GAM Run 10-010

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EXECUTIVE SUMMARY:

Texas State Water Code, Section 36.1071, Subsection (h), states that, in developing its groundwater management plan, a groundwater conservation district 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 Live Oak Underground Water Conservation District for its groundwater management plan. The groundwater management plan for the Live Oak Underground Water Conservation District was due for approval by the Executive Administrator of the Texas Water Development Board before September 21, 2010.

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, the central part of the Gulf Coast Aquifer, and the Yegua-Jackson Aquifer. Tables 1 through 3 summarizes the groundwater availability model data required by the statute, and figures 1 through 3 shows the area of each model from which the values in tables were extracted.

METHODS:

We ran the groundwater availability models for the southern part of the Carrizo-Wilcox, Queen City, and Sparta aquifers (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).

We ran the groundwater availability models for the central part of the Gulf Coast aquifer (1) extracted water budgets for each year of the 1981 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).

We ran the groundwater availability model for Yegua-Jackson Aquifer and (1) extracted water budgets for each year of the 1980 through 1997 period and (2) averaged the annual water budget values for recharge, surface water outflow, inflow to the district, outflow from the district for the portions of the Yegua-Jackson Aquifer located within the district.

PARAMETERS AND ASSUMPTIONS:

Carrizo-Wilcox Aquifer

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

  Information extracted and summarized for layer 5 to 8 represents the Carrizo-Wilcox Aquifer.
- The root mean squared error (a measure of the difference between simulated and actual water levels during model calibration) in the groundwater availability model is 23 feet for the Sparta Aquifer, 18 feet for the Queen City Aquifer, and 33 feet for the Carrizo Aquifer for the calibration period (1980 to 1989) and 19, 22, and 48 feet for the same aquifers, respectively, in the verification period (1990 to 1999) (Kelley others, 2004). These root mean squared errors are between seven and ten percent of the range of measured water levels (Kelley others, 2004).
- 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.
- We used Groundwater Vistas Version 5 (Environmental Simulations, Inc. 2007) as the interface to process model output.

Gulf Coast Aquifer

- We used version 1.01 of the groundwater availability model for the central portion of the Gulf Coast Aquifer. See Chowdhury and others (2004) and Waterstone and others (2003) for assumptions and limitations of the groundwater availability model.
- The model for the central portion of the Gulf Coast Aquifer assumes partially penetrating wells in the Evangeline Aquifer due to a lack of data for aquifer properties in the lower portion of the aquifer.
- The model includes four layers representing: the Chicot Aquifer (Layer 1), the Evangeline Aquifer (Layer 2), the Burkeville Confining Unit (Layer 3), and the Jasper Aquifer (Layer 4).
- The mean absolute error (a measure of the difference between simulated and measured water levels) in the entire model for 1999 is 26 feet, which is 4.6 percent of the hydraulic head drop across the model area (Chowdhury and others, 2004).
- We used Processing Modflow for Windows (PMWIN) version 5.3 (Chiang and Kinzelbach, 2001) as the interface to process model output.

Yegua-Jackson Aquifer

- We used version 1.01 of the groundwater availability model for the western section of the Yegua-Jackson Aquifer. See Kelley and others (2010) for assumptions and limitations of the model.
- The Yegua-Jackson Aquifer model includes five layers representing:
  1. outcrop section for the Yegua-Jackson Aquifer and younger overlying units,
  2. the upper portion of the Jackson Group,
  3. the lower portion of the Jackson Group,
  4. the upper portion of the Yegua Group, and
  5. the lower portion of the Yegua Group.

  Information was extracted and summarized for portions of layer 1 that represent the Yegua-Jackson as well as layers 2 to 5.
- The mean absolute error (a measure of the difference between simulated and actual water levels during model calibration) for the four main aquifers in the model (Jackson Group, Upper Yagua and Lower Yagua) for the transient calibration period (1980 through 1997) ranged from approximately 31 to23 feet. The root mean squared error was about ten percent (or less) of the maximum change in water levels across the model (Deeds and others, 2010).
- The recharge used for the model run represents average recharge as described in Deeds and others (2010).
- We used Groundwater Vistas Version 5 (Environmental Simulations, Inc. 2007) as the interface to process model output.
- The model results presented in this report were extracted from all areas of the model representing the units comprising the Yegua-Jackson Aquifer. For this reason, the reported values may reflect water of quality ranging from fresh to brackish and saline. This is especially true for the subcrop portions of the aquifer in the northeastern part of the District.

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 calibration and verification portion of the model run (1980 through 1999 for the southern part of the Carrizo-Wilcox, Queen City, and Sparta aquifers, 1981 through 1999 for the central Gulf Coast Aquifer, and 1980 through 1997 for the Yegua-Jackson Aquifer) in the district, as shown in tables 1 through 3. The components of the modified budgets shown in Tables include:

- Precipitation recharge—This is the aerially 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 tables 1 through 3. 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 figures 1 to 3).

As depicted by Kalaswad and Arroyo (2006), groundwater in the Gulf Coast Aquifer and the southern Carrizo-Wilcox, Queen City, and Sparta aquifers ranges from fresh to saline. The reported values in this report for flow terms include fresh (less than 1,000 milligrams per liter total dissolved solids) and brackish (1,000 to 10,000 milligrams per liter total dissolved solids) groundwater.

Table 1: Carrizo-Wilcox Aquifer's summarized information required for the Live Oak Underground Water 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. Reported flow estimates include both fresh and brackish waters present in the aquifers.

Management Plan requirement	Aquifer or confining unit	Results
Estimated annual amount of recharge from precipitation to the district	Carrizo-Wilcox Aquifer	0
Estimated annual volume of water that discharges from the aquifer to springs and any surface water body including lakes, streams, and rivers	Carrizo-Wilcox Aquifer	0
Estimated annual volume of flow into the district within each aquifer in the district	Carrizo-Wilcox Aquifer	1,609
Estimated annual volume of flow out of the district within each aquifer in the district	Carrizo-Wilcox Aquifer	1,554
Estimated net annual volume of flow between each aquifer in the district	Carrizo-Wilcox Aquifer to overlying Reklaw Confining Unit	70

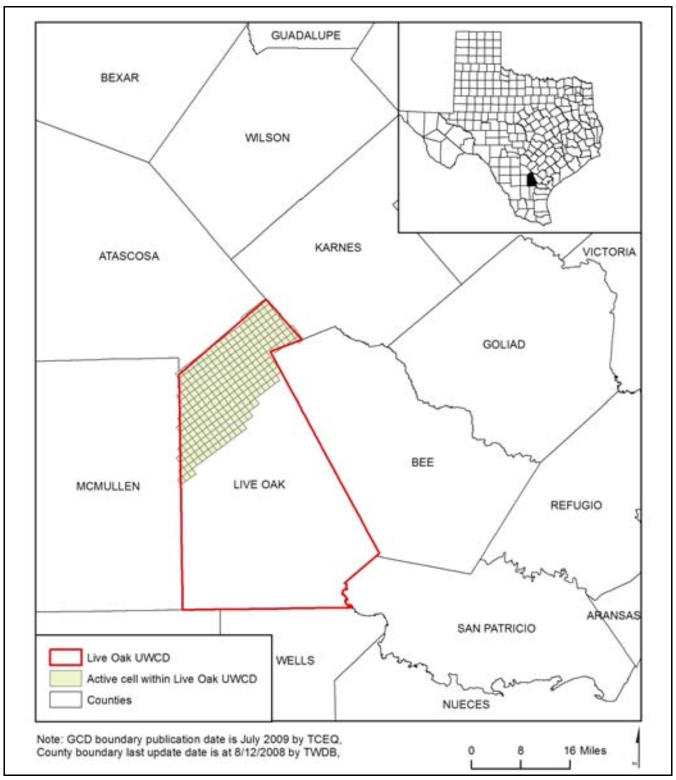

Figure 1: Area of the groundwater availability model for the Carrizo-Wilcox Aquifer from which the information in Table 3 was extracted (the aquifer extent within the Live Oak Underground Water Conservation District boundary).

Table 2: Gulf Coast Aquifer's summarized information required for the Live Oak Underground Water 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. Reported flow estimates include both fresh and brackish waters present in the aquifers.

Management Plan requirement	Aquifer	Results
Estimated annual amount of recharge from precipitation to the district	Gulf Coast Aquifer	5,490
Estimated annual volume of water that discharges from the aquifer to springs and any surface water body including lakes, streams, and rivers	Gulf Coast Aquifer	10,383
Estimated annual volume of flow into the district within each aquifer in the district	Gulf Coast Aquifer	4,127
Estimated annual volume of flow out of the district within each aquifer in the district	Gulf Coast Aquifer	1,573
Estimated net annual volume of flow between each aquifer in the district	Not applicable	Not Applicable

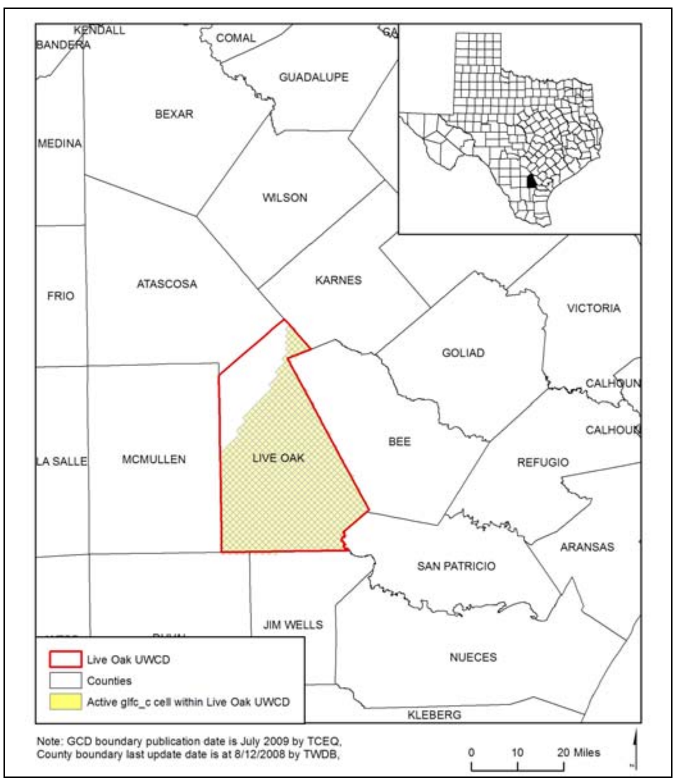

Figure 2: Area of the groundwater availability model for the central portion of the Gulf Coast Aquifer from which the information in Table 2 was extracted (the aquifer extent within the Live Oak Underground Water Conservation District boundary).

Table 3: Yegua-Jackson Aquifer's summarized information required for the Live Oak Underground Water 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. Reported flow estimates include both fresh and brackish waters present in the aquifers.

Management Plan requirement	Aquifer	Results
Estimated annual amount of recharge from precipitation to the district	Yegua-Jackson Aquifer	618
Estimated annual volume of water that discharges from the aquifer to springs and any surface water body including lakes, streams, and rivers	Yegua-Jackson Aquifer	859
Estimated annual volume of flow into the district within each aquifer in the district	Yegua-Jackson Aquifer	1,029
Estimated annual volume of flow out of the district within each aquifer in the district	Yegua-Jackson Aquifer	814
Estimated net annual volume of flow between each aquifer in the district	Not applicable	Not applicable

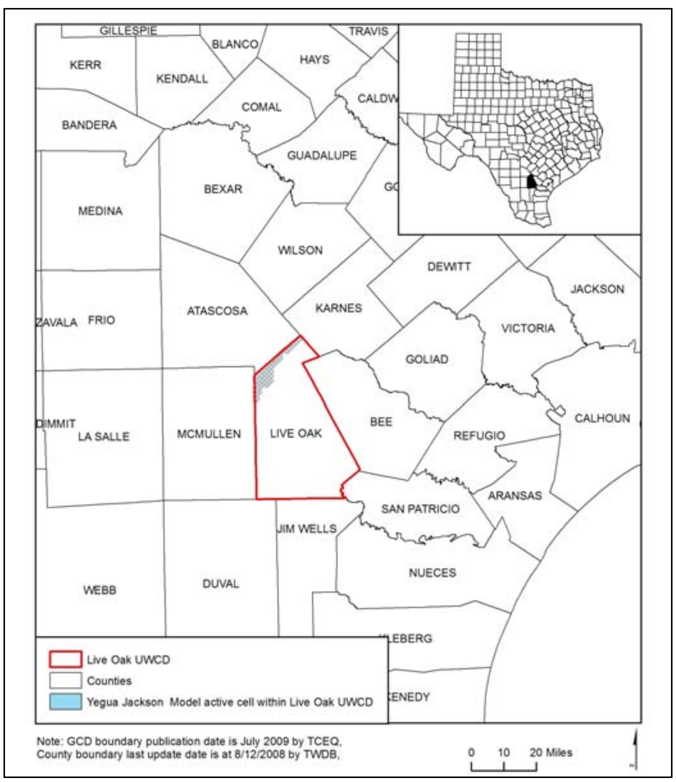

Figure 3: Area of the groundwater availability model for the Yegua-Jackson Aquifer from which the information in Table 3 was extracted (the aquifer extent within the Live Oak Underground Water Conservation District boundary).

REFERENCES:

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