

To: Brazos G Regional Water Planning Group	
From: Larry Land, PE David Dunn, PE	Project: Brazos G 2011 Regional Water Plan
CC: Trey Buzbee, Brazos River Authority	
Date: April 8, 2009	Job No: 00010486-003

RE: Recommended groundwater availability estimates for the 2011 Brazos G Regional Water Plan

Introduction

Groundwater availability estimates have been determined on an aquifer-by-aquifer, and county-by-county basis. These estimates are used in the planning process to determine: (1) if a shortage exists from projected demands on this resource and (2) if a surplus exists for potential water management strategies. The locations of the major and minor aquifers in Brazos G are shown in Figures 1 and 2, respectively. Groundwater availability is also called Managed Available Groundwater (MAG).

Methods

For the 2006 Brazos G Regional Water Plan (2006 Plan), the groundwater availability estimates adopted by Brazos G Regional Water Planning Group (BGRWPG) were developed using one the following three generalized methodologies:

1. Application of a Groundwater Availability Model (GAM) developed by the Texas Water Development Board (TWDB). A GAM does not directly determine groundwater availability, but calculates the response (groundwater levels and inflow/outflow rates) of an aquifer system over time to a specific pattern and rate of pumping. Only the Carrizo-Wilcox Aquifer System (C-W Aquifer) GAM was available at the time the 2006 Plan was prepared.
2. Analysis of historical pumping records, groundwater level data, and knowledge of the hydrogeology of the aquifer system.
3. Adoption of estimates from earlier TWDB studies.

House Bill 1763 of the 79th Texas Legislature (2005) revised the source of groundwater availability estimates that are to be used in regional water plans. A summary of the new process follows:

1. Sixteen Groundwater Management Areas (GMA) have been delineated to cover Texas. GMA representation is provided by Groundwater Conservation Districts (GCD) within a given GMA.
2. GMA representatives are to defined Future Desired Conditions (DFC) for each aquifer.
3. The TWDB is to determine the Managed Available Groundwater (MAG) for each county and each aquifer on the basis of the DFC with a GAM, if available. If not, the TWDB is to determine the MAG on the basis of the DFC by a hydrologic analysis.
4. Regional planning groups are to use the MAG for groundwater availability (maximum potential groundwater supplies).

The new process for defining the groundwater availability in a planning region is in progress at this time (2009). In some cases, the MAG has been defined by the TWDB, but in most cases, either the

GMA representatives have not defined the DFC or the TWDB has not completed the necessary analyses to determine the MAG from the DFC. Until a final MAG has been determined, HDR has recommended, and BGRWPG has adopted, the following protocol for establishing groundwater availability estimates for the 2011 Plan. The protocol for utilizing a MAG is dependent on available information and occurs in the following sequence.

1. MAG was officially determined by the TWDB from an adopted DFC for a given aquifer by GMA representatives.
2. Preliminary MAG estimates have been made by a GMA consultant from adopted DFC. However, the TWDB has not officially made a MAG determination.
3. Preliminary MAG estimates have been made by a GMA consultant using a TWDB GAM from likely DFC criteria. The GMA officials have not formally adopted the DFC, nor has the TWDB made an official MAG determination.
4. Preliminary MAG estimates were made from a 2011 Brazos G GAM (Study 2) for the Dockum Aquifer in western Nolan County.
5. Preliminary MAG estimates are temporarily set equal to 2006 Brazos G groundwater availability estimates.
6. Preliminary MAG estimates are temporarily set equal to net recharge, which is based on estimated recharge rates and area of outcrop for newly delineated aquifers.

Of the five GMAs in Brazos G (see Figure 3), only GMA-8 has adopted a DFC for all counties and aquifers. However, the TWDB has completed a MAG determination on only a few of them. GMA 12 has potential consensus on DFCs and a preliminary MAG for the all aquifers except the Brazos River Alluvium and Yegua-Jackson. Two of the major aquifers [Edwards-Trinity (Plateau) and Seymour] have applicable GAMs; however, the GMAs and the TWDB have determined these GAMs are not suitable for the development of a MAG. For these and several other reasons, a preliminary MAG will not be available for aquifers in GMA 6, 7 and 14. In most cases, the preliminary MAG for the 2011 Plan is set to 2006 Plan estimates. In the cases where the TWDB has made new minor aquifer delineations, the estimates are made on the basis of hydrologic analyses, which assume all of the net recharge is available for development.

Results

HDR's recommendations for groundwater availability are presented in Table 1. As shown, the recommendations are subdivided by aquifer and county. For comparison purposes, the 2006 Brazos G groundwater availability and the change from the 2006 Plan to MAG are included. Finally, the protocol code that was used to determine the 2011 Plan groundwater availability is provided.

Discussion

Western Area

The Blaine Aquifer has been remapped by the TWDB. Previously, it was delineated to occur only in Knox County. The revised map shows that it also occurs in Fisher, Nolan and Stonewall Counties. HDR's recommends groundwater availability for the Blaine Aquifer to be based on the net recharge rate for the Blaine Aquifer. This rate is the calibrated value for the Blaine Aquifer in the Seymour GAM.

The Dockum Aquifer occurs mostly in Nolan County. In this county, the groundwater availability in the 2006 Plan has been revised on the basis of a GAM that was developed for Brazos G to evaluate Sweetwater's Champion Well Field. A Dockum GAM is available; however, its scale is too coarse to be suitable to estimate groundwater availability in the limited areas of Fisher and Kent

Counties. For these counties, HDR recommends using the groundwater availability estimates in the 2006 Plan for the 2011 Plan.

The Edwards-Trinity (Plateau) Aquifer occurs in Nolan and Taylor Counties. Lacking any new information, HDR recommends using the groundwater availability estimates in the 2006 Plan for the 2011 Plan.

The Seymour Aquifer occurs in six Brazos G counties. The Seymour GAM has been completed; however, it is considered by GMA-6 representatives and the TWDB to be unsuitable for calculating the MAG. Thus, HDR recommends using the groundwater availability estimates in the 2006 Plan for the 2011 Plan.

Central Area

A MAG has been determined by the TWDB for the Brazos River Alluvium (GMA-8 only), Edwards-BFZ (Northern Segment), and the Woodbine Aquifers. For the Brazos River Alluvium in GMA-8, the MAG is less than the 2006 Plan in two counties and greater in one county. This GMA-8 analysis shows some groundwater is available from the Brazos River Alluvium in Hill County. For the Edwards-BFZ (Northern Segment), the MAG is substantially greater than the 2006 Plan in Bell County and substantially less in Williamson County. For the Woodbine in Brazos G, the MAG is about 7,000 acft/yr; and, the 2006 Plan shows an availability of about 2,400 acft/yr. Most all this increase occurred in Johnson County.

For the Ellenburger-San Saba and Marble Falls Aquifers, a DFC has been adopted and a preliminary MAG has been determined by GMA-8. The revised groundwater availability shows a substantial increase for the Ellenburger-San Saba, and a substantial decrease for the Marble Falls.

For the Trinity Aquifer, a DFC has been adopted by representatives of GMA-8; and, preliminary MAG estimates have been made on the basis of a GAM simulation by the TWDB. However, the TWDB has not officially made a MAG determination. The simulations with the Trinity GAM were from 2000 to 2060 and held the pumping constant at the groundwater availability levels within each county. This annual pumping rate from 1980-2060 for the Trinity Aquifer in the Brazos G counties is shown in Figure 4. This chart shows that: (1) the total groundwater availability estimates for the 2006 Plan are somewhat less than actual pumping before 2000, and (2) the MAG is considerably greater than historical pumping. To illustrate the effects of long-term pumping at the 2006 Plan estimates and the preliminary MAG estimates, HDR conducted comparable GAM simulations.

The simulated pumping for the 2006 Plan was about 77,600 acft/yr from 2000 to 2060. The 1999 historical pumping (last year of actual pumping in the GAM) for Brazos G was 85,900 acft/yr. For the 2006 Plan and for the Hosston model layer, maps showing the 2060 water levels and the 2000-2060 drawdowns are presented in Figures 5 and 6, respectively. A study of the drawdown map shows a substantial recovery of groundwater levels (negative drawdown) because of the substantial reduction in pumping from historical to 2006 Plan rates, especially in Johnson and McLennan Counties.

The simulated pumping for the preliminary MAG is about 136,300 acft/yr from 2000 to 2060. For the preliminary MAG, maps of 2060 groundwater levels and drawdowns from 2000 to 2060 are shown in Figures 7 and 8, respectively. The water level map (figure 7) shows a major cone of depression in McLennan County, with water levels as low as 800 ft below mean sea level (msl). For reference to the position of the Trinity Aquifer, the elevations of the top and bottom of the major water-bearing zones are about 1,000 ft and 1,250 ft below msl, respectively. The drawdowns from 2000 to 2060 are as much as 700 ft in McLennan County and 300 ft in central Johnson County.

The difference in computed groundwater levels between the 2006 Plan groundwater availability estimates and the preliminary MAG is shown in Figure 9 for the most productive water-bearing zone (Hosston) of the Trinity Aquifer. In Johnson and McLennan Counties, the preliminary MAG shows water levels to be lower than the 2006 Plan by as much as 600 and 1,200 ft, respectively. This is caused by the groundwater availability being much greater in the preliminary MAG than in the 2006 Plan.

In summary, the total groundwater availability increased from about 77,600 acft/yr in the 2006 Plan to 136,300 acft/yr from the MAG determination, which is an increase of about 75 percent. The greatest increases are in Erath, Johnson, and McLennan Counties. In Johnson County, the groundwater availability increased by a factor of about 6; and in McLennan County, it increased by a factor of about 12. This would result in substantially lower groundwater levels than would pumping under the availability estimates used for the 2006 Plan.

Eastern Area

The Brazos River Alluvium and Gulf Coast Aquifer do not have an adopted DFC. Thus, no official MAG is available for the 2011 Plan. Without new information, HDR recommends using the groundwater availability estimates in the 2006 Plan for the 2011 Plan.

For the Sparta, Queen City, and Carrizo-Wilcox Aquifers, GMA-12 representatives are determining the DFC and the resulting MAG from simulations with the Queen City and Sparta GAM, which includes the Carrizo-Wilcox Aquifer. This GAM is an update of the Carrizo-Wilcox GAM that was used in 2006 Brazos G studies. The selection of the DFC and the resulting MAG is being determined by the GMA-12 representatives and consultants from tests of several pumping scenarios. At this time, there is a great possibility for consensus on an acceptable DFC and resulting MAG from a simulation called GAM-12 Run-3B. For purposes of the 2011 Plan, the 2060 pumping in Run-3B is believed to a reasonable estimate of MAG that will eventually be determined by the TWDB. Thus, for the 2011 Plan, the 2060 pumping in the Run 3B file is recommended as the preliminary MAG for the Sparta, Queen City and Carrizo-Wilcox Aquifers in GMA-12. In GMA-14, preliminary DFC and MAG determinations have not been made, thus, HDR recommends using groundwater availability from the 2006 Plan.

To illustrate the effects of long-term pumping at the 2006 Plan groundwater availability and the preliminary MAG, HDR conducted comparable GAM simulations. The simulations were from 1975 to 2060. HDR held the pumping for the 2006 Plan constant from 2010 till 2060 and adopted the pumping in Run 3B for the preliminary MAG (Figure 10). Pumping in Run-3B reflects the best available estimates of actual and permitted pumping. As shown in Figure 10, there is a transition in pumping for the 2000 decade from the historical levels to the groundwater availability levels. The historical pumping of the Carrizo-Wilcox Aquifer in 1999 within Brazos G was 91,500 acft/yr. The total Carrizo-Wilcox availability for the 2006 Plan and the preliminary MAG in 2060 was about 251,000 and 204,300 acft/yr, respectively. The preliminary MAG in relation to the 2006 Plan at the county level shows: (1) there is substantially less pumping in Burleson, Lee, Limestone and Milam Counties, and (2) substantially more pumping in Robinson County, and (3) little or no change in Brazos, Falls and Grimes Counties.

For 2006 Plan and for the Simsboro model layer, maps showing the 2060 water levels and drawdown from 2000 to 2060 are presented in Figures 11 and 12, respectively. The water level map of the Simsboro for the 2006 Plan (Figure 11) shows a major cone of depression in western Burleson County of about 450 ft below msl, and another one in western Brazos County where the groundwater levels are as low as 300 ft below msl. The drawdown is about 700 ft in western Burleson County. These water levels are greatly affected by the representation of major faults to the west.

For the preliminary MAG and the Simsboro layer, maps showing the groundwater level for 2060 and drawdown from 2000 to 2060 are shown Figures 13 and 14, respectively. The water level map of the Simsboro for the preliminary MAG (Figure 13) shows similar cones of depression as were shown for the 2006 Plan. Like the 2006 Plan, these water levels are greatly affected by the representation of major faults to the west.

The difference in water levels between the 2006 Plan and the MAG is shown in Figure 15. The preliminary MAG shows the impact on water levels in the Simsboro to be about 250 ft less in western Lee County and 190 ft less in western Milam County.

For the Queen City Aquifer, the groundwater availability in Brazos G for the 2006 Plan and preliminary MAG is about 3,500 and 1,800 acft/yr, respectively. Decreases occurred in all the GMA-12 counties. The greatest decrease was in Lee County.

For the Sparta Aquifer in the Brazos G area, the groundwater availability for the 2006 Plan and the preliminary MAG is about 10,300 and 13,900 acft/yr, respectively. The preliminary MAG shows a substantial increase over the 2006 Plan in Brazos County, while Lee County shows a substantial decrease.

The Yegua-Jackson Aquifer has been added by the TWDB to the list of minor aquifers in Texas. Lacking a preliminary or official MAG, HDR's recommends groundwater availability for the Yegua-Jackson Aquifer to be based on the net recharge rate. Using a hydrogeologic study of Grimes County, HDR estimated the groundwater availability for the five counties. This calculations show the groundwater availability to be about 22,900 acft/yr from the Yegua-Jackson in Brazos G.

Recommendations

HDR recommends that the Brazos G Regional Water Planning Group adopt the groundwater availability estimates listed in Table 1 for use in the 2011 Plan.

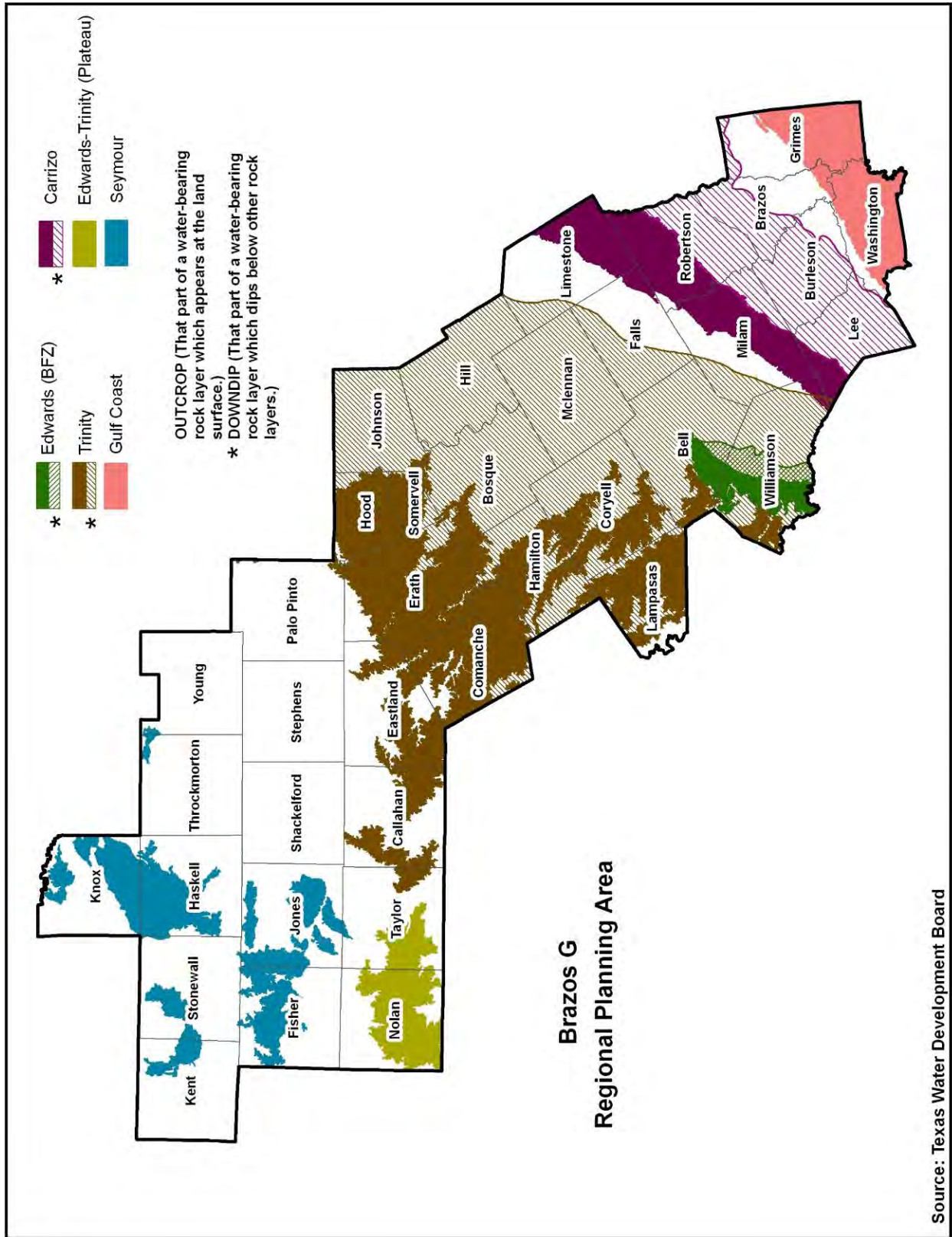
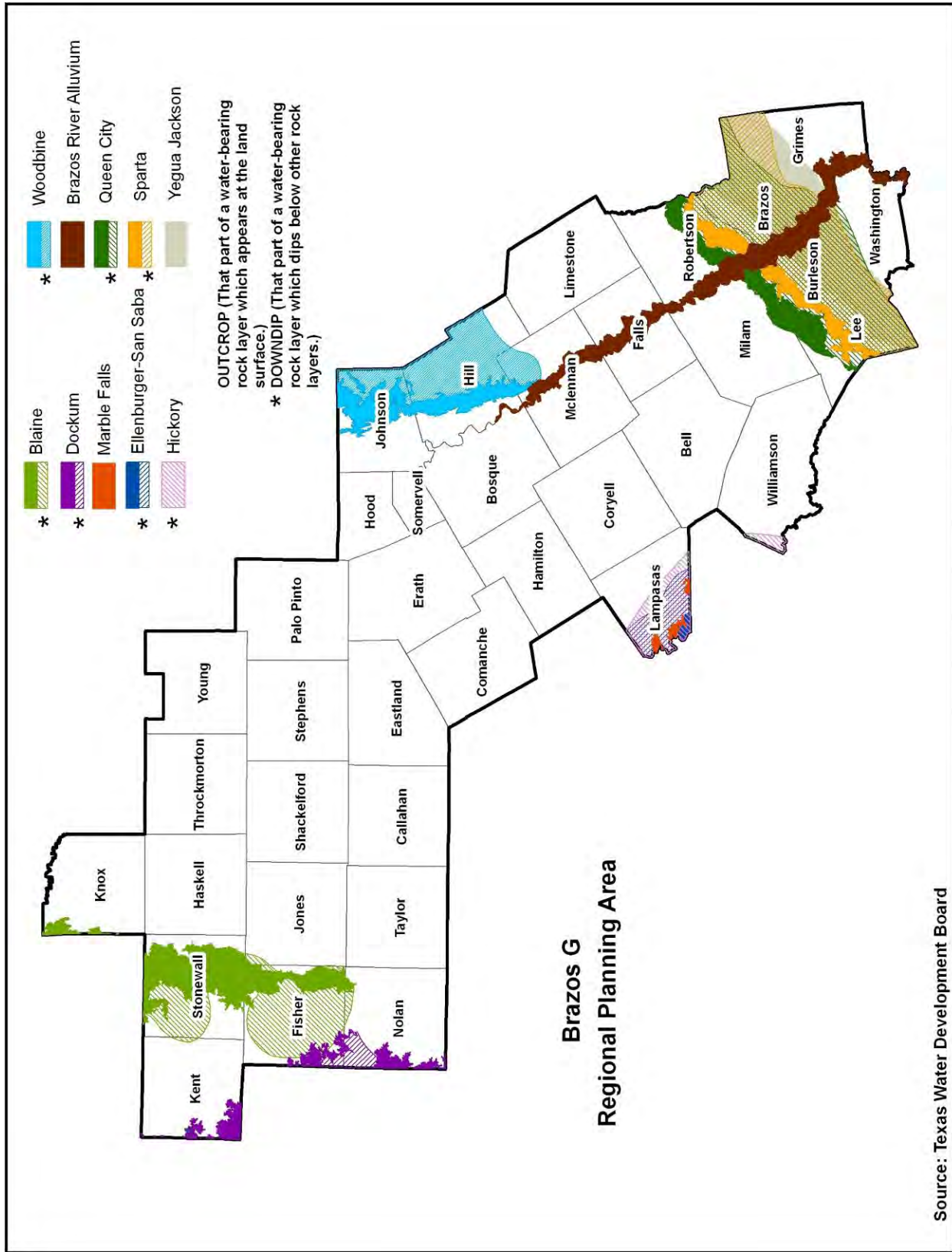
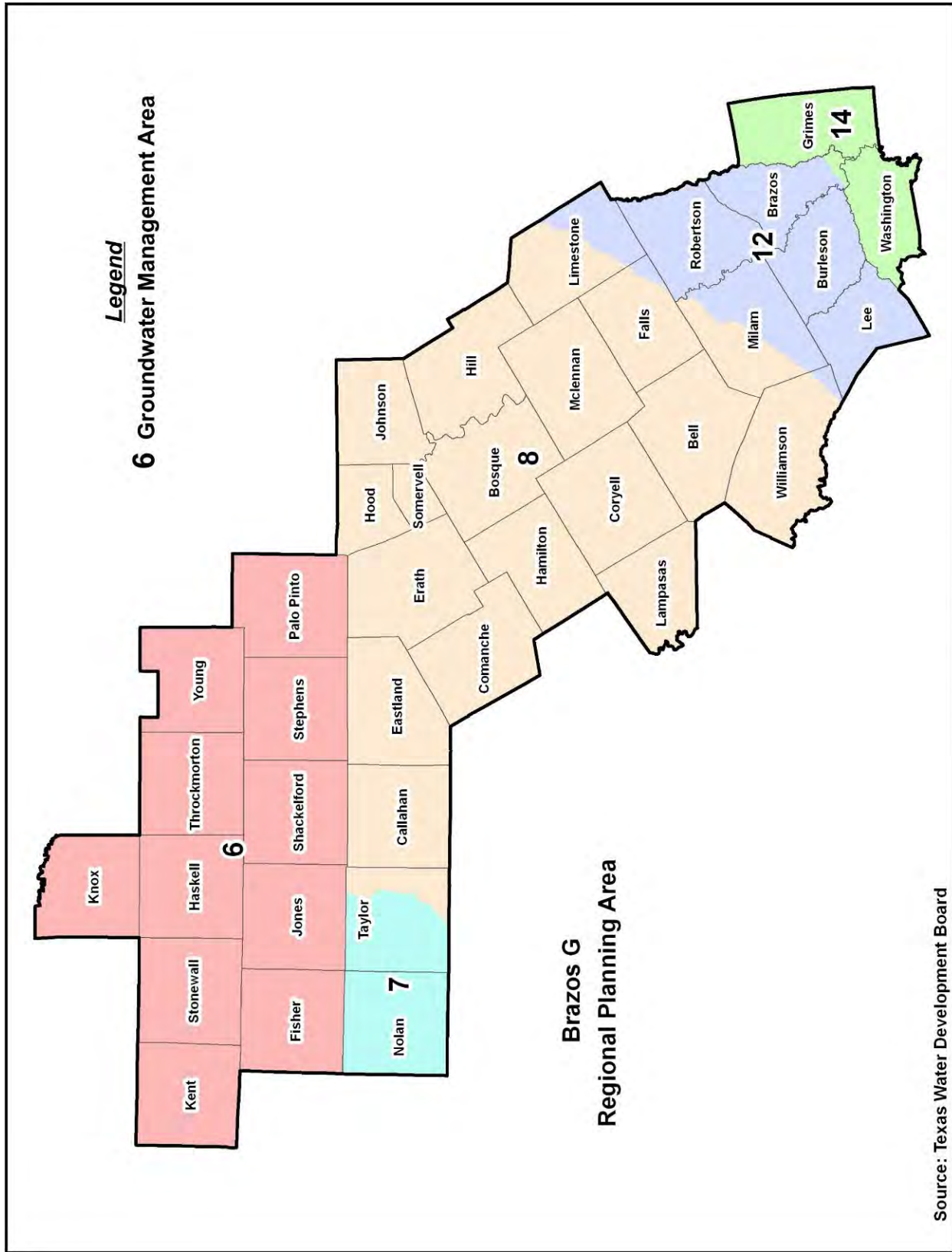


Figure 1. Major Aquifers in Brazos G



Source: Texas Water Development Board

Figure 2. Minor Aquifers in Brazos G



Source: Texas Water Development Board

Figure 3. Groundwater Management Areas in Brazos G

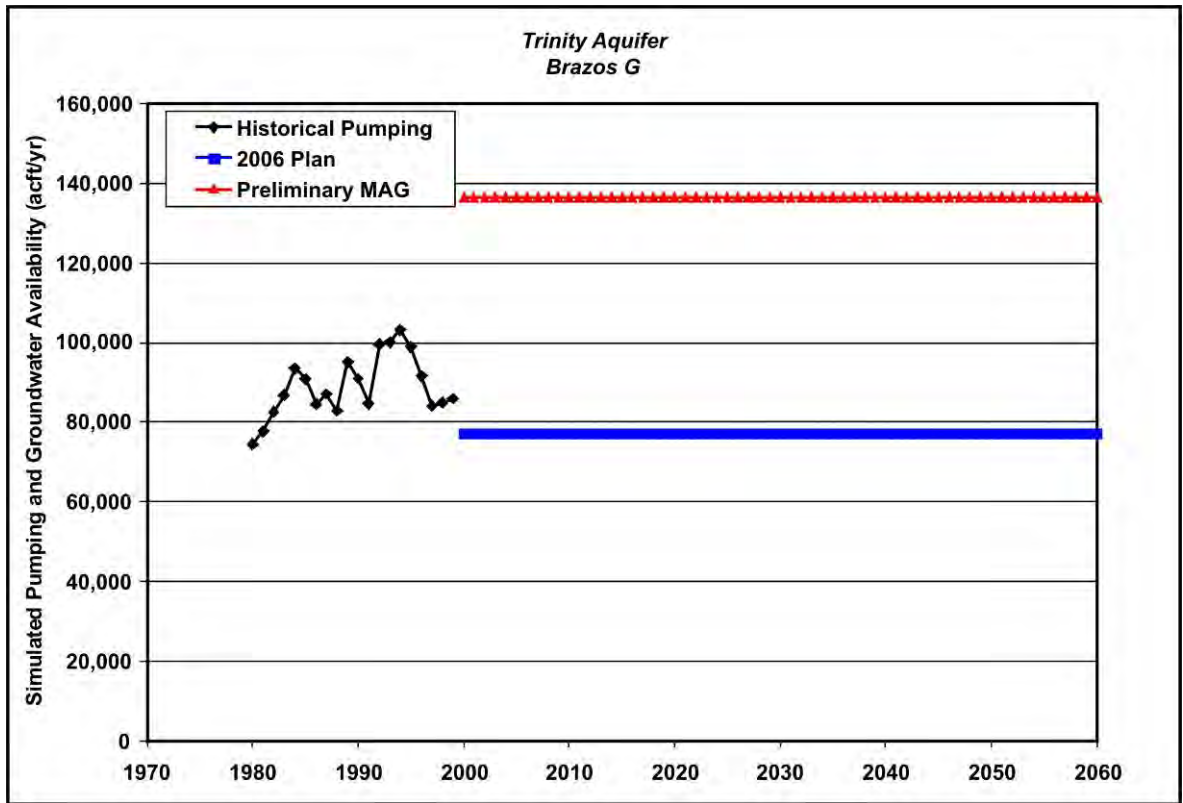


Figure 4. Simulated Brazos G Pumping from Trinity Aquifer

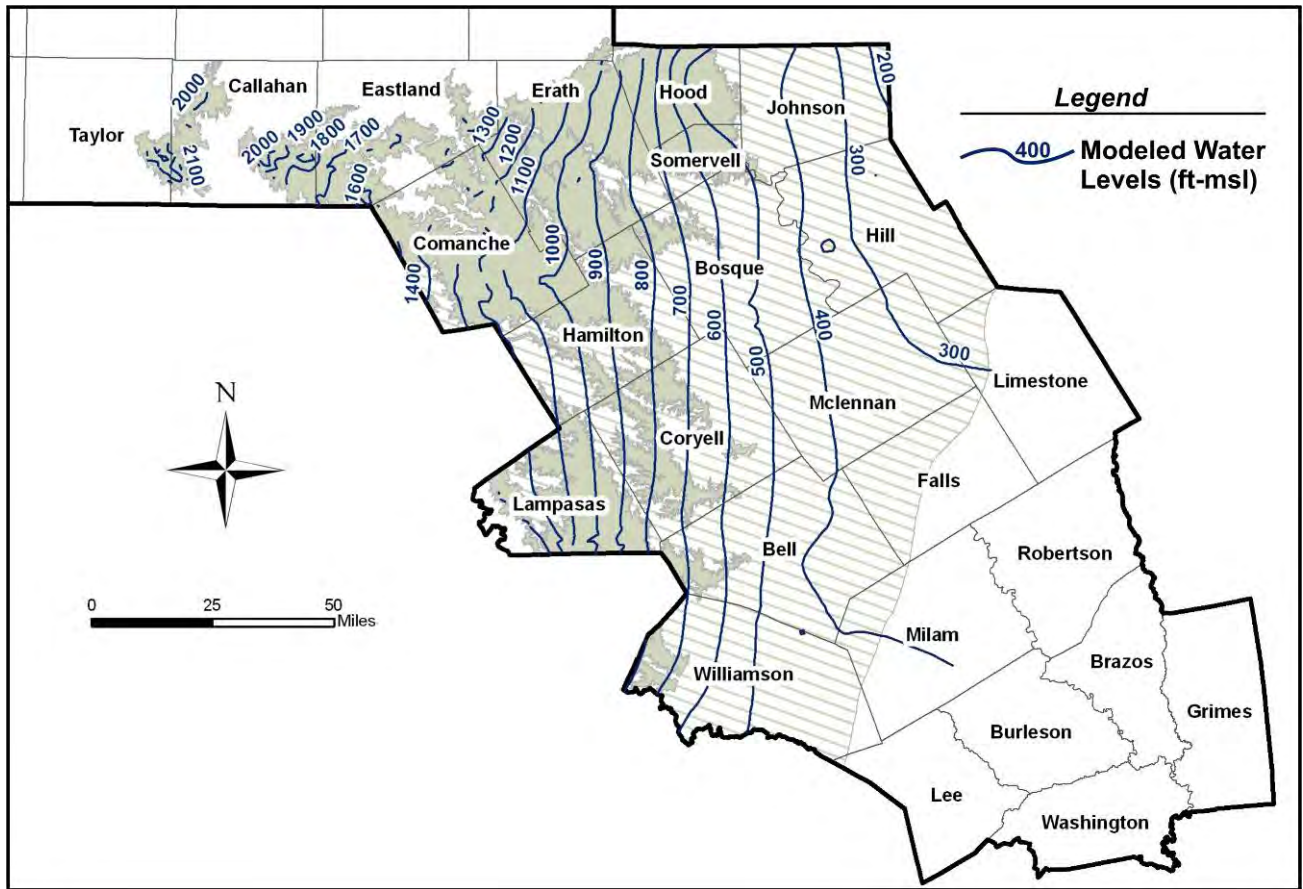


Figure 5. Water Levels in Hosston Layer Resulting from Pumping at Groundwater Availability in 2006 Brazos G Plan, 2060

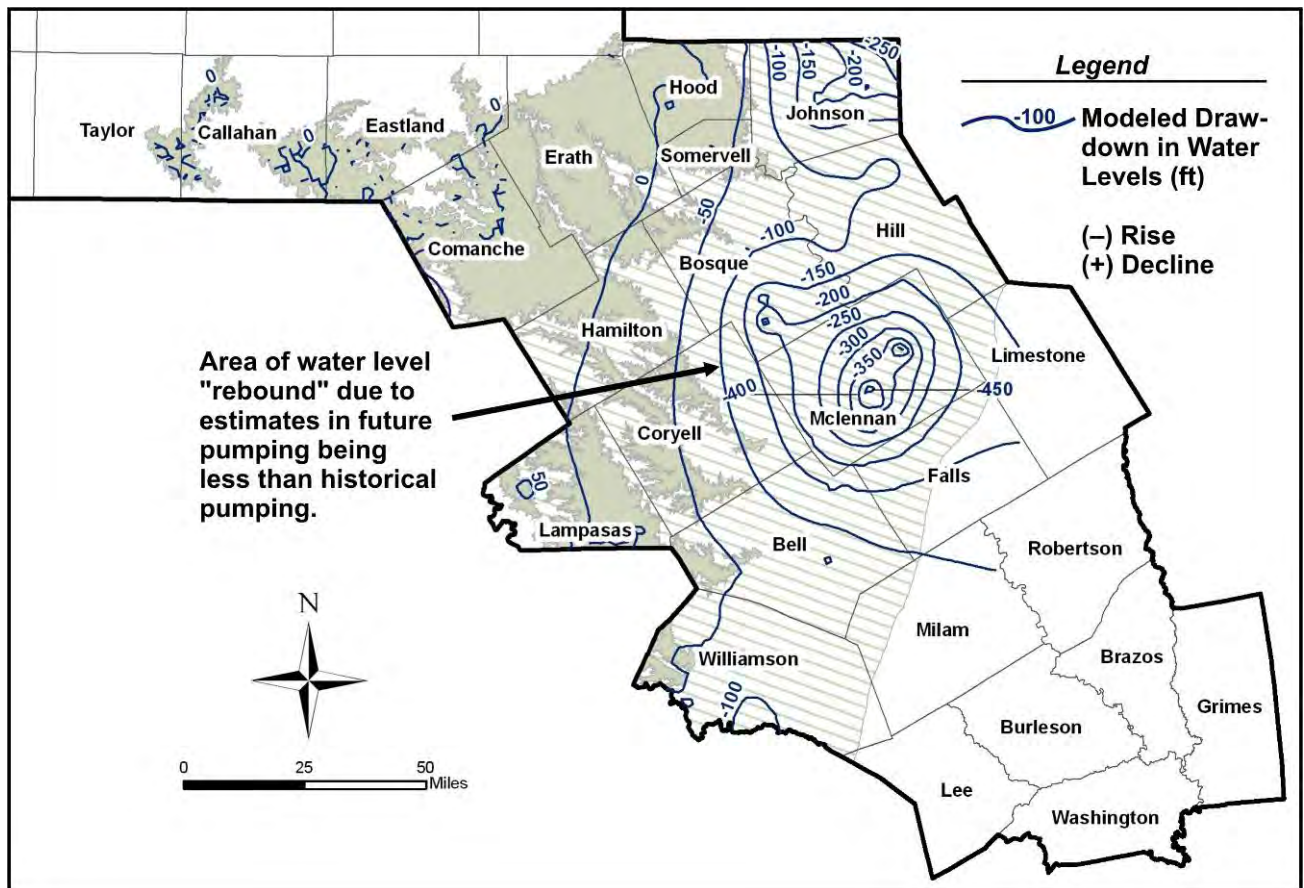


Figure 6. Drawdown in Hosston Layer Resulting from Pumping at Groundwater Availability in 2006 Brazos G Plan, 2000 - 2060

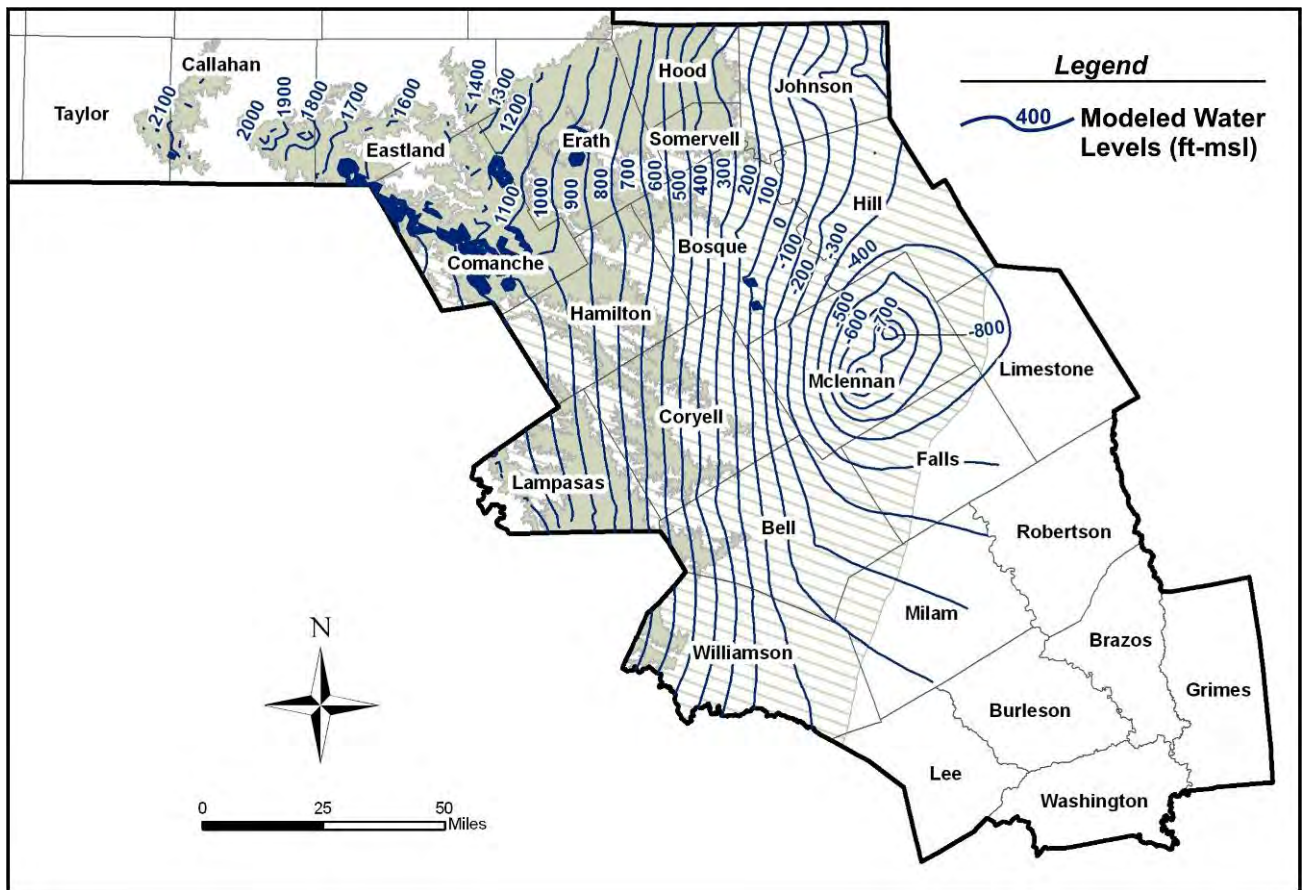


Figure 7. Water Levels in Hosston Layer Resulting from Preliminary MAG with Trinity GAM, 2060

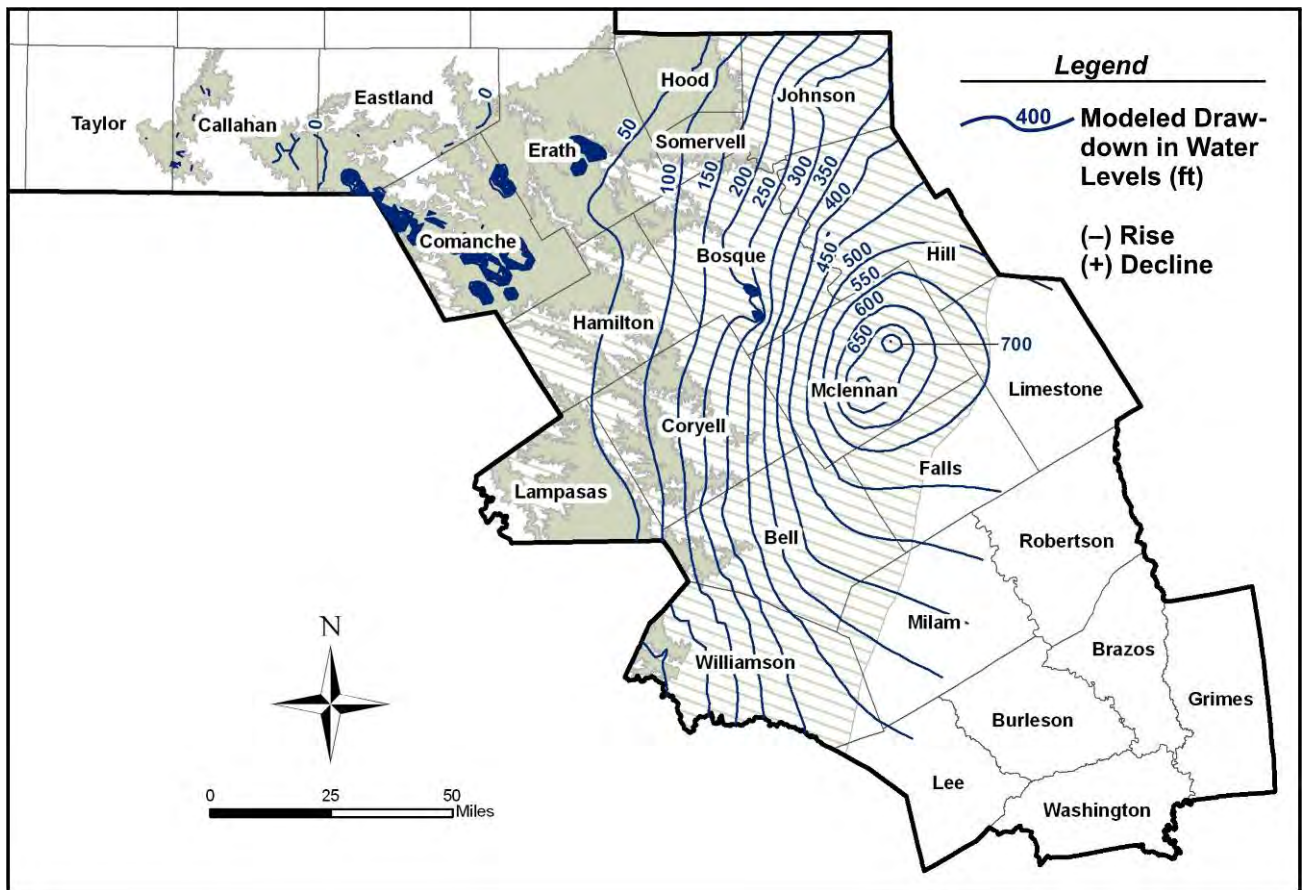


Figure 8. Drawdown in Hosston Layer Resulting from Pumping at Preliminary MAG with Trinity GAM, 2000 – 2060

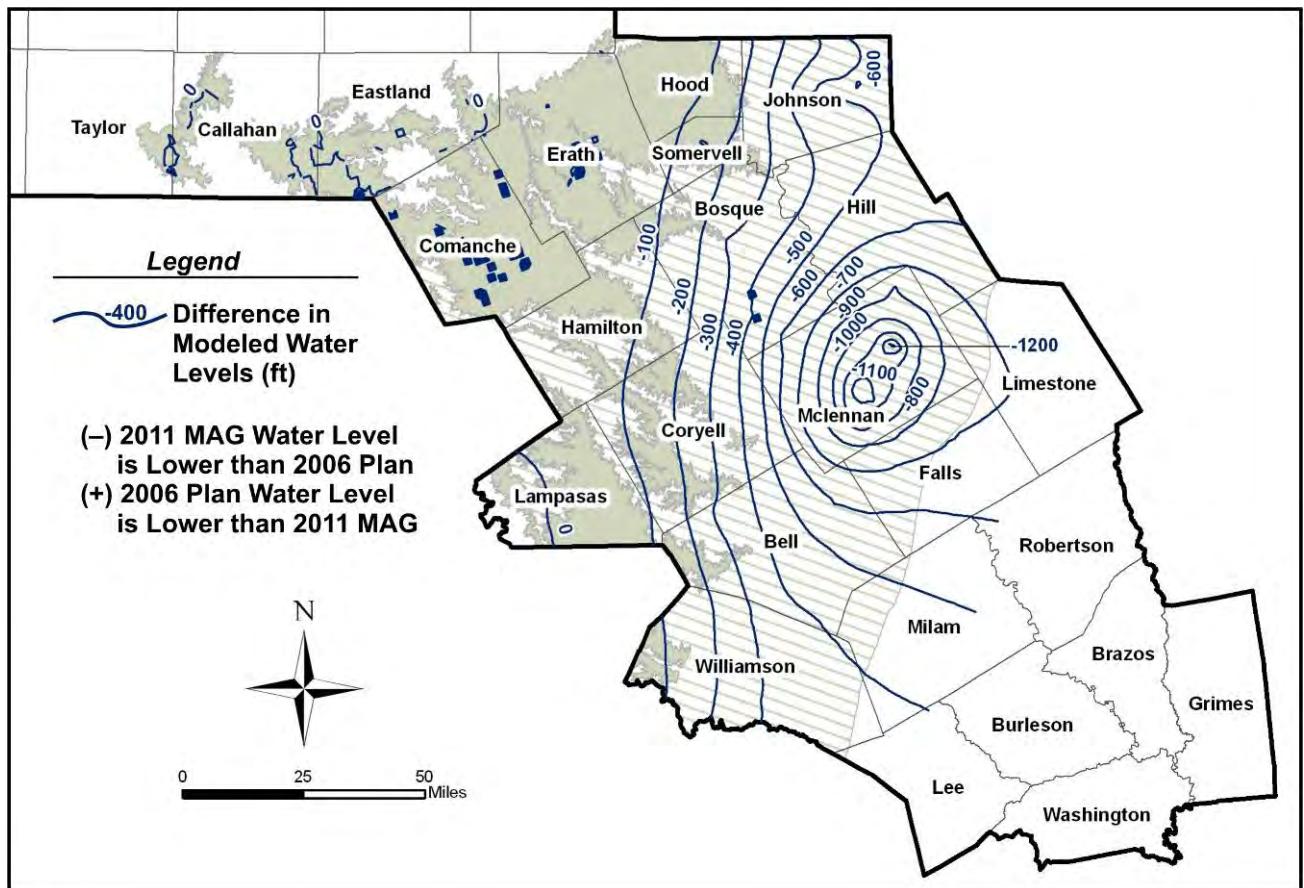


Figure 9. Differences in Modeled Water Levels Between Groundwater Availability in 2006 Plan and Preliminary MAG, 2060, in the Hosston Layer

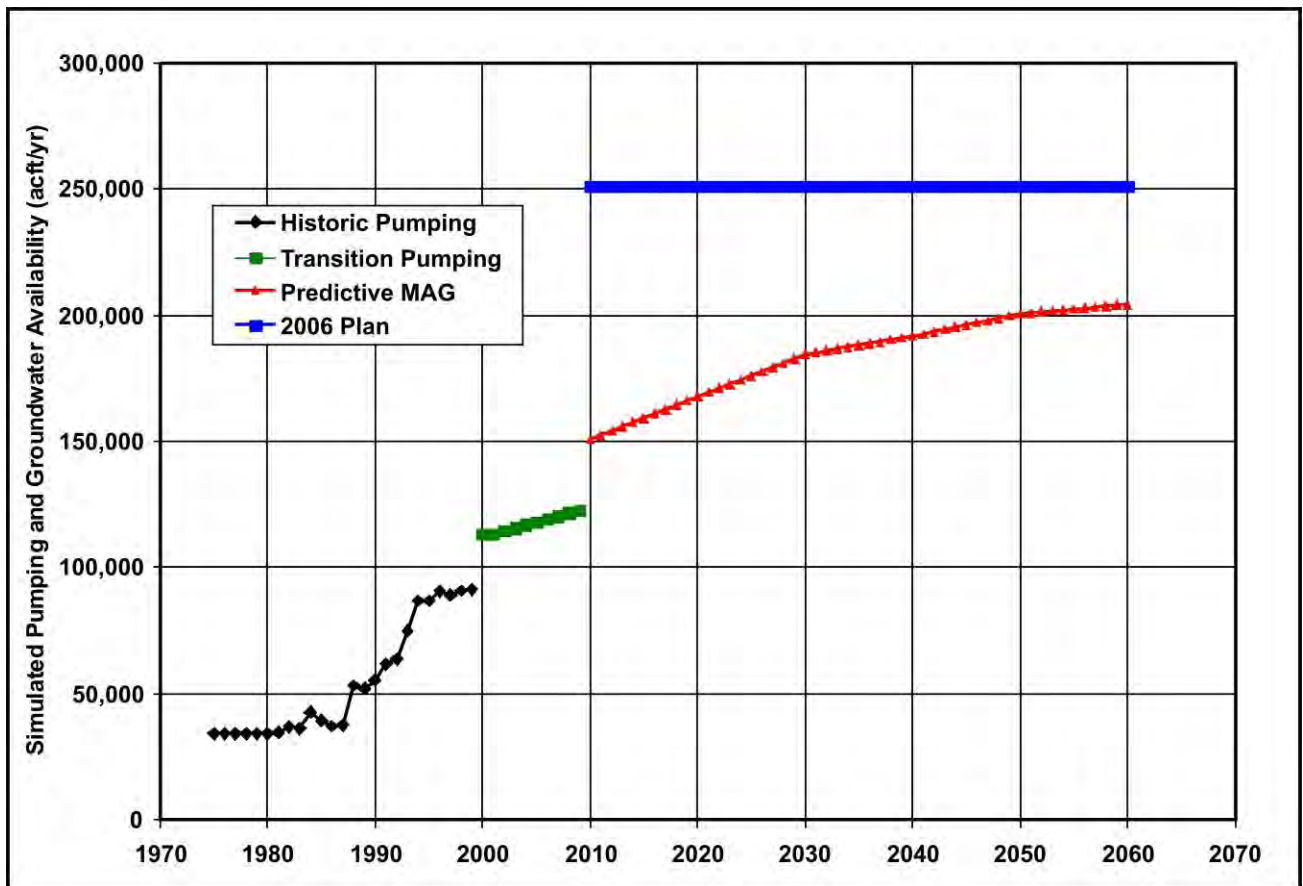


Figure 10. Simulated Brazos G Pumping from Carrizo-Wilcox Aquifer

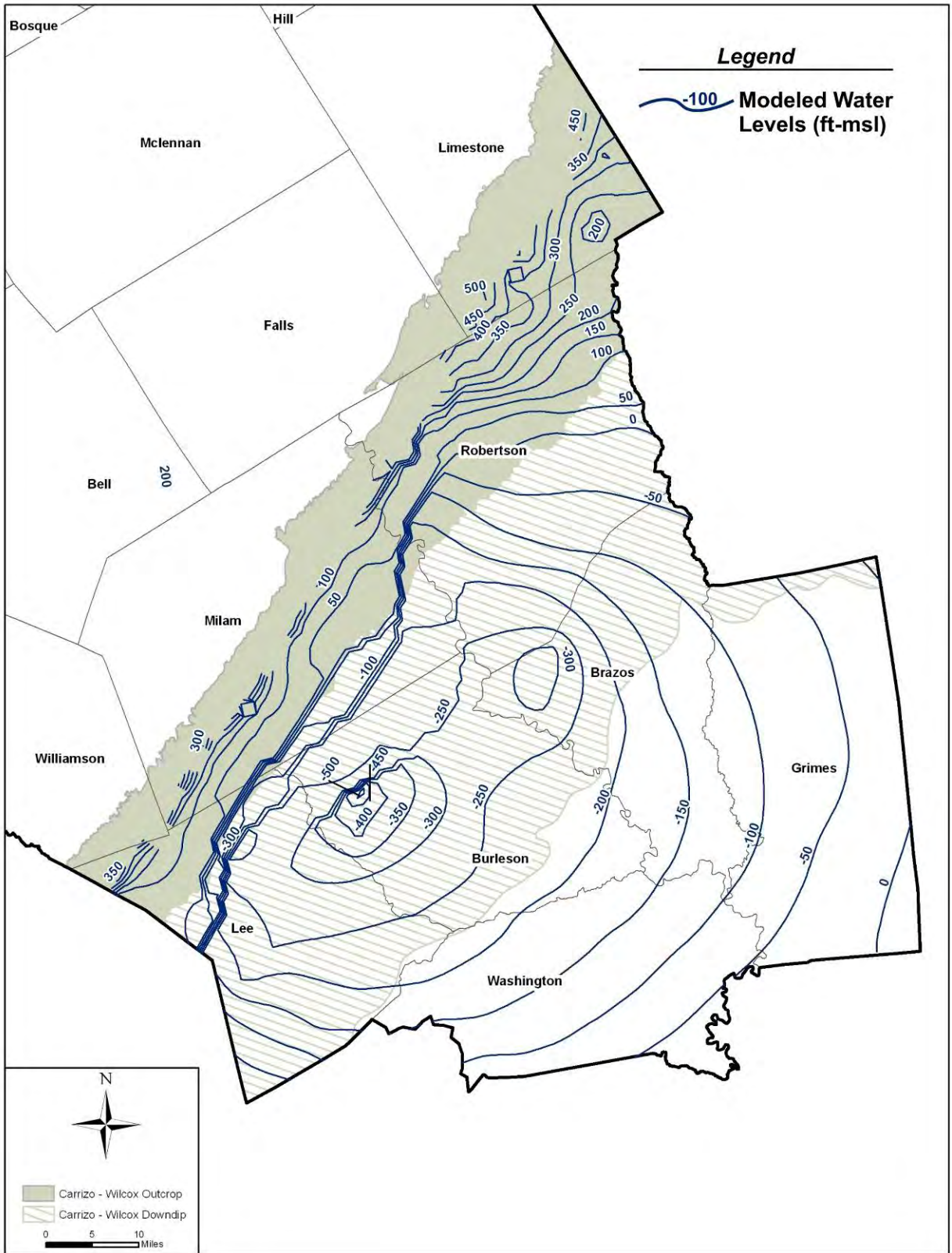


Figure 11. Water Levels in Simsboro Layer Resulting from Pumping at Groundwater Availability in 2006 Brazos G Plan, 2060

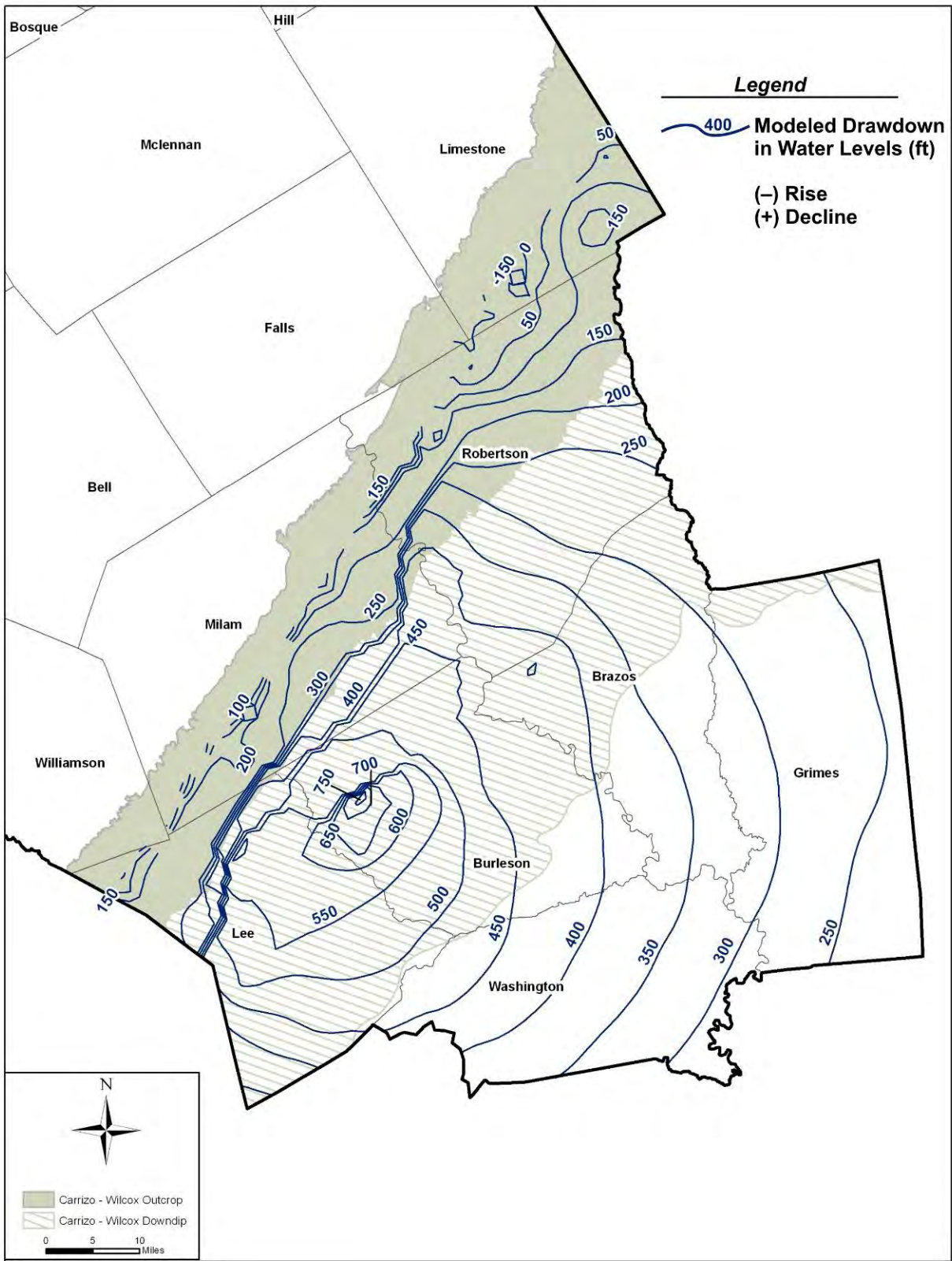


Figure 12. Drawdown in Water Levels in Simsboro Layer Resulting from Pumping at Groundwater Availability in 2006 Brazos G Plan, 2000 – 2060

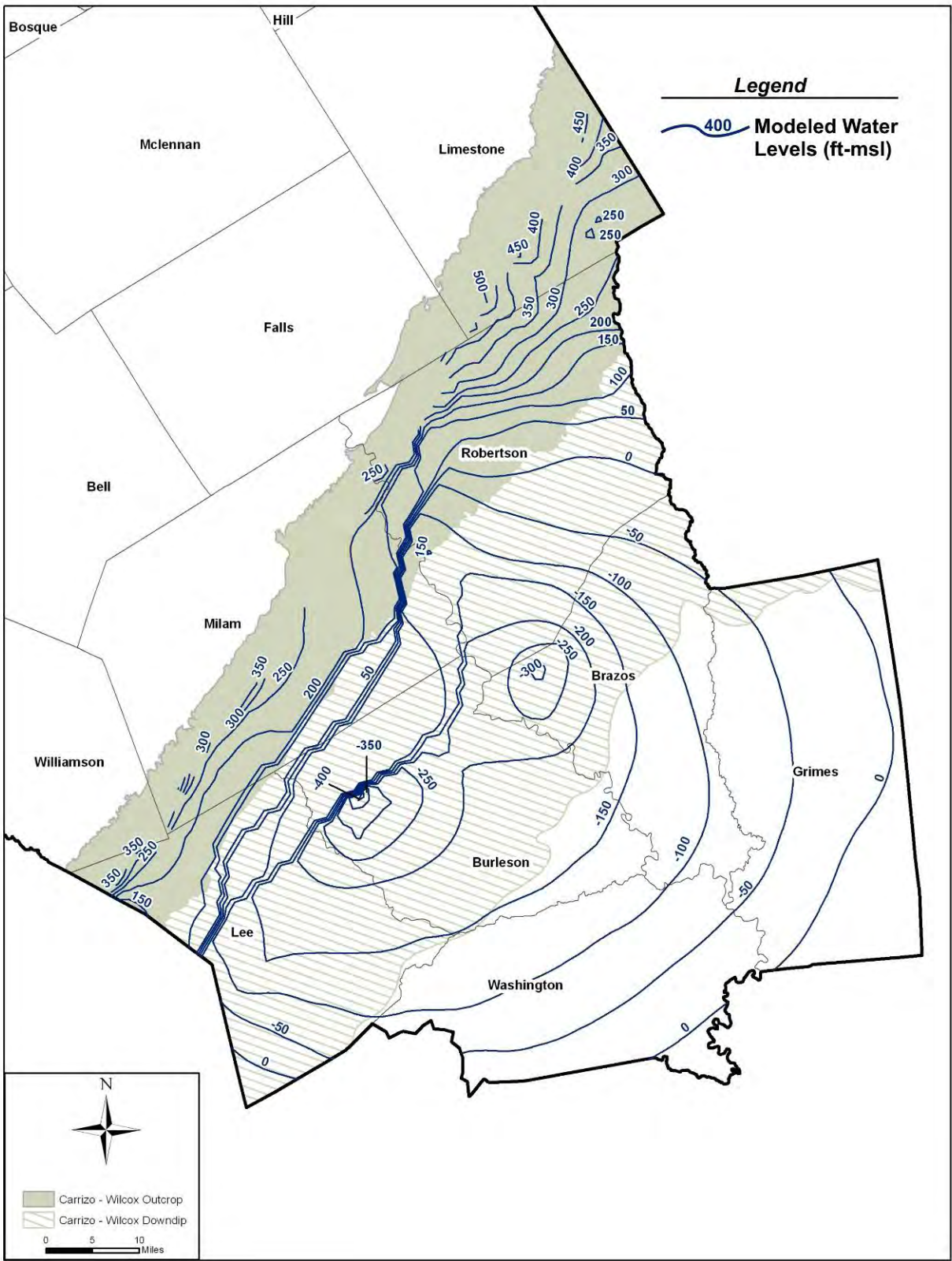


Figure 13. Water Levels in Simsboro Layer Resulting from Pumping at Preliminary MAG, 2060

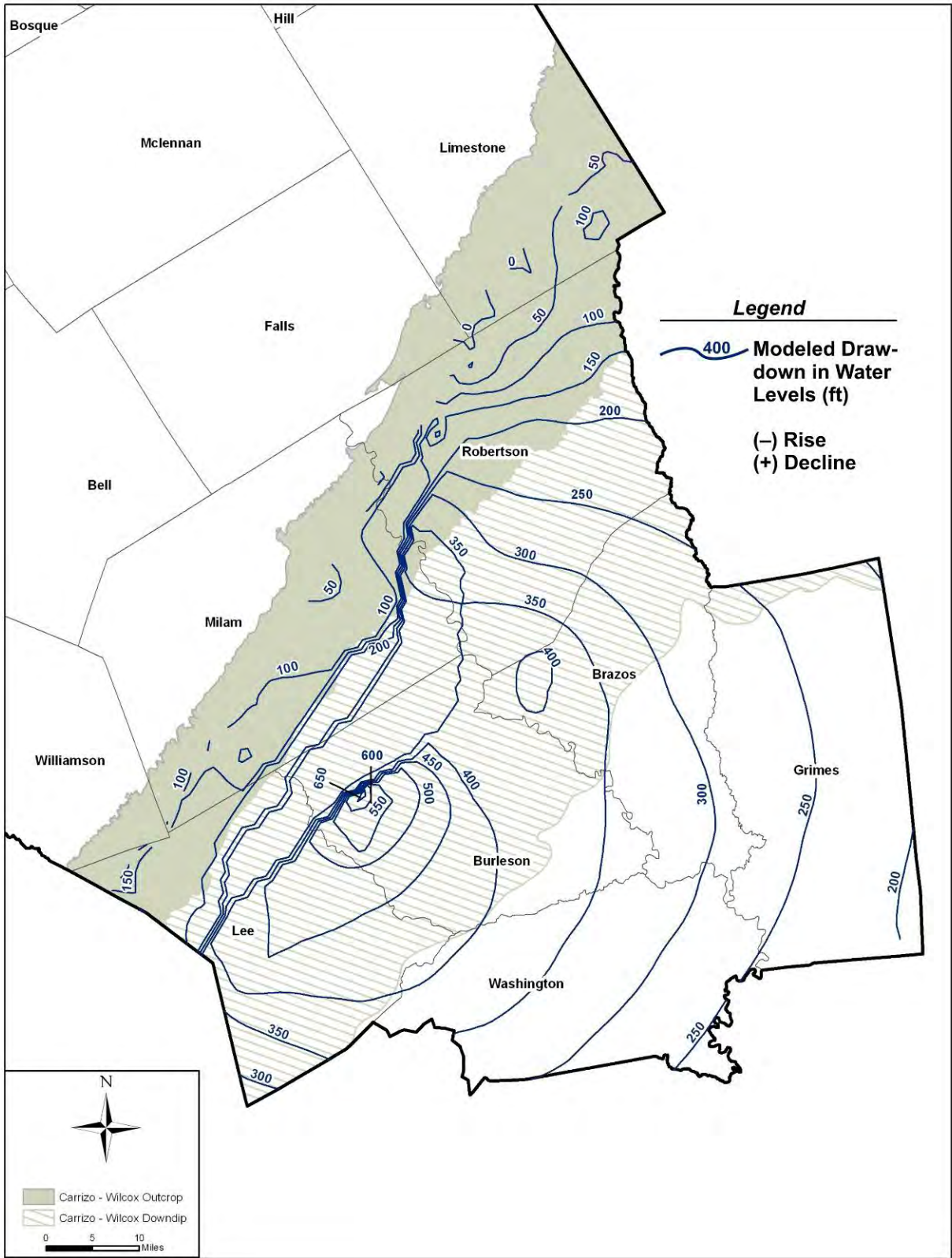


Figure 14. Drawdown in Water Levels in Simsboro Layer Resulting from Preliminary MAG, 2000 – 2060

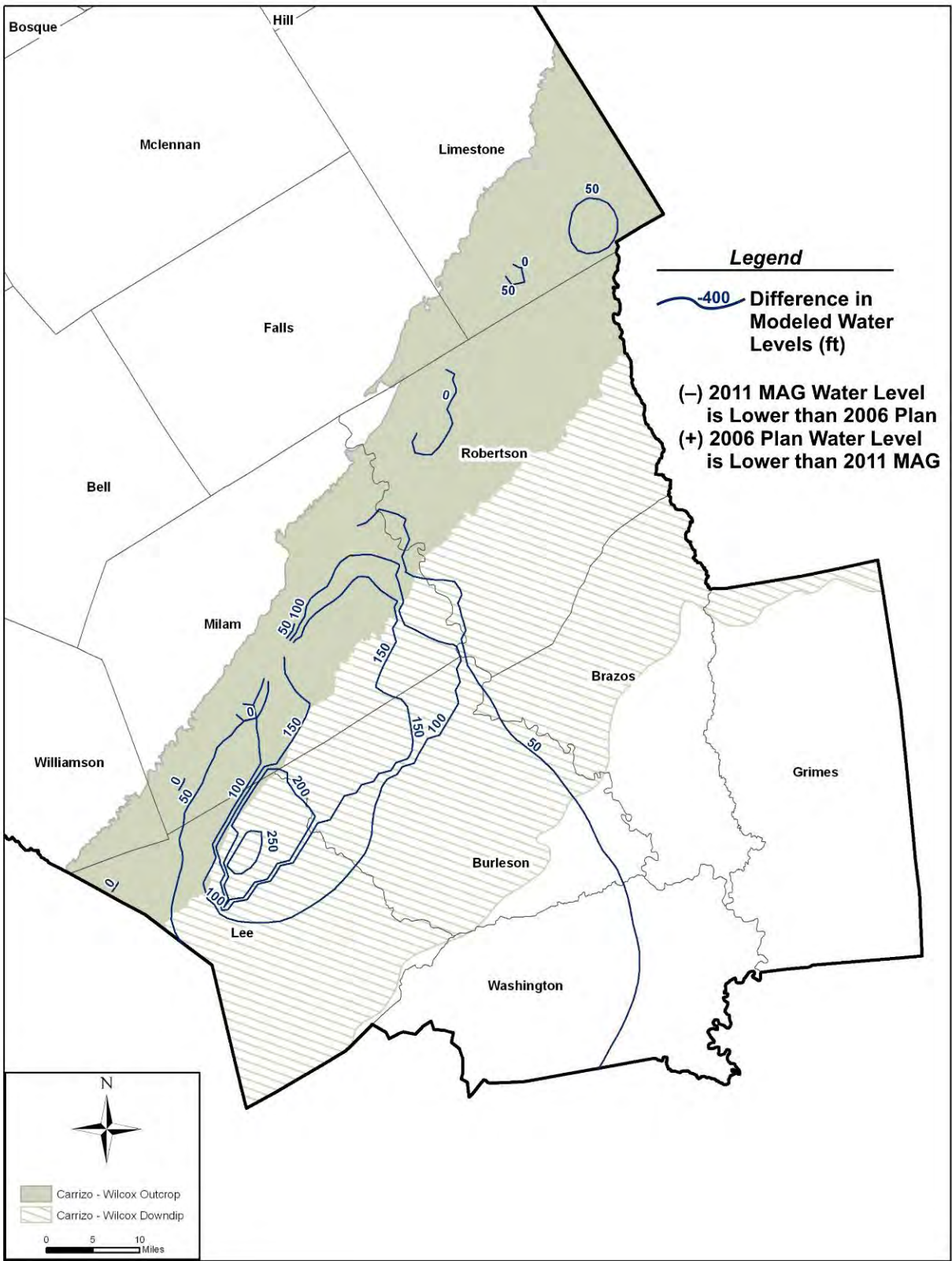


Figure 15. Difference in Modeled Water Levels Between Groundwater Availability in 2006 Plan and Preliminary MAG in the Simsboro Layer

**Table 1.
Groundwater Availability for 2011 Brazos G Plan (page 1 of 3)**

Aquifer	County	2006 Availability (Existing)	2011 Availability (Proposed)	Change (2011- 2006)	Procedure Code
Western					
Blaine	Fisher		3,600		6
Blaine	Knox	1,333	700	-633	6
Blaine	Nolan		100		6
Blaine	Stonewall		8,700		6
Dockum	Fisher	100	100	0	5
Dockum	Kent	100	100	0	5
Dockum	Nolan	3,500	5,750	2,250	4
Edwards-Trinity (Plateau)	Nolan	1,000	1,000	0	5
Edwards-Trinity (Plateau)	Taylor	500	500	0	5
Other (Local) Aquifer	Stephens	705	705	0	5
Other (Local) Aquifer	Throckmorton	364	364	0	5
Other (Local) Aquifer	Young	1,181	1,181	0	5
Seymour	Fisher	7,000	7,000	0	5
Seymour	Haskell	20,000	20,000	0	5
Seymour	Jones	8,000	8,000	0	5
Seymour	Kent	5,700	5,700	0	5
Seymour	Knox	24,000	24,000	0	5
Seymour	Stonewall	2,300	2,300	0	5
TOTAL		75,783	89,800		
Central					
Brazos River Alluvium	Bosque	2,500	830	-1,670	1
Brazos River Alluvium	Falls	15,600	16,684	1,084	1
Brazos River Alluvium	Hill	ND	632		1
Brazos River Alluvium	McLennan	15,600	15,023	-577	1
Edwards-BFZ (Northern Segment)	Bell	2,500	6,469	3,969	1
Edwards-BFZ (Northern Segment)	Williamson	10,000	3,462	-6,538	1
Ellenburger-San Saba	Lampasas	551	2,341	1,790	2
Hickory	Lampasas				ND
Hickory	Williamson				ND
Marble Falls	Lampasas	4,183	2,872	-1,311	2
Other (Local) Aquifer	Williamson	665	665	0	5
Trinity	Bell	2,169	7,075	4,906	2
Trinity	Bosque	1,718	5,823	4,105	2
Trinity	Callahan	3,787	3,787	0	2
Trinity	Comanche	21,976	23,294	1,318	2
Trinity	Coryell	1,791	3,722	1,931	2
Trinity	Eastland	4,853	4,713	-140	2
Trinity	Erath	20,165	29,536	9,371	2
Trinity	Falls	161	161	0	2
Trinity	Hamilton	2,146	2,146	0	2
Trinity	Hill	2,383	3,148	765	2

Table 1.
Groundwater Availability for 2011 Brazos G Plan (page 2 of 3)

<i>Aquifer</i>	<i>County</i>	<i>2006 Availability (Existing)</i>	<i>2011 Availability (Proposed)</i>	<i>Change (2011- 2006)</i>	<i>Procedure Code</i>
Trinity	Hood	6,163	11,064	4,901	2
Trinity	Johnson	2,053	12,870	10,817	2
Trinity	Lampasas	2,145	3,146	1,001	2
Trinity	Limestone	66	66	0	2
Trinity	McLennan	1,718	20,689	18,971	2
Trinity	Milam	321	321	0	2
Trinity	Palo Pinto	286	12	-274	2
Trinity	Somervell	1,233	2,485	1,252	2
Trinity	Taylor	679	431	-248	2
Trinity	Williamson	1,750	1,811	61	2
Woodbine	Hill	1,433	2,261	828	1
Woodbine	Johnson	866	4,732	3,866	1
Woodbine	Limestone	33	34	1	1
Woodbine	McLennan	100	5	-95	1
TOTAL		131,594	192,310		
Eastern					
Brazos River Alluvium	Brazos	12,500	12,500	0	2
Brazos River Alluvium	Burleson	9,400	9,400	0	2
Brazos River Alluvium	Grimes	1,700	1,700	0	2
Brazos River Alluvium	Milam		475		1
Brazos River Alluvium	Robertson	6,300	6,300	0	2
Brazos River Alluvium	Washington	3,100	3,100	0	2
Carrizo-Wilcox	Brazos	53,000	57,156	4,156	3
Carrizo-Wilcox	Burleson	44,000	35,482	-8,518	3
Carrizo-Wilcox	Falls	1,000	910	-90	3
Carrizo-Wilcox	Grimes	5,000	5,000	0	3
Carrizo-Wilcox	Lee	45,000	27,533	-17,467	3
Carrizo-Wilcox	Limestone	20,000	12,162	-7,838	3
Carrizo-Wilcox	Milam	45,000	20,090	-24,910	3
Carrizo-Wilcox	Robertson	38,000	46,016	8,016	3
Gulf Coast	Brazos	1,177	1,177	0	5
Gulf Coast	Grimes	14,083	14,083	0	5
Gulf Coast	Washington	13,036	13,036	0	5
Queen City	Brazos	645	531	-114	3
Queen City	Burleson	672	293	-379	3
Queen City	Grimes	462	462	0	3
Queen City	Lee	1,240	99	-1,141	3
Queen City	Milam		51		3
Queen City	Robertson	440	356	-84	3
Sparta	Brazos	2,107	10,464	8,357	3
Sparta	Burleson	1,666	1,049	-617	3
Sparta	Grimes	2,044	2,044	0	3
Sparta	Lee	3,900	145	-3,755	3
Sparta	Robertson	616	172	-444	3

Table 1.
Groundwater Availability for 2011 Brazos G Plan (page 3 of 3)

Aquifer	County	2006 Availability (Existing)	2011 Availability (Proposed)	Change (2011- 2006)	Procedure Code
Yegua-Jackson	Brazos	ND	6,100		6
Yegua-Jackson	Burleson	ND	5,900		6
Yegua-Jackson	Grimes	ND	5,800		6
Yegua-Jackson	Lee	ND	3,700		6
Yegua-Jackson	Washington	ND	1,400		6
TOTAL		326,088	304,686		
GRAND TOTAL		533,465	586,796		
Code	2011 Procedure				
1	MAG was officially determined by the TWDB from adopted DFC by officials of the GMA.				
2	MAG estimates have been made by GMA from adopted DFC. However, the TWDB has not officially made a MAG determination.				
3	MAG estimates have been made by GMA using a TWDB GAM from likely DFC. However, the GMA has not formally adopted the DFC. Thus, the TWDB has not made an official MAG determination.				
4	MAG estimates were made from 2011 Brazos G GAM (Study 2) for western Nolan and eastern Mitchell Counties.				
5	MAG temporarily set equal to 2006 Brazos G groundwater availability estimates.				
6	MAG temporarily set equal to net recharge, which is based on unit recharge rates and area of outcrop.				
ND	Not Determined.				