GAM Task 10-009 Model Run Report

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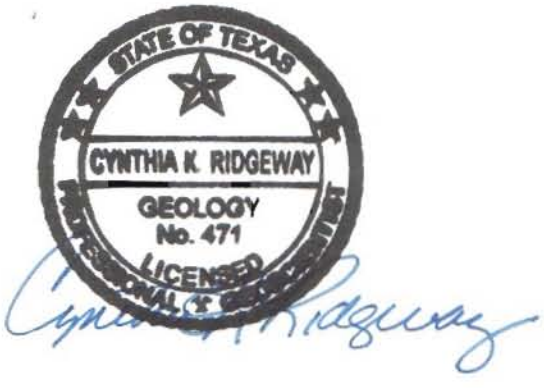

Cynthia K. Ridgeway is the Manager of the Groundwater Availability Modeling Section and is responsible for oversight of work performed by employees under her direct supervision. The seal appearing on this document was authorized by Cynthia K. Ridgeway, P.G. 471 on September 3, 2010.

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EXECUTIVE SUMMARY:

This report documents the methods and results for two 51-year predictive groundwater availability model runs. In the first simulation, using the groundwater availability model for the northern portion of the Carrizo-Wilcox, Queen City, and Sparta aquifers, pumping levels requested by the members of Groundwater Management Area 11 resulted in an overall average drawdown of 17 feet. In the second simulation, using the groundwater availability model for the Yegua-Jackson Aquifer, pumping was determined iteratively to achieve 17 feet of drawdown in the aquifer over the management area.

PURPOSE AND DESCRIPTION OF MODEL RUNS:

The model runs contained in this report were performed using the groundwater availability models for the northern portion of the Carrizo-Wilcox, Queen City, and Sparta aquifers and the Yegua-Jackson Aquifer. The two model simulations presented here were run at the request of the members of Groundwater Management Area 11. The model run for the Carrizo-Wilcox, Queen City, and Sparta aquifers was performed using pumping specified by the members of the Groundwater Management Area 11 over the 51-year period from 2010 through 2060. For the model run for the Yegua-Jackson Aquifer, pumping was adjusted to achieve 17-feet of drawdown over the same 51-year period.

PARAMETERS AND ASSUMPTIONS:

Northern Portion of the Carrizo-Wilcox, Queen City, and Sparta Aquifers

The parameters and assumptions for the groundwater availability model run for the northern portion of the Carrizo-Wilcox, Queen City, and Sparta aquifers are described below:

- We used version 2.01 of the groundwater availability model for the northern portion of the Queen City, Sparta, and Carrizo-Wilcox aquifers.

- We used Groundwater Vistas Version 5 (Environmental Simulations, Inc. 2007) as the interface to process model output.

- See Fryar and others (2003) and Kelley and others (2004) for assumptions and limitations of the groundwater availability model for the northern part of the Carrizo-Wilcox, Queen City, and Sparta aquifers.

- The model includes eight layers, representing:

    1. Sparta Aquifer (Layer 1)
    2. Weches confining unit (Layer 2)
    3. Queen City Aquifer (Layer 3)
    4. Reklaw confining unit (Layer 4)
    5. Carrizo Aquifer (Layer 5)
    6. Upper Wilcox Aquifer (Layer 6)
    7. Middle Wilcox Aquifer (Layer 7)

8. Lower Wilcox Aquifer (Layer 8)

- In the Sabine Uplift area, a portion of Layer 8, though active in the model, is outside the extent of the Lower Wilcox unit of the Carrizo-Wilcox Aquifer as described in Kelley and others (2004). Because of this, results for Layer 8 in this area were not included when determining the average drawdown over Groundwater Management Area 11 (see Figure 1).

- The mean absolute error (a measure of the difference between simulated and measured water levels during model calibration) in the groundwater availability model is 15 feet for the Sparta Aquifer, 24 feet for the Queen City Aquifer, 28 feet for the Carrizo Aquifer, 24 feet for the Upper Wilcox Aquifer, 29 feet for the Middle Wilcox Aquifer, and 25 feet for the Lower Wilcox Aquifer between 1990 and 1999 (Kelley and others, 2004).

- Recharge rates are based on average (1961 to 1990) precipitation (Kelley and others, 2004).

Yegua-Jackson Aquifer

The parameters and assumptions for the model run using the groundwater availability model for the Yegua-Jackson Aquifer are described below:

- We used version 1.01 of the groundwater availability model for the Yegua-Jackson Aquifer. See Deeds and others (2010) for assumptions and limitations of the groundwater availability model.

- The model includes five layers representing the Yegua-Jackson Aquifer and the overlying Catahoula unit.

- As reported in Deeds and others (2010), the mean absolute errors (a measure of the difference between simulated and measured water levels during model calibration) for the Jackson Group (combined upper and lower Jackson units), Upper Yegua, and Lower Yegua portions of the Yegua-Jackson Aquifer for the historical-calibration period of the model are 31, 24, and 25 feet, respectively.

- Cells were assigned to individual counties and groundwater conservation districts as shown in the March 23, 2010 version of the cell assignment model grid for the Yegua-Jackson Aquifer.

- The recharge used for the model run represents average recharge as described in Deeds and others (2010).

- The model results presented in this report were extracted from all areas of the model representing the units comprising the Yegua-Jackson Aquifer. This includes some areas outside the “official” boundary of the aquifer shown in the 2007 State Water

Plan (TWDB, 2007). For this reason, the reported drawdowns may reflect water of quality ranging from fresh to brackish and saline.

Pumping

The pumping in the Carrizo-Wilcox, Queen City, and Sparta aquifers for the predictive simulation for each county was provided by the members of Groundwater Management Area 11. These values are shown in Table 1. Beginning with the pumping distribution for the last year of the historical-calibration period (1999), pumping was adjusted in each county to match the requested pumping in Table 1. Where a decrease in pumping was necessary, the pumping in each cell in the county was reduced by a uniform factor, preserving the original pumping distribution. Where an increase in pumping was required, pumping was spread evenly among those cells in the county that contained pumping during the last year of the historical-calibration period.

It was necessary to make one change to the pumping distribution for the last year of the historical-calibration period prior to adjusting pumping in each county. As described above, there is a portion of Layer 8 in the model in the Sabine uplift area that, though active, does not represent the Lower Wilcox unit of the Carrizo-Wilcox Aquifer (Figure 1). Because of this, the pumping in this area was moved to Layer 7 prior to making the above adjustments. Also, when predictive pumping was requested for the Lower Wilcox in this area, it was applied to Layer 7 as opposed to Layer 8.

The pumping in the groundwater availability model for the Yegua-Jackson Aquifer was adjusted to match a requested drawdown over the groundwater management area of 17 feet. The methods for adjusting the pumping in this model are the same as described in GAM Task 10-012 (Oliver, 2010). For comparison, the model simulation for the Yegua-Jackson Aquifer documented in this report would correspond approximately to a “Scenario 3.9” in Oliver (2010).

RESULTS:

Table 2 below shows the pumping output from the groundwater availability model for the northern portion of the Carrizo-Wilcox, Queen City, and Sparta aquifers for the last year of the predictive simulation (representing 2060) by county. In Anderson County, results are split between the portion of the county in Anderson County Underground Water Conservation District and the portion in Neches and Trinity Valleys Groundwater Conservation District.

The total pumping for the Carrizo-Wilcox, Queen City, and Sparta aquifers for 2060 is approximately 512,000 acre-feet per year. This is less than the requested 532,000 acre-feet per year, primarily due to the occurrence of dry cells. A cell becomes dry in the model when the water level in the cell drops below the base of the aquifer. In this situation, pumping can no longer occur.

Also notice that some of the pumping requested for the Lower Wilcox unit (Layer 8) has been moved to the Middle Wilcox (Layer 7). This is due to the portion of Layer 8 outside the

extent of the Lower Wilcox unit in the model (see Figure 1). As described above, the pumping was consolidated into Layer 7 in this area (for example, Cass County).

Table 3 below shows the average drawdown over the 51-year predictive simulation for each of the areas shown in Table 2. Drawdown in the Weches and Reklaw confining units has also been included, though no pumping exists in these units in the model. The average drawdown over Groundwater Management Area 11 for these aquifers is 17 feet.

Table 4 below shows the results of the 51-year predictive simulation for the Yegua-Jackson Aquifer. The pumping in each county that achieves the average 17-foot drawdown over Groundwater Management Area 11 is shown, as well as the associated drawdown for each county. The pumping for the last year of the historical-calibration period of the model has also been included for comparison. As mentioned above, the simulation used the same methods described in GAM Task 10-012 and would approximately correspond to a "Scenario 3.9" in Table A-1 and Figure A-1 of that report (Oliver, 2010).

It is important to note that sub-regional water budgets are not exact. This is due to the size of the model cells and the approach used to extract data from the model. To avoid double accounting, a model cell that straddles a political boundary is assigned to one side of the boundary based on the location of the centroid of the model cell. For example, if a cell contains two counties, the cell is assigned to the county where the centroid of the cell is located.

REFERENCES AND ASSOCIATED MODEL RUNS:

Deeds, N.E., Yan, T., Singh, A., Jones, T.L., Kelley, V.A., Knox, P.R., Young, S.C., 2010, Groundwater availability model for the Yegua-Jackson Aquifer: Final report prepared for the Texas Water Development Board by INTERA, Inc., 582 p.

Environmental Simulations, Inc., 2007, Guide to using Groundwater Vistas Version 5, 381 p

Fryar, D., Senger, R., Deeds, N., Pickens, J., Jones, T., Whallon, A. J., and Dean, K. E., 2003, Groundwater Availability Model for the Northern Carrizo-Wilcox Aquifer: contract report to the Texas Water Development Board, 529 p.

Kelley, V. A., Deeds, N. E., Fryar, D. G., and Nicot, J. P., 2004, Groundwater availability models for the Queen City and Sparta aquifers: contract report to the Texas Water Development Board, 867 p.

Oliver, W., 2010, GAM Task 10-012: Texas Water Development Board, GAM Task 10-012 Report, 48 p.

Texas Water Development Board, 2007, Water for Texas – 2007—Volumes I-III; Texas Water Development Board Document No. GP-8-1, 392 p.

Table 1. Pumping requested by members of Groundwater Management Area 11 for the Carrizo-Wilcox, Queen City, and Sparta aquifers for the predictive groundwater availability model run. All values are in acre-feet per year.

County	Sparta	Queen City	Carrizo	Upper Wilcox	Middle Wilcox	Lower Wilcox	Total
Anderson	616	18,800	7,182	2,277	351	275	29,501
Angelina	690	1,093	23,540	2,875	0	0	28,199
Bowie				7,354	5,357	279	12,990
Camp		3,705	1,963	1,111	968	2	7,749
Cass		39,194	1,989	882	483	181	42,729
Cherokee	359	22,396	5,556	5,648	19	0	33,978
Franklin			2,012	1,257	6,228	309	9,807
Gregg		7,574	4,154	2,381	1,117	0	15,226
Harrison		10,373	5,533	1,747	1,162	472	19,288
Henderson		15,849	4,732	1,837	1,365	1,622	25,406
Hopkins			485	203	1,334	2,233	4,254
Houston	897	410	5,319	38	0	0	6,664
Marion		15,549	1,420	426	230	3	17,628
Morris		9,652	1,291	405	958	5	12,312
Nacogdoches	409	5,003	11,000	9,708	679	1	26,800
Panola		0	2,528	774	5,227	1,264	9,792
Rains				661	673	423	1,757
Rusk	4,362	59	6,957	5,157	8,732	0	25,266
Sabine	296	0	4,229	1,695	472	472	7,165
San Augustine	206	7	1,130	646	5	0	1,995
Shelby		0	4,247	3,322	4,856	107	12,531
Smith	0	54,254	15,012	13,674	4,567	0	87,507
Titus		139	3,153	1,920	5,955	33	11,200
Trinity	617	0	2,215	0	0	0	2,832
Upshur	0	25,571	4,184	2,322	613	0	32,689
Van Zandt		3,814	3,193	1,548	4,017	2,226	14,798
Wood	0	10,112	13,563	5,907	2,263	20	31,865
Total	**8,452**	**243,556**	**136,586**	**75,775**	**57,633**	**9,926**	**531,929**

Table 2. Pumping output from the groundwater availability model in Groundwater Management Area 11 for the Carrizo-Wilcox, Queen City, and Sparta aquifers for the for the last year of the predictive simulation (2060). All values are in acre-feet per year. "Anderson (ACUWCD)" refers to the Anderson County Underground Water Conservation District within Anderson County. "Anderson (NTVGCD)" refers to the portion of Neches and Trinity Valleys Groundwater Conservation District in Anderson County.

County	Sparta	Queen City	Carrizo	Upper Wilcox	Middle Wilcox	Lower Wilcox	Total
Anderson (ACUWCD)		951	282	107	15	7	1,361
Anderson (NTVGCD)	616	17,849	6,896	2,169	336	267	28,133
Angelina	689	1,093	23,540	2,874	0	0	28,196
Bowie				1,542	5,541	0	7,083
Camp		3,542	1,963	1,110	968	0	7,583
Cass		39,194	1,989	882	663	0	42,727
Cherokee	359	22,396	5,556	5,647	19	0	33,977
Franklin			1,895	1,257	6,332	0	9,484
Gregg		7,573	4,153	2,380	1,116	0	15,222
Harrison		10,373	5,262	1,746	1,627	4	19,012
Henderson		15,849	4,365	1,837	1,364	1,619	25,034
Hopkins			325	203	2,864	0	3,392
Houston	896	410	5,317	38	0	0	6,662
Marion		15,549	1,420	425	232	0	17,626
Morris		9,537	1,193	404	961	0	12,095
Nacogdoches	409	5,002	11,000	9,707	678	0	26,796
Panola		0	810	770	5,764	725	8,069
Rains				506	1,001	76	1,583
Rusk		58	6,927	5,156	8,731	0	20,872
Sabine	296	0	4,221	1,695	471	471	7,154
San Augustine	205	7	1,130	645	5	0	1,992
Shelby		0	1,451	3,316	4,855	106	9,728
Smith	0	54,254	14,987	13,673	4,566	0	87,479
Titus		138	1,791	1,905	5,941	0	9,776
Trinity	616	0	2,215	0	0	0	2,831
Upshur	0	25,390	4,182	2,321	612	0	32,505
Van Zandt		3,814	2,322	1,541	4,129	2,059	13,864
Wood	0	10,112	13,124	5,906	2,281	0	31,423
Total	**4,085**	**243,090**	**128,316**	**69,762**	**61,071**	**5,334**	**511,659**

Table 3. Average drawdown over the 51-year predictive groundwater availability model run in Groundwater Management Area 11 for the Carrizo-Wilcox, Queen City, and Sparta aquifers and Weches and Reklaw confining units. All values are in feet. "Anderson (ACUWCD)" refers to the Anderson County Underground Water Conservation District within Anderson County. "Anderson (NTVGCD)" refers to the portion of Neches and Trinity Valleys Groundwater Conservation District in Anderson County. Negative values indicate a rise in water levels.

County	Sparta	Weches (CU)	Queen City	Reklaw (CU)	Carrizo	Upper Wilcox	Middle Wilcox	Lower Wilcox	Overall
Anderson (ACUWCD)			1	12	35	26	12	5	15
Anderson (NTVGCD)	-2	1	7	15	36	26	11	4	16
Angelina	10	11	16	22	42	5	-18	-3	11
Bowie						21	0	0	1
Camp			12	0	18	17	39	0	19
Cass			8	6	10	7	7	0	8
Cherokee	7	14	11	11	32	32	15	10	18
Franklin				-16	-3	7	19	0	11
Gregg			7	11	42	49	56	79	35
Harrison			0	2	24	13	5	4	9
Henderson			4	15	41	32	27	15	23
Hopkins				-22	-12	-15	-28	0	-26
Houston	2	1	2	15	35	12	2	-2	8
Marion			17	11	21	15	15	0	16
Morris			13	10	29	25	23	0	21
Nacogdoches	3	3	11	10	14	11	-10	-6	4
Panola			-11	-19	11	2	1	4	2
Rains						7	-10	-5	-8
Rusk	0	-46	-15	-2	6	6	23	21	12
Sabine	5	5	7	15	24	13	6	5	10
San Augustine	-4	-4	-3	11	20	9	-3	-2	3
Shelby			-18	-19	23	-3	3	1	1
Smith	-5	-5	11	34	103	118	92	76	68
Titus			-1	-3	31	14	5	0	9
Trinity	5	4	4	12	33	-3	-7	-1	6
Upshur	-5	-5	5	17	56	66	66	97	44
Van Zandt			7	11	31	13	17	11	14
Wood	-5	-7	-2	36	110	83	55	114	59
Total	**3**	**4**	**7**	**15**	**38**	**26**	**15**	**11**	**17**

Table 4. Pumping and average drawdown in the portion of the Yegua-Jackson Aquifer in Groundwater Management Area 11 (GMA 11) in the predictive groundwater availability model run. Pumping for the last year of the historical-calibration portion of the model has also been included for comparison. All pumping values are in acre-feet per year. All drawdown values are in feet.

County	1997 Pumping	Pumping for 17-foot Scenario	Drawdown for 17-foot Scenario
Angelina	6,313	16,507	32
Houston	851	5,385	3
Nacogdoches	104	235	8
Sabine	2,490	4,299	15
San Augustine	118	2,111	13
Trinity	956	2,891	11
GMA 11	**10,833**	**31,426**	**17**

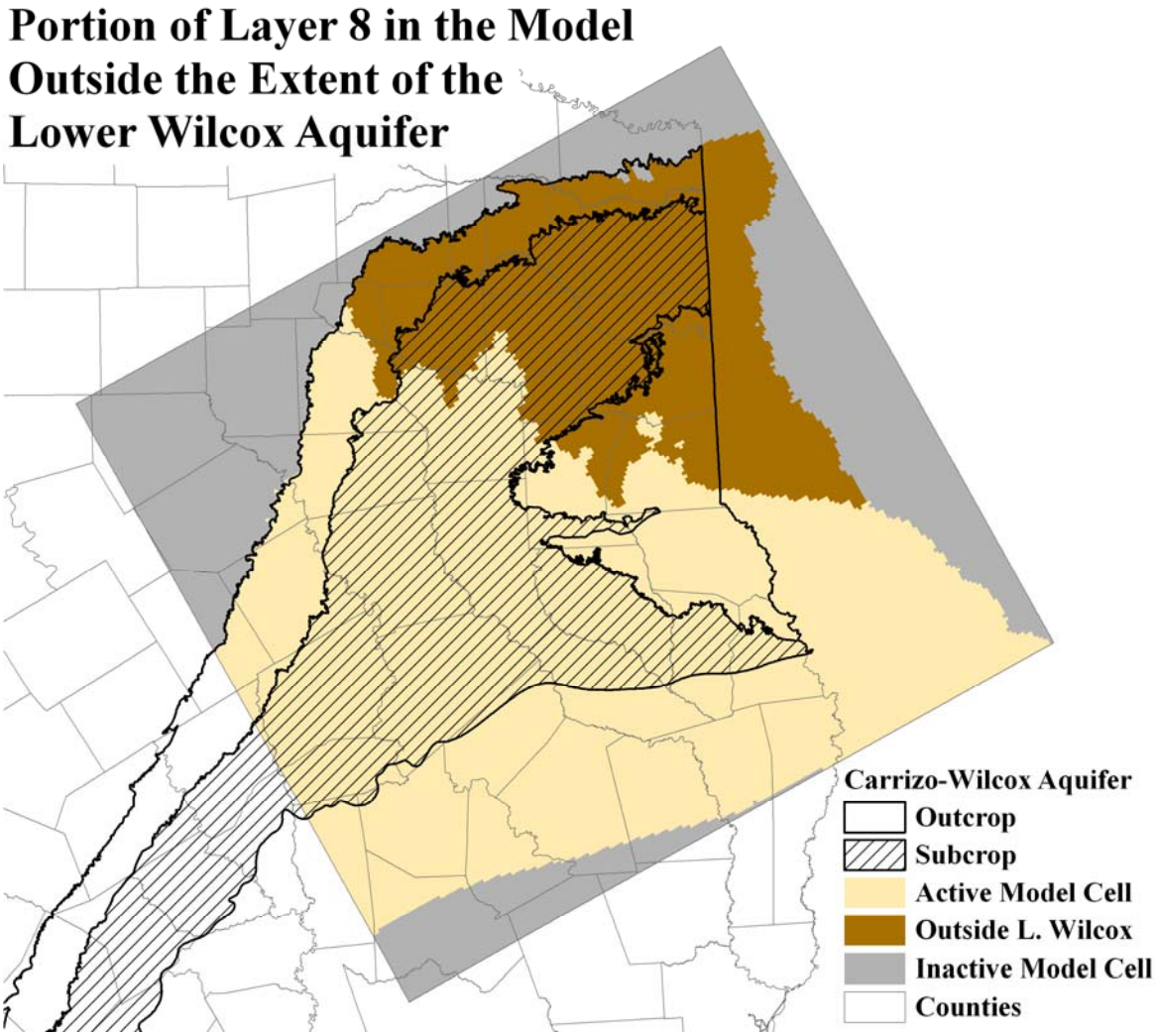

Figure 1. Portion of Layer 8 in the groundwater availability model that is outside the extent of the Lower Wilcox unit of the Carrizo-Wilcox Aquifer.