GAM Run 18-019: Brazos Valley Groundwater Conservation District Groundwater Management Plan

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Texas Water Development Board
Groundwater Division
Groundwater Availability Modeling Department
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July 6, 2018

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EXECUTIVE SUMMARY:

Texas State Water Code, Section 36.1071, Subsection (h) (Texas Water Code, 2015), 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 (TWDB) in conjunction with any available site-specific information provided by the district for review and comment to the Executive Administrator.

The TWDB provides data and information to the Brazos Valley Groundwater Conservation District in two parts. Part 1 is the Estimated Historical Water Use/State Water Plan dataset report, which will be provided to you separately by the TWDB Groundwater Technical Assistance Department. Please direct questions about the water data report to Mr. Stephen Allen at 512-463-7317 or stephen.allen@twdb.texas.gov. Part 2 is the required groundwater availability modeling information and this information includes:

1. the annual amount of recharge from precipitation, if any, to the groundwater resources within the district;

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 groundwater management plan for the Brazos Valley Groundwater Conservation District should be adopted by the district on or before December 13, 2019, and submitted to the Executive Administrator of the TWDB on or before January 12, 2020. The current

management plan for the Brazos Valley Groundwater Conservation District expires on March 12, 2020.

We used four groundwater availability models to estimate the management plan information for the aquifers within the Brazos Valley Groundwater Conservation District. Information for the Carrizo-Wilcox, Queen City, and Sparta aquifers is from version 2.02 of the groundwater availability model for the central part of the Carrizo-Wilcox, Queen City, and Sparta aquifers (Kelley and others, 2004). Information for the Yegua-Jackson Aquifer is from version 1.01 of the groundwater availability model for the Yegua-Jackson Aquifer (Deeds and others, 2010). Information for the Gulf Coast Aquifer System is from version 3.01 of the groundwater availability model for the northern portion of the Gulf Coast Aquifer System (Kasmarek, 2013). Information for the Brazos River Alluvium Aquifer is from version 1.01 of the groundwater availability model for the Brazos River Alluvium Aquifer (Ewing and Jigmond, 2016).

This report replaces the results of GAM Run 14-005 (Jones, 2014). GAM Run 18-019 includes results from the recently released groundwater availability model for the Brazos River Alluvium Aquifer (Ewing and Jigmond, 2016) and the approach used for analyzing model results has been refined. Tables 1 through 6 summarize the groundwater availability model data required by statute and Figures 1 through 6 show the area of the models from which the values in the tables were extracted. If, after review of the figures, the Brazos Valley Groundwater Conservation District determines that the district boundaries used in the assessment do not reflect current conditions, please notify the TWDB at your earliest convenience.

METHODS:

In accordance with the provisions of the Texas State Water Code, Section 36.1071, Subsection (h), the four groundwater availability models mentioned above were used to estimate information for the Brazos Valley Groundwater Conservation District management plan. Water budgets were extracted for the historical model periods for the Carrizo-Wilcox, Queen City, and Sparta aquifers (1980 through 1999), Yegua-Jackson Aquifer (1980 through 1997) and Gulf Coast Aquifer System (1980 through 2009) using ZONEBUDGET Version 3.01 (Harbaugh, 2009). The water budget for the Brazos River Alluvium Aquifer was extracted for the historical model period (1980 through 2012) using ZONEBUDGET-USG (Panday and others, 2013). The average annual water budget values for recharge, surface-water outflow, inflow to the district, and outflow from the district for the aquifers within the district are summarized in this report.

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, which generally represent the Sparta Aquifer (Layer 1), the Weches Formation confining unit (Layer 2), the Queen City Aquifer (Layer 3), the Reklaw Formation confining unit (Layer 4), the Carrizo Formation (Layer 5), the Calvert Bluff Formation (Layer 6), the Simsboro Formation (Layer 7), and the Hooper Formation (Layer 8).

- 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 (Layers 5 through 8, collectively).

- The model was run with MODFLOW-96 (Harbaugh and McDonald, 1996).

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, which represent the outcrop of the Yegua-Jackson Aquifer and younger overlying units—the Catahoula Formation (Layer 1), the upper portion of the Jackson Group (Layer 2), the lower portion of the Jackson Group (Layer 3), the upper portion of the Yegua Group (Layer 4), and the lower portion of the Yegua Group (Layer 5).

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

- The model was run with MODFLOW-2000 (Harbaugh and others, 2000).

Gulf Coast Aquifer System

- We used version 3.01 of the groundwater availability model for the northern portion of the Gulf Coast Aquifer System for this analysis. See Kasmarek (2013) for assumptions and limitations of the model.

- The model has four layers, which represent the Chicot Aquifer (Layer 1), the Evangeline Aquifer (Layer 2), the Burkeville Confining Unit (Layer 3), and the Jasper Aquifer and parts of the Catahoula Formation in direct hydrologic communication with the Jasper Aquifer (Layer 4).

- Water budgets for the district were determined for the Gulf Coast Aquifer System (Layers 1 through 4 collectively).

- The model was run with MODFLOW-2000 (Harbaugh and others, 2000).

- Because this model assumes a no-flow boundary condition at the base we used version 1.01 of the groundwater availability model for the Yegua-Jackson Aquifer to investigate groundwater flows between the Catahoula Formation and the base of the Gulf Coast Aquifer System. See Deeds and others (2010) for assumptions and limitations of the groundwater availability model for the Yegua-Jackson Aquifer.

Brazos River Alluvium Aquifer

- We used version 1.01 of the groundwater availability model for the Brazos River Alluvium Aquifer released on December 16, 2016. See Ewing and Jigmond (2016) for assumptions and limitations of the model.

- The groundwater availability model for the Brazos River Alluvium Aquifer contains three layers. Layers 1 and 2 represent the Brazos River Alluvium Aquifer and Layer 3 represents the surficial portions of the Carrizo-Wilcox, Queen City, Sparta, Yegua-Jackson, and Gulf Coast aquifers as well as various geologic units of the Cretaceous System.

- In the Brazos Valley Groundwater Conservation District flow between underlying aquifers and the Brazos River Alluvium Aquifer is represented by flow between model layers 2 and 3.

- Perennial rivers and streams were simulated using the MODFLOW Streamflow-Routing package and ephemeral streams were simulated using the MODFLOW River package. Springs were simulated using the MODFLOW Drain package.

- The model was run with MODFLOW-USG (unstructured grid; Panday and others, 2013).

RESULTS:

A groundwater budget summarizes the amount of water entering and leaving the aquifers according to the groundwater availability model. Selected groundwater budget components listed below were extracted from the groundwater availability model results for the Carrizo-Wilcox, Queen City, Sparta, Yegua-Jackson, and Brazos River Alluvium aquifers and the Gulf Coast Aquifer System, located within Brazos Valley Groundwater Conservation District and averaged over the historical calibration periods, as shown in Tables 1 through 6.

1. Precipitation recharge—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.

2. Surface-water outflow—the total water discharging from the aquifer (outflow) to surface-water features such as streams, reservoirs, and springs.

3. Flow into and out of district—the lateral flow within the aquifer between the district and adjacent counties.

4. Flow between aquifers—the net vertical flow between the aquifer and adjacent aquifers or confining units. This flow is controlled by the relative water levels in each aquifer and aquifer properties of each aquifer or confining unit that define the amount of leakage that occurs.

The information needed for the district's management plan is summarized in Tables 1 through 6. 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 a district or county 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.

TABLE 1. SUMMARIZED INFORMATION FOR THE CARRIZO-WILCOX AQUIFER FOR 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 or confining unit	Results
Estimated annual amount of recharge from precipitation to the district	Carrizo-Wilcox Aquifer	26,906
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	16,869
Estimated annual volume of flow into the district within each aquifer in the district	Carrizo-Wilcox Aquifer	26,578
Estimated annual volume of flow out of the district within each aquifer in the district	Carrizo-Wilcox Aquifer	11,362
Estimated net annual volume of flow between each aquifer in the district	Flow into the Carrizo-Wilcox Aquifer from the overlying Reklaw Confining Unit	62
	Flow into the Carrizo-Wilcox Aquifer from downdip brackish Carrizo-Wilcox units	3,477
	Flow from the Carrizo-Wilcox Aquifer into the Brazos River Alluvium Aquifer[1]	2,290

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[1] Flow based on water budget from the groundwater availability model for the Brazos River Alluvium.

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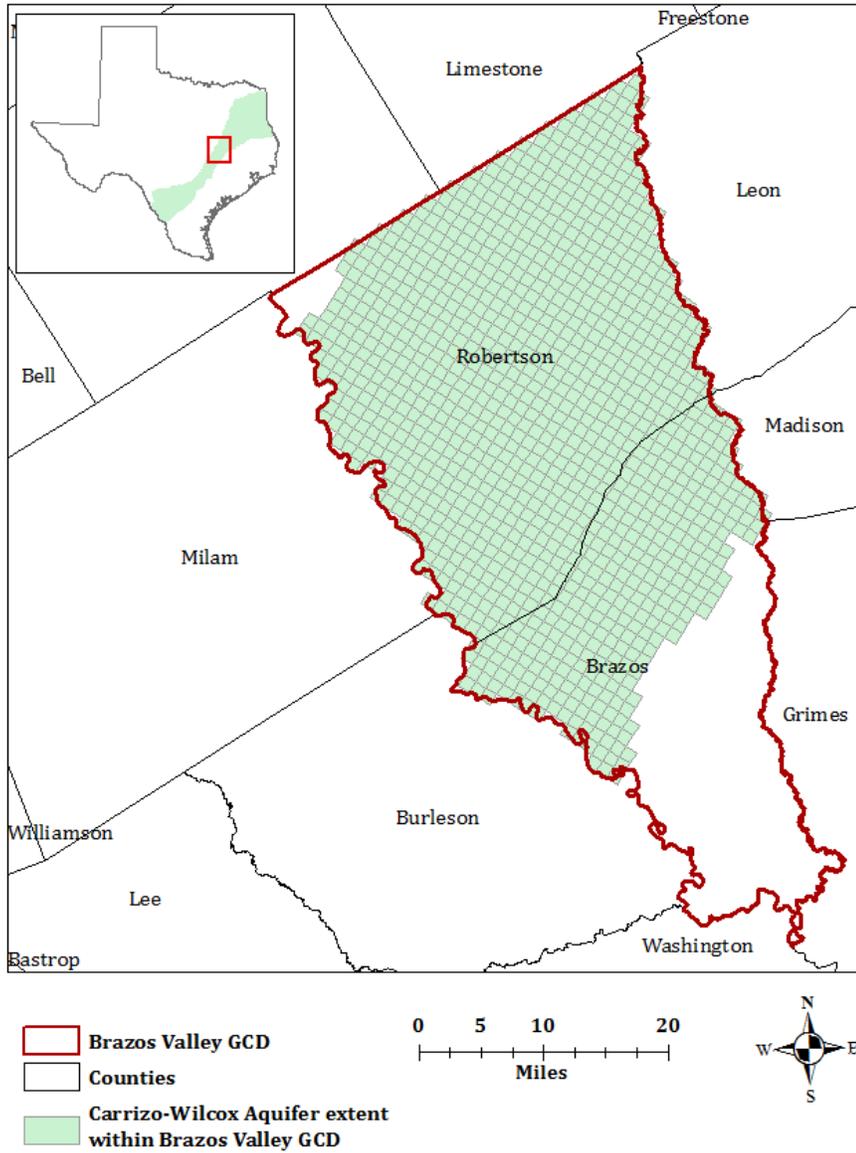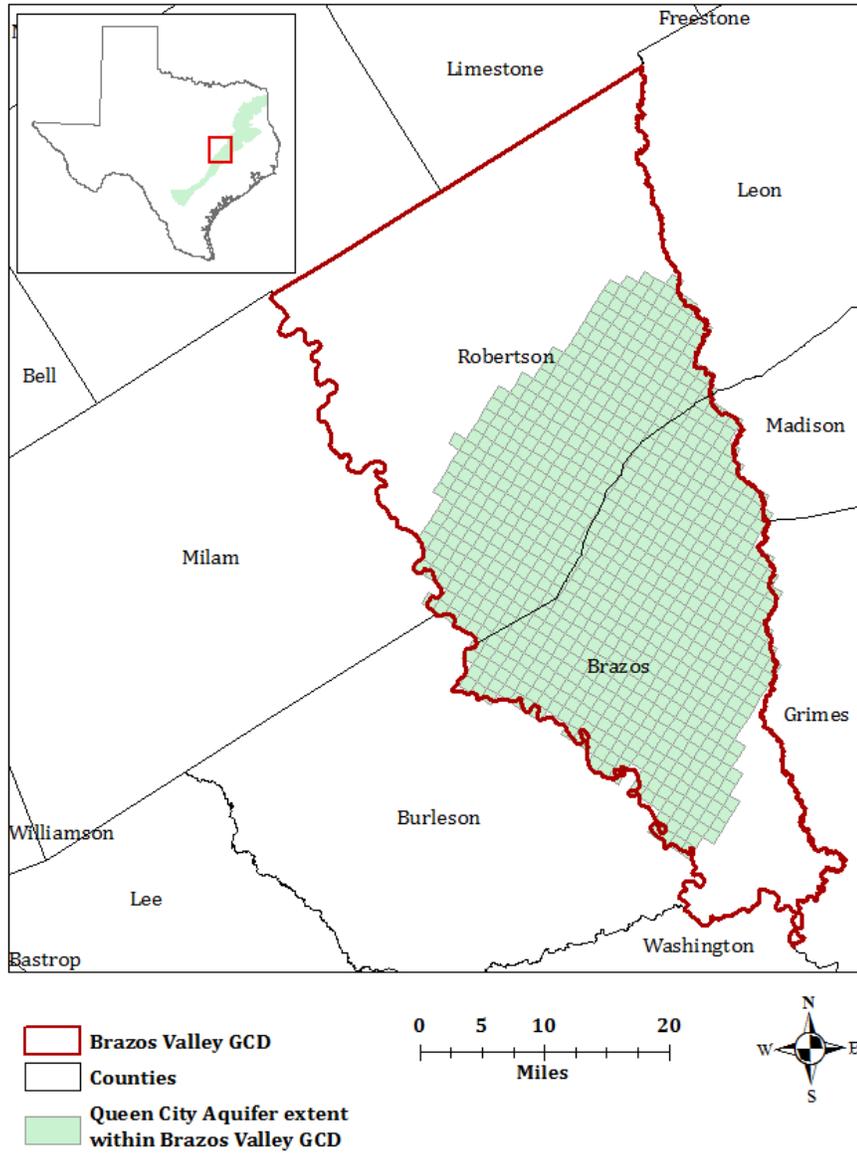
FIGURE 1. AREA OF THE GROUNDWATER AVAILABILITY MODEL FOR THE CARRIZO-WILCOX AQUIFER FROM WHICH THE INFORMATION IN TABLE 1 WAS EXTRACTED (THE AQUIFER SYSTEM EXTENT WITHIN THE DISTRICT BOUNDARY).

TABLE 2.   SUMMARIZED INFORMATION FOR THE QUEEN CITY AQUIFER FOR 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 or confining unit	Results
Estimated annual amount of recharge from precipitation to the district	Queen City Aquifer	6,091
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	11,902
Estimated annual volume of flow into the district within each aquifer in the district	Queen City Aquifer	1,863
Estimated annual volume of flow out of the district within each aquifer in the district	Queen City Aquifer	818
Estimated net annual volume of flow between each aquifer in the district	Flow into the Queen City Aquifer from the underlying Reklaw Confining Unit	148
	Flow into the Queen City Aquifer from the overlying Weches Confining Unit	209
	Flow from the Queen City Aquifer into downdip brackish Queen City units	35
	Flow from the Queen City Aquifer into the Brazos River Alluvium Aquifer[2]	6,288

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[2] Flow based on water budget from the groundwater availability model for the Brazos River Alluvium.
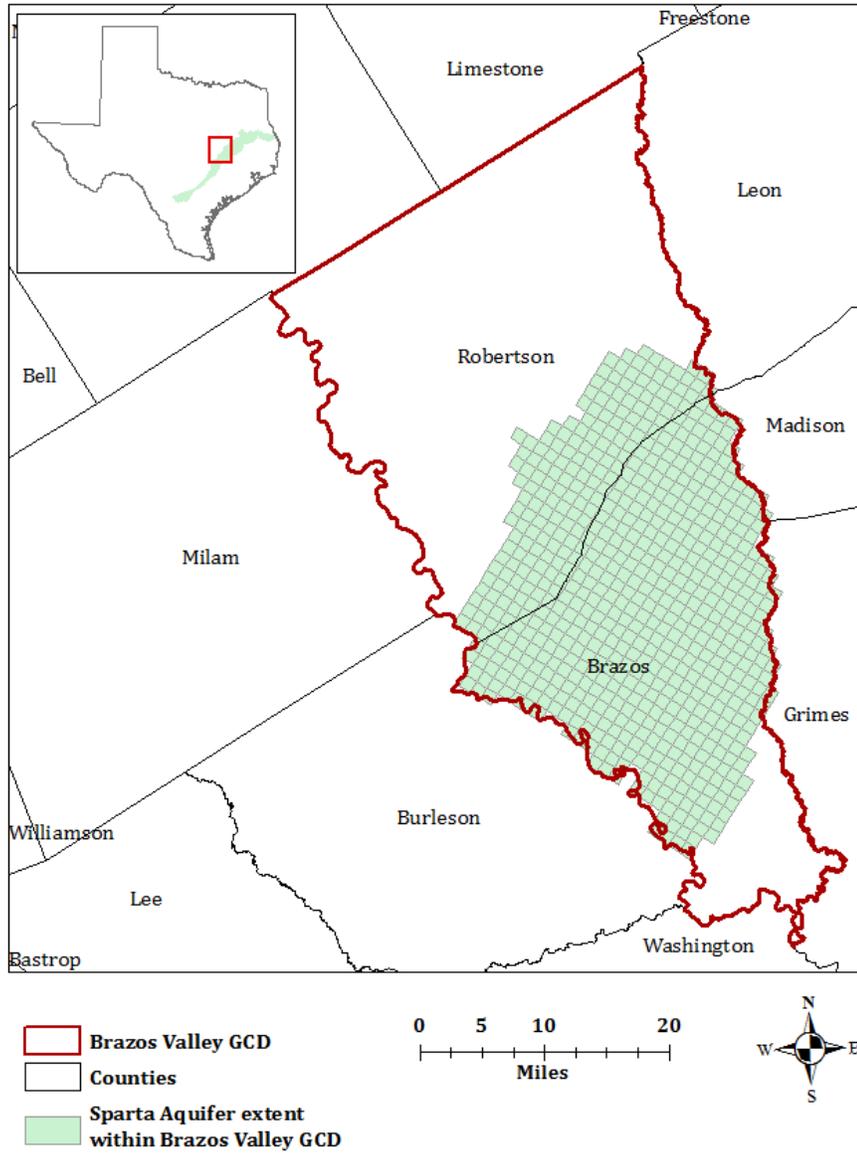
FIGURE 2. AREA OF THE GROUNDWATER AVAILABILITY MODEL FOR THE QUEEN CITY AQUIFER FROM WHICH THE INFORMATION IN TABLE 2 WAS EXTRACTED (THE AQUIFER SYSTEM EXTENT WITHIN THE DISTRICT BOUNDARY).

TABLE 3.   SUMMARIZED INFORMATION FOR THE SPARTA AQUIFER FOR 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 or confining unit	Results
Estimated annual amount of recharge from precipitation to the district	Sparta Aquifer	9,970
Estimated annual volume of water that discharges from the aquifer to springs and any surface-water body including lakes, streams, and rivers	Sparta Aquifer	1,861
Estimated annual volume of flow into the district within each aquifer in the district	Sparta Aquifer	630
Estimated annual volume of flow out of the district within each aquifer in the district	Sparta Aquifer	495
Estimated net annual volume of flow between each aquifer in the district	Flow into the Sparta Aquifer from the overlying units	714
	Flow from the Sparta Aquifer into the underlying Weches Confining Unit	599
	Flow from the Sparta Aquifer into downdip brackish Sparta units	77
	Flow from the Sparta Aquifer into the Brazos River Alluvium Aquifer[3]	3,870

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[3] Flow based on water budget from the groundwater availability model for the Brazos River Alluvium.

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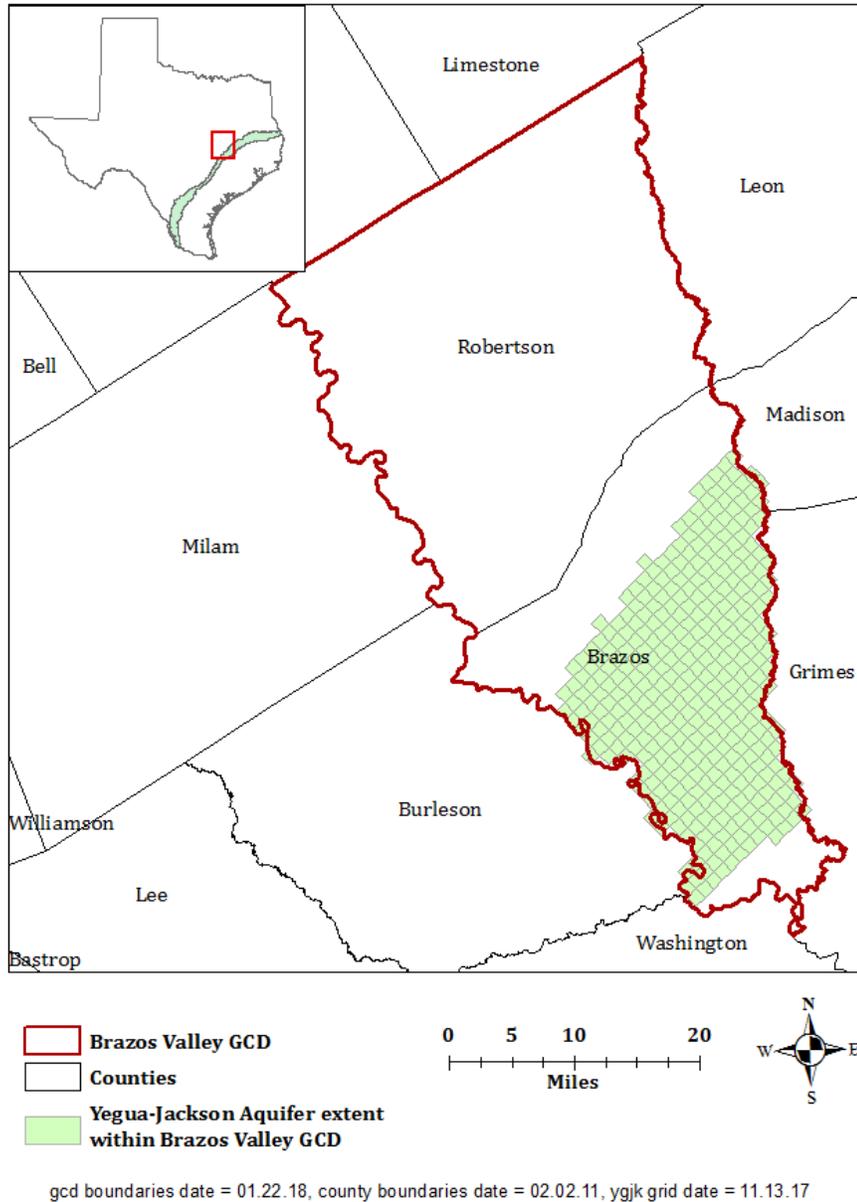
FIGURE 3. AREA OF THE GROUNDWATER AVAILABILITY MODEL FOR THE SPARTA AQUIFER FROM WHICH THE INFORMATION IN TABLE 3 WAS EXTRACTED (THE AQUIFER SYSTEM EXTENT WITHIN THE DISTRICT BOUNDARY).

TABLE 4.   SUMMARIZED INFORMATION FOR THE YEGUA-JACKSON AQUIFER FOR 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 or confining unit	Results
Estimated annual amount of recharge from precipitation to the district	Yegua-Jackson Aquifer	26,512
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	39,287
Estimated annual volume of flow into the district within each aquifer in the district	Yegua-Jackson Aquifer	12,069
Estimated annual volume of flow out of the district within each aquifer in the district	Yegua-Jackson Aquifer	9,923
Estimated net annual volume of flow between each aquifer in the district	Flow into the Yegua-Jackson Aquifer from the Catahoula and younger units	17
	Flow from the confined portion of the Yegua and Jackson groups into the Yegua-Jackson Aquifer	134
	Flow from the Yegua-Jackson Aquifer into the Brazos River Alluvium Aquifer[4]	2,399

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[4] Flow based on water budget from the groundwater availability model for the Brazos River Alluvium.

FIGURE 4. AREA OF THE GROUNDWATER AVAILABILITY MODEL FOR THE YEGUA-JACKSON AQUIFER FROM WHICH THE INFORMATION IN TABLE 4 WAS EXTRACTED (THE AQUIFER SYSTEM EXTENT WITHIN THE DISTRICT BOUNDARY).
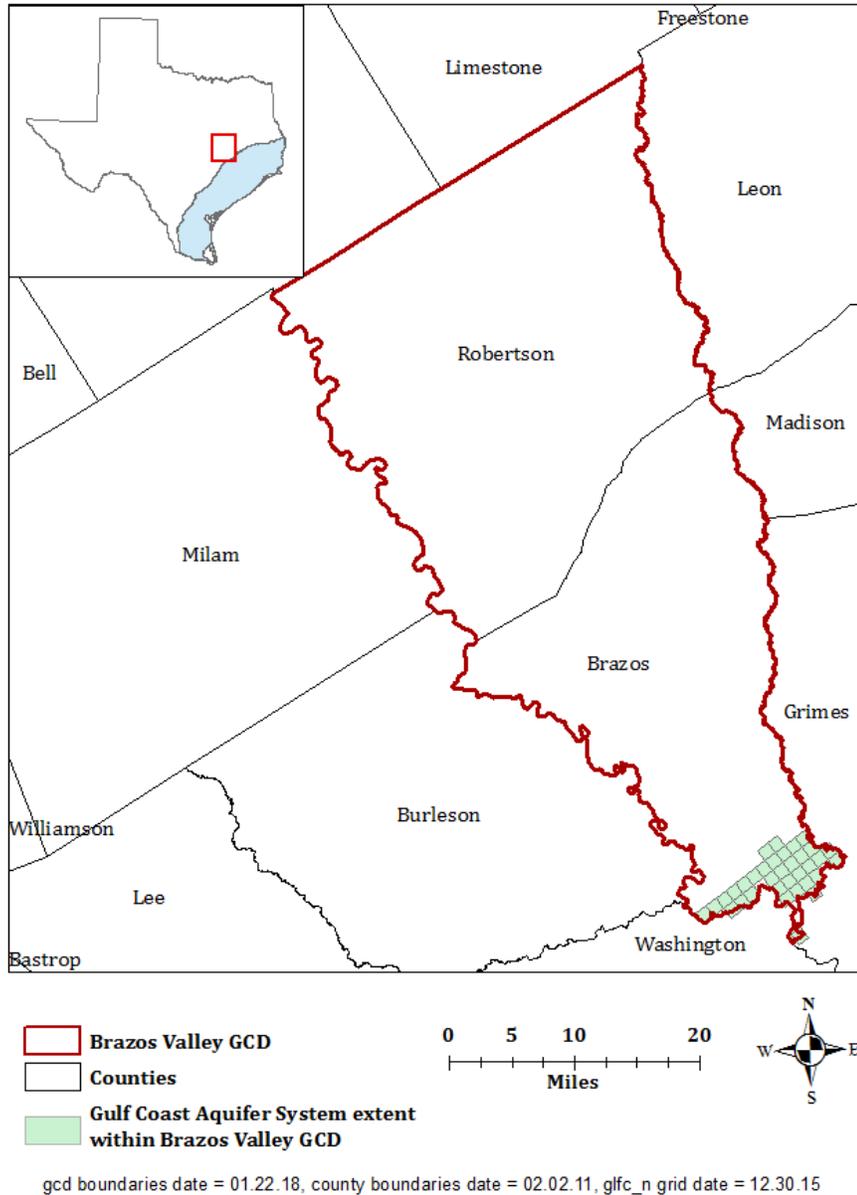
TABLE 5. SUMMARIZED INFORMATION FOR THE GULF COAST AQUIFER SYSTEM FOR BRAZOS VALLEY GROUNDWATER CONSERVATION DISTRICT'S GROUNDWATER MANAGEMENT PLAN. ALL VALUES ARE REPORTED IN ACRE-FEET PER YEAR AND ROUNDED TO THE NEAREST 1 ACRE-FOOT.

Management Plan requirement	Aquifer or confining unit	Results
Estimated annual amount of recharge from precipitation to the district	Gulf Coast Aquifer System	40
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 System	255
Estimated annual volume of flow into the district within each aquifer in the district	Gulf Coast Aquifer System	332
Estimated annual volume of flow out of the district within each aquifer in the district	Gulf Coast Aquifer System	48
Estimated net annual volume of flow between each aquifer in the district	Flow into the Catahoula unit from the Jasper Aquifer[5]	46
	Flow from the Gulf Coast Aquifer System into the Brazos River Alluvium[6]	2,154

[5] Based on the general head boundary flux from the groundwater availability model for the Yegua-Jackson Aquifer. A part of the flow between the Catahoula confining system and the Jasper Aquifer represents flow between the Gulf Coast Aquifer System and deeper units and part represents flow within the Gulf Coast Aquifer System.
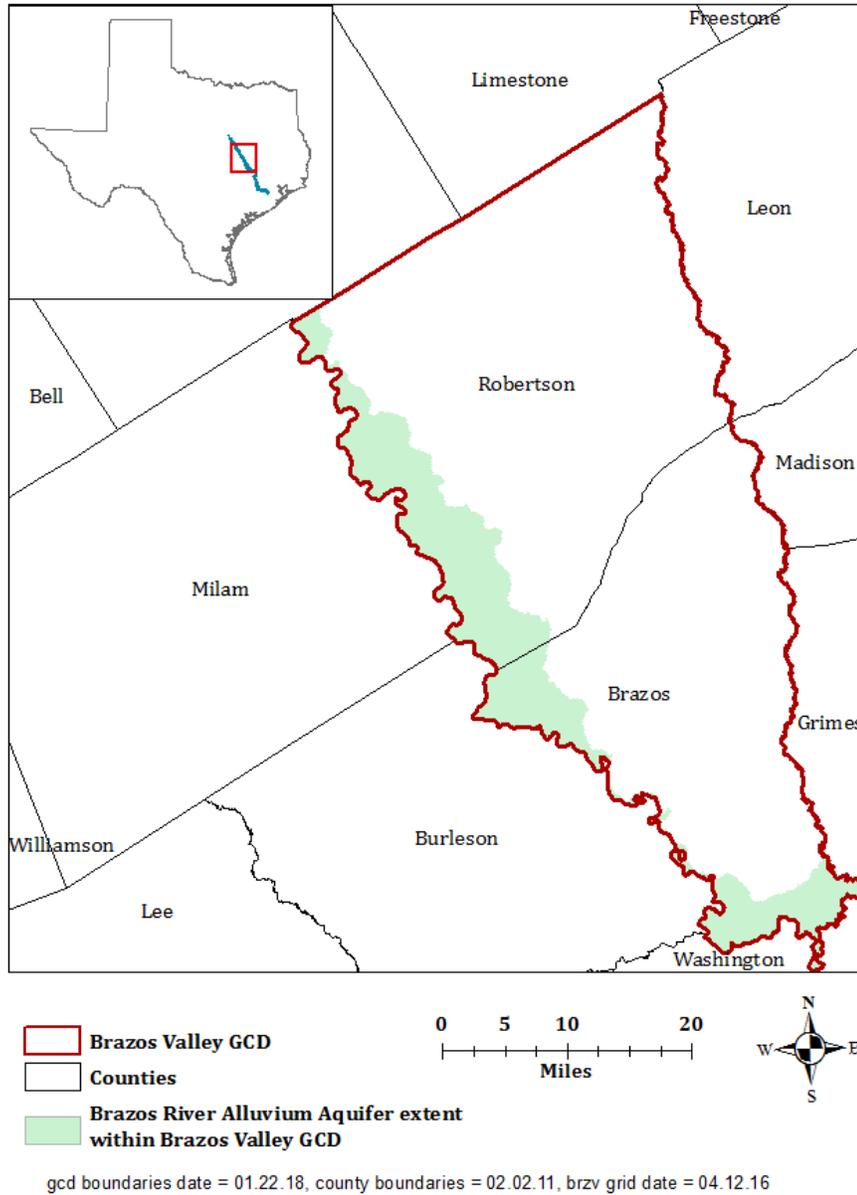
[6] Flow based on water budget from the groundwater availability model for the Brazos River Alluvium.

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

TABLE 6. SUMMARIZED INFORMATION FOR THE BRAZOS RIVER ALLUVIUM AQUIFER FOR 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 or confining unit	Results
Estimated annual amount of recharge from precipitation to the district	Brazos River Alluvium Aquifer	23,333
Estimated annual volume of water that discharges from the aquifer to springs and any surface-water body including lakes, streams, and rivers	Brazos River Alluvium Aquifer	33,859
Estimated annual volume of flow into the district within each aquifer in the district	Brazos River Alluvium Aquifer	24,447
Estimated annual volume of flow out of the district within each aquifer in the district	Brazos River Alluvium Aquifer	20,432
Estimated net annual volume of flow between each aquifer in the district	Flow from the Carrizo-Wilcox Aquifer into the Brazos River Alluvium Aquifer	2,290
	Flow from the Queen City Aquifer into the Brazos River Alluvium Aquifer	6,288
	Flow from the Sparta Aquifer into the Brazos River Alluvium Aquifer	3,870
	Flow from the Yegua-Jackson Aquifer into the Brazos River Alluvium Aquifer	2,399
	Flow from the Gulf Coast Aquifer System into the Brazos River Alluvium	2,154

FIGURE 6. AREA OF THE GROUNDWATER AVAILABILITY MODEL FOR THE BRAZOS RIVER ALLUVIUM AQUIFER FROM WHICH THE INFORMATION IN TABLE 6 WAS EXTRACTED (THE AQUIFER SYSTEM EXTENT WITHIN THE DISTRICT BOUNDARY).

LIMITATIONS:

The groundwater models used in completing this analysis are the best available scientific tools that can be used to meet the stated objectives. 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 historical groundwater flow conditions includes the assumptions about the location in the aquifer where historical pumping was placed. Understanding the amount and location of historical 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 interaction with streams are specific to particular historical time periods.

Because the application of the groundwater models was designed to address regional-scale questions, the results are most effective on a regional scale. The TWDB makes no warranties or representations related 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. Historical 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.

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