DESIRED FUTURE CONDITION EXPLANATORY REPORT FOR GROUNDWATER MANAGEMENT AREA 12

This report was considered and approved by the member districts of Groundwater Management Area 12 on September 20, 2017.

Member Districts:

1. Brazos Valley Groundwater Conservation District
2. Fayette County Groundwater Conservation District
3. Lost Pines Groundwater Conservation District
4. Mid-East Texas Groundwater Conservation District
5. Post Oak Savannah Groundwater Conservation District

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ACRONYMS AND ABBREVIATIONS

ac-ft/yr	acre-feet per year
DBSA	Daniel B. Stephens & Associates
DFCs	Desire Future Conditions
GAM	Groundwater Availability Model
GCD	Groundwater Conservation District
GMA	Groundwater Management Area
gpm	gallons per minute
HB	House Bill
INTERA	INTERA Incorporated
IO models	input/output models
LBG-Guyton	LBG-Guyton Associates
MAG	modeled available groundwater
mg/L	milligrams per liter
PS	potential scenarios
RWPG	regional water planning group
SAM	social accounting matrix
TDS	total dissolved solids
TERS	total estimated recoverable storage
TWDB	Texas Water Development Board
WSC	Water Supply Corporation

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1.0 INTRODUCTION

1.1 GMA 12

Groundwater Management Areas (GMAs) were created "in order to provide for the conservation, preservation, protection, recharging, and prevention of waste of the groundwater, and of groundwater reservoirs or their subdivisions, and to control subsidence caused by withdrawal of water from those groundwater reservoirs or their subdivisions, consistent with the objectives of Section 59, Article XVI, Texas Constitution…" (Texas Water Code §35.001). The responsibility for GMA delineation was delegated to the Texas Water Development Board (TWDB) (Section 35.004, Chapter 35, Title 2, Texas Water Code). The initial GMA delineations were adopted on December 15, 2002, and are modified as necessary according to agency rules. There are 16 GMAs in Texas. **Figure 1-1** shows the boundaries of these 16 GMAs, including GMA 12.

GMAs consist of all Groundwater Conservation Districts (GCDs) located within the GMA boundary. **Figure 1-2** shows the location of the five GCDs that are contained wholly or in part within the boundary of GMA 12: Brazos Valley GCD, Fayette County GCD, Lost Pines GCD, Mid-East Texas GCD and Post Oak Savannah GCD. The GMA area may also include counties that are not included in a GCD. GMA 12 includes portions of four counties that are not associated with GCDs: Falls, Limestone, Navarro and Williamson counties.

Portions of three major aquifers, as defined by TWDB, fall within GMA 12: the Gulf Coast Aquifer, the Carrizo-Wilcox Aquifer and the Trinity Aquifer. **Figure 1-3** shows the outlines of the major aquifers within GMA 12. The Carrizo-Wilcox Aquifer is, by far, the most extensive and important aquifer in the region, occurring in all five GCDs and providing significant quantities of groundwater across the GMA. The other two major aquifers that occur within GMA 12 only occur in a very limited area within the GMA: the Gulf Coast Aquifer only outcrops in a very small area in the southernmost portion of Brazos County, along the southeast boundary of GMA 12, and the Trinity Aquifer subcrop only exists in a small area along the northwest GMA 12 boundary in Bastrop, Lee and Williamson counties. In addition to these major aquifers, portions of four minor aquifers, as defined by TWDB, are also present within GMA 12: the Brazos River Alluvium Aquifer, the Queen City Aquifer, the Sparta Aquifer, and the Yegua-Jackson Aquifer. **Figure 1-4** shows the outlines of the minor aquifers within GMA 12. All minor aquifers are used as water supply sources within GMA 12. **Table 1-1** is a stratigraphic column showing the relative ages of the aquifers.

With the exception of the Brazos River Alluvium Aquifer, which is heavily pumped for irrigation purposes, most of the groundwater pumped in GMA 12 is from the Carrizo-Wilcox Aquifer. In this report, the Carrizo-Wilcox Aquifer will be subdivided into four major hydrogeologic units, from youngest to oldest: the Carrizo Aquifer, the Calvert Bluff Aquifer (Upper Wilcox Aquifer), the Simsboro Aquifer (Middle Wilcox Aquifer), and the Hooper Aquifer (Lower Wilcox Aquifer), as shown in Table 1-1.

GMA 12 includes all or part of 14 Texas counties: Bastrop, Brazos, Burleson, Falls, Fayette, Freestone, Lee, Leon, Limestone, Madison, Milam, Navarro, Robertson, and Williamson counties. Table 1-2 lists the fourteen counties and their area and population projections. As of the 2010 Census, these counties had a population of about 930,700 that is projected to grow to almost 3 million by 2070. Most of this growth will occur in Williamson County, of which only a small portion falls within the GMA 12 boundary.

However, even excluding Williamson County, the population of GMA 12 is expected to more than double by 2070, and this growing population and the accompanying water demand could have significant implications for groundwater resources GMA 12. After Williamson County, the most populated and fastest growing counties are Bastrop County, whose population values include fast-growing suburbs of Austin, and Brazos County, which contains the fast-growing Bryan/College Station area.

1.2 Joint Groundwater Planning Process

The joint groundwater planning process was first adopted by the Texas Legislature with the passage of House Bill (HB) 1763 in 2005. One of the requirements of HB 1763 is that, where two or more GCDs are located within the same boundaries of a GMA, the GCDs shall establish Desire Future Conditions (DFCs) for all relevant aquifers in the GMA by no later than September 1, 2010 and every five years thereafter.

DFCs are defined in Title 31, Part 10, §356.10 (6) of the Texas Administrative Code as "the desired, quantified condition of groundwater resources (such as water levels, spring flows, or volumes) within a management area at one or more specified future times as defined by participating groundwater conservation districts within a groundwater management area as part of the joint planning process." Once DFCs are adopted, the Executive Administrator of the TWDB calculates the modeled available groundwater (MAG) for the aquifers, which is the estimated amount of pumping that will achieve the DFC. DFCs are essentially planning goals that could be reached, but should not be exceeded.

The joint groundwater planning horizon extends through at least the end of the current regional water planning period pursuant to §16.053, Texas Water Code, or in perpetuity, as defined by participating GCDs within a GMA as part of the joint groundwater planning process.

The joint groundwater planning process was expanded significantly by the passage of Senate Bill 660 in 2011. The more substantive elements of the expanded process include: (1) new requirements that an Explanatory Report be developed and submitted as part of the joint groundwater planning process to document that required factors have been considered; (2) a change from requirements involving estimates of managed available groundwater to modeled available groundwater (MAG) (including the process for addressing exempt use); (3) new requirements for individual GCDs to provide for a 90-day public comment period, during which the individual GCD is to hold a public hearing on the proposed DFCs before final adoption by at least two thirds of the GCD representatives in the GMA; and (4) as soon as possible after final adoption of the DFCs by GCD representatives in the GMA, individual GCDs are to adopt the DFCs. The deadline for adopting proposed DFCs for the second round of joint groundwater planning was extended to May 1, 2016, by the passage of Senate Bill 1282 by the Texas Legislature in 2013.

If a GMA includes more than one GCD, those districts must engage in a joint groundwater planning process, including at least an annual meeting. The districts must jointly determine the DFCs for the management area and, in doing so, are required to consider the nine following factors:

1. Aquifer uses or conditions within the management area, including conditions that differ substantially from one geographic are to another;
2. The water supply needs and water management strategies included in the state water plan;

3. Hydrological conditions, including for each aquifer in the management area the total estimated recoverable storage as provided by the executive administrator, and the average annual recharge, inflows, and discharge;
4. Other environmental impacts, including impacts on spring flow and other interactions between groundwater and surface water;
5. The impact on subsidence;
6. Socioeconomic impacts reasonably expected to occur;
7. The impact on the interests and rights in private property, including ownership and the rights of management area landowners and their lessees;
8. The feasibility of achieving the DFC; and
9. Any other information relevant to the specific DFCs.

After the DFCs are adopted by a GMA, the TWDB determines a MAG value based on the adopted DFCs. A MAG is defined in Title 31, Part 10, §356.10 (13) of the Texas Administrative Code as "the amount of water that the executive administrator determines may be produced on an average annual basis to achieve a desired future condition."

1.3 GMA 12 Joint Planning

The joint groundwater planning process established by HB 1763 in 2005 and amended by Senate Bill 660 in 2011 is a public, transparent process, where all planning decisions are made in open, publicly noticed meetings in accordance with provisions contained in Texas Water Code Chapter 36. From 2012 to 2017, GMA 12 convened 23 times at the dates listed in **Table 1-3.** All of the meetings were open to the public and were held at the Milano Civic Center in Milano, Texas. All meeting notices were posted at least 10 days in advance of the meeting and included an invitation to submit comments, questions and requests for additional information to the Post Oak Savannah GCD.

Table 1-3 lists the dates and the major discussion topics of the GMA 12 joint planning meetings from 2012 to 2017. **Appendix A** contains the agenda and the minutes for all of the GMA 12 meetings. The GCDs that are members of GMA 12 retain hydrogeologic consultants for GCD-level management and modeling. INTERA Incorporated (INTERA) serves as the consultant for Post Oak Savannah GCD, Daniel B. Stephens & Associates (DBSA) serves as the consultant for Lost Pines GCD and Fayette County GCD, LBG-Guyton Associates (LBG-Guyton) serves as the consultant for Brazos Valley GCD and Matthew M. Uliana, P.G. serves as the consultant for Mid-East Texas GCD. This Explanatory Report is a joint effort of these four consulting firms.

During the GMA 12 meeting on April 15, 2016, GMA 12 proposed the DFCs for adoption. As required by Texas Water Code Section 36.108 (d-2), the proposed DFCs were subsequently distributed to the individual GCDs in GMA 12. A copy of the resolution for proposed DFCs is included as **Appendix B**. A period of not less than 90 days was provided by each GCD to allow for public comments on the proposed DFCs. During this comment period, each GCD held a public hearing on the proposed DFCs. **Table 1-4** lists the date on which each GCD conducted a public hearing on the proposed DFCs. Minutes for these public hearings are included in **Appendix C**.

Table 1-1 A simplified stratigraphic column for GMA 12

System	Series	Geologic Unit	Hydrogeologic Unit
Quaternary		Brazos River Alluvium	Brazos River Alluvium Aquifer
Tertiary	Upper Eocene	Jackson Group	Yegua-Jackson Aquifer
	Middle Eocene	Yegua Formation	
		Cook Mountain Formation	confining unit
		Sparta Sand	Sparta Aquifer
		Weches Formation	confining unit
		Queen City Sand	Queen City Aquifer
		Reklaw Formation	confining unit
		Carrizo Sand	Carrizo- Wilcox Aquifer
	Lower Eocene	Calvert Bluff Fm. (*Upper Wilcox*)	
		Simsboro Fm. (*Middle Wilcox*)	
	Upper Paleocene	Hooper Fm. (*Lower Wilcox*)	

Table 1-2 Population projection from the 2017 State Water Plan

Name	Area[1] (square miles)	Population 2010[2]	Population 2020	Population 2030	Population 2040	Population 2050	Population 2060	Population 2070
Bastrop	896	74,171	95,487	125,559	164,648	217,608	289,140	384,244
Brazos	590	194,851	227,654	264,665	302,997	349,894	400,135	455,529
Burleson	678	17,187	18,539	19,946	20,838	21,735	22,442	23,022
Falls	774	17,866	19,413	20,397	20,610	20,126	20,736	21,364
Fayette	959	24,554	28,373	32,384	35,108	37,351	39,119	40,476
Freestone	892	19,816	20,437	21,077	22,947	31,142	44,475	73,287
Lee	634	16,612	19,131	21,511	22,877	23,375	23,709	23,889
Leon	1,081	16,801	18,211	19,536	20,603	22,071	23,340	24,582
Limestone	933	23,384	25,136	26,615	27,817	29,134	30,206	31,152
Madison	472	13,664	14,753	15,817	16,786	17,872	18,886	19,877
Milam	1,022	24,757	26,234	27,793	28,896	30,300	31,501	32,629
Navarro	1,086	47,735	52,544	57,032	61,667	71,452	86,952	107,814
Robertson	865	16,622	18,358	20,150	21,801	23,525	25,174	26,771
Williamson	1,137	422,679	632,433	794,478	987,495	1,195,374	1,431,101	1,675,901
TOTAL		**930,699**	**1,216,703**	**1,466,960**	**1,755,090**	**2,090,959**	**2,486,916**	**2,940,537**

[1] calculated from the Stratmap county shapefile from TNRIS

[2] from the 2010 Census

Table 1-3 GMA 12 meetings convened from 2012 to 2017

Meeting Date	Quorum Present	Major Discussion Topic
October 18, 2012	Yes	Appointed representatives to regional water planning groups, discussed TWDB MAG runs and proposed improvements to Queen City-Sparta (Central Carrizo) GAM, GCD reports on status of Management Plans
July 25, 2013	Yes	GCD updates on joint planning and anticipated changes to DFCs, discussion of new DFC adoption process (Water Code Chapter 36.108), discussed proposed improvements to Queen City-Sparta (Central Carrizo) GAM
December 19, 2013	Yes	Discussed joint planning requirements and GCD consultants' roles, GCD updates on Management Plans and monitoring, began process to update Queen City-Sparta (Central Carrizo) GAM
June 6, 2014	Yes	Discussed pumping and projected groundwater demand used in GAMs, discussion of costs and strategy for extending the calibration period for the Queen City-Sparta (Central Carrizo) GAM
June 27, 2014	Yes	Accepted a standardized form for written comments, discussion of process and schedule for proposing DFCs, discussed shallow management zone DFCs and drawdown-based DFCs, received public comments concerning groundwater/surface water interactions and private property rights.
December 4, 2014	Yes	Presentations on preliminary modeling results, updated pumping files for the Queen City-Sparta (Central Carrizo) GAM, shallow zone management strategies, and Total Estimated Recoverable Storage in GMA 12.
February 26, 2015	Yes	Discussed DFCs for shallow management zones, presentation of GAM results up to predictive scenario 4 (PS4), PS4 submitted for public comment
March 27, 2015	Yes	Received comments on PS4 & DFC options
April 30, 2015	Yes	Discussed GAM results up to predictive scenario 4 (PS4) and comments received on PS4, accepted a standardized form for GCDs to submit proposed DFCs.
May 28, 2015	Yes	Presentations on Hydrologic Conditions* and Aquifer Uses and Conditions*
June 25, 2015	Yes	Presentations on Private Property Rights* and Water Supply Needs and Water Management Strategies*
August 13, 2015	Yes	Presentations on 1) Environmental Impacts*, 2) Socioeconomic Impacts* and 3) DFC Feasibility*
September 24, 2015	Yes	Presentation on Subsidence* and discussion of the previous presentations on 1) Aquifer Uses and Conditions*, 2) Water Supply Needs and Water Management Strategies*, 3) Private Property Rights*, including comments received on these topics
October 22, 2015	Yes	Presentation on Feasibility of DFCs*, discussion of previous presentations on 1) Socioeconomic Impacts*, 2) Environmental Impacts*, and 3) Hydrological Conditions including comments received on these topics.
December 17, 2015	Yes	Presentation on GAM results for Predictive Scenario 5 (PS5), TWDB presentation on role of GAMs in joint planning, discussion of previous presentation on Feasibility of DFCs* as well as comments received on that topic.
February 4, 2016	Yes	Updated pumping files used for groundwater modeling, presentation on Brazos

Meeting Date	Quorum Present	Major Discussion Topic
		River alluvium DFCs, receive public comments on impact of DFCs on GW/SW interaction
March 24, 2016	Yes	Presentation of GAM results for a modified Predictive Scenario 5 (PS5)
April 15, 2016	Yes	Proposed GMA 12 DFCs approved and released for public comment
October 11, 2016	Yes	Presentation on GAM results for Predictive Scenario 10 (PS10), discussion of comments received on GMA 12 DFCs.
December 1, 2016	Yes	Discussed and accepted submission of Predictive Scenario 10 (PS10) in lieu of Predictive Scenario 6 (PS6) for purposes of evaluation of proposed DFCs.
April 27, 2017	Yes	Discussed draft of Explanatory Report for GMA 12 DFCs
May 25, 2017	Yes	Adoption of GMA 12 DFCs and Explanatory Report
September 20, 2017	Yes	Adoption of updated GMA 12 DFC Resolution and Explanatory Report (with PS12 pumping)

* Denotes the nine factors required during considerations for DFCs under Texas Water Code Section 36.108

Table 1-4 Public hearings conducted by the GCDs regarding the proposed DFCs.

GCD	Public Hearing Date
Brazos Valley GCD	May 12 & June 9, 2016
Fayette County GCD	July 11, 2016
Lost Pines GCD	July 20, 2016
Mid-East Texas GCD	June 28, 2016
Post Oak Savannah GCD	July 12, 2016

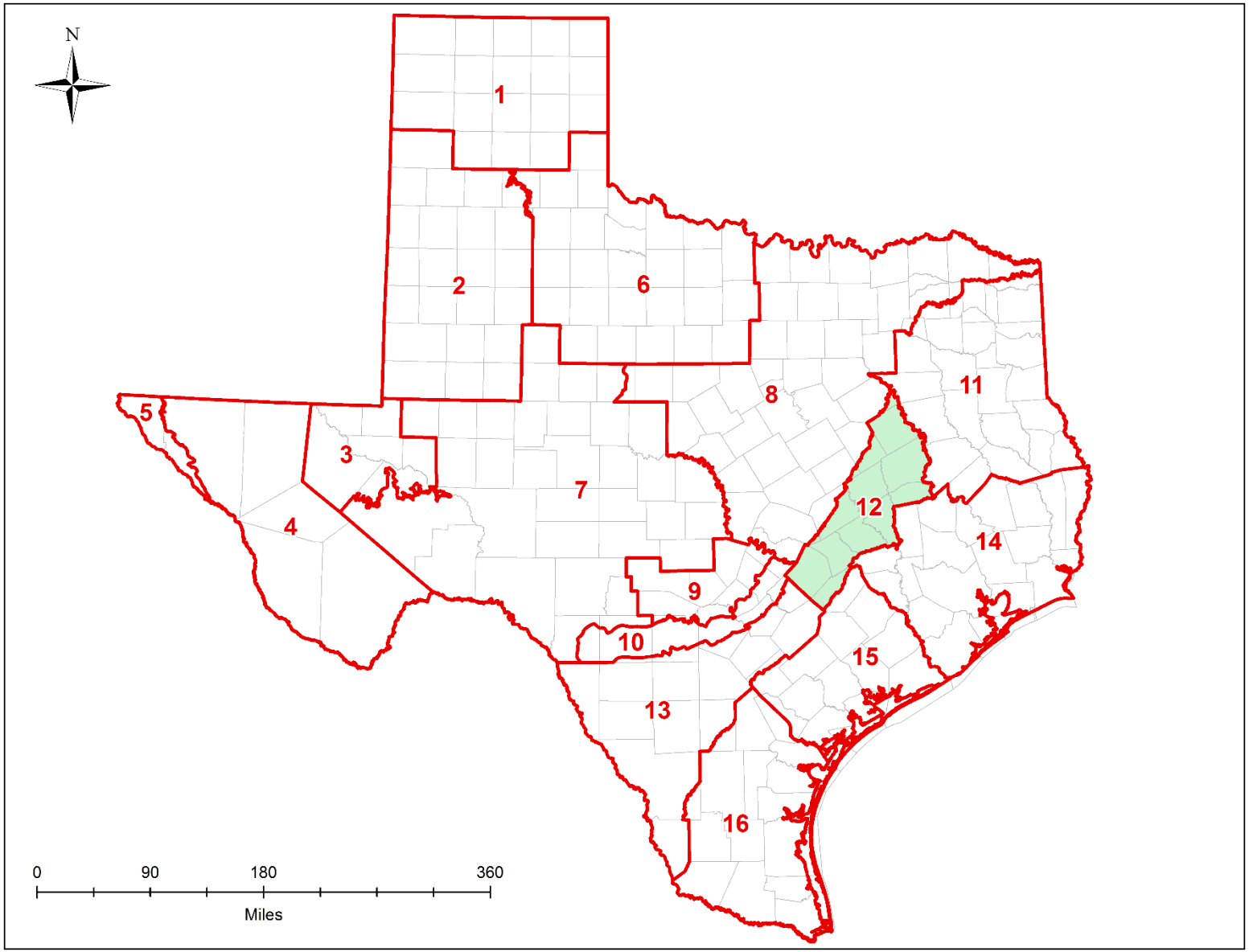

Figure 1-1 Groundwater Management Areas in Texas

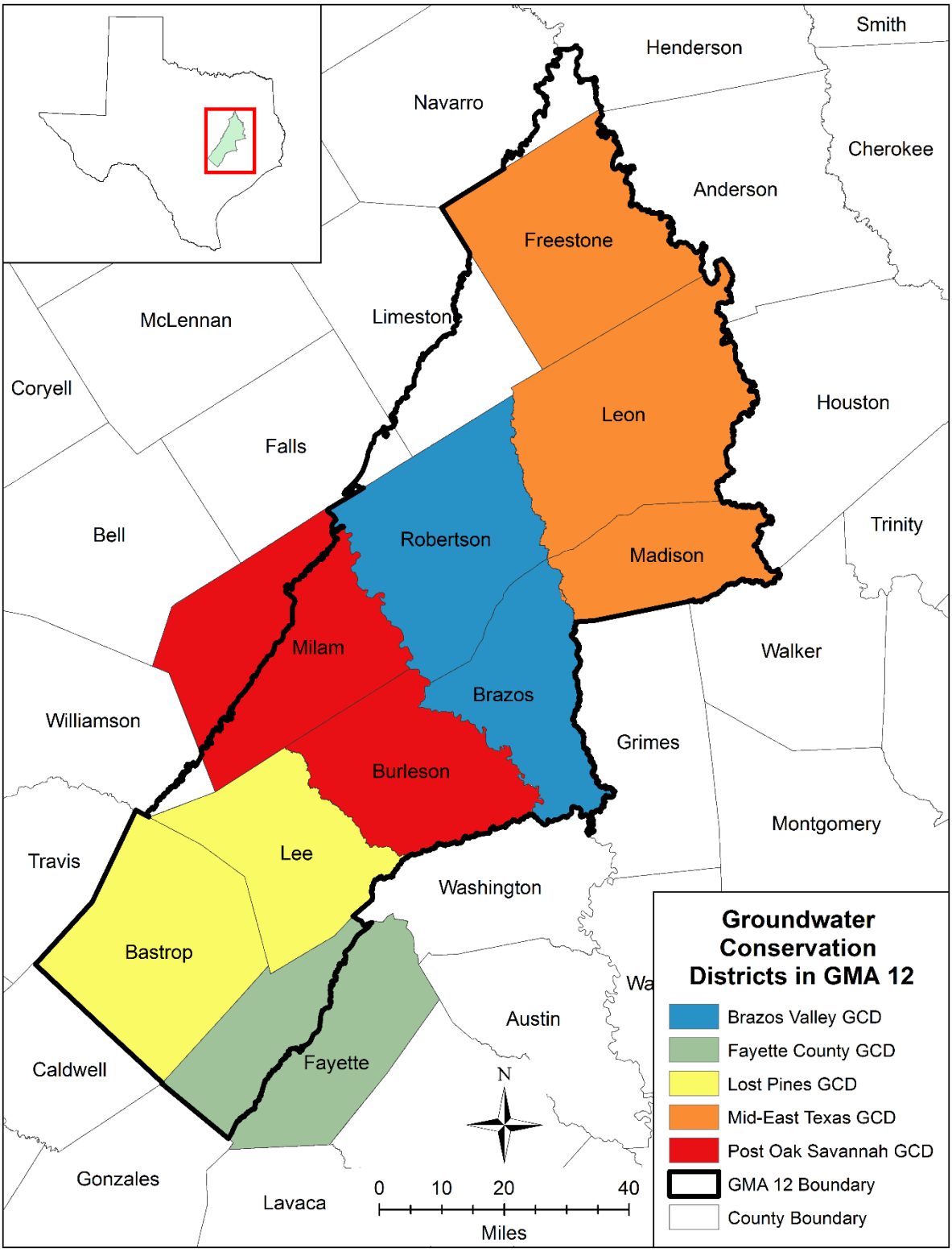

Figure 1-2 Groundwater Conservation Districts in GMA 12

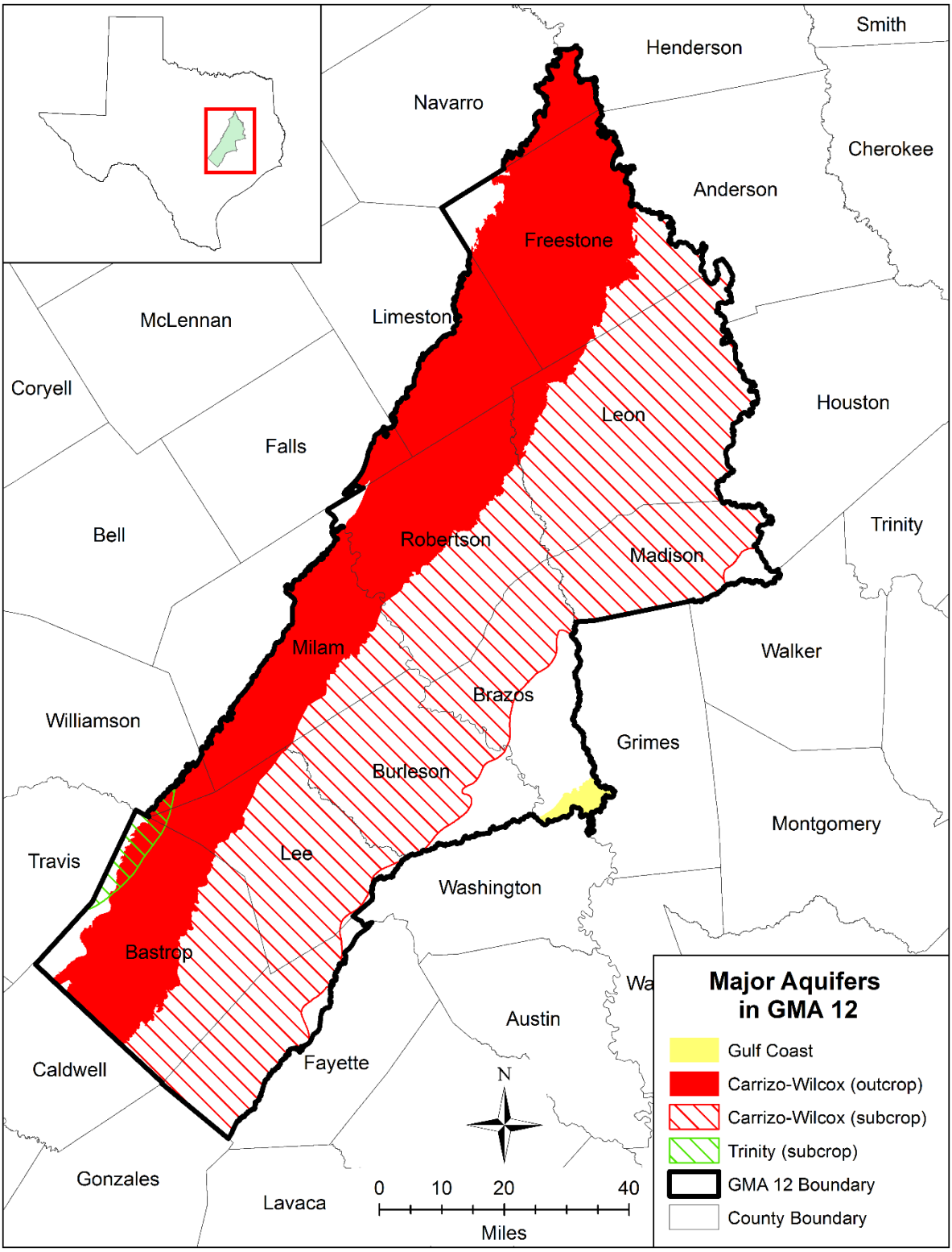

Figure 1-3 Major Aquifers in GMA 12

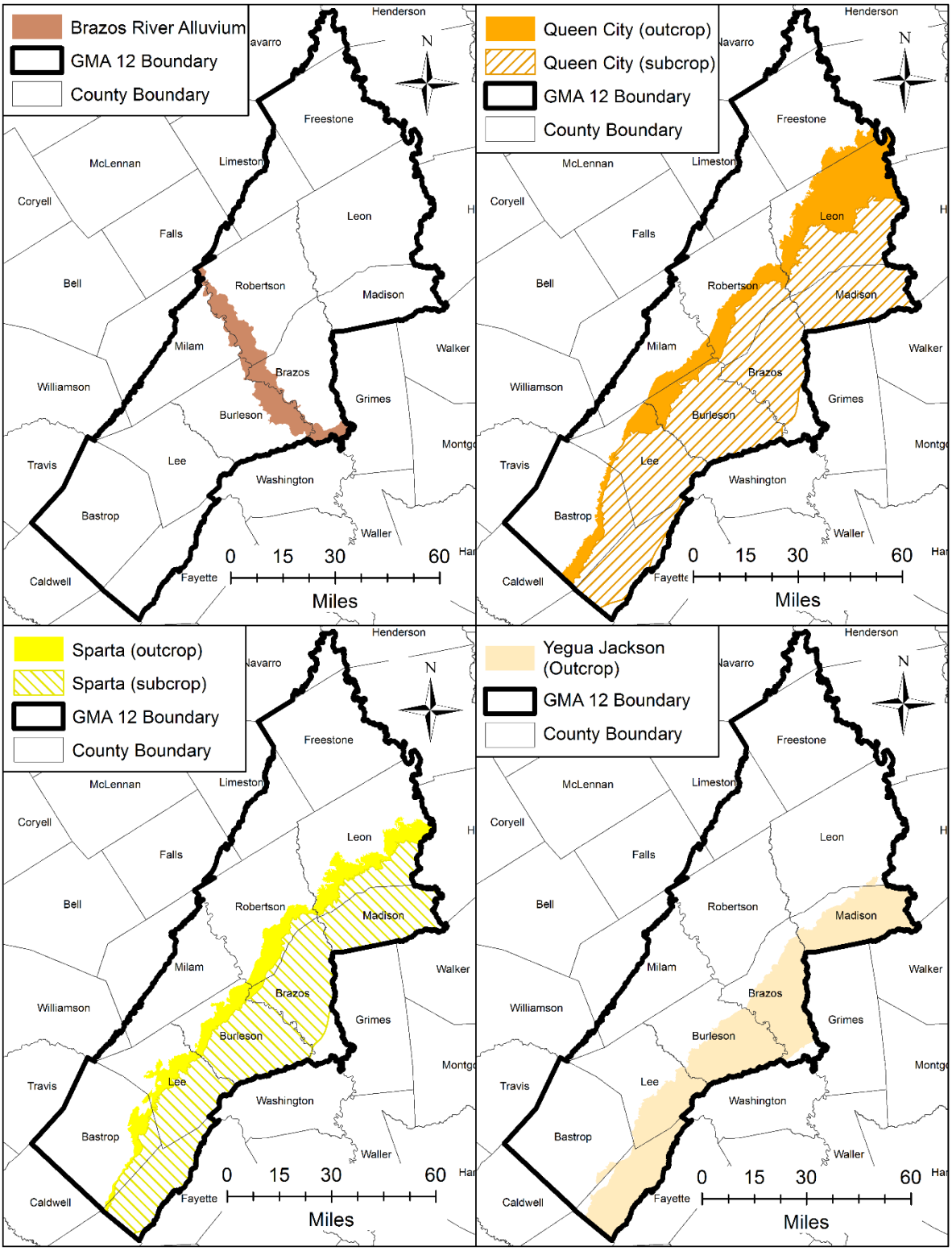

Figure 1-4 Minor Aquifers in GMA 12

2.0 GMA 12 DESIRED FUTURE CONDITIONS

2.1 Sparta, Queen City, Carrizo, Calvert Bluff, Simsboro, and Hooper Aquifers

The Sparta, Queen City, and Carrizo aquifers are present and used in all GCDs within GMA 12. Therefore, all GCDs submitted DFCs for these aquifers. The Calvert Bluff, Simsboro, and Hooper aquifers are present in all GCDs but not used in Fayette County. Therefore, GMA 12 declared these aquifers not relevant for Fayette County, and Fayette County GCD did not submit a DFC for these aquifers. For the purpose of establishing DFCs, the Groundwater Availability Model (GAM) for the Queen City and Sparta Aquifers (Kelley and others, 2004) was used to determine the compatibility and physical possibility of the DFCs proposed by each GCD. Note that this GAM also includes the Carrizo-Wilcox Aquifer. The DFCs proposed by each GCD for these six aquifers are provided in **Table 2-1**, as well as the DFC adopted by GMA 12 as a whole. The DFC is based on the average drawdown from January 2000 through December 2069.

Table 2-1 Adopted DFCs for the Sparta, Queen City, Carrizo, Calvert Bluff, Simsboro, and Hooper Aquifers

GCD or County	Average Aquifer Drawdown (ft) measured from January 2000 through December 2069					
	Sparta	Queen City	Carrizo	Calvert Bluff	Simsboro	Hooper
Brazos Valley GCD	12	12	61	125	295	207
Fayette County GCD	47	64	110	Declared as non-relevant		
Lost Pines GCD	5	15	62	100	240	165
Mid-East Texas GCD	5	2	80	90	138	125
Post Oak Savannah GCD	28	30	67	149	318	205
Falls County	--	--	--	--	-2	27
Limestone County	--	--	--	11	50	50
Navarro County	--	--	--	-1	3	3
Williamson County	--	--	--	-11	47	69
GMA-12	*16*	*16*	*75*	*114*	*228*	*168*

2.2 Yegua-Jackson Aquifer

The Yegua-Jackson Aquifer is present in all GCDs in GMA 12. All GCDs except Brazos Valley GCD manage the Yegua-Jackson Aquifer as a single unit. Consequently, the Brazos Valley GCD adopted two DFCs for the Yegua-Jackson Aquifer: a DFC for the Jackson Aquifer and separate DFC for the Yegua Aquifer. The DFCs proposed by each GCD for the Yegua-Jackson Aquifer are provided in **Table 2-2**, as well as the DFC adopted by GMA 12 as a whole. Lost Pines GCD did not propose a DFC because the district has declared the Yegua-Jackson Aquifer as a non-relevant aquifer. For the purpose of establishing and evaluating DFCs, the GAM for the Yegua-Jackson Aquifer (Deeds and others, 2010) was used to determine the compatibility and physical possibility of the DFCs submitted by each GCD. The DFC is based on the average drawdown from January 2010 through December 2069.

Table 2-2 Adopted DFCs for the Yegua and Jackson Aquifers

GCD	Average Aquifer Drawdown (ft) measured from January 2010 through December 2069		
	Yegua	Jackson	Yegua-Jackson
Brazos Valley GCD	70	114	--
Fayette County GCD	--	--	77
Lost Pines GCD	--	--	--
Mid-East Texas GCD	--	--	7
Post Oak Savannah GCD	--	--	100
GMA-12	--	--	*65*

2.3 Brazos Alluvium Aquifer

In GMA 12, the Brazos River Alluvium Aquifer is only present in Post Oak Savannah GCD and the Brazos Valley GCD. For this reason, GMA 12 adopted DFCs at a county level in these two GCDs, as shown in **Table 2-3**. DFCs for the Brazos River Alluvium Aquifer were not adopted for GMA 12 as a whole.

Table 2-3 Adopted DFCs for the Brazos River Alluvium Aquifer

GCD	County	Brazos River Alluvium Aquifer
Brazos Valley	Brazos & Robertson	North of State Highway 21: Percent saturation shall average at least 30% of total well depth. South of State Highway 21: Percent saturation shall average at least 40% of total well depth.
Post Oak Savannah	Burleson	A decrease in 6 feet in the average saturated thickness over the period from 2010 to 2070.
	Milam	A decrease of 5 feet in average saturated thickness over the period from 2010 to 2070

2.4 Non-relevant Areas of Aquifers

There are four areas where aquifers were declared non-relevant during the current cycle of joint groundwater planning. The Trinity Aquifer was declared non-relevant in Bastrop, Lee and Williamson counties because of its small areal coverage, great depth and poor water quality. The Yegua-Jackson Aquifer was declared non-relevant in Lost Pines GCD because it has a minimal amount of pumpage within the district. The Wilcox portion of the Carrizo-Wilcox Aquifer was declared non-relevant in Fayette County GCD because of the poor water quality and the great depth to these units. The Gulf Coast aquifer was declared non-relevant in Brazos Valley GCD because it is thin, can only provide water in small quantities and is very limited in areal extent. It should be noted that this small outcrop of Gulf Coast Aquifer in the southernmost part of Brazos County was included in GMA 12 as a result of a 2013 amendment to the boundaries of GMA 12 and 14. The supporting documents for this administrative change are included in **Appendix D.**

3.0 POLICY JUSTIFICATION

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. DFCs are planning goals that state a desired condition of the groundwater resources in the future in order to promote better long-term management of those resources. GCDs are authorized to utilize different approaches in developing and adopting DFCs based on local conditions and the consideration of other statutory criteria as set forth in Texas Water Code Section 36.108.

GMA 12 and each of its member districts evaluated DFCs with regard to the nine factors required by Texas Water Code Section 36.108(d). In addition to these nine factors, GMA 12 and the individual districts evaluated DFCs with regard to providing a balance between the highest practicable level of groundwater production and the conservation, preservation, protection and recharging, and prevention of waste of groundwater in GMA 12. While much of this process was guided by scientific analysis including groundwater availability models, the actual creation of DFCs requires a blending of both science and policy. Policy is able to take into account the limitations and uncertainty inherent in groundwater availability models, and provide guidance for and define the bounds of what these scientific tools can reasonably be expected to accomplish.

In evaluating the DFCs, GMA 12 and the individual districts recognize that: (1) the production capability of the aquifers varies significantly across GMA 12, (2) historical groundwater production is significantly different across GMA 12, and (3) the importance of groundwater production to the social-economic livelihood of an area is significantly varied among the districts. As a result of this recognition, a key GMA 12 policy decision was to allow districts to set different DFCs for the portion of an aquifer within their boundaries, as long as the different DFCs could be shown to be physically possible. The allowance of different DFCs among the districts is justified for several reasons. First, the Texas Water Code Section 36.108(d)(1) authorizes the adoption of different DFCs for different geographic areas over the same aquifer based on the boundaries of political subdivisions. The statute expressly and specifically directs GCDs "to consider uses or conditions of an *aquifer* within the management area, including conditions that differ substantially from one geographic area to another "when developing and adopting DFCs for:

1. each aquifer, subdivision of an aquifer, or geologic strata located in whole or in part within the boundaries of the management area; or
2. each geographic area overlying an aquifer in whole or in part or subdivision of an aquifer within the boundaries of the management area."

The Legislature's addition of the phrase "in whole or in part" makes it clear that GCDs may establish a "different" DFC for a geographic area that does not cover the entire aquifer but only part of that aquifer. Moreover, the plain meaning of the term "geographic area" in this context would include an area defined by political boundaries, such as those of a GCD or a county.

Secondly, GMA 12 is composed of several different GCDs, each of which manages a separate portion of the aquifer. By statute, GCDs cannot regulate outside of their district boundary, and the rules that they pass in order to regulate the management of groundwater only apply within their boundaries. Therefore, GMA 12 recognized that separate DFCs had to be defined for each GCD within the GMA.

Each GMA 12 GCD compiled all relevant comments received during the 90-day public comment period regarding the proposed DFCs and suggested revisions to the proposed DFCs and the basis for the

revisions. The comments received and the GMA's responses to them are summarized in **Section 7** and provided in **Appendices S** through **V**.

Based on public comments, District Representatives of GMA 12 considered and approved limited changes to the proposed DFCs. The DFCs that GMA 12 considered and proposed for final adoption, inclusive of all non-substantive changes, provided acceptable drawdown levels in the various aquifers on a county-by county basis and across the entire GMA 12 area.

4.0 TECHNICAL JUSTIFICATION

4.1 Central Queen City-Sparta Groundwater Availability Model

The proposed DFCs for the Sparta, Queen City, Calvert, Simsboro and Hooper aquifers were developed based on simulations of potential scenarios (PS) of future pumping using the groundwater availability model for the Central Queen City-Sparta/Carrizo-Wilcox Aquifers (Kelley and others, 2004). This GAM supersedes the GAM of the Central Carrizo-Wilcox Aquifer (Dutton and others, 2003) as it added the Sparta and Queen City aquifers to the original GAM. The GAM used in the current cycle of joint groundwater planning was calibrated for the time period from 1975 to 1989, and the verification period was from 1990 to 1999. The report for the GAM states that it "provides an integrated tool for the assessment of water management strategies to directly benefit state planners, regional water planning groups and groundwater conservation districts." In addition, the model documentation states that based the resolution of the 1-mile by 1-mile grid cells that comprise the model grid, the GAM is not capable of accurate predictions of aquifer responses at specific points such as a particular well. The documentation also states that "the GAM is accurate at a scale of tens of miles, which is adequate to understand groundwater availability at the regional scale" (Kelley and others, 2004). In summary, the model is a regional tool that was developed for utilization in water resources planning. The GAM is currently being updated and revised by the TWDB and the results of that effort should be available in the next two to three years.

The current GAM simulates groundwater flow in as the eight model layers shown on **Figure 4-1**. The model simulates varying degrees of vertical interaction between aquifers, which can result in pumping effects in a particular aquifer spreading to the aquifers above or below. The magnitude of this effect will vary substantially based on the aquifer hydraulic parameters assigned to aquifers in the GAM. A conceptual "block diagram" of flow in the GAM is shown on Figure 4-1. As with all models, there are limitations to the current GAM, but it is the best tool available for estimating the effects of pumping the relevant aquifers in GMA 12. Several different potential pumping scenarios were developed and considered by GMA 12 in 2015, 2016, and 2017. These pumping scenarios helped GMA 12 evaluate the predicted impact that varying amounts of pumpage would have on future water levels across the GMA.

4.2 Potential Pumping Scenarios Using Queen City-Sparta GAM

Modeling simulations were performed for the period from 2000 to 2070 utilizing the GAM. Because the GAM calibration/verification ended in 1999, the simulations started where the calibrated model ended and continued through the planning period defined by the TWDB guidelines. As part of the GMA 12 planning effort, the well file for pumping from the Sparta, Queen City, Carrizo, Calvert Bluff, Simsboro and Hooper aquifers in the Brazos Valley GCD, Lost Pines GCD and Mid-East Texas GCD was updated for 2000 through 2010. This update included amounts and areal distribution of pumping from the aquifers modeled with the GAM.

A number of potential scenarios (PSs) were developed for consideration by the GMA. Some scenarios evaluated the impact that the full production of existing permits would have on future water levels, while other scenarios evaluated the impact of the amount of pumpage that was estimated to actually occur. The results of these simulations were presented to the GMA over the course of several meetings held in 2014 and 2015. These simulation results showed a substantial increase in the drawdowns within

GMA 12, particularly for the Simsboro Aquifer. This was because pumping from the Simsboro Aquifer in these simulations was significantly higher than in the model simulation utilized to establish DFCs in the first cycle of GMA planning ending in 2010. The pumping scenario PS-6 included updated pumping for 2000 through 2010 based on TWDB and GCD pumping data. Based on comments received on the proposed DFCs, an additional simulation, PS-10, was developed. The results of that simulation were presented to GMA 12 on December 1, 2016. This simulation included the areal redistribution of pumping in Robertson County from the Simsboro Aquifer to better represent the areas where the greatest amounts of pumping were occurring and were estimated to occur in the future. The timing and total amount of pumping from the Simsboro Aquifer in Robertson County as a whole did not change. In the north part of Brazos County, pumping from the Simsboro Aquifer was added to the PS-6 value for the period from 2011 through 2039. Based on comments received from the Texas Water Development Board on the GMA 12 DFCs, it was necessary to update the PS-10 pumping scenario to adjust pumpage in the Lost Pines GCD so that the approved DFCs would be met. The results of this simulation were presented to GMA 12 on September 20, 2017 and a copy of that presentation is included in **Appendix E**. With these changes, PS-12 was accepted as the well file utilized to evaluate GMA 12 DFCs. **Table 4-1** provides the average drawdowns simulated using PS-12**.**

Table 4-1 Average Aquifer Drawdown calculated for Sparta, Queen City, Carrizo, Calvert Bluff, Simsboro, and Hooper Aquifers using PS-12.

GCD or County	Average Aquifer Drawdown (ft) measured from January 2000 through December 2069					
	Sparta	Queen City	Carrizo	Calvert Bluff	Simsboro	Hooper
Brazos Valley GCD	12	13	61	125	295	208
Fayette County GCD	46	63	109	Declared as non-relevant		
Lost Pines GCD	4	16	68	109	251	181
Mid-East Texas GCD	1	-3	81	90	138	125
Post Oak Savannah GCD	28	30	67	148	322	206
Falls County	--	--	--	--	-2	27
Limestone County	--	--	--	12	51	55
Navarro County	--	--	--	-1	5	5
Williamson County	--	--	--	-11	47	69
GMA-12	*18*	*19*	*76*	*117*	*231*	*173*

4.3 Yegua-Jackson GAM

The proposed DFCs for the Yegua-Jackson aquifers were developed based on simulations of potential scenarios of future pumping using the GAM for the Yegua-Jackson (Deeds and others, 2010). The Yegua-Jackson Aquifer is a minor aquifer in Texas that is primarily used for rural domestic water uses. The hydrogeological framework of the aquifer system and its location in the state are shown in **Figure 4-2**. The GAM was developed using MODFLOW 2000 and consists of five layers. The conceptual model representation is shown in **Figure 4-3**. The first layer represents the shallow outcrop section of the

Yegua-Jackson Aquifer and Catahoula Formation. The remaining layers represent, from top to bottom, the Upper Jackson Unit, the Lower Jackson Unit, the Upper Yegua Unit, and the Lower Yegua Unit. The model was calibrated for two time periods, one representing pre-development conditions (prior to 1900) and the other representing transient conditions (1980 through 1997). Because each model grid block covers one square mile, the applicability of the model is limited to regional-scale assessments of groundwater availability. The groundwater pumping and hydraulic properties are averaged over the area of model grid blocks, so at the current scale of the model, it is not capable of predicting aquifer responses at specific locations such as pumping wells. However, the model is applicable for simulating aquifer response at a scale of tens of miles, which is appropriate for the regional planning needs of GMA 12. The model is limited in its approach to coupling surface water features to the groundwater and does not provide a rigorous solution to surface-water flow in the region.

4.4 Potential Pumping Scenario Using Yegua-Jackson GAM

The GCDs within GMA 12 developed estimates of potential uses that could occur in the upcoming decades based on existing use and projected future demands. The potential future uses were about the same as estimated in the previous round of joint groundwater planning, with the exception that the estimate of water use for oil and gas drilling and completion was estimated to be lower. A well file was developed and the simulation performed to develop DFCs for the period from 2010 through December 2069. The simulation utilized to develop the DFCs for the Yegua-Jackson Aquifer was identified as YGJK-PS1. **Table 4-2** provides the average drawdowns simulated using YGJK-PS1.

Table 4-2 Average Aquifer Drawdown calculated for Yegua-Jackson Aquifer using YGJK-PS1.

GCD or County	Average Aquifer Drawdown (ft) measured from January 2010 through December 2069		
	Yegua	Jackson	Yegua-Jackson
Brazos Valley GCD	70	114	--
Fayette County GCD	--	--	77
Lost Pines GCD	--	--	--
Mid-East Texas GCD	--	--	7
Post Oak Savannah GCD	--	--	100
GMA 12	--	--	*65*

4.5 Use of Groundwater Availability Models

The joint groundwater planning process in GMA 12 involved using the Queen City-Sparta and Yegua-Jackson GAMs in evaluating potential desired future conditions for the aquifers while also considering the nine factors required by Texas Water Code §36.108(d)(1-8). As discussed previously, several model simulations were completed before adopting desired future conditions for the aquifers. Based on data collected and simulations performed since the development of the existing Queen City-Sparta GAM, it is evident that the existing Queen City-Sparta GAM can overestimate the effects from pumping in certain areas of the GAM. Because of these inconsistencies, this GAM is currently being revised and updated.

The realization that a revised and improved Queen City-Sparta GAM would be developed prior to the next cycle of GMA planning was a consideration in the adoption of DFCs for the current planning cycle. The Yegua-Jackson GAM was developed in 2009-2010 to simulate conditions in the minor aquifer and there are no current plans to revise the model.

In utilizing GAMs in the process of developing DFCs, it is necessary to have the amount and areal distribution of pumping as inputs in order to evaluate drawdown values for the various aquifers over a prescribed time. As discussed previously, this process is an iterative approach that includes running several predictive scenarios with the model and then evaluating the results in the process of developing DFCs. This process helps the GMA understand the impacts of varying amounts of pumpage on the aquifers over time. GMA 12's approach is similar to the process undertaken by many GMAs across the state, where GMAs evaluated the relationship between pumping and DFCs prior to finalizing the DFCs. DFCs are policy decisions being made by the GMAs, and it is reasonable and prudent for GMAs to want to understand the ramifications of major policy decisions prior to adopting these policies.

In the case of groundwater management, a scientific method that can include the use of GAMs can be used to understand the relationship between groundwater pumping and drawdown or groundwater pumping and the effects on flow between aquifers. The GAMs are a tool that can be used to run various simulations to better understand the cause and effect relationships within a groundwater system as they relate to groundwater management. A substantial amount of the consideration of the nine statutory factors involves understanding the effects or impacts of DFCs. The effects can include drawdowns, environmental factors, socioeconomic and private property rights. The use of GAMs in the iterative process of the development of DFCs for groundwater management is an effective method for developing information that is a consideration by GMAs or districts as they develop DFCs.

4.6 Potential Pumping of Brazos River Alluvium

The Brazos River Alluvium Aquifer is primarily used for irrigation in Brazos, Burleson and Robertson counties and to a much lesser degree for domestic and stock use. The largest volume of pumping occurs during the growing season. Outside of the growing season (approximately half the year), there is a very limited amount of pumping from the aquifer. DFCs were developed for the Brazos River Alluvium Aquifer based on static water-level changes that have occurred in screened wells over the past approximately 60 years. The DFCs are based on allowing aquifer users to lower static water levels in wells to essentially the deepest levels previously recorded, as groundwater was still available for pumping when those levels were reached.

When the DFCs were developed for this round of joint groundwater planning, there was not a three-dimensional groundwater flow model available for the Brazos River Alluvium Aquifer. A new Brazos River Alluvium Aquifer GAM (Ewing and Jigmond, 2016) was released in late 2016 and so will be available for estimating DFCs during the next GMA 12 joint planning cycle. This, as well as historical and future groundwater pumping and water-level data, will be used to assess the availability of water from this aquifer.

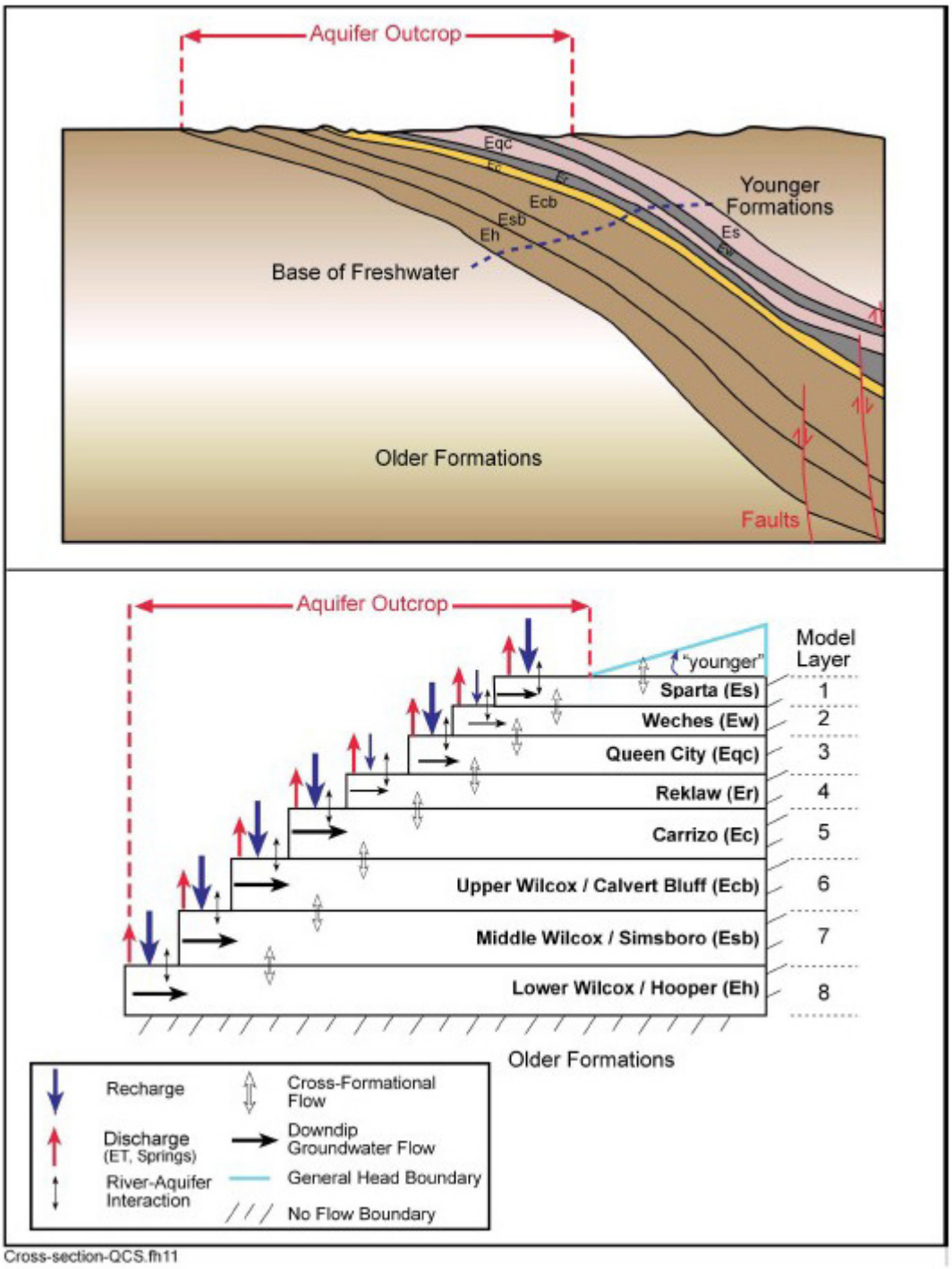

Figure 4-1 Conceptual Flow Model of the Sparta, Queen City, and Carrizo-Wilcox Aquifers (from Kelley and others, 2004, Figure 5.1)

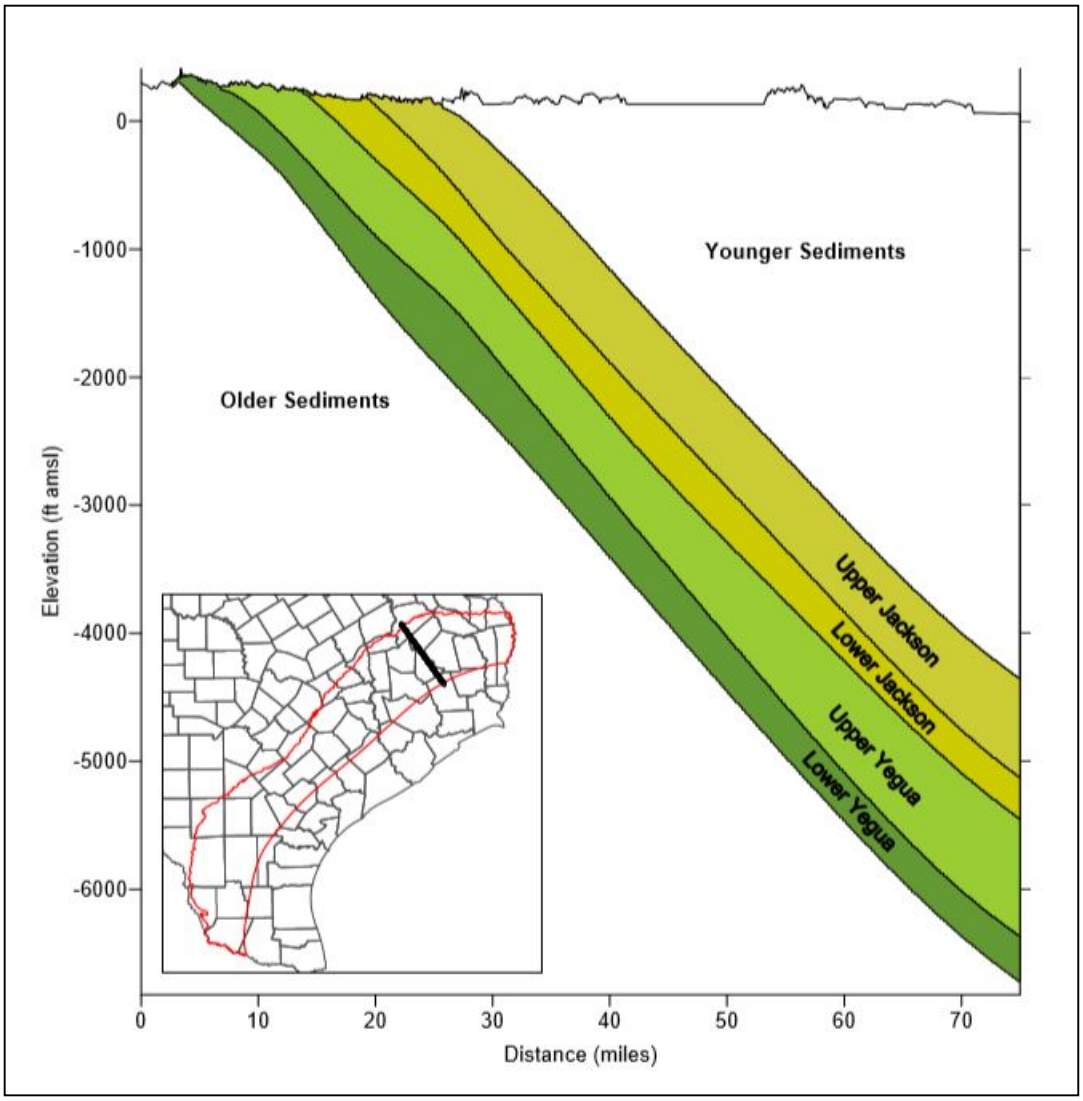

Figure 4-2 Yegua-Jackson Aquifer System and Location (from Deeds and others, 2010, Figure 2.2.4)

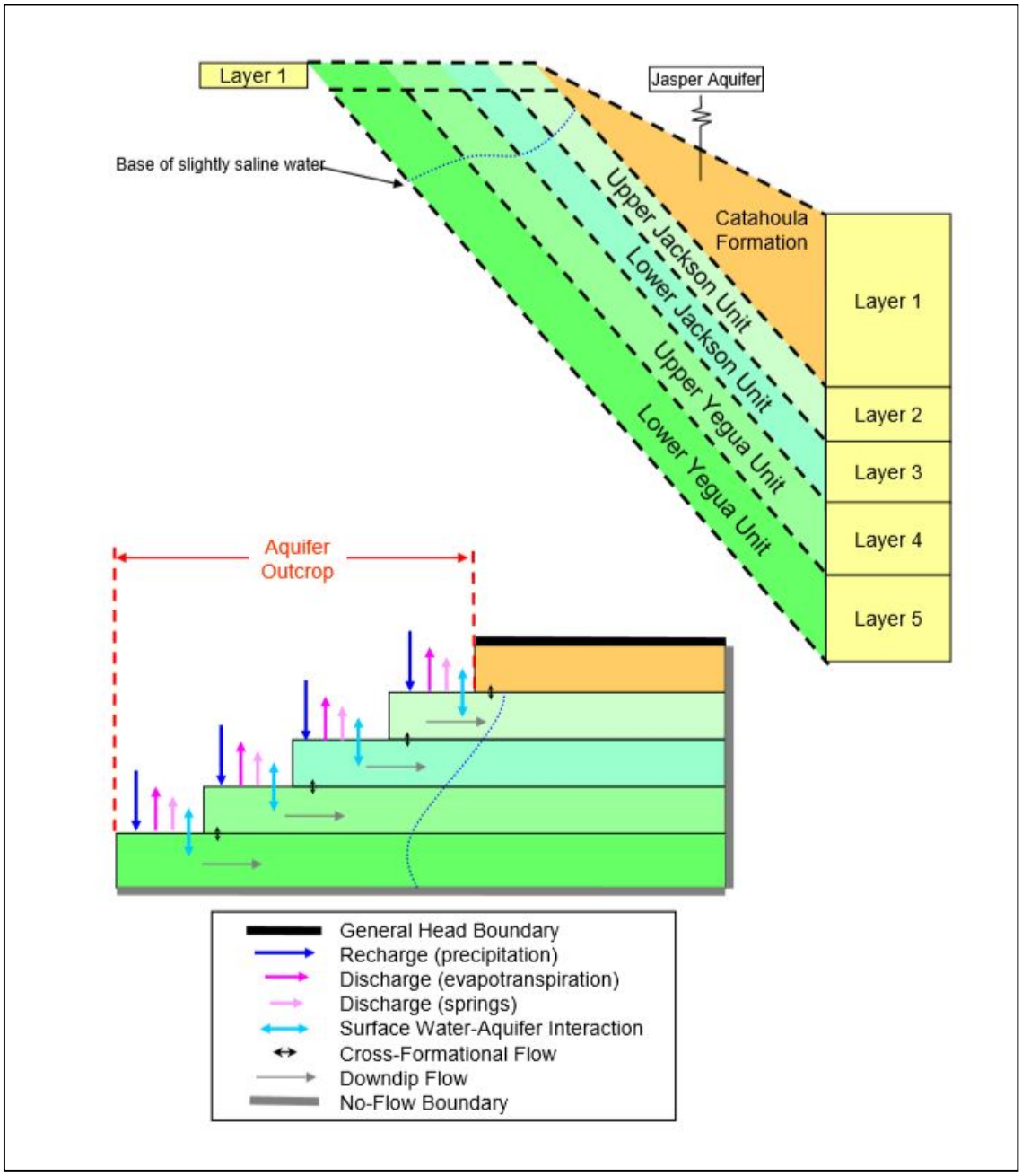

Figure 4-3 Conceptual Flow Model of the Yegua-Jackson Aquifer (from Deeds and others, 2010, Figure 5.0.1)

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5.0 FACTORS CONSIDERED FOR THE DESIRED FUTURE CONDITIONS

This section of the Explanatory Report summarizes some of the information considered by GMA 12 in deliberations and discussions of the DFCs.

5.1 Aquifer Uses and Conditions

Texas Water Code Section 36.108 (d)(1) requires that, during the joint-planning process, GCDs shall consider "aquifer uses or conditions within the management area, including conditions that differ substantially from one geographic area to another." On May 28, 2015, a presentation titled "GMA 12 Aquifer Uses and Conditions Consideration Discussion" was given by GMA 12's hydrogeological consultants. This presentation is included as **Appendix F**. The following section provides additional information about the aquifer uses or conditions of each major and minor aquifer present within GMA 12 for which DFCs were developed. These aquifers include:

- Carrizo-Wilcox Aquifer, which includes the Carrizo, Calvert Bluff, Simsboro, and Hooper hydrostratigraphic units
- Queen City Aquifer
- Sparta Aquifer
- Yegua-Jackson Aquifer
- Brazos River Alluvium Aquifer

The outcrop for each of these aquifers is shown in **Figure 5-1**. With the exception of the Brazos River Alluvium, which is a shallow alluvial unit present along the Brazos River, these formations all outcrop from southwest to northeast and dip to the southeast towards the Gulf of Mexico.

Water uses, as defined by the TWDB, include:

- Municipal - includes city-owned, districts, water supply corporations, or other private utilities supplying residential, commercial (non-goods-producing businesses), and institutional (schools, governmental operations), as well as non-surveyed municipal (rural domestic)
- Manufacturing - refers to process water use reported by large manufacturing plants. This is also sometimes referred to as "industrial"
- Livestock
- Irrigated agriculture
- Mining - includes water used in the mining of oil, gas, coal, sand, gravel, and other materials
- Steam-Electric Power - refers to consumptive use of water by large power generation plants

Within GMA 12, groundwater comprises a significant amount of the total water used. **Table 5-1** summarizes the approximate percent of each type of water use that is supplied by groundwater. This table shows that groundwater is the major supplier of water for irrigation, mining, and municipal uses across the GMA, and is a significant supplier for livestock and manufacturing. Only steam-electric is not a significant user of groundwater at the current time.

Table 5-1 Estimated historic overall water use met with groundwater

Purpose	Lost Pines GCD	Post Oak Savannah GCD	Brazos Valley GCD	Mid-East Texas GCD	Fayette County GCD
Irrigation	100%	75%	90%	100%	90%
Livestock	25%	30%	30%	10%	50%
Manufacturing	75%	45%	100%	0%	30%
Mining	100%	95+%	100%	50%	60%
Municipal	100%	80%	95%	100%	100%
Steam-Electric	0%	0%	30%	0%	0%

The total reported groundwater production for each GCD in GMA 12 in 2012 is shown in **Table 5-2**. This table shows the metered/reported volume of groundwater from each of the aquifers. It should be noted that the Fayette County GCD is a member of two different GMAs, and a large portion of Fayette County's overall groundwater production occurs within GMA 15, and therefore is not included in Table 5-2.

Table 5-2 2012 metered/reported groundwater production in acre-feet

Formation	Lost Pines GCD	Post Oak Savannah GCD	Brazos Valley GCD	Mid-East Texas GCD	Fayette County GCD
Brazos River Alluvium	NA	17,000	90,814	NA	NA
Yegua-Jackson	0	700	1,707	78	579
Sparta	104	850	3,237	1,374	20
Queen City	110	300	685	417	0
Carrizo	3,444	1,400	810	2,038	0
Calvert Bluff	493	300	364	2,670	NA
Simsboro	16,980	13,000	59,538	1,074	NA
Hooper	0	700	1,086	2,614	NA
Carrizo-Wilcox	*20,917*	*15,400*	*61,798*	*8,396*	*0*
TOTAL	**21,131**	**34,250**	**158,241**	**10,265**	**599**

NA- Not applicable because the aquifer is either not present or not used in that district.

5.1.1 Carrizo-Wilcox Aquifer

The Carrizo-Wilcox is a major aquifer present across GMA 12, as shown in **Figure 5-2**. Although the Carrizo-Wilcox is considered a single aquifer system by the TWDB, the individual aquifer units within the Carrizo-Wilcox are used differently within GMA 12 and so they are each summarized separately below. The overall use from the whole Carrizo-Wilcox Aquifer is summarized in **Table 5-3**. As shown, the Carrizo-Wilcox is heavily used for municipal purposes throughout much of GMA 12, with a few counties also using it extensively for manufacturing, mining or irrigation.

Table 5-3 Total estimated groundwater production from the Carrizo-Wilcox Aquifer in 2013

County	Municipal	Manufacturing	Mining	Steam Electric	Irrigation	Livestock	Total
Bastrop	11,339	76	44	0	2,029	100	13,588
Brazos	35,173	1,149	0	0	0	0	36,322
Burleson	1,036	0	0	0	177	9	1,222
Fayette	0	29	0	0	0	7	36
Freestone	2,930	0	1,607*	338	598	513	5,986
Lee	5,145	1,332	5,985	0	420	99	12,981
Leon	2,456	671	2,275*	0	601	195	6,198
Madison	57	0	0	0	0	48	105
Milam	1,321	8,642	108	0	2,173	314	12,558
Robertson	2,259	43	0	4,747	21,462	280	28,791

Source: Texas Water Development Board web site, District production records, and District estimates.

* Mining estimate includes Oil & Gas water use as well as surface mining water use reported by the Railroad Commission of Texas (RRC) at the Jewett Mine 32F/47A and the Big Brown Mine for de-watering/pressurization.

Carrizo Aquifer- The Carrizo Formation is the uppermost hydrostratigraphic unit within the Carrizo-Wilcox Aquifer, and is present through the middle of GMA 12, as shown in **Figure 5-3**. There has historically been moderate production from the Carrizo across much of GMA 12. Groundwater from the Carrizo is produced from wells shown in Figure 5-3, with some wells being up to 2,000 feet deep. Groundwater produced from the Carrizo is primarily used for domestic, livestock, and municipal purposes. Lesser amounts of water from the Carrizo are used for irrigation purposes. Some significant users of water from the Carrizo include the cities of Giddings, College Station and Smithville, Aqua Water Supply Cooperative (WSC), Lee County WSC, Texas A&M University, the Texas Department of Criminal Justice Ferguson Unit, and several rural WSCs.

Calvert Bluff Aquifer- The Calvert Bluff Formation is found below the Carrizo and is the uppermost of the three Wilcox hydrostratigraphic units within the Carrizo-Wilcox Aquifer. The Calvert Bluff is present through the middle of GMA 12, as shown in **Figure 5-4**. There has historically been moderate production from the Calvert Bluff across much of GMA 12. Groundwater from the Calvert Bluff is produced from wells shown in Figure 5-4, with most of the wells being shallow (less than 800 feet deep). Groundwater produced from the Calvert Bluff is primarily used for domestic and livestock purposes. Lesser amounts of water from the Calvert Bluff is used for municipal and oil and gas drilling purposes. Some significant users of water from the Calvert Bluff include the Bastrop County WCID#2, numerous WSCs in the Mid-East Texas GCD, Nucor Steel, and numerous landowners using the aquifer for domestic and livestock purposes.

Simsboro Aquifer- The Simsboro Formation is found below the Calvert Bluff and is the middle of three Wilcox hydrostratigraphic units within the Carrizo-Wilcox Aquifer. The Simsboro is present through the middle of GMA 12, as shown in **Figure 5-5**. There has historically been significant production from the Simsboro across much of GMA 12. Groundwater from the Simsboro is produced from wells shown in Figure 5-5, with some of these wells being very deep (greater than 2,000 feet). The Simsboro can be a very productive aquifer, making it the target for groundwater development projects in many areas of GMA 12. Groundwater produced from the Simsboro is primarily used for municipal purposes as well as mine depressurization. Lesser amounts of water from the Simsboro are used for industrial, livestock, and irrigation purposes. Some significant users of water from the Simsboro include the cities of Bryan/College Station and Elgin, Manville and Aqua WSCs, several WSCs in Mid-East Texas GCD, the LCRA, Texas A&M University, NRG Texas Power, Major Oak Power, two lignite mines, and landowners throughout the GMA.

Hooper Aquifer- The Hooper Formation is found below the Simsboro and is the lowermost of the three Wilcox hydrostratigraphic units within the Carrizo-Wilcox Aquifer. The Hooper is present across the northwestern edge of GMA 12, as shown in **Figure 5-6**. There has historically been little production from the Hooper across much of GMA 12. Groundwater from the Hooper is produced from wells shown in Figure 5-6, with most of the wells being shallow (less than 500 feet deep) in and near the Hooper outcrop. Groundwater produced from the Hooper is primarily used for domestic and livestock purposes. Lesser amounts of water from the Hooper are used for municipal and power generation purposes. Some significant users of water from the Hooper include the cities of Bremond, Fairfield, and Teague and the TDCJ Boyd Unit.

5.1.2 Queen City Aquifer

The Queen City Aquifer is a minor aquifer present through the middle of GMA 12, as shown in **Figure 5-7**. Groundwater production from the Queen City in 2013 is summarized in **Table 5-4**. As shown in this table, there is only limited use across most of GMA 12. Groundwater from the Queen City is primarily produced from shallow to moderately deep wells, with most wells being less than 1,000 feet deep, but a few up to 2,000 feet. Groundwater produced from the Queen City is primarily used for domestic/municipal, livestock, and irrigation purposes. Some significant users of water from the Queen City include some rural WSCs in Mid-East Texas GCD, the Town of Lincoln, and numerous landowners for livestock and domestic purposes.

Table 5-4 Total estimated groundwater production from the Queen City Aquifer in 2013

County	Municipal	Manufacturing	Mining	Steam Electric	Irrigation	Livestock	Total
Bastrop	19	0	0	0	407	24	450
Brazos	44	0	0	0	0	24	68
Burleson	486	0	0	0	0	98	584
Fayette	509	0	0	0	0	0	509
Freestone	38	0	0	0	0	8	46
Lee	209	0	0	0	417	112	738
Leon	188	0	253	0	0	33	474
Madison	14	0	28	0	0	0	42
Milam	20	0	0	0	870	17	907
Robertson	35	0	0	0	0	49	84

Source: Texas Water Development Board web site, District production records, and District estimates.

5.1.3 Sparta Aquifer

The Sparta Aquifer is a minor aquifer present through the middle of GMA 12, as shown in **Figure 5-8**. Groundwater production from the Sparta in 2013 is summarized in **Table 5-5**. As shown in this table, there is some use from this aquifer in Brazos, Burleson, and Madison counties, with significantly less use from this aquifer in the rest of the GMA. Groundwater from the Sparta is primarily produced from shallow to moderately deep wells, with most wells being less than 1,000 feet deep, but a few up to 2,000 feet. Groundwater produced from the Sparta is primarily used for domestic/municipal, livestock, and irrigation purposes. It is also used for manufacturing in a few counties. Some significant users of water from the Sparta include the City of Madisonville and several municipalities and WSCs in Brazos and Lee counties.

Table 5-5 Total estimated groundwater production from the Sparta Aquifer in 2013

County	Municipal	Manufacturing	Mining	Steam Electric	Irrigation	Livestock	Total
Bastrop	6	0	0	0	97	17	120
Brazos	2,869	433	0	75	19	85	3,481
Burleson	733	111	0	0	0	61	905
Fayette	6	0	0	0	87	7	100
Lee	149	0	0	0	0	36	185
Leon	19	0	14	0	0	5	38
Madison	2,776	0	171	0	95	24	3,066
Robertson	15	0	0	0	70	49	134

Source: Texas Water Development Board web site, District production records, and District estimates.

5.1.4 Yegua-Jackson Aquifer

The Yegua-Jackson Aquifer is a minor aquifer present in the southeastern third of GMA 12, as shown in **Figure 5-9**. Groundwater production from the Yegua-Jackson in 2013 is summarized in **Table 5-6**. As shown in this table, there is some production from this aquifer in Brazos County, with significantly less production from this aquifer in the rest of the GMA. Groundwater from the Yegua-Jackson is primarily produced from shallow wells, and is largely used for domestic/municipal, livestock, and irrigation purposes. Lesser amounts of water from the Yegua-Jackson are used for mining (oil and gas drilling). Some significant users of water from the Yegua-Jackson include several municipalities in Fayette County and golf course irrigation and some industrial users in Brazos Valley GCD.

Table 5-6 Total estimated groundwater production from the Yegua-Jackson Aquifer in 2013 in acre-feet

County	Municipal	Manufacturing	Mining	Steam Electric Power	Irrigation	Livestock	Total
Bastrop	0	0	0	0	0	2	2
Brazos	1,109	0	0	0	4	194	1,307
Burleson	322	0	0	0	88	98	508
Fayette	299	0	0	0	80	18	397
Lee	28	0	0	0	0	21	49
Madison	752	0	476	0	115	16	1,359

Source: Texas Water Development Board web site, District production records, and District estimates.

5.1.5 Brazos River Alluvium Aquifer

The Brazos River Alluvium Aquifer is a minor aquifer present along the Brazos River between Brazos Valley GCD (Brazos and Robertson counties) and Post Oak Savannah GCD (Burleson and Milam counties), as shown in **Figure 5-10**. Groundwater is produced from the Brazos River Alluvium entirely from very shallow (less than 100 feet) wells, and is used almost entirely for irrigation purposes. Overall reported use is much higher in Brazos Valley GCD than in Post Oak Savannah GCD, as shown in **Table 5-7**.

Table 5-7 Total estimated groundwater production from the Brazos River Alluvium Aquifer in 2013 in acre-feet

County	Municipal	Manufacturing	Mining	Steam Electric Power	Irrigation	Livestock	Total
Brazos	0	0	0	0	42,298	0	42,298
Burleson	0	0	0	0	22,731	0	22,731
Robertson	621	0	0	0	80,634	61	81,316

Source: Texas Water Development Board web site

5.1.6 Trinity Aquifer

The Trinity Aquifer is present in GMA 12 only in a very small area in Bastrop, Lee, and Williamson counties. There is no historic use within GMA 12, and no known wells within the GMA. It is found only at very great depths, and was declared “not relevant” for the purposes of joint planning in GMA 12 on September 24, 2015.

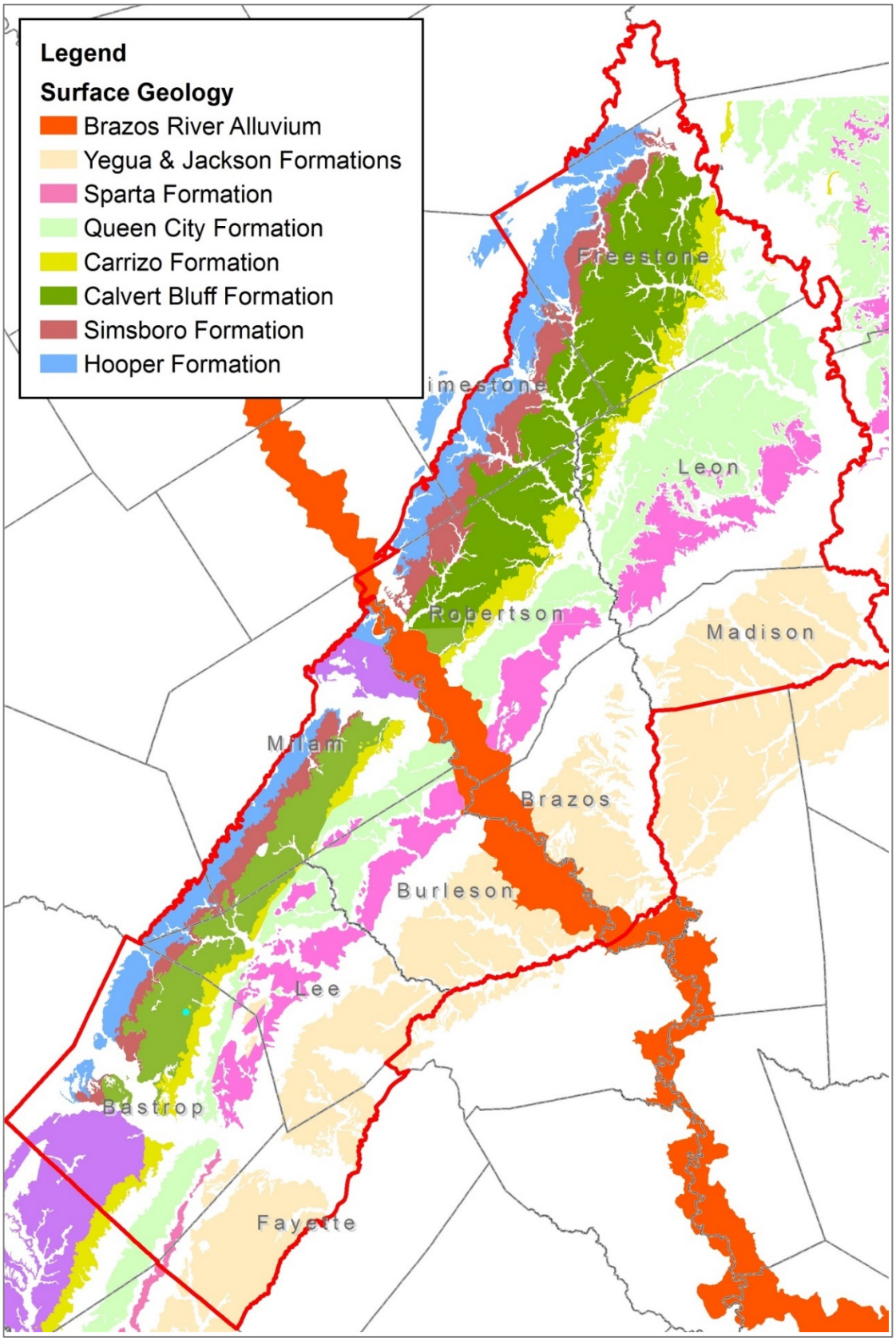

Figure 5-1 Surface geology of GMA 12

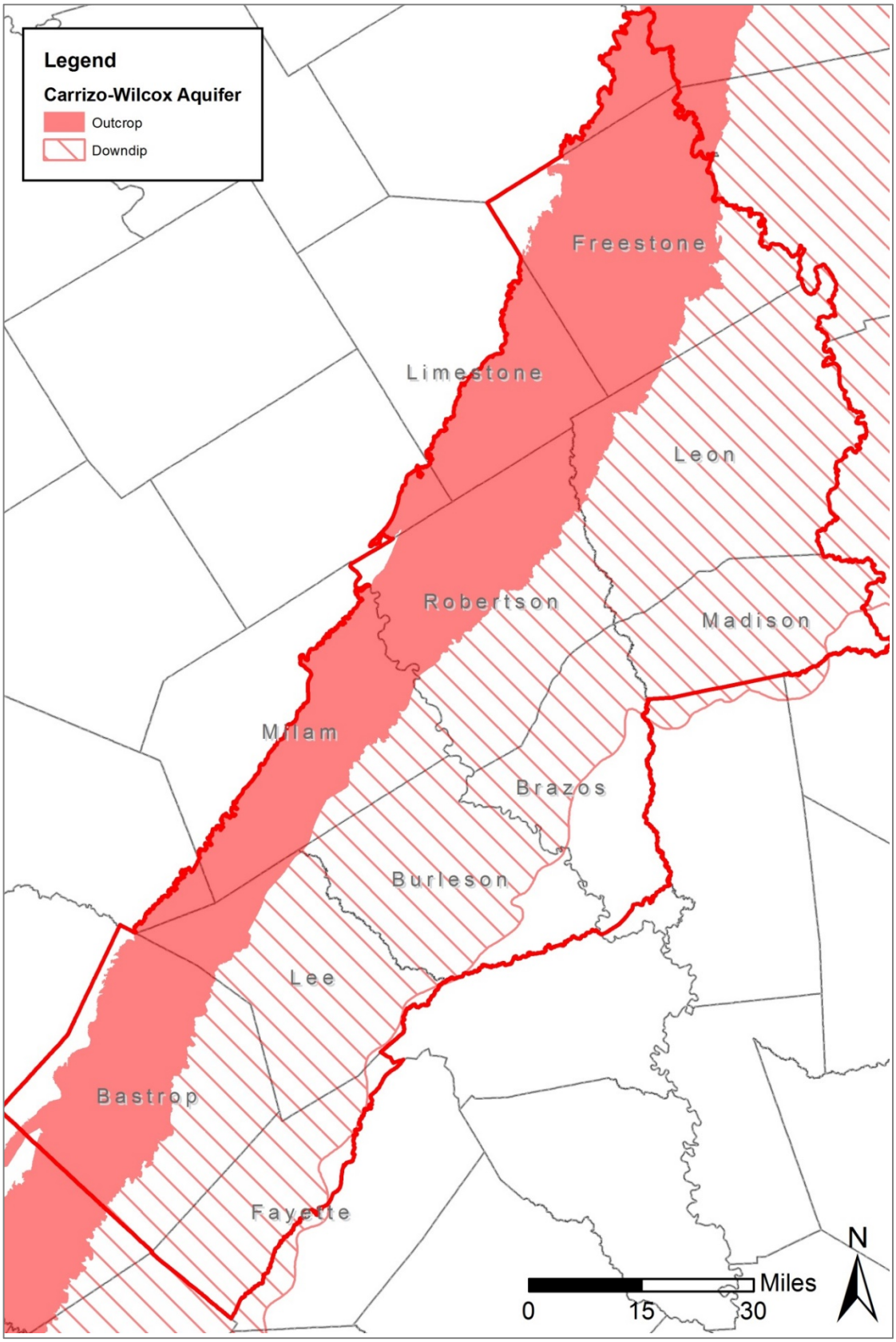

Figure 5-2 Extent of Carrizo-Wilcox Aquifer within GMA 12

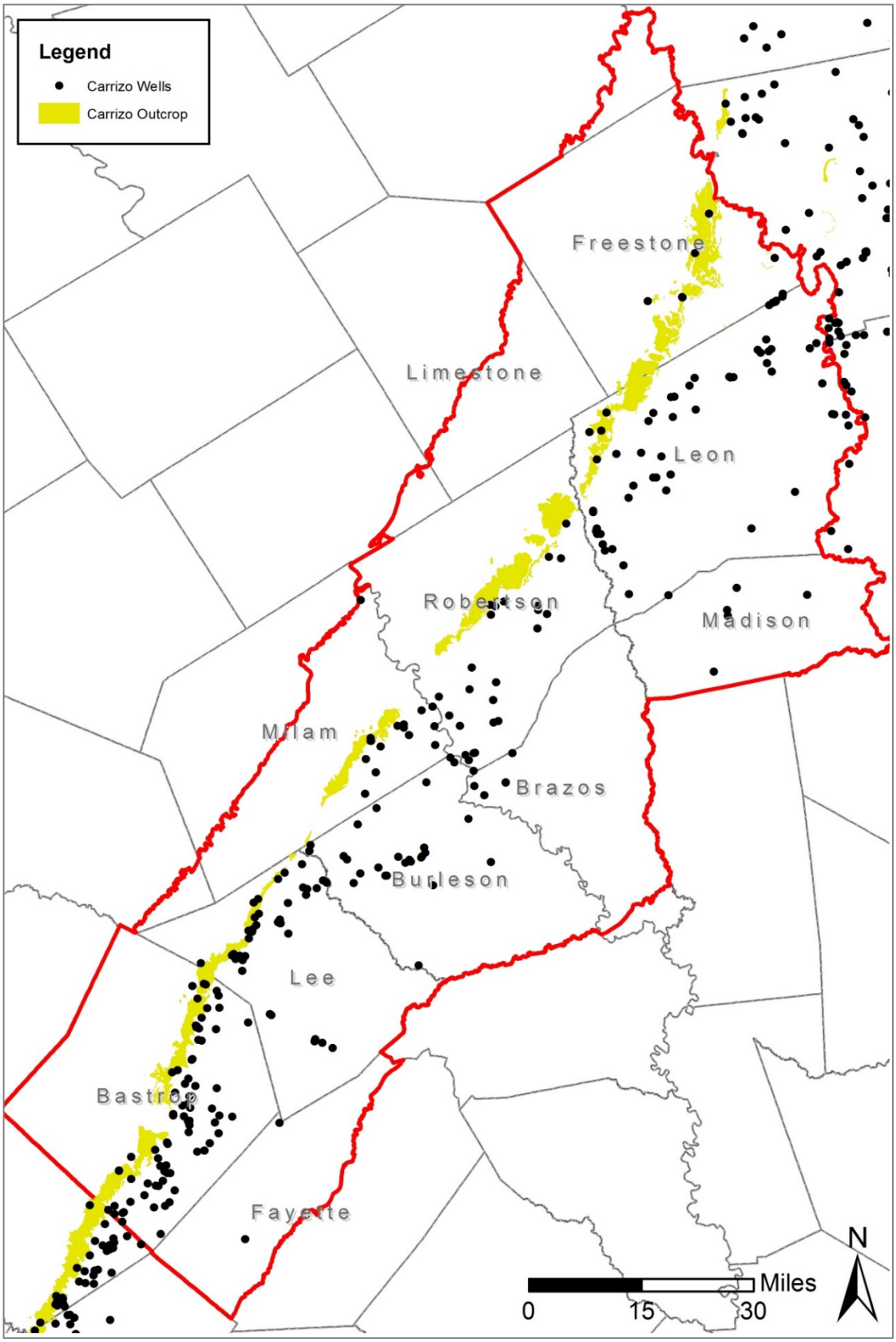

Figure 5-3 Extent of Carrizo Aquifer within GMA 12

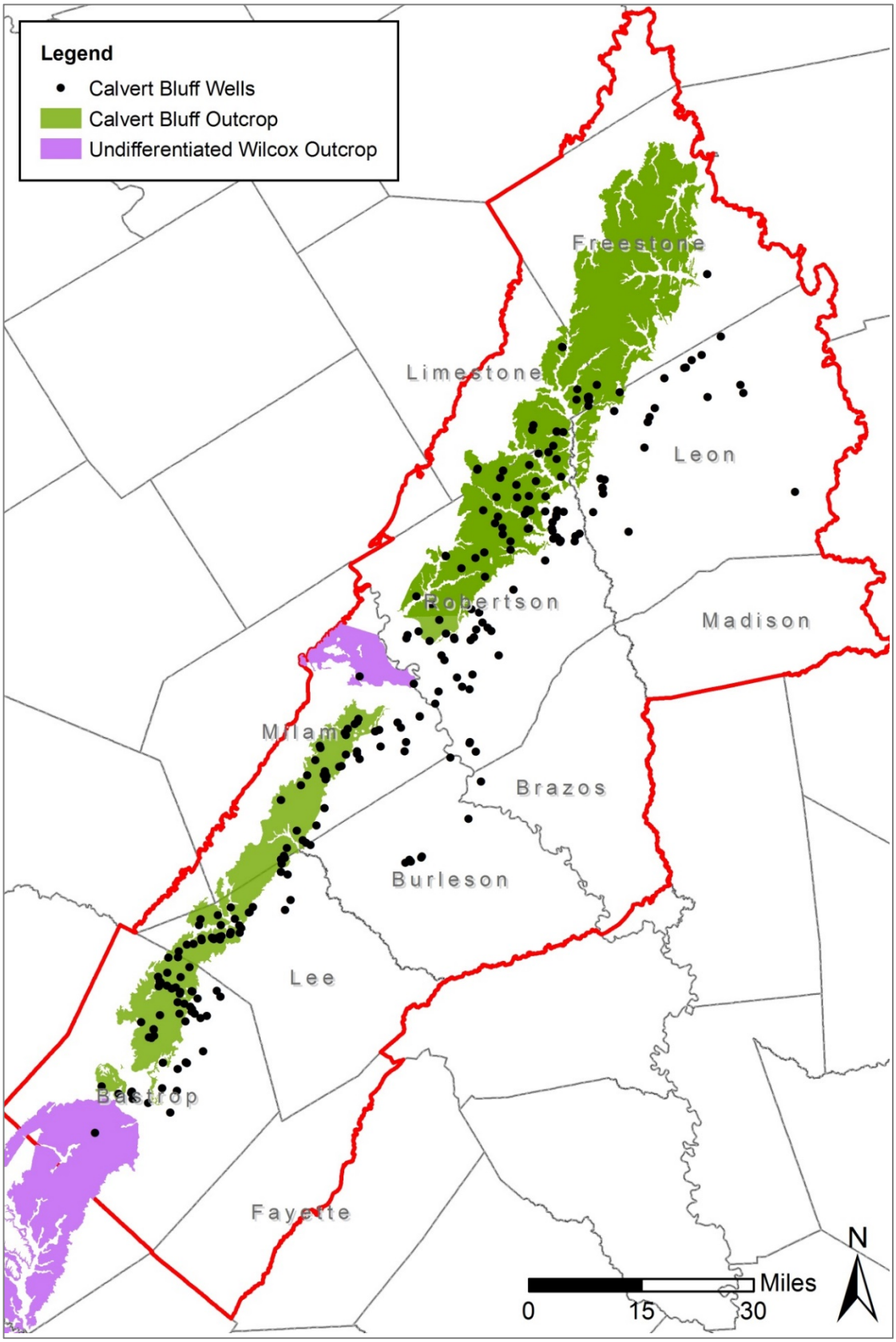

Figure 5-4 Extent of Calvert Bluff Aquifer within GMA 12

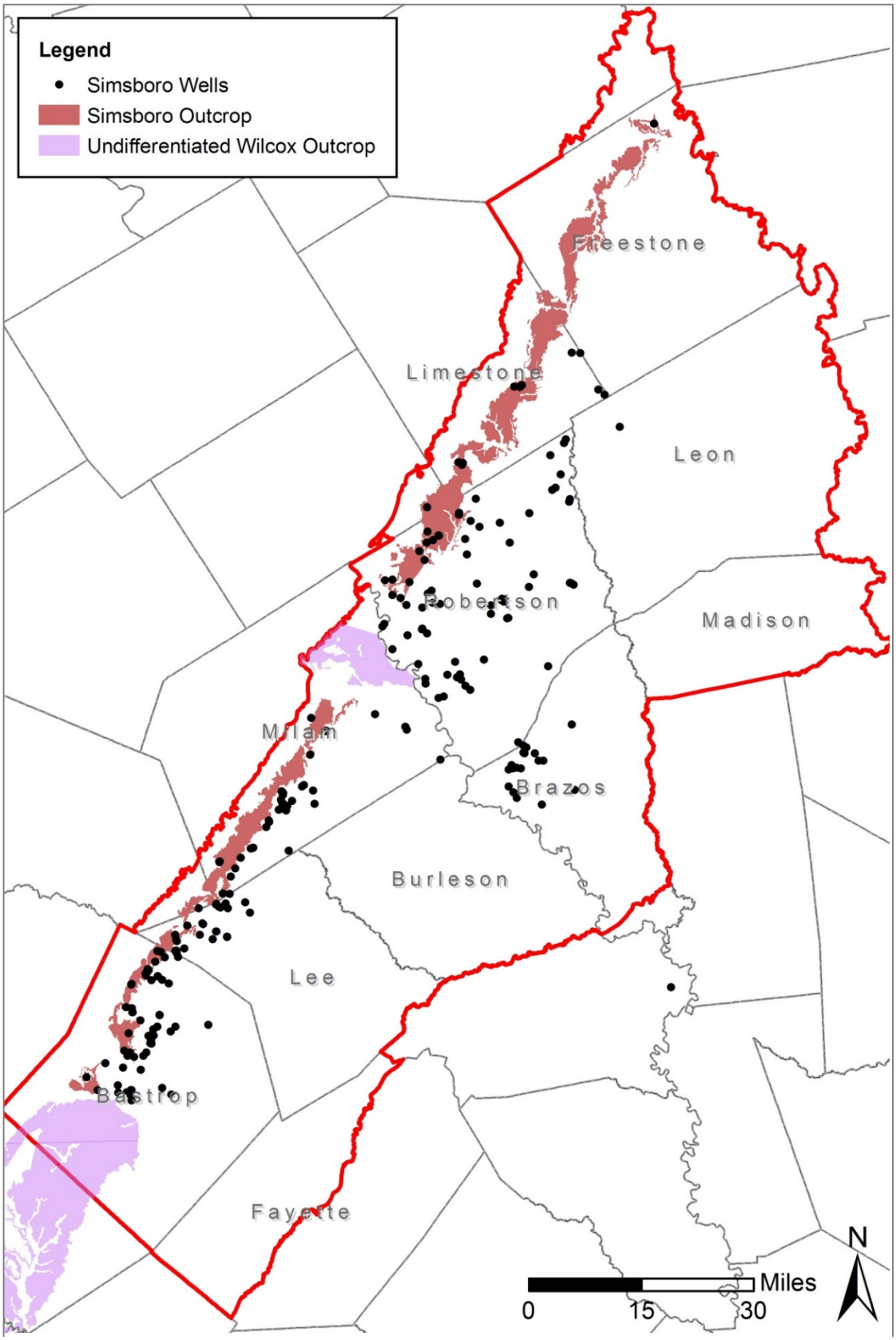

Figure 5-5 Extent of Simsboro Aquifer within GMA 12

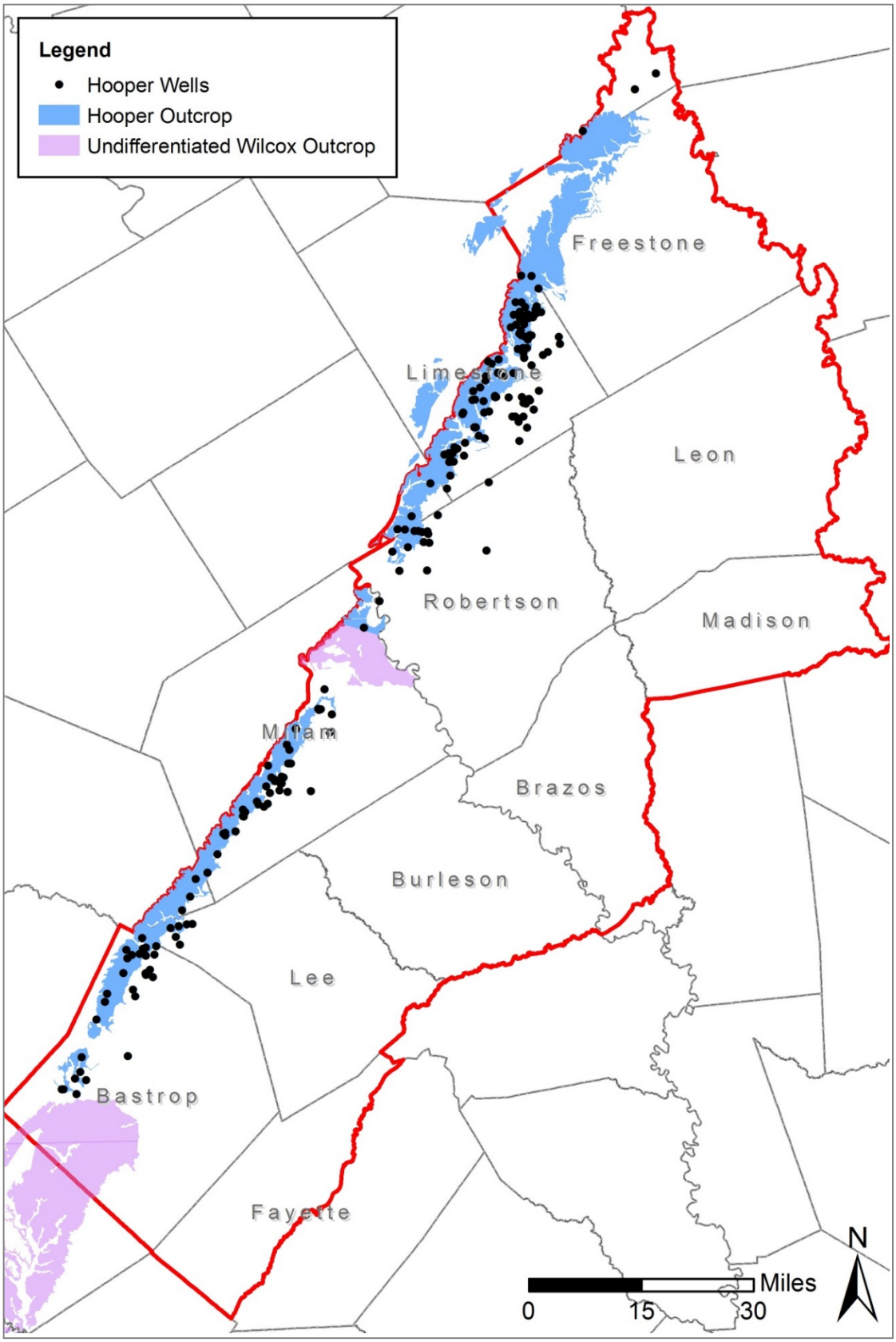

Figure 5-6 Extent of Hooper Aquifer within GMA 12

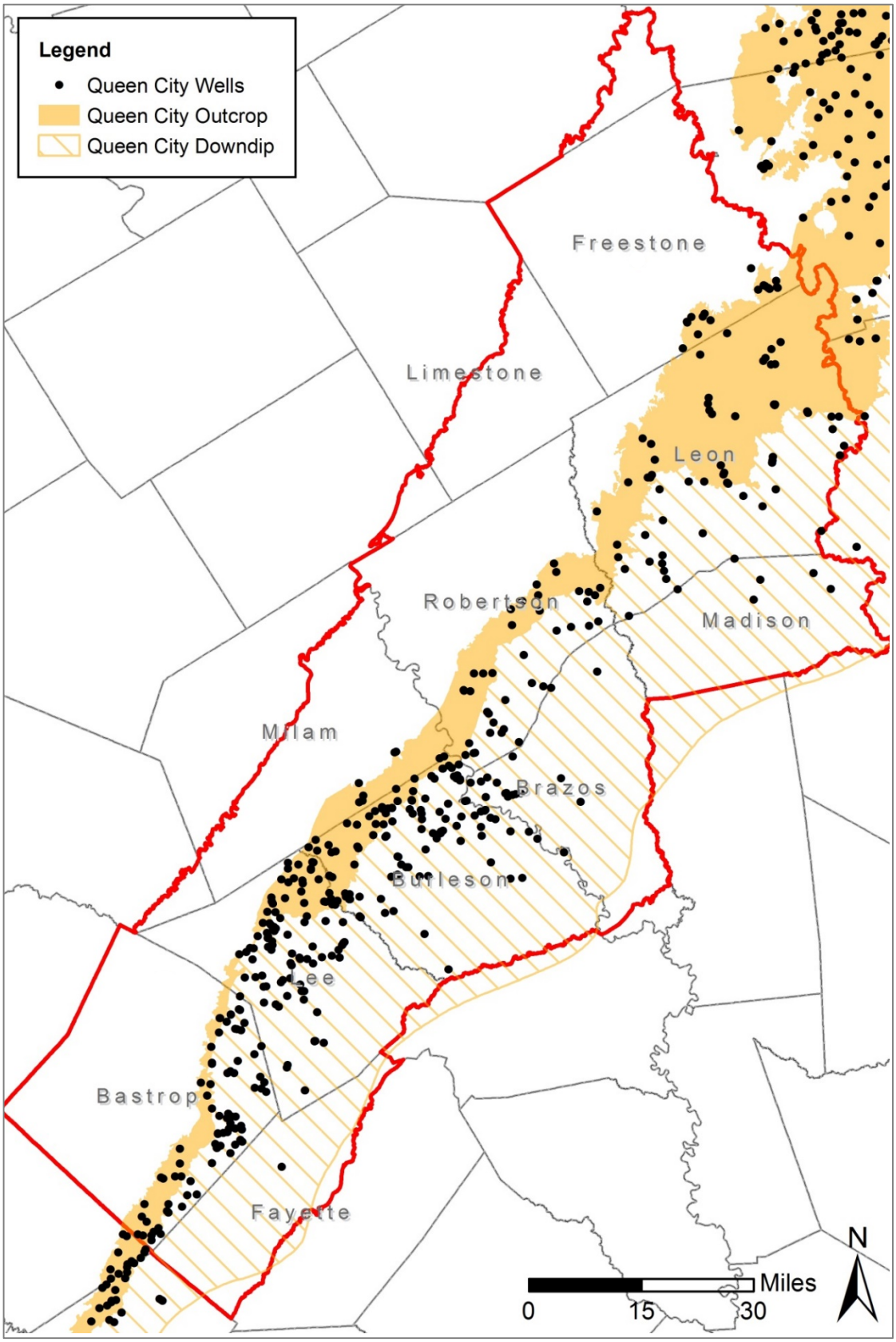

Figure 5-7 Extent of Queen City Aquifer within GMA 12

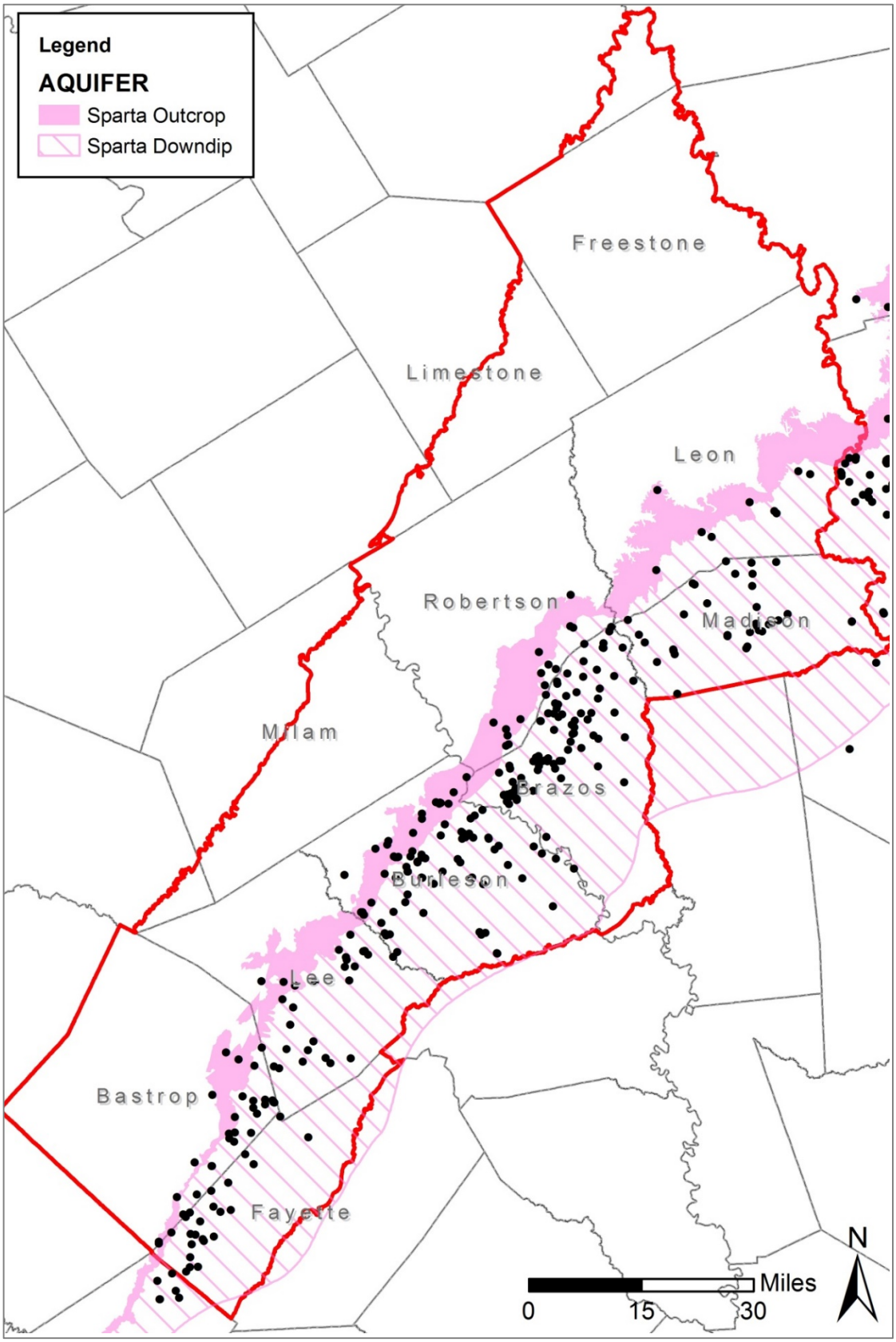

Figure 5-8 Extent of Sparta Aquifer within GMA 12

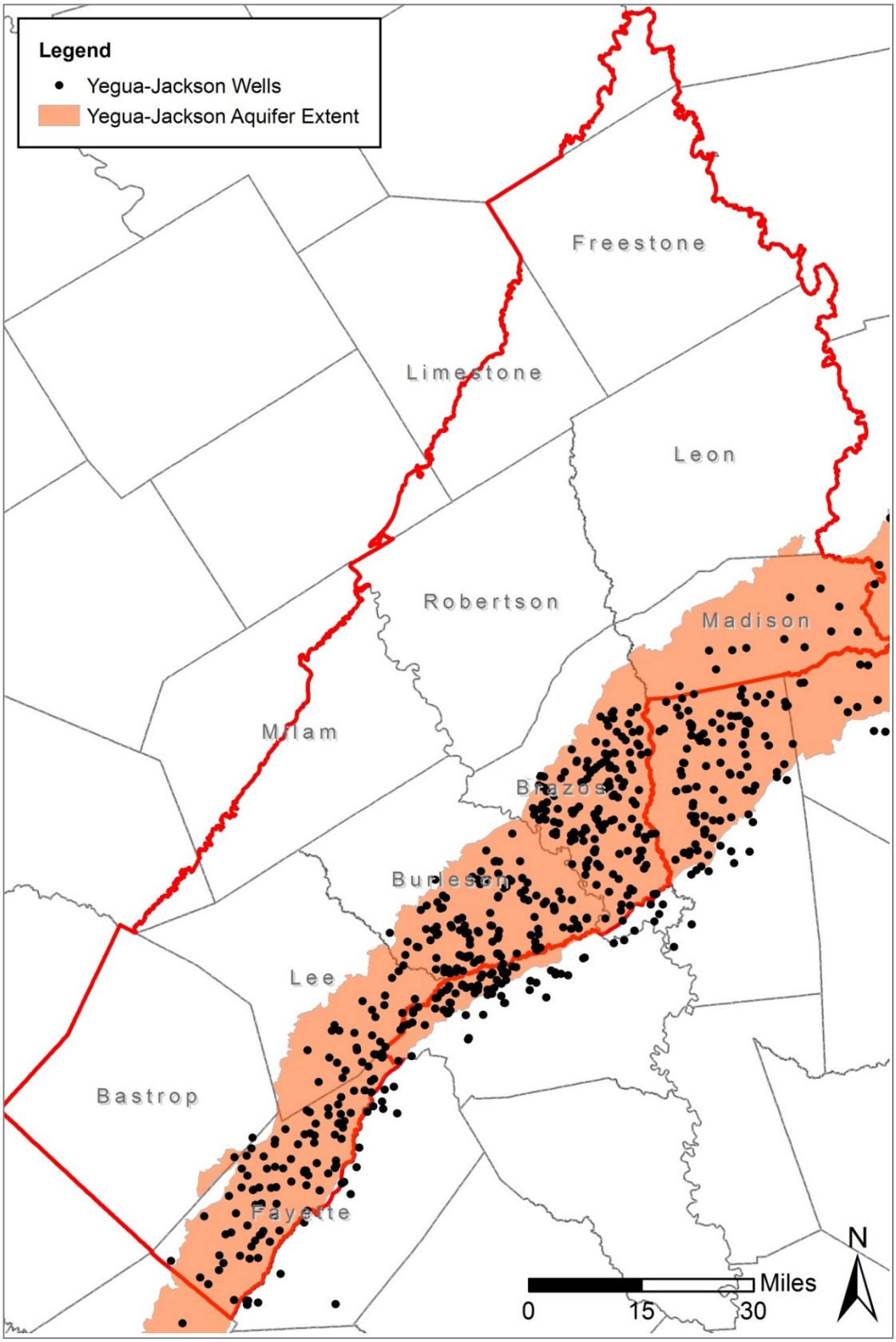

Figure 5-9 Extent of Yegua-Jackson Aquifer within GMA 12

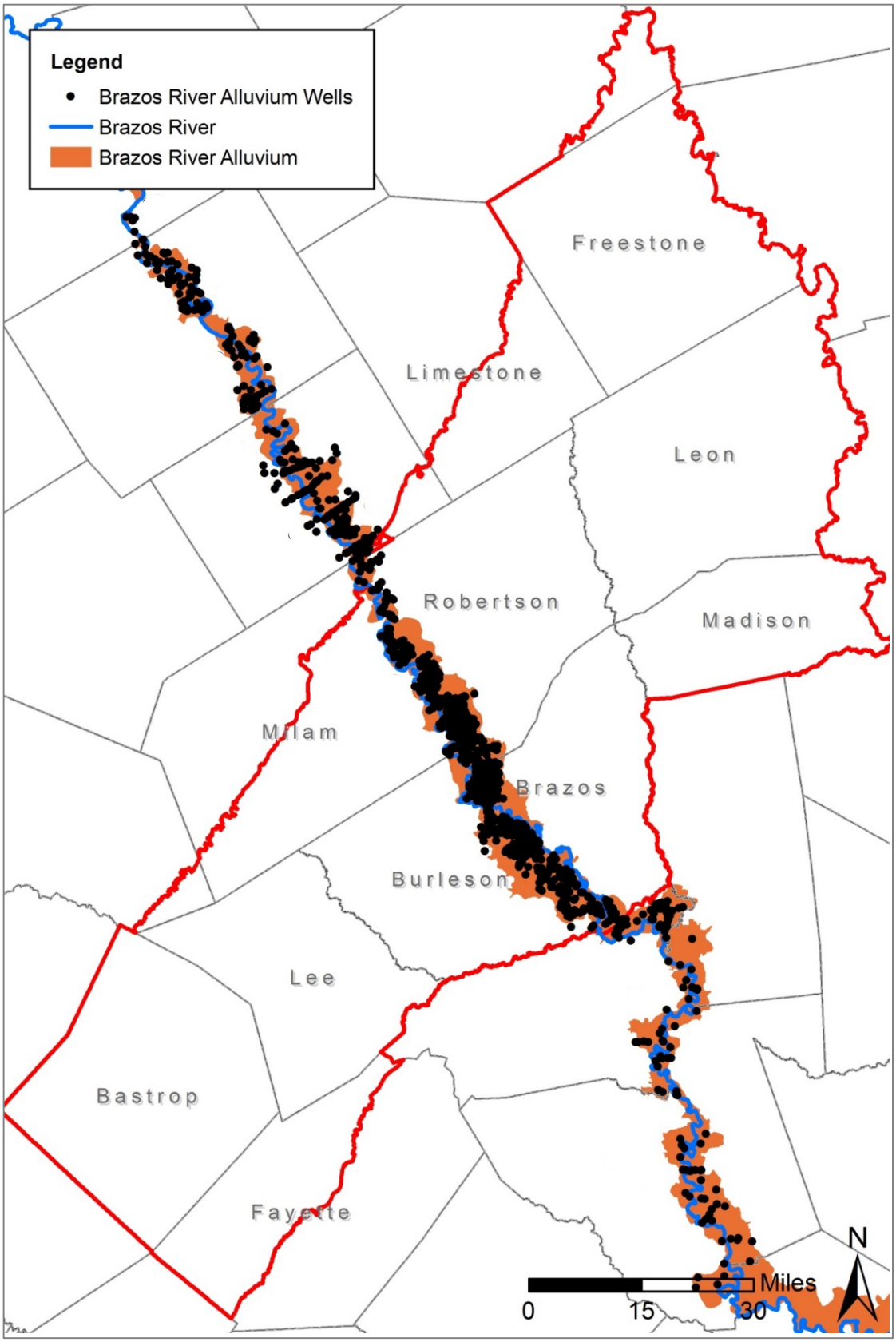

Figure 5-10 Extent of Brazos River Alluvium Aquifer within GMA 12

5.2 Water Supply Needs and Water Management Strategies

Texas Water Code Section 36.108 (d)(2) requires that, during the joint-planning process, GCDs shall consider "the water supply needs and water management strategies included in the state water plan." For the current joint-planning process, GMA 12 relied on the 2012 State Water Plan to provide estimates of future water needs and water management strategies within the GMA. It should be noted that during the development of the proposed DFCs, the 2017 State Water Plan was not available and the 2012 State Water Plan was the most current state water plan. The State Water Plan is a combination of regional water plans created by regional planning groups across the state. Portions of GMA 12 fall within Regional Water Planning Areas C, G, H, and K. GCD representatives from GMA 12 regularly attended the planning meetings for areas C, G, H, and K and thus were able to provide some insight into the unpublished (at the time) 2017 State Water Plan for consideration during the DFC development process.

The overall water needs for a region, as defined within the Texas State Water Plan, are the demands that cannot be met with existing supplies. The "demands" are based on water demand projections developed during the water planning process for the six major water use sectors: municipal, manufacturing, mining, steam-electric, irrigation, and livestock. Existing supplies may be inadequate to satisfy projected demands due to natural conditions (e.g. sustainable supply of an aquifer or firm yield of a reservoir) or infrastructure limitations (e.g., inadequate diversion, treatment, or transmission capacity). On June 25, 2015, a presentation titled "GMA 12: Needs and Strategies" was given by GMA 12's hydrogeological consultants. This presentation is included as **Appendix G.** The presentation discussed the supply, demand, surplus/need, and water management strategies for each groundwater conservation district in GMA 12.

A review of the water management strategies within a region gives some insight into the potential future supply for meeting identified needs. **Table 5-8** provides 2012 State Water Planning Values for 2060 for the 14 counties that comprise GMA 12. The total groundwater and surface water supplies for the GMA 12 counties are 552,265 acre-feet per year (ac-ft/yr), of which 35% are groundwater supplies. The projected 2060 water demand is 710,222 ac-ft/yr and the 2060 projected water need is 157,957 ac-ft/yr. The proposed water management strategies identify projects that will generate 365,324 ac-ft/yr of water. Thus, the management strategies include approximately 200,000 ac-ft/yr more than is needed to meet the projected water needs for GMA 12 counties.

As shown in Table 5-8, most of the projected water supply shortfall in GMA 12 occurs in counties that are not a part of a GCD. **Table 5-9** provides 2012 State Water Planning data for each of the five GCDs in GMA 12 and shows that the GCD's groundwater and surface water supplies in 2060 total 365,707 ac-ft/yr. Given that their 2060 water demand is 386,428 ac-ft/yr, their resulting projected water need (or shortfall) is only 20,721 ac-ft/yr, a small percentage of the total projected shortfall in GMA 12 as a whole. Additionally, this shortfall should be addressed by the proposed water strategies in the five GCDs, which provide for an additional 170,110 ac-ft/yr, or more than eight times the projected water shortfall. Thus, in terms of planning and providing for future water needs in 2060, the ten counties associated with GCDs are in a significantly better position to meet future water demands with their current supplies and proposed water strategies than are the four counties not associated with GCDs.

Table 5-9 also includes information on MAGs, production permits, and groundwater management strategies for the five GCDs in GMA 12. It should be noted that Table 5-9 shows the data that was presented during the development of the proposed DFCs in 2015 and 2016. The amount of permitted

pumpage and production under these permits changes regularly as the GCDs review and approve new permits. The total permitted pumpage in the five GCDs is 419,688 ac-ft/yr. This amount is approximately 165,000 ac-ft/yr greater than the total for the district MAGs, which is 254,472 ac-ft/yr. The total permitted pumpage is also more than 130,000 ac-ft/yr greater than the sum of the current groundwater supplies and groundwater management strategies, which totals approximately 285,000 ac-ft/yr.

Based on this review, GMA 12 determined that the proposed DFCs are not anticipated to have a significant impact on the water supplies, water supply needs, or water management strategies of the 2012 State Water Plan. This evaluation of water supply needs, as presented in the 2012 State Water Plan, was vital to the GMA 12 deliberations on how to provide a balance between the highest practicable level of groundwater production and the conservation, preservation, protection, recharging and prevention of waste of groundwater in the management area.

Table 5-8 2012 State Water Plan Amounts for Supplies, Demands and Strategies for the 14 Counties that Comprise GMA 12

% of County in GMA 12	County (*non-GCD)	2012 State Water Plan Amounts for 2060 (ac-ft/yr)				
		Groundwater Supplies	Surface Water Supplies	Water Demands	Water Supply Need (-) Surplus (+)	Water Management Strategies
100%	Bastrop	24,489	20,016	65,266	-20,761	62,600
	Brazos	62,743	24,317	59,564	27,496	20,349
	Burleson	14,745	10,357	19,168	5,934	31,798
	Freestone	5,313	26,348	39,396	-7,735	8,967
	Lee	4,799	1,728	6,603	-76	20,986
	Leon	6,439	0	7,347	-908	1,024
	Madison	2,816	0	3,266	-450	569
	Robertson	24,352	38,580	69,342	-6,410	19,001
More than 40%	Milam	11,434	32,743	36,934	7,243	2,951
	Fayette	8,622	45,866	79,542	-25,054	1,865
Less than 40%	Falls*	5,547	11,758	7,958	9,347	7,872
	Limestone*	5,760	27,771	49,418	-15,887	8,612
	Navarro*	496	14,899	31,482	-16,087	110,598
	Williamson*	13,791	106,536	234,936	-114,609	68,132
Total		191,346	360,919	710,222	-157,957	365,324

Table 5-9 2012 State Water Plan Amounts for Supplies, Demands and Strategies for the Five GCDs that a part of GMA 12

		Groundwater Conservation District					
		Brazos Valley GCD	Fayette County GCD	Lost Pines GCD	Mid-East Texas GCD	Post Oak Savannah GCD	All GCDs
2010 MAG (AF)		90,889	10,656	42,845	28,088	81,994	254,472
Existing Permits (AF)		137,711	12,222	61,710	18,014	190,031	419,688
2012 State Water Plan Amounts for 2060 (AF)	Groundwater Supplies	87,095	8,622	29,288	14,568	26,179	165,752
	Surface Water Supplies	62,897	45,866	21,744	26,348	43,100	199,955
	Water Demands	128,906	79,542	71,869	50,009	56,102	386,428
	Water Balance Need (-) Surplus (+)	21,086	-25,054	-20,837	-9,093	13,177	-20,721
	All Water Management Strategies	39,350	1,865	83,586	10,560	34,749	170,110
	Groundwater Management Strategies	4,500	1,681	78,563	1,358	33,411	119,513

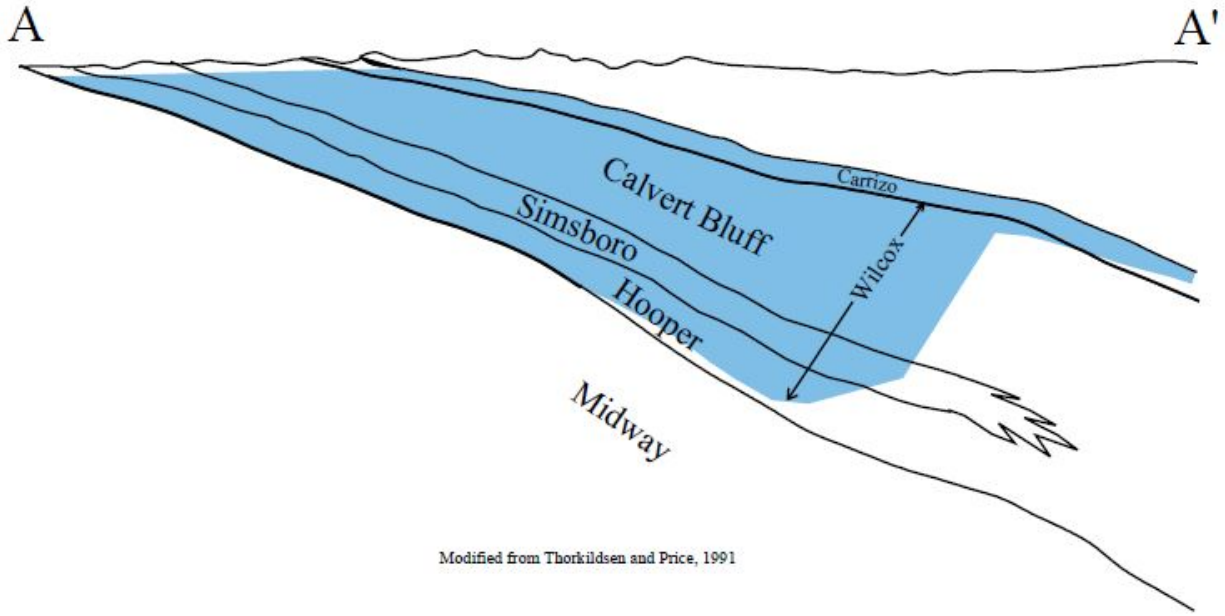

Figure 5-11 Generic cross-section of the Carrizo-Wilcox Aquifer in GMA 12 (modified from Ashworth and Hopkins, 1995).

5.3 Hydrological Conditions

Texas Water Code Section 36.108 (d)(3) requires that, during the joint-planning process, GCDs shall consider "hydrological conditions, including for each aquifer in the management area the total estimated recoverable storage as provided by the executive administrator, and the average annual recharge, inflows, and discharge." This section describes the hydrological conditions for each of the major and minor aquifers present within GMA 12 for which DFCs were developed. These aquifers include:

- Carrizo-Wilcox Aquifer, which includes the Carrizo, Calvert Bluff, Simsboro, and Hooper hydrostratigraphic units
- Queen City Aquifer
- Sparta Aquifer
- Yegua-Jackson Aquifer, and
- Brazos River Alluvium Aquifer.

In this section, we also will provide a discussion on the total estimated recoverable storage (TERS) values provided by the TWDB to GMA 12, as well as the annual average recharge, inflows, and discharge estimates provided to each GCD in the GMA by the TWDB in support of the development of each GCD's management plan.

5.3.1 Geology and Hydrogeology

The aquifers for which DFCs were developed in GMA 12 consists of, from oldest to youngest, the Carrizo-Wilcox, Queen City, Sparta, Yegua-Jackson and Brazos River Alluvium aquifers. The outcrop for each of these aquifers is shown in Figure 5-1. With the exception of the Brazos River Alluvium, which is a shallow alluvial unit present along the Brazos River, these formations are composed of layers of partially consolidated sands, silts, and clays and all outcrop from southwest to northeast, and dip to the southeast towards the Gulf of Mexico.

5.3.1.1 Carrizo-Wilcox Aquifer

The largest and most productive unit in GMA 12 is the Carrizo-Wilcox Aquifer. This aquifer system contains four separate and distinct hydrostratigraphic units within most of GMA 12. From oldest to youngest, the hydrostratigraphic units comprising the Carrizo-Wilcox Aquifer are the Hooper, Simsboro, Calvert Bluff, and Carrizo aquifers. These individual aquifers are identifiable through most of GMA 12 where the Simsboro is present as a hydrostratigraphic unit and acts as a readily identifiable divider. However, the Simsboro is absent south of the Colorado River and north of the Trinity River, so the Hooper and Calvert Bluff sediments there are simply lumped together as undifferentiated Wilcox Group sediments. **Figure 5-11** shows a generic cross-section of the Carrizo-Wilcox Aquifer in the GMA 12 area. Each of the hydrostratigraphic units within the Carrizo-Wilcox Aquifer System is described separately below.

Carrizo Formation. The uppermost hydrostratigraphic unit in the Carrizo-Wilcox Aquifer is the Carrizo Formation. This hydrostratigraphic unit consists of fine to coarse-grained massive, well-sorted sand (Thorkildsen and Price, 1991; Rogers, 1967). The Carrizo occurs under unconfined conditions in the outcrop area and under confined conditions downdip. As with the three Wilcox hydrostratigraphic units, most groundwater development in the Carrizo Formation occurs in and near the outcrop, but fresh

groundwater has been produced from the Carrizo as far downdip as Fayette County, as shown in Figure 5-3. The Carrizo is also a much more extensive unit, with significant production occurring from it across the state. The Carrizo is a highly productive unit to the south in GMA 12, where water developers have installed and are planning on installing large-volume well fields. Water quality in the Carrizo Aquifer has typically been considered fresh to moderately saline. A recently installed municipal well by the Fayette Water Supply Corporation produces significant quantities of groundwater at over 1,200 gallons per minute (gpm) with a total dissolved solids (TDS) concentration of approximately 230 milligrams per liter (mg/L).

Calvert Bluff Formation. The Calvert Bluff Formation is the uppermost of the three Wilcox units and is found directly below the Carrizo. This hydrostratigraphic unit consists of fine- to coarse-grained sandstones interbedded with varying amounts of finer grained sediments as well as some lignite beds (Thorkildsen and Price, 1991). The Calvert Bluff can be up to 2,000 feet thick, and although not as productive as the Simsboro, it can be very productive in limited areas (Thorkildsen and Price, 1991). Most of the development of groundwater from the Calvert Bluff is in the area within about 8 to 10 miles of the outcrop, as shown in Figure 5-4. A few deeper wells are found in the downdip areas, but most wells producing from this unit are relatively shallow.

Simsboro Formation. The next aquifer below the Calvert Bluff is the Simsboro Formation. This hydrostratigraphic unit is identifiable as a separate unit only in GMA 12. The Simsboro is composed of fine- to coarse-grained sand with only small amounts of finer sediments (Thorkildsen and Price, 1991). The Simsboro can be up to 800 feet thick and highly productive. The Simsboro is well developed in and near the outcrop, but it is also highly productive and mainly utilized downdip (Figure 5-5), with many high capacity wells completed to screen depths of 1,000 to 3,000 feet. Most of the Wilcox pumpage in GMA 12 is from the Simsboro, and it is the unit that is typically targeted for groundwater development in the region.

Hooper Formation. The oldest and deepest unit producing groundwater in GMA 12 is the Hooper Formation. This hydrostratigraphic unit is below the Simsboro and is the deepest of the three main hydrostratigraphic units that make up the Wilcox Aquifer in the region. The Hooper consists primarily of mudstone with some fine- to medium-grained sandstone. In GMA 12 the Hooper can be more than 1,300 feet thick, but is generally less than 500 feet thick in the updip areas where groundwater development typically occurs (Thorkildsen and Price, 1991). It is the least productive of the hydrostratigraphic units within the Carrizo-Wilcox Aquifer, with most development occurring in and near the outcrop, as shown in Figure 5-6. In some areas, however, the Hooper can be moderately productive.

5.3.1.2 Queen City Aquifer

Above the Carrizo-Wilcox Aquifer, separated by the Reklaw Formation, is the Queen City Aquifer. This aquifer is formed by the Queen City Sand, which is a loosely-cemented, Tertiary-aged, very-fine-grained sandstone interbedded with silt and silty shale (LBG-Guyton, 2003; George and others, 2011; Kelley and others, 2004; Follett, 1974). Like the other aquifers in the GMA, the Queen City Aquifer occurs under unconfined conditions in the outcrop area and under confined conditions downdip. And as with the other GMA 12 aquifers, much of the groundwater development in the Queen City has occurred in and near the outcrop, but some development in the downdip areas also has occurred, as shown in Figure 5-7. Recharge occurs within the outcrop areas. Water quality in the Queen City Aquifer is mostly fresh to slightly saline within GMA 12, with increasing salinity farther downdip. The Queen City Aquifer can yield small to moderate quantities of water to wells.

5.3.1.2 Sparta Aquifer

Above the Queen City Aquifer, separated by the Weches Formation, is the Sparta Aquifer. This aquifer is formed by the Sparta Sand, which is a massive to cross-bedded, generally well-sorted, fine- to medium-grained sand with some thin interbeds of clay and silt throughout. The Sparta Aquifer occurs under unconfined conditions in the outcrop area and under confined conditions downdip. Recharge occurs within the outcrop areas. Fresh water usually occurs in and near the outcrop areas, and water quality deteriorates with depth. Much of the development of groundwater resources from the Sparta has occurred in and near the outcrop, with some wells producing water in the downdip areas within about 15 miles of the outcrop, as shown in Figure 5-8. The saturated thickness of the Sparta aquifer averages about 120 feet and will yield small to moderate quantities of fresh to moderately saline water to wells in GMA 12 (LBG-Guyton, 2003; George and others, 2011; Kelley and others, 2004; Follett, 1974).

5.3.1.4 Yegua-Jackson Aquifer

The uppermost of the dipping coastal aquifers in GMA 12 is the Yegua-Jackson Aquifer. This aquifer is formed by the Yegua Formation and the Jackson Group, which consist of beds of clay, silt, sand, and shale, with some lignite and gypsum. The Yegua-Jackson Aquifer outcrops through most of the lower third of GMA 12, as shown in Figure 5-9. The aquifer occurs under water table conditions in the outcrop areas and artesian conditions in the deeper portions of the aquifer. Water quality in the Yegua-Jackson is highly variable due to the nature of the sediments that make up the aquifer matrix. Fresh to moderately saline groundwater can be found in many areas, but the groundwater generally becomes more saline with increasing depth. The more productive sand units within the Yegua-Jackson tend to pinch out farther downdip, and the overall productivity of the aquifer decreases. The Yegua-Jackson Aquifer can yield small to moderate quantities of groundwater to wells in GMA 12 (LBG-Guyton, 2003; George and others, 2011; Rogers, 1967).

5.3.1.5 Brazos River Alluvium Aquifer

The Brazos River Alluvium Aquifer occurs along the Brazos River between the Post Oak Savannah and Brazos Valley GCDs. The aquifer is present in the shallow floodplain deposits of the Brazos River that range from clay to gravels or large cobbles. The aquifer is typically less than 100 feet thick and only occurs under unconfined conditions and is hydraulically connected to the Brazos River. It is typically also in hydraulic connection with underlying aquifers where the alluvial sediments overlie the outcrops of those aquifers. The Brazos River Alluvium Aquifer only occurs within about five miles of the Brazos River, as shown in Figure 5-10.

5.3.2 Total Estimated Recoverable Storage (TERS)

Part of the evaluation of the hydrological conditions of the aquifers within a GMA is the total estimated recoverable storage (TERS) value provided by the TWDB. The TWDB defines “recoverable” as the estimated amount of groundwater that accounts for recovery scenarios that range from 25% to 75% of the total amount of groundwater in storage.

It is important to note that the TERS is solely based on how much water is present in the subsurface within the “official” aquifer extents defined by the TWDB according to the regional GAM or other method used to estimate the storage. If an aquifer had an active model cell within an area in the GAM, it was included in the TERS calculations regardless of whether or not it could actually produce water for

water supply purposes. The process does not take into account water quality, meaning that brackish or even saline groundwater present in an aquifer is included in the total. TERS is a "one-size-fits-all" definition of groundwater based solely on GAM parameters, when in reality the actual amount of recoverable groundwater will vary based on the aquifer type and other conditions.

A good example of this is the Carrizo-Wilcox Aquifer in Fayette County. According to the TWDB TERS report to GMA 12 (Wade and Shi, 2014), there is 95,000,000 acre-feet of water in storage in the Carrizo-Wilcox in Fayette County, as shown in **Table 5-10**.

Table 5-10 Total estimated recoverable storage (TERS) in the Carrizo-Wilcox Aquifer in Fayette County

Hydrostratigraphic Unit	Total Storage (acre-feet)
Carrizo	20,000,000
Calvert Bluff	36,000,000
Simsboro	14,000,000
Hooper	25,000,000
Total	95,000,000

The TWDB TERS report states that there is 75,000,000 acre-feet of water in storage in the Wilcox portion of the Carrizo-Wilcox Aquifer in Fayette County. In reality, there are no wells in the Wilcox portion of the Carrizo-Wilcox Aquifer in Fayette County. All three Wilcox hydrologic units were declared "not relevant" by the GMA because these units are too deep and contain water that is too poor quality to be usable for water supply purposes.

For realistic planning purposes, the Carrizo is the only hydrostratigraphic unit within the Carrizo-Wilcox aquifer in Fayette County that is actually suitable for water supply purposes. Therefore, the stated TERS for the Carrizo-Wilcox Aquifer in Fayette County of 95,000,000 acre-feet is misleading. In reality, the true amount of groundwater storage available for water supply purposes is probably at most 20,000,000 acre-feet, which is significantly less than the 95,000,000 acre-feet estimated in Wade and Shi (2014).

The TERS for GMA 12 were provided by the TWDB in GAM Task 13-035 (Wade and Shi, 2014). This report is provided in **Appendix H**. **Table 5-11** summarizes the total amount of groundwater in storage according to the estimates made by the TWDB and provided in that report.

Table 5-11 Total amount of groundwater in storage (TERS) (in acre-feet) in GMA 12

County	Trinity	Carrizo-Wilcox	Queen City	Sparta	Yegua-Jackson	Gulf Coast	Brazos River Alluvium
Bastrop	9,000,000	98,000,000	9,500,000	2,500,000	290,000	--	--
Brazos	--	69,000,000	25,000,000	4,250,000	30,000,000	450,000	290,000
Burleson	--	120,000,000	29,000,000	4,000,000	27,000,000	--	450,000
Falls	--	820,000	--	--	--	--	140
Fayette	--	95,000,000	4,750,000	12,000,000	27,000,000	--	--
Freestone	--	46,000,000	290,000	--	--	--	--
Lee	500,000	130,000,000	23,000,000	10,000,000	10,000,000	--	--
Leon	--	180,000,000	25,000,000	4,600,000	76,000	--	--
Limestone	--	12,000,000	--	--	--	--	--
Madison	--	110,000,000	20,000,000	16,000,000	15,000,000	--	--
Milam	--	47,000,000	650,000	--	--	--	28,000
Navarro	--	1,000,000	--	--	--	--	--
Robertson	--	110,000,000	8,800,000	1,300,000	--	--	270,000
Williamson	1,600,000	500,000	--	--	--	--	--
TOTAL	**11,100,000**	**1,019,320,000**	**160,240,000**	**79,400,000**	**109,366,000**	**450,000**	**1,038,140**

5.3.3 Average Annual Recharge, Inflows, and Discharge

A required component for characterizing the hydrological conditions of aquifers within a GMA is estimating values for average annual recharge, inflows, and discharge for each aquifer. These values were provided by the TWDB to each GCD within GMA 12 as "GAM Run" reports in support of the development of district management plans. The following reports were provided for the GMA 12 area by the TWDB:

- **Fayette County GCD -** GAM Run 13-002 (Wade, 2013)
- **Lost Pines GCD -** GAM Run 10-014 (Hassan, 2010)
- **Post Oak Savannah GCD -** GAM Run 10-029 (Aschenbach, 2011)
- **Brazos Valley GCD -** GAM Run 14-005 (Jones, 2014)
- **Mid-East Texas GCD -** GAM Run 13-024 (Jones, 2013)

These TWDB reports are provided in **Appendix I** through **Appendix M**. The values of the annual average recharge, inflows, and discharge compiled from these reports were provided to GMA 12 in a presentation on May 28, 2015 entitled "GMA 12: Hydrological Conditions Consideration Discussion." This presentation is included as **Appendix N**.

Values for the Brazos River Alluvium Aquifer were not provided by the TWDB and are therefore not included in this report.

5.4 Environmental Factors

Texas Water Code §36.108 (d)(4) requires that, during the joint-planning process, districts shall consider "other environmental impacts, including impacts on spring flow and other interactions between groundwater and surface water."

Groundwater pumping causes the hydraulic pressure in the pumped well and in the surrounding aquifer to decline. If the pumping is sufficiently large and sufficiently long, the decline in hydraulic pressure can spread into the shallow groundwater flow system near a spring or surface water body. If this occurs, the water level in the aquifer decreases and hydraulic gradient between the groundwater and the surface water body changes. If the water flowed from the aquifer to a spring or a surface water body prior to pumping, then groundwater pumping will lessen or reverse the hydraulic gradient. A decrease in the hydraulic gradient from the groundwater system to the surface water system can cause a reduction in spring flow or a reduction in stream baseflow. A complete reversal of the hydraulic gradient causes the flow direction to change, resulting in flow from the stream or surface water body into the aquifer. In the case of springs, if the pumping causes the water level to drop below land surface, and the regional flow system is the only source of water to the spring, then the spring will stop flowing.

The process by which pumping can impact the direction and magnitude of the flows between groundwater and surface water was discussed in a GMA 12 meeting on August 13, 2015. A presentation was prepared and presented by the hydrogeological consultants to member districts of GMA 12 and is titled "Presentation to GMA-12: Environmental Impact Considerations." This presentation is included as **Appendix O**. As explained in the presentation, the groundwater availability models used to set the GMA 12 DFCs are not reliable simulators of groundwater-surface water interaction and should not be used to predict the impacts that pumping can have on groundwater-surface water interaction. Reliable simulations of flow interactions between surface water bodies and aquifers requires that the groundwater model properly represent the shallow groundwater flow system in the vicinity of the surface water body. The Central Queen City and Sparta Aquifers GAM, like most groundwater availability models, does not have sufficient refinement in the thicknesses of the model layers near the ground surface to accurately simulate a shallow groundwater flow system. A review of the water balances associated with the model calibration and DFC future pumping scenarios from the Central Queen City and Sparta Aquifers GAM indicates that the Central Queen City and Sparta aquifers GAM tend to underestimate the contribution of groundwater to stream baseflow during pre-development conditions and overestimate the capture of stream baseflow where large pumping is occurring near the river. Because GMA 12 does not consider the Central Queen City and Sparta Aquifers GAM to be a reliable simulator of groundwater-surface water interaction, the values produced by the model were not directly used to evaluate and develop DFCs.

GMA 12 acknowledges that both spring flow and groundwater-surface water interactions are potentially important environmental issues. However, GMA 12 did not set a DFC for these flow components for several reasons. In the case of groundwater-surface water interaction, it is redundant to set a DFC since river authorities are already actively monitoring and managing flows in the major rivers as part of the Texas Instream Flow Program. The Texas Instream Flow Program was created by the Texas Legislature in 2001 to assess how much water rivers need to maintain a sound ecological environment. The program is administered by three agencies: Texas Commission on Environmental Quality, Texas Parks and Wildlife Department, and TWDB. The dam releases and active monitoring by the river authorities as part of this program will prevent groundwater pumping from ever reducing river flows enough to cause a risk to the

health of the river aquatic system. This also provides an early warning system if groundwater pumping ever does become a problem, without the need for the GMA to set an additional DFC. Another reason for not developing a DFC for stream or spring flow is that the GAMs do not yet provide reliable predictions of how pumping will impact flows to either springs or rivers and streams. Therefore, the GMA has no defensible scientific basis by which to set establish DFC for spring flow. In addition, the concept of a spring flow DFC is more problematic than the limitations associated with the GAM predictions because there is insufficient historical data on spring flows from which to develop a meaningful spring flow DFC.

5.5 Subsidence

Texas Water Code Section 36.108 (d)(5) requires that, during the joint-planning process, GCDs shall consider "the impact on subsidence." This section details the potential impact of the DFCs on subsidence within GMA 12.

The potential for significant measurable subsidence is generally related to the age of the sediments and the depth of sediment burial (Gabrysch, 1984). This is because fine grained sedimentary strata will naturally experience compaction over geologic time as more sediment is deposited above the layers and as the layers are more deeply buried. The aquifers that provide water in GMA 12 are composed of essentially unconsolidated layers of sand, clay, shale and minor amounts of gravel. Sand and clay layers are interbedded throughout most of the aquifers within the GMA, with some layers consisting of mostly clay with minor amounts of sand (e.g. the Hooper Formation) and others with thick sand layers and minor amounts of clay (e.g., the Simsboro Formation). In these types of aquifers, land subsidence can occur when pumping from wells results in large decreases in artesian hydraulic head that in turn cause depressurization of the clay layers and a subsequent release of water and vertical compaction of the clays. The vertical compaction of the clay layers, if sufficiently large, will be associated with an equivalent lowering of land surface elevation.

Land surface subsidence within the state of Texas has been identified and measured in the Houston-Galveston area (Gabrysch, 1984; Holdahl et al., 1898) as well as in parts of far West Texas (Chi and Reilinger, 1984). Although the Gulf Coast formations in the Houston-Galveston area are lithologically similar to those in GMA 12, they are much younger (typically less than 5 million years old), meaning that the clay strata have not experienced much natural consolidation. Therefore, the Gulf Coast sediments are more susceptible to significant pumping-related dewatering and vertical compaction than the sediments in the GMA 12 area.

The aquifers that provide water in GMA 12 are substantially older (33 to 55 million years old) than the Gulf Coast formations in the Houston-Galveston area (Dutton et al., 2003). The clay and shale strata within the aquifers of GMA 12 have already experienced considerable natural compaction and are considered to have a low risk of pumping-related consolidation. In addition, subsidence has not been identified anywhere within GMA 12, despite large-scale pumping and associated drawdowns in several major pumping centers including Bastrop and the Bryan-College Station area (Huang et al., 2012).

Subsidence was briefly discussed at the GMA 12 meetings on June 25, 2015 and September 24, 2015 and the GMA's hydrological consultants confirmed that subsidence was not currently an issue for any district in GMA 12. Based on the available data and the results of previous studies, the overall risk of

subsidence within GMA 12 is assumed to be negligible. Therefore, the proposed DFCs are not expected to have any negative impact on subsidence within GMA 12.

5.6 Socioeconomics

Texas Water Code Section 36.108 (d)(6) requires that, during the joint-planning process, GCDs shall consider "socioeconomic impacts reasonably expected to occur." The following is a discussion of GMA 12's consideration of the sixth factor listed in Subsection 36.108 (d) of the Texas Water Code to be examined in the Explanatory Report (ER), and a review of how the relevant aquifer DFCs within GMA 12, impact this factor. The GMA considered socioeconomic impacts reasonably expected to occur as a result of the proposed DFCs for relevant aquifers. The consideration of socioeconomic impacts as part of state water planning, both at the regional and state level, has been an element of the planning process dating back to the 1990s.

5.6.1 Regional Planning Assessment of Socioeconomic Impact

During each five-year planning cycle, regional water planning groups (RWPGs) evaluate population projections, water demand projections, and existing water supplies. Each planning group then identifies water shortages under drought of record conditions, a critical component to both the regional water plans (RWPs) and the State Water Plan. Determining and evaluating both short- and long-term water supply needs help us to better understand "how the needs for water could affect communities throughout the State during a severe drought and to plan for meeting those needs" (TWDB, 2012). In addition, water management strategies are developed and recommended by the planning groups to address the potential shortages identified. The goal of the water planning process is to ensure that entities have adequate water supplies in times of drought. In order to reach this goal, the TWDB, which is statutorily responsible for administering the regional water planning process, provides guidance within the Texas Administrative Water Code.

The analysis performed by the TWDB consists of a series of point estimates of one-year droughts at 10-year intervals. The socioeconomic impact analysis attempts to measure the impacts on water user groups should the identified water supply needs not be met. For this socioeconomic impact analysis, multiple impacts are examined including:

- sales income and tax revenue
- jobs
- population
- school enrollment

The regional water planning process and the development of the State Water Plan are governed differently statutorily than the GMA's joint planning process. The processes for both the regional water plans and the State Water Plan are directed by 31 Texas Administrative Code Chapter 357, which requires planning groups to use the results of the socioeconomic impact analysis provided by the TWDB and the data developed within the joint planning process by the GMAs. In contrast, the joint planning process is governed by the Texas Water Code Chapter 36, which has a different directive provided to GMAs and GCDs in Subsection 36.108(d). This directive requires GCDs to consider the socioeconomic impacts reasonably expected to occur prior to adopting a proposed DFC, and then for an adopted DFC,

the Explanatory Report developed in support of the joint planning process, should document that the nine factors were considered.

5.6.2 Other Considerations of Socioeconomic Impacts

The method used by the TWDB for evaluating social and economic impacts for not meeting shortages considers the demand side. This analysis concentrates on impacts or benefits of providing water to people, business and the environment. To develop economic baselines, the most widely used tools are input/output models (IO models) combined with social accounting matrices (SAMs). These are referred to as IO/SAM models. These tools formed the basis for estimating agriculture (irrigation and livestock water uses), and industry (manufacturing, mining, steam-electric, and commercial business activity for municipal water uses).

The socioeconomic impact analyses provided by the TWDB to Regions C, G, H and K regional planning groups for the 2011 Regional Water Plans (Norvell and Shaw, 2010a through 2010d) were considered as part of the GMA 12 deliberations on socioeconomic impacts reasonably expected to occur as a result of the proposed DFCs for relevant aquifers in GMA 12. Those documents illustrate the regional impacts of not meeting water supply needs within a region for specific water user groups. **Figures 5-12** and **5-13** illustrate the socioeconomic impacts of not meeting water supply needs in Region G based on the 2011 Region G Regional Water Plan. As shown on the Figure 5-12, lost income within the region could reach about $8 billion by 2060 on an annual basis. Similarly, Figure 5-13 illustrates that there could be a loss in population of about 70,000 people by 2060 if the projected water demands are not met.

5.6.3 Socioeconomic Considerations in GMA-12

The requirement that districts shall consider the socioeconomic impacts before voting on the desired futures conditions of the aquifers was added to the statues of joint planning with the passage of Senate Bill 660 in 2011. As part of their continued efforts to meet the “balance test” described in Subsection 36.108 (d-2) of the Texas Water Code, GMA 12 has considered socioeconomic impacts for this second round of joint planning.

The potential socioeconomic impacts reasonably expected to occur due to DFCs were discussed in a GMA 12 meeting on August 13, 2015. A presentation was prepared and presented by the hydrogeological consultants to member districts of GMA 12 and is titled “GMA 12 Socioeconomic impacts considerations.” This presentation is included as **Appendix P**. GMA 12 held numerous meetings during the second cycle of joint planning that provided opportunities for unrestricted public comment regarding socioeconomic impacts or the potential for them to occur. In this manner, district representatives were able to obtain stakeholder input from across GMA 12’s geographical boundaries from a variety of interest areas such as recreation, real estate, commerce, irrigation and agriculture, political subdivisions, environmental groups, private property, tourism, cities, groundwater developers, river authorities and others. From a qualitative perspective, GMA 12 realizes that both positive and negative socioeconomic impacts may potentially result from the implementation of the proposed DFCs. In their deliberations while creating DFCs, district representatives aimed to achieve a balance of the positive and negative impacts.

GMA 12 examined the following socioeconomic considerations that would potentially have a positive impact upon the adoption of the proposed DFCs:

- Proposed DFCs in some areas of the GMA may reduce or eliminate the costs of lowering pumps and either deepening existing wells or constructing new wells.
- Proposed DFCs may serve to sustain or enhance economic growth due to assurances provided by diversified water portfolios.
- Proposed DFCs may result in a short-term reduction in utility rates due to reduction in cost of water management strategy implementation.

Comparatively, the following socioeconomic considerations were identified as potentially having a negative impact upon the adoption of the proposed DFCs:

- Proposed DFCs may require conversion of part or all of a supply to an alternative supply or supplies, which may have increased costs associated with infrastructure, operation and maintenance.
- Proposed DFCs in some areas of the GMA may result in significant but unquantified production cost increases due to continuing to lower water levels in wells.
- Proposed DFCs may result in a reduced groundwater supply being available on a long-term basis.
- Proposed DFCs may require the lowering of well pumps and/or the deepening of existing wells or constructing new wells.

5.6.4 Impacts of Major and Minor Aquifer DFCs on Socioeconomic Impacts Reasonably Expected to Occur

There are many challenges involved with directly assessing socioeconomic impacts likely to occur for the major and minor aquifer DFCs within GMA 12. Numerous factors can feasibly contribute to potential economic or social impacts of water planning on the water user. Regional DFCs are one factor to be considered, and are not a guarantee for social or economic stability, development opportunities or prosperity to any user.

Although DFCs are an important variable in establishing a framework for setting long-term water management plans and practices, they are not the only variable to be studied. Other factors to be considered are the occurrence of drought and demographic shifts. Both of these factors play a role in impacting the outcome of how water is managed economically and socially.

By setting DFCs for the Carrizo-Wilcox, Queen City, Sparta, Yegua-Jackson, and Brazos River Alluvium aquifers that meet current demands and achieve a balance in providing water availability for growth and preservation, GMA 12 believes these DFCs meet the “balance test” prescribed by Subsection 36.108 (d-2) of the Texas Water Code.

5.7 Private Property Rights

Texas Water Code Section 36.108 (d)(7) requires that, during the joint-planning process, GCDs shall consider “the impact 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 Section 36.002.” GMA 12 recognizes that the primary method by which private property rights are protected in GMA 12 is through each GCD’s management plan and groundwater rules. Because the local hydrogeological conditions, environmental, and socioeconomic factors vary across GMA 12, the manner in which GCDs protect private property rights may vary among the GCDs.

GMA 12 members considered private property rights during the DFC creation process in several ways. GMA 12 members reviewed the component GCDs' management plans to insure they appropriately address private property rights. Groundwater Management Area 12 also had a presentation on the private property rights impact from DFCs on June 25, 2015 (**Appendix Q**). This presentation included discussion on recent court cases involving groundwater and private property rights as well as the potential consequences that imposing too lax or too restrictive DFCs can have on personal property rights. A keystone to all discussions regarding private property rights was the Texas Water Code Section 36.002, which reads as follows:

> *"Sec. 36.002. OWNERSHIP OF GROUNDWATER.*
> *(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 entitle the landowner, including a landowner's lessees, heirs, or assigns, to:*
> > *(1) 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; and*
> > *(2) have any other right recognized under common law.*
> *(b-1) The groundwater ownership and rights described by this section do not:*
> > *(1) 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; or*
> > *(2) 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.*

Based on a review of the GCDs' individual management plans and related factors, GMA 12 members do not anticipate that the adoption of the GMA 12 DFCs will significantly affect personal property rights

associated with groundwater during the planning horizon. In crafting DFCs, GMA 12 aimed to balance property interests and rights that are benefitted by the use of groundwater in the present, near future and long term and those benefitted by preservation, or leaving groundwater in place. The DFCs adopted by GMA 12 are consistent with protecting property rights of landowners who are currently pumping groundwater and landowners who have chosen to conserve groundwater by not pumping. All current and projected uses, as defined in the Regions C, G, H and K plans, were considered in developing the adopted desired future conditions. By setting DFCs for the GMA 12 that meet current demands and achieve a balance in providing water availability for growth and preservation, GMA 12 believes the adopted DFCs meet the "balance test" prescribed by Subsection 36.108 (d-2), Texas Water Code.

5.8 Feasibility of Achieving the Proposed Desired Future Condition

Texas Water Code Section 36.108 (d)(8) requires that GCDs, during the joint groundwater planning process, consider the feasibility of achieving the proposed DFC(s). This requirement was added to the joint groundwater planning process with the passage of Senate Bill 660 by the 82nd Texas Legislature in 2011. This review concept can be traced back to 2007, when the TWDB adopted rules that provided guidance for petitions contesting the reasonableness of an adopted DFC. Under these 2007 rules, the TWDB required that an adopted DFC must be physically possible from a hydrological perspective.

From 2010 to 2011, the TWDB reviewed multiple petitions regarding the reasonableness of adopted DFCs in GMAs. Their evaluation of whether or not an adopted DFC was physically possible was based on whether or not the DFC(s) could be reasonably simulated using the TWDB's adopted GAM for the aquifer(s) in question. This approach assumes that, if an adopted DFC is not physically possible, then, under the physical laws of hydrology as incorporated in the mathematical calculations executed during model simulations, the model would not execute the prescribed simulation successfully.

While GMA 12 recognizes that the GAMs represent the best science for understanding the groundwater flow systems in GAM 12, they also recognize that the GAMs have been demonstrated to contain error and uncertainty. As such, GMA 12's philosophy for both the previous and the current joint planning periods was that DFCs are feasible if they can be generated by a GAM *within a reasonable tolerance*. The factors used to determine what "a reasonable tolerance" means for GMA 12 include:

- GMA predictive uncertainty/error
- Unknown errors in starting 2000 water level conditions
- Uncertainty in future environmental conditions (for example, recharge and rivers levels)
- Uncertainty in future pumping rates & locations
- Error/uncertainty in measurement of DFCs to demonstrate compliance
- Non-uniqueness of model calibration

Based on an evaluation of these factors, GMA 12 considers DFCs to be feasible, compatible and physically possible if the following conditions were met.

1. For the Queen City, Sparta, Carrizo, Hooper and Calvert Bluff aquifers, the difference between the proposed DFCs and the DFC predicted by Central Queen City -Sparta GAM (Kelley and others, 2004) must be no more than 10% or 5 feet, whichever is greater.

2. For the Simsboro Aquifer, the difference between proposed DFCs and the DFC predicted by Central Queen City -Sparta GAM (Kelley and others, 2004) must be no more than 5% or 5 feet, whichever is greater.
3. For the Yegua-Jackson Aquifer, the difference between the proposed DFCs and the DFC predicted by Yegua-Jackson GAM (Deeds and others, 2010) must be no more than 10% or 5 feet, whichever is greater.

As the newly adopted GMA 12 DFCs meet these criteria, the GMA considers them feasible, compatible and physically possible.

GMA 12's approach to evaluating the feasibility of DFCs by applying tolerance criteria to the relevant GAMs was presented on August 13, 2015 in a presentation titled "Presentation to GMA-12: Feasibility of a DFC." This presentation is included in **Appendix R**.

5.9 Any Other Relevant Information

Texas Water Code Section 36.108 (d)(9) requires that, during the joint-planning process, GCDs shall consider "any other information relevant to the specific desired future conditions." All relevant comments and input discussed by GMA 12 during the 19 joint groundwater planning meetings from 2012-2016 (**Table 1-3**), are sufficiently covered in Sections 5.1 to 5.8 above. There was no other information deemed relevant to the proposed DFCs presented or discussed at any GMA meeting.

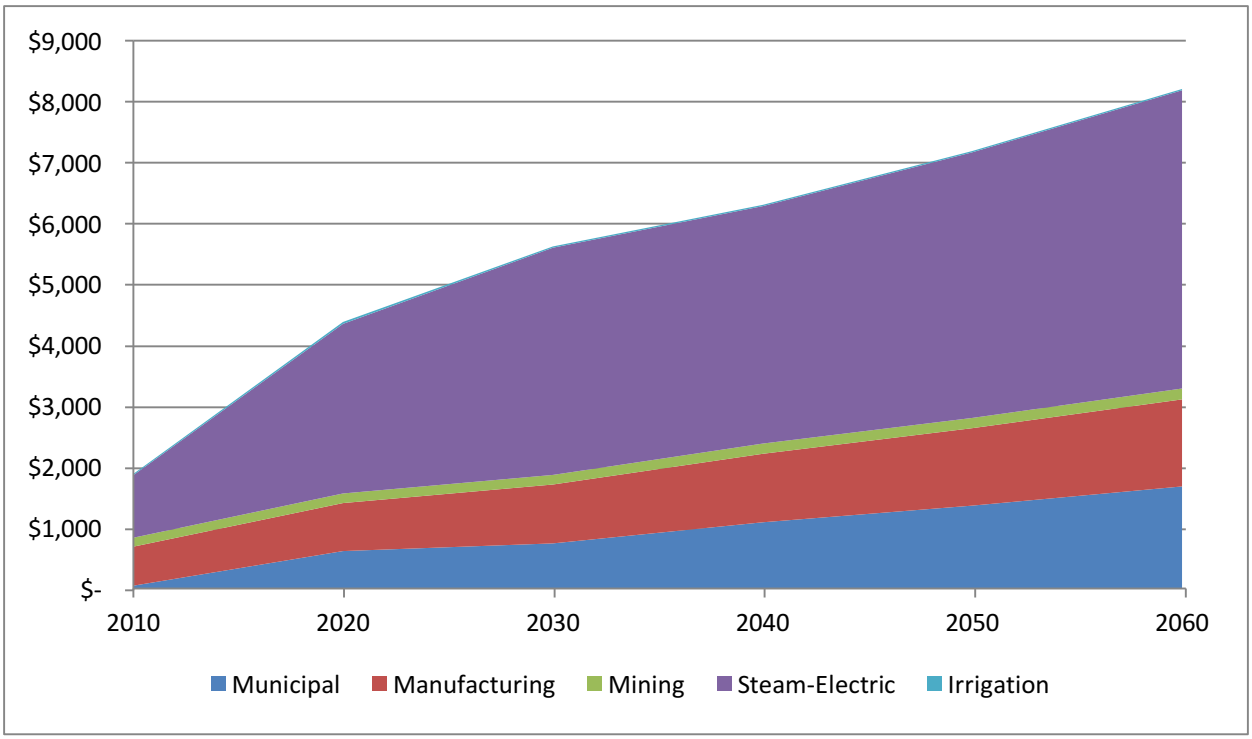

Figure 5-12 Socioeconomic Impacts Analysis – 2011 Brazos G Regional Water Plan Lost Income by Sector ($millions)

For full analysis, see Norvell and Shaw (2010a).

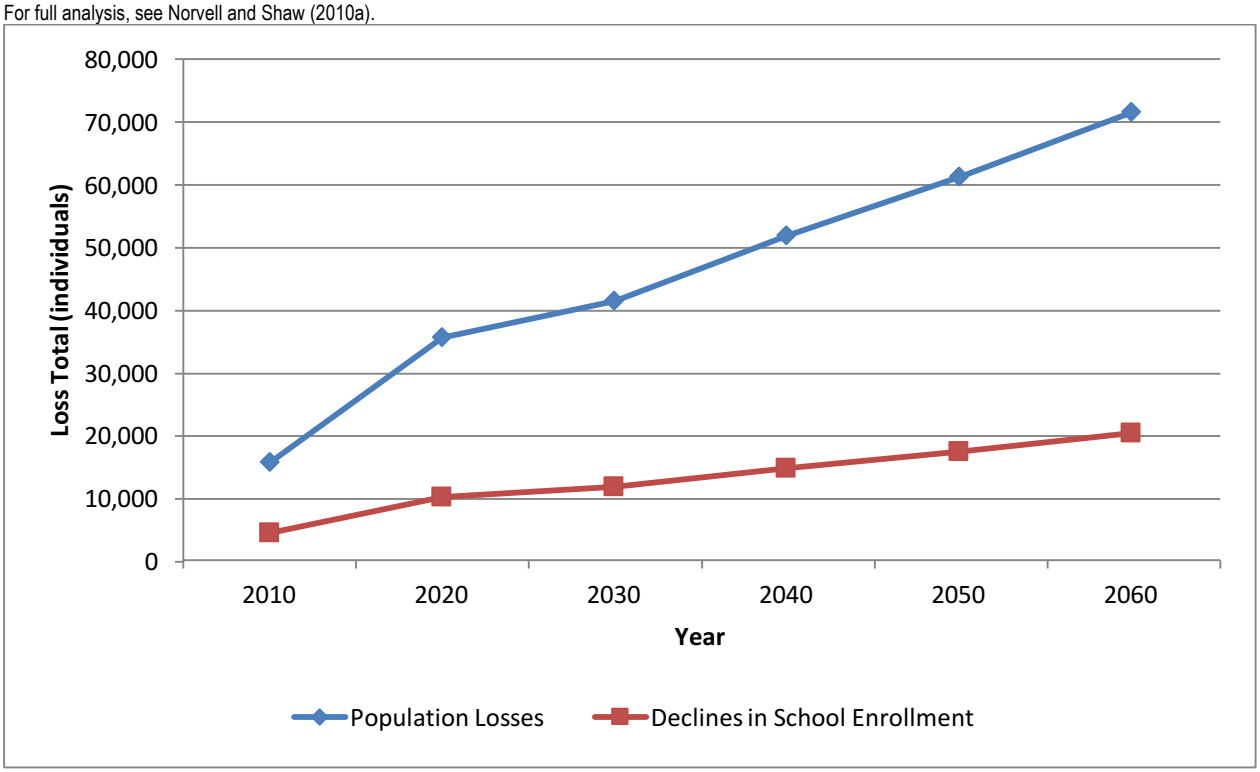

Figure 5-13 Social Impacts of Water Shortages in Region G

For full analysis, see Norvell and Shaw (2010a).

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6.0 OTHER DESIRED FUTURE CONDITIONS CONSIDERED

Texas Water Code Section 36.108(d-3)(4) requires that, during the joint groundwater planning process, GCDs shall "list other desired future condition options considered, if any, and the reasons why those options were not adopted."

There were no other DFCs officially considered during the current round of joint groundwater planning. There were, however, many ideas and perspectives regarding groundwater planning and the DFCs discussed during the planning process. Many of these are covered in previous sections of this Explanatory Report. In particular, GMA 12 spent considerable time and effort producing several other GAM runs with different amounts and locations of groundwater pumpage and evaluating the drawdowns that would result from these different pumpage scenarios. However, while these additional runs were discussed in terms similar to how the DFCs are described (i.e., by average county and GCD-wide drawdowns), none of these ideas were ever technically considered to be potential DFCs. Rather, the different pumping scenarios were just the evaluation of pumping extremes on the aquifers for discussion purposes.

Ultimately, a conservative approach was taken by GMA 12 whereby the DFCs would largely stay the same as the DFCs from the first round of joint groundwater planning. The reason for this was two-fold. First, most of the nine factors specified for consideration by Texas Water Code § 36.108 (see Section 5 of this Explanatory Report) were already considered during the development of the previous set of DFCs, although not as formally as during the current round of joint groundwater planning. Using the same consideration process led to adopting DFCs very similar to those from the previous round of planning. Second, the GAM for the major aquifer(s) of interest in the GMA 12 area is currently being revised, and many of the issues raised by GMA 12 stakeholders that could not be addressed by the current model should be addressed by the update of this model. For this reason, GMA 12 felt that the best approach for the current round of joint groundwater planning would be to leave the DFCs from the first round of planning largely unchanged. Once a new model is available, the updated GAM will be available to evaluate these concerns and guide development of a new set of DFCs.

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7.0 RECOMMENDATIONS AND COMMENTS RECEIVED

This section provides a summary of the comments received by GMA 12 and GMA 12 member GCDs on the proposed DFCs and during the 90-day period for public comment on the DFCs proposed by GMA 12. Comments received by GMA 12 or GMA 12 member GCDs on the proposed DFCs during the 90-day comment period are summarized in **Table 7-1**. Only specific comments on the proposed DFCs are addressed in this Explanatory Report. Because of the lengthy nature of these comments and responses, only a summary is provided here. The full text of the comments and GMA 12's response to the comments are provided in **Appendices S** through **V**.

7.1 Comments Received by Brazos Valley GCD

Two sets of comments in Table 7-1 were received by the Brazos Valley GCD. One set of comments was from the City of Bryan and another was from Cathy Lazarus. The comments and GMA 12's responses to them are provided in **Appendix S**.

7.2 Comments Received by Fayette County GCD

No comments were received by the Fayette County GCD on the proposed DFCs.

7.3 Comments Received by Lost Pines GCD

Four sets of comments in Table 7-1 were received by the Lost Pines GCD; three written comments and one set of oral comments at the public hearing held by the Lost Pines GCD on July 20, 2016. These include:

- Environmental Stewardship
- Thornhill Group Inc. on behalf of Forestar
- Lower Colorado River Authority
- Mr. Hugh Brown

These comments and GMA 12's responses to them are provided in **Appendix T**.

7.4 Comments Received by Mid-East Texas GCD

No comments in Table 7-1 were received by the Mid-East Texas GCD on the proposed DFCs.

7.5 Comments Received by Post Oak Savannah GCD

No comments in Table 7-1 were received by Post Oak Savannah GCD. Post Oak Savannah GCD did respond to a set of comments submitted by Mr. Curtis Chubb on 3/27/2015. These comments and GMA 12's responses to them are provided in **Appendix U**.

7.6 Comments Received from Texas Water Development Board

Comments were received from the Texas Water Development Board following the initial submittal of the proposed DFCs. Responses to the comments are provided in **Appendix V**.

Table 7-1 Summary of all comments received by GMA 12 on the proposed DFCs

Date	Stakeholder	Description
7/8/2016	Cathy Lazarus	Public comments
7/14/2016	LCRA	Letter submitted to LPGCD
7/18/2016	City of Bryan	Letter submitted to BVGCD
7/20/2016	Forestar/TGI	Letter submitted to LPGCD
7/20/2016	Environmental Stewardship	Letter submitted to LPGCD
7/20/2016	Hugh Brown	Oral comments made to LPGCD during public hearing

8.0 SUMMARY

The adopted DFCs were approved by GMA 12 on April 27, 2017. This Explanatory Report provides a review of the GMA 12 area, the technical and policy justifications for the adopted DFCs, and the nine factors that were considered during the development of the DFCs, as required by Section 36.108(d)(1-8) of the Texas Water Code. This Explanatory Report also includes all comments and alternative DFCs that were proposed by stakeholders in the GMA, and GMA 12's responses to these comments.

8.1 Summary of DFCs

The final DFCs adopted by GMA 12 are summarized in **Tables 8-1** through **8-3**.

Table 8-1 Adopted DFCs for the Sparta, Queen City, Carrizo, Calvert Bluff, Simsboro, and Hooper Aquifers.

Groundwater Conservation District or County	Average Aquifer Drawdown (ft) Measured					
	From January 2000 thru December 2069					
	Sparta	Queen City	Carrizo	Calvert Bluff	Simsboro	Hooper
Brazos Valley	12	12	61	125	295	207
Fayette County	47	64	110	Declared as non-relevant		
Lost Pines	5	15	62	100	240	165
Mid-East Texas	5	2	80	90	138	125
Post Oak Savannah	28	30	67	149	318	205
Falls County	-	-	-	-	-2	27
Limestone County	-	-	-	11	50	50
Navarro County	-	-	-	-1	3	3
Williamson County				-11	47	69
GMA 12	16	16	75	114	228	168

Table 8-2 Adopted DFCs for the Yegua-Jackson Aquifer.

Groundwater Conservation District	Average Aquifer Drawdown (ft) Measured From January 2010 thru December 2069		
	Yegua	Jackson	Yegua-Jackson Combined
Brazos Valley	70	114	--
Fayette County	--	--	77
Lost Pines	Declared as non-relevant		
Mid-East Texas	--	--	7
Post Oak Savannah	--	--	100
GMA 12	--	--	65

Table 8-3 Adopted DFCs for the Brazos River Alluvium Aquifer.

County	DFC Statement
Milam	A decrease of 5 feet in the average saturated thickness over the period from 2010 to 2070. The baseline average saturated thickness for 2010 is estimated at 24.5 feet and is based on an analysis of historical water level data and well depth values.
Burleson	A decrease of 6 feet in the average saturated thickness over the period from 2010 to 2017. The baseline average saturated thickness for 2010 is estimated at 38.5 feet and is based on analysis of historical water level data and well depth values.
Brazos and Robertson	Percent saturation above well depth shall average at least 30 percent for wells located north of State Highway 21 and 40 percent for wells located south of State Highway 21. If the percent saturation criteria are reached for three consecutive years then the DFC would be reached.

8.2 Rationale and Justification for DFC Selection

The newly adopted DFCs for GMA 12 are similar to those adopted by GMA 12 in 2010 during the first round of joint groundwater planning. Minor adjustments were made to the DFCs to account for new information regarding site conditions. As the previous DFCs were designed for a 50-year period ending in 2060, the new DFCs also had to be modified slightly to accommodate the new planning timeline ending in 2070.

The newly adopted DFCs are very similar to the existing DFCs because GMA 12 had similar objectives for groundwater management during both joint planning cycles. The joint groundwater planning process has undergone some significant changes since the first round of planning in 2010, in particular, the addition of nine factors that must be formally considered by the GMA when developing DFCs, as itemized in Texas Water Code § 36.108. However, in GMA 12's case, most of these factors were already taken into consideration during the first round of planning, just not formally as currently specified in statute. The result is new DFCs that are very similar to the previous DFCs. An additional reason for adopting similar DFCs is that the TWDB is currently updating the Central Queen City-Sparta GAM.

Section 5 of this Explanatory Report provides a detailed discussion of the nine factors that were considered during the development of the initially proposed DFCs. In addition to these nine factors, GMA 12 has also considered three other factors, including (a) the reliability of the Central Queen City-Sparta GAM to accurately predict drawdowns caused by pumping, (b) stakeholder comments, and (c) an assessment of achieving a balance between groundwater production and preservation. These additional factors are discussed below.

Prior to the start of the second joint groundwater planning session in 2011, GMA 12 consultants identified concerns regarding the capability of the Central Queen City-Sparta GAM (Kelley and others, 2004) to accurately simulate groundwater-surface water interactions and drawdowns in the vicinity of the Mexia-Talco fault zone. One concern was the overprediction of drawdowns near the Mexia-Talco fault zone, which were likely caused by an oversimplified mapping of the fault locations. Another concern was the overprediction of stream losses caused by pumping near the streams that is attributed to the oversimplified manner in which the model is constructed, in particular the unrealistic manner in which the model simulates a direct hydraulic connection between deep aquifers and surface water resources. As a result of identifying these two major issues, a new project to improve the Central Queen City-Sparta GAM was initiated and is scheduled to be completed in 2018. This project is supported by TWDB, Brazos Valley GCD, Fayette County GCD, Lost Pines GCD, Mid-East Texas GCD, Post Oak Savannah GCD, the Lower Colorado River Authority, the Brazos River Authority, and the Colorado and Lavaca Rivers and Matagorda and Lavaca Bays Basin and Bay Area Stakeholder Committee (BBASC). The identification of these issues, combined with the prospect of new model development, discouraged GMA 12 from making significant changes to the existing DFCs until this new update of the Central Queen City-Sparta GAM is completed.

GMA 12's decision to be conservative toward changing the DFCs is shared by several stakeholders. Provided below are comments submitted by during the development of the DFCs:

- "…, it is incumbent upon us to use the best science we have available and common sense to estimate the potential impacts from the trends that are evident, and act accordingly. An appropriate action is to improve the tools, as is being done with the GMA-12 GAM improvement project, and to defer serious changes in the adopted desired future conditions until we have

better information available from monitoring and the improved tools to predict impacts. (Comments submitted September 21, 2015, by Environmental Stewardship)"

- "We unequivocally join ES's recommendation that GMA-12 take the following actions in completing the current round the DFCs review and adoption process: Re-adopt the currently adopted DFCs unchanged until the GAM improvements have been completed and adopted. (Comments submitted February 4, 2016 by the League of Independent Voters of Texas)"

Another reason GMA 12 was reluctant to significantly change the DFCs is that the existing DFCs already represent a reasonable balance between groundwater production and conservation, preservation, and protection of groundwater. The petitions received by GMA 12 on the existing DFCs provide evidence of this balance. During the first round of regional planning, the GMA was petitioned by two groups with opposing viewpoints —with one petition arguing that future pumping was *too little* based on the large amount of groundwater in storage while another petition argued that future pumping was *too large* based on potential impacts for surface water bodies.

Another test of the reasonableness of the existing DFCs is whether the planned groundwater production in GMA 12 is sufficient to help meet the anticipated water supply needs of Texas in the future. In the 2012 State Water Plan, the combined amount of groundwater supplies and groundwater strategies for GMA 12 in 2060 is 285,000 ac-ft/yr. This amount is slightly greater than GMA 12's total anticipated 2060 MAGs, which is 254,000 ac-ft/yr and significantly less that the 420,000 ac-ft/yr, which is currently permitted pumping in GMA 12. Since the existing DFCs can meet anticipated water supply needs, this implies that the existing DFCs are, in fact, reasonable.

9.0 REFERENCES

Chi, S.C. and Reilinger, R.E., 1984. Geodetic evidence for subsidence due to groundwater withdrawal in many parts of the United States of America; Journal of Hydrology, 67, 155-182.

Deeds, N.E., T. Yan, A. Singh, T.L. Jones, V.A. Kelley, P.R. Knox, and S.C. Young, 2010, Groundwater Availability Model for the Yegua-Jackson Aquifer; report prepared for the Texas Water Development Board, March , 2010, 582 p.

Dutton, A.R., B. Harden, J-P. Nicot, and D. O'Rourke, 2003, Groundwater Availability Model for the Central Part of the Carrizo-Wilcox Aquifer in Texas; report prepared for the Texas Water Development Board, February, 2003, 311 p.

Ewing, J.E., and M. Jigmond, 2016, Draft Numerical Model Report of the Brazos River Alluvium Aquifer Groundwater Availability Model; report prepared for the Texas Water Development Board, March, 2016, 320 p.

Follett, C.R., 1974. Ground-Water Resources of Brazos and Burleson Counties, Texas; Texas Water Development Board, Report No. 185, 66 p.

Gabrysch, R.K., 1984. Ground-water withdrawals and land-surface subsidence in the Houston-Galveston region, Texas, 1906-80; Texas Department of Water Resources Report 287, 64 p.

George, P.G., R.E. Mace, and R. Petrossian, Aquifers of Texas; Texas Water Development Board Report 380, July, 2011, 182 p.

Holdahl, S.R.; Holzschuh, J.C.; and Zilkoski, D.B.; 1989. Subsidence at Houston, Texas 1973-87; NOAA Technical Report NOS 131 NGS 44, 21 p.

Huang, Y., Scanlon, B.R., Nicot, J-P, Reedy, R., Dutton, A.R., Kelley, V.A., and Deeds, N.E., 2012. Sources of groundwater pumpage in a layered aquifer system in the Upper Gulf Coastal Plain, USA; Hydrogeology Journal, published online 13 April, 2012 (DOI 10.1007/s10040-012-0846-2), 14 p.

LBG-Guyton Associates, 2003, Brackish Groundwater Manual for Texas Regional Water Planning Groups: Texas Water Development Board.

Kelley, V.A., Deeds, N.E., Fryar, D.G., Nicot, J-P., Jones, T.L., Dutton, A.R., Bruehl, G., Unger-Holtz, T., and Machin, J.L., 2004, Groundwater Availability Models for the Queen City and Sparta Aquifers; report prepared for the Texas Water Development Board, October, 2004, 867 p.

Norvell, Stuart D. and Shaw, S. Doug, May 2010a. Socioeconomic Impacts of Projected Water Shortages for the Brazos G Regional Water Planning Area (Region G), Prepared in Support of the 2011 Region G Regional Water Plan. Texas Water Development Board. http://www.twdb.texas.gov/waterplanning/data/analysis/doc/2011/Region_G.pdf

Norvell, Stuart D. and Shaw, S. Doug, May 2010b. Socioeconomic Impacts of Projected Water Shortages for the Region H Regional Water Planning Area, Prepared in Support of the 2011 Region H Regional Water Plan. Texas Water Development Board. http://www.twdb.texas.gov/waterplanning/data/analysis/doc/2011/Region_H.pdf

Norvell, Stuart D. and Shaw, S. Doug, May 2010c. Socioeconomic Impacts of Projected Water Shortages for the Lower Colorado Regional Water Planning Area (Region K), Prepared in Support of the

2011 Region K Regional Water Plan. Texas Water Development Board. http://www.twdb.texas.gov/waterplanning/data/analysis/doc/2011/Region_K.pdf

Norvell, Stuart D. and Shaw, S. Doug, July 2010d. Socioeconomic Impacts of Projected Water Shortages for the Region C Regional Water Planning Area, Prepared in Support of the 2011 Region C Regional Water Plan. Texas Water Development Board. http://www.twdb.texas.gov/waterplanning/data/analysis/doc/2011/Region_C.pdf

Rogers, L. T., 1967. Availability and Quality of Ground Water in Fayette County, Texas; Texas Water Development Board Report no. 56.

Texas Water Development Board, 2012. Water for Texas 2012 State Water Plan. January 2012. http://www.twdb.texas.gov/waterplanning/swp/2012/index.asp

Thorkildsen, D., and R.D. Price, 1991. Ground-Water Resources of the Carrizo-Wilcox Aquifer in the Central Texas Region; Texas Water Development Board, Report No. 332, 59 p.

Wade, S., 2013, GAM Run 13-002: Fayette County Groundwater Conservation District Management Plan; TWDB Groundwater Availability Modeling Section Report, March 21, 2013, 19 p.

Wade, S., and J. Shi, 2014, GAM Task 13-035 Version 2: Total Estimated Recoverable Storage for Aquifers in Groundwater Management Area 12; TWDB Groundwater Availability Modeling Section Report, May 16, 2014, 43 p.