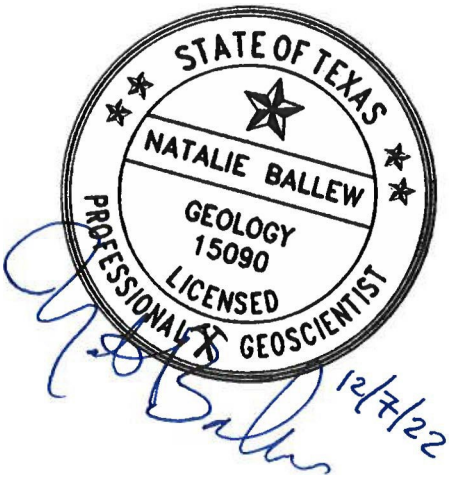
GAM RUN 21-021 MAG:
MODELED AVAILABLE GROUNDWATER FOR THE GULF COAST AQUIFER SYSTEM IN GROUNDWATER MANAGEMENT AREA 16

Ki Cha, Ph.D., EIT
Texas Water Development Board
Groundwater Division
Groundwater Modeling Department
512-463-5604
October 31, 2022



Natalie Ballew, P.G. 15090, is the Director of the Groundwater Division and is responsible for oversight of work performed by Ki Cha under her supervision.

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EXECUTIVE SUMMARY:

The modeled available groundwater for Groundwater Management Area 16 for the Gulf Coast Aquifer System is summarized by decade by groundwater conservation district and county (Table 1) and for use in the regional water planning process by county, regional water planning area, and river basin (Table 2). The modeled available groundwater estimates range from approximately 229,000 acre-feet per year in 2020 to approximately 294,000 acre-feet per year in 2080 (Tables 1 and 2). The estimates are based on the desired future conditions for the Gulf Coast Aquifer System adopted by groundwater conservation districts in Groundwater Management Area 16 on November 23, 2021 and re-adopted with minor clerical corrections on June 28, 2022. The explanatory report and other materials submitted to the TWDB were determined to be administratively complete on August 26, 2022.

REQUESTOR:

Mr. Scott Bledsoe, III, coordinator for Groundwater Management Area 16.

DESCRIPTION OF REQUEST:

In a letter dated January 22, 2022, Dr. Steve C. Young, consultant for Groundwater Management Area 16, provided the TWDB with the desired future conditions of the Gulf Coast Aquifer System adopted by the groundwater conservation district representatives in Groundwater Management Area 16. The Carrizo-Wilcox and Yegua-Jackson aquifers were declared non-relevant for joint planning purposes by Groundwater Management Area 16.

On June 2, 2022, TWDB requested clarifications about the wording of the desired future conditions, as some were unachievable based on TWDB analysis of the submitted model files during administrative review. In response, the Groundwater Management Area 16 consultant and groundwater conservation district representatives submitted an amended explanatory report (Young, 2022) on July 4, 2022. Groundwater Management Area 16

adopted a revised version of the desired future conditions for the Gulf Coast Aquifer System. The final desired future conditions adopted by the groundwater conservation district representatives in Groundwater Management Area 16 as described in Resolution No. 2022-01, on June 28, 2022 (Young, 2022; Appendix C), are presented below:

> *"Groundwater Management Area 16 adopts Desired Future Conditions for each county within the groundwater management area (county-specific DFC's) and adopts a Desired Future Condition for the counties in the groundwater management area (gma-specific DFC's). The Desired Future Condition for the counties in the groundwater management area shall not exceed an average drawdown of 78 feet for the Gulf Coast Aquifer System at December 2080. Desired Future Conditions for each county within the groundwater management area (county-specific DFC's) shall not exceed the values specified in Scenario 2 at December 2080.*
>
> *Table A-1: Desired Future Conditions for GMA 16 expressed as an Average Drawdown between January 2010 and December 2079.*
>
> *Bee GCD: 93 feet of drawdown of the Gulf Coast Aquifer System;*
>
> *Live Oak UWCD: 45 feet of drawdown of the Gulf Coast Aquifer System;*
>
> *McMullen GCD: 12 feet of drawdown of the Gulf Coast Aquifer System;*
>
> *Red Sands GCD: 60 feet of drawdown of the Gulf Coast Aquifer System;*
>
> *Kenedy County GCD: 27 feet of drawdown of the Gulf Coast Aquifer System;*
>
> *Brush Country GCD: 89 feet of drawdown of the Gulf Coast Aquifer System;*
>
> *Duval County GCD: 137 feet of drawdown of the Gulf Coast Aquifer System;*
>
> *San Patricio County GCD: 69 feet of drawdown of the Gulf Coast Aquifer System;*
>
> *Starr County GCD: 94 feet of drawdown of the Gulf Coast Aquifer System;*
>
> *Cameron: 119 feet of drawdown of the Gulf Coast Aquifer System;*
>
> *Hidalgo: 138 feet of drawdown of the Gulf Coast Aquifer System;*
>
> *Kleberg: 21 feet of drawdown of the Gulf Coast Aquifer System;*
>
> *Nueces: 26 feet of drawdown of the Gulf Coast Aquifer System;*
>
> *Webb: 161 feet of drawdown of the Gulf Coast Aquifer System;*
>
> *Willacy: 44 feet of drawdown of the Gulf Coast Aquifer System."*

METHODS:

The alternative groundwater availability model for Groundwater Management Area 16 (version 1.01; Hutchison and others, 2011) was run using the predictive model files ("Pumping Scenario #2") submitted with the desired future condition explanatory report (Young, 2022). Model-calculated water levels were extracted for January 2010 (stress period 11) and December 2079 (stress period 81), and drawdown was calculated as the difference between these water levels. Drawdown averages were calculated for the Gulf Coast Aquifer System by county, groundwater conservation district, and the entire groundwater management area. The calculated drawdown averages were compared with the desired future conditions to verify that the submitted pumping scenario can achieve the desired future conditions within the three-foot tolerance specified by Groundwater Management Area 16.

The modeled available groundwater values were determined by extracting pumping rates by decade from the model results using ZONEBUDGET Version 3.01 (Harbaugh, 2009). The modeled available groundwater can be presented by groundwater conservation district and county within Groundwater Management Area 16 (Figure 1) and by county, regional water planning area, and river basin within Groundwater Management Area 16 (Figure 2)

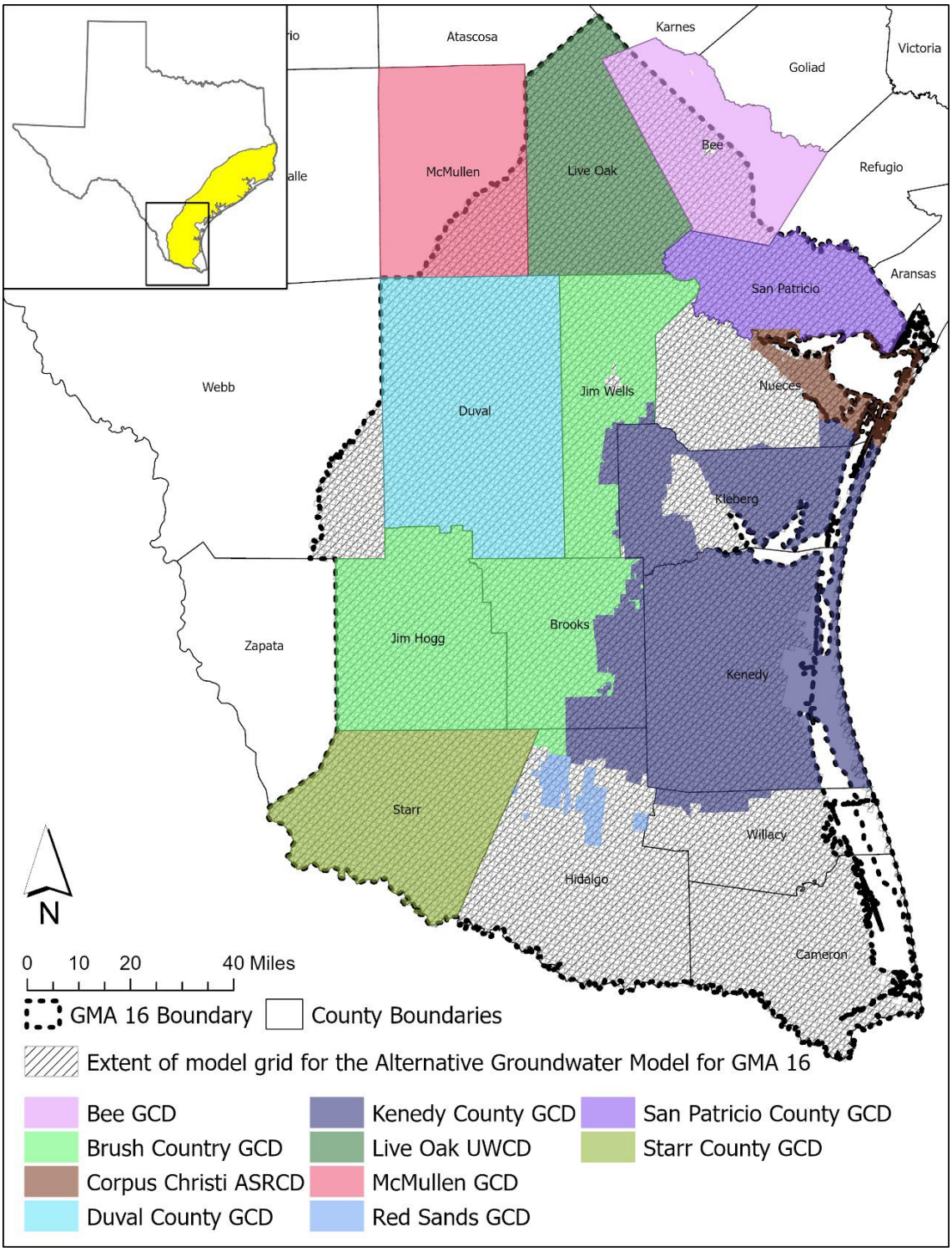

FIGURE 1. MAP SHOWING GROUNDWATER CONSERVATION DISTRICTS (GCDS) AND COUNTIES IN GROUNDWATER MANAGEMENT AREA 16, OVERLAIN ON THE EXTENT OF THE ALTERNATIVE GROUNDWATER AVAILABILITY MODEL FOR GROUNDWATER MANAGEMENT AREA 16.

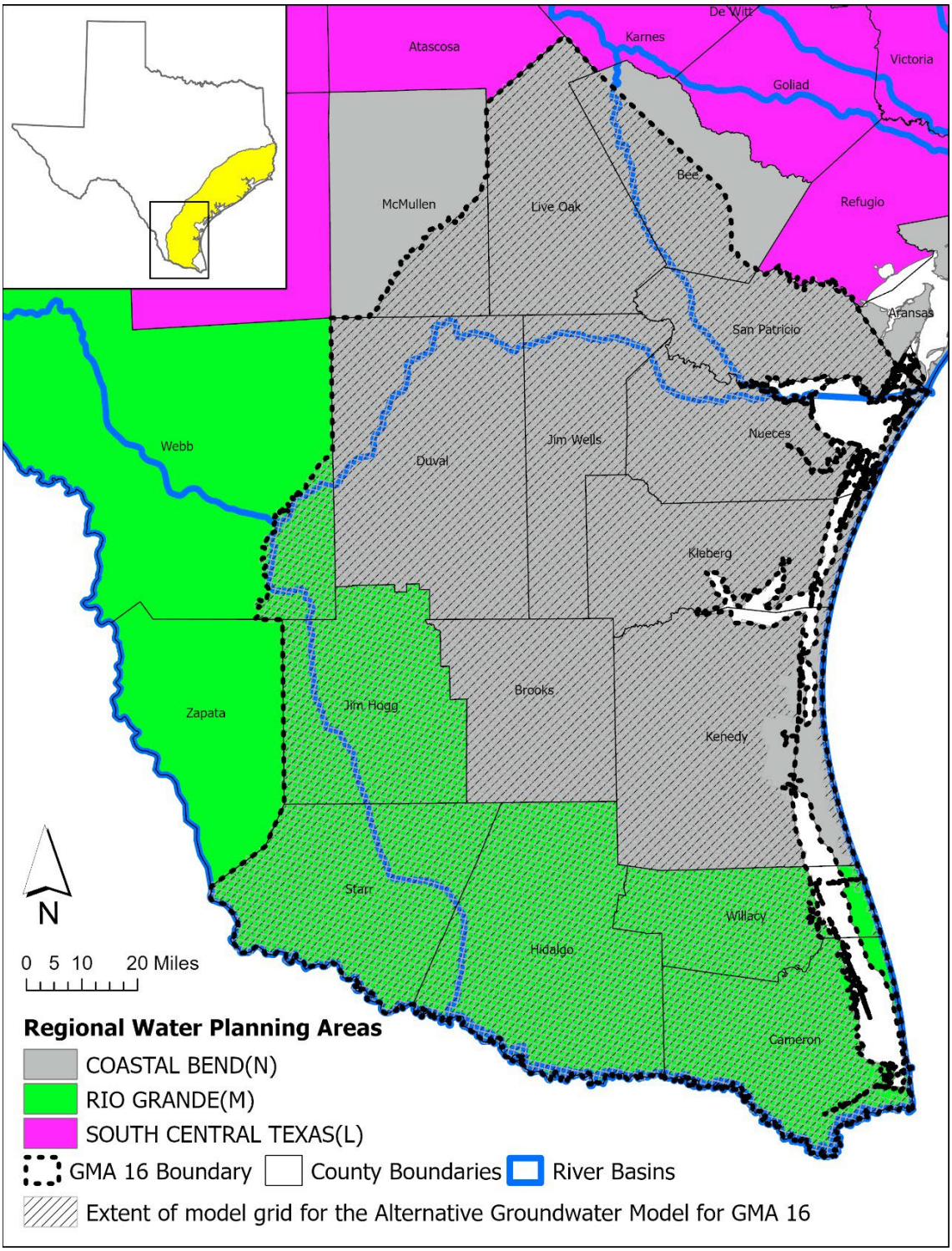

FIGURE 2. MAP SHOWING THE REGIONAL WATER PLANNING AREAS, COUNTIES, AND RIVER BASINS IN GROUNDWATER MANAGEMENT AREA 16, OVERLAIN ON THE EXTENT OF THE ALTERNATIVE GROUNDWATER AVAILABILITY MODEL FOR GROUNDWATER MANAGEMENT AREA 16.

Modeled Available Groundwater and Permitting

As defined in Chapter 36 of the Texas Water Code (2011), "modeled available groundwater" is the estimated average amount of water that may be produced annually to achieve a desired future condition. Groundwater conservation districts must consider modeled available groundwater when issuing permits in order to manage groundwater production to achieve the desired future condition(s). Districts must also consider annual precipitation and production patterns, the estimated amount of pumping exempt from permitting, existing permits, and a reasonable estimate of actual groundwater production under existing permits.

PARAMETERS AND ASSUMPTIONS:

The parameters and assumptions for the modeled available groundwater estimates are described below:

- Version 1.01 of the alternate groundwater availability model for Groundwater Management Area 16 was the base model for this analysis. See Hutchison and others (2011) for assumptions and limitations of the model. Groundwater Management Area 16 constructed a predictive model simulation to extend the base model to 2080 for planning purposes. See Young (2022) for the assumptions of this predictive model simulation.

- The model has six layers that represent the Chicot aquifer (Layer 1), the Evangeline aquifer (Layer 2), the Burkeville confining unit (Layer 3), the Jasper aquifer (Layer 4), the Yegua-Jackson Aquifer (Layer 5), and the Queen-City, Sparta and Carrizo-Wilcox Aquifer System (Layer 6). Layers 1 through 4 were lumped to calculate modeled available groundwater for the Gulf Coast Aquifer System.

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

- To be consistent with Groundwater Management Area 16, the TWDB model grid file dated May 1, 2014 (alt1_gma16) was used to determine model cell entity assignment (county, groundwater management area, groundwater conservation district, river basin, regional water planning area).

- Although the original groundwater availability model was only calibrated to the end of 1999, an analysis during the previous round of joint planning verified that the measured water levels did not change significantly for the period from 2000 to 2010 (Goswami, 2017). For this reason, TWDB considers it acceptable to use 2010 as the reference year for drawdown calculations.

- Drawdown averages and modeled available groundwater values are based on the official TWDB boundary for the groundwater conservation district, county, regional water planning area, river basin, and Regional Water Planning Areas within Groundwater Management Area 16 (Figures 1 and 2).

- Drawdown values for cells with water levels below the base elevation of the cell ("dry" cells) were included in the average drawdown calculations. The groundwater availability model for Groundwater Management Area 16 was constructed using the confined aquifer assumption (and LAYCON=0 option), meaning the transmissivity of "dry" cells remains constant and pumping from those cells continues. The desired future conditions adopted by Groundwater Management Area 16 are based on the average drawdowns that include "dry" cells. Therefore, pumping values from "dry" cells were also included in the calculation of modeled available groundwater. Please note that the confined aquifer assumption may also lead to physically unrealistic conditions, with pumping in a model cell continuing even when water levels have dropped below the base of the model cell.

- Drawdown was calculated as the difference in modeled water levels between the baseline date January 2010 (stress period 11) and the final date December 2079 (stress period 81). Average drawdowns were calculated as the sum of drawdowns for all model cells within a specified area divided by the number of cells in that specified area.

- Estimates of modeled available groundwater from the model simulation were rounded to whole numbers.

RESULTS:

The modeled available groundwater for the Gulf Coast Aquifer System that achieves the desired future conditions adopted by Groundwater Management Area 16 increases from approximately 229,000 acre-feet per year in 2020 to 294,000 acre-feet per year in 2080. The modeled available groundwater is summarized by groundwater conservation district and county (Table 1) and by county, regional water planning area, and river basin (Table 2) for use in the regional water planning process.

TABLE 1. MODELED AVAILABLE GROUNDWATER FOR THE GULF COAST AQUIFER SYSTEM IN GROUNDWATER MANAGEMENT AREA 16 SUMMARIZED BY GROUNDWATER CONSERVATION DISTRICT (GCD) AND COUNTY FOR EACH DECADE BETWEEN 2020 AND 2080. VALUES ARE IN ACRE-FEET PER YEAR.

Groundwater Conservation District (GCD)	County	2020	2030	2040	2050	2060	2070	2080
Bee GCD	**Bee**	10,338	11,849	12,593	12,944	13,146	13,146	13,146
Brush Country GCD	Brooks	3,660	3,660	3,660	3,660	3,660	4,205	4,205
Brush Country GCD	Hidalgo	131	131	131	131	131	150	150
Brush Country GCD	Jim Hogg	6,167	6,167	6,167	6,167	6,167	7,084	7,084
Brush Country GCD	Jim Wells	8,701	9,065	9,393	9,758	10,050	11,544	11,544
Brush Country GCD Total		**18,659**	**19,023**	**19,351**	**19,716**	**20,008**	**22,983**	**22,983**
Duval County GCD	**Duval**	**20,571**	**22,169**	**23,764**	**25,363**	**26,963**	**26,963**	**26,963**
Kenedy County GCD	Brooks	1,308	1,463	1,693	1,847	2,078	2,232	2,232
Kenedy County GCD	Hidalgo	412	460	534	582	654	703	703
Kenedy County GCD	Jim Wells	296	330	383	417	469	505	505
Kenedy County GCD	Kenedy	9,040	10,104	11,698	12,762	14,358	15,421	15,421
Kenedy County GCD	Kleberg	4,291	4,796	5,553	6,058	6,815	7,320	7,320
Kenedy County GCD	Nueces	171	191	221	241	271	291	291
Kenedy County GCD	Willacy	328	365	424	462	520	558	558
Kenedy County GCD Total		**15,846**	**17,709**	**20,506**	**22,369**	**25,165**	**27,030**	**27,030**
Live Oak UWCD	**Live Oak**	**10,169**	**11,394**	**10,444**	**10,294**	**10,294**	**10,294**	**10,294**
McMullen GCD	**McMullen**	**510**	**510**	**510**	**510**	**510**	**510**	**510**
Red Sands GCD	**Hidalgo**	**1,667**	**1,966**	**2,265**	**2,563**	**2,863**	**2,863**	**2,863**
San Patricio County GCD	**San Patricio**	**43,611**	**45,016**	**46,422**	**47,828**	**49,234**	**49,234**	**49,234**
Starr County GCD	**Starr**	**3,798**	**4,797**	**5,797**	**6,794**	**7,795**	**7,795**	**7,795**

TABLE 1. CONTINUED

Groundwater Conservation District (GCD)	County	2020	2030	2040	2050	2060	2070	2080
No District-Cameron	Cameron	6,688	7,999	9,311	10,620	11,932	11,932	11,932
No District-Hidalgo	Hidalgo	85,634	90,905	96,175	101,445	106,715	106,715	106,715
No District-Kleberg	Kleberg	4,051	4,243	4,436	4,629	4,822	4,822	4,822
No District-Nueces	Nueces	6,339	6,596	6,857	7,115	7,372	7,372	7,372
No District-Webb	Webb	620	789	959	1,129	1,299	1,299	1,299
No District-Willacy	Willacy	664	785	905	1,024	1,145	1,145	1,145
No District-Total		**103,996**	**111,317**	**118,643**	**125,962**	**133,285**	**133,285**	**133,285**
GMA 16 Total		**229,165**	**245,750**	**260,295**	**274,343**	**289,263**	**294,103**	**294,103**

TABLE 2. MODELED AVAILABLE GROUNDWATER FOR THE GULF COAST AQUIFER SYSTEM IN GROUNDWATER MANAGEMENT AREA 16. RESULTS ARE IN ACRE-FEET PER YEAR AND ARE SUMMARIZED BY COUNTY, REGIONAL WATER PLANNING AREA (RWPA), AND RIVER BASIN FOR EACH DECADE BETWEEN 2030 AND 2080.

County	RWPA	River Basin	2030	2040	2050	2060	2070	2080
Bee	N	Nueces	981	1,043	1,072	1,089	1,089	1,089
Bee	N	San Antonio-Nueces	10,868	11,550	11,872	12,057	12,057	12,057
Brooks	N	Nueces-Rio Grande	5,123	5,353	5,507	5,738	6,437	6,437
Cameron	M	Nueces-Rio Grande	7,536	8,771	10,005	11,241	11,241	11,241
Cameron	M	Rio Grande	463	540	615	691	691	691
Duval	N	Nueces	351	376	401	428	428	428
Duval	N	Nueces-Rio Grande	21,818	23,388	24,962	26,535	26,535	26,535
Hidalgo	M	Nueces-Rio Grande	91,421	96,658	101,867	107,103	107,171	107,171
Hidalgo	M	Rio Grande	2,041	2,447	2,854	3,260	3,260	3,260
Jim Hogg	M	Nueces-Rio Grande	5,230	5,230	5,230	5,230	6,008	6,008
Jim Hogg	M	Rio Grande	937	937	937	937	1,076	1,076
Jim Wells	N	Nueces	593	593	593	593	681	681
Jim Wells	N	Nueces-Rio Grande	8,802	9,183	9,582	9,926	11,368	11,368
Kenedy	N	Nueces-Rio Grande	10,104	11,698	12,762	14,358	15,421	15,421
Kleberg	N	Nueces-Rio Grande	9,039	9,989	10,687	11,637	12,142	12,142
Live Oak	N	Nueces	11,326	10,382	10,233	10,233	10,233	10,233
Live Oak	N	San Antonio-Nueces	68	62	61	61	61	61
McMullen	N	Nueces	510	510	510	510	510	510
Nueces	N	Nueces	756	787	816	845	845	845
Nueces	N	Nueces-Rio Grande	6,031	6,291	6,540	6,798	6,818	6,818
San Patricio	N	Nueces	4,502	4,874	5,247	5,619	5,619	5,619
San Patricio	N	San Antonio-Nueces	40,514	41,548	42,581	43,615	43,615	43,615

TABLE 2. CONTINUED

County	RWPA	River Basin	2030	2040	2050	2060	2070	2080
Starr	M	Nueces-Rio Grande	1,958	2,366	2,772	3,180	3,180	3,180
Starr	M	Rio Grande	2,839	3,431	4,022	4,615	4,615	4,615
Webb	M	Nueces	22	27	32	37	37	37
Webb	M	Nueces-Rio Grande	642	780	918	1,056	1,056	1,056
Webb	M	Rio Grande	125	152	179	206	206	206
Willacy	M	Nueces-Rio Grande	1,150	1,329	1,486	1,665	1,703	1,703
GMA 16 Total			**245,750**	**260,295**	**274,343**	**289,263**	**294,103**	**294,103**

*GCAS: Gulf Coast Aquifer System

LIMITATIONS:

The groundwater model used in completing this analysis is the best available scientific tool 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 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 groundwater levels in 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.

REFERENCES:

Goswami, R.R., 2017, GAM Run 17-025 MAG: Modeled Available Groundwater for the Gulf Coast Aquifer System in Groundwater Management Area 16. Texas Water Development Board. Ay 2017

Hutchison, W.R., Hill, M.E., Anaya, R., Hassan, M.M., Oliver, W., Jigmond, M., Wade, S., and Aschenbach, E. 2011. Groundwater Management Are 16 Groundwater Flow Model, Texas Water Development Board,306 p. https://www.twdb.texas.gov/groundwater/models/alt/gma16/GMA16_Model_Report_DRAFT.pdf?d=3579

Harbaugh, A. W., 2009, Zonebudget Version 3.01, A computer program for computing subregional water budgets for MODFLOW ground-water flow models, U.S. Geological Survey Groundwater Software.

Harbaugh, A.W., Banta, E.R., Hill, M.C., and McDonald, M.G., 2000, MODFLOW-2000, The U.S. Geological Survey modular ground-water model- user guide to modularization concepts and the groundwater flow process: U.S. Geological Survey, Open-File Report 00-92.

National Research Council, 2007, Models in Environmental Regulatory Decision Making Committee on Models in the Regulatory Decision Process, National Academies Press, Washington D.C., 287 p.,http://www.nap.edu/catalog.php?record_id=11972.

Texas Water Code, 2011, http://www.statutes.legis.state.tx.us/docs/WA/pdf/WA.36.pdf.

Young, S., 2022. Desired Future Condition Explanatory Report for Groundwater Management Area 16. Prepared for Groundwater Management Area 16 Member Districts. July 2022.