcdlist(k)
409 1210 format (i10,1x,a15,1x,i10)
410 do 1201 isp=1,68
411 write (12,1211)
412 isp,isp+2012,addgib(1,isp,k),addgaq(1,isp,k),addgib(2,isp,k),addgaq(2,isp,k)
413 1211 format (2i10,4f10.2)
414 1201 continue

```

```

415 close (12)
416 1200 continue
417
418 ! dry cell summary
419
420 ! dcctyib(4,68,27),dcctyaq(4,68,27),dgcgdib(4,68,8),dgcgdaq(4,68,8)
421
422 ! county-based
423
424 open (13,file='drycellscounty.dat')
425 do 1300 il=1,4
426 do 1301 isp=1,68
427 do 1302 k=1,27
428 if (dcctyib(il,isp,k).gt.0) write (13,1310) il,isp,k,dcctyib(il,isp,k)
429 1310 format ('IB',2x,3i10,f10.0)
430 if (dcctyaq(il,isp,k).gt.0) write (13,1311) il,isp,k,dcctyaq(il,isp,k)
431 1311 format ('AQ',2x,3i10,f10.0)
432 1302 continue
433 1301 continue
434 1300 continue
435
436 ! gcd=based
437
438 open (14,file='drycellsgcd.dat')
439 do 1400 il=1,4
440 do 1401 isp=1,68
441 do 1402 k=1,8
442 if (dgcgdib(il,isp,k).gt.0) write (14,1410) il,isp,k,dgcgdib(il,isp,k)
443 1410 format ('IB',2x,3i10,f10.0)
444 if (dgcgdaq(il,isp,k).gt.0) write (14,1411) il,isp,k,dgcgdaq(il,isp,k)
445 1411 format ('AQ',2x,3i10,f10.0)
446 1402 continue
447 1401 continue
448 1400 continue
449
450 ! decadal drawdown summaries
451
452 open (151,file='decddcib.dat')
453 open (152,file='decddcaq.dat')
454 open (153,file='decddgib.dat')
455 open (154,file='decddgaq.dat')
456
457 do 1500 k=1,27
458 write (151,1510) county(k),(addcib(1,isp,k),isp=18,68,10),(addcib(2,isp,k),isp=18,68,10)
459 write (152,1510)
460 county(k),(addcaq(1,isp,k),isp=18,68,10),(addcaq(2,isp,k),isp=18,68,10)

```

```
461 1510 format (a16,1x,12f10.0)
462 1500 continue
463
464 do 1501 k=1,8
465 write (153,1510) gcd(k),(addgib(1,isp,k),isp=18,68,10),(addgib(2,isp,k),isp=18,68,10)
466 write (154,1510) gcd(k),(addgaq(1,isp,k),isp=18,68,10),(addgaq(2,isp,k),isp=18,68,10)
467 1501 continue
468
469
470 stop
471 end
```

Appendix D

Source Code for *getpump.exe*

```

1  ! getpump.exe
2  !
3  ! reads grid file
4  ! read county list
5  ! read gcd list
6  ! read cbb file (pumping in position 6)
7  ! sum pumping
8  ! write county, gcd, and summary files
9
10 !declare arrays
11
12 dimension icounty(932,580),xc(932,580),yc(932,580),igma(932,580),igcd(932,580)
13 dimension ib(4,932,580),iaq(4,932,580)
14 dimension iclist(27),igcdlist(8)
15 dimension cbb(4,580,932)
16 dimension pumpcib(4,68,27),pumpcaq(4,68,27),pumpgib(4,68,8),pumpgaq(4,68,8)
17 dimension
18 pumpcoghp(2,68,27),pumpcdock(2,68,27),pumpgoghp(2,68,8),pumpgdock(2,68,8)
19 character*30 text,county(27),gcd(8),avgddcf(27),avgddgfn(8),simcbbfn
20 character*16 txtcbb
21
22 ! read grid file
23
24 open (1,file='hpas_grid_poly082615.csv')
25 read (1,*) text
26 do 100 k=1,540560
27 read (1,*)
28 ir,ic,(ib(il,ir,ic),il=1,4),x1,text,icounty(ir,ic),text,igcd(ir,ic),text,i1,igma(ir,ic),text,text,text,i1,(
29 iaq(il,ir,ic),il=1,4),xc(ir,ic),yc(ir,ic),i1,i2,i3
30 100 continue
31
32 ! read county list and output file names
33
34 open (2,file='countylist.dat')
35 do 200 k=1,27
36 read (2,*) county(k),iclist(k),avgddcf(k)
37 200 continue
38
39 open (3,file='gcdlist.dat')
40 do 300 k=1,8
41 read (3,*) gcd(k),igcdlist(k),avgddgfn(k)
42 300 continue
43
44 ! read cbb file (pumping in position 6)
45
46 open (41,file='simpumpfn.dat')

```

```

47 read (41,*) simcbbfn
48 open (42,file=simcbbfn,form='binary')
49 open (43,file='cbbheader.dat')
50
51 do 401 isp=1,68
52 write (*,411) isp
53 411 format ('+', 'Stress Period', 1x, i3)
54 do 402 kk=1, 10
55 read (42) kstp, kper, txtcbb, ncol, nrow, nlay
56 write (43,410) kstp, kper, txtcbb, ncol, nrow, nlay
57 410 format (2i10, 1x, a16, 1x, 3i10)
58 read (42) (((cbb(il,ic,ir), ic=1, 580), ir=1, 932), il=1, 4)
59
60 ! if position 6 (pumping data), sum for each county-layer unit and each gcd-layer unit
61
62 if (kk.eq.6) then
63 do 403 il=1, 4
64 do 404 ir=1, 932
65 do 405 ic=1, 580
66
67 ! convert pumping to AF/yr
68
69 paf=-cbb(il,ic,ir)*365/43560
70
71 ! ib-based
72
73 if (igma(ir,ic).eq.2.and.ib(il,ir,ic).gt.0) then
74
75 ! county-based ib totals
76
77 do 406 k=1, 26
78 if (icounty(ir,ic).eq.iclist(k)) then
79 pumpcib(il,isp,k)=pumpcib(il,isp,k)+paf
80 pumpcib(il,isp,27)=pumpcib(il,isp,27)+paf
81 end if
82 406 continue
83
84 ! gcd-based ib totals
85
86 do 407 k=1, 7
87 if (igcd(ir,ic).eq.igcdlist(k)) then
88 pumpgib(il,isp,k)=pumpgib(il,isp,k)+paf
89 pumpgib(il,isp,8)=pumpgib(il,isp,8)+paf
90 end if
91 407 continue
92

```

```

93  end if
94
95  ! aq-based
96
97  if (igma(ir,ic).eq.2.and.iaq(il,ir,ic).gt.0) then
98
99  ! county-based aq totals
100
101  do 408 k=1,26
102  if (icounty(ir,ic).eq.iclist(k)) then
103  pumpcaq(il,isp,k)=pumpcaq(il,isp,k)+paf
104  pumpcaq(il,isp,27)=pumpcaq(il,isp,27)+paf
105  end if
106  408 continue
107
108  ! gcd-based aq totals
109
110  do 409 k=1,7
111  if (igcd(ir,ic).eq.igcdlist(k)) then
112  pumpgaq(il,isp,k)=pumpgaq(il,isp,k)+paf
113  pumpgaq(il,isp,8)=pumpgaq(il,isp,8)+paf
114  end if
115  409 continue
116  end if
117
118  405 continue
119  404 continue
120  403 continue
121  end if
122  402 continue
123  401 continue
124
125  ! sum Ogallala-ETHP pumping (layers 1 and 2) and Dockum pumping (layers 3 and 4)
126  ! for county and gcd units
127
128  do 500 isp=1,68
129
130  ! county-based
131
132  do 501 k=1,27
133  pumpcoghp(1,isp,k)=pumpcib(1,isp,k)+pumpcib(2,isp,k)
134  pumpcdock(1,isp,k)=pumpcib(3,isp,k)+pumpcib(4,isp,k)
135  pumpcoghp(2,isp,k)=pumpcaq(1,isp,k)+pumpcaq(2,isp,k)
136  pumpcdock(2,isp,k)=pumpcaq(3,isp,k)+pumpcaq(4,isp,k)
137  501 continue
138

```

```

139 ! gcd=based
140
141 do 502 k=1,8
142 pumpgoghp(1,isp,k)=pumpgib(1,isp,k)+pumpgib(2,isp,k)
143 pumpgdock(1,isp,k)=pumpgib(3,isp,k)+pumpgib(4,isp,k)
144 pumpgoghp(2,isp,k)=pumpgaq(1,isp,k)+pumpgaq(2,isp,k)
145 pumpgdock(2,isp,k)=pumpgaq(3,isp,k)+pumpgaq(4,isp,k)
146 502 continue
147
148 500 continue
149
150 ! open each county file and write results
151
152 do 600 k=1,27
153 open (61,file=avgddcfm(k))
154 do 601 isp=1,68
155 write (61,610)
156 isp,isp+2012,pumpcoghp(1,isp,k),pumpcdock(1,isp,k),pumpcoghp(2,isp,k),pumpcdock(2
157 ,isp,k)
158 601 continue
159 610 format (2i10,4f10.0)
160 close (61)
161 600 continue
162
163 do 602 k=1,8
164 open (62,file=avgddgfn(k))
165 do 603 isp=1,68
166 write (62,610)
167 isp,isp+2012,pumpgoghp(1,isp,k),pumpgdock(1,isp,k),pumpgoghp(2,isp,k),pumpgdock(
168 2,isp,k)
169 603 continue
170 602 continue
171
172 ! write summary decadal files
173 !
174 open (71,file='decumpcib.dat')
175 open (72,file='decumpcaq.dat')
176 open (73,file='decumpgib.dat')
177 open (74,file='decumpgaq.dat')
178
179 do 700 k=1,27
180 write (71,710)
181 county(k),(pumpcoghp(1,isp,k),isp=18,68,10),(pumpcdock(1,isp,k),isp=18,68,10)
182 write (72,710)
183 county(k),(pumpcoghp(2,isp,k),isp=18,68,10),(pumpcdock(2,isp,k),isp=18,68,10)
184 710 format (a16,1x,12f10.0)

```

```
185 700 continue
186
187 do 701 k=1,8
188 write (73,710)
189 gcd(k),(pumpgogh(1,isp,k),isp=18,68,10),(pumpgdock(1,isp,k),isp=18,68,10)
190 write (74,710)
191 gcd(k),(pumpgogh(2,isp,k),isp=18,68,10),(pumpgdock(2,isp,k),isp=18,68,10)
192 701 continue
193
194
195 stop
196 end
```

Appendix E

Decadal Summaries of Average Drawdown and Pumping Ogallala-ETHP Aquifers County

Scenario 16 - Ogallala-ETHP Aquifers

County	Pumping (AF/yr) - All Active HPAS Cells						Average Drawdown from 2012 (ft) - All HPAS Active Cells					
	2030	2040	2050	2060	2070	2080	2030	2040	2050	2060	2070	2080
Andrews	19,391	17,897	16,937	16,260	15,764	15,378	2	3	3	4	4	4
Bailey	65,138	50,725	42,532	37,743	34,724	32,675	11	14	16	18	19	19
Borden	4,433	3,896	3,595	3,398	3,233	3,079	3	4	4	5	5	6
Briscoe	17,859	12,598	9,600	7,844	6,743	6,016	8	10	12	13	13	14
Castro	179,928	119,075	70,199	44,331	31,691	24,953	40	53	61	65	67	68
Cochran	73,991	62,095	54,265	48,560	43,632	40,036	11	14	17	19	20	22
Crosby	108,065	75,302	53,525	41,038	33,731	29,158	33	44	51	55	58	60
Dawson	121,339	98,595	84,200	75,460	70,276	66,962	19	25	29	32	34	35
Deaf Smith	135,383	95,875	70,425	55,842	47,248	41,961	17	22	25	27	29	30
Floyd	93,953	65,087	52,305	44,155	39,232	35,986	28	35	41	45	48	51
Gaines	205,487	177,779	159,527	147,035	138,166	131,986	15	19	22	24	25	26
Garza	13,508	12,402	11,717	11,263	10,948	10,721	6	8	9	10	11	12
Hale	116,615	75,108	53,298	41,142	34,308	30,298	32	38	42	44	46	46
Hockley	111,788	81,785	66,407	58,982	54,882	52,401	13	16	19	20	21	22
Howard	15,635	14,828	14,382	14,113	13,945	13,835	1	1	1	0	0	0
Lamb	120,172	77,677	60,088	52,063	47,868	45,425	25	30	32	33	34	35
Lubbock	110,472	100,950	95,478	91,655	88,877	86,736	11	14	16	17	19	19
Lynn	88,768	82,064	77,033	73,324	70,707	68,886	7	9	11	12	14	15
Martin	48,298	43,045	39,041	36,392	34,566	33,228	6	9	10	11	12	13
Parmer	92,026	63,568	46,836	37,743	32,290	28,758	22	27	31	33	34	35
Swisher	73,407	48,754	35,887	28,540	23,972	20,935	18	23	26	28	29	30
Terry	134,879	108,182	96,191	89,978	86,344	84,043	14	17	19	20	21	22
Yoakum	90,983	70,810	59,346	53,002	49,187	46,687	13	17	20	21	23	24
GMA2	2,041,508	1,558,096	1,272,815	1,109,868	1,012,332	950,143	16	21	24	26	27	28

Scenario 17 - Ogallala-ETHP Aquifers

County	Pumping (AF/yr) - All Active HPAS Cells						Average Drawdown from 2012 (ft) - All HPAS Active Cells					
	2030	2040	2050	2060	2070	2080	2030	2040	2050	2060	2070	2080
Andrews	19,391	17,897	16,937	16,260	15,764	15,378	2	3	3	4	4	4
Bailey	65,138	50,725	42,532	37,743	34,724	32,675	11	14	16	18	19	19
Borden	4,431	3,893	3,591	3,393	3,227	3,073	3	4	4	5	5	6
Briscoe	17,859	12,598	9,600	7,844	6,743	6,016	8	10	12	13	13	14
Castro	179,928	119,075	70,199	44,331	31,691	24,953	40	53	61	65	67	68
Cochran	73,991	62,095	54,265	48,560	43,632	40,036	11	14	17	19	20	22
Crosby	108,064	75,302	53,525	41,038	33,731	29,158	33	44	51	55	58	60
Dawson	121,337	98,591	84,193	75,449	70,264	66,947	19	25	29	32	34	35
Deaf Smith	135,383	95,875	70,425	55,842	47,248	41,961	17	22	25	27	29	30
Floyd	93,953	65,087	52,305	44,155	39,232	35,986	28	35	41	45	48	51
Gaines	205,486	177,777	159,523	147,029	138,158	131,975	15	19	22	24	25	26
Garza	13,508	12,402	11,717	11,263	10,948	10,721	6	8	9	10	11	12
Hale	116,615	75,108	53,298	41,142	34,308	30,298	32	38	42	44	46	46
Hockley	111,788	81,785	66,407	58,982	54,882	52,401	13	16	19	20	21	22
Howard	15,631	14,819	14,367	14,092	13,917	13,803	1	1	1	1	0	0
Lamb	120,172	77,677	60,088	52,063	47,868	45,425	25	30	32	33	34	35
Lubbock	110,472	100,950	95,478	91,655	88,877	86,736	11	14	16	17	19	19
Lynn	88,768	82,064	77,033	73,324	70,707	68,886	7	9	11	12	14	15
Martin	48,294	43,034	39,022	36,362	34,525	33,176	6	9	10	12	13	14
Parmer	92,026	63,568	46,836	37,743	32,290	28,758	22	27	31	33	34	35
Swisher	73,407	48,754	35,887	28,540	23,972	20,935	18	23	26	28	29	30
Terry	134,879	108,182	96,191	89,978	86,344	84,043	14	17	19	20	21	22
Yoakum	90,983	70,810	59,346	53,002	49,187	46,687	13	17	20	21	23	24
GMA2	2,041,495	1,558,068	1,272,763	1,109,794	1,012,238	950,027	16	21	24	26	27	28

Scenario 18 - Ogallala-ETHP Aquifers

County	Pumping (AF/yr) - All Active HPAS Cells						Average Drawdown from 2012 (ft) - All HPAS Active Cells					
	2030	2040	2050	2060	2070	2080	2030	2040	2050	2060	2070	2080
Andrews	19,391	17,897	16,937	16,260	15,764	15,378	2	3	3	4	4	4
Bailey	65,138	50,725	42,532	37,743	34,724	32,675	11	14	16	18	19	19
Borden	4,431	3,893	3,591	3,393	3,227	3,072	3	4	4	5	5	6
Briscoe	17,859	12,598	9,600	7,844	6,743	6,016	8	10	12	13	13	14
Castro	179,928	119,075	70,199	44,331	31,691	24,953	40	53	61	65	67	68
Cochran	73,991	62,095	54,265	48,560	43,632	40,036	11	14	17	19	20	22
Crosby	108,064	75,302	53,525	41,038	33,731	29,158	33	44	51	55	58	60
Dawson	121,337	98,590	84,192	75,449	70,263	66,946	19	25	29	32	34	35
Deaf Smith	135,383	95,875	70,425	55,842	47,248	41,961	17	22	25	27	29	30
Floyd	93,953	65,087	52,305	44,155	39,232	35,986	28	35	41	45	48	51
Gaines	205,486	177,777	159,523	147,028	138,157	131,974	15	19	22	24	25	26
Garza	13,508	12,402	11,717	11,263	10,948	10,721	6	8	9	10	11	12
Hale	116,615	75,108	53,298	41,142	34,308	30,298	32	38	42	44	46	46
Hockley	111,788	81,785	66,407	58,982	54,882	52,401	13	16	19	20	21	22
Howard	15,631	14,818	14,366	14,090	13,916	13,801	1	1	1	1	0	0
Lamb	120,172	77,677	60,088	52,063	47,868	45,425	25	30	32	33	34	35
Lubbock	110,472	100,950	95,478	91,655	88,877	86,736	11	14	16	17	19	19
Lynn	88,768	82,064	77,033	73,324	70,707	68,886	7	9	11	12	14	15
Martin	48,293	43,033	39,020	36,360	34,523	33,173	6	9	10	12	13	14
Parmer	92,026	63,568	46,836	37,743	32,290	28,758	22	27	31	33	34	35
Swisher	73,407	48,754	35,887	28,540	23,972	20,935	18	23	26	28	29	30
Terry	134,879	108,182	96,191	89,978	86,344	84,043	14	17	19	20	21	22
Yoakum	90,983	70,810	59,346	53,002	49,187	46,687	13	17	20	21	23	24
GMA2	2,041,494	1,558,066	1,272,760	1,109,790	1,012,232	950,020	16	21	24	26	27	28

Scenario 19 - Ogallala-ETHP Aquifers

County	Pumping (AF/yr) - All Active HPAS Cells						Average Drawdown from 2012 (ft) - All HPAS Active Cells					
	2030	2040	2050	2060	2070	2080	2030	2040	2050	2060	2070	2080
Andrews	19,391	17,897	16,937	16,260	15,764	15,378	2	3	3	4	4	4
Bailey	65,138	50,725	42,532	37,743	34,724	32,675	11	14	16	18	19	19
Borden	4,431	3,893	3,591	3,392	3,227	3,072	3	4	4	5	5	6
Briscoe	17,859	12,598	9,600	7,844	6,743	6,016	8	10	12	13	13	14
Castro	179,928	119,075	70,199	44,331	31,691	24,953	40	53	61	65	67	68
Cochran	73,991	62,095	54,265	48,560	43,632	40,036	11	14	17	19	20	22
Crosby	108,064	75,302	53,525	41,038	33,731	29,158	33	44	51	55	58	60
Dawson	121,336	98,590	84,192	75,448	70,262	66,945	19	25	29	32	34	35
Deaf Smith	135,383	95,875	70,425	55,842	47,248	41,961	17	22	25	27	29	30
Floyd	93,953	65,087	52,305	44,155	39,232	35,986	28	35	41	45	48	51
Gaines	205,486	177,777	159,523	147,028	138,157	131,974	15	19	22	24	25	26
Garza	13,508	12,402	11,717	11,263	10,948	10,721	6	8	9	10	11	12
Hale	116,615	75,108	53,298	41,142	34,308	30,298	32	38	42	44	46	46
Hockley	111,788	81,785	66,407	58,982	54,882	52,401	13	16	19	20	21	22
Howard	15,631	14,818	14,365	14,089	13,914	13,800	1	1	1	1	0	0
Lamb	120,172	77,677	60,088	52,063	47,868	45,425	25	30	32	33	34	35
Lubbock	110,472	100,950	95,478	91,655	88,877	86,736	11	14	16	17	19	19
Lynn	88,768	82,064	77,033	73,324	70,707	68,886	7	9	11	12	14	15
Martin	48,293	43,032	39,019	36,358	34,521	33,171	6	9	10	12	13	14
Parmer	92,026	63,568	46,836	37,743	32,290	28,758	22	27	31	33	34	35
Swisher	73,407	48,754	35,887	28,540	23,972	20,935	18	23	26	28	29	30
Terry	134,879	108,182	96,191	89,978	86,344	84,043	14	17	19	20	21	22
Yoakum	90,983	70,810	59,346	53,002	49,187	46,687	13	17	20	21	23	24
GMA2	2,041,493	1,558,064	1,272,758	1,109,785	1,012,228	950,015	16	21	24	26	27	28

Scenario 20 - Ogallala-ETHP Aquifers

County	Pumping (AF/yr) - All Active HPAS Cells						Average Drawdown from 2012 (ft) - All HPAS Active Cells					
	2030	2040	2050	2060	2070	2080	2030	2040	2050	2060	2070	2080
Andrews	19,391	17,897	16,937	16,260	15,764	15,378	2	3	3	4	4	4
Bailey	65,138	50,725	42,532	37,743	34,724	32,675	11	14	16	18	19	19
Borden	4,431	3,893	3,591	3,392	3,227	3,072	3	4	4	5	5	6
Briscoe	17,859	12,598	9,600	7,844	6,743	6,016	8	10	12	13	13	14
Castro	179,928	119,075	70,199	44,331	31,691	24,953	40	53	61	65	67	68
Cochran	73,991	62,095	54,265	48,560	43,632	40,036	11	14	17	19	20	22
Crosby	108,064	75,302	53,525	41,038	33,731	29,158	33	44	51	55	58	60
Dawson	121,336	98,590	84,191	75,447	70,261	66,945	19	25	29	32	34	35
Deaf Smith	135,383	95,875	70,425	55,842	47,248	41,961	17	22	25	27	29	30
Floyd	93,953	65,087	52,305	44,155	39,232	35,986	28	35	41	45	48	51
Gaines	205,486	177,777	159,523	147,028	138,157	131,973	15	19	22	24	25	26
Garza	13,508	12,402	11,717	11,263	10,948	10,721	6	8	9	10	11	12
Hale	116,615	75,108	53,298	41,142	34,308	30,298	32	38	42	44	46	46
Hockley	111,788	81,785	66,407	58,982	54,882	52,401	13	16	19	20	21	22
Howard	15,630	14,818	14,364	14,088	13,913	13,798	1	1	1	1	0	0
Lamb	120,172	77,677	60,088	52,063	47,868	45,425	25	30	32	33	34	35
Lubbock	110,472	100,950	95,478	91,655	88,877	86,736	11	14	16	17	19	19
Lynn	88,768	82,064	77,033	73,324	70,707	68,886	7	9	11	12	14	15
Martin	48,293	43,032	39,018	36,357	34,519	33,169	6	9	10	12	13	14
Parmer	92,026	63,568	46,836	37,743	32,290	28,758	22	27	31	33	34	35
Swisher	73,407	48,754	35,887	28,540	23,972	20,935	18	23	26	28	29	30
Terry	134,879	108,182	96,191	89,978	86,343	84,043	14	17	19	20	21	22
Yoakum	90,983	70,810	59,346	53,002	49,187	46,687	13	17	20	21	23	24
GMA2	2,041,493	1,558,062	1,272,756	1,109,782	1,012,223	950,009	16	21	24	26	27	28

Scenario 21 - Ogallala-ETHP Aquifers

County	Pumping (AF/yr) - All Active HPAS Cells						Average Drawdown from 2012 (ft) - All HPAS Active Cells					
	2030	2040	2050	2060	2070	2080	2030	2040	2050	2060	2070	2080
Andrews	19,391	17,897	16,937	16,260	15,764	15,378	2	3	3	4	4	4
Bailey	65,138	50,725	42,532	37,743	34,724	32,675	11	14	16	18	19	19
Borden	4,431	3,893	3,590	3,392	3,226	3,072	3	4	4	5	5	6
Briscoe	17,859	12,598	9,600	7,844	6,743	6,016	8	10	12	13	13	14
Castro	179,928	119,075	70,199	44,331	31,691	24,953	40	53	61	65	67	68
Cochran	73,991	62,095	54,265	48,560	43,632	40,036	11	14	17	19	20	22
Crosby	108,064	75,302	53,525	41,038	33,731	29,158	33	44	51	55	58	60
Dawson	121,336	98,590	84,191	75,447	70,261	66,944	19	25	29	32	34	35
Deaf Smith	135,383	95,875	70,425	55,842	47,248	41,961	17	22	25	27	29	30
Floyd	93,953	65,087	52,305	44,155	39,232	35,986	28	35	41	45	48	51
Gaines	205,486	177,777	159,522	147,028	138,156	131,973	15	19	22	24	25	26
Garza	13,508	12,402	11,717	11,263	10,948	10,721	6	8	9	10	11	12
Hale	116,615	75,108	53,298	41,142	34,308	30,298	32	38	42	44	46	46
Hockley	111,788	81,785	66,407	58,982	54,882	52,401	13	16	19	20	21	22
Howard	15,630	14,817	14,363	14,087	13,912	13,796	1	1	1	1	0	0
Lamb	120,172	77,677	60,088	52,063	47,868	45,425	25	30	32	33	34	35
Lubbock	110,472	100,950	95,478	91,655	88,877	86,736	11	14	16	17	19	19
Lynn	88,768	82,064	77,033	73,324	70,707	68,886	7	9	11	12	14	15
Martin	48,293	43,031	39,017	36,355	34,517	33,167	6	9	10	12	13	14
Parmer	92,026	63,568	46,836	37,743	32,290	28,758	22	27	31	33	34	35
Swisher	73,407	48,754	35,887	28,540	23,972	20,935	18	23	26	28	29	30
Terry	134,879	108,182	96,191	89,978	86,343	84,043	14	17	19	20	21	22
Yoakum	90,983	70,810	59,346	53,002	49,187	46,687	13	17	20	21	23	24
GMA2	2,041,492	1,558,061	1,272,754	1,109,779	1,012,220	950,005	16	21	24	26	27	28

Appendix F

Decadal Summaries of Average Drawdown and Pumping Dockum Aquifer County

Scenario 16 - Dockum Aquifer

County	Pumping (AF/yr) - All Active HPAS Cells						Average Drawdown from 2012 (ft) - All Active HPAS Cells					
	2030	2040	2050	2060	2070	2080	2030	2040	2050	2060	2070	2080
Andrews	1,503	1,503	1,503	1,503	1,503	1,503	2	3	4	5	6	7
Bailey	949	949	949	949	949	949	7	11	14	18	21	24
Borden	1,025	1,025	1,025	1,025	1,025	1,025	2	3	3	4	5	5
Briscoe	0	0	0	0	0	0	5	6	7	8	8	9
Castro	484	484	484	484	484	484	25	38	49	59	67	73
Cochran	1,107	1,107	1,107	1,107	1,107	1,107	5	7	10	12	15	17
Crosby	4,393	4,393	4,393	4,393	4,393	4,393	23	31	36	40	43	45
Dawson	0	0	0	0	0	0	4	7	9	11	13	15
Deaf Smith	5,012	5,012	5,012	5,012	5,012	5,012	16	23	28	33	37	40
Floyd	3,674	3,674	3,674	3,674	3,674	3,674	27	36	43	47	51	54
Gaines	0	0	0	0	0	0	6	10	13	16	19	21
Garza	1,038	1,038	1,038	1,038	1,038	1,038	1	1	1	1	1	1
Hale	1,277	1,277	1,277	1,277	1,277	1,277	31	43	53	61	69	75
Hockley	1,204	1,204	1,204	1,204	1,204	1,204	6	8	11	14	17	20
Howard	1,809	1,809	1,809	1,809	1,809	1,809	2	3	3	4	4	4
Lamb	1,051	1,051	1,051	1,051	1,051	1,051	17	25	32	39	44	49
Lubbock	1,236	1,236	1,236	1,236	1,236	1,236	13	19	24	29	33	37
Lynn	1,039	1,039	1,039	1,039	1,039	1,039	4	7	9	12	14	16
Martin	9	9	9	9	9	9	2	3	4	5	5	6
Parmer	6,207	6,207	6,207	5,202	5,187	5,182	25	37	48	58	67	75
Swisher	1,795	1,795	1,795	1,795	1,795	1,795	17	23	28	33	36	39
Terry	0	0	0	0	0	0	2	4	5	6	7	8
Yoakum	0	0	0	0	0	0	2	3	5	6	7	8
GMA2	34,811	34,811	34,811	33,806	33,792	33,786	11	16	20	24	27	30

Scenario 17 - Dockum Aquifer

County	Pumping (AF/yr) - All Active HPAS Cells						Average Drawdown from 2012 (ft) - All Active HPAS Cells					
	2030	2040	2050	2060	2070	2080	2030	2040	2050	2060	2070	2080
Andrews	1,503	1,503	1,503	1,503	1,503	1,503	2	3	4	5	6	7
Bailey	949	949	949	949	949	949	7	11	14	18	21	24
Borden	1,025	1,025	1,025	1,025	1,025	1,025	2	3	4	4	5	5
Briscoe	0	0	0	0	0	0	5	6	7	8	8	9
Castro	484	484	484	484	484	484	25	38	49	59	67	73
Cochran	1,107	1,107	1,107	1,107	1,107	1,107	5	7	10	12	15	17
Crosby	4,393	4,393	4,393	4,393	4,393	4,393	23	31	36	40	43	45
Dawson	480	480	480	480	480	480	5	8	10	12	14	16
Deaf Smith	5,012	5,012	5,012	5,012	5,012	5,012	16	23	28	33	37	40
Floyd	3,674	3,674	3,674	3,674	3,674	3,674	27	36	43	47	51	54
Gaines	660	660	660	660	660	660	7	11	14	17	20	23
Garza	1,038	1,038	1,038	1,038	1,038	1,038	1	1	1	1	1	1
Hale	1,277	1,277	1,277	1,277	1,277	1,277	31	43	53	61	69	75
Hockley	1,204	1,204	1,204	1,204	1,204	1,204	6	8	11	14	17	20
Howard	5,530	5,530	5,530	5,530	5,530	5,530	5	6	7	8	8	9
Lamb	1,051	1,051	1,051	1,051	1,051	1,051	17	25	32	39	44	49
Lubbock	1,236	1,236	1,236	1,236	1,236	1,236	13	19	24	29	33	37
Lynn	1,039	1,039	1,039	1,039	1,039	1,039	4	7	9	12	14	16
Martin	8,589	8,589	8,589	8,589	8,589	8,589	14	18	22	26	30	33
Parmer	6,207	6,207	6,207	5,202	5,187	5,182	25	37	48	58	67	75
Swisher	1,795	1,795	1,795	1,795	1,795	1,795	17	23	28	33	36	39
Terry	0	0	0	0	0	0	2	4	5	6	7	8
Yoakum	0	0	0	0	0	0	2	3	5	6	7	8
GMA2	48,252	48,252	48,252	47,247	47,233	47,227	12	17	21	25	28	31

Scenario 18 - Dockum Aquifer

County	Pumping (AF/yr) - All Active HPAS Cells						Average Drawdown from 2012 (ft) - All Active HPAS Cells					
	2030	2040	2050	2060	2070	2080	2030	2040	2050	2060	2070	2080
Andrews	1,503	1,503	1,503	1,503	1,503	1,503	2	3	4	5	6	7
Bailey	949	949	949	949	949	949	7	11	14	18	21	24
Borden	1,025	1,025	1,025	1,025	1,025	1,025	2	3	4	4	5	5
Briscoe	0	0	0	0	0	0	5	6	7	8	8	9
Castro	484	484	484	484	484	484	25	38	49	59	67	73
Cochran	1,107	1,107	1,107	1,107	1,107	1,107	5	7	10	12	15	17
Crosby	4,393	4,393	4,393	4,393	4,393	4,393	23	31	36	40	43	45
Dawson	560	560	560	560	560	560	5	8	10	12	14	16
Deaf Smith	5,012	5,012	5,012	5,012	5,012	5,012	16	23	28	33	37	40
Floyd	3,674	3,674	3,674	3,674	3,674	3,674	27	36	43	47	51	54
Gaines	770	770	770	770	770	770	7	11	14	17	20	23
Garza	1,038	1,038	1,038	1,038	1,038	1,038	1	1	1	1	1	1
Hale	1,277	1,277	1,277	1,277	1,277	1,277	31	43	53	61	69	75
Hockley	1,204	1,204	1,204	1,204	1,204	1,204	6	8	11	14	17	20
Howard	6,150	6,150	6,150	6,150	6,150	6,150	5	6	7	8	8	9
Lamb	1,051	1,051	1,051	1,051	1,051	1,051	17	25	32	39	44	49
Lubbock	1,236	1,236	1,236	1,236	1,236	1,236	13	19	24	29	33	37
Lynn	1,039	1,039	1,039	1,039	1,039	1,039	4	7	9	12	14	16
Martin	10,020	10,020	10,020	10,020	10,020	10,020	14	19	23	27	31	34
Parmer	6,207	6,207	6,207	5,202	5,187	5,182	25	37	48	58	67	75
Swisher	1,795	1,795	1,795	1,795	1,795	1,795	17	23	28	33	36	39
Terry	0	0	0	0	0	0	2	4	5	6	7	8
Yoakum	0	0	0	0	0	0	2	3	5	6	7	8
GMA2	50,493	50,493	50,493	49,488	49,474	49,468	12	17	21	25	28	31

Scenario 19 - Dockum Aquifer

County	Pumping (AF/yr) - All Active HPAS Cells						Average Drawdown from 2012 (ft) - All Active HPAS Cells					
	2030	2040	2050	2060	2070	2080	2030	2040	2050	2060	2070	2080
Andrews	1,503	1,503	1,503	1,503	1,503	1,503	2	3	4	5	6	7
Bailey	949	949	949	949	949	949	7	11	14	18	21	24
Borden	1,025	1,025	1,025	1,025	1,025	1,025	2	3	4	4	5	5
Briscoe	0	0	0	0	0	0	5	6	7	8	8	9
Castro	484	484	484	484	484	484	25	38	49	59	67	73
Cochran	1,107	1,107	1,107	1,107	1,107	1,107	5	7	10	12	15	17
Crosby	4,393	4,393	4,393	4,393	4,393	4,393	23	31	36	40	43	45
Dawson	640	640	640	640	640	640	5	8	10	12	14	16
Deaf Smith	5,012	5,012	5,012	5,012	5,012	5,012	16	23	28	33	37	40
Floyd	3,674	3,674	3,674	3,674	3,674	3,674	27	36	43	47	51	54
Gaines	880	880	880	880	880	880	7	11	14	17	20	23
Garza	1,038	1,038	1,038	1,038	1,038	1,038	1	1	1	1	1	1
Hale	1,277	1,277	1,277	1,277	1,277	1,277	31	43	53	61	69	75
Hockley	1,204	1,204	1,204	1,204	1,204	1,204	6	8	11	14	17	20
Howard	6,770	6,770	6,770	6,770	6,770	6,770	5	7	8	8	9	9
Lamb	1,051	1,051	1,051	1,051	1,051	1,051	17	25	32	39	44	49
Lubbock	1,236	1,236	1,236	1,236	1,236	1,236	13	19	24	29	33	37
Lynn	1,039	1,039	1,039	1,039	1,039	1,039	4	7	9	12	14	16
Martin	11,449	11,449	11,449	11,449	11,449	11,449	15	20	24	28	32	36
Parmer	6,207	6,207	6,207	5,202	5,187	5,182	25	37	48	58	67	75
Swisher	1,795	1,795	1,795	1,795	1,795	1,795	17	23	28	33	36	39
Terry	0	0	0	0	0	0	2	4	5	6	7	8
Yoakum	0	0	0	0	0	0	2	3	5	6	7	8
GMA2	52,732	52,732	52,732	51,727	51,713	51,707	12	17	21	25	28	31

Scenario 20 - Dockum Aquifer

County	Pumping (AF/yr) - All Active HPAS Cells						Average Drawdown from 2012 (ft) - All Active HPAS Cells					
	2030	2040	2050	2060	2070	2080	2030	2040	2050	2060	2070	2080
Andrews	1,503	1,503	1,503	1,503	1,503	1,503	2	3	4	5	6	7
Bailey	949	949	949	949	949	949	7	11	14	18	21	24
Borden	1,025	1,025	1,025	1,025	1,025	1,025	2	3	4	4	5	5
Briscoe	0	0	0	0	0	0	5	6	7	8	8	9
Castro	484	484	484	484	484	484	25	38	49	59	67	73
Cochran	1,107	1,107	1,107	1,107	1,107	1,107	5	7	10	12	15	17
Crosby	4,393	4,393	4,393	4,393	4,393	4,393	23	31	36	40	43	45
Dawson	720	720	720	720	720	720	5	8	10	12	14	16
Deaf Smith	5,012	5,012	5,012	5,012	5,012	5,012	16	23	28	33	37	40
Floyd	3,674	3,674	3,674	3,674	3,674	3,674	27	36	43	47	51	54
Gaines	990	990	990	990	990	990	7	11	14	18	20	23
Garza	1,038	1,038	1,038	1,038	1,038	1,038	1	1	1	1	1	1
Hale	1,277	1,277	1,277	1,277	1,277	1,277	31	43	53	61	69	75
Hockley	1,204	1,204	1,204	1,204	1,204	1,204	6	8	11	14	17	20
Howard	7,390	7,390	7,390	7,390	7,390	7,390	5	7	8	8	9	10
Lamb	1,051	1,051	1,051	1,051	1,051	1,051	17	25	32	39	44	49
Lubbock	1,236	1,236	1,236	1,236	1,236	1,236	13	19	24	29	33	37
Lynn	1,039	1,039	1,039	1,039	1,039	1,039	4	7	9	12	14	16
Martin	12,880	12,880	12,880	12,880	12,880	12,880	15	20	25	29	33	37
Parmer	6,207	6,207	6,207	5,202	5,187	5,182	25	37	48	58	67	75
Swisher	1,795	1,795	1,795	1,795	1,795	1,795	17	23	28	33	36	39
Terry	0	0	0	0	0	0	2	4	5	6	7	8
Yoakum	0	0	0	0	0	0	2	3	5	6	7	8
GMA2	54,974	54,974	54,974	53,969	53,954	53,949	12	17	21	25	28	32

Scenario 21 - Dockum Aquifer

County	Pumping (AF/yr) - All Active HPAS Cells						Average Drawdown from 2012 (ft) - All Active HPAS Cells					
	2030	2040	2050	2060	2070	2080	2030	2040	2050	2060	2070	2080
Andrews	1,503	1,503	1,503	1,503	1,503	1,503	2	3	4	5	6	7
Bailey	949	949	949	949	949	949	7	11	14	18	21	24
Borden	1,025	1,025	1,025	1,025	1,025	1,025	2	3	4	4	5	5
Briscoe	0	0	0	0	0	0	5	6	7	8	8	9
Castro	484	484	484	484	484	484	25	38	49	59	67	73
Cochran	1,107	1,107	1,107	1,107	1,107	1,107	5	7	10	12	15	17
Crosby	4,393	4,393	4,393	4,393	4,393	4,393	23	31	36	40	43	45
Dawson	800	800	800	800	800	800	5	8	10	12	15	16
Deaf Smith	5,012	5,012	5,012	5,012	5,012	5,012	16	23	28	33	37	40
Floyd	3,674	3,674	3,674	3,674	3,674	3,674	27	36	43	47	51	54
Gaines	1,100	1,100	1,100	1,100	1,100	1,100	7	11	14	18	21	23
Garza	1,038	1,038	1,038	1,038	1,038	1,038	1	1	1	1	1	1
Hale	1,277	1,277	1,277	1,277	1,277	1,277	31	43	53	61	69	75
Hockley	1,204	1,204	1,204	1,204	1,204	1,204	6	8	11	14	17	20
Howard	8,010	8,010	8,010	8,010	8,010	8,010	5	7	8	9	9	10
Lamb	1,051	1,051	1,051	1,051	1,051	1,051	17	25	32	39	44	49
Lubbock	1,236	1,236	1,236	1,236	1,236	1,236	13	19	24	29	33	37
Lynn	1,039	1,039	1,039	1,039	1,039	1,039	4	7	9	12	14	16
Martin	14,310	14,310	14,310	14,310	14,310	14,310	15	21	25	30	34	38
Parmer	6,207	6,207	6,207	5,202	5,187	5,182	25	37	48	58	67	75
Swisher	1,795	1,795	1,795	1,795	1,795	1,795	17	23	28	33	36	39
Terry	0	0	0	0	0	0	2	4	5	6	7	9
Yoakum	0	0	0	0	0	0	2	3	5	6	7	8
GMA2	57,213	57,213	57,213	56,208	56,194	56,188	12	17	21	25	29	32

Appendix G

Decadal Summaries of Average Drawdown and Pumping Ogallala-ETHP Aquifers GCD

Scenario 16 - Ogallala-ETHP Aquifers

County	Pumping (AF/yr) - All Active HPAS Cells						Average Drawdown from 2012 (ft) - All HPAS Active Cells					
	2030	2040	2050	2060	2070	2080	2030	2040	2050	2060	2070	2080
Garza	13,508	12,402	11,717	11,263	10,948	10,721	6	8	9	10	11	12
HighPlains	1,330,390	969,810	757,049	637,331	567,401	523,798	21	27	30	33	34	35
LlanoEstacado	205,487	177,779	159,527	147,035	138,166	131,986	15	19	22	24	25	26
Mesa	121,339	98,595	84,200	75,460	70,276	66,962	19	25	29	32	34	35
PermianBasin	63,462	57,398	52,939	50,010	48,006	46,550	4	6	7	7	8	8
SandyLand	90,983	70,810	59,346	53,002	49,187	46,687	13	17	20	21	23	24
SouthPlains	137,517	109,187	96,684	90,309	86,609	84,278	14	17	19	21	22	23
GMA2 (GCD Area Only)	1,962,677	1,495,978	1,221,463	1,064,414	970,592	910,982	16	20	22	24	26	26

Scenario 17 - Ogallala-ETHP Aquifers

County	Pumping (AF/yr) - All Active HPAS Cells						Average Drawdown from 2012 (ft) - All HPAS Active Cells					
	2030	2040	2050	2060	2070	2080	2030	2040	2050	2060	2070	2080
Garza	13,508	12,402	11,717	11,263	10,948	10,721	6	8	9	10	11	12
HighPlains	1,330,390	969,810	757,049	637,331	567,401	523,798	21	27	30	33	34	35
LlanoEstacado	205,486	177,777	159,523	147,029	138,158	131,975	15	19	22	24	25	26
Mesa	121,337	98,591	84,193	75,449	70,264	66,947	19	25	29	32	34	35
PermianBasin	63,454	57,379	52,905	49,960	47,939	46,467	4	6	7	7	8	9
SandyLand	90,983	70,810	59,346	53,002	49,187	46,687	13	17	20	21	23	24
SouthPlains	137,517	109,187	96,684	90,308	86,609	84,277	14	17	19	21	22	23
GMA2 (GCD Area Only)	1,962,666	1,495,952	1,221,416	1,064,346	970,504	910,873	16	20	22	24	26	27

Scenario 18 - Ogallala-ETHP Aquifers

County	Pumping (AF/yr) - All Active HPAS Cells						Average Drawdown from 2012 (ft) - All HPAS Active Cells					
	2030	2040	2050	2060	2070	2080	2030	2040	2050	2060	2070	2080
Garza	13,508	12,402	11,717	11,263	10,948	10,721	6	8	9	10	11	12
HighPlains	1,330,390	969,810	757,049	637,331	567,401	523,798	21	27	30	33	34	35
LlanoEstacado	205,486	177,777	159,523	147,028	138,157	131,974	15	19	22	24	25	26
Mesa	121,337	98,590	84,192	75,449	70,263	66,946	19	25	29	32	34	35
PermianBasin	63,454	57,377	52,903	49,956	47,935	46,462	4	6	7	7	8	9
SandyLand	90,983	70,810	59,346	53,002	49,187	46,687	13	17	20	21	23	24
SouthPlains	137,517	109,187	96,684	90,308	86,609	84,277	14	17	19	21	22	23
GMA2 (GCD Area Only)	1,962,665	1,495,950	1,221,413	1,064,341	970,499	910,866	16	20	22	24	26	27

Scenario 19 - Ogallala-ETHP Aquifers

County	Pumping (AF/yr) - All Active HPAS Cells						Average Drawdown from 2012 (ft) - All HPAS Active Cells					
	2030	2040	2050	2060	2070	2080	2030	2040	2050	2060	2070	2080
Garza	13,508	12,402	11,717	11,263	10,948	10,721	6	8	9	10	11	12
HighPlains	1,330,390	969,810	757,049	637,331	567,401	523,798	21	27	30	33	34	35
LlanoEstacado	205,486	177,777	159,523	147,028	138,157	131,974	15	19	22	24	25	26
Mesa	121,336	98,590	84,192	75,448	70,262	66,945	19	25	29	32	34	35
PermianBasin	63,453	57,376	52,901	49,954	47,931	46,458	4	6	7	7	8	9
SandyLand	90,983	70,810	59,346	53,002	49,187	46,687	13	17	20	21	23	24
SouthPlains	137,517	109,187	96,684	90,308	86,609	84,277	14	17	19	21	22	23
GMA2 (GCD Area Only)	1,962,665	1,495,949	1,221,411	1,064,337	970,495	910,862	16	20	22	24	26	27

Scenario 20 - Ogallala-ETHP Aquifers

County	Pumping (AF/yr) - All Active HPAS Cells						Average Drawdown from 2012 (ft) - All HPAS Active Cells					
	2030	2040	2050	2060	2070	2080	2030	2040	2050	2060	2070	2080
Garza	13,508	12,402	11,717	11,263	10,948	10,721	6	8	9	10	11	12
HighPlains	1,330,390	969,810	757,049	637,331	567,401	523,798	21	27	30	33	34	35
LlanoEstacado	205,486	177,777	159,523	147,028	138,157	131,973	15	19	22	24	25	26
Mesa	121,336	98,590	84,191	75,447	70,261	66,945	19	25	29	32	34	35
PermianBasin	63,453	57,375	52,899	49,951	47,928	46,454	4	6	7	7	8	9
SandyLand	90,983	70,810	59,346	53,002	49,187	46,687	13	17	20	21	23	24
SouthPlains	137,517	109,187	96,684	90,308	86,609	84,277	14	17	19	21	22	23
GMA2 (GCD Area Only)	1,962,664	1,495,947	1,221,409	1,064,334	970,491	910,856	16	20	22	24	26	27

Scenario 21 - Ogallala-ETHP Aquifers

County	Pumping (AF/yr) - All Active HPAS Cells						Average Drawdown from 2012 (ft) - All HPAS Active Cells					
	2030	2040	2050	2060	2070	2080	2030	2040	2050	2060	2070	2080
Garza	13,508	12,402	11,717	11,263	10,948	10,721	6	8	9	10	11	12
HighPlains	1,330,390	969,810	757,049	637,331	567,401	523,798	21	27	30	33	34	35
LlanoEstacado	205,486	177,777	159,522	147,028	138,156	131,973	15	19	22	24	25	26
Mesa	121,336	98,590	84,191	75,447	70,261	66,944	19	25	29	32	34	35
PermianBasin	63,452	57,374	52,898	49,949	47,926	46,451	4	6	7	8	8	9
SandyLand	90,983	70,810	59,346	53,002	49,187	46,687	13	17	20	21	23	24
SouthPlains	137,517	109,187	96,684	90,308	86,609	84,277	14	17	19	21	22	23
GMA2 (GCD Area Only)	1,962,664	1,495,946	1,221,407	1,064,332	970,487	910,852	16	20	22	24	26	27

Appendix H

Decadal Summaries of Average Drawdown and Pumping Dockum Aquifer GCD

Scenario 16 - Dockum Aquifer

County	Pumping (AF/yr) - All Active HPAS Cells						Average Drawdown from 2012 (ft) - All HPAS Active Cells					
	2030	2040	2050	2060	2070	2080	2030	2040	2050	2060	2070	2080
Garza	1,038	1,038	1,038	1,038	1,038	1,038	1	1	1	1	1	1
HighPlains	29,244	29,244	29,244	28,240	28,225	28,219	18	25	32	37	42	46
LlanoEstacado	0	0	0	0	0	0	6	10	13	16	19	21
Mesa	0	0	0	0	0	0	4	7	9	11	13	15
PermianBasin	1,684	1,684	1,684	1,684	1,684	1,684	2	3	3	4	5	5
SandyLand	0	0	0	0	0	0	2	3	5	6	7	8
SouthPlains	0	0	0	0	0	0	2	4	5	6	7	8
GMA2 (GCD Area Only)	31,966	31,966	31,966	30,961	30,947	30,941	11	15	19	23	26	28

Scenario 17 - Dockum Aquifer

County	Pumping (AF/yr) - All Active HPAS Cells						Average Drawdown from 2012 (ft) - All HPAS Active Cells					
	2030	2040	2050	2060	2070	2080	2030	2040	2050	2060	2070	2080
Garza	1,038	1,038	1,038	1,038	1,038	1,038	1	1	1	1	1	1
HighPlains	29,244	29,244	29,244	28,240	28,225	28,219	18	25	32	37	42	46
LlanoEstacado	660	660	660	660	660	660	7	11	14	17	20	23
Mesa	480	480	480	480	480	480	5	8	10	12	14	16
PermianBasin	13,985	13,985	13,985	13,985	13,985	13,985	10	13	16	18	20	22
SandyLand	0	0	0	0	0	0	2	3	5	6	7	8
SouthPlains	0	0	0	0	0	0	2	4	5	6	7	8
GMA2 (GCD Area Only)	45,407	45,407	45,407	44,402	44,388	44,382	11	16	20	24	27	30

Scenario 18 - Dockum Aquifer

County	Pumping (AF/yr) - All Active HPAS Cells						Average Drawdown from 2012 (ft) - All HPAS Active Cells					
	2030	2040	2050	2060	2070	2080	2030	2040	2050	2060	2070	2080
Garza	1,038	1,038	1,038	1,038	1,038	1,038	1	1	1	1	1	1
HighPlains	29,244	29,244	29,244	28,240	28,225	28,219	18	25	32	37	42	46
LlanoEstacado	770	770	770	770	770	770	7	11	14	17	20	23
Mesa	560	560	560	560	560	560	5	8	10	12	14	16
PermianBasin	16,036	16,036	16,036	16,036	16,036	16,036	10	13	16	19	21	23
SandyLand	0	0	0	0	0	0	2	3	5	6	7	8
SouthPlains	0	0	0	0	0	0	2	4	5	6	7	8
GMA2 (GCD Area Only)	47,648	47,648	47,648	46,643	46,629	46,623	11	16	20	24	27	30

Scenario 19 - Dockum Aquifer

County	Pumping (AF/yr) - All Active HPAS Cells						Average Drawdown from 2012 (ft) - All HPAS Active Cells					
	2030	2040	2050	2060	2070	2080	2030	2040	2050	2060	2070	2080
Garza	1,038	1,038	1,038	1,038	1,038	1,038	1	1	1	1	1	1
HighPlains	29,244	29,244	29,244	28,240	28,225	28,219	18	25	32	37	42	46
LlanoEstacado	880	880	880	880	880	880	7	11	14	17	20	23
Mesa	640	640	640	640	640	640	5	8	10	12	14	16
PermianBasin	18,085	18,085	18,085	18,085	18,085	18,085	10	14	17	19	22	24
SandyLand	0	0	0	0	0	0	2	3	5	6	7	8
SouthPlains	0	0	0	0	0	0	2	4	5	6	7	8
GMA2 (GCD Area Only)	49,887	49,887	49,887	48,882	48,868	48,862	11	16	20	24	27	30

Scenario 20 - Dockum Aquifer

County	Pumping (AF/yr) - All Active HPAS Cells						Average Drawdown from 2012 (ft) - All HPAS Active Cells					
	2030	2040	2050	2060	2070	2080	2030	2040	2050	2060	2070	2080
Garza	1,038	1,038	1,038	1,038	1,038	1,038	1	1	1	1	1	1
HighPlains	29,244	29,244	29,244	28,240	28,225	28,219	18	25	32	37	42	46
LlanoEstacado	990	990	990	990	990	990	7	11	14	18	20	23
Mesa	720	720	720	720	720	720	5	8	10	12	14	16
PermianBasin	20,136	20,136	20,136	20,136	20,136	20,136	11	14	17	20	22	25
SandyLand	0	0	0	0	0	0	2	3	5	6	7	8
SouthPlains	0	0	0	0	0	0	2	4	5	6	7	8
GMA2 (GCD Area Only)	52,129	52,129	52,129	51,124	51,109	51,104	11	16	20	24	27	30

Scenario 21 - Dockum Aquifer

County	Pumping (AF/yr) - All Active HPAS Cells						Average Drawdown from 2012 (ft) - All HPAS Active Cells					
	2030	2040	2050	2060	2070	2080	2030	2040	2050	2060	2070	2080
Garza	1,038	1,038	1,038	1,038	1,038	1,038	1	1	1	1	1	1
HighPlains	29,244	29,244	29,244	28,240	28,225	28,219	18	25	32	37	42	46
LlanoEstacado	1,100	1,100	1,100	1,100	1,100	1,100	7	11	14	18	21	23
Mesa	800	800	800	800	800	800	5	8	10	12	15	16
PermianBasin	22,185	22,185	22,185	22,185	22,185	22,185	11	15	18	21	23	26
SandyLand	0	0	0	0	0	0	2	3	5	6	7	8
SouthPlains	0	0	0	0	0	0	2	4	5	6	7	8
GMA2 (GCD Area Only)	54,368	54,368	54,368	53,363	53,349	53,343	11	16	20	24	27	30