GAM Run 08-73

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EXECUTIVE SUMMARY:

Texas State Water Code, Section 36.1071, Subsection (h), states that, in developing its groundwater management plan, groundwater conservation districts shall use groundwater availability modeling information provided by the Executive Administrator of the Texas Water Development Board in conjunction with any available site-specific information provided by the district for review and comment to the Executive Administrator. Information derived from groundwater availability models that shall be included in the groundwater management plan includes:

(1) the annual amount of recharge from precipitation to the groundwater resources within the district, if any;
(2) for each aquifer within the district, the annual volume of water that discharges from the aquifer to springs and any surface water bodies, including lakes, streams, and rivers; and
(3) the annual volume of flow into and out of the district within each aquifer and between aquifers in the district.

The purpose of this model run is to provide information to Brazos Valley Groundwater Conservation District for its groundwater management plan. The groundwater management plan for Brazos Valley Groundwater Conservation District is due for approval by the Executive Administrator of the Texas Water Development Board before July 22, 2009.

This report discusses the method, assumptions, and results from model runs using the groundwater availability models for the central part of the Carrizo-Wilcox, Queen City, and Sparta aquifers, and the northern part of the Gulf Coast Aquifer. Table 1 summarizes the groundwater availability model data required by the statute, and Figure 1 shows the area of each model from which the values in Table 1 were extracted.

The Yegua Jackson Aquifer and Brazos River Alluvium Aquifer also underlie the Brazos Valley Groundwater Conservation District. However, groundwater availability models for these minor aquifers have not been completed at this time. If the district would like information for the Yegua Jackson Aquifer or Brazos River Alluvium Aquifer, they may request it from the Groundwater Technical Assistance Section of the Texas Water Development Board.

METHODS:

We ran the groundwater availability models for the central part of the Carrizo-Wilcox, Queen City, and Sparta aquifers, and the northern part of the Gulf Coast Aquifer and (1) extracted water budgets for each year of the 1980 through 1999 period and (2) averaged the annual water budget values for recharge, surface water outflow, inflow to the district, outflow from the district, net inter-aquifer flow (upper), and net inter-aquifer flow (lower).

PARAMETERS AND ASSUMPTIONS:

Groundwater availability model for the central parts of the Carrizo-Wilcox, Queen City, and Sparta aquifers

- We used Version 2.01 of the groundwater availability model for the central part of the Carrizo-Wilcox, Queen City, and Sparta aquifers. See Dutton and others (2003) and Kelley and others (2004) for assumptions and limitations of the groundwater availability model for the central part of the Carrizo-Wilcox, Queen City, and Sparta aquifers.

- This groundwater availability model includes eight layers, representing (from top to bottom):

    1. the Sparta Aquifer (Layer 1),
    2. the Weches Confining Unit (Layer 2),
    3. the Queen City Aquifer (Layer 3),
    4. the Reklaw Confining Unit (Layer 4),
    5. the Carrizo Aquifer (Layer 5),
    6. the Upper Wilcox Aquifer (Calvert Bluff Formation—Layer 6),
    7. the Middle Wilcox Aquifer (Simsboro Formation—Layer 7), and
    8. the Lower Wilcox Aquifer (Hooper Formation—Layer 8).

- The root mean square error (a measure of the difference between simulated and actual water levels during model calibration) in the groundwater availability model is 22 feet for the Sparta Aquifer, 27 feet for the Queen City Aquifer, 36 feet for the Carrizo Aquifer, and 31 feet for the Simsboro Aquifer for the calibration period (1980 to 1990) and 24, 33, 32, and 43 feet for the same aquifers, respectively, in the verification period (1991 to 1999) (Kelley and others, 2004). These root mean square errors are between four and eleven percent of the range of measured water levels (Kelley and others, 2004)

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

Groundwater availability model for the northern part of the Gulf Coast Aquifer

- We used Version 2.01 of the groundwater availability model for the northern part of the Gulf Coast Aquifer. See Kasmarek and Robinson (2004) for assumptions and limitations of the groundwater availability model for the northern part of the Gulf Coast Aquifer.

- The model simulates groundwater flow through four hydrostratigraphic layers. These layers are (from top to bottom):

  1. the Chicot Aquifer,
  2. the Evangeline Aquifer,
  3. the Burkeville Confining Unit, and
  4. the Jasper Aquifer.

- The root mean square (RMS) error (a measure of the difference between simulated and actual water levels during model calibration) in the groundwater availability model for 2000 is about 31 ft for the Chicot aquifer, about 40 ft for the Evangeline aquifer, and about 34 ft for the Jasper aquifer. The RMS errors are about 7, 8, and 17 percent, respectively, of the total range in measured heads for the respective aquifers (Kasmarek and Robinson, 2004).

- The transient portion of the model has a total of 53 stress periods for the 1980 through 1999 period. Of these, monthly stress periods were assigned for 1980, 1982 and 1988. Monthly stress periods were assigned for those years due to substantially lower-than-average precipitation recorded in the GAM area. The remainder of the stress periods are annual.

- We used Processing Modflow for Windows (PMWIN) version 5.3 (Chiang and Kinzelbach, 2001) as the interface to process model output.

RESULTS:

A groundwater budget summarizes the amount of water entering and leaving the aquifer according to the groundwater availability model. Selected components were extracted from the groundwater budget for the aquifers located within the district and averaged over the duration of the calibrated portion of the model run (1980 to 1999) in the district, as shown in Table 1. The components of the modified budgets shown in Table 1 include:

- Precipitation recharge—This is the areally distributed recharge sourced from precipitation falling on the outcrop areas of the aquifers (where the aquifer is exposed at land surface) within the district.

- Surface water outflow—This is the total water exiting the aquifer (outflow) to surface water features such as streams, reservoirs, and drains (springs).

- Flow into and out of district—This component describes lateral flow within the aquifer between the district and adjacent counties.

- Flow between aquifers—This describes the vertical flow, or leakage, between aquifers or confining units. This flow is controlled by the relative water levels in each aquifer or confining unit and aquifer properties of each aquifer or confining unit that define the amount of leakage that occurs. "Inflow" to an aquifer from an overlying or underlying aquifer will always equal the "Outflow" from the other aquifer.

The information needed for the district's management plan is summarized in Table 1. 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, such as district or county boundaries, 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 (see Figure 1).
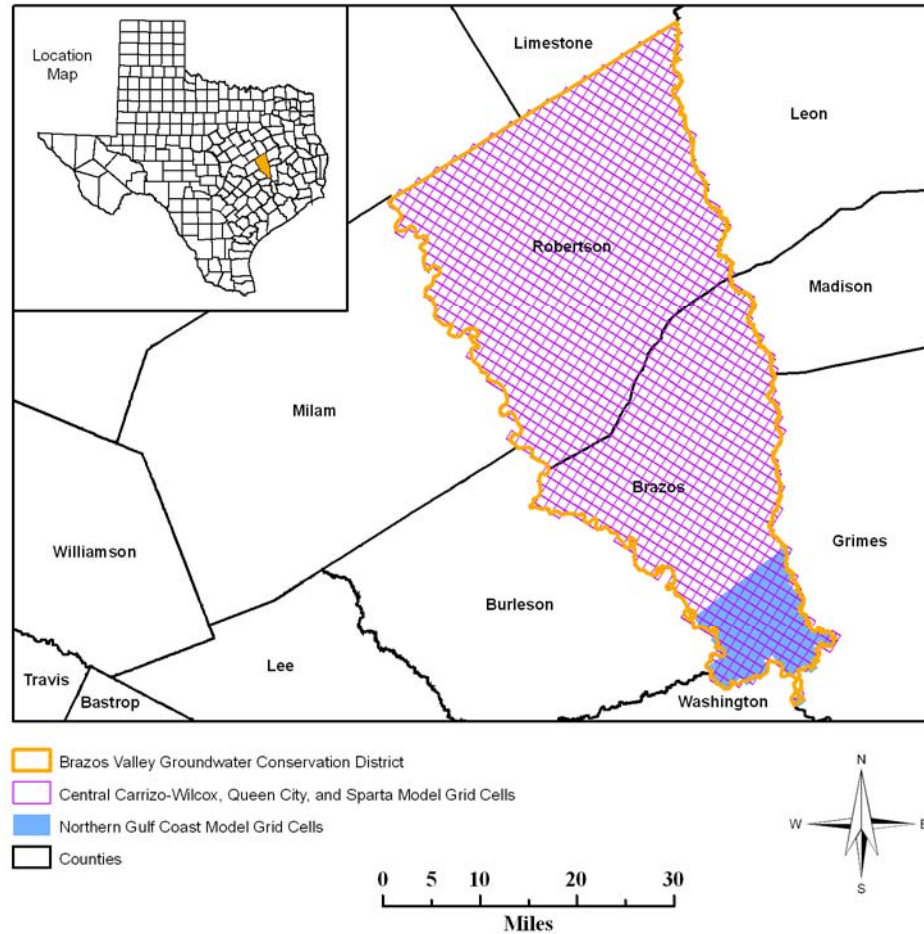
Groundwater in the Carrizo-Wilcox, Queen City, and Sparta aquifers ranges from fresh to brackish in composition (Kelley and others, 2004). Groundwater with total dissolved solids of less than 1,000 milligrams per liter are considered fresh and total dissolved solids of 1,000 to 10,000 milligrams per liter are considered brackish.

Table 1:   Summarized information needed for Brazos Valley Groundwater Conservation District's groundwater management plan. All values are reported in acre-feet per year. All numbers are rounded to the nearest 1 acre-foot. Flows include fresh and brackish waters.

Management Plan requirement	Aquifer or confining unit	Results
Estimated annual amount of recharge from precipitation to the district	Chicot Aquifer	0
	Evangeline Aquifer	0
	Burkeville Confining Unit	0
	Jasper Aquifer	38
	Sparta Aquifer	10,141
	Weches Confining Unit	748
	Queen City Aquifer	6,168
	Reklaw Confining Unit	1,012
	Carrizo Aquifer	9,651
	Wilcox (upper) Aquifer	10,373
	Wilcox (middle) Aquifer	6,220
	Wilcox (lower) Aquifer	693
Estimated annual volume of water that discharges from the aquifer to springs and any surface water body including lakes, streams,	Chicot Aquifer	0
	Evangeline Aquifer	0
	Burkeville Confining Unit	0
	Jasper Aquifer	300
	Sparta Aquifer	1,888
	Weches Confining Unit	158

Management Plan requirement	Aquifer or confining unit	Results
and rivers	Queen City Aquifer	13,957
	Reklaw Confining Unit	600
	Carrizo Aquifer	1,579
	Wilcox (upper) Aquifer	6,967
	Wilcox (middle) Aquifer	6,154
	Wilcox (lower) Aquifer	649
Estimated annual volume of flow into the district within each aquifer in the district	Chicot Aquifer	0
	Evangeline Aquifer	0
	Burkeville Confining Unit	0
	Jasper Aquifer	61
	Sparta Aquifer	719
	Weches Confining Unit	70
	Queen City Aquifer	1,930
	Reklaw Confining Unit	227
	Carrizo Aquifer	2,215
	Wilcox (upper) Aquifer	2,684
	Wilcox (middle) Aquifer	21,458
	Wilcox (lower) Aquifer	5,138
Estimated annual volume of flow out of the district within each aquifer in the district	Chicot Aquifer	0
	Evangeline Aquifer	0
	Burkeville Confining Unit	0
	Jasper Aquifer	18
	Sparta Aquifer	483
	Weches Confining Unit	45
	Queen City Aquifer	831
	Reklaw Confining Unit	140
	Carrizo Aquifer	4,335
	Wilcox (upper) Aquifer	2,010
	Wilcox (middle) Aquifer	5,581
	Wilcox (lower) Aquifer	2,431
Estimated net annual volume of flow between each aquifer in the district	Sparta Aquifer into the Weches Confining Unit	453
	Weches Confining Unit into the Queen City Aquifer	45
	Reklaw Confining Unit into the Queen City Aquifer	226
	Carrizo Aquifer into the Reklaw Confining Unit	17
	Carrizo Aquifer into the Wilcox (upper) Aquifer	875
	Wilcox (upper) Aquifer into the Wilcox (middle) Aquifer	5,390
	Wilcox (lower) Aquifer into the Wilcox (middle) Aquifer	3,255

Figure 1:   Area of the groundwater availability model for the central part of the Carrizo-Wilcox, Queen City, and Sparta aquifers, and the northern part of the Gulf Coast Aquifer from which the information in Table 1 was extracted (the aquifer extent within the Brazos Valley Groundwater Conservation District boundary).

REFERENCES:

Chiang, W., and Kinzelbach, W., 2001, Groundwater Modeling with PMWIN, 346 p.

Dutton, A.R., Harden, B., Nicot, J.P., and O'Rourke, D., 2003, Groundwater availability model for the central part of the Carrizo-Wilcox Aquifer in Texas: Contract report to the Texas Water Development Board, 295 p., http://www.twdb.state.tx.us/gam/czwx_c/czwx_c.htm.

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

Kasmarek, M.C., and Robinson, J.L., 2004, Hydrogeology and simulation of ground-water flow and land-surface subsidence in the northern part of the Gulf Coast aquifer system, Texas: U.S. Geological Survey Scientific Investigations Report 2004–5102, 111 p., http://www.twdb.state.tx.us/gam/glfc_n/glfc_n.htm.

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., http://www.twdb.state.tx.us/gam/qc_sp/qc_sp.htm.

Cynthia K. Ridgeway is 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., on December 9, 2008.