GAM Run 10-013: Brazos Valley Groundwater Conservation District Management Plan

by Shirley Wade
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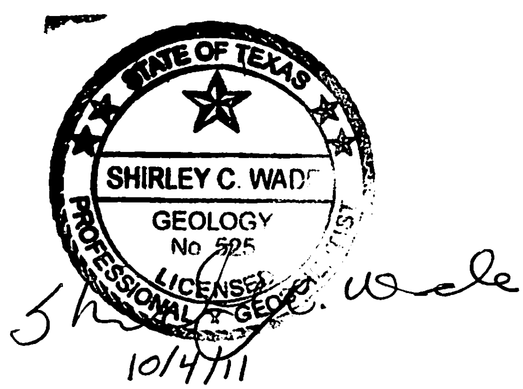
Groundwater Resources Division
Groundwater Availability Modeling Section
(512) 936-0883

October 4, 2011



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EXECUTIVE SUMMARY:

Texas 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 before being used in the plan. Information for your groundwater management plan that was derived from groundwater availability model(s) in this report includes:

- the annual amount of recharge from precipitation to the groundwater resources within the district, if any;
- 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
- the annual volume of flow into and out of the district within each aquifer and between aquifers in the district.

This report supersedes Groundwater Availability Model (GAM) Run 08-73. A groundwater availability model was not previously completed for the Yegua Jackson Aquifer, but a model that includes the Brazos Valley Groundwater Conservation District was released in May 2010. The purpose of this report is to provide Part 2 of a two-part package of information from the Texas Water Development Board to the Brazos Valley Groundwater Conservation District for its groundwater management plan. 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 northern part of the Gulf Coast Aquifer, and the Yegua Jackson Aquifer. Tables 1 through 5 summarize the groundwater availability model data required by the statute, and Figures 1 through 5 show the area of each model from which the values in the respective tables were extracted.

The Brazos River Alluvium Aquifer also underlies the Brazos Valley Groundwater Conservation District. However, a groundwater availability model for this minor aquifer has not been completed at this time. If the district would like information for the 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 (1980 through 1999), the northern part of the Gulf Coast Aquifer (1980 through 1999), and the Yegua Jackson Aquifer (1980 through 1997) and (1) extracted water budgets for each year of the transient model 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:

Carrizo-Wilcox, Queen City, and Sparta aquifers

- We used Version 2.02 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. Layers 1 through 4 represent the Sparta Aquifer, the Weches Confining Unit, the Queen City Aquifer and the Reklaw Confining Unit respectively. Layers 5 through 8 represent the Carrizo Aquifer and the Upper Wilcox (Calvert Bluff Formation), the Middle Wilcox (Simsboro Formation) and the Lower Wilcox (Hooper Formation) respectively. Individual water budgets for the District were determined for the Sparta Aquifer (Layer 1), the Queen City Aquifer (Layer 3), and the Carrizo-Wilcox Aquifer (Layer 4 through Layer 8 collectively).

- 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).

- 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.

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.

- This groundwater availability model includes four layers. Layer 1 represents the Chicot Aquifer, layer 2 represents the Evangeline Aquifer, layer 3 represents the Burkeville Confining Unit, and layer 4 represents the Jasper Aquifer (including portions of the Catahoula Formation). An overall water budget for the District was determined for the Gulf Coast Aquifer (Layer 1 through Layer 4 collectively). Since Layers 1, 2, and 3 are not present in the District, the water budget consists entirely of Layer 4.

- 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 feet for the Chicot aquifer, about 40 feet for the Evangeline aquifer, and about 34 feet 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 model area. The remaining 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.

Yegua Jackson Aquifer

- 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. This groundwater availability model includes five layers. Layer 1 represents the outcrop section for the Yegua Jackson Aquifer and younger overlying units, layer 2 represents the upper portion of the Jackson Group , layer 3 represents the lower portion of the Jackson Group, layer 4 represents the upper portion of the Yegua Group , and layer 5 represents the lower portion of the Yegua Group.

- An overall water budget for the District was determined for the Yegua Jackson Aquifer (Layer 1 through Layer 5 collectively for the portions that represent the Yegua Jackson Aquifer).

- 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 31.1, 23.9, and 24.5 feet, respectively. These represent 10.3, 5.7 and 6.3 percent of the hydraulic head drop across each model area, respectively.

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 tables 1 to 5. 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 5).

LIMITATIONS

The groundwater model(s) used in completing this analysis is the best available scientific tool that can be used to meet the stated objective(s). To the extent that this analysis will be used for planning purposes and/or regulatory purposes related to pumping in the past and into the future, it is important to recognize the assumptions and limitations associated with the use of the results. In reviewing the use of models in environmental regulatory decision making, the National Research Council (2007) noted:

> “Models will always be constrained by computational limitations, assumptions, and knowledge gaps. They can best be viewed as tools to help inform decisions rather than as machines to generate truth or make decisions. Scientific advances will never make it possible to build a perfect model that accounts for every aspect of reality or to prove that a given model is correct in all respects

> for a particular regulatory application. These characteristics make evaluation of a regulatory model more complex than solely a comparison of measurement data with model results."

A key aspect of using the groundwater model to evaluate historic groundwater flow conditions includes the assumptions about the location in the aquifer where historic pumping was placed. Understanding the amount and location of historic pumping is as important as evaluating the volume of groundwater flow into and out of the district, between aquifers within the district (as applicable), interactions with surface water (as applicable), recharge to the aquifer system (as applicable), and other metrics that describe the impacts of that pumping. In addition, assumptions regarding precipitation, recharge, and streamflow are specific to a particular historic time period.

Because the application of the groundwater model was designed to address regional scale questions, the results are most effective on a regional scale. The TWDB makes no warranties or representations relating to the actual conditions of any aquifer at a particular location or at a particular time.

It is important for groundwater conservation districts to monitor groundwater pumping and overall conditions of the aquifer. Because of the limitations of the groundwater model and the assumptions in this analysis, it is important that the groundwater conservation districts work with the TWDB to refine this analysis in the future given the reality of how the aquifer responds to the actual amount and location of pumping now and in the future. Historic precipitation patterns also need to be placed in context as future climatic conditions, such as dry and wet year precipitation patterns, may differ and affect groundwater flow conditions.

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

Management Plan requirement	Aquifer or confining unit	Results
Estimated annual amount of recharge from precipitation to the district	Sparta Aquifer	10,141
Estimated annual volume of water that discharges from the aquifer to springs and any surface water body including lakes, streams, and rivers	Sparta Aquifer	1,888
Estimated annual volume of flow into the district within each aquifer in the district	Sparta Aquifer	719
Estimated annual volume of flow out of the district within each aquifer in the district	Sparta Aquifer	483
Estimated net annual volume of flow between each aquifer in the district	Sparta Aquifer into the Weches Confining Unit	453

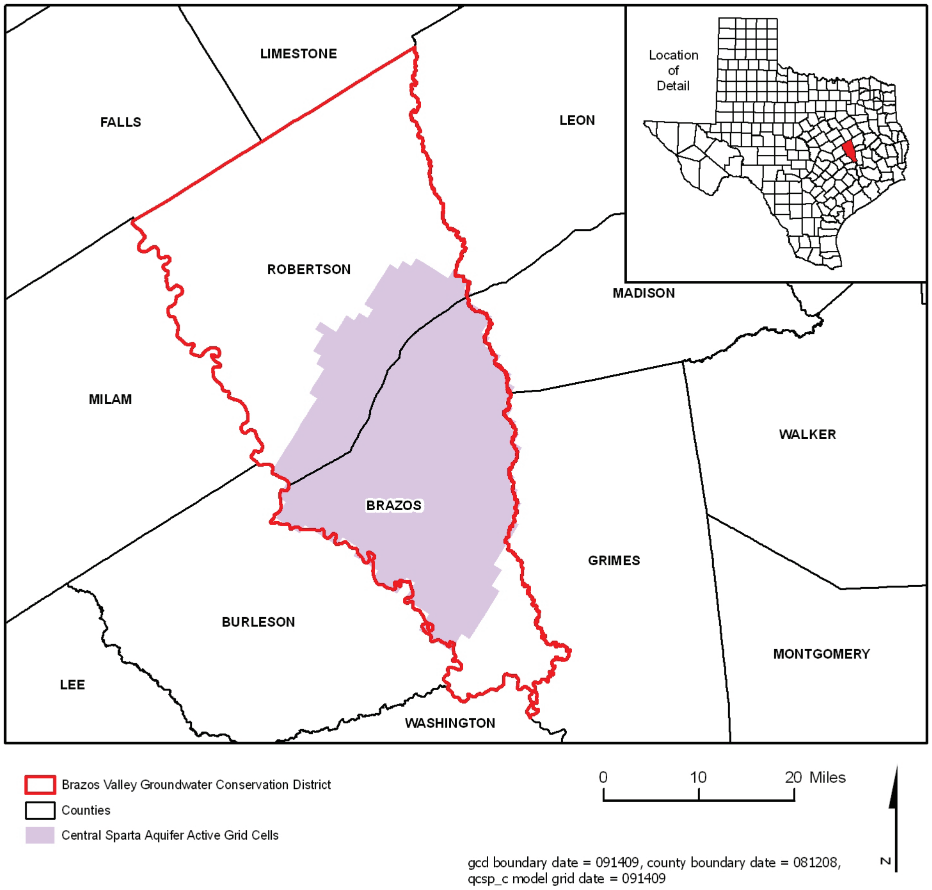

FIGURE 1: AREA OF THE GROUNDWATER AVAILABILITY MODEL FOR THE CENTRAL PART OF THE SPARTA AQUIFER FROM WHICH THE INFORMATION IN TABLE 1 WAS EXTRACTED (THE AQUIFER EXTENT WITHIN THE DISTRICT BOUNDARY).

TABLE 2: SUMMARIZED INFORMATION FOR THE QUEEN CITY AQUIFER THAT IS REQUIRED FOR THE BRAZOS VALLEY GROUNDWATER CONSERVATION DISTRICT'S GROUNDWATER MANAGEMENT PLAN. ALL VALUES ARE REPORTED IN ACRE-FEET PER YEAR AND ROUNDED TO THE NEAREST 1 ACRE-FOOT. FLOWS MAY INCLUDE FRESH AND BRACKISH WATERS.

Management Plan requirement	Aquifer or confining unit	Results
Estimated annual amount of recharge from precipitation to the district	Queen City Aquifer	6,168
Estimated annual volume of water that discharges from the aquifer to springs and any surface water body including lakes, streams, and rivers	Queen City Aquifer	13,957
Estimated annual volume of flow into the district within each aquifer in the district	Queen City Aquifer	1,930
Estimated annual volume of flow out of the district within each aquifer in the district	Queen City Aquifer	831
Estimated net annual volume of flow between each aquifer in the district	Weches Confining Unit into the Queen City Aquifer	45
	Reklaw Confining Unit into the Queen City Aquifer	226

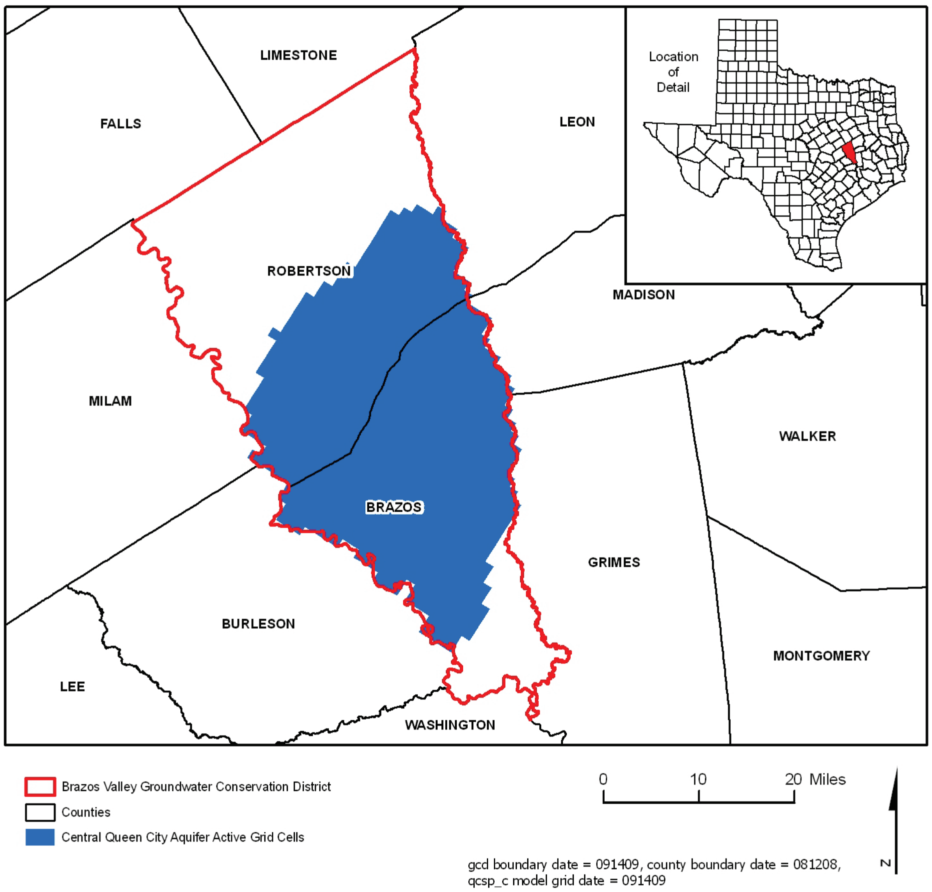

FIGURE 2: AREA OF THE GROUNDWATER AVAILABILITY MODEL FOR THE CENTRAL PART OF THE QUEEN CITY AQUIFER FROM WHICH THE INFORMATION IN TABLE 2 WAS EXTRACTED (THE AQUIFER EXTENT WITHIN THE DISTRICT BOUNDARY).

TABLE 3: SUMMARIZED INFORMATION FOR THE CARRIZO-WILCOX AQUIFER THAT IS REQUIRED FOR THE BRAZOS VALLEY GROUNDWATER CONSERVATION DISTRICT'S GROUNDWATER MANAGEMENT PLAN. ALL VALUES ARE REPORTED IN ACRE-FEET PER YEAR AND ROUNDED TO THE NEAREST 1 ACRE-FOOT. FLOWS MAY INCLUDE FRESH AND BRACKISH WATERS.

Management Plan requirement	Aquifer or confining unit	Results
Estimated annual amount of recharge from precipitation to the district	Carrizo-Wilcox Aquifer	26,937
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	15,349
Estimated annual volume of flow into the district within each aquifer in the district	Carrizo-Wilcox Aquifer	31,495
Estimated annual volume of flow out of the district within each aquifer in the district	Carrizo-Wilcox Aquifer	14,357
Estimated net annual volume of flow between each aquifer in the district	Carrizo-Wilcox Aquifer into the Reklaw Confining Unit	17

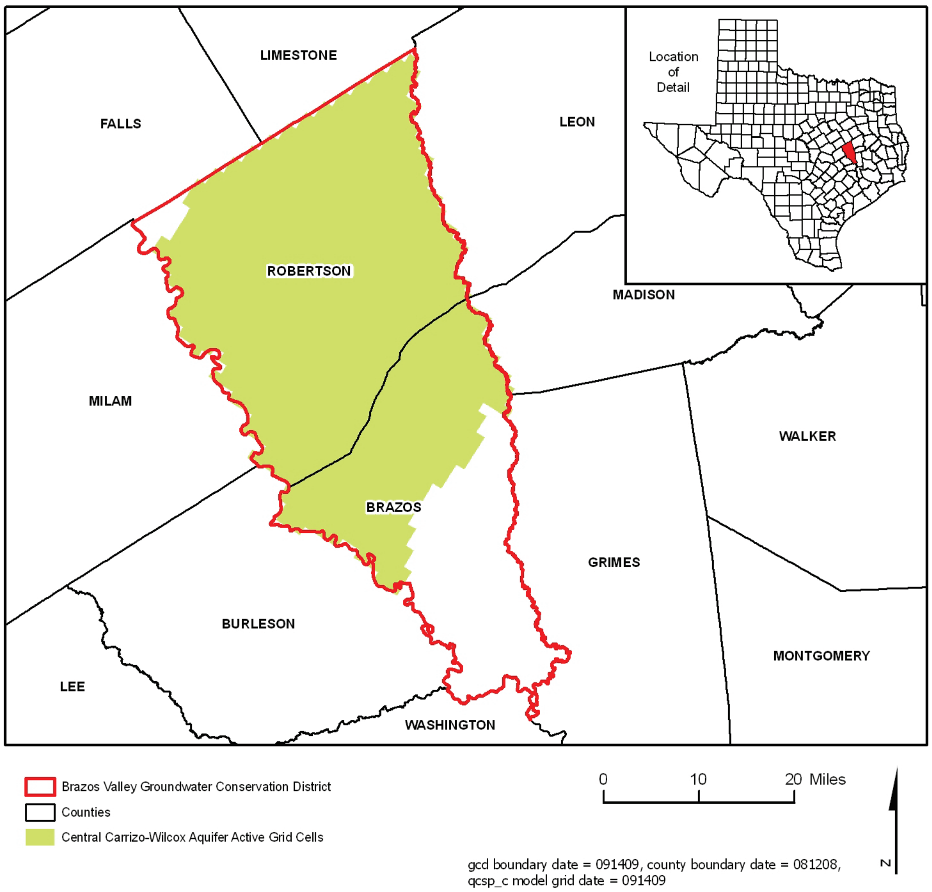

FIGURE 3: AREA OF THE GROUNDWATER AVAILABILITY MODEL FOR THE CENTRAL PART OF THE CARRIZO-WILCOX AQUIFER FROM WHICH THE INFORMATION IN TABLE 3 WAS EXTRACTED (THE AQUIFER EXTENT WITHIN THE DISTRICT BOUNDARY).

TABLE 4: SUMMARIZED INFORMATION FOR THE YEGUA JACKSON AQUIFER THAT IS REQUIRED FOR THE BRAZOS VALLEY GROUNDWATER CONSERVATION DISTRICT'S GROUNDWATER MANAGEMENT PLAN. ALL VALUES ARE REPORTED IN ACRE-FEET PER YEAR AND ROUNDED TO THE NEAREST 1 ACRE-FOOT. FLOWS MAY INCLUDE FRESH AND BRACKISH WATERS.

Management Plan requirement	Aquifer	Results
Estimated annual amount of recharge from precipitation to the district	Yegua Jackson Aquifer	26,539
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	41,725
Estimated annual volume of flow into the district within each aquifer in the district	Yegua Jackson Aquifer	12,324
Estimated annual volume of flow out of the district within each aquifer in the district	Yegua Jackson Aquifer	7,555
Estimated net annual volume of flow between each aquifer in the district	Yegua Jackson Aquifer into the Catahoula Formation and other overlying units	11

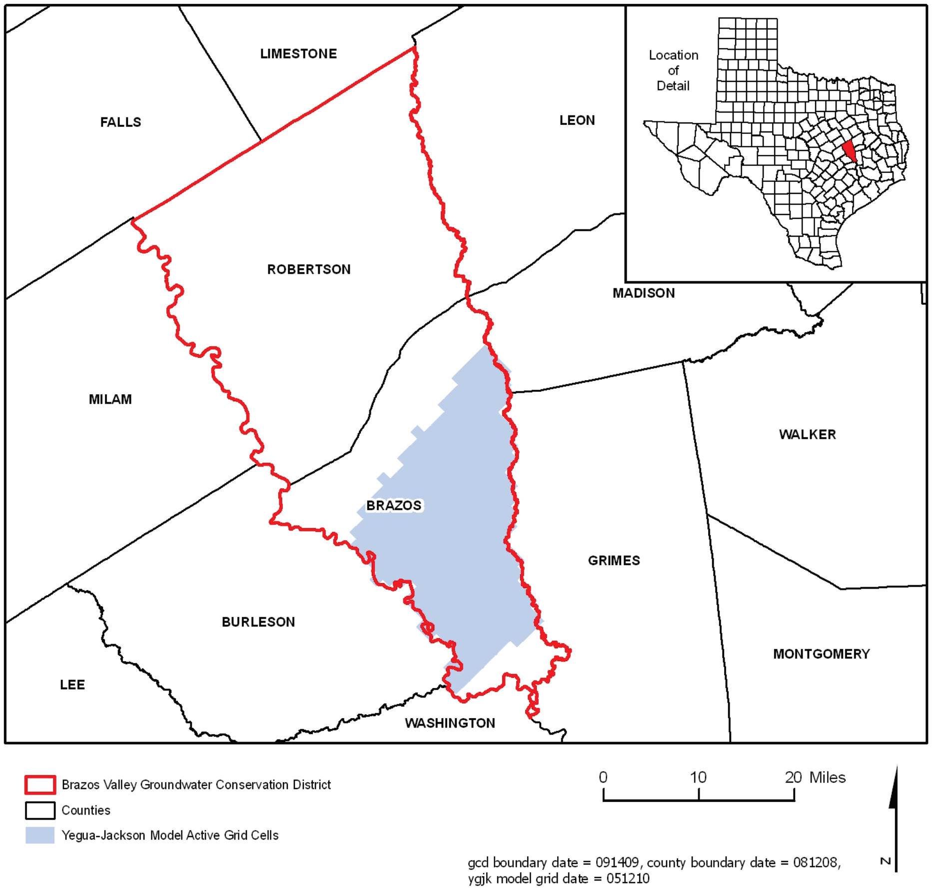

FIGURE 4: AREA OF THE GROUNDWATER AVAILABILITY MODEL FOR THE YEGUA JACKSON AQUIFER FROM WHICH THE INFORMATION IN TABLE 4 WAS EXTRACTED (THE AQUIFER EXTENT WITHIN THE DISTRICT BOUNDARY).

TABLE 5: SUMMARIZED INFORMATION FOR THE GULF COAST AQUIFER THAT IS REQUIRED FOR THE BRAZOS VALLEY GROUNDWATER CONSERVATION DISTRICT'S GROUNDWATER MANAGEMENT PLAN. ALL VALUES ARE REPORTED IN ACRE-FEET PER YEAR AND ROUNDED TO THE NEAREST 1 ACRE-FOOT.

Management Plan requirement	Aquifer	Results
Estimated annual amount of recharge from precipitation to the district	Gulf Coast Aquifer	38
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	300
Estimated annual volume of flow into the district within each aquifer in the district	Gulf Coast Aquifer	61
Estimated annual volume of flow out of the district within each aquifer in the district	Gulf Coast Aquifer	18
Estimated net annual volume of flow between each aquifer in the district	Not applicable	Not applicable

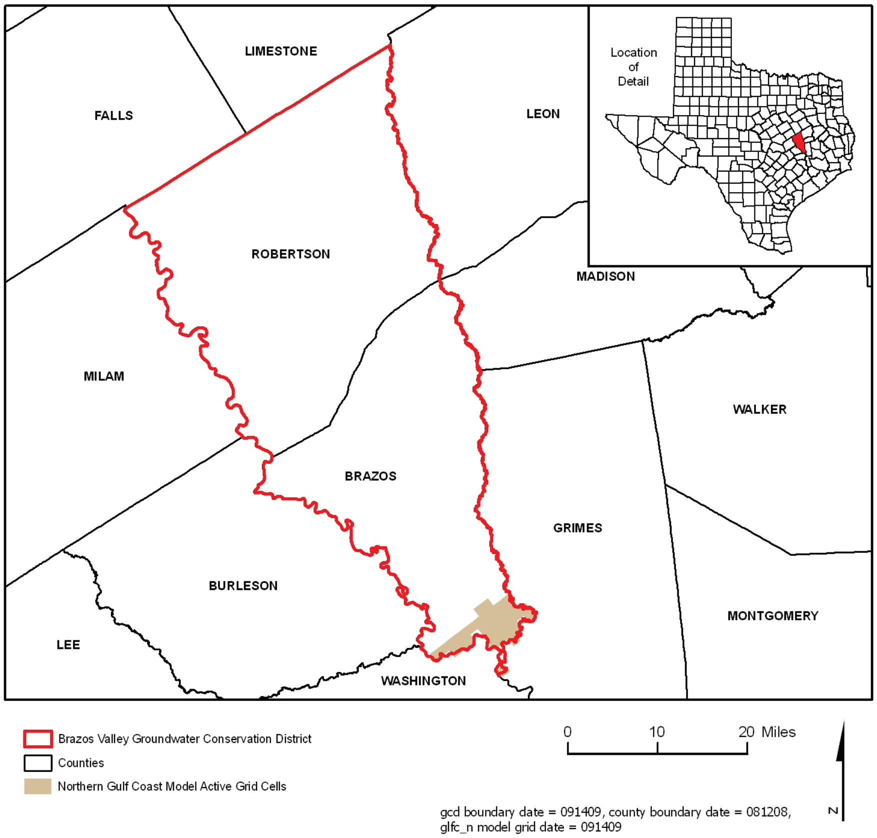

FIGURE 5: AREA OF THE GROUNDWATER AVAILABILITY MODEL FOR THE NORTHERN PORTION OF THE GULF COAST AQUIFER FROM WHICH THE INFORMATION IN TABLE 5 WAS EXTRACTED (THE AQUIFER EXTENT WITHIN THE DISTRICT BOUNDARY).

REFERENCES:

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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.