GAM Run 06-24

by Richard M. Smith, P.G.
Texas Water Development Board
Groundwater Availability Modeling Section
(512) 936-0877
January 3, 2007

REQUESTOR:

Mr. David Alford of the Piney Woods Groundwater Conservation District (GCD).

DESCRIPTION OF REQUEST:

Mr. Alford requested the following information for his district from the groundwater availability model (GAM) for the northern part of the Queen City, Sparta, and Carrizo-Wilcox aquifers:

1) estimated annual amount of recharge from precipitation to the district;
2) estimated annual volume of water that discharges from the aquifer to springs and any surface water body including lakes, streams, and rivers;
3) estimated annual volume of flow into and out of the district within each aquifer and between each aquifer in the district; and
4) estimated annual amount of groundwater being used in the district on an annual basis as of 1999.

METHODS:

To address the request, we:

- ran the transient GAM for the northern Queen City, Sparta, and Carrizo-Wilcox aquifers and extracted water budgets for each year of the 1980 through 1999 period and

- averaged the twenty year period for recharge, surface water inflow, 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:

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

- The GAM 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 (Calvert Bluff Formation—Layer 6),
    7. Middle Wilcox (Simsboro Formation—Layer 7), and
    8. Lower Wilcox (Hooper Formation—Layer 8).

- The mean absolute error (a measure of the difference between simulated and actual water levels during model calibration) in the GAM for the transient calibration-verification period is 26 feet for the Lower Wilcox aquifer (Layer 7) for the calibration period (1980-89) and 29 feet for the verification period (1990-99), or between five and six percent of the range of measured water levels (Kelley and others, 2004).

- The results of this analysis only include the aquifers that are in the GAM. They do not include younger sediments such as the Yegua-Jackson that overlie the Sparta aquifer (layer 1)..

RESULTS:

Recharge and water budget

A groundwater budget summarizes how the model estimates water entering and leaving the aquifer. The groundwater budget for the average values from the transient model (1980 to 1999) is shown in Table 1. The components of the budgets shown in Table 1 include:

- Surface water inflow and outflow—This is the total surface water entering the aquifer (inflow) through streams or reservoirs, or total surface water exiting the aquifer (outflow) to streams, reservoirs, drains (springs), or through evapotranspiration (return of moisture to the air through both evaporation from the soil and transpiration or loss of water vapor by plants).

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

- Net inter–aquifer flow—This describes the vertical flow, or leakage, between aquifers or confining units. This flow is controlled by the relative water levels in each aquifer and aquifer properties of each aquifer that define the amount of leakage that can occur. “Inflow” to an aquifer from an overlying or underlying aquifer will always equal the “Outflow” from the other aquifer, except for the top

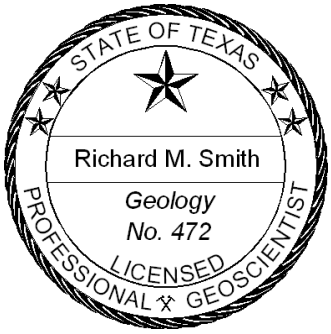
layer where flow from and to overlying younger aquifers are simulated with a general head boundary condition.

Precipitation recharge is the areally distributed recharge due to precipitation falling on the outcrop areas of the aquifers (where the aquifer is exposed at land surface) within the district. The information needed for the district's management plan is summarized in Table 2. Table 3 gives the pumpage for the district as of 1999.

REFERENCES:

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.



The seal appearing on this document was authorized by Richard M. Smith, P.G. on January 3, 2007

Table 1: Groundwater flow budget for each aquifer layer, into and out of the Piney Woods Groundwater Conservation District, averaged for the years 1980 to 1999 from the GAM of the northern part of the Queen City, Sparta, and Carrizo-Wilcox aquifers. Flows are in acre-feet per year. Note: a negative sign refers to flow out of the aquifer in the district. A positive sign refers to flow into the aquifer in the district. All numbers are rounded to the nearest 1 acre-foot and are probably only accurate to two significant figures. Flow into and out of the confining layers are negligible compared to the aquifers and are not included.

Aquifer	Surface Water Inflow (1980 to 1999)	Surface Water Outflow (1980 to 1999)	Lateral Inflow into district	Lateral Outflow from district	Net Inter-aquifer flow (upper)	Net Inter-aquifer flow (lower)
Sparta aquifer (Layer 1)	154	-8,509	1,488	-357	1,261	-9,482
Queen City aquifer (Layer 3)	39	-601	383	-317	9,957	-11,307
Carrizo aquifer (Layer 5)	7	-4,056	11,677	-2,282	16,402	-1,891
Upper Wilcox (Calvert Bluff Formation—Layer 6)	29	-2,737	12,574	-2,191	1,891	1,936
Middle Wilcox (Simsboro Formation—Layer 7)	66	0	9,381	-1,397	-1,936	2,227
Lower Wilcox (Hooper Formation—Layer 8)	0	0	1,398	-271	-2,227	0

Table 2: Summarized information needed for the district's management plan. All values reported in acre-feet per year. All numbers are rounded to the nearest 1 acre-foot and are probably only accurate to two significant figures.

Management Plan requirement	**Aquifer**	**Results from model simulation**
Estimated annual amount of recharge from precipitation to the district	All aquifers and confining units	53,984
Estimated annual volume of water that discharges from the aquifer to springs and any surface water body including lakes, streams, and rivers	Sparta, Queen City, Carrizo, and Upper Wilcox aquifers (no discharge from Middle and Lower Wilcox aquifers)	15,903
Estimated annual volume of flow into the district within each aquifer in the district	Sparta aquifer	1,488
	Queen City aquifer	383
	Carrizo aquifer	11,677
	Upper Wilcox (Calvert Bluff Formation)	12,574
	Middle Wilcox (Simsboro Formation)	9,381
	Lower Wilcox (Hooper Formation)	1,398
Estimated annual volume of flow out of the district within each aquifer in the district	Sparta aquifer	-357
	Queen City aquifer	-317
	Carrizo aquifer	-2,282
	Upper Wilcox (Calvert Bluff Formation)	-2,191
	Middle Wilcox (Simsboro Formation)	-1,397
	Lower Wilcox (Hooper Formation)	-271
Estimated annual volume of flow between each aquifer in the district	Younger Units and Sparta aquifer	1,261
	Sparta and Weches confining unit	-9,482
	Weches and Queen City	9,957
	Queen City and Reklaw	-11,307
	Reklaw and Carrizo	16,402
	Carrizo and Upper Wilcox	1,891
	Upper Wilcox and Middle Wilcox	1,936
	Middle Wilcox and Lower Wilcox	2,227

Table 3: Groundwater usage for the Piney Woods Groundwater Conservation District in 1999 as the base year. All values are in acre-feet per year.

County	Aquifer	1999 Pumpage
Nacogdoches	Sparta aquifer (Layer 1)	339
Angelina	Sparta aquifer (Layer 1)	281
Nacogdoches	Queen City aquifer (Layer 3)	313
Angelina	Queen City aquifer (Layer 3)	96
Nacogdoches	Carrizo aquifer (Layer 5)	9601
Angelina	Carrizo aquifer (Layer 5)	17500
Nacogdoches	Upper Wilcox (Calvert Bluff Formation—Layer 6)	4320
Angelina	Upper Wilcox (Calvert Bluff Formation—Layer 6)	1910
Nacogdoches	Middle Wilcox (Simsboro Formation—Layer 7)	302
Angelina	Middle Wilcox (Simsboro Formation—Layer 7)	0
Nacogdoches	Lower Wilcox (Hooper Formation—Layer 8)	1
Angelina	Lower Wilcox (Hooper Formation—Layer 8)	0