Draft GAM Run 09-035 (version 2)

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This document is released for the purpose of interim review under the authority of William R. Hutchison, P.E. 96287, P.G. 286 on August 7, 2010

EXECUTIVE SUMMARY:

Eleven simulations of groundwater pumping were run using the modified and recalibrated groundwater availability model of the Edwards-Trinity (Plateau) and Pecos Valley aquifers. Scenario 1 represents pumping that is consistent with the requested pumping by the groundwater conservation districts in both Groundwater Management Areas 3 and 7. Scenario 2 represents an increase of ten percent in pumping in each county of Groundwater Management Area 7 as compared to Scenario 1. Scenarios 3, 4 and 5 represent 20, 30, and 40 percent pumping increases in each county in Groundwater Management Area 7 as compared to Scenario 1, respectively. The results from Scenario 1 to 5 were summarized and distributed at the July 29, 2010 meeting of Groundwater Management Area 7. At the meeting, representatives of the groundwater conservation districts provided updates to their requested pumping on a county by county basis, pumping was adjusted in the model, and the results discussed. Scenarios 6 to 10 were run during the meeting, and were based on input from the groundwater conservation districts.

In Groundwater Management Area 7, the average drawdown in Scenario 1 is 6 feet. Scenarios 2 to 5 (run prior to the July 29 meeting of Groundwater Management Area 7) resulted in a foot of additional drawdown for each ten percent increase in pumping. Scenarios 6 to 10 resulted in average drawdown of seven feet in Groundwater Management Area 7.

Subsequent to the Groundwater Management Area 7 meeting, representative of interested parties in Groundwater Management Area 3 reviewed the model calibration and the model runs, including the first draft version of this report. As a result of that review and subsequent conversations, Scenario 11 was run for use in the establishing desired future conditions in Groundwater Management Area 3. Average drawdown in Groundwater Management Area 3 in Scenario 11 is estimated to be 28 feet.

REQUESTOR:

Ms Caroline Runge, General Manager of the Menard County Underground Water Conservation District, on behalf of Groundwater Management Area 7 requested a series of runs that involved running the groundwater availability model for the Edwards-Trinity (Plateau) and Pecos Valley aquifers under a variety of pumping scenarios to estimate drawdown in each county in Groundwater Management Area 7. As a result of limitations with the existing groundwater availability model, the existing model was modified and recalibrated subsequent to the initial requests.

During the work associated with the modification and recalibration, presentations to the groundwater conservation districts in Groundwater Management Area 7 were made at the April, May and June meetings of Groundwater Management Area 7. As a result of those presentations, the scope of the request runs was simplified. Prior to the July 29, 2010 meeting of Groundwater Management Area 7, a summary table with the results of one

simulation were transmitted to the groundwater conservation districts in Groundwater Management Area 7.

On the basis of the results of the initial simulation, Mr. Scott Holland and Mr. Allan Lange requested additional scenarios. At the July 29, 2010 meeting of Groundwater Management Area 7, the results of five scenarios were presented. During the meeting, an additional five scenarios were run based on input from the groundwater conservation districts. This report summarizes the results of the ten scenarios.

Because the modified and recalibrated model also covers all of Groundwater Management Area 3, the model runs also provide results that can be used in the consideration of desired future condition adoption in Groundwater Management Area 3. The initial requests for Groundwater Management Area 3 were developed through public meetings held by the Middle Pecos Groundwater Conservation District (the only groundwater conservation district in Groundwater Management Area 3) in May and June of 2010.

Subsequent to the Groundwater Management Area 7 meeting, representative of interested parties in Groundwater Management Area 3 reviewed the model calibration and the model runs, including the first draft version of this report. As a result of that review and subsequent conversations, Scenario 11 was run for use in the establishing desired future conditions in Groundwater Management Area 3.

DESCRIPTION OF REQUEST:

Eleven simulations of groundwater pumping were run using the modified and recalibrated groundwater availability model of the Edwards-Trinity (Plateau) and Pecos Valley Alluvium aquifers. Each scenario was completed under the assumption of average groundwater recharge conditions. Scenarios 1 to 5 were run prior to the July 29, 2010 meeting of Groundwater Management Area 7. Scenarios 6 to 10 were run during the meeting, and were based on input from the groundwater conservation districts. The objective of running the model at the meeting was to provide an opportunity for the groundwater conservation districts to evaluate the effects of changes in pumping on their own district and neighboring districts and facilitate communication among the districts on these impacts. Scenario 11 was run as a result of discussions with interested parties in Groundwater Management Area 3.

A county-by-county summary of pumping for the Groundwater Management Area 7 portion of the model area is presented in Table 1. Please note that pumping in Pecos County in Table 1 represents pumping for the entire county, even though part of Pecos County is located in Groundwater Management Area 3. Pumping in the rest of Groundwater Management Area 3 did not change in these ten scenarios, and is summarized in Table 2. Pumping in Winkler County for Scenarios 1 to 10 was 50,000 acre-feet per year for Scenarios 1 to 10, and 40,000 acre-feet per year in Scenario 11.

Table 1. Summary of pumping in GMA 7 counties.
Note that Pecos County pumping includes all pumping in GMA 3 and GMA 7

County	Pumping (AF/yr)									
	1	2	3	4	5	6	7	8	9	10
Coke	300	330	360	390	420	300	1,000	1,000	1,000	1,000
Concho	350	385	420	455	490	490	490	490	490	490
Crockett	5,475	6,023	6,570	7,118	7,665	5,475	5,475	5,475	5,475	5,475
Ector	5,534	6,087	6,641	7,194	7,748	5,534	5,534	5,534	5,534	5,534
Edwards	7,782	8,560	9,338	10,117	10,895	4,000	4,000	4,000	5,659	5,659
Gillespie	5,000	5,500	6,000	6,500	7,000	5,000	5,000	5,000	5,000	5,000
Glasscock	59,252	65,177	71,102	77,028	82,953	59,252	59,252	65,177	65,177	65,177
Irion	2,300	2,530	2,760	2,990	3,220	2,300	2,300	2,300	2,300	2,300
Kimble	1,000	1,100	1,200	1,300	1,400	1,400	1,400	1,400	1,400	1,400
Kinney	65,000	71,500	78,000	84,500	91,000	65,000	65,000	65,000	65,000	65,000
McCulloch	150	165	180	195	210	150	150	150	150	150
Mason	20	22	24	26	28	20	20	20	20	20
Menard	1,843	2,027	2,212	2,396	2,580	2,580	2,580	2,580	2,580	2,580
Midland	21,130	23,243	25,356	27,469	29,582	21,130	21,130	23,243	23,243	23,243
Nolan	500	550	600	650	700	700	700	700	700	700
Pecos	220,000	242,000	264,000	286,000	308,000	240,000	240,000	240,000	240,000	240,000
Reagan	62,039	68,243	74,447	80,651	86,855	62,039	62,039	68,243	68,243	68,243
Real	11,468	12,615	13,762	14,908	16,055	4,000	4,000	4,000	7,533	7,533
Schelicher	6,200	6,820	7,440	8,060	8,680	8,060	8,680	8,680	8,680	8,060
Sterling	2,500	2,750	3,000	3,250	3,500	2,500	2,500	2,500	2,500	2,500
Sutton	4,000	4,400	4,800	5,200	5,600	6,450	6,450	6,450	6,450	6,450
Taylor	350	385	420	455	490	490	490	490	490	490
Terrell	1,031	1,134	1,237	1,340	1,443	1,443	1,443	1,443	1,443	1,443
TomGreen	2,000	2,200	2,400	2,600	2,800	2,800	2,800	2,800	2,800	2,800
Upton	20,341	22,375	24,409	26,443	28,477	20,341	20,341	22,375	22,375	22,375
Uvalde	2,000	2,200	2,400	2,600	2,800	2,000	2,000	2,000	2,000	2,000
ValVerde	25,000	27,500	30,000	32,500	35,000	25,000	25,000	25,000	25,000	25,000

Table 2. Simulated pumping in Groundwater Management Area (GMA) 3 counties (except for Pecos County) for all ten scenarios.

GMA 3 counties	Simulated pumping (AF/yr) Scenarios 1 to 10	Simulated pumping (AF/yr) Scenario 11
Crane	5,000	5,000
Loving	3,000	3,000
Reeves	190,000	190,000
Ward	50,000	50,000
Winkler	50,000	40,000

Pumping in counties outside of Groundwater Management Area 3 and Groundwater Management Area 7 did not change in these ten scenarios, and is summarized in Table 3.

Table 3. Simulated pumping in counties outside of Groundwater Management Area 3 and Groundwater Management Area 7 for all eleven scenarios.

Counties outside of GMA 3 and GMA 7	Simulated pumping (AF/yr)
Andrews	1,200
Bandera	2,600
Bexar	11,000
Blanco	744
Brewster	1,200
Burnet	700
Comal	3,058
Culberson	37
Hays	7,000
Howard	700
Jeff Davis	140
Kendall	4,500
Kerr	6,000
Martin	250
Medina	1,843
Travis	3,000
Outside of Texas	20

METHODS:

Scenarios 1 to 10 were developed in response to various model run requests by the groundwater conservation districts in Groundwater Management Area 7 as later modified in discussions during Groundwater Management Area 7 meetings in April, May and June 2010. These requests revolved around certain county by county future pumping scenarios and general management goals regarding the amount of drawdown in various portions of Groundwater Management Area 7. In summary, relatively high drawdown was anticipated in the western portion of Groundwater Management Area 7, and essentially no drawdown was anticipated in the eastern portion of Groundwater Management Area 7 in order to maintain groundwater discharge to surface water.

Scenario 1 represents pumping that is consistent with the requested pumping by the groundwater conservation districts in both Groundwater Management Areas 3 and 7. Scenario 2 represents an increase of ten percent in pumping for each county located in Groundwater Management Area 7 as compared to Scenario 1. Scenarios 3, 4 and 5 represent 20, 30, and 40 percent pumping increases in each county in Groundwater Management Area 7 as compared to Scenario 1, respectively. The results from Scenario 1 to 5 were summarized and distributed at the July 29, 2010 meeting of Groundwater Management Area 7. At the meeting, representatives of the groundwater conservation districts provided updates to their requested pumping on a county by county basis, pumping was adjusted in the model, and the results discussed. Scenarios 6 to 10 were run during the meeting, and were based on input from the groundwater conservation districts.

Scenario 11 was developed after discussions with Mr. Neil Blandford of Daniel B. Stephens & Associates, Inc., representing the Colorado River Municipal Water District. Mr. Blandford had reviewed the model subsequent to the July 29, 2010 Groundwater Management Area 7 meeting, and reviewed the first draft of this report. Mr. Blandford expressed concerns regarding the specific storage parameter in Crane, Ward, and Winkler counties. He had prepared hydrographs that demonstrated the sensitivity of this parameter to drawdown in these counties.

As a result of Mr. Blandford's comments, a detailed sensitivity analysis was completed on specific storage in those counties. Increases in specific storage up to ten times the values specified in the model used in Scenarios 1 to 10 in Crane, Ward, and Winkler counties resulted in some minor changes to the model calibration statistics. Although increasing specific storage generally resulted in a worse calibration based on the statistics, they were generally deemed insignificant. However, analysis of hydrographs based on the results of the sensitivity analysis suggested that drawdown in some wells was better simulated when specific storage was slightly increaased as compared to the model used in Scenarios 1 to 10. The resulting changes in specific storage are summarized below in terms of storativity (specific storage times saturated thickness).

County	Average storativity used in Scenarios 1 to 10 (dimensionless)	Average storativity used in Scenario 11 (dimensionless)
Crane	0.00234	0.01420
Ward	0.01359	0.05919
Winkler	0.00669	0.03254

Because field data on specific storage (or storativity) is sparse, all the values listed above are considered reasonable given the uncertainty in this parameter. Because the historic pumping in these counties is substantially less than that requested in the predictive runs, the increased pumping will undoubtedly cause substantial drawdown in these area. However, there is considerable uncertainty associated with estimating the drawdown as evidenced by the sensitivity analysis which demonstrated that small changes in storativity can result in differences in drawdown in the tens of feet.

Scenario 11 was run with the alternative specific storage values listed above as input into the process of establishing desired future conditions in Groundwater Management Area 3. These changes did not affect the results of adjacent areas of Groundwater Management Area 7.

PARAMETERS AND ASSUMPTIONS:

- The recently modified and calibrated groundwater flow model of the Edwards Trinity (Plateau) and Pecos Valley aquifers (Hutchison and Jones, 2010) was used for these simulations. The model was calibrated based on groundwater elevation data from 1930 to 2005. Scenarios 1 to 10 used the calibrated model. As discussed above, specific storage values were modified in Crane, Ward, and Winkler counties for Scenario 11.

- The model has one layer which represents the Pecos Valley Aquifer in the northwest portion of the model area, the Edwards-Trinity (Plateau) Aquifer in the southeast portion of the model area, and a lumped representation of both aquifers in the relatively narrow area where the Pecos Valley Aquifer overlies the Edwards-Trinity (Plateau) Aquifer.

- As further detailed in the model report (Hutchison and Jones, 2010), model calibration statistics for the entire model domain for groundwater elevation is summarized below. Note that the calibrated model statistics are presented as well as the statistics for the modified model used in Scenario 11.

Statistic	Calibrated Model Used in Scenarios 1 to 10	Modified Model Used in Scenario 11
Average residual	-1.3 feet	-2.9 feet
Standard deviation	70 feet	70 feet
Range of measurements	3058 feet	3058 feet
Standard deviation divided by range	0.02	0.02

- Eleven different pumping scenarios were used as described above
- Each simulation consisted of 55 annual stress periods. Pumping for the first five stress periods (2006 to 2010) was set equal to pumping estimated during model calibration for 2005. Pumping in stress periods 6 to 55 (2011 to 2060) was set equal to the values previously presented in Tables 1, 2 and 3, based on the scenario.
- Drawdown was calculated based on the difference between an initial condition at the end of 2010 (stress period 5) and the end of stress period 55 (2060).
- Recharge in each stress period was assumed to be equal to average recharge during the calibration period (1930 to 2005).
- Other model inputs were based on average recharge conditions, and did not vary during the simulations.
- The model was run with MODFLOW-2000 (Harbaugh and others, 2000).

RESULTS:

Groundwater Management Area 7 Results

Estimated drawdown in 2060 for the ten scenarios on a county basis is presented in Table 4. Note that the drawdown estimate for Pecos County is limited to the portion of Pecos County that is in Groundwater Management Area 7. Also listed is the average drawdown for each scenario averaged over all of Groundwater Management Area 7. Note that the average drawdown in Scenario 1 is 6 feet. Scenarios 2 to 5 (run prior to the July 29 meeting of Groundwater Management Area 7) resulted in a foot of additional drawdown for each ten percent increase in pumping. Scenarios 6 to 10 resulted in average drawdown of seven feet, and the differences between scenarios can be seen in individual county drawdown estimates due to changes in pumping in individual counties.

Table 4. Estimated drawdown in feet from 2010 conditions for ten scenarios. Groundwater Management Area 7

County	Drawdown in 2060 (ft)									
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Coke	0	0	0	0	0	0	0	0	0	0
Concho	0	0	0	0	0	0	0	0	0	0
Crockett	8	9	10	12	13	8	9	9	9	9
Ector	7	7	7	8	8	7	7	7	7	7
Edwards	2	2	3	3	3	1	1	1	2	2
Gillespie	5	5	6	6	6	5	5	5	5	5
Glasscock	31	34	38	42	45	31	31	34	34	34
Irion	8	9	11	12	14	8	9	10	10	10
Kimble	1	1	1	1	1	1	1	1	1	1
Kinney	0	1	1	1	1	0	0	0	0	0
McCulloch	0	0	0	0	0	0	0	0	0	0
Mason	0	0	0	0	0	0	0	0	0	0
Menard	0	1	1	1	1	1	1	1	1	1
Midland	9	10	10	11	12	9	9	10	10	10
Nolan	0	0	0	0	0	0	0	0	0	0
Pecos (GMA 7 portion)	9	11	12	14	15	11	11	11	11	11
Reagan	32	37	42	47	51	33	33	37	37	37
Real	6	7	8	9	10	1	1	1	4	4
Schelicher	6	7	8	9	10	7	7	8	8	8
Sterling	5	6	7	8	9	5	5	6	6	6
Sutton	5	6	7	7	8	6	6	6	6	6
Taylor	0	0	0	0	0	0	0	0	0	0
Terrell	2	2	3	3	3	2	2	2	2	2
TomGreen	2	2	2	3	3	2	2	2	2	2
Upton	12	13	15	16	18	12	12	13	13	13
Uvalde	3	4	4	5	5	1	1	1	2	2
ValVerde	1	1	1	2	2	1	1	1	1	1
GMA 7 Average	**6**	**7**	**8**	**9**	**10**	**7**	**7**	**7**	**7**	**7**

Groundwater Management Area 3 Results

Estimated drawdown in 2060 for the counties in Groundwater Management Area 3 for Scenario 11 is presented in Table 5. Please note that the overall average drawdown in Groundwater Management Area 3 shown in Table 5 only includes the Groundwater Management Area 3 portion of Pecos County.

Table 5. Estimated drawdown in Groundwater Management Area (GMA) 3 based on Scenario 11

County	**Drawdown in 2060 (feet)**
Crane	50
Loving	5
Pecos (GMA 3 portion only)	12
Reeves	6
Ward	56
Winkler	113
GMA 3 Average	**28**

REFERENCES:

Harbaugh, A.W., Banta, E.R., Hill, M.C., and McDonald, M.G., 2000, MODFLOW-2000, The U.S. Geological Survey modular ground-water model-user guide to modularization concepts and the ground-water flow process: U.S. Geological Survey Open-File Report 00-92, 121 p.

Hutchison, William R., and Jones, Ian, 2010 (in preparation). Evaluation of Groundwater Flow in Groundwater Management Areas 3 and 7 Using a MODFLOW-2000 Model. Texas Water Development Board Unpublished Report.