GTA Aquifer Assessment 10-35 MAG

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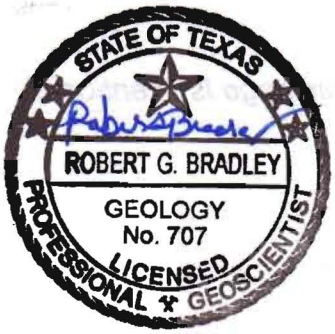

Robert G. Bradley, P.G. 707, authorized the seal appearing on this document on November 20, 2011.

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EXECUTIVE SUMMARY:

The estimated modeled available groundwater from the saline Edwards Aquifer in the “northern subdivision” of Groundwater Management Area (GMA) 10 that achieves the desired future condition adopted by members of Groundwater Management Area 10 is approximately 1,180 acre-feet per year and is summarized by county, regional water planning area, and river basin as shown in Table 3. Within this area, the estimated modeled available groundwater for the Barton Springs Edwards Aquifer Conservation District is approximately 523 acre-feet per year from 2010 to 2060 and the modeled available groundwater for the Plum Creek Conservation District is approximately 112 acre feet between 2010 and 2060.

REQUESTOR:

Mr. Rick Illgner of the Edwards Aquifer Authority acting on behalf of the member groundwater conservation districts of Groundwater Management Area 10.

DESCRIPTION OF REQUEST:

In a letter received September 2, 2010, Mr. Illgner provided the Texas Water Development Board (TWDB) with the desired future condition of the saline zone of Edwards Aquifer in the “northern subdivision” as adopted by the members of Groundwater Management Area 10. The term “northern subdivision” was designated by Groundwater Management Area 10 and is used in this report to describe this assessment area. The desired future condition for the saline Edwards Aquifer, as described in Resolution No. 2010-06 and adopted August 4, 2010 by the groundwater conservation districts in Groundwater Management Area 10 is described below:

- Well drawdown at the saline-freshwater interface (the so called Edwards "bad water line") in the northern subdivision of GMA 10 that averages no more than 5 feet and does not exceed a maximum of 25 feet at any one point on the interface.

In response to receiving the adopted desired future condition, TWDB has estimated the modeled available groundwater that achieves the above desired future condition for the northern area saline zone of the Edwards Aquifer in Groundwater Management Area 10.

METHODS:

Groundwater Management Area 10, located in South Central Texas, includes an areas designated by the GMA as the “northern subdivision” (Figure 1). This area includes all of the Edwards Aquifer in Groundwater Management Area 10 north of the Edwards Aquifer Authority. The saline zone of the Edwards Aquifer in this area has been determined to be relevant for joint planning purposes. There is no distinction between fresh and saline water from the aquifer within the jurisdiction of the Edwards Aquifer Authority.

The Theis equation (Theis, 1935) was used to simulate the desired future conditions on the saline-freshwater interface. Median values for transmissivity and storativity from Hunt and others (2010) were used to calculate the drawdown values.

The Barton Springs-Edwards Aquifer Conservation District established a 3-mile buffer from the saline-freshwater interface in the saline Edwards Aquifer (BSEAD, 2009), and this was honored in the estimation of the modeled available groundwater. It was assumed that no saline Edwards Aquifer wells would be pumping within the buffer zone and that this buffer zone would be applied to the Plum Creek Conservation District in order to achieve the desired future condition. It was assumed that if wells were located within the buffer zone it would result in greater drawdown at the saline-freshwater interface.

To show effects of pumping that averages no more than 5 feet the interface, a series of ten wells were assumed to be spaced one mile apart starting at the 3-mile buffer out to out to a distance of 12 miles. This maximum distance is approximately the distance where the Edwards Aquifer becomes too deep or too saline for use. Discharge volumes for each well that would result in a 5 feet drawdown at the saline-freshwater interface over a 50-year period were calculated iteratively in a Microsoft Excel worksheet (Table 1).

To determine the cumulative effect of pumping all of these wells upon a hypothetical monitoring well at the saline-freshwater interface, a drawdown superposition formula derived from the Theis equation (Briscoe, 1984, pp.574-575) was used to calculate a distance of a single hypothetical monitoring well that would represent the previous ten wells used in calculation of the discharge.

The formula is:

$$r = (r_1 * r_2 * \ldots r_n)^{1/n}$$

Where

r = distance of individual well from fresh water/ saline-freshwater interface

The product of the distances raised to the inverse number results in an equivalent distance of approximately 7 miles. Using the sum of the discharges of 1,506 gallons per minute (2,431 acre-feet per year) as the pumping rate, the estimated drawdown at the interface is 51.4 feet over 50 years (Table 2). Therefore, the maximum desired future condition, a maximum of 25 feet at any one point on the interface, is not honored.

Table 1. Results of pumping wells and resulting drawdowns upon a hypothetical monitoring well at the saline-freshwater interface to achieve the desired future conditions for the saline Edwards Aquifer.

Description	Distance (miles)	Discharge (gpm)	Discharge (AF/YR)	Drawdown at interface (feet)
Wells used to determine effects of pumping to create 5 feet drawdown at the saline-freshwater interface.	3	106	171	5.0
	4	116	187	5.0
	5	127	204	5.0
	6	136	220	5.0
	7	147	238	5.0
	8	156	252	5.0
	9	164	264	5.0
	10	175	283	5.0
	11	185	298	5.0
	12	194	313	5.0

gpm = gallons per minute AF/YR = acre-feet per year

Table 2. Results of the cumulative effect of pumping all ten wells (Table 1) upon a hypothetical monitoring well at the saline-freshwater interface.

Description	Distance (miles)	Discharge (gpm)	Discharge (AF/YR)	Drawdown at interface (feet)
Cumulative drawdown from wells in Table 1	7	1,506	2,431	51.4

gpm = gallons per minute AF/YR = acre-feet per year

The maximum desired future condition of 25 feet of drawdown was determined to be the constraining factor and was used to calculate the modeled available groundwater. The distance of 7 miles was used to literately calculate the discharge that would result in 25 feet of drawdown at the saline-freshwater interface over a 50-year period. The maximum desired future condition is achievable by using an estimated modeled available groundwater volume of 731 gallons per minute or 1,180 acre-feet per year (Table 3).

Table 3. Resulting drawdown upon a hypothetical monitoring well at the saline-freshwater interface to achieve the maximum desired future conditions for the saline Edwards Aquifer.

Description	Distance (miles)	Discharge (gpm)	Discharge (AF/YR)	Drawdown at interface (feet)
Well used to determine effects of pumping to create a maximum 25 feet drawdown at the saline-freshwater interface.	7	731	1,180	25.0

gpm = gallons per minute AF/YR = acre-feet per year

PARAMETERS AND ASSUMPTIONS:

- The Theis equation is used to determine drawdown at the saline-freshwater interface, which assumes that the aquifer is homogenous and has infinite areal extent; and all wells penetrate the aquifer fully and have an infinitesimal diameter.
- The entire saline Edwards Aquifer is under confined conditions.
- Pumping will only occur outside of the “buffer zone” as defined in Barton Springs/Edwards Aquifer Conservation District rules (BSEACD, 2009).
- The storage coefficient of the aquifer is estimated to be $7X10^{-4}$ (Hunt and others, 2010).
- The transmissivity of the aquifer is estimated to be 2,000 ft^2/day (converted from 15,000 gallons/day/ft from Hunt and others, 2010) and it is constant at all times and in all places within the aquifer.

- The aquifer area was calculated from the TWDB shapefile for the Trinity Aquifer, projected into the GAM projection (Anaya, 2001).
- Areas, in acres, were calculated within ArcGIS 9.2.
- The map area percentages were calculated by including all of the area covered by the saline Edwards Aquifer.
- Map areas were designated as Plum Creek Conservation District only where their jurisdiction does not overlap with the BSEACD.

MODELED AVAILABLE GROUNDWATER AND PERMITTING:

As defined in Chapter 36 of the Texas Water Code, “modeled available groundwater” is the estimated average amount of water that may be produced annually to achieve a desired future condition. This is distinct from “managed available groundwater,” shown in the draft version of this report dated April 18, 2011, which was a permitting value and accounted for the estimated use of the aquifer exempt from permitting. This change was made to reflect changes in statute by the 82nd Texas Legislature, effective September 1, 2011.

Groundwater conservation districts are required to consider modeled available groundwater, along with several other factors, when issuing permits in order to manage groundwater production to achieve the desired future condition(s). The other factors districts must consider include annual precipitation and production patterns, the estimated amount of pumping exempt from permitting, existing permits, and a reasonable estimate of actual groundwater production under existing permits.

The estimated amount of pumping exempt from permitting, which the Texas Water Development Board is now required to develop after soliciting input from applicable groundwater conservation districts, will be provided in a separate report.

RESULTS:

The estimated modeled available groundwater from the saline Edwards Aquifer within the “northern subdivision “of Groundwater Management Area 10 that achieves the adopted desired future condition is approximately 1,180 acre-feet per year.

The modeled available groundwater for the entire area was split by county, regional water planning area, river basin, and groundwater conservation district in order to apportion the total amount to each area. Table 2 shows the individual areas and the calculated modeled available groundwater for each split.

Table 4. Modeled available groundwater by county, regional water planning area, river basin, and groundwater conservation district (See Figure 1).

GMA	Aquifer	County	RWPA	Basin	GCD	Map Areas	Areal extent (acres)	Percent area	Estimated total pumping for study area (AC-FT/YR)	Estimated total pumping for each map area (AC-FT/YR)
10	Saline Edwards	Caldwell	L	Colorado	Barton Springs/Edwards Aquifer CD	1	3,905	2.39%	1,180	28
					N/A	2	5,022	3.08%	1,180	36
				Guadalupe	Barton Springs/Edwards Aquifer CD	3	12,433	7.62%	1,180	90
					N/A	4	2,005	1.23%	1,180	15
					Plum Creek CD	5	4,008	2.46%	1,180	29
		Hays	K	Colorado	Barton Springs/Edwards Aquifer CD	6	1,259	0.77%	1,180	9
			L	Guadalupe	Barton Springs/Edwards Aquifer CD	7	21,052	12.91%	1,180	152
					Plum Creek CD	8	11,470	7.03%	1,180	83
		Travis	K	Colorado	Barton Springs/Edwards Aquifer CD	9	28,378	17.40%	1,180	205
					N/A	10	68,243	41.84%	1,180	494
				Guadalupe	Barton Springs/Edwards Aquifer CD	11	5,336	3.27%	1,180	39
						Total	163,111	100.0%	n/a	1,180

GMA = groundwater management area GCD = groundwater conservation district RWPA = regional water planning area
ac-ft/yr = acre-feet per year CD = conservation district
Values calculated in this table are the estimated total pumping determined by the assessment and then multiplied by the percent area

Modeled available groundwater estimates are also summarized by county, regional water planning area, and river basin for each decade between 2010 and 2060 for use in the regional water planning process (Table 3). The modeled available groundwater estimates are also summarized by individual counties, regional water planning areas, river basins, and groundwater conservation districts (Tables 4-7).

Table 5. Estimated modeled available groundwater by decade for the saline Edwards Aquifer within the "northern subdivision" of Groundwater Management Area 10. Results are in acre-feet per year and are divided by county, regional water planning area, and river basin.

County	Regional Water Planning Area	River Basin	Year					
			2010	2020	2030	2040	2050	2060
Caldwell	L	Colorado	64	64	64	64	64	64
		Guadalupe	134	134	134	134	134	134
Hays	K	Colorado	9	9	9	9	9	9
	L	Guadalupe	235	235	235	235	235	235
Travis	K	Colorado	699	699	699	699	699	699
		Guadalupe	39	39	39	39	39	39
		Total	1,180	1,180	1,180	1,180	1,180	1,180

Table 6. Estimated modeled available groundwater, by county, for the saline Edwards Aquifer within the "northern subdivision" of Groundwater Management Area 10 for each decade between 2010 and 2060. Results are in acre-feet per year.

County	Year					
	2010	**2020**	**2030**	**2040**	**2050**	**2060**
Caldwell	198	198	198	198	198	198
Hays	244	244	244	244	244	244
Travis	738	738	738	738	738	738
Total	**1,180**	**1,180**	**1,180**	**1,180**	**1,180**	**1,180**

Table 7. Estimated modeled available groundwater, by regional water planning group, for the saline Edwards Aquifer within the "northern subdivision" of Groundwater Management Area 10 for each decade between 2010 and 2060. Results are in acre-feet per year.

Regional Water Planning Area	Year					
	2010	**2020**	**2030**	**2040**	**2050**	**2060**
K	747	747	747	747	747	747
L	433	433	433	433	433	433
Total	**1,180**	**1,180**	**1,180**	**1,180**	**1,180**	**1,180**

Table 8. Estimated modeled available groundwater, by river basin, for the saline Edwards Aquifer within the "northern subdivision" of Groundwater Management Area 10 for each decade between 2010 and 2060. Results are in acre-feet per year.

River Basin	Year					
	2010	**2020**	**2030**	**2040**	**2050**	**2060**
Colorado	772	772	772	772	772	772
Guadalupe	408	408	408	408	408	408
Total	**1,180**	**1,180**	**1,180**	**1,180**	**1,180**	**1,180**

Table 9. Estimates of modeled available groundwater for saline Edwards Aquifer within the "northern subdivision" of Groundwater Management Area for each decade between 2010 and 2060. Results are in acre-feet per year.

Groundwater Conservation District	**Year**					
	2010	**2020**	**2030**	**2040**	**2050**	**2060**
Barton Springs/Edwards Aquifer CD	523	523	523	523	523	523
Plum Creek CD	112	112	112	112	112	112
Total (excluding non-district areas)	**635**	**635**	**635**	**635**	**635**	**635**
No District	545	545	545	545	545	545
Total (including non-district areas)	**1,180**	**1,180**	**1,180**	**1,180**	**1,180**	**1,180**

CD = Conservation District

LIMITATIONS:

The analytical method used was determined to be the best method to calculate estimates of modeled available groundwater; however, this method has limitations and should be replaced with better tools, including groundwater models and additional data that are not currently available, whenever possible.

This analysis assumes homogeneous and isotropic aquifers; however, aquifer conditions may not be uniform. However, it is understood that conditions for the saline Edwards Aquifer do not behave in a uniform manner. This assessment does not take in to account conduit flow and assumes only a matrix flow aquifer. Further, it assumes lateral inflow to the aquifer is equal to lateral outflow from the aquifer, and that future pumping will not alter this balance. In addition, certain assumptions have been made regarding future conditions, and these assumptions need to be considered and compared to actual future data when evaluating achievement of the desired future condition.

Given these limitations, users of this information are cautioned that the modeled available groundwater numbers should not be considered a definitive, permanent description of the amount of groundwater that can be pumped to meet the adopted desired future condition. The TWDB makes no warranties or representations relating to the actual conditions of any aquifer at a particular location or at a particular time.

It is important for groundwater conservation districts to monitor future groundwater pumping and water levels to know if they are achieving their desired future conditions.

Because of the limitations and assumptions in this analysis, it is important that the groundwater conservation districts work with the TWDB to refine these modeled available groundwater numbers given the reality of how the aquifer responds to the actual amount and location of pumping now and in the future.

REFERENCES:

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Thorkildsen D. and Backhouse S., 2010, GTA Aquifer Assessment 10-29: Texas Water Development Board, GTA Aquifer Assessment 10-29 Report, 11 p.

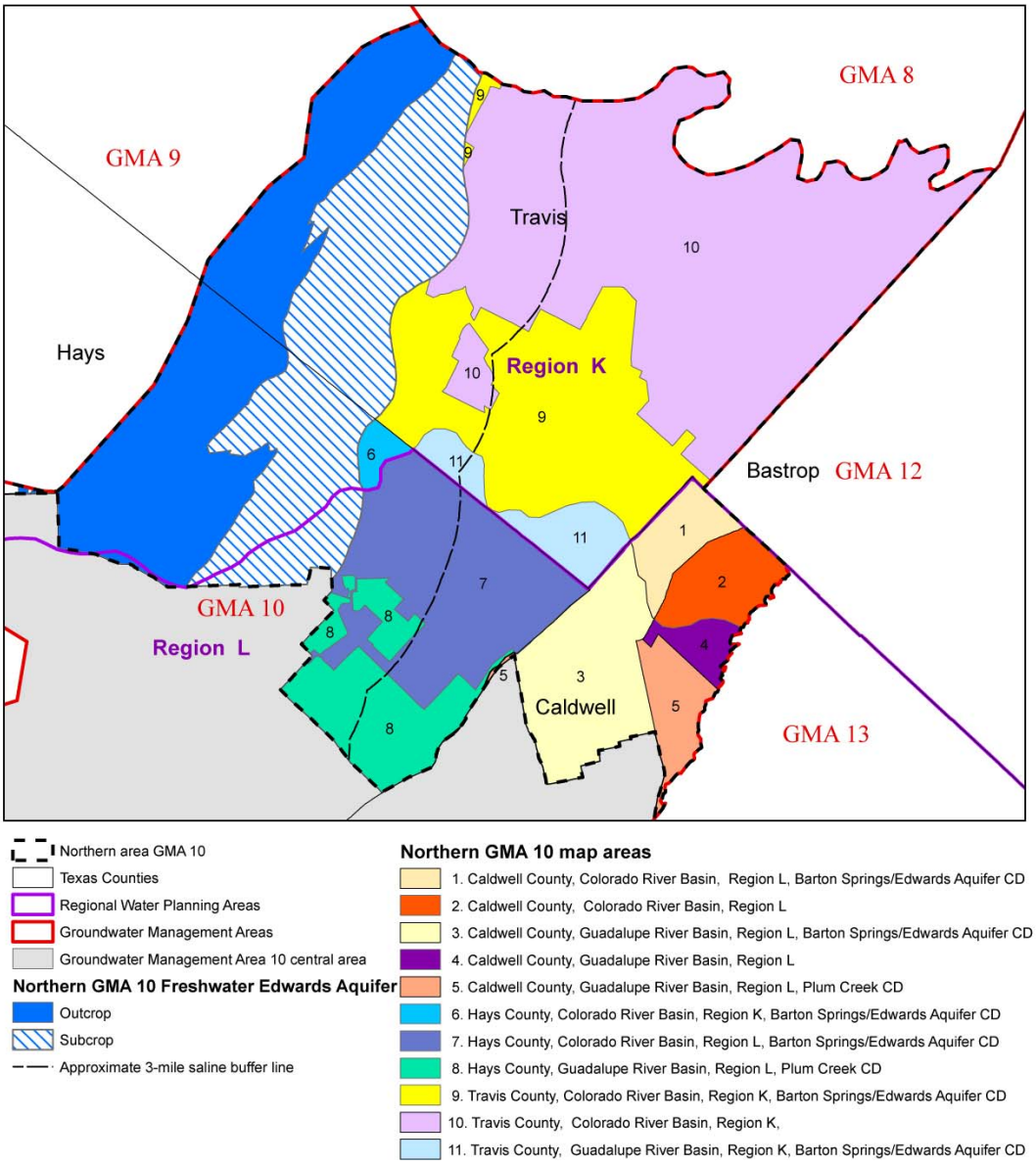

Figure 1. Map showing the areas used for estimating modeled available groundwater in the saline Edwards Aquifer in the “northern subdivision” of Groundwater Management Area 10.

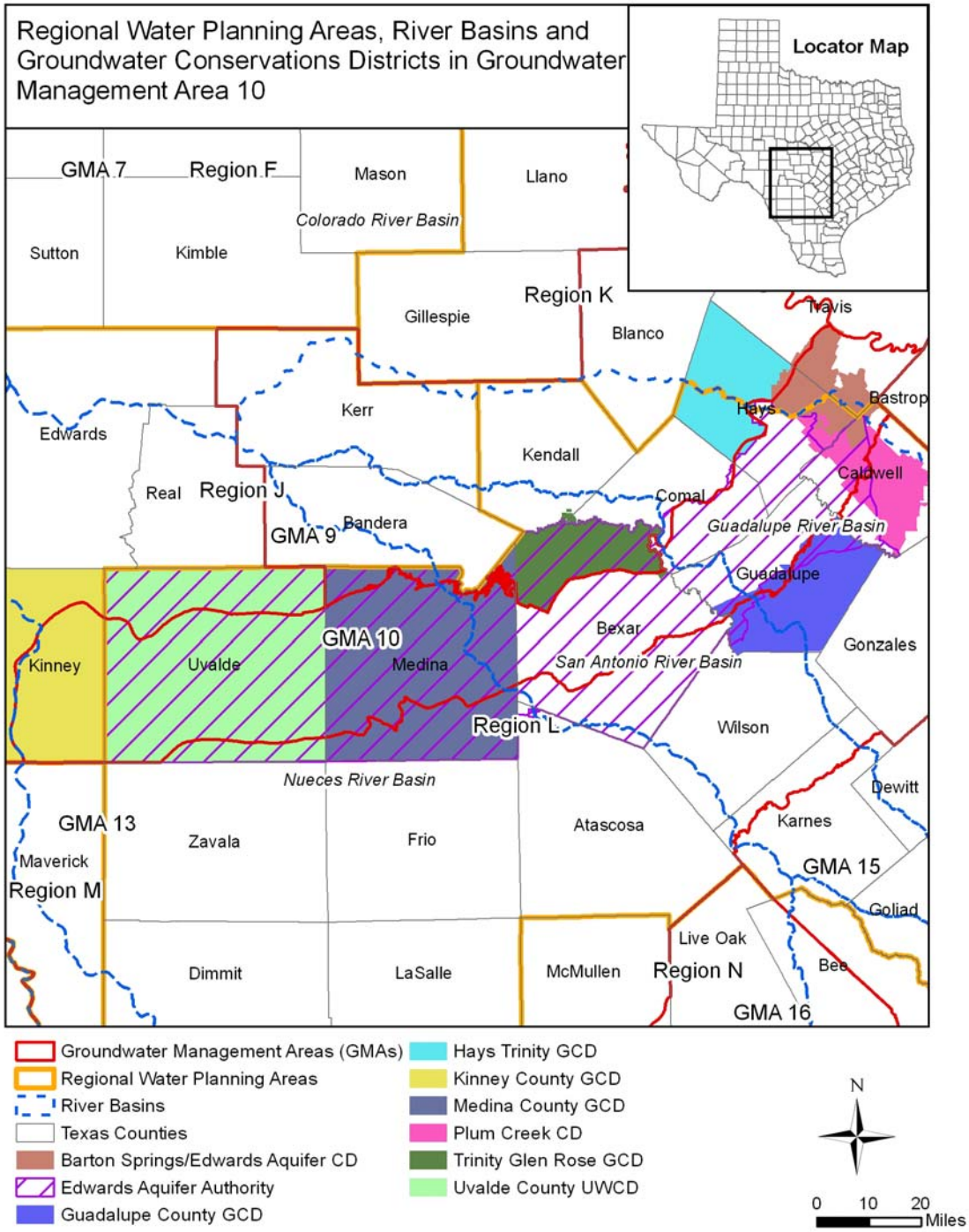

Figure 2. Map showing regional water planning areas, river basins, groundwater conservation districts and counties in Groundwater Management Area 10 (From Thorkildsen and Backhouse, 2010). CD = Conservation District, GCD = Groundwater Conservation District, UWCD = Underground Water Conservation District