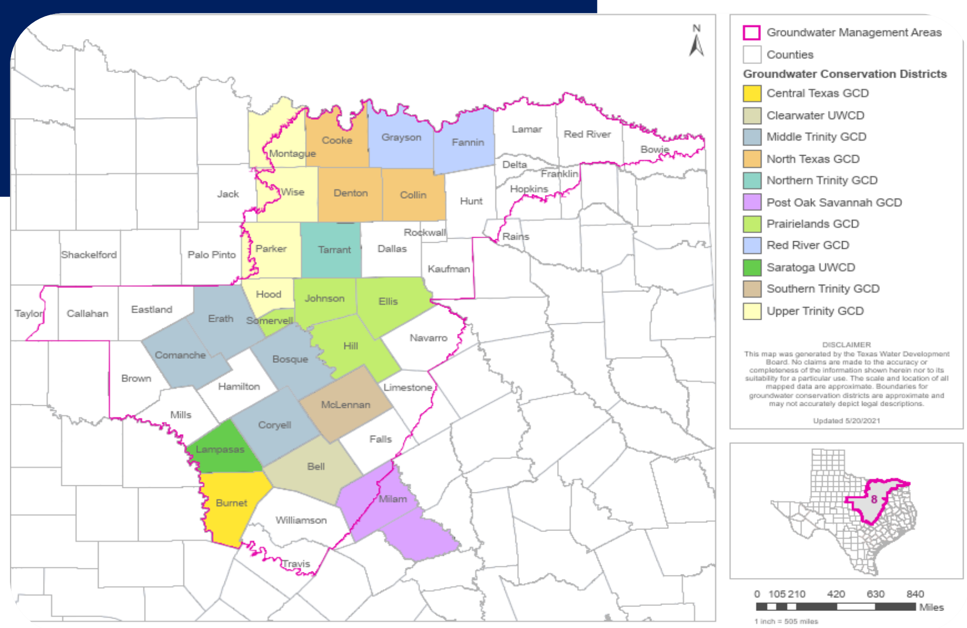
August 2021

Groundwater Management Area 8 Desired Future Conditions Explanatory Report



Advanced Groundwater Solutions, LLC

Blanton & Associates, Inc.

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Groundwater Management Area 8 Desired Future Conditions Explanatory Report

***Prepared by*:**

Groundwater Management Area 8

***With technical Assistance from*:**

WSP USA

Advanced Groundwater Solutions, LLC

Blanton & Associates, Inc.

August 2021

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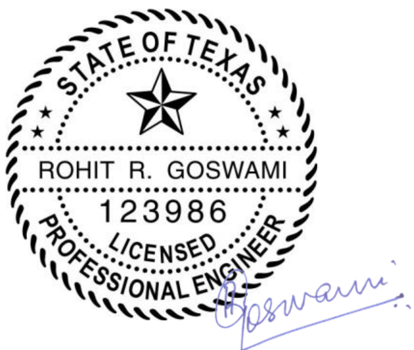
Geoscientist and Engineering Seal

GMA 8 contracted with WSP USA, a licensed professional engineering firm (Texas License No. 2263).

This report is released to the GMA 8 for review and further submittal to the Texas Water Development Board by the following licensed professional engineer in the State of Texas:



Dated: January 3, 2022
Rohit R. Goswami, Ph.D., P.E.

Dated: January 3, 2022
James A. Beach, P.G.

James Beach, P.G., with Advanced Groundwater Solutions, LLC, a licensed professional geoscientist firm in the State of Texas (License No. 50639) was responsible for interacting with District Representatives to develop the proposed DFCs, helping develop model runs, and the presentation and discussion of nine factors at GMA 8 meetings.

Velma R. Danielson and her team were responsible for updating and presenting information related to certain of the nine factors considered by the GMA 8 Committee prior to adopting proposed DFCs, updating select explanatory report chapters and appendix documents, and preparing the combined draft of the explanatory report and appendix documents that were submitted to the GMA 8 Committee for consideration at their final meeting of the third DFC joint planning cycle

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1 EXECUTIVE SUMMARY

On July 26, 2022, District Representatives in Groundwater Management Area 8 ("GMA 8"), after posting notice, met and adopted statements of desired future conditions ("DFCs") for all relevant aquifers within the boundaries of GMA 8 as required by Texas Water Code Section 36.108. The resolution adopting these DFCs is included in this Explanatory Report as part of the requirements included in Texas Water Code Section 36.108. The adopted DFCs were developed as part of the joint-planning process for the current round of joint planning.

This GMA 8 Explanatory Report contains two main elements required in statute for the joint-planning process: the DFC statement for all relevant aquifers adopted by District Representatives for GMA 8 during a regularly scheduled meeting on July 26, 2022, and also documentation of all data, analyses, and supporting materials including policy and technical justifications considered by the District Representatives of GMA 8 from May 6, 2019, through July 26, 2022. All required considerations as set forth in Texas Water Code Section 36.108 (d)(1-9) are included in this GMA 8 Explanatory Report.

The Texas Water Development Board ("TWDB") has made available an "Explanatory Report Checklist," which it uses to determine administrative completeness with respect to the requirements of statute and administrative rules. To facilitate this review by the TWDB, a populated Explanatory Report Checklist is included in **Appendix A** of this report.

This Explanatory Report documents that the District Representatives in GMA 8 have considered all the elements required by Texas Water Code Section 36.108(d-3) in establishing the 2021 DFCs by:

- Identifying each DFC;
- Providing the policy and technical justifications for each DFC;
- Documenting that the factors under Texas Water Code Section 36.108(d) were considered by the districts along with how the adopted DFCs impact each factor;
- Listing other DFC options considered, if any, and the reasons why those options were not adopted; and
- Discussing reasons why recommendations made by any advisory committee and relevant public comments received by the districts were or were not incorporated into the DFCs.

All discussions, considerations, and decisions made by District Representatives in GMA 8 were made in open, publicly noticed meetings in accordance with Texas Water Code Section 36.108. The process for this planning cycle was impacted by the COVID-19 global pandemic requiring GMA 8 to meet virtually for 4 of its 8 meetings in accordance with the Governor's March 13, 2020 emergency order. Meeting agendas for the eight meetings held by GMA 8 for this round of joint planning are included for review in **Appendix B** of this report. Additional documentation regarding these meetings is available on the GMA 8 webpage located at http://www.gma8.org/meetings.html.

The primary tools for analyzing groundwater conditions and for groundwater management are computer simulations or models. Computer models are the preferred means of assessing the effects of past, current, and future pumping and droughts on groundwater availability. Modeling involves developing and using computer programs to estimate future trends in the amount of water available in an aquifer based on hydrogeologic principles, actual aquifer measurements, and stakeholder guidance. In correspondence dated November 21, 2014, the TWDB formally approved the updated Northern Trinity and Woodbine Aquifer Groundwater Availability Model as the official Groundwater Availability Model ("GAM") for the Northern Trinity and Woodbine aquifers in GMA 8 ("Northern Trinity and Woodbine Aquifer GAM") (Appendix C in the 2017 Explanatory Report.) in the 2017 GMA 8 DFCs Explanatory Report (hereinafter referred to as "2017 Explanatory Report")). The 2021 DFCs adopted are the result, in part, of the modeling prepared by the GMA's consultants using the updated Northern Trinity and Woodbine Aquifer GAM.

Texas Water Code Section 36.108(d) states "Not later than May 1, 2021, and every five years thereafter, the districts shall consider groundwater availability models and other data or information for the management area and shall propose for adoption desired future conditions for the relevant aquifers within the management area. Before voting on the proposed desired future conditions of the aquifers under Subsection (d-2) ..." In addition, Texas Water Code Section 36.108(d) also requires GCDs to consider nine factors, which includes other relevant information before adopting proposed DFCs and to prepare a report documenting that the factors were considered. The nine factors are discussed below and in greater detail in Section 3.2.

1.1 Aquifer Uses and Conditions

The Northern Trinity, Woodbine, Edwards, Ellenburger, and Hickory aquifers in GMA 8 are predominant sources of water for GMA 8. Groundwater data was obtained from the TWDB, which maintains records and reports of groundwater use, water wells, and other relevant data. The District Representatives received presentations from its technical consultants of the modeled effects of the adopted DFCs on existing aquifer uses and conditions.

1.2 Water Supply Needs and Water Management Strategies

The District Representatives considered the water supply needs (the amount of projected water demand beyond existing supplies) and water management strategies (new water supplies to meet water supply needs) for GMA 8. Specifically, information on water supply needs and water management strategies from 2017 State Water Plan for Texas was considered. GMA 8 includes parts of Regional Water Planning Areas B, C, D, F, G, and K. The reports show most future water supplies will be from sources other than groundwater.[1]

1.3 Hydrologic Conditions

The District Representatives considered presentations and reports on the total estimated recoverable storage ("TERS"), average annual recharge, inflows and discharge for the relevant aquifers. After the District Representatives began the work for the 2021 DFCs, the TWDB provided the TERS numbers for GMA 8, a required consideration in establishing the DFCs. TERS is the estimated amount of groundwater within an aquifer that accounts for recoverable storage scenarios that range between 25 percent and 75 percent of the porosity-adjusted aquifer volume. The District Representatives also considered potentiometric surface contour maps showing the current aquifer/hydrologic conditions. All of this information was used to set the adopted DFCs.

1.4 Environmental Factors

The District Representatives considered the potential impacts by the DFCs on environmental factors such as spring flow and other interactions between groundwater and surface water. Available information from the models and other technical resources relevant to these potential impacts were presented. The District Representatives determined there are varying degrees of interactions between the aquifer systems as a whole and surface water within the region encompassing GMA 8.

1.5 Subsidence

The potential impacts of subsidence resulting from the DFCs, based on information presented by GMA 8 consultants, were determined to not be of concern or significant to the overall considerations.

1.6 Socioeconomic Impacts

The District Representatives considered the socioeconomic impact analysis provided by the TWDB to Water Planning Regions B, C, D, F, G, and K, for the 2016Regional Water Plans. In addition, GMA 8 District Representatives revisited the topics and issues from the survey that was completed by each of the 11 GCDs in the previous round of joint DFC planning to more fully understand the spectrum of socioeconomic impacts from the DFCs. The discussions indicated that the findings of the previous survey were still appropriate in the current round of planning and that while there are economic impacts to limiting groundwater production, the negative socioeconomic impacts of lower water

[1] The GMA 8 District Representatives did not review water management strategies of the 2021 regional water plans or the 2022 State Water Plan because this information was not available until the end of the joint-planning period.

quality, higher groundwater production costs and other socioeconomic impacts discussed support the adopted DFCs.

1.7 Private Property Rights

The District Representatives in GMA 8 extensively considered the potential effects of the DFCs on the interests and rights in private property. It was recognized that there are many property owners competing to pump groundwater and that excessive withdrawals can cause increased pumpage costs, the lowering of water tables, and the potential need to convert to alternative supplies. In addition, the District Representatives acknowledge that Texas law provides a delicate balance between the landowner's groundwater ownership and the opportunity to produce a fair share of that groundwater and the right of groundwater districts to manage and regulate groundwater in a common reservoir. On this point, District Representatives also indicated that the findings of the previous survey among the 11 GCDs were still appropriate in describing how their districts consider impacts of the DFCs on private property rights and how GCD Management Plans and Rules have been developed to protect private property rights.

1.8 Feasibility of Achieving the DFCS

The District Representatives considered groundwater modeling to assess predicted impacts through 2080 and compared that modeling to the many modeling scenarios that were completed in the last round of planning and the impact of changes in projected pumping into the future on those districts and areas that did not make changes to their projected pumping. The District Representatives also evaluated information about historic use, current and projected supplies, projected water demands, and applicable management plans, rules, regulations, and laws to determine that the adopted DFCs are feasible. The GCDs have adequate authority to implement regulations necessary to achieve the adopted DFCs. The District Representatives also noted that they have no control over geographic areas within GMA 8 that do not have a GCD.

1.9 Other Relevant Information

The GMA 8 District Representatives considered other material and relevant information as reflected in the materials contained in this Explanatory Report. For example, many GMA 8 GCDs continue to improve groundwater monitoring programs to further improve current and future model calibration to increase reliability of predictive groundwater availability modeling simulations.

1.10 Conclusion

The District Representatives in GMA 8 have extensively reviewed and evaluated the adopted 2021 DFCs and determined that they are reasonable under the criteria set forth in the Texas Water Code.

2 INTRODUCTION

Groundwater Management Area 8 ("GMA 8"), delineated by the Texas Water Development Board ("TWDB") on December 15, 2002 covers all or portions of 47 counties and 11 groundwater conservation districts ("GCDs") (**Table 1**) and as amended by TWDB on March 12, 2021 and May 19, 2021, for the purposes of joint planning as required by Texas Water Code Section 36.108. In addition, GMA 8 extends into six regional water planning areas: Regions B, C, D, F, G, and K. GMA 8 extends from Austin in Travis County in the south to the Texas border with Oklahoma and Arkansas in the north and northeast (**Figure 1** and **Figure 2**). The relationship between GMA boundaries and regional water planning area boundaries are illustrated in **Figure 3**.

Table 1. Listing of GCDs and counties included, in whole or in part, in GMA 8.

District	County
Central Texas GCD	Burnet
Clearwater Underground Water Conservation District ("UWCD")	Bell
Middle Trinity GCD	Bosque
	Comanche
	Coryell
	Erath
North Texas GCD	Collin
	Cooke
	Denton
Northern Trinity GCD	Tarrant
Post Oak Savannah GCD	Milam
Prairielands GCD	Ellis
	Hill
	Johnson
	Somervell
Red River GCD	Fannin
	Grayson
Saratoga UWCD	Lampasas
Southern Trinity GCD	McLennan
Upper Trinity GCD	Hood
	Montague
	Parker
	Wise
No GCD	Bowie

District	County
	Brown
	Callahan
	Dallas
	Delta
	Eastland
	Falls
	Franklin
	Hamilton
	Hopkins
	Hunt
	Jack
	Kaufman
	Lamar
	Limestone
	Mills
	Navarro
	Palo Pinto
	Rains
	Red River
	Rockwall
	Taylor
	Travis
	Williamson

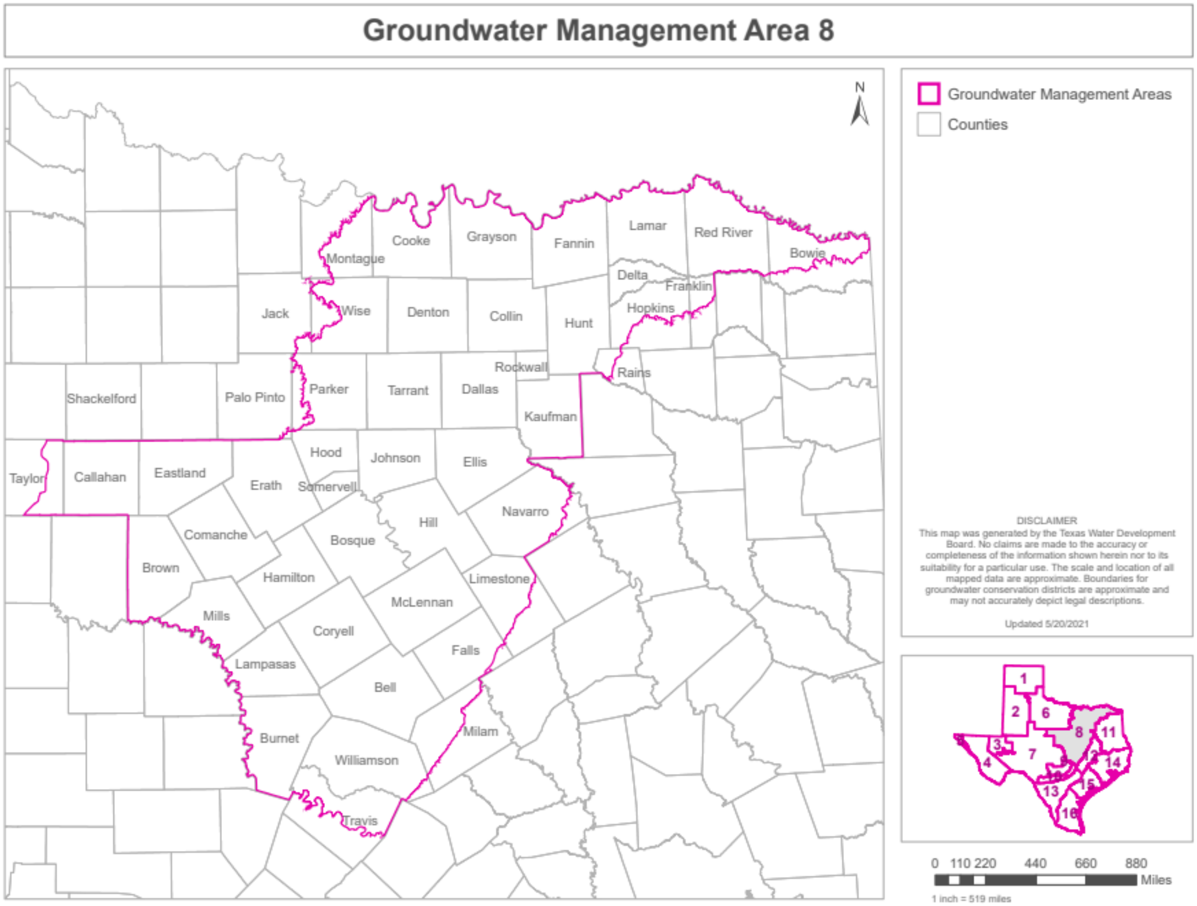

Figure 1. Counties in Groundwater Management Area 8.[2]

[2] Texas Water Development Board, Groundwater Management Area 8 Map (updated March 12, 2021 and May 19, 2021). See https://www.twdb.texas.gov/groundwater/management_areas/maps/GMA8.pdf?d=5392.684999853373.

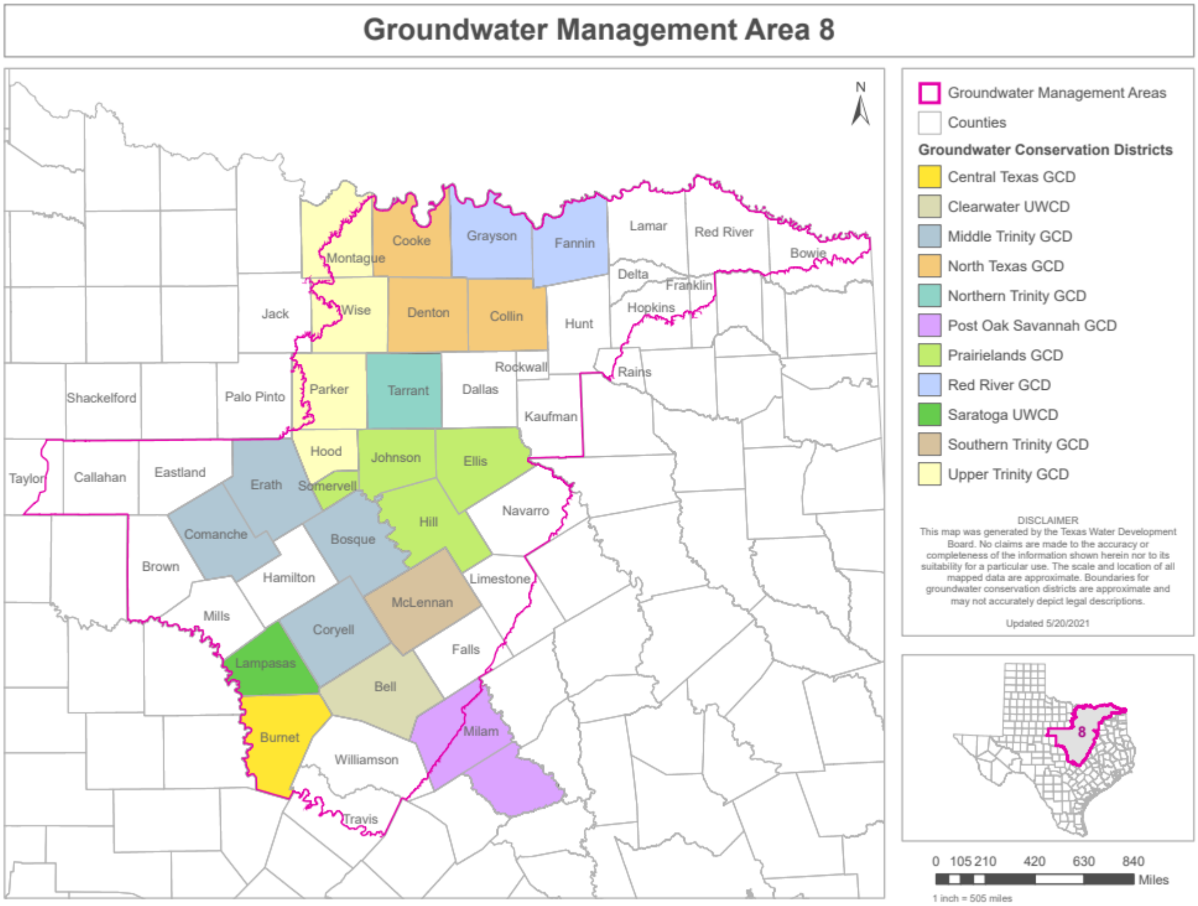

Figure 2. Groundwater Conservation Districts in Groundwater Management Area 8.[3]

[3] Texas Water Development Board Groundwater Management Area 8 Map (updated March 12, 2021 and May 19, 2021). See https://www.twdb.texas.gov/groundwater/management_areas/maps/GMA8_GCD.pdf? d=5392.684999853373.

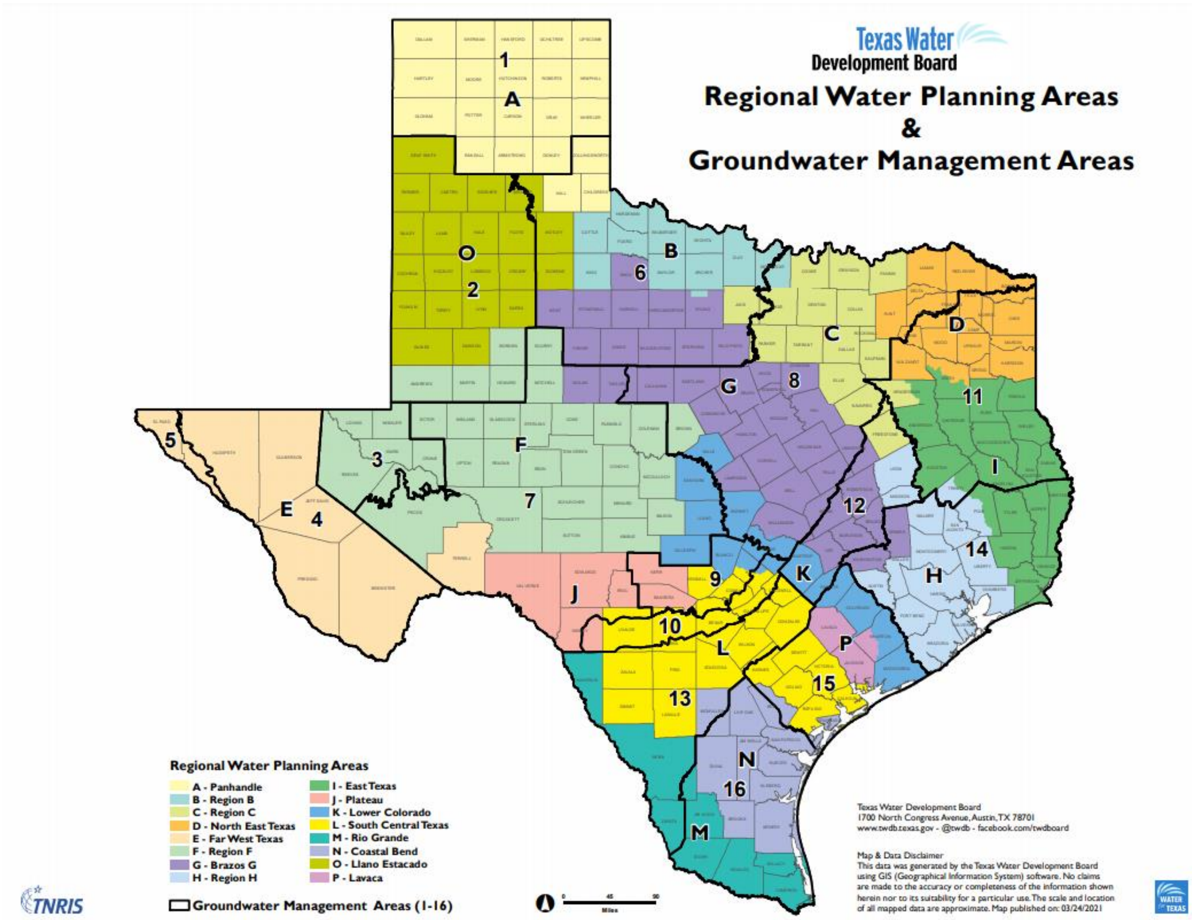

Figure 3. Map illustrating geographic boundaries of Groundwater Management Areas and regional water planning areas in Texas.[4]

The March 12, 2021 amendment to the GMA 8 boundaries consisted of reassigning: (1) the western portions of Montague, Parker, and Wise Counties that do not overlie the Trinity Aquifer to GMA 6; and (2) the northeastern and southeastern portions of Jack, southeastern portion of Palo Pinto, and southern portion of Shackelford counties that overlie the Trinity Aquifer to GMA 8. This amendment placed the Upper Trinity Groundwater Conservation District ("GCD") into both GMA 6 and GMA 8.

The May 19, 2021 amendment to the GMA 8 boundaries consisted of reassigning the boundaries between GMA 8 and GMA 9 based on the delineation of Southwestern Travis County GCD boundaries: (1) the slivers in central Travis County outside of the boundaries of Southwestern Travis County GCD were reassigned to GMA 8; and (2) the slivers in

[4] Texas Water Development Board map delineating Regional Water Planning Areas and Groundwater Management Areas (updated March 24, 2021; please note that this does not reflect the March 12, 2021 and May 19, 2021 boundary reassignment). See https://data.tnris.org/9c5f54d3-5d7b-42ca-b4b0-7a347ab2d088/ assets/ bbc4bc9f-5981-4240-acbc-a9ff7da1f031-RWPA_GMA_8.5x11.pdf.

central Travis County inside the boundaries of Southwestern Travis County GCD were reassigned to GMA 9.

Both the March 12, 2021 and May 19, 2021 boundary amendments are included in **Appendix C** of this Explanatory Report.

GMA 8 is one of the largest areally and most demographically complex management areas of the 16 GMAs in Texas, with both major metropolitan and rural areas providing a rich diversity of economic and social settings. According to population projections adopted by the TWDB for the 2021 regional water planning processes and the draft 2022 State Water Plan for Texas, GMA 8 was projected to have a population of 11,305,622 residents in 2020 and is projected to increase to 21,265,312 by 2070 (see **Table 2**). This 88-percent population increase, both in magnitude and geographic scale, places significant importance and incentives on District Representatives in GMA 8 to adequately consider water use, water demands, water management strategies, hydrologic conditions, environmental impacts, impacts on subsidence, socioeconomic impacts, and impacts on private property rights, for the joint groundwater planning period ending in 2080. The population projection numbers presented in **Table 2** from the TWDB database for the 2021 regional water plans were not shown to the GMA 8 Representatives during the joint planning process because they were not approved until early 2021. The information that the District Representatives took under consideration during the joint planning period was the most up-to-date available at the time.

Following is a summary of DFCs adopted for GMA 8, information considered regarding the nine factors included in Texas Water Code Section 36.108(d)(1–9), and a description of aquifers in GMA 8 designated as non-relevant for the purposes of joint planning.

Table 2. Population projections adopted by the TWDB for 2020 – 2070 for use in the 2021 regional water plans and the 2022 State Water Plan for Texas.[5]

GMA 8 Population Projections by County						
County Name	**2020**	**2030**	**2040**	**2050**	**2060**	**2070**
BELL	371,956	433,618	497,830	560,252	624,686	688,107
BOSQUE	20,310	22,184	23,147	23,747	24,129	24,362
BOWIE	95,703	98,413	99,263	103,909	107,829	111,008
BROWN	39,761	40,717	40,717	40,717	40,717	40,717
BURNET	53,114	64,268	73,673	82,668	90,571	97,426
CALLAHAN	14,482	15,504	16,061	16,351	16,564	16,700
COLLIN	1,050,506	1,239,303	1,497,921	1,807,279	2,093,720	2,373,092
COMANCHE	14,502	15,078	15,467	15,974	16,406	16,814
COOKE	40,903	44,035	46,984	52,427	62,905	95,351
CORYELL	86,105	97,771	110,752	122,101	134,199	146,240
DALLAS	2,587,960	2,871,662	3,180,529	3,429,783	3,627,334	3,770,858
DELTA	5,320	5,376	5,376	5,376	5,376	5,376
DENTON	891,063	1,115,119	1,329,551	1,584,015	1,866,215	2,113,136

[5] Texas Water Development Board, 2021 Regional Water Plan County Population Projections for 2020-2070. See: https://www3.twdb.texas.gov/apps/reports/Projections/2022%20Reports/pop_county.

Table 2. Population projections adopted by the TWDB for 2020 – 2070 for use in the 2021 regional water plans and the 2022 State Water Plan for Texas.[5]

GMA 8 Population Projections by County						
County Name	**2020**	**2030**	**2040**	**2050**	**2060**	**2070**
EASTLAND	19,289	19,712	19,730	19,732	19,732	19,732
ELLIS	191,638	241,778	280,745	360,584	479,939	670,845
ERATH	42,135	46,923	50,968	54,827	58,474	61,844
FALLS	19,413	20,397	20,610	20,126	20,736	21,364
FANNIN	38,330	43,084	52,891	69,328	101,706	137,732
FRANKLIN	11,124	11,627	11,930	12,226	12,447	12,622
GRAYSON	135,311	149,527	159,610	178,907	242,865	337,120
HAMILTON	8,562	8,703	8,703	8,703	8,703	8,703
HILL	37,828	40,277	41,935	43,643	44,937	45,989
HOOD	61,316	71,099	78,111	84,147	88,785	92,339
HOPKINS	37,978	40,895	43,555	46,610	49,556	52,517
HUNT	104,894	130,351	164,886	207,929	271,952	367,505
JACK	9,751	10,409	10,817	11,033	11,190	11,291
JOHNSON	173,835	200,573	228,160	258,414	291,047	325,967
KAUFMAN	146,389	195,107	242,354	306,833	423,277	566,840
LAMAR	52,170	54,189	55,683	57,037	58,092	58,943
LAMPASAS	21,800	24,100	25,874	27,689	29,296	30,741
LIMESTONE	25,136	26,615	27,817	29,134	30,206	31,152
MCLENNAN	252,211	272,216	289,887	307,661	325,373	342,757
MILAM	26,234	27,793	28,896	30,300	31,501	32,629
MILLS	4,912	5,076	5,213	5,417	5,625	5,859
MONTAGUE	20,507	21,260	21,600	21,979	22,223	22,401
NAVARRO	52,505	59,556	65,958	74,213	83,221	99,056
PALO PINTO	30,535	32,771	34,280	35,675	36,739	37,579
PARKER	201,491	260,194	276,979	360,125	472,097	593,000
RAINS	11,888	12,605	12,809	12,947	13,007	13,035
RED RIVER	12,976	12,976	12,976	12,976	12,976	12,976
ROCKWALL	119,410	160,315	213,619	246,938	291,850	325,052
SOMERVELL	9,482	10,594	11,395	12,013	12,539	12,958
TARRANT	2,004,609	2,279,113	2580,325	2,799,127	2,978,034	3,167,377
TAYLOR	140,675	147,183	152,561	156,822	160,004	162,423
TRAVIS	1,298,624	1,538,784	1,767,636	1,936,583	2,075,875	2,233,259
WILLIAMSON	631,097	771,834	941,827	1,141,301	1,394,412	1,643,646
WISE	79,882	95,086	110,343	135,797	162,282	208,872
GMA 8 Total	**11,305,622**	**13,105,770**	**14,987,954**	**16,931,375**	**19,031,349**	**21,265,312**

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3 DESIRED FUTURE CONDITIONS FOR THE NORTHERN TRINITY AND WOODBINE AQUIFERS, THE EDWARDS (BFZ) AQUIFER, AND THE LLANO UPLIFT AQUIFERS

Desired Future Conditions ("DFCs") were adopted for Groundwater Management Area 8 ("GMA 8") using a wide variety of quantitative parameters as required by statute and Texas Water Development Board ("TWDB") rules (see **Appendix A** of this Explanatory Report for the detailed checklist of TWDB requirements). These parameters on which the adopted DFCs are based include water level declines (Northern Trinity and Woodbine aquifers), spring and stream flow (Edwards (Balcones Fault Zone, or "BFZ") Aquifer), and percentage of water remaining in storage (Llano Uplift Aquifers). In addition, for the Northern Trinity and Woodbine aquifers, DFCs were adopted at a number of different scales to facilitate the efficient and effective utilization of the adopted DFCs by groundwater conservation districts ("GCDs") and regional water planning groups when evaluating potential amendments to GCD management plans and rules and regional water plans. Hydrogeologic and geographic scales for which DFCs for the Northern Trinity and Woodbine aquifers were adopted include:

- By aquifer for the entire GMA 8;
- By aquifer for each GCD;
- By aquifer for each county; and
- By outcrop and subcrop.

These tables in their entirety are included in **Appendix D**. The planning period is from January 1, 2010 through December 31, 2080.

DFCs for the Northern Trinity and Woodbine aquifers in GMA 8 are based on the "Results of Predictive Simulation in Support of GMA 8 Joint Planning—GMA 8 Run 11" memorandum included in this Explanatory Report in **Appendix E** - Summary of Run 11 Predictive Simulations for GMA 8 Joint Planning - of this Explanatory Report. DFCs for the Edwards (BFZ) Aquifer in GMA 8 are based on GAM Run 08-10mag (see Appendix F in the 2017 Explanatory Report). DFCs for the Llano Uplift Aquifers in GMA 8 are based on the Numerical Model Report: Minor Aquifers of the Llano Uplift Region of Texas (Marble Falls, Ellenburger-San Saba, and Hickory and the results described in **Appendix F** of this Explanatory Report) (see Section 3.1.2 of this Explanatory Report).

Table 3. GMA 8 DFCs adopted at an aquifer-wide scale for Northern Trinity and Woodbine aquifers based on total average drawdown in feet (both unconfined and confined drawdown).

GMA 8 Adopted DFCs -Aquifer-Wide Scale	
Woodbine	146
Paluxy	193
Glen Rose	148
Twin Mountain	345
Travis Peak	207
Hensell	148
Hosston	262
Antlers	193

Table 4. GMA 8 DFCs adopted at a GCD scale for Northern Trinity and Woodbine aquifers (except for Upper Trinity GCD, see below for Upper Trinity GCD) based on total average drawdown in feet (both unconfined and confined drawdown).

GMA 8 Adopted DFCs - GCD Scale								
GCD	Wood-bine	Paluxy	Glen Rose	Twin Mtn	Travis Peak	Hensell	Hosston	Antlers
Central Texas GCD	—	—	2	—	19	7	21	—
Clearwater UWCD	—	17	83	—	333	145	375	—
Middle Trinity GCD	—	5	29	8	98	77	124	12
North Texas GCD	263	690	366	601	—	—	—	305
Northern Trinity GCD	6	105	163	348	—	—	—	177
Post Oak Savannah GCD	—	—	241	—	412	261	412	—
Prairielands GCD	44	44	142	170	323	201	364	—
Red River GCD	209	830	335	405	291	—	—	321
Saratoga UWCD	—	—	1	—	6	1	11	—
Southern Trinity GCD	6	41	148	—	504	242	582	—

Table 5. GMA 8 DFCs adopted for Upper Trinity GCD for Northern Trinity and Woodbine aquifers based on total average feet of drawdown, discretized based on outcrop and downdip extent.

GMA 8 Adopted DFCs – Upper Trinity GCD		
Antlers	**Outcrop**	**47**
	Downdip	**154**
Paluxy	**Outcrop**	**6**
	Downdip	**2**
Glen Rose	**Outcrop**	**15**
	Downdip	**45**
Twin Mtn	**Outcrop**	**10**
	Downdip	**70**

Table 6. GMA 8 DFCs adopted at a county scale for Northern Trinity and Woodbine aquifers (except for Upper Trinity GCD counties, see Table 7 below for these counties) based on total average drawdown in feet (both unconfined and confined drawdown).

GMA 8 Adopted DFCs - County Scale								
County	Wood-bine	Paluxy	Glen Rose	Twin Mtn	Travis Peak	Hensell	Hosston	Antlers
Bell	—	17	83	—	333	145	375	—
Bosque	—	6	53	—	189	139	232	—
Bowie	—	—	—	—	—	—	—	—
Brown	—	—	1	—	2	1	1	2
Burnet	—	—	2	—	19	7	21	—
Callahan	—	—	—	—	—	—	—	1
Collin	482	729	366	560	—	—	—	596
Comanche	—	—	2	—	4	2	3	12
Cooke	2	—	—	—	—	—	—	191
Coryell	—	5	15	—	107	70	141	—
Dallas	137	346	288	515	415	362	419	—
Delta	—	279	198	—	202	—	—	—
Denton	22	558	367	752	—	—	—	416
Eastland	—	—	—	—	—	—	—	4
Ellis	76	128	220	413	380	290	390	—
Erath	—	6	6	8	25	12	35	14
Falls	—	159	238	—	505	296	511	—
Fannin	259	709	305	400	291	—	—	269
Franklin	—	—	—	—	—	—	—	—
Grayson	163	943	364	445	—	—	—	364
Hamilton	—	2	4	—	26	14	38	—
Hill	20	45	149	—	365	211	413	—
Hopkins	—	—	—	—	—	—	—	—
Hunt	631	610	326	399	350	—	—	—
Johnson	4	-57	66	184	235	120	329	—
Kaufman	242	311	305	427	372	349	345	—
Lamar	42	100	107	—	125	—	—	132
Lampasas	—	—	1	—	6	1	11	—
Limestone	—	199	301	—	433	214	445	—
McLennan	6	41	148	—	504	242	582	—
Milam	—	—	241	—	412	261	412	—
Mills	—	1	1	—	9	2	13	—
Navarro	110	139	266	—	343	295	343	—
Rains	—	—	—	—	—	—	—	—

Table 6. GMA 8 DFCs adopted at a county scale for Northern Trinity and Woodbine aquifers (except for Upper Trinity GCD counties, see Table 7 below for these counties) based on total average drawdown in feet (both unconfined and confined drawdown).

GMA 8 Adopted DFCs - County Scale								
County	Wood-bine	Paluxy	Glen Rose	Twin Mtn	Travis Peak	Hensell	Hosston	Antlers
Red River	2	24	40	—	57	—	—	15
Rockwall	275	433	343	466	—	—	—	—
Somervell	—	4	4	50	64	17	120	—
Tarrant	6	105	163	348	—	—	—	177
Taylor	—	—	—	—	—	—	—	0
Travis	—	—	90	—	219	68	226	—
Williamson	—	—	78	—	220	89	225	—

Table 7. GMA 8 DFCs adopted at a county scale for Upper Trinity GCD counties for Northern Trinity and Woodbine aquifers based on total average drawdown in feet for outcrop and downdip areas.

GMA 8 Adopted DFCs - Upper Trinity GCD by county (O-Outcrop, D-Downdip)				
County	Antlers	Paluxy	Glen Rose	Twin Mtn
Hood -O	—	6	9	13
Hood-D	—	—	39	72
Montague-O	40	—	—	—
Montague-D	—	—	—	—
Parker-O	42	6	20	7
Parker-D	—	2	50	68
Wise-O	60	—	—	—
Wise-D	154	—	—	—

Table 8. GMA 8 DFCs in acre-feet per month spring/stream flow adopted for the Edwards (BFZ) Aquifer.

County	DFC
Bell	Maintain at least 100 acre-feet per month of stream/spring flow in Salado Creek during a repeat of the drought of record
Travis	Maintain at least 42 acre-feet per month of aggregated stream/spring flow during a repeat of the drought of record
Williamson	Maintain at least 60 acre-feet per month of aggregated stream/spring flow during a repeat of the drought of record

Table 9. GMA 8 DFCs adopted at a county scale for the Llano Uplift Aquifers based on total average feet of drawdown.

County	Ellenburger-San Saba Aquifer	Hickory Aquifer	Marble Falls Aquifer
Brown	3	3	3
Burnet	12	11	11
Lampasas	16	16	16
Mills	9	9	9

3.1 Policy and Technical Justifications

The purpose of this section of the Explanatory Report is to provide the policy and technical justifications for the DFCs adopted by the District Representatives of GMA 8 as required by Texas Water Code Section 36.108(d-3)(2). In general, the policy and technical justifications for the adopted DFCs are embodied by, and not differentiable from, the careful consideration and balancing by the GMA 8 District Representatives of all of the policy and technical information that was considered in working through the statutory criteria required by Texas Water Code Section 36.108 and detailed in Section 3.2 of this Explanatory Report. Nonetheless, below are some of the policy and technical justifications that can be gleaned from the information considered by District Representatives of GMA 8 in their evaluation and adoption of the DFCs. The policy and technical justifications discussed in this section are not intended to be exhaustive of all the considerations of the GMA 8 District Representatives or the individual GMA 8 GCDs.

3.1.1 Policy Justifications

The adoption of DFCs by GCDs, pursuant to the requirements and procedures set forth in Texas Water Code Chapter 36, is an important policy-making function. GMA 8 District Representatives believe that their most important task in developing and adopting DFCs is to carefully consider all available information related to the aquifers and their past, present, and future use, including without limitation, all information related to the statutory criteria detailed in Section 3.2 of this Explanatory Report, and also to achieve an appropriate balance of those criteria using their best judgment and discretion, as well as the best available science. From a policy perspective, a number of key considerations emerge from that "balancing act" that justify the adoption of the DFCs.

Socioeconomic impacts and impacts on the interests and rights in private property are two significant policy considerations that justify the DFCs adopted for all relevant aquifers by GMA 8 District Representatives. As described further herein, these policy considerations are inevitably and fundamentally interconnected. Ultimately, the primary socioeconomic and private property impact analyses that were considered by GMA 8 District Representatives, which justified the adoption of the DFCs, included the impacts of the adopted DFCs on the economic costs to landowners producing groundwater, the ability of landowners to recover their reasonable investment-backed expectations that utilize groundwater (including the ability to recover some portion of the groundwater beneath their property), and the continued availability of groundwater in the future for other landowners whose lands overlie the aquifers, while also attempting to promote conservation to address the significant historic water level declines in many parts of the aquifers. These inseparable economic, private property rights, and groundwater conservation considerations served as the controlling policy factors behind the selections of the DFCs adopted by GMA 8 District Representatives.

The consideration of socioeconomic impacts included, among other factors, the cost to individual landowners to drill a well and produce quality groundwater in sufficient quantities, the protection of existing economic investments in wells, and the existing water management strategies that rely on groundwater from GMA 8 in the 2017 State Water Plan for Texas. The 2017 State Water Plan includes the use of existing and new surface water supplies to meet many of the needs in the area over the joint-planning period. The water management strategies listed in the 2017 State Water Plan were an important consideration for GMA 8 in considering future groundwater uses and needs.[6]

The cost of drilling a producing water well is largely driven by how deep the well must be drilled to reach the quantity and quality of groundwater required. The cost to lift the water from the pump to the land surface is also relevant, not only in terms of the initial cost to properly equip the well with the appropriate pump and wiring to extend the length of the well bore, but also in terms of the ongoing cost of energy to lift the water. Additionally, the water needs to be of a sufficient quality that it can either be used for its beneficial purpose without treatment or with economically-affordable treatment. In some areas, groundwater quality tends to diminish as groundwater levels decline in the aquifer and landowners could be forced to produce ever-deepening groundwater resources. And, finally, the amount of groundwater that the water well will yield at the land surface is an important consideration for a landowner in determining whether drilling a well is economically feasible for the intended purpose.

[6] The GMA 8 District Representatives did not review the 2021 regional water plans or the 2022 State Water Plan because this information was not available until the end of the joint-planning period.

In the subcrop areas of aquifers, minimizing water level declines is advantageous in maintaining well yields and in avoiding increased pumping costs. The vast majority of groundwater produced in GMA 8 comes from the subcrop areas of the various layers of the Northern Trinity and Woodbine aquifers where confining conditions create artesian pressure and push groundwater into and up water well bores and to water well pumps. Without the driving force of that artesian pressure, the costs of equipping a well, lifting the water to the surface, the potential decrease in well yields, and in some cases water quality degradation may decrease the economic feasibility of drilling a water well. In addition, maintaining an investment in an existing well may become less viable or even economically infeasible to landowners over the subcrop of the aquifer. And, for a large number of landowners throughout GMA 8, the subcrop is the only water supply option available to their properties. Without water being economically available on their properties, the negative impacts to the property values of landowners can be significant in some cases.

The preservation of artesian pressure in the subcrops of the aquifers and the preservation of sufficient saturated thickness of groundwater in the outcrops of the aquifers protects landowners' private property rights in the groundwater located beneath their property as well as current and future use of the resource. As set forth in Texas Water Code Chapter 36 and reiterated by the Texas Supreme Court in Edwards Aquifer Authority v. Day,[7] landowners own the groundwater beneath their property "in place," meaning landowners have a vested property interest in the groundwater before that groundwater is ever produced.

Landowners with existing water wells on their property have made investments in their water wells and the economic activities that those wells support and may have expectations that those investments will continue to be recovered in the foreseeable future. Landowners also have an expectation of being able to drill cost-affordable water wells on their properties in the future. Virtually all well owners, both existing and future, both large and small, count upon the availability of quality groundwater in sufficient quantities at a reasonable depth from the land surface. In GMA 8, by and large, this means preservation of artesian conditions in the subcrops of the Northern Trinity and Woodbine aquifers and preservation of an adequate amount of saturated thickness of groundwater in its outcrops throughout the joint-planning period.

Because the cost of drilling and equipping a water well is directly related to its depth from land surface, most landowners with investment-backed expectations in existing wells, including water utility service providers, historically drilled wells only to the depths needed to produce the amount and quality of groundwater desired for their purposes. Water levels have declined substantially over time throughout most of GMA 8. Allowing continued pumping at historical amounts or increased pumping in order to make water available to existing and new users will continue to cause water level

[7] *Edwards Aquifer Authority v. Day, 369 S.W.3d 814, 823 (Tex. 2012).*

declines. And, allowing such production will necessarily have impacts to shallower wells, causing many of them to go dry or otherwise fail to produce groundwater in a manner sufficient for their intended purpose. While many landowners could still physically produce groundwater through new or deepened wells or by lowering pumps in existing wells, there are economic costs associated with the need to do so ranging from several thousand to millions of dollars, depending upon the nature of the investment and the depth to groundwater at a specific location. At the same time, setting DFCs at levels that would protect every existing well, no matter how shallow it was completed from the land surface, would mean cutting groundwater production amounts from current rates to such low volumes that it would have enormous economic consequences for both existing and future well owners. This reality, which was modeled under different pumping scenarios using the Northern Trinity and Woodbine Aquifer Groundwater Availability Model "(Northern Trinity and Woodbine Aquifer GAM") for the region, is one of many analyses that were carefully considered by District Representatives in striking a balance between the highest practicable amount of groundwater that can be produced in the region while promoting conservation in order to protect investments by landowners in existing wells. In a parallel manner, this balancing test was achieved in DFCs adopted for the Edwards, Ellenburger, Hickory, and Marble Falls aquifers where present in GMA 8. Therefore, for all aquifers designated as relevant for joint-planning purposes, this balance is represented by the DFCs that were adopted for GMA 8, and is one of the policy justifications for them.

It is undisputed that heavy population growth, specifically along the Interstate-35 corridor around the City of Waco and the Dallas/ Fort Worth Metroplex, and increased water demands, have resulted in the steady decline of aquifer water levels in the various layers of the Northern Trinity and Woodbine aquifers in GMA 8, with some areas experiencing more than 1,000 feet in water level declines over the last 130+ years. In order to address continued groundwater level declines and the problems resulting from those declines, and after carefully balancing the statutory criteria that must be considered in the development and establishment of DFCs, GMA 8 District Representatives adopted DFCs that establish desired drawdown levels between now and 2080 for each of the relevant aquifers underlying GMA 8, including each hydrogeologic unit comprising the Northern Trinity Aquifer Group, the Woodbine Aquifer, the Edwards (BFZ) Aquifer, and the Ellenburger, Hickory, and Marble Falls aquifers of the Llano Uplift, and in each geographic area of the region based upon varying hydrogeologic conditions and varying uses of groundwater on the land overlying those aquifers (see Section 3.1.2 of this Explanatory Report for the technical basis for determining the DFCs). From a policy standpoint, the adopted DFCs set goals for the future conditions of the aquifers in terms of limiting drawdown levels, percentage of water in storage, or spring flows, in order to preserve artesian pressure and confined conditions in the subcrops of the aquifers to allow for the economically feasible production of groundwater to protect private property rights for all landowners in the region on a long-term basis.

The outcrop areas of the Northern Trinity Aquifer Group and Woodbine aquifers typically are not very deep, have less saturated thickness, and can be impacted by drought conditions on the land surface. The outcrop areas of the aquifers generally do not have enough water to be utilized in the long-term as a supply source for high-volume wells. The main uses in the outcrop areas for most landowners in GMA 8 both presently and in the long-term provide a source of water to overlying lands for domestic, livestock, smaller municipal and commercial purposes, and other relatively low-volume needs, especially in areas where alternative water supplies are not economically viable. If the outcrop areas of the aquifers are depleted to a point where even low-volume water wells are not viable, there could be significant economic consequences across large areas of land in the outcrop as the cost to build the infrastructure throughout those large areas to deliver water to every property from alternative water supplies could cost more. Thus, the District Representatives considered the need to preserve the availability of saturated thickness in the outcrop areas of the aquifers and the current and future economic considerations set for landowners in those areas, as well as the hydraulic connection between pumping in the subcrops of the aquifers and associated impacts to the outcrop areas, when establishing the DFCs, thereby justifying the adoption of the DFCs. These policy justifications were also reflective of considerations in the second round of DFC joint planning.

3.1.2 Technical Justifications

It is impossible to articulate the technical justifications for the adopted DFCs in terms that are not intricately connected to the policy justifications set forth above. Rather, the technical information considered by GMA 8 District Representatives in balancing the competing interests associated with the establishment of DFCs and evaluating the various interests and economic costs to landowners associated with groundwater production both drive and support those policy justifications.

As set forth under Subsection 3.1.1, the adopted DFCs are primarily focused on achieving the appropriate balance of all of the statutory criteria required to be considered by maintaining appropriate groundwater levels in all areas of GMA 8, whether in terms of maintaining appropriate artesian levels in the subcrop areas of the aquifers' layers or water table levels and saturated thickness in the outcrop areas. In that regard, while this section will highlight a number of the technical justifications for the adopted DFCs, all of the technical information detailed in Section 3.2 of this Explanatory Report was considered by GMA 8 District Representatives as required by Texas Water Code Section 36.108.

In addition to the technical justifications discussed below for DFCs adopted for the Northern Trinity Group and Woodbine Aquifer, GMA 8 District Representatives also adopted DFCs for the Edwards (BFZ) Aquifer and aquifers of the Llano Uplift present within the geographic boundaries of GMA 8 (Ellenberger, Hickory, and Marble Falls aquifers). The primary technical justifications for DFCs adopted for the two aquifer systems is based on information presented in reports by Anaya (2008)[8] (see Appendix F

[8] Anaya, R., 2008, GAM Run 08 – 10mag: Texas Water Development Board, 7 p.

in the 2017 Explanatory Report), Shi and others (2016)[9] (hereinafter Numerical Model Report: Minor Aquifers of the Llano Uplift Region of Texas), and modeling developed by the Central Texas GCD (see **Appendix F** of this Explanatory Report). Technical justifications for DFCs adopted for the Edwards (BFZ) Aquifer remain unchanged since the adoption of DFCs in GMA 8 during the first round of joint planning from 2005 – 2010. The Numerical Model Report: Minor Aquifers of the Llano Uplift Region of Texas and the modeling evaluations completed by Central Texas GCD serve as the technical supporting documentation for these aquifers.

The primary tool utilized by GMA 8 District Representatives in the development of DFCs for the Northern Trinity and Woodbine aquifers was the Northern Trinity and Woodbine Aquifer GAM[10] (see Appendices I, J, and K in the 2017 Explanatory Report). The Northern Trinity and Woodbine Aquifer GAM, and the information embodied in it, presently represents the best available science on these aquifers. The updated Northern Trinity and Woodbine Aquifer GAM is composed of eight model layers that corresponded with the hydrogeologic units (i.e. aquifers) comprising the Trinity Aquifer Group, as well as the Woodbine Aquifer (such as the Woodbine, Fredericksburg/Washita, Antlers, Paluxy, Glen Rose, Twin Mountains/Travis Peak, Hensell, and Hosston). These different hydrogeologic units comprising the Trinity Aquifer Group and Woodbine Aquifer underlying GMA 8 were evaluated according to their hydrostratigraphy, hydraulic properties, and lithology and the extent to which the units were differentiable at different locations. Ultimately, the technical results of this evaluation and the advanced capabilities of the updated Northern Trinity and Woodbine Aquifer GAM justified using the Antlers, Paluxy, Glen Rose, Twin Mountains, Travis Peak, Hensell, and Hosston aquifers, which collectively represent the Trinity Aquifer Group, and the Woodbine Aquifer to define the spatial and vertical extent for which to adopt different DFCs.

In developing the different DFCs for each of these aquifers, GMA 8 District Representatives used the Northern Trinity and Woodbine Aquifer GAM to modify and make adjustments to "Run 10," which was the simulation used to calculate modeled available groundwater ("MAG") estimates from the previous round of joint planning. In the last round of joint planning, Run 10 was the culmination of nine prior simulations used to assess aquifer impacts under various pumpage scenarios. In this round of joint planning, Run 10 was slightly modified to adjust pumping in certain areas and extended to the year 2080. The modified scenario and associated model files were called "Run 11."

[9] Shi, J., Boghici, R., Kohlrenken, W., and Hutchinson, W., Numerical Model Report: Minor Aquifers of the Llano Uplift Region of Texas (Marble Falls, Ellenburger-San Saba, and Hickory): Texas Water Development Board, variously paginated. See http://www.twdb.texas.gov/groundwater/models/gam/llano/Llano_Uplift_Numerical_Model_Report_Final.pdf?d=5898.085000000719.

[10] Kelley, -V.A., Ewing, J., Jones, T. L., Young, S. C., Deeds, N., and Hamlin, S., 2014, Updated groundwater availability model of the Northern Trinity and Woodbine Aquifers: - Final Report: Prepared for the North Texas Groundwater Conservation District, Northern Trinity Groundwater Conservation District, Prairielands Groundwater Conservation District, and Upper Trinity Groundwater Conservation District by INTERA, Inc., The Bureau of Economic Geology, and LBG-Guyton Associates, Volumes I, II, and III, variously paginated.

As noted in the description of Run 10 in the 2017 Explanatory Report, some of the nine simulations leading up to Run 10 included multiple analyses and sub-simulations. Generally, in conducting these runs, GMA 8 District Representatives looked at variations in declines in the water levels and artesian head levels for each of the aquifers, the number of existing wells that would go dry at various water level drops, the specific users and types of uses impacted based on local needs and demands, and the impacts of groundwater produced between GCDs in GMA 8. Ultimately, all 10 model runs served an important role towards the development of the adopted DFCs. As further described herein, the purpose of each run and the conclusions derived from those simulations illustrate the technical justifications that lead to the adoption of the DFCs for GMA 8. Run 11 is considered a fairly minor change to Run 10 and represents the changing conditions or a more refined understanding of production from various aquifer layers or geographic areas in GMA 8. The description of the first 10 runs from the previous round of planning is considered to be a crucial part of establishing the technical justifications for this round of planning and for accepting the results of Run 11 as DFCs for GMA 8. Therefore, the discussion of those simulations is included below.

GMA 8's first model run for the Northern Trinity and Woodbine Aquifer GAM was a re-simulation of the MAG estimates generated by the previous model[11] from the second round of joint planning. The purpose of this run was to better understand the advanced capabilities of the new model by comparing the results of the updated Northern Trinity and Woodbine Aquifer GAM to the previous model. A technical memorandum and GMA 8 meeting presentation materials are included in the 2017 Explanatory Report as Appendices L, M, and N, respectively. As expected, due to the Northern Trinity and Woodbine Aquifer GAM's updated structure and hydrogeologic properties, the new model predicted different drawdowns at local and regional levels. Next, GMA 8 conducted Runs 2 and 3 in an effort to establish relevant bookends between the highest practicable level of groundwater production and conservation of the groundwater resources (see Appendix N of the 2017 Explanatory Report). Run 2, the "highest practicable" run, attempted to achieve 2070 future conditions where the confined head in all aquifers was assumed to decline to an elevation 10 feet above the top of each aquifer. Run 3, the "conservation" run, attempted to achieve then-current (2010) water levels using constant 2010 pumping rates from 2010 to 2025 (15 years) at which point pumping was decreased by a factor adequate to recover to 2010 water levels at the end of the planning simulation (2070). The assumption was that alternative supplies would become available by 2026 to augment groundwater pumping. While neither of these runs resulted in realistic DFCs for the aquifers, the runs were beneficial in setting parameters to identify the bookends that must necessarily be balanced in adopting reasonable DFCs pursuant to Texas Water Code Section 36.108(d-2), and in determining what might or might not be physically possible or feasible to achieve based upon the current conditions in the aquifers and their hydraulic properties.

[11] R.W. Harden & Associates, Inc., Freese & Nichols, Inc., HDR Engineering, Inc., LBG-Guyton Associates, United States Geological Survey, and Dr. Joe Yelderman, Jr., 2004, Northern Trinity / Woodbine Aquifer Groundwater Availability Model: Contract report to the Texas Water Development Board, 192 p.

In light of the results in Runs 1, 2, and 3, GMA 8 District Representatives focused on achieving a baseline run based on 2010 pumping conditions in GMA 8. As a result, Run 4 was performed to estimate the impacts associated with continued pumping at present rates over the course of the planning period (see Appendices L and N of the 2017 Explanatory Report). However, upon further review of the data upon which Run 4 was based and after comparing them to the latest available data on current groundwater production, current pumping conditions were later revised, and thus a new baseline run was established by re-running the model in Run 5 (see Appendices O and P of the 2017 Explanatory Report) to reflect such changes. All subsequent predictive simulations, including Runs 6, 7, 8, 9, and 10, utilized Run 5 and its improved 2010 pumping data as the baseline to compare and evaluate aquifer conditions, impacts, and pumping under varying levels of decreased and increased groundwater production from 2010 levels.

After establishing a supportable baseline in Run 5, GMA 8 conducted a series of additional runs to better understand potential impacts from increased pumping on an aquifer-wide basis as well as between counties and GCDs. Run 6 included a set of simulations that provided technical information on aquifer conditions resulting from pro-rata increases and decreases in Run 5 baseline-pumping levels on an aquifer-wide basis, including 0.7, 1.1, 1.2, 1.3, 1.6, and 1.9 times baseline pumping (see Appendices O and P of the 2017 Explanatory Report).

Run 7 also addressed increases to Run 5 baseline pumping, but this time increases in pumping were applied on a county-by-county basis in order to illustrate the impacts of increased pumping by one county or GCD on neighboring counties and GCDs in GMA 8 (see Appendix Q of the 2017 Explanatory Report). Specifically, these runs illustrated not only the varying impacts of pumping increases by one county on groundwater levels in other counties in the region, but also that in certain cases increased pumping in the subcrop of the aquifer resulted in significant drawdowns in the outcrop areas of the aquifer, impacting landowners' ability to produce groundwater. With that said, GMA 8 District Representatives also considered the transient hydrodynamics of the regional Trinity and Woodbine aquifer systems regardless of pumping. This was accomplished in Run 8, which included a predictive simulation approach that terminated all pumping in the GMA over a 50-year time period (see Appendix Q of the 2017 Explanatory Report). The results from this run showed that even with no pumping, some counties may continue to see average water level declines through the planning predictive period, whereas other counties may recover strongly. The reason for this is that the existing, steep drawdown cones in the deep confined sections of the aquifer system do not completely recover, even with no pumping, over the joint-planning horizon. As a result, groundwater continues to flow from areas of relatively little drawdown to the areas of higher drawdown even if there were no pumping whatsoever in the aquifer. While this model run does not represent the DFCs for the aquifers, it provides important technical information as to the practical realities and limitations of what the District Representatives and the GCDs comprising GMA 8 could achieve.

Each of the aquifer units comprising the Trinity Aquifer Group (Antlers, Paluxy, Glen Rose, Twin Mountains, Travis Peak, Hensell and Hosston), as well as the Woodbine

Aquifer, have both an outcrop area, where the aquifer is at the land surface, and a subcrop area. In the subcrop area the aquifer dips underneath another geologic layer, which typically confines the aquifer and creates pressure in it, causing water levels in a well to rise above the top of the aquifer. Based on the model runs, GMA 8 District Representatives determined that, in some areas, if pumping levels caused loss of confined conditions in the subcrop areas so that water levels in a well completed in an aquifer dropped below the top of that aquifer, the result would be reduced well yields and increased costs associated with pumping. Such drops in water levels would also render many existing pumps to encounter dry conditions, requiring pumps to be lowered where possible and, in some instances, deepening the well or abandonment of the well entirely and the loss of the economic investment in the well.

Runs 6, 7, and 8 all generated important technical information that assisted GMA 8 District Representatives in understanding the conditions of the aquifers and impacts of various pumping scenarios on an aquifer-wide scale and on a county-by-county basis. Upon analysis of this information coupled with the need to account for more pumping already occurring in the southern parts of the region, GMA 8 District Representatives elected to perform two additional model runs, Runs 9 and 10 (see Appendices R, S, T, and U of the 2017 Explanatory Report). Run 9 applied baseline pumping from Run 5 to certain areas of the GMA, generally the GCDs in the northern portion of GMA 8, while the southern GCDs in the GMA increased Run 5 baseline pumping by various multipliers to account for increases in anticipated future pumping over the course of the planning period. These numbers were later further refined for purposes of Run 10, after northern GCDs, in a manner similar to the southern GCDs in Run 9, increased certain predicted pumping levels to account for increases in anticipated future pumping over the course of the planning period. In Run 10, the pumping file from Run 9 was used as the baseline for pumping amounts and distributions for GCDs in the southern portion of GMA 8, and then modified based on input from the northern GCDs. The District Representatives also considered Run 10.1, which was similar to Run 10, but which involved different pumping distributions using the Northern Trinity and Woodbine Aquifer GAM (see Appendix V of the 2017 Explanatory Report).

In considering the different pumping scenarios, District Representatives in GMA 8 found the pumping scenario and resulting impacts to the aquifers and landowners in the region used in Run 10 struck the best balance of the required statutory criteria set forth in Texas Water Code Section 36.108. Run 10 also most accurately reflected current pumping in each county and predictions of future production to meet water demands throughout the planning period. Run 10 generated important technical information resulting from the simulated pumping, such as changes in hydraulic head (drawdowns) on an aquifer and county basis, the impacts of drawdowns to existing water wells, water budget information including recharge, discharge, lateral flow, and cross formational flow on an aquifer, and county basis, remaining vertical separation between potentiometric surface and the top of the aquifer to maintain confined conditions on an aquifer and county basis, and average annual changes in water levels. After careful evaluation of this information as described in more detail in Section 3.2.3 of this Explanatory Report, GMA 8 District Representatives adopted DFCs for each of the aquifers in the Trinity and Woodbine

Aquifer system in terms of available drawdowns on an aquifer, GCD, and county basis as simulated by Run 10, which do not differ substantially in their application. These adopted DFCs set drawdown levels that are acceptable to preserve artesian pressure and reduce impacts to existing wells for both existing and future well owners and strike an appropriate balance of the statutory criteria in Texas Water Code Section 36.108.

3.1.3 Other GCD-Specific Justifications

As part of the previous GMA 8 joint-planning process, the Upper Trinity GCUpper Trinity GCDrequested that DFCs within their boundaries (Hood, Montague, Parker, and Wise counties) be stated in terms of outcrop and subcrop, rather than an average of the two. This request was based on recommendations submitted by the Upper Trinity GCD in response to the 90-day public comment period. GMA 8 District Representatives unanimously approved this request at the September 29, 2016, GMA 8 meeting. GMA 8 has continued to follow this approach in this round of joint planning, as reflected in this Explanatory Report. A brief summary of why the Upper Trinity GCD made this request follows.

The Upper Trinity GCD is in a unique position due to its location on the northwest edge of the Trinity Aquifer and the large number of shallow exempt domestic wells completed each year. In data received from the TWDB, from 2005-2020, there were more domestic wells drilled in Parker County than in any other county in Texas (approximately 8,000). In the last few years, Parker County has seen an average of about 550-600 new domestic wells per year. Furthermore, Wise County has also seen a large number of new domestic wells, averaging around 300 per year. The vast majority of these wells are completed into the shallow outcrop portions of the Trinity Aquifer Group. This situation is due to two conditions: the majority of Parker County and a smaller portion of Wise County are extremely high growth areas due to proximity to the Dallas/Fort Worth Metroplex, and the geology of the area leads to the capability to complete a productive water well at a relatively low cost (the majority of these wells are approximately 250 feet in total depth). Thus, the majority of housing subdivisions in these counties are relying on private water wells as the sole source of water rather than developing public water systems and transmission infrastructure.

Also, the Upper Trinity GCD is faced with a unique geology as compared to the other GMA 8 GCDs. The slope and thickness of the formation within Upper Trinity GCD's boundaries are such that averaging simulated drawdown for the outcrop and subcrop in the DFC statement would not provide a meaningful measurement for groundwater management purposes for the people that live within the Upper Trinity GCD.

To illustrate this point, the average DFC for the Twin Mountains portion of the Trinity Group in Hood County is 25 ft. of drawdown; however, when the outcrop and subcrop are separated the DFCs are 4 ft. of drawdown in the outcrop and 46 ft. of drawdown in the subcrop. Also, the average DFC for the Antlers portion of the Trinity Group in Wise County is 45 ft. of drawdown; however, when the outcrop and subcrop are separated the DFCs are 34 ft. of drawdown in the outcrop and 142 ft. of drawdown in the subcrop.

Because of the geology of the four counties that make up the Upper Trinity GCD, the District intends to manage the aquifers on an outcrop/subcrop basis. However, in order to avoid any confusion by the public as to why Upper Trinity GCD may seem to be managing the aquifers differently than what the DFCs state, the separation of the outcrop and subcrop is crucial to better correlate the District's groundwater management efforts in both the outcrop and the subcrop with the goals that have been established for the aquifer in those respective areas.

Furthermore, the Board of Directors of Upper Trinity GCD has determined, for the purpose of groundwater management within the boundaries of the Upper Trinity GCD, that it is in the best interests of the Upper Trinity GCD and its citizens to also utilize the existing simulated model runs of the Northern Trinity and Woodbine Aquifer GAM that distribute projected pumping within each layer of the model in the district (surficial layer, Antlers, Paluxy, Glen Rose, and Twin Mountains). Because many of the water wells in Upper Trinity GCD are actually completed in shallow sands represented by the upper layer of the Northern Trinity and Woodbine Aquifer GAM, model runs which allowed for water level declines in the model cells of that layer provide a more appropriate portrayal of local future groundwater conditions and water level impacts from pumping within the boundaries of the Upper Trinity GCD. The Upper Trinity GCD Board of Directors believes that local management options within Upper Trinity GCD's boundaries are best considered with the insight developed from these model runs. This decision by the Upper Trinity GCD Board of Directors is largely due to the unique geology within the District which is largely predominated by shallow outcrop areas.

3.2 Factor Considerations

During this round of joint planning, GMA 8 District Representatives had multiple discussions on the nine factors required by Texas Water Code Section 36.108 (d)(1 – 9). The meeting dates during which specific factors were discussed are documented in **Table 10** below. Meeting agendas are included in their entirety for these meetings in **Appendix B** of this Explanatory Report. Meeting agendas, minutes, and packets, along with presentations shown during meetings, can all be found on the GMA 8 webpage: http://www.gma8.org/meetings.html. Meeting notices can be found in the files of each GCD.

Table 10. GMA 8 meeting dates for the 2021 DFC Joint-Planning Cycle (including when each factor to be considered by District Representatives, as required by Texas Water Code Section 36.108 (d)(1 - 9) was specifically discussed).

Factor	GMA 8 Meeting Dates							
	5/6/2019	7/26/2019	11/22/2019	2/26/2020	5/17/2020	8/7/2020	10/27/2020	11/4/2021
Aquifer Uses and Conditions				✓			✓	✓
Supply Needs and Management Strategies				✓			✓	✓
Hydrological Conditions			✓				✓	✓
Environmental Impacts			✓				✓	✓
Subsidence Impacts			✓				✓	✓
Socioeconomic Impacts					✓		✓	✓
Private property Impacts				✓			✓	✓
Feasibility of achieving DFCs					✓		✓	✓
Other relevant information					✓		✓	✓

3.2.1 Aquifer Uses and Conditions

Texas Water Code Section 36.108(d)(1) requires District Representatives in a GMA to consider "aquifer uses or conditions within the management area, including conditions that differ substantially from one geographic area to another." GMA 8 District Representatives considered aquifer uses, both historical and projected, along with historical, current, and projected aquifer conditions. Data and presentation materials considered by the District Representatives are included in Appendices W, X, Y of the 2017 Explanatory Report and **Appendices G** and **H** of this Explanatory Report.

The major aquifers in GMA 8 are shown in **Figure 4**. As defined by TWDB, a major aquifer is one that supplies a large volume of water over a large area. There are two major aquifers in GMA 8: the northern portion of the Trinity Aquifer (herein referred to as the Northern Trinity Aquifer) and the Edwards (BFZ) Aquifer. The Northern Trinity Aquifer occupies most of GMA 8 and is the primary source of groundwater in the area. The northern portion of the Edwards (BFZ) Aquifer occurs only in southern GMA 8 in Travis, Williamson, and Bell counties.

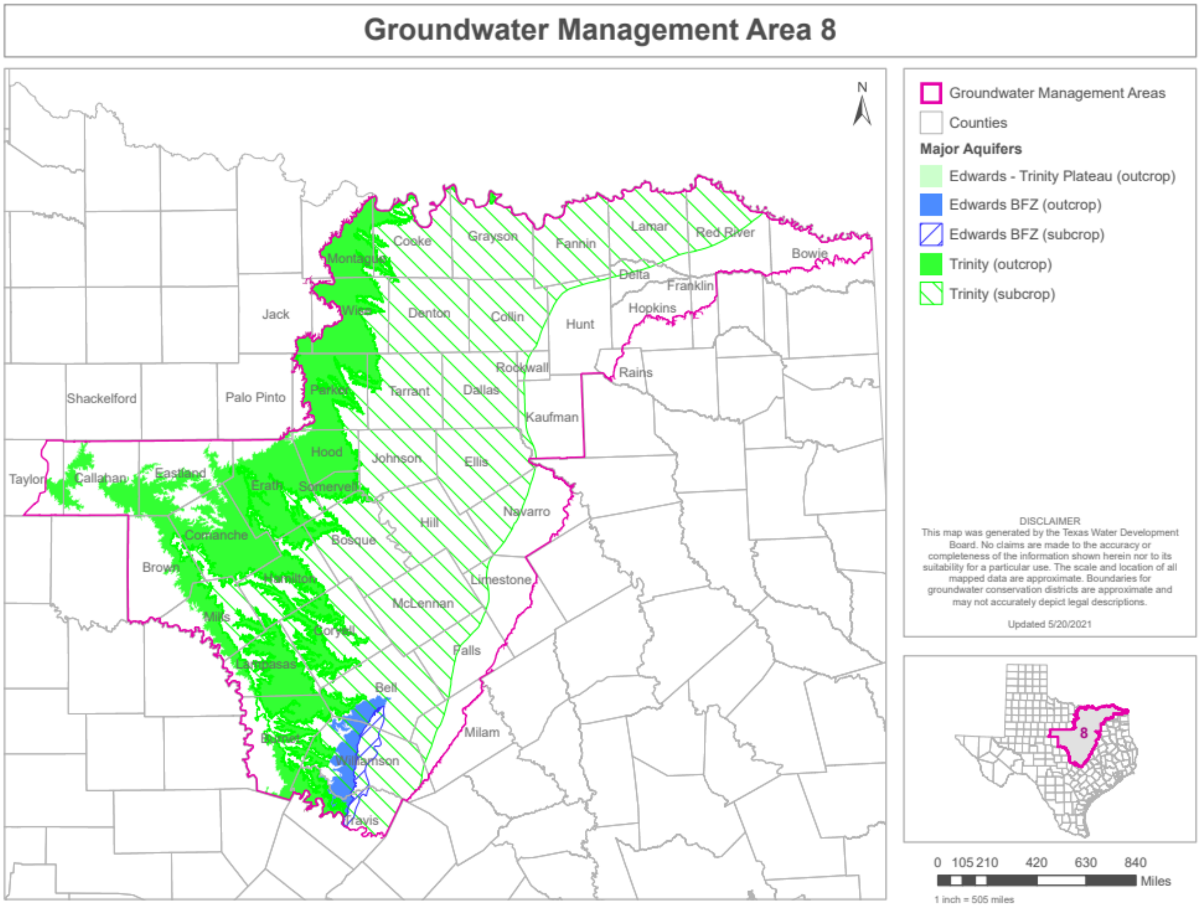

Figure 4. Map of Groundwater Management Area 8 highlighting location of major aquifers.[12]

The minor aquifers in GMA 8 are shown in **Figure 5**. As defined by TWDB, a minor aquifer is one that supplies either a large volume of water over a small area or a small volume of water over a large area. The seven minor aquifers in GMA 8 include the Brazos River Alluvium, Nacatoch, Blossom, Woodbine, Marble Falls, Ellenburger – San Saba and Hickory aquifers. Of these the Woodbine Aquifer occurs over the largest area in GMA 8 and overlies the Northern Trinity Aquifer. The Blossom and Nacatoch aquifers are in far eastern GMA 8, while the older Marble Falls, Ellenburger – San Saba and Hickory aquifers are in far southwestern GMA 8 in central Texas. These aquifers, present in much older geologic strata, are collectively known as the Llano Uplift aquifers because of their occurrence in an area of geologic uplift surrounding Llano County in neighboring GMA 7.

[12] Texas Water Development Board, Major Aquifers in Groundwater Management Area 8 Map (updated May 20, 2021). See https://www.twdb.texas.gov/groundwater/management_areas/maps/GMA8_MajorAquifer.pdf?d=5392.684999853373

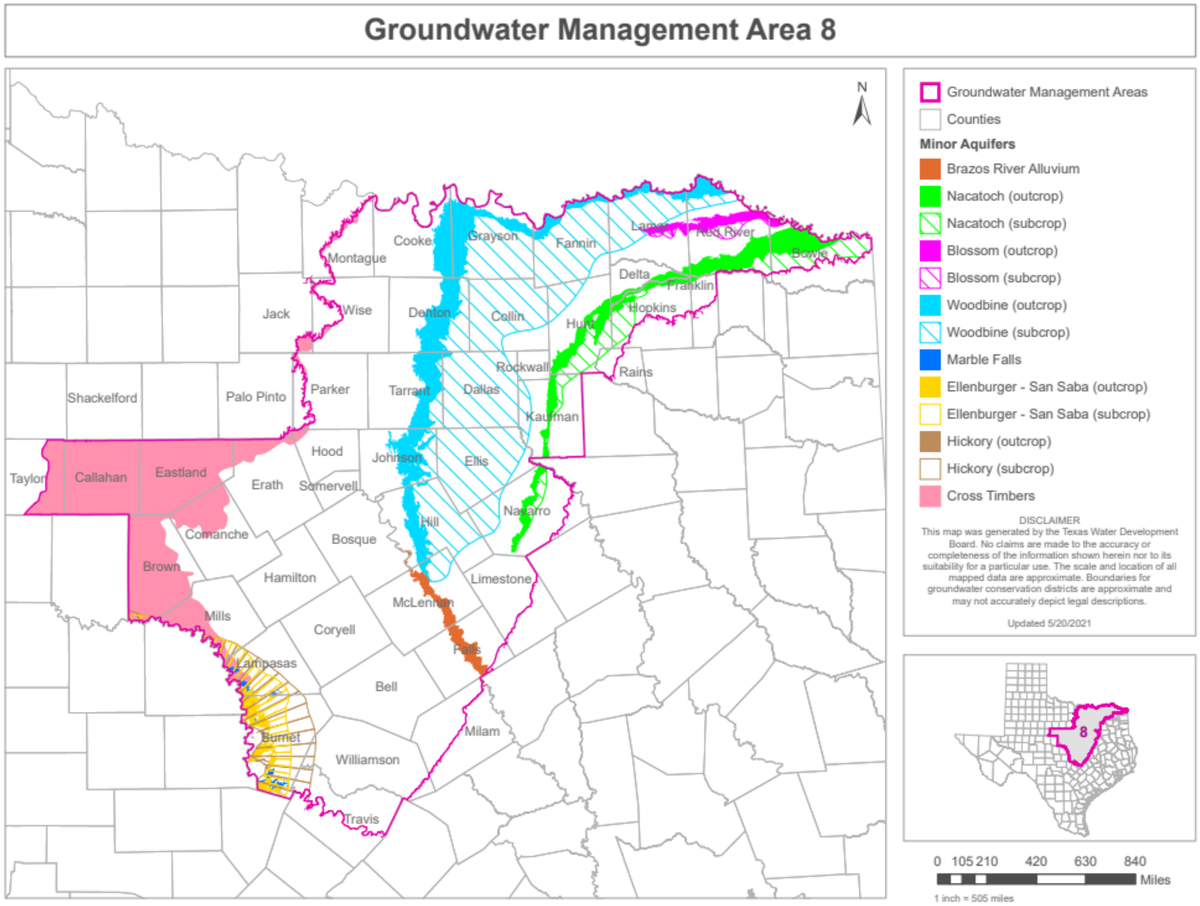

Figure 5. Map of Groundwater Management Area 8 highlighting location of minor aquifers.[13]

Information on historical aquifer uses was taken from two primary sources: 1) the TWDB Groundwater Pumpage Estimates developed as part of the Water Use Survey program, and 2) the Northern Trinity and Woodbine Aquifer GAM.[14] Note that these are not two independent sources because the Northern Trinity and Woodbine Aquifer GAM used the TWDB data as one of many sources of pumping information.

Figure 6 shows the groundwater pumping estimated by the TWDB Water Use Survey program for GMA 8. Values shown are in acre-feet per year and percentage estimates are rounded to the nearest whole percent. The values shown are the average for the period from 2014 to 2018 – the last five years that were available when information for this factor was compiled for consideration by GMA 8 District Representatives. Municipal use

[13] Texas Water Development Board, Minor Aquifers in Groundwater Management 8 Map (updated May 20, 2021) https://www.twdb.texas.gov/groundwater/management_areas/maps/GMA8_MinorAquifer.pdf? d=5392.684999853373.

[14] Kelley, V.A., Ewing, J., Jones, T.L., Young, S.C., Deeds, N., and Hamlin, S., 2014, Updated Groundwater Availability Model of the Northern Trinity and Woodbine Aquifers – Draft Final Model Report (May 2014), 984 p.

is approximately 159,000 acre-feet per year, comprising 59 percent of the estimated groundwater pumping in GMA 8. The second major sector of use is irrigation, estimated at approximately 86,000 acre-feet per year (32 percent of total) and the third ranking pumping type was livestock at about 14,000 acre-feet per year (6 percent of total). Note that these totals include all aquifers for all counties in GMA 8. For counties where an aquifer is only partially within GMA 8 (e.g. Travis County), the volume of pumping from the TWDB Groundwater Pumpage estimates was reduced using the fraction of the area of the county that is in GMA 8.

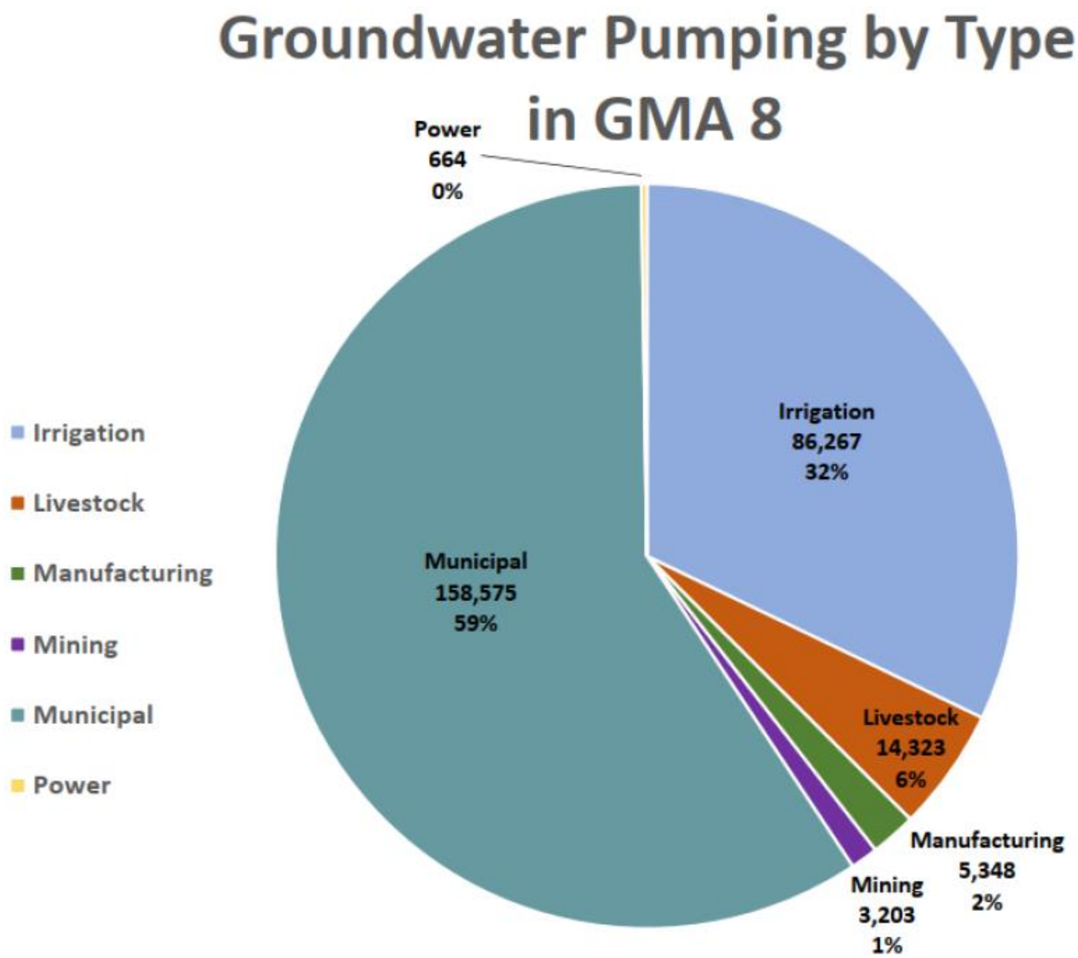

Figure 6. Average groundwater pumping in GMA 8 between 2014 and 2018 from TWDB Groundwater Pumpage estimates by type of water use.

Whereas **Figure 6** shows the total volume of groundwater produced in GMA 8 as estimated by TWDB for the major water use sectors, **Figure 7** shows the breakdown of total groundwater produced from each aquifer. Note that these values are from the Northern Trinity and Woodbine Aquifers GAM, and therefore include only the Trinity, Woodbine, Edwards (BFZ), and Brazos River Alluvium aquifers. According to TWDB Water Use Surveys, the total use from the other aquifers in GMA 8 – the Blossom, Ellenburger-San Saba, Hickory, Marble Falls, and Nacatoch aquifers – ranged from approximately 10,000 to 16,000 acre-feet per year between 2007 and 2011. The Trinity

Aquifer is the largest source of groundwater in GMA 8, supplying between 160,000 and 200,000 acre-feet per year over the last 30 to 40 years.

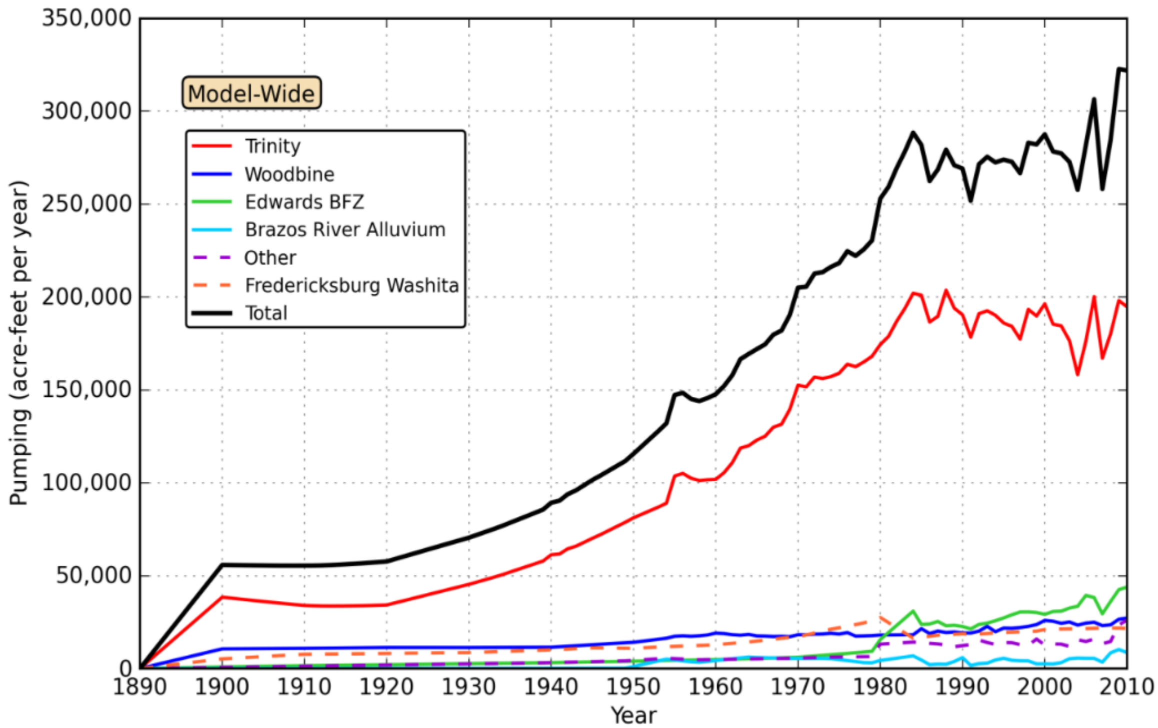

Figure 7. Estimated pumping for the Trinity, Woodbine, Edwards (BFZ), and Brazos River Alluvium aquifers in GMA 8.[15]

Estimates of groundwater pumping in Texas are characterized as estimates because much, if not most, of groundwater production is not metered, except for public water supply systems. This is particularly true in areas without GCDs. TWDB employs many methods to estimate pumping, which we will not describe in detail here, but which carry certain assumptions and limitations. The methods and assumptions used by the TWDB have also changed over the years.

As an example, the TWDB Groundwater Pumpage Estimates are reported by aquifer. However, about 95 percent of groundwater pumping for mining activities (which includes oil and gas uses) is classified as occurring from "Unknown Aquifer." There is also an "Other Aquifer" designation, which averages over 30,000 acre-feet per year in GMA 8 between 2007 and 2011. This is intended to be used for groundwater produced from aquifers not officially recognized as major or minor aquifers by TWDB such as the Paleozoic Aquifers in western GMA 8. However, use from named aquifers is sometimes mistakenly classified as "Other Aquifer" because of differences in what the aquifer is called locally. For example, in the northern portion of GMA 8, the Trinity Aquifer is often called the Antlers Aquifer. Individuals completing online Water Use Surveys may not

[15] *Id.*

recognize that these refer to the same aquifer and fill in "Other Aquifer" instead. Despite some inherent limitations, the water use surveys and groundwater pumpage estimates are an indispensable source of data for estimating pumping and are a key input to groundwater availability models.

Appendix Y of the 2017 Explanatory Report shows Groundwater Planning Datasheets that were compiled to assist with development of DFCs. A datasheet was developed for each county and distributed to the District Representatives in GMA 8 early in the second round of joint planning. For each decade between 2010 and 2070, these datasheets included the following:

- Estimated current pumping from Northern Trinity and Woodbine Aquifer GAM by aquifer
- The MAG for each aquifer for the DFCs developed during the last round of joint planning
- Groundwater pumping in the 2012 Texas State Water Plan and the percent of the total pumping allocated to each aquifer
- Total water demand in the 2012 Texas State Water Plan between 2010 and 2060 and the fraction of that total demand designated to be met by groundwater supplies
- Total water demand in the 2017 State Water Plan for Texas between 2020 and 2070 and the annual volume designated to be met by each aquifer.

An example of one of these datasheets is shown in **Figure 8** below for Bell County. Appendix Y of the 2017 Explanatory Report contains datasheets for all counties reflecting the 2010 and 2070 planning period. The datasheets were not updated for the current round of joint planning, but several GCDs did use the data collected since the last round of planning to adjust future pumping for Run 11, which was used to develop the 2021 DFCs and were the basis for this Explanatory Report. A discussion of these changes is summarized below.

Bell County Groundwater Planning Datasheet
(all values in acre-feet per year unless otherwise noted)

	2010	2020	2030	2040	2050	2060	2070
NTGAM Est. Current Pumping (avg. 2010-12)	**6,237**						
Edwards (BFZ)	2,793						
Trinity	1,689						
Other	1,755						
Modeled Available Groundwater	**13,537**	**13,537**	**13,537**	**13,537**	**13,537**	**13,537**	
Edwards (BFZ)	6,469	6,469	6,469	6,469	6,469	6,469	
Trinity	7,068	7,068	7,068	7,068	7,068	7,068	
Other							
Groundwater Pumping in 2012 SWP	**5,378**	**5,378**	**5,378**	**5,378**	**5,378**	**5,378**	
Edwards (BFZ)	2,010	2,010	2,010	2,010	2,010	2,010	
Trinity	3,368	3,368	3,368	3,368	3,368	3,368	
Other							
Edwards (BFZ) Percent	37%	37%	37%	37%	37%	37%	
Trinity Percent	63%	63%	63%	63%	63%	63%	
Other Percent	0%	0%	0%	0%	0%	0%	
Total Demand in 2012 SWP	**63,783**	**77,506**	**84,599**	**90,499**	**95,994**	**101,625**	
GW Pumping % of Demand in 2012 SWP	8%	7%	6%	6%	6%	5%	
Total Demand in 2017 SWP		**76,075**	**85,958**	**97,041**	**109,131**	**121,622**	**134,411**
Projected GW Pumping in 2017 SWP		**5,279**	**5,464**	**5,767**	**6,114**	**6,436**	**7,113**
Edwards (BFZ)		1,973	2,042	2,155	2,285	2,405	2,658
Trinity		3,306	3,422	3,612	3,829	4,031	4,455
Other							

Figure 8. Example of Groundwater Planning Datasheet developed for each county in GMA 8.

3.2.2 Water Supply Needs and Water Management Strategies

Texas Water Code Section 36.108 (d)(2), requires District Representatives in a GMA to consider the water supply needs and water management strategies included in the State Water Plan for Texas. In order to meet this requirement, District Representatives in GMA 8 considered the continued population growth in the area (see **Table 2**), all water supplies needs, and recommended water management strategies included in the 2017 State Water Plan for Texas.[16] Applicable information for this factor is included as Appendices G and H of this Explanatory Report, and was included as Appendix Y of the 2017 Explanatory Report.

By considering the data from the regional and State Water Plans, the District Representatives sought to gain insight that supports the joint-planning process. The principle embodied by this factor is that District Representatives in a GMA, when adopting DFCs for groundwater resources, must consider water supply needs and water management strategies included within regional water plans for the area. Consideration of this factor first included a discussion of terminology important to the regional water planning process in Texas. To understand the process for quantifying "water supply

[16] The GMA 8 District Representatives did not review the 2021 regional water plans or the 2022 State Water Plan because this information was not available until the end of the joint-planning period.

needs," first the process for quantifying "water demands" must be established. In the Texas regional water planning process, water demands (or projections) as opposed to estimates of water use, is the volume of water projected to be needed during drought conditions. Water demand projections are always for the future. For the regional water planning process, they are calculated on a decadal basis. The difference in water demands and water supplies on a water user group or wholesale water supplier basis quantifies surpluses and needs. Water availability is the maximum amount of water available from a source during the drought of record, regardless of whether the supply is physically or legally available to water user groups. Existing water supply is the maximum amount of water available from existing sources for use during drought of record conditions that is physically and legally available for use by a water user group. Therefore, a water supply need (as referred to in Texas Water Code Section 36.108 (d)(2)), exists when the water demand for a water user group or a wholesale water provider is greater than the existing supply for that same planning entity.

A "water management strategy" in the Texas regional water planning process is described as a plan or specific project to meet a need for additional water by a discrete user group, which can mean increasing the total water supply or maximizing an existing supply, including through reducing demands. A "water user group" is an identified user or group of users for which water demands and water supplies have been identified and analyzed and plans developed to meet water needs. Water user groups include cities, and on a county aggregate basis rural, manufacturing, irrigation, steam electric power generation, mining, and livestock watering for each county. Water supply needs are also calculated for "wholesale water providers" which are defined as any person or entity, including river authorities and irrigation districts, that has contracts to sell more than 1,000 acre-feet of water wholesale in any one year during the five years immediately preceding the adoption of the last regional water plan.

Due to the demographic complexity of GMA 8 (population, urban rural, etc.), and the corresponding diversity of challenges that water user groups and wholesale water providers face in the region, the amount and complexity of information regarding water supply needs and water management strategies included in the current State Water Plan for Texas to be considered by GMA 8 District Representatives is quite significant. To facilitate these considerations, data tables in multiple formats for water supply needs and water management strategies included in the 2017 State Water Plan for Texas were made available via the TWDB State Water Plan website for further consideration at the individual GCD level. Maps and graphs showing the sources of new water strategies in GMA 8 for the 2020 and 2050 decades were considered by the GMA 8 District Representatives. These maps and graphs are included in **Appendix G** of this Explanatory Report. Because there are limits to the level of detail and accuracy of regional and state water planning, and because there are unknown groundwater demands that may arise at any time within the boundaries of a GCD or within areas not covered by a GCD, District Representatives also considered the potential for growth in demand that was not accounted for in the regional and state water planning. Each District Representative considered this potential increase in demand based on local knowledge, demand patterns, availability of other sources, GCD rules and management plans, and other factors. While not specifically identified, these factors played a role in determining future demand projections (i.e., pumping in Run 11) as the District Representatives sought to find a balance between the highest practicable production and conservation and preservation of groundwater resources in GMA 8.

3.2.3 Hydrological Conditions

Texas Water Code Section 36.108(d)(3) requires District Representatives in a GMA to consider "hydrological conditions, including for each aquifer in the management area the total estimated recoverable storage ("TERS") as provided by the executive administrator, and the average annual recharge, inflows, and discharge." Of the nine factors required to be considered in the joint-planning process, the factor considered most often, based on technical presentations and discussions was "hydrological conditions." Two comprehensive presentations given to GMA 8 District Representatives can be found in the GMA 8 webpage meeting documents for the November 22, 2019 meeting and in **Appendix G** of this Explanatory Report.

The overarching hydrological condition in GMA 8 regarding the Northern Trinity and Woodbine aquifers relates to historical decline in artesian water levels, especially in the Dallas/Fort Worth and Waco metropolitan areas. As illustrated in

Figure 9 (from George and others, 2011)[17], water level declines in this region of the state are greater than any other aquifer or region. The impact of any DFC option considered throughout the joint-planning process included a discussion of how any additional water level declines would impact current hydrological conditions.

[17] George, P. G., Mace, R. E., and Petrossian, R., 2011, Aquifers of Texas: Texas Water Development Board, Report 380, 172 p.

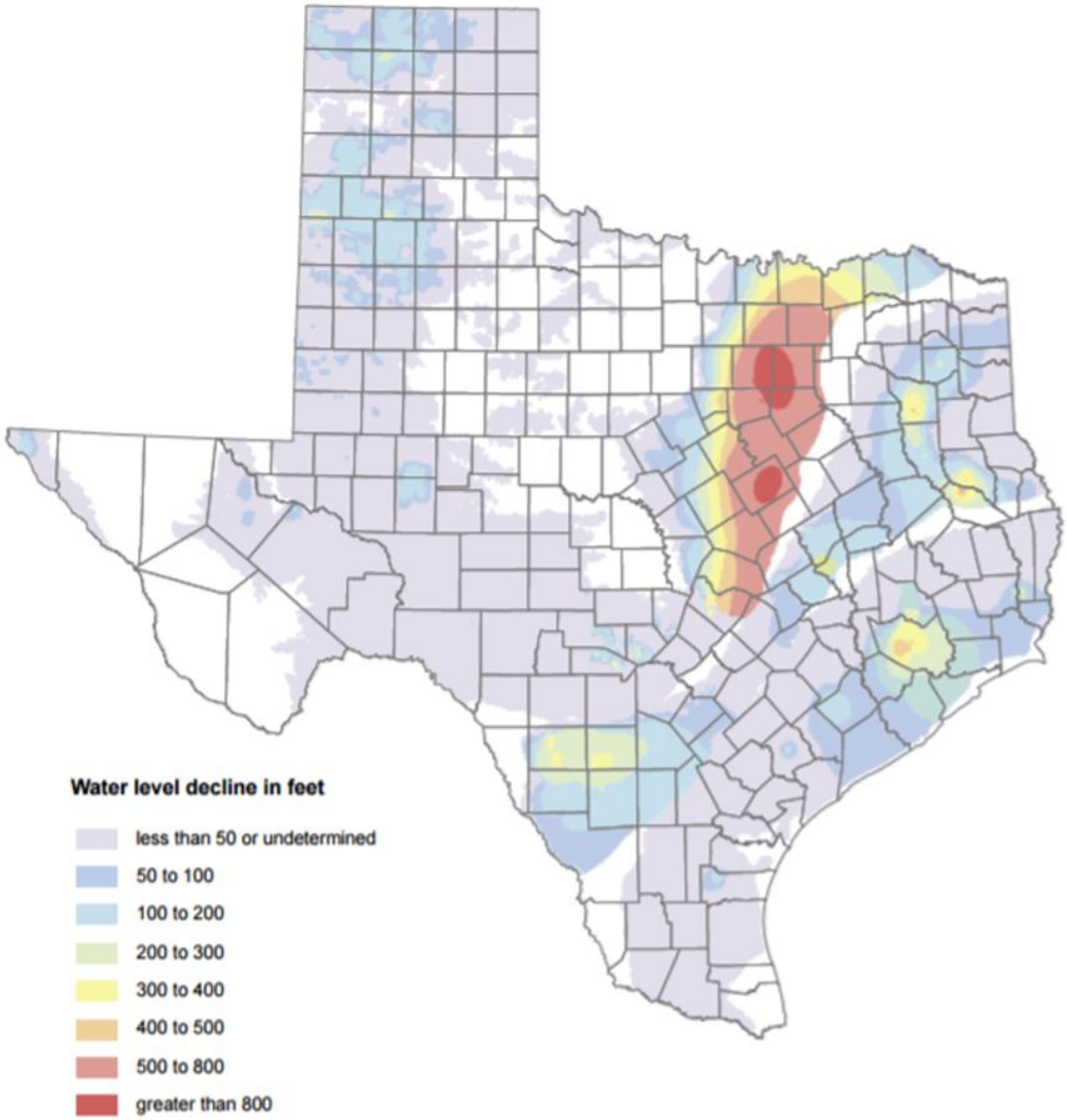

Figure 9. Map illustrating location and magnitude of historical water level declines in the aquifers of Texas.

Figure 10 shows a conceptual cross-section of many of the aquifer units in GMA 8 as described in Kelley and others (2014)[18] (see Appendices I, J, and K of the 2017 Explanatory Report). The Paluxy, Glen Rose, Hensell, Pearsall-Cow Creek-Hammett, and Hosston units make up the Trinity Aquifer. The Woodbine Aquifer overlies the Trinity Aquifer as well as the Fredericksburg and Washita Groups, which include the Edwards (BFZ) Aquifer in the southern portion of GMA 8. The Blossom and Nacatoch aquifers are younger units in far eastern GMA 8. The Hickory, Ellenburger – San Saba and Marble Falls aquifers are older units in southwestern GMA 8.

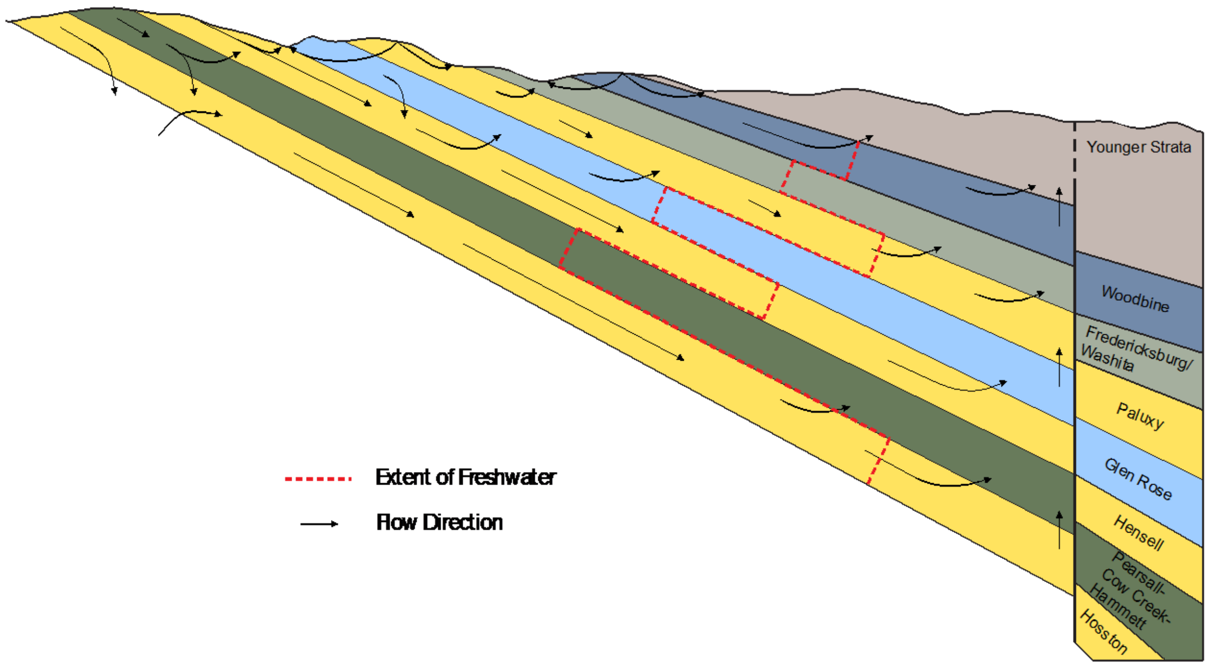

Figure 10. Conceptual cross-section of the Trinity and Woodbine aquifers in GMA 8.

As mentioned in Sections 3.1.2 and 3.2.1 of this Explanatory Report and in Kelley and others (2014),[19] the makeup of the Trinity Aquifer varies significantly across GMA 8. **Figure 11** is a map from Kelley and others (2014)[20] delineating distinct aquifer regions in GMA 8. (Note – these regional delineations are not to be confused with regional water planning area boundaries illustrated on Figure 4.) **Figure 12** shows a diagram designating the local aquifer names used in each region.

[18] Kelley, V.A., Ewing, J., Jones, T. L., Young, S. C., Deeds, N., and Hamlin, S., 2014, Updated groundwater availability model of the Northern Trinity and Woodbine Aquifers: - Final Report: Prepared for the North Texas Groundwater Conservation District, Northern Trinity Groundwater Conservation District, Prairielands Groundwater Conservation District, and Upper Trinity Groundwater Conservation District by INTERA, Inc., The Bureau of Economic Geology, and LBG-Guyton Associates, Volumes I, II, and III, variously paginated.
[19] Id.
[20] Id.

In Region 1, the Trinity Aquifer is generally known as the Antlers Aquifer. In Regions 2 and 3, the Glen Rose unit is present and acts to separate the overlying Paluxy from the underlying Twin Mountains/Travis Peak units. Note that in some areas the Twin Mountains is simply referred to as the "Trinity," distinct from the overlying Paluxy, even though both units are considered part of the Trinity Aquifer as defined by TWDB. In Regions 4 and 5, the Pearsall/Cow Creek/Hammett/Sligo confining units are present, dividing the Travis Peak into the overlying Hensell and underlying Hosston units.

Figure 13 shows a cross-section of geophysical logs for each region. The locations of the logs used in the cross-section are shown in **Figure 11**. In **Figure 13**, the yellow represents sand, the blue represents limestone, and the brown represents clay or shale. The sand zones are the most common targets for water well completions, though limestone can provide significant groundwater where it is fractured or partially dissolved. The clay and shale zones restrict the flow of groundwater and act as confining units. The differences between each of the aquifer regions described above correlate with the differences in lithology shown in **Figure 13**.

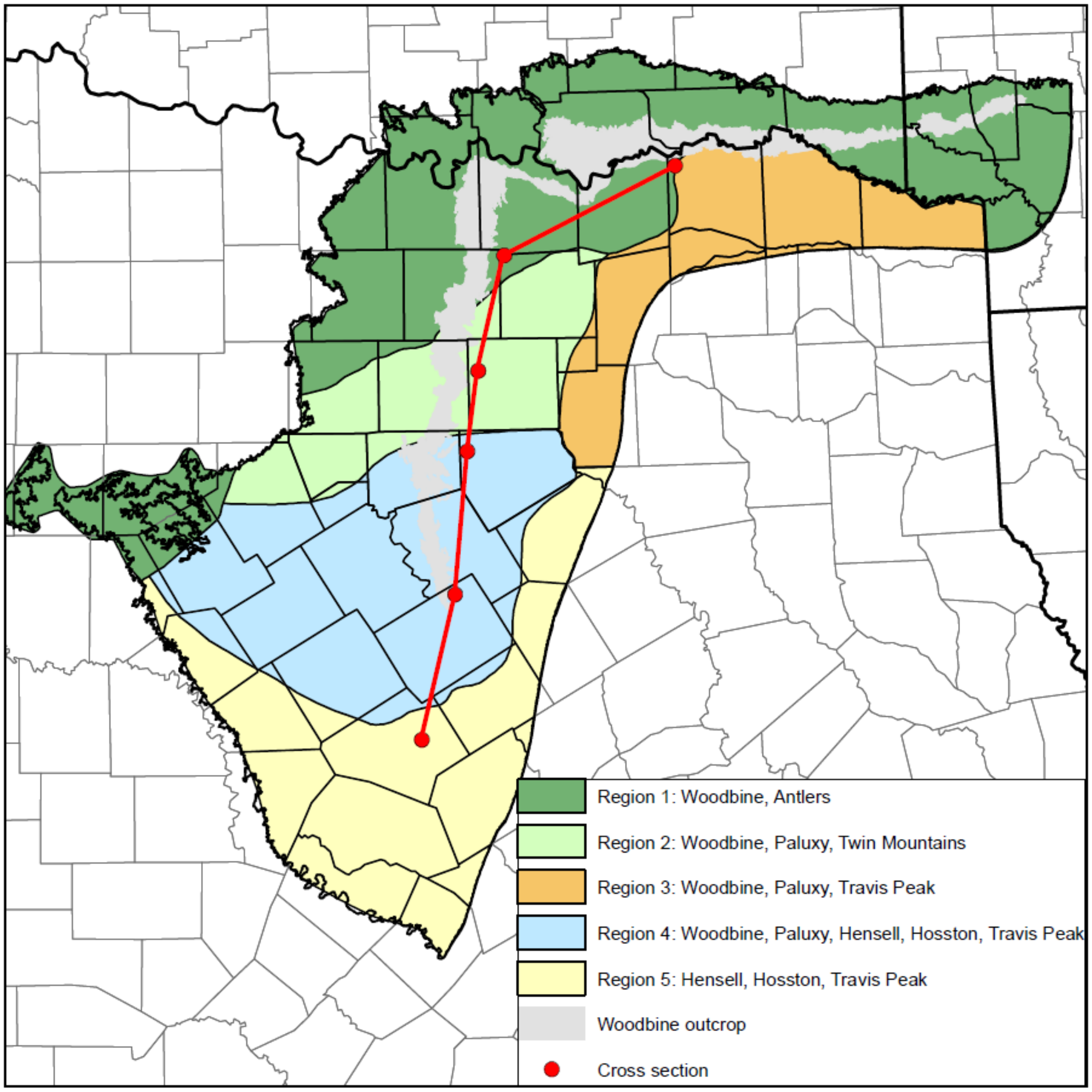

Figure 11. Aquifer Regions of the Trinity and Woodbine aquifers.[21]

[21] Kelley, -V.A., Ewing, J., Jones, T. L., Young, S. C., Deeds, N., and Hamlin, S., 2014, Updated groundwater availability model of the Northern Trinity and Woodbine Aquifers: - Final Report: Prepared for the North Texas Groundwater Conservation District, Northern Trinity Groundwater Conservation District, Prairielands Groundwater Conservation District, and Upper Trinity Groundwater Conservation District by INTERA, Inc., The Bureau of Economic Geology, and LBG-Guyton Associates, Volumes I, II, and III, variously paginated.

Model Terminology	Region 1	Region 2	Region 3	Region 4	Region 5
Woodbine Aquifer	Woodbine	Woodbine	Woodbine	Woodbine	Woodbine (no sand)
Washita/ Fredericksburg Groups	Washita/ Fredericksburg	Washita/ Fredericksburg	Washita/ Fredericksburg	Washita/ Fredericksburg	Washita/ Fredericksburg
Paluxy Aquifer	Antlers	Paluxy	Paluxy	Paluxy	Paluxy (no sand)
Glen Rose Formation	Antlers	Glen Rose	Glen Rose	Glen Rose	Glen Rose
Hensell Aquifer	Antlers	Twin Mountains	Travis Peak	Hensell/ Travis Peak	Hensell/ Travis Peak
Pearsall Formation	Antlers	Twin Mountains	Travis Peak	Pearsall/ Sligo	Pearsall/ Sligo
Hosston Aquifer	Antlers	Twin Mountains	Travis Peak	Hosston/ Travis Peak	Hosston/ Travis Peak

Figure 12. Aquifer names by region shown in Figure 11. [22]

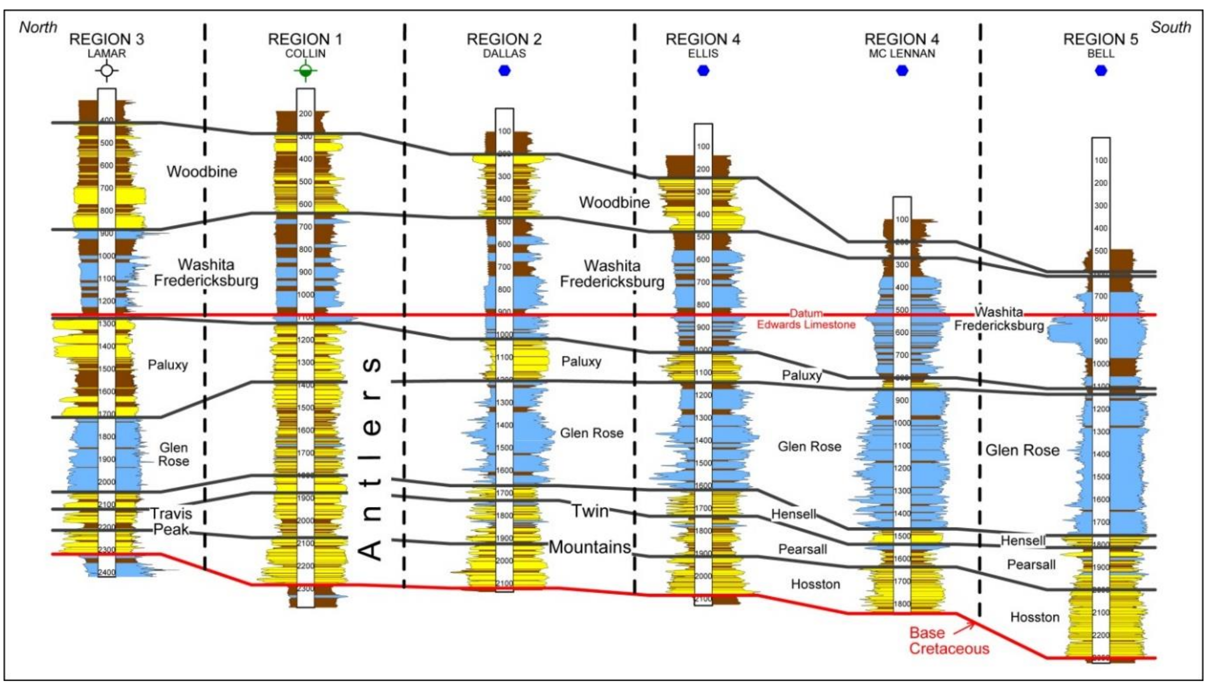

Figure 13. Cross-section showing representative geophysical logs for each aquifer region.

[22] Id.

3.2.3.1 Total Estimated Recoverable Storage

As described in Title 31, Texas Administrative Code Section 356.10, TERS is defined by TWDB as "[t]he estimated amount of groundwater within an aquifer that accounts for recovery scenarios that range between 25% and 75% of the porosity-adjusted aquifer volume." The TERS estimates developed by TWDB are shown in in GAM Task 13-031, which is included in Appendix FF of the 2017 Explanatory Report.[23]

As described in GAM Task 13-031, the total storage is calculated by TWDB as the product of the aquifer area, saturated thickness, and specific yield. For confined aquifers, a small amount of additional water is added to the total storage using the storativity or specific storage and the height of the potentiometric surface (water level as measured in a well) above the top of the aquifer. This total storage calculation is then reported along with the 25 percent and 75 percent bounds to reflect the amount that may be recoverable based on the bounds established by the TWDB.

TERS should not be confused with groundwater availability. For example, as described in GAM Task 13-031:

> Total estimated recoverable storage values may include a mixture of water quality types, including fresh, brackish, and saline groundwater, because the available data and the existing groundwater availability models do not permit the differentiation of different water quality types. These values do not take into account the effects of land surface subsidence, degradation of water quality, or any changes to surface water-groundwater interaction that may occur due to pumping.[24]

In addition, the TERS calculation does not consider aquifer lithology (the distribution of sands and clays) or the practicality and economics of recovering volumes of water within the 25 percent to 75 percent range of total storage.

While the TERS for the aquifers in GMA 8 is not analogous to groundwater availability or how much can be pumped, it serves as a reminder of the large volume of water in the aquifers. As required by Texas Water Code Section 36.108 (d)(3), GMA 8 District Representatives considered these TERS values along with the other factors in Texas Water Code Section 36.108(d)(3) when developing DFCs. The TERS for each aquifer in GMA 8 is shown below in **Table 11** through **Table 19**. Values in these tables have been rounded to two significant figures.

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[23] Shi, J., Bradley, R.G., Wade, S., Jones, J., Anaya, R., Seiter-Weatherford, C., 2014, GAM Task 13-031: Total Estimated Recoverable Storage for Aquifers in Groundwater Management Area 8, Texas Water Development Board GAM Task Report, 41 p.

[24] *Id.*

Table 11. Total estimated recoverable storage by county for the Hickory Aquifer in GMA 8.

County	25 percent of Total Storage (acre-feet)	75 percent of Total Storage (acre-feet)
Brow	55,000	165,000
Burnet	1,650,000	4,950,000
Lampasas	700,000	2,100,000
Mills	157,500	472,500
Travis	8,250	24,750
Williamson	4,250	12,750
Total	**2,575,000**	**7,725,000**

Table 12. Total estimated recoverable storage by county for the Ellenburger – San Saba Aquifer in GMA 8.

County	25 percent of Total Storage (acre-feet)	75 percent of Total Storage (acre-feet)
Brow	55,000	165,000
Burnet	1,650,000	4,950,000
Lampasas	700,000	2,100,000
Mills	157,500	472,500
Travis	8,250	24,750
Williamson	4,250	12,750
Total	**2,575,000**	**7,725,000**

Table 13. Total estimated recoverable storage by county for the Marble Falls Aquifer in GMA 8.

County	25 percent of Total Storage (acre-feet)	75 percent of Total Storage (acre-feet)
Burnet	9,500	28,500
Lampasas	9,750	29,250
Total	**19,250**	**57,750**

Table 14. Total estimated recoverable storage by county for the Trinity Aquifer in GMA 8.

County	25 percent of Total Storage (acre-feet)	75 percent of Total Storage (acre-feet)
Bell	14,750,000	44,250,000
Bosque	10,000,000	30,000,000
Brow	650,000	1,950,000
Burnet	2,750,000	8,250,000
Callahan	450,000	1,350,000
Collin	22,000,000	66,000,000
Comanche	2,075,000	6,225,000
Cooke	11,250,000	33,750,000
Coryell	8,500,000	25,500,000
Eastland	400,000	1,200,000
Ellis	19,500,000	58,500,000
Erath	5,000,000	15,000,000
Falls	9,000,000	27,000,000
Fannin	19,750,000	59,250,000
Grayson	15,750,000	47,250,000
Hamilton	5,500,000	16,500,000
Hill	13,000,000	39,000,000
Hood	2,750,000	8,250,000
Hunt	3,000,000	9,000,000
Johnson	8,750,000	26,250,000
Kaufman	2,350,000	7,050,000
Lamar	19,250,000	57,750,000
Lampasas	3,000,000	9,000,000
Limestone	2,750,000	8,250,000
McLennan	14,750,000	44,250,000
Milam	5,500,000	16,500,000
Mills	2,125,000	6,375,000
Montague	1,950,000	5,850,000
Navarro	9,750,000	29,250,000
Parker	5,500,000	16,500,000
Red River	11,000,000	33,000,000
Rockwall	1,225,000	3,675,000
Somervell	1,500,000	4,500,000
Tarrant	12,250,000	36,750,000
Taylor	157,500	472,500
Travis	9,750,000	29,250,000
Williamson	19,250,000	57,750,000
Wise	5,000,000	15,000,000
Total	**339,882,500**	**1,019,647,500**

Table 15. Total estimated recoverable storage by county for the Edwards (BFZ) Aquifer in GMA 8.

County	25 percent of Total Storage (acre-feet)	75 percent of Total Storage (acre-feet)
Bell	2,750	8,250
Travis	1,475	4,425
Williamson	19,500	58,500
Total	**23,725**	**71,175**

Table 16. Total estimated recoverable storage by county for the Woodbine Aquifer in GMA 8.

County	25 percent of Total Storage (acre-feet)	75 percent of Total Storage (acre-feet)
Collin	8,000,000	24,000,000
Cooke	300,000	900,000
Dallas	7,500,000	22,500,000
Denton	2,225,000	6,675,000
Ellis	6,250,000	18,750,000
Fannin	9,750,000	29,250,000
Grayson	8,000,000	24,000,000
Hill	1,675,000	5,025,000
Hunt	2,050,000	6,150,000
Johnson	1,125,000	3,375,000
Kaufman	1,175,000	3,525,000
Lamar	5,250,000	15,750,000
McLennan	225,000	675,000
Navarro	850,000	2,550,000
Red River	1,125,000	3,375,000
Rockwall	11,500	34,500
Tarrant	1,325,000	3,975,000
Total	**56,836,500**	**170,509,500**

Table 17. Total estimated recoverable storage by county for the Nacatoch Aquifer in GMA 8.

County	25 percent of Total Storage (acre-feet)	75 percent of Total Storage (acre-feet)
Bowie	525,000	1,575,000
Delta	25,000	75,000
Ellis	17	50
Franklin	1,825	5,475
Hopkins	82,500	247,500
Hunt	137,500	412,500
Kaufman	30,000	90,000
Lamar	3,000	9,000
Navarro	23,750	71,250
Rains	4,500	73,500
Red River	145,000	435,000
Rockwall	70	210
Total	**978,162**	**2,934,485**

Table 18. Total estimated recoverable storage by county for the Blossom Aquifer in GMA 8.

County	25 percent of Total Storage (acre-feet)	75 percent of Total Storage (acre-feet)
Bowie	227,500	682,500
Lamar	242,500	727,500
Red River	1,300,000	3,900,000
Total	**1,770,000**	**5,310,000**

Table 19. Total estimated recoverable storage by county for the Brazos River Alluvium Aquifer in GMA 8.

County	25 percent of Total Storage (acre-feet)	75 percent of Total Storage (acre-feet)
Bosque	2,400	7,200
Falls	40,000	120,000
Hill	1,650	4,950
McLennan	22,500	67,500
Milam	2,175	6,525
Total	**68,725**	**206,175**

3.2.3.2 Water Budgets

A water budget is an accounting of the inflows and outflows to and from an aquifer. These budgets are important to understanding how the aquifer works and what characteristics of the aquifer are most important when evaluating groundwater availability.

Table 20 shows a partial water budget for the Trinity and Woodbine aquifers for the period prior to development (pumping) of the aquifer. This budget is for the extent of the Northern Trinity and Woodbine Aquifer GAM, which encompasses most of GMA 8. In **Table 20**, positive values indicate inflows to the aquifer and negative values indicate outflows.

As shown in **Table 20** (from Kelley and others, 2014), recharge to the Trinity and Woodbine aquifers prior to development is approximately 1.8 million acre-feet per year. However, the vast majority of this volume discharged in the outcrop area of the aquifer by evapotranspiration ("ET") or into streams and springs. Only approximately 12,000 acre-feet per year of recharged water percolated down into the deeper portions of the aquifer through cross-formational flow under pre-development conditions. All values are in acre-feet per year.

Table 20. Partial pre-development water budget for the Trinity and Woodbine aquifers.

Pre-development	Cross-formational Flow			Recharge	ET	Ephemeral Streams	Perennial Streams	Spring
	Surficial	Top	Bottom					
Younger Formations	0	0	8,354	0	0	0	0	0
Woodbine Aquifer	2,561	-8,354	5,901	326,201	-13,334	-197,776	-97,917	-61
Wash/Fred Groups	5,886	-5,901	275	532,484	-6,633	-270,802	-236,638	-286
Paluxy Aquifer	1,859	-275	-1,565	245,673	-6,771	-113,235	-120,812	-126
Glen Rose Formation	16,844	1,565	-18,638	230,422	-6,503	-83,409	-131,395	-86
Hensell Aquifer	-11,214	18,638	-6,579	208,440	-11,756	-130,060	-67,678	-188
Pearsall Formation	3,374	6,579	-9,899	45,455	-3,697	-38,571	-24,689	0
Hosston Aquifer	-7,050	9,899	0	177,891	-4,352	-122,037	-58,080	-343
Total	**12,259**	**22,151**	**-22,151**	**1,766,567**	**-53,046**	**-955,888**	**-737,209**	**-1,090**

Table 21 (from Kelley and others, 2014) presents the water budget for 2000, a relatively low-recharge year. Recharge is still the largest inflow, but for this year, more water discharged through evapotranspiration (ET) and by ephemeral and perennial streams and springs than came into the aquifer. As this is a post-development water budget, it contains new terms for reservoirs, pumping ("Well"), flowing wells ("Flowing"), and storage. Following the convention in hydrogeology, water removed from storage in the aquifer is shown as a positive value. For this dry year, the volume of pumping from these

aquifers was approximately 266,000 acre-feet, but the reduction in storage in the aquifer was approximately 787,000 acre-feet. All values in Table 21 are in acre-feet per year.

Table 21. Water budget for Year 2000 for the Trinity and Woodbine aquifers.

		Woodbine Aquifer	Wash/Fred Groups	Paluxy Aquifer	Glen Rose	Hensell Aquifer	Pearsall	Hosston Aquifer	Total
Cross-formational Flow	Surficial	24,864	58,069	23,325	64,531	17,688	21,485	22,725	232,687
	Top	5,407	5,976	25,510	21,510	73,590	56,062	72,303	260,358
	Bottom	-5,976	-25,510	-21,510	-73,590	-56,062	-72,303	0	-254,951
Recharge		231,840	345,628	173,587	142,829	151,900	32,744	127,805	1,206,333
ET		-13,556	-8,652	-7,235	-6,716	-12,074	-3,702	-4,270	-56,205
Ephemeral		-208,440	-298,137	-124,408	-88,150	-137,903	-38,336	-126,396	-1,021,770
Perennial		-96,990	-181,195	-99,809	-114,108	-56,508	-22,424	-50,753	-621,787
Reservoir		-4,596	-11,257	-459	-540	-821	-384	-991	-19,048
Spring		-64	-227	-118	-85	-198	0	-318	-1,010
Well		-26,241	-41,062	-31,035	-16,179	-37,487	-8,821	-105,581	-266,406
Flowing		-904	0	-56	-6	-520	-15	-226	-1,727
Storage		136,163	226,979	91,566	125,376	89,177	25,638	91,890	786,789

Recharge to aquifers in GMA 8 depends on the precipitation on the outcrop areas of the aquifers and the characteristics of the land surface and geologic units. **Figure 14** shows the estimated average annual recharge to the Trinity and Woodbine aquifers in inches per year. This ranges from less than 0.5 inches per year in the far western portion of GMA 8 to over 4 inches per year in northern GMA 8 along the Texas-Oklahoma Border.

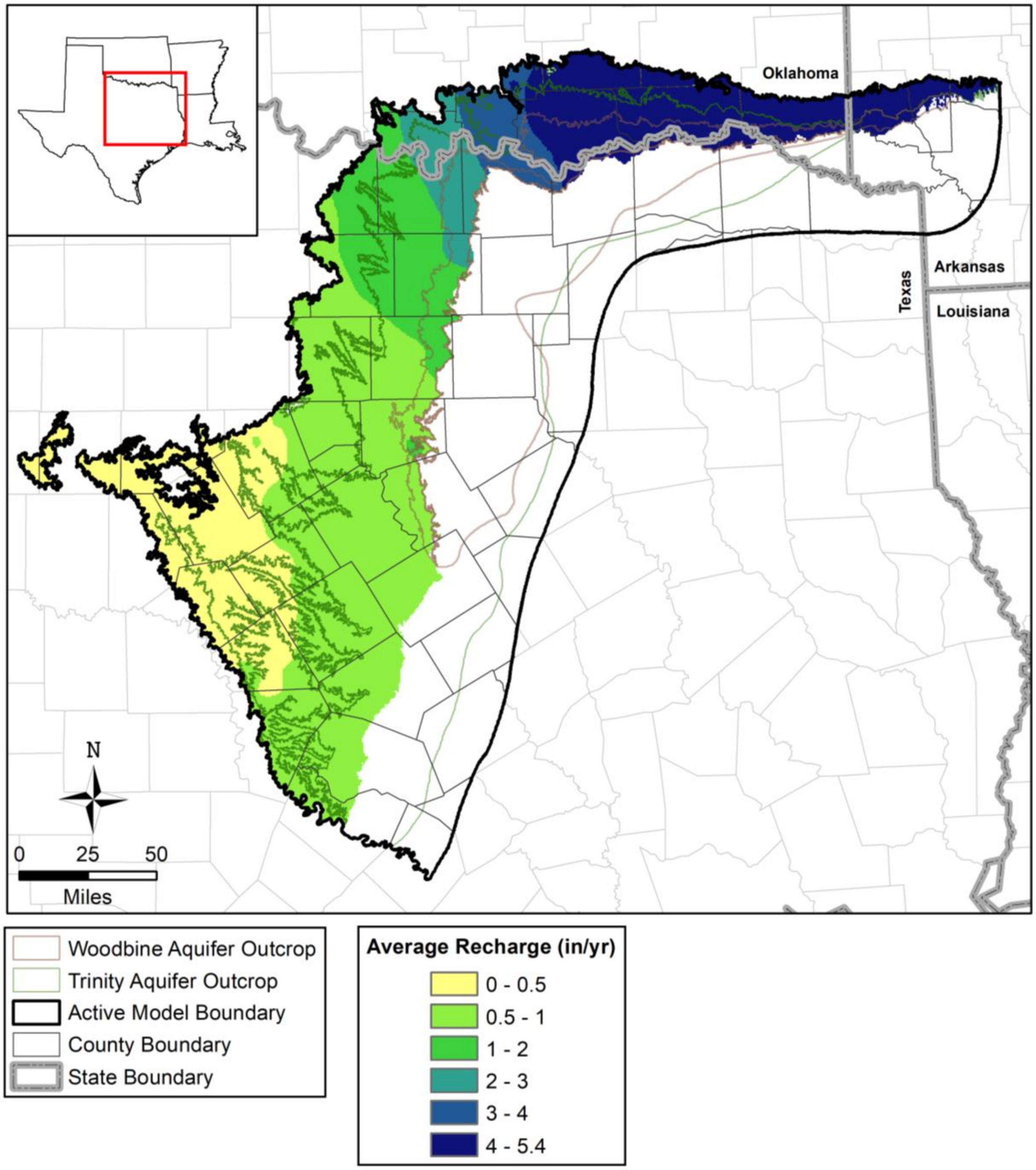

Figure 14. Estimated average recharge to the Trinity and Woodbine aquifers.

The water budget information presented above, which includes average annual recharge, inflows and outflows, was reviewed by District Representatives in GMA 8 and is included in the Kelley and others (2014), documenting development of the updated groundwater availability model for the northern portion of the Trinity and Woodbine aquifers. In addition, GMA 8 District Representatives reviewed water budget information for potential DFCs as they were considered. For Run 11, water budget information was prepared for each aquifer in each county by decade between 2010 and 2080. This information is provided in Appendix E of this Explanatory Report, and an example of one of these tables is included in **Table 22** below for the Paluxy Aquifer in Bosque County. All values are in acre-feet per year.

Note in the example below that recharge remains constant through the period with the exception of 2060 due to inclusion of a one-time drought-of-record in the simulation. Pumping in Bosque County is relatively limited, but water level declines still occur (positive storage). This is caused by increased leakage to underlying aquifers and results in decreased outflow to perennial and ephemeral streams.

Table 22. Example water budget for Run 11.[25]

Bosque County – Paluxy Aquifer								
	2010	2020	2030	2040	2050	2060	2070	2080
Storage	8	8	6	5	3	2	2	2
Pumping	−357	−357	−357	−357	−357	−357	−357	−357
SW and GW Interactions	−6,568	−6,568	−6,300	−6,163	−6,067	−5,996	−5,940	−5,824
Recharge	3,683	3,683	3,683	3,683	3,683	3,683	3,683	3,196
Vertical Leakage Upper	5,698	5,698	6,357	6,847	7,116	7,273	7,372	7,438
Vertical Leakage Lower	−5,543	−5,543	−6,200	−6,678	−6,939	−7,090	−7,186	−7,250
Lateral Flow	194	194	193	184	176	172	168	166

Water budget information for the Edwards (BFZ) Aquifer can be found as part of the groundwater availability model developed for the northern segment of the Edwards (BFZ) Aquifer (Jones, 2003).[26] The Northern Edwards (BFZ) Aquifer GAM was used in the development of GAM Run 08-10 mag (Anaya, 2008)[27] referenced in the Resolution 2017-01-01 (see Appendix F of the 2017 Explanatory Report) for the Edwards (BFZ) Aquifer. This GAM Run report is itself based on GAM Run 07-21 (Anaya, 2007).[28] The area of the GAM for the northern segment of the Edwards (BFZ) Aquifer closely aligns with GMA 8. The water budget information in Jones (2003) indicates that the majority of recharge to the aquifer discharges through spring flow and cross-formational flow to overlying units.

Water budget information for the Llano Uplift Aquifers (Marble Falls, Ellenburger – San Saba, and Hickory) can be found as part of the GAM report for these aquifers (see

[25] Beach, J., Keester, M., and Konetchy, B., 2016, Results of Predictive Simulation in Support of GMA 8 Joint Planning – NTGCD GMA 8 Run 10, 186 p.
[26] Jones, I.C., 2003, Groundwater availability modeling: northern segment of the Edwards Aquifer, Texas, Texas Water Development Board Report 358, 83 p.
[27] Anaya, R.A., 2008, GAM Run 08-10mag, Texas Water Development Board Managed Available Groundwater GAM run report, 7 p.
[28] Anaya, R.A., 2007, GAM Run 07-21, Texas Water Development Board GAM run report, 11 p.

https://www.twdb.texas.gov/groundwater/models/gam/llano/Llano_Uplift_Numerical_Model_Report_Final.pdf?d=12845.185000005586).[29]

As shown in the Numerical Model Report: Minor Aquifers of the Llano Uplift Region of Texas, the majority of recharge to the Llano Uplift Aquifers in the counties in GMA 8 discharges to rivers and lakes, though in some counties (e.g., Burnet), pumping accounts for a significant portion of the county-wide water budget.

As described in Chapter 6 of this Explanatory Report, District Representatives in GMA 8 considered the Nacatoch, Brazos River Alluvium, Cross Timbers, and Blossom aquifers non-relevant for joint-planning purposes. There is, however, some water budget information available for these aquifers. The Nacatoch Aquifer groundwater availability model contains water budget information by county including recharge and discharge mechanisms (Beach and others, 2009).[30] The TWDB is in the process of developing a groundwater availability model for the Brazos River Alluvium Aquifer. See Ewing and others (2016)[31] for the report documenting the conceptual model of this aquifer, including some water budget components such as recharge and discharge to surface water. The TWDB is also currently developing a groundwater availability model for the Blossom Aquifer, though no results from this study are available for review as of the date of this Explanatory Report.

3.2.4 Environmental Impacts

Texas Water Code Section 36.108(d)(4) requires District Representatives in a GMA to consider "other environmental impacts, including impacts on spring flow and other interactions between groundwater and surface water." The water budget components described in Section 3.2.3 of this Explanatory Report for Run 11 include impacts on spring flow and interactions between groundwater and surface water for each aquifer in each county relevant to the DFCs. These are presented in **Appendix E** of this Explanatory Report. Some additional information on spring flow and groundwater – surface water interaction is included below. The results of a detailed analysis of these components were completed and reviewed by District Representatives in GMA 8 as part of the update to the groundwater availability model for the northern portion of the Trinity and Woodbine aquifers. This is included in the presentation given to the GMA District Representatives at the November 22, 2019 meeting and in the presentation given at the conclusion of the joint-planning process (see **Appendix G** of this Explanatory Report).

[29] Shi, J., Boghici, R., Kohlrenken, W., and Hutchinson, W., 2016, Numerical Model Report: Minor Aquifers of the Llano Uplift Region of Texas (Marble Falls, Ellenburger-San Saba, and Hickory): Texas Water Development Board, variously paginated.

[30] Beach, J.A., Huang, Y., Symank, L., Ashworth, J.B., Davidson, T., Vreugdenhil, A.M., Deeds, N.E., 2009, Final report: Nacatoch Aquifer Groundwater Availability Model, Prepared for the Texas Water Development Board, 304 p.

[31] Ewing, J.E., and M. Jigmond, 2016. Final Numerical Model Report for the Brazos River Alluvium Aquifer Groundwater Availability Mode, 514 p.

3.2.4.1 Spring Flow

Figure 15 shows the locations of springs in GMA 8 presented by aquifer and data source. Since a spring is a feature where groundwater discharges at the land surface, the springs are aligned with the aquifer outcrops – where it is exposed at land surface. Please refer to Kelley and others (2014) for full data source references.[32] The southern portion of GMA 8 contains the greatest density of springs. Many of these issue from the Fredericksburg/Washita group, which includes the Edwards (BFZ) Aquifer in this area of GMA 8. There are also many springs that issue from the far western extent of the Trinity Aquifer and in northern GMA 8 and in the counties that comprise Upper Trinity GCD (Hood, Montague, Parker, and Wise counties).

Groundwater discharges from a spring when the water level elevation of the aquifer is above the elevation of a spring hydrogeologically connected to it. The rate of flow from the spring directly relates to the difference in these two elevations. Water level declines in the outcrop area of aquifers can significantly reduce or stop spring flow if the groundwater level drops close to or below the spring elevation. The water budgets described in Section 3.2.3 and included in **Appendix E** of this Explanatory Report reflect reductions in spring flow in areas where the DFCs include drawdowns in aquifer outcrop areas.

[32] Kelley, V.A., Ewing, J., Jones, T. L., Young, S. C., Deeds, N., and Hamlin, S., 2014, Updated groundwater availability model of the Northern Trinity and Woodbine Aquifers: - Final Report: Prepared for the North Texas Groundwater Conservation District, Northern Trinity Groundwater Conservation District, Prairielands Groundwater Conservation District, and Upper Trinity Groundwater Conservation District by INTERA, Inc., The Bureau of Economic Geology, and LBG-Guyton Associates, Volumes I, II, and III, variously paginated.

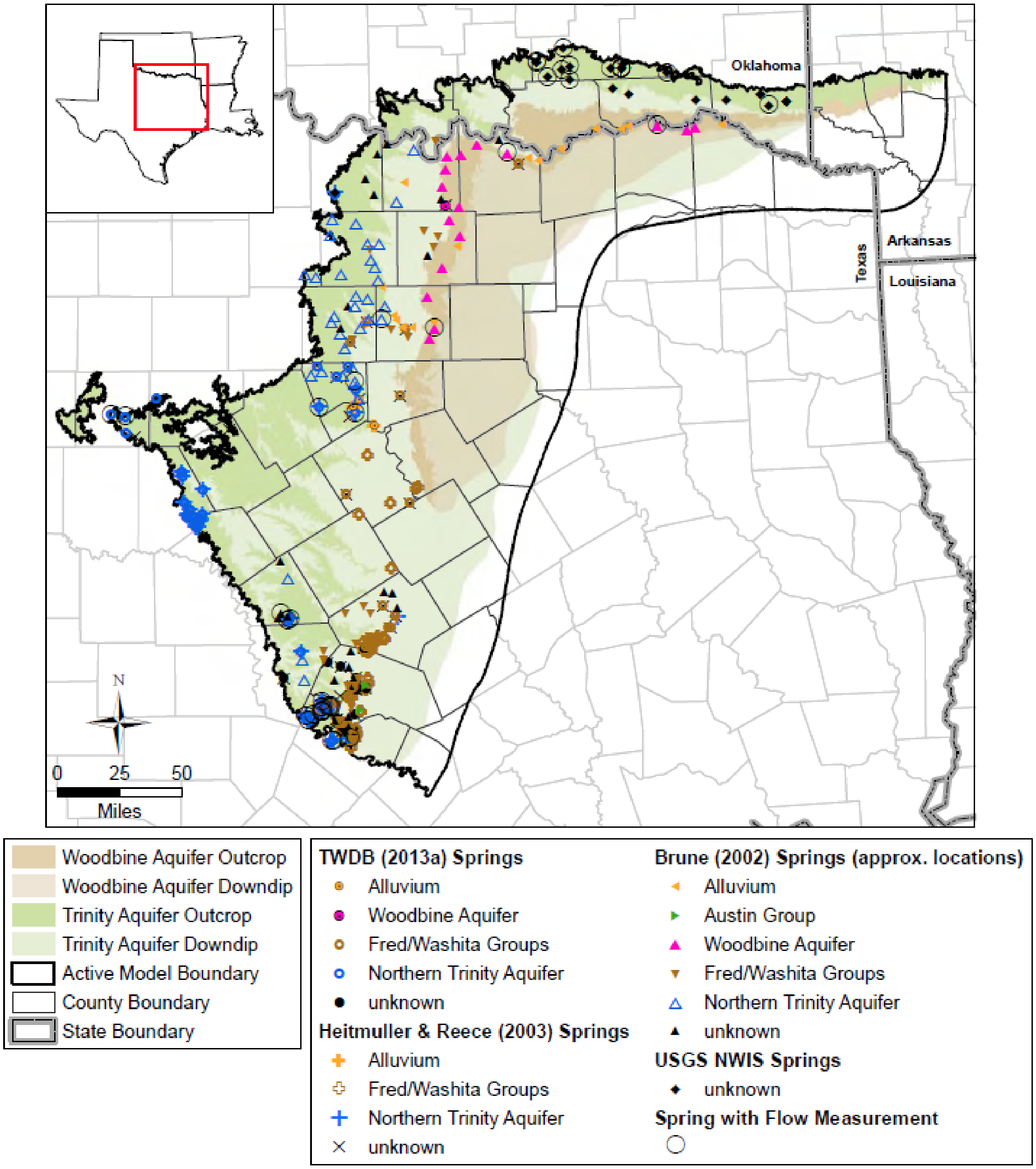

Figure 15. Spring locations by data source and aquifer in GMA 8.

3.2.4.2 Groundwater/Surface Water Interaction

Figure 16 shows the average annual baseflow to streams intersecting the aquifers in GMA 8. Note that this is limited to sections of streams with more than ten years of unregulated stream gage data. "Unregulated" refers to sections of streams in their natural state as opposed to those where the flow is influenced by dams or diversions. This information was reviewed by District Representatives in GMA 8 meetings to consider environmental impacts in the development of the DFCs.

Baseflow is the contribution of flow in a stream or river that is sourced from groundwater discharges along the stream channel. Similar to the mechanics of spring flow, baseflow to streams occurs when the water level in the aquifer is above the water level in the stream. Streams where this occurs are known as "gaining streams." Unlike springs, interaction between streams and aquifers can occur in either direction. If the water level in the aquifer is below the water level in the stream, water will flow from the stream into the aquifer. Streams where this occurs are known as "losing streams."

As shown in **Figure 16**, the streams in GMA 8 are typically gaining streams. However, water level declines in aquifer outcrop areas can lead to reductions in baseflow to streams or even a reversal in the direction of flow. The water budgets included in **Appendix E** of this Explanatory Report show the estimated changes in baseflow to streams resulting from the adopted DFCs.

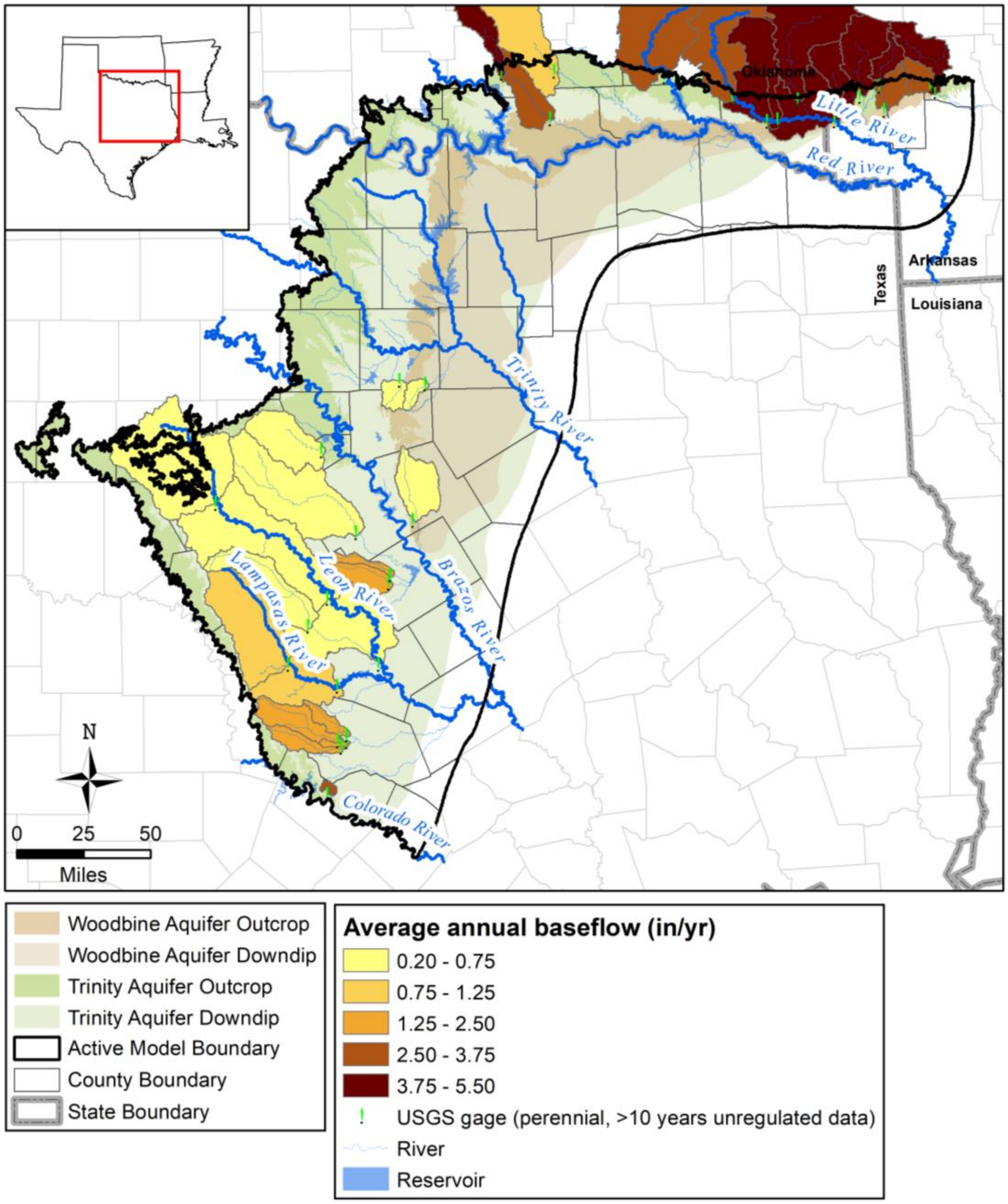

Figure 16. Average annual baseflow to streams with greater than 10 years of unregulated stream gage data.[33]

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[33] Kelley, -V.A., Ewing, J., Jones, T. L., Young, S. C., Deeds, N., and Hamlin, S., 2014, Updated groundwater availability model of the Northern Trinity and Woodbine Aquifers: - Final Report: Prepared for the North Texas Groundwater Conservation District, Northern Trinity Groundwater Conservation District, Prairielands Groundwater Conservation District, and Upper Trinity Groundwater Conservation District by INTERA, Inc., The Bureau of Economic Geology, and LBG-Guyton Associates, Volumes I, II, and III, variously paginated.

3.2.5 Subsidence Impacts

Texas Water Code Section 36.108(d)(5) requires District Representatives in a GMA to consider the impacts of proposed DFCs on subsidence. Subsidence is the geologic term used to describe the sinking of the land surface with respect to sea level. Subsidence may occur as a result of natural causes or from man-induced or anthropogenic causes. Subsidence, especially in low lying coastal areas, may cause significant damage due to flooding, including structural damage to roads and buildings. For example, subsidence in the Houston/Galveston area has been caused by removal of oil and gas minerals as well as groundwater from the confined Gulf Coast Aquifer. Subsidence may also result from the removal of other minerals in the subsurface such as salt and sulfur.[34]

When subsidence is the result of the removal of fluids, this is because the fluids are pressurized or confined. Therefore, when naturally occurring, the pressurized fluids act to hold up the loosely consolidated sedimentary particles in the subsurface (clays, silts, and sands). Due to the inelastic nature of the sediments, in particular clays in areas where subsidence occurs, subsidence is permanent. Flooding resulting from subsidence in the Harris/Galveston area has resulted in major losses to land and property over the past fifty plus years.

Mace and others (1994)[35] reported on the observed and potential effects of water-level declines in the Woodbine, Paluxy, and Trinity aquifers on subsidence and water quality. Based on an analysis of water-level declines and the elastic and hydraulic properties of confining units for the subject aquifers, Mace and others (1994) concluded that either because of the structural stability of the geologic units in the region or due to a consolidation time-lag, no subsidence has been observed in the North-Central Texas area (coincident with GMA 8). This conclusion was supported by the absence of any measured subsidence by the U.S. Geological Survey in the region from 1957-1991.

In 2017, the TWDB completed a study to identify and characterize areas within Texas' major and minor aquifers that are susceptible to land subsidence related to groundwater pumping.[36] The report and subsidence prediction tool were used to assess potential subsidence in GMA 8 and these results were used to provide insight into potential subsidence related to pumping associated with DFCs. The District Representatives reviewed results from the subsidence prediction tool for various locations across GMA 8. Based on the geologic and hydrogeologic characteristics of the aquifers in GMA 8, the predicted water level decline, and the estimates of subsidence predicted by the

[34] Mullican, W. F., III, 1988, Subsidence and collapse of Texas *S*alt Domes: The University of Texas at Austin, Bureau of Economic Geology Geological Circular 88-2, 36 p.
[35] Mace, R. E., Dutton, A. R., and Nance, H. S., 1994, Water-level declines in the Woodbine, Paluxy, and Trinity aquifers of North-Central Texas: Transactions of the Gulf Coast Association of Geological Sciences, Vol. XLIV, pp. 413-420.
[36] Furnans, J., M. Keester, D. Colvin, J. Bauer, J. Barber, G. Gin, V. Danielson, L. Erickson, R. Ryan, K. Khorzad, A. Worsley, G. Snyder, 2017. Identification of the Vulnerability of the Major and Minor Aquifers of Texas to Subsidence with Regard to Groundwater Pumping. Texas Water Development Board.

subsidence model, the adopted DFCs were deemed to be reasonable in regards to the impact they would have on subsidence.

3.2.6 Socioeconomic Impacts

Texas Water Code Section 36.108 (d)(6) requires District Representatives in a GMA to consider socioeconomic impacts reasonably expected to occur as a result of the proposed DFCs for relevant aquifers. Consideration of socioeconomic impacts as part of water planning in Texas, both at the regional and state level, has been a primary element of the water planning process dating back to the 1960s. This includes statutory guidance for regional water planning [37] and state water planning.[38] Title 31 of Texas Administrative Code, Sections 357.11(j) and 357.33(c), respectively, provide the following:

> "Upon request, the EA [executive administrator] will provide technical assistance to RWPGs [Regional Water Planning Groups], including on water supply and demand analysis, methods to evaluate the social and economic impacts of not meeting needs, and regarding Drought Management Measures and water conservation practices."

"The social and economic impacts of not meeting Water Needs shall be evaluated by RWPGs and reported for each RWPA [Regional Water Planning Area]."This technical assistance and analysis provided by the executive administrator is the only consistent analysis of socioeconomic impacts available for joint planning in regards to socioeconomic impacts, at the local, regional, and state level. This analysis is based on water supply needs from the regional water plans. This analysis consists of a series of point estimates of 1-year droughts at 10-year intervals. The socioeconomic impact analysis attempts to measure the impacts in the event that water user groups do not meet their identified water supply needs associated with a drought-of-record for one year. For this socioeconomic impact analysis, multiple impacts are examined, including (1) sales, income, and tax revenue, (2) jobs, (3) population, and (4) school enrollment. Results from this analysis are then incorporated into the final regional water plan, and then comprehensively presented in the subsequent state water plan. Socioeconomic impact analysis reports provided by the executive administrator of the TWDB for the 2016 and 2021 regional water plans in Regions B, C, D, F, G, and K were available for review at the TWDB water planning website. Concepts and details of this information were considered during the May 15, 2020 and October 27, 2020 (see **Appendices G** and **H** of this Explanatory Report for the presentation of these meetings) and at the conclusion of the joint-planning process. While TWDB assessments are useful to understand importance of meeting projected water needs, analyses do not evaluate socioeconomic impacts of proposed DFCs at the GMA level and a similar analysis does not exist. DFCs result in groundwater availability amounts for potential water management strategies that can

[37] Texas Water Code Section 16.053 (a), (b).
[38] Texas Water Code Section 16.051 (a), (b).

meet some of the water supply needs and, therefore, are indirectly tied to this discussion for regional and state water planning.

Information regarding socioeconomic impacts reasonably expected to occur as a result of the proposed DFCs was developed by District Representatives utilizing a survey tool developed specifically for use by GMA 8 in the previous round of joint planning and was documented in the 2017 Explanatory Report. The survey tool was used by individual District Representatives to discuss and consider both socioeconomic impacts and impacts on private property rights (see Section 3.2.7) of DFCs under consideration with each GMA 8 GCD Board of Directors. District Representatives were reminded that the results of that 2016 survey were still representative of GMA 8 GCD sentiment and management approach in 2020, and therefore, the survey was not repeated. The completed surveys were included in their entirety in Appendix NN of the 2017 Explanatory Report.

The GMA 8 survey asked individual GCDs for both binary responses (yes/no) to a set of questions and, for certain questions, requested any additional information that the GCD considered during discussions of potential socioeconomic impacts. The questions and binary responses were included in Appendix NN of the 2017 Explanatory Report. While it was difficult to specifically characterize survey responses from a qualitative perspective, it was clear that GMA 8 GCDs recognize that in their deliberation and adoption of DFCs, management plans, and rules, it was critical to evaluate all policy decisions based, in part, on the potential socioeconomic impacts of the policy question under consideration. A partial listing of socioeconomic impacts considered include: impacts of lowering water levels on costs of production included increased pumping lifts, decreasing well yields and potential need for additional wells, potential for and additional costs of developing alternative supplies, and the need to meet water supply needs in order to avoid socioeconomic impacts of water shortages.

Due to the absence of non-exempt pumping in the Northern Trinity and Woodbine aquifers in Post Oak Savannah GCD, the District's responses to questions pertaining to socioeconomic impacts of proposed DFCs were determined to be "not applicable." Five GCDs provided specific information regarding additional socioeconomic impact studies deemed to be relevant to the individual GCD. GCDs submitting district-specific information on socioeconomic impacts included Central Texas GCD, Clearwater UWCD, Post Oak Savannah GCD, Southern Trinity GCD, and Upper Trinity GCD. All additional information considered by these five GCDs were included along with survey responses in Appendix NN of the 2017 Explanatory Report. Overall, almost all of the questions regarding whether or not a GCD's Board of Directors considered a specific aspect of socioeconomic impacts potentially resulting from proposed DFCs were answered in the affirmative (61 – yes; 4 – no). In addition, an examination of survey responses illustrated that the GCDs in GMA 8 held focused discussions during multiple properly noticed, Board of Directors' meetings, on the socioeconomic impacts of proposed DFCs within their individual GCDs.

3.2.7 Private Property Impacts

Texas Water Code Section 36.108(d)(7) requires that District Representatives in a GMA consider the impact of proposed DFCs on the interests and rights in private property, including ownership and the rights of management area landowners and their lessees and assigns in groundwater, as recognized under Texas Water Code Section 36.002. GMA 8 District Representatives formally considered this factor throughout the joint-planning process (including focused discussions on this criterion during meetings on February 26, 2020 and October 27, 2020 (see **Appendices G** and **H** for the presentations from these meetings) and at the conclusion of the joint-planning process (See **Appendices G** and **H** of this Explanatory Report).

During initial GMA 8 discussions regarding the impacts of proposed DFCs on private property rights, District Representatives identified the following issues/topics for subsequent discussions with individual GCDs:

- Existing uses within the GCD
- Projected future uses within the GCD
- Investment-backed expectations of existing users and property owners within the GCD
- Long-term viability of groundwater resources in area
- Availability of water to all properties and ability to allocate MAG through rules after DFC adoption
- Whether immediate cutbacks would be required in setting a particular DFC or whether cutbacks, if any, would need to occur over a certain timeframe
- For outcrop areas, how the outcrop depletes rapidly in dry times, and whether drought rules or triggers based on the DFC/MAG for the outcrop could be beneficial to ensure viability of the resource during dry times
- Economic consequences to existing users (i.e., cost to drop pumps, reconfigure or drill new wells upon water table dropping, etc.). Also consider the reverse—economic consequences of less water available to protect the existing users from the economic consequences relevant to existing users—reaching a balance between these two dynamics
- Review the sustainability GAM run versus additional GAM runs that provide for more pumping from an aquifer, and how those two differ with respect to private property rights
- Focus on finding a balance, as that balance is defined by each GCD, between all of these considerations

In the prior round of joint planning, a survey tool was developed and utilized by each of the GMA 8 District Representatives with their individual GCDs Board of Directors to initiate discussion of private property rights and to document that this factor was appropriately considered and documented in the 2017 Explanatory Report. The survey and results from each GMA 8 District Representative are presented in Appendix NN of the 2017 Explanatory Report. In the current round of planning, the District Representatives were reminded that the previous survey results still represented the sentiment and management approaches of the GCDs in GMA 8, and the prior survey results were used in the consideration of private property rights in this round of joint planning and to develop this Explanatory Report

While it was clear that GMA 8 District Representatives invested significant time during multiple GMA 8 meetings on the impacts of proposed DFCs on private property rights, it was also understood that the impacts of proposed DFCs on private property rights have truly been an overarching consideration throughout the joint-planning process. Each District Representative provided input to GMA 8 on not only the impacts of proposed DFCs, but also how individual GCD management plans and rules have been developed to achieve current DFCs (adopted in 2007, 2008, 2009, and 2011) while protecting private property rights. GCDs must consider all private property rights when considering management plans, rules, and permit decisions. GCDs must balance the interests of historic groundwater users, landowners who desire to preserve the aquifer levels beneath their property, and property owners who may be damaged by either groundwater-level declines, reduction of water in storage, and reduced spring flow. The adopted DFCs attempted to strike a balance between all of these property interests.

Among the results from the 2017 GMA 8 survey, ten of the eleven GCDs in GMA 8 reported that they discussed the impacts of proposed DFC options on private property. The exception was Post-Oak Savannah GCD, which stated that due to the absence of established production within their jurisdictional boundaries from any relevant aquifers designated in GMA 8, the proposed DFCs were not applicable to Post Oak Savannah GCD. Northern Trinity GCD reported that they did not discuss how the proposed DFCs may impact the ability of existing well owners and property owners who have yet to drill a well. All of the remaining responses by GMA 8 District Representatives to the survey were in the affirmative.

For a more complete record of these discussions, see survey results presented in Appendix NN of the 2017 Explanatory Report. While the approach to protecting private property rights varies somewhat from GCD to GCD in GMA 8, depending upon local conditions, it is recognized that in addition to the adopted DFCs, all GCDs in GMA 8 have developed management plans and rules that fundamentally work to protect private property rights. Chapter 36 of the Texas Water Code allows for the development of locally-responsive management programs and management strategies and incentives. GCDs can utilize a number of tools, including but not limited to management zones, and water conservation measures, and encouraging reuse and rainwater harvesting, to further reduce demand, help achieve DFCs, and consider potential impacts to aquifers and wells within a GCD.

For reference, Texas Water Code Section 36.002 reads as follows:

a) The legislature recognizes that a landowner owns the groundwater below the surface of the landowner's land as real property.

b) The groundwater ownership and rights described by this section:

1) entitle the landowner, including a landowner's lessees, heirs, or assigns, to drill for and produce the groundwater below the surface of real property, subject to Subsection (d), without causing waste or malicious drainage of other property or negligently causing subsidence, but does not entitle a landowner, including a landowner's lessees, heirs, or assigns, to the right to capture a specific amount of groundwater below the surface of that landowner's land; and

2) do not affect the existence of common law defenses or other defenses to liability under the rule of capture.

c) Nothing in this code shall be construed as granting the authority to deprive or divest a landowner, including a landowner's lessees, heirs, or assigns, of the groundwater ownership and rights described by this section.

d) This section does not:

1) prohibit a district from limiting or prohibiting the drilling of a well by a landowner for failure or inability to comply with minimum well spacing or tract size requirements adopted by the district;

2) affect the ability of a district to regulate groundwater production as authorized under Section 36.113, 36.116, or 36.122 or otherwise under this chapter or a special law governing a district; or

3) require that a rule adopted by a district allocate to each landowner a proportionate share of available groundwater for production from the aquifer based on the number of acres owned by the landowner.

e) This section does not affect the ability to regulate groundwater in any manner authorized under:

1) Chapter 626, Acts of the 73rd Legislature, Regular Session, 1993, for the Edwards Aquifer Authority;

2) Chapter 8801, Special District Local Laws Code, for the Harris-Galveston Subsidence District; and

3) Chapter 8834, Special District Local Laws Code, for the Fort Bend Subsidence District.

While this provision of Texas Water Code Section 36.002 was substantively amended to its current scope with the passage of Senate Bill 660 by the Texas Legislature in 2011,[39] the spirit of this section has been at the core of groundwater laws regarding groundwater management since passage of House Bill 162 by the Texas Legislature in 1949.[40] GMA 8

[39] Act of May 29, 2011, 82nd Leg., R.S., ch. 1233, 2011 Tex. Gen. Laws 3287.
[40] Act of May 23, 1949, 51st Leg., R.S., ch. 306, 1949 Tex. Gen. Laws 559.

District Representatives ultimately based the adopted DFCs on a balancing of private property rights, for both current and future users, as exemplified in each GCDs' management plan and rules.

3.2.8 Feasibility of Achieving Desired Future Conditions

Texas Water Code Section 36.108(d)(8) requires District Representatives in a GMA to consider the feasibility of achieving the proposed DFC(s). This requirement was added to the joint-planning process with the passage in 2011 of Senate Bill 660 by the 82nd Texas Legislature.[41] This evaluation consideration dates back to the rules adopted by the TWDB in 2007 to provide guidance to District Representatives in GMAs as to what would be considered by the TWDB during a petition process regarding the reasonableness of an adopted DFC. In these rules (subsequently amended), the TWDB required that an adopted DFC must be physically possible from a hydrological perspective. During the first round of joint planning, the TWDB definition for DFCs was "the desired, quantified condition of groundwater resources (such as water levels, water quality, spring flows, or volumes) for a specified aquifer within a management area at a specified time or times in the future, through at least the period that includes the current planning period for the development of regional water plans pursuant to §16.053, Texas Water Code, or in perpetuity, as defined by participating groundwater conservation districts within a groundwater management area as part of the joint-planning process. Desired future conditions have to be physically possible, individually and collectively, if different desired future conditions are stated for different geographic areas overlying an aquifer or subdivision of an aquifer."[42]

In addition, in these original rules, Title 31, Texas Administrative Code Section 356.34 (1) stated the following: "Submission Package - Districts must include the following when submitting an adopted desired future condition to the board:(1) the desired future condition of the aquifer in the groundwater management area (multiple desired future conditions for the same aquifer in a groundwater management area need to be physically compatible)."

Upon passage of Senate Bill 660 in 2011,[43] the TWDB made significant revisions to the rules contained in Title 31, Texas Administrative Code Chapter 356 to be consistent with the new statutes. During this process, reference to the need for a DFC to be physically possible or physically compatible was removed, under the rationale that the reference to consideration of feasibility of achieving a DFC included in Texas Water Code Section 36.108(d)(8) equated to a DFC being physically possible or physically compatible.

During the second round of joint planning in GMA 8, which resulted in the 2017 Explanatory Report, a number of DFC options were modeled using the TWDB's updated Northern Trinity and Woodbine GAM. One of these scenarios, Northern Trinity and

[41] Act of May 29, 2011, 82nd Leg., R.S., ch. 1233, 2011 Tex. Gen. Laws 3287.
[42] Previously included in Title 31, Texas Administrative Code, Section 356.2(8).
[43] Act of May 29, 2011, 82nd Leg., R.S., ch. 1233, 2011 Tex. Gen. Laws 3287.

Woodbine GAM Run 2, also referred to as the "Highest Practicable Run" was executed in an effort to better understand potential "bookends" of DFC options for GMA 8. However, after execution and analysis of GAM Run 2 results, it was determined that this DFC option was not physically possible, or feasible. For comparison purposes only, a TERS approach was taken to quantify potential estimates of MAG, however, it was clearly stated in GMA discussions on this point that the option was not feasible from a hydrologic perspective. For GMA 8 District Representatives, this was an important point during the consideration of DFC options in that it helped to better understand that certain management goals, while being potentially laudable, may not be feasible due to the specifics of hydrologic conditions on a local or regional basis.

The DFCs and resulting estimates of MAG initially presented during the February 17, 2016 GMA 8 meeting, referred to as the Northern Trinity and Woodbine GAM Run 10, and utilized throughout the remainder of the joint-planning process in GMA 8, were successfully simulated and corresponding potential estimates of MAG were produced. Therefore, utilizing the approach taken by the TWDB during the first round of joint planning, the adopted DFCs for the Northern Trinity and Woodbine aquifers in GMA 8 are physically possible, and thus are feasible.

A common definition of feasibility is "capable of being accomplished or brought about; possible." Using this definition, it becomes important to consider the potential estimates of MAG resulting from proposed DFCs with respect to both historic use, current and projected supplies, projected water demands, and available regulatory framework necessary to achieve proposed DFCs. To achieve a DFC from a regulatory point of view, each GCD needs to have and maintain rules and a management plan that allow for achievement of the DFC, and each of the GCDs in GMA 8 does have these tools. All of these elements were considered by GMA 8 District Representatives to confirm this finding of feasibility.

3.2.9 Other Relevant Information Considered

Texas Water Code Section 36.108(d)(8) requires District Representatives in a GMA to consider any other information relevant to the specific desired future condition. Although there were multiple discussions regarding the complexity of the joint-planning process as amended by Senate Bill 660,[44] as GMA 8 District Representatives worked through the considerations process required in Texas Water Code Section 36.108(d)(1)–(8), no additional information was are presented above identified for inclusion in this Explanatory Report.

[44] Act of May 29, 2011, 82nd Leg., R.S., Ch. 1233, 2011 Tex. Gen. Laws 3287.

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4 OTHER DESIRED FUTURE CONDITIONS CONSIDERED

The revisions to the DFCs identified in Attachment C to this Resolution, which is fully incorporated herein, are those revisions identified under Section 36.108(d-3) of the Texas Water Code that are necessary in order for the district-wide and county-wide scale DFC values to align with the aquifer-wide DFC values as set forth in the model results.

There were a few DFC calculations completed by TWDB that were different than those included in the original Appendix D, Attachment B of the GMA 8 Resolution approved on October 27, 2020. Most of the differences were due to typographical errors in Table 2 of Attachment B, which was the summary of DFCs by aquifer for each GCD. Appendix E of the Explanatory Report agreed with TWDB calculations in most cases, but this Appendix was included only in the draft explanatory report and was not available for review when the district representatives considered adoption of the DFCs on October 27, 2020.

In summary, six of the nine differences in Table 2 (Appendix D, Attachment B) were explained by typographical errors. The other three differences occur in the DFC calculations in the Middle Trinity GCD for the Glen Rose and Hensell aquifers, which should have been 29 feet (instead of 21) and 77 feet (instead of 68) according to TWDB calculations. Table 4 (Appendix D, Attachment B) contained one difference in Travis County in the Glen Rose Aquifer. The TWDB found no differences in Tables 1, 3, 5, 6 and 7 of Attachment B.

There were no other DFC options considered during the third round of joint planning by GMA 8 District Representatives. The GMA 8 District Representatives opted not to consider any other DFC options in this round of joint planning because of the variety and number of DFC scenarios and modeling runs considered during the second round which were also reconsidered during this round of joint planning. The spectrum of these various scenarios ranged from less restrictive DFC scenarios that allowed for more pumping from the aquifers to more restrictive DFC scenarios that allowed for less pumping from the aquifers.

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5 RECOMMENDATIONS BY ADVISORY COMMITTEES AND RELEVANT PUBLIC COMMENTS

The nature of the joint-planning process described in Texas Water Code Section 36.108(d) is that policy and technical decisions made by District Representatives in a Groundwater Management Area ("GMA") be made in an open and transparent process. In accordance with Texas Water Code Section 36.108(d-3) and (d-4), this section of the Explanatory Report discusses recommendations made by advisory committees and other relevant comments. In addition, relevant comments received during the public comment period by the groundwater conservation districts ("GCDs") during the joint-planning process are discussed, along with whether the comments were or were not incorporated into the desired future conditions ("DFCs") ultimately adopted on July 26, 2022.

The GCDs in GMA 8 each prepared a Summary Report inclusive of all relevant comments received during the 90-day public comment period regarding the proposed DFCs, any suggested revisions to the proposed DFCS, and the basis for the revisions. The GCDs' Summary Reports were submitted to GMA 8 for further review by the District Representatives at a joint-planning meeting held July 26, 2022. The 11 Summary Reports are presented in their entirety in **Appendix I**.

GMA 8 received little to no public participation or comments throughout much of the joint-planning process. Within the 90-day public comment period only one GCD in GMA 8 received a substantive comment from the public. Felps LLC submitted a timely comment to the Central Texas GCD (CTGCD) requesting, among other things, a modification of the DFC. Additionally, at the CTGCD January 22, 2021 public hearing, Felps LLC provided oral comments substantially the same as its written comments.

The comments submitted by Felps LLC addressed issues with technical and compliance aspects of the CTGCD DFC. Felps LLC requested that the existing DFC be re-adopted instead of the DFC proposed by the district for the 2021 DFC joint-planning cycle. In response to these comments, the CTGCD hired a hydrogeologic consultant (INTERA) to assess the points made in the comments and to perform additional analysis of public water supply permits and wells in CTGCD. In addition, CTGCD completed another model run to assess water level declines and proposed DFCs with slightly modified pumping volumes and locations.

On June 28, 2021, the results of these assessments were presented to the CTGCD Board. Based on the results and the Board's review of the comments, the CTGCD Board adopted its summary of written comments with no revision to the proposed DFCs. The CTGCD public comments summary, including as attachments the Felps comments and INTERA's technical memos, MAG run, WEL pumping files and analysis of public water supply permits and wells, is provided in **Appendix I** of this Explanatory Report.

In response to the summary of public comments and resolution adopted by the CTGCD, on June 28, 2021, and a memo dated July 2, 2021, was submitted to the GMA 8 District Representatives.

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6 AQUIFERS CLASSIFIED AS NON-RELEVANT FOR THE PURPOSE OF JOINT PLANNING

TWDB allows for classification of aquifers, including major or minor aquifers as designated by TWDB, as non-relevant for the purposes of joint planning. Specifically, the districts in a groundwater management area may, as part of the process for adopting and submitting desired future conditions ("DFCs"), propose classification of a portion or portions of a relevant aquifer as non-relevant if the districts determine that aquifer characteristics, groundwater demands, and current groundwater uses do not warrant adoption of a desired future condition. In such a case no desired future condition is required. The districts must submit the following documentation to the agency related to the portion of the relevant aquifer proposed to be classified as non-relevant.[45]

District Representatives in GMA 8 have adopted DFCs for the Trinity, Woodbine, Edwards Balcones Fault Zone ("BFZ"), Marble Falls, Hickory and Ellenburger – San Saba aquifers. The Nacatoch, Blossom, Cross Timbers and Brazos River Alluvium aquifers were classified as non-relevant for the purposes of joint planning, and therefore DFCs were not adopted for these aquifers.

In a guidance document titled "How Will the Texas Water Development Board Support Development of Desired Future Conditions Statements and Review Desired Future Conditions Submittals?" TWDB indicates that districts must submit three items to classify aquifers as non-relevant. Each of these are discussed below for the Nacatoch, Blossom, Cross Timbers and Brazos River Alluvium aquifers.

6.1 Overview of the Aquifers Classified as Non-Relevant for the Purpose of Joint Planning

The Nacatoch, Blossom, Brazos River Alluvium, and Cross Timbers aquifers in GMA 8 are shown in **Figure 5** and in more detail in **Figure 17**, **Figure 18**, **Figure 19**, and **Figure 20**, respectively. **Figure 17**through **Figure 19** are reproduced from George and others (2011).[46] **Figure 20** is after Blandford and others (2021).[47] The Nacatoch and Blossom aquifers are in northeastern GMA 8. The portion of the Brazos River Alluvium Aquifer in GMA 8 is limited to a narrow strip along the Brazos River in McLennan and Falls counties. The Cross Timbers aquifer lies on the far western side of GMA 8. The full extent of these aquifers within GMA 8 are designated as non-relevant for joint planning purposes.

[45] Title 31, Texas Administrative Code Section 356.31(b).

[46] George, P. G., Mace, R. E., and Petrossian, R., 2011, Aquifers of Texas: Texas Water Development Board, Report 380, 172 p.

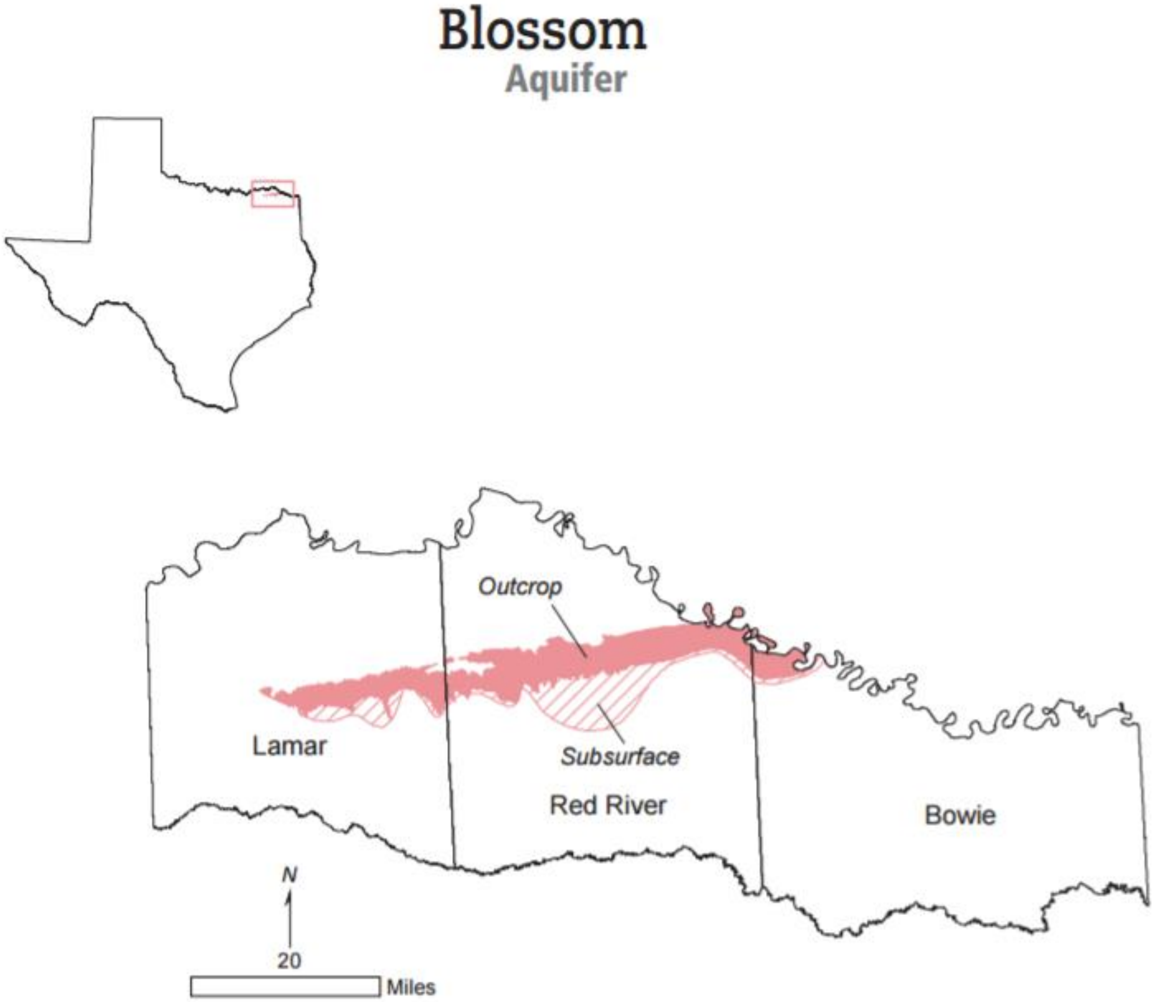

Figure 17. Location of the Blossom Aquifer in GMA 8

Figure 18. Location of the Brazos River Aquifer in Texas. Southern boundary for Brazos. River Alluvium Aquifer in GMA 8 is county boundary between Milam and Robertson counties.[48]

[48] *Id.*

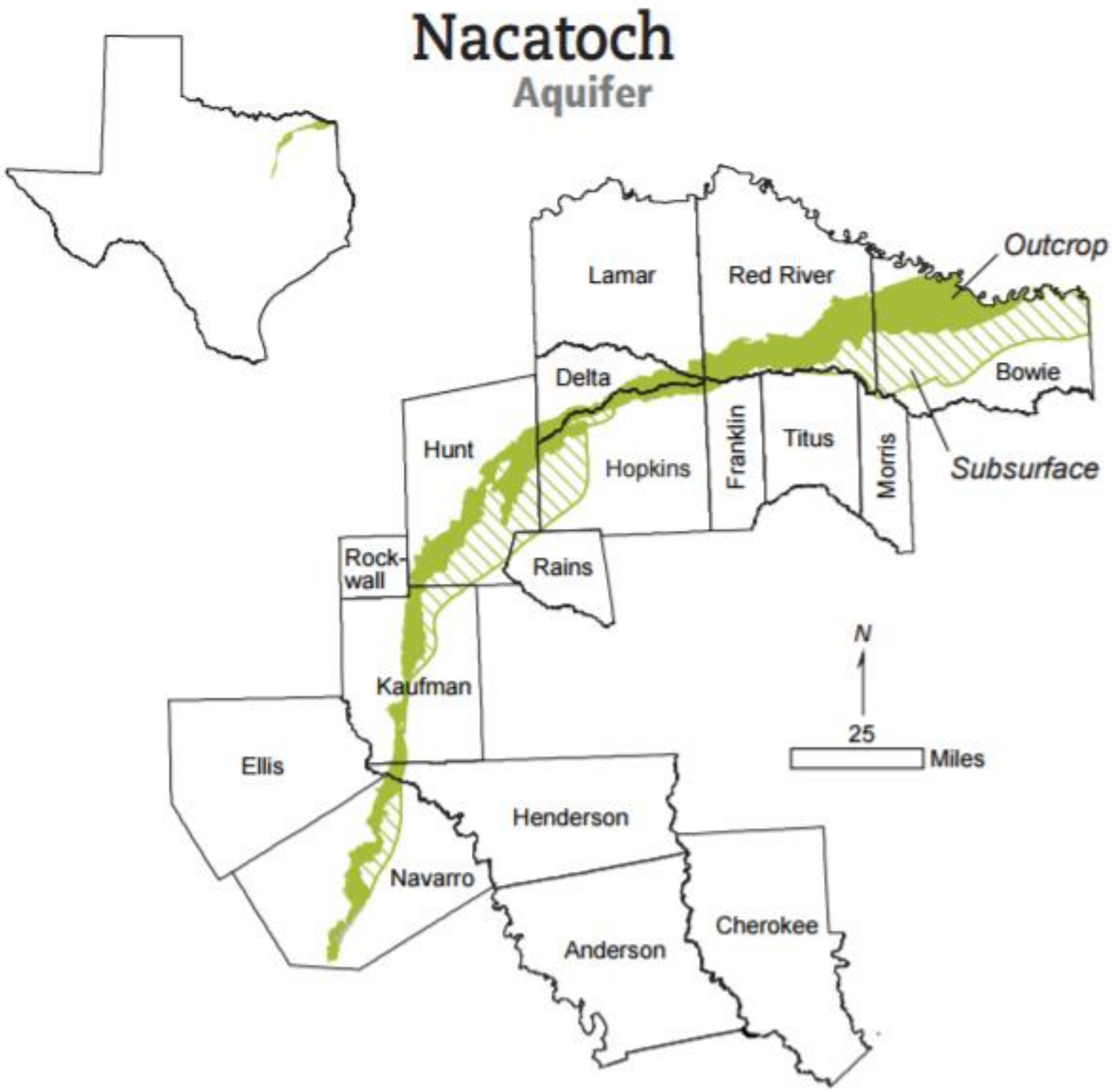

Figure 19. Location of the Nacatoch Aquifer in GMA 8.

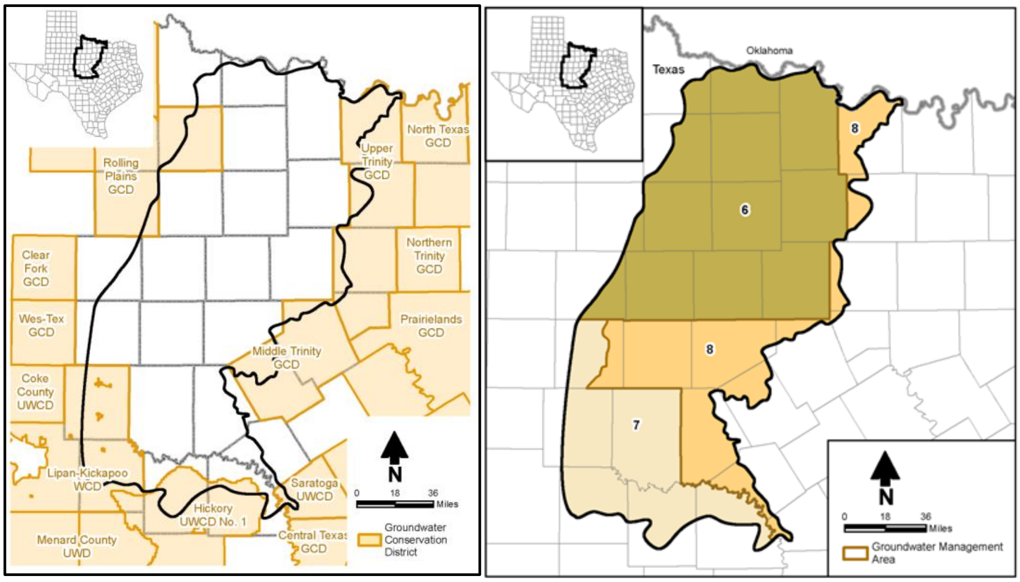

Figure 20. (a) Location of the Cross Timbers Aquifer in relation to Groundwater Conservation Districts and (b) Location of the Cross Timbers Aquifer in relation to GMA 8 and other GMAs.

6.1.1 Aquifer Characteristics

The aquifer characteristics, groundwater demands, current groundwater uses, and total estimated recoverable storage ("TERS") are presented above in Sections 3.2.1 and 3.2.3. Notably, the water use from the aquifer is relatively small. **Table 23** shows the TWDB Water Use Survey Groundwater Pumpage Estimates for each of these aquifers between 2007 and 2011.

Table 23. TWDB Groundwater Pumpage Estimates for Non-Relevant Aquifers.

Aquifer	2007	2008	2009	2010	2011	Average
Blossom	5,409	10,666	9,128	8,421	3,522	7,429
Brazos River Alluvium	2,536	7,308	9,539	8,304	7,555	7,048
Nacatoch	2,664	2,901	2,509	4,801	3,656	3,306

The Cross Timbers Aquifer, as defined by TWDB, exists in all or portions of 31 counties in north-central Texas and covers an area of approximately 17,800 square miles. The aquifer was designated as a minor aquifer by the Texas Water Development Board in 2017. TERS has not been calculated for this aquifer and the TWDB has not completed a groundwater availability model for the aquifer. The Cross Timbers Aquifer is composed of rocks of Paleozoic age that include the Clear Fork, Wichita-Albany, Cisco, Canyon, Strawn, and Atoka Groups. The Cross Timbers Aquifer consists of a shallow groundwater flow system, bounded below by a high salinity/brine water interface that occurs at relatively shallow depth (often several hundred feet), and in some locations very shallow depths (100 feet or less). Total estimated pumpage from the entire Cross Timbers Aquifer ranges from 7,570 acre-feet in 2004 to 28,780 acre-feet in 2010, and averages 11,690 acre-feet per year from 1984 to 2018.

Regarding any potential impact these aquifers could have on the DFCs adopted for other aquifers in GMA 8, as shown in **Figure 4** and **Figure 5**, the Blossom and Nacatoch aquifers are outside of the extent of the other aquifers in GMA 8 which have DFCs. This includes the far down-dip areas of the Trinity and Woodbine aquifers. The Brazos River Alluvium Aquifer is present over the confined portion of the Trinity Aquifer in McLennan and Falls counties but is separated from the Trinity Aquifer by the Washita/Fredericksburg group. For these reasons, designating these aquifers as non-relevant for the purposes of joint planning will not have any significant impact on desired future conditions ("DFCs") for other aquifers in GMA 8.

6.1.2 Explanation of Why Aquifers Are Non-Relevant for Joint Planning

As shown in **Figure 17** and **Figure 19**, the Blossom and Nacatoch aquifers in far eastern GMA 8 exist entirely outside the boundaries of any groundwater conservation district. That is, there is no administrative entity to manage and monitor progress toward any desired future condition set for these aquifers. For the Nacatoch, Blossom, and Brazos River Alluvium aquifers, the water use is limited (**Table 23**) compared to other aquifers such as the Trinity, Woodbine and Edwards (BFZ). As shown in **Table 17**, **Table 18**, and **Table 19**, the TERS for these aquifers is also relatively small. After considering these facts and determining that a non-relevant designation for these aquifers will not affect the DFCs for other aquifers in the GMA, the districts in GMA 8 have determined that these aquifers are non-relevant for joint planning.