GTA Aquifer Assessment 10-30 MAG

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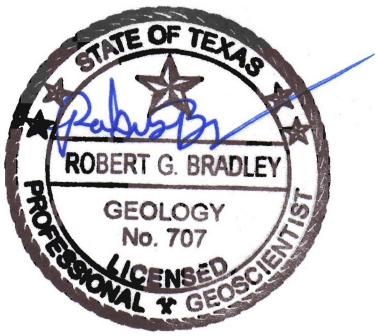

Robert G. Bradley, P.G. 707, authorized the seal appearing on this document on June 22, 2011.

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Groundwater Management Area 14
Brazos River Alluvium Aquifer
Managed Available Groundwater estimates
June 22, 2011

EXECUTIVE SUMMARY:

The estimated total pumping from the Brazos River Alluvium Aquifer that achieves the desired future condition adopted by members of Groundwater Management Area 14 is approximately 30,853 acre-feet per year and is summarized by county, regional water planning area, and river basin as shown in Table 3. The estimated managed available groundwater for Bluebonnet Groundwater Conservation District in Groundwater Management Area 14 for the aquifer ranges from 24,973 acre-feet per year in 2010 down to 24,847 acre-feet per year in 2060 and is shown in Table 6.

REQUESTOR:

Mr. Lloyd Behm, of the Bluebonnet Groundwater Conservation (GCD) acting on behalf of the member groundwater conservation districts of Groundwater Management Area 14.

DESCRIPTION OF REQUEST:

In a letter dated August 25, 2010, Mr Behm provided the Texas Water Development Board (TWDB) with the desired future condition of the Brazos River Alluvium Aquifer adopted by the members of Groundwater Management Area 14. The desired future condition for the Brazos River Alluvium Aquifer, as described in a resolution and adopted August 25, 2010

- In Austin, Grimes, Waller, and Washington counties, from estimated 2010 conditions, the saturated thickness of the Brazos River Alluvium should be maintained at 90 percent.

The GMA adopted that the portion of the Brazos River Alluvium Aquifer in the Brazos Valley Groundwater Conservation District (Brazos County) as not relevant at this time for purposes of joint planning. In addition, no desired future condition was established for the Brazos River Alluvium in Fort Bend County, which is under the jurisdiction of the Fort Bend Subsidence District.

In response to receiving the adopted desired future condition, TWDB has estimated the managed available groundwater that achieves the above desired future condition for Groundwater Management Area 14.

METHODS:

A transient hydrologic budget for the saturated portion of an aquifer is described by Freeze and Cherry (1979, p.365):

$$Q(t) = R(t) - D(t) + \frac{dS}{dt}$$

where Q(t)= total rate of groundwater withdrawal
R(t)= total rate of groundwater recharge to the basin
D(t)= total rate of groundwater discharge from the basin
$\frac{dS}{dt}$ = rate of change of storage in the saturated zone of the basin

For this analysis, it is assumed that

$$R(t) = R(r) + R(e)$$

where R(r) = rejected recharge for the basin
R(e) = effective recharge

Effective recharge is the amount of water that enters an aquifer and is available for development (Muller and Price, 1979, p. 5). Rejected recharge is the amount of total (or potential) recharge that discharges from an aquifer because it is overfull and cannot accept more water (Theis, 1940, p. 1).

In addition, it is assumed that

$$R(r) \cong D(t)$$

Therefore, the total rate of groundwater withdrawal equals effective recharge plus the change in storage of the aquifer, or

$$Q(t) = R(e) + \frac{dS}{dt}$$

County and groundwater conservation district boundaries were used to split the aquifer into map areas (Figure 1). The areal extent of each aquifer map area was calculated.

Annual effective recharge was calculated by multiplying the outcrop area by the average precipitation (1971-2000) and an effective recharge rate of 5 percent.

Water-level data from the TWDB groundwater database was used to calculate average saturated thickness. Shah and Houston (2007) provided raster surface elevations for the top and bottom of the Brazos River Alluvium. Every water level measurement was assigned an elevation from the top of aquifer data. The base of aquifer elevations at every well were subtracted from the water level elevations. This resulted in a saturated thickness for every water-level measurement for the aquifer. Average saturated thickness was determined by averaging all saturated thickness estimates within an aquifer map area.

The calculations were completed in a Microsoft Excel worksheet.

The Brazos River Alluvium Aquifer within GMA 14 is located in Regional Water Planning areas G and H, and completely within the Brazos River Basin. A regional map of the area is shown in Figure 2.

PARAMETERS AND ASSUMPTIONS:

- The areas for each map area were calculated from the Texas Water Development Board (TWDB) shapefile for the Brazos River Alluvium, projected into the GAM projection (Anaya, 2001).
- Areas, in acres, were calculated within ArcGIS 9.2.
- Average annual precipitation was used to calculate recharge volumes.
- The average annual precipitation for the aquifer area was determined from the Texas Climatic Atlas (Narasimhan and others, 2008).
- Average annual precipitation was estimated to be 44 inches for Austin County, 42 inches for Grimes County, and 43 inches for Waller and Washington counties (Table 1).
- Recharge from precipitation is estimated to be 5 percent of annual precipitation (Cronin and Wilson, 1967; Chowdhury and others, 2010; Williams, 2010).
- There is sufficient saturated thickness to achieve the desired future condition based on available data (TWDB, 2010; Shah and Houston, 2007).
- Annual volumes are calculated by dividing the total volume by 50 years.
- Annual total pumping estimates are calculated by adding the annual volume to the recharge volume.
- Specific yield of the aquifer is estimated to be 0.15 (Cronin and Wilson, 1967, pp.2, 27).

GMA	Aquifer	County	Groundwater Conservation District	Map Area	Areal extent (acres)	Estimated average annual precipitation (inches)	Estimated average annual precipitation (feet)	Effective recharge rate (percent)	Estimated annual effective recharge (ac-ft/yr)
14	Brazos River Alluvium	Austin	Bluebonnet GCD	1	41,013	44	3.7	5	7,587
14	Brazos River Alluvium	Grimes	Bluebonnet GCD	2	27,254	42	3.5	5	4,769
14	Brazos River Alluvium	Waller	Bluebonnet GCD	3	63,032	43	3.6	5	11,346
14	Brazos River Alluvium	Washington	N/A	4	30,580	43	3.6	5	5,504
								Total	**29,206**

GMA = groundwater management area ac-ft/yr = acre-feet per year

The formula for this table is: areal extent (acres) * estimated average annual precipitation (feet) * effective recharge rate = estimated annual effective recharge (ac-ft/yr).

Table 1. Estimated total annual effective recharge volume for the Brazos River Alluvium Aquifer by map area (see Figure 1).

DETERMINING MANAGED AVAILABLE GROUNDWATER:

As defined in Chapter 36 of the Texas Water Code, “managed available groundwater” is the amount of water that may be permitted by a groundwater conservation district. The estimated total annual volume of groundwater calculated, however, represents the total amount of pumping from the aquifer. The total pumping includes uses of water both subject to permitting and exempt from permitting. Examples of exempt uses include domestic, livestock, and oil and gas exploration. Each district may also exempt additional uses as defined by its rules or enabling legislation.

Because exempt uses are not available for permitting, it is necessary to account for them when determining managed available groundwater. To do this the Texas Water Development Board developed a standardized method for estimating exempt use for domestic and livestock purposes based on projected changes in population and the ratio of domestic and livestock wells in an area to the total number of wells. Because other exempt uses can vary significantly from district to district and there is much higher uncertainty associated with estimating use due to oil and gas exploration, estimates of exempt pumping outside domestic and livestock uses have not been included. If a district believes it has a more appropriate estimate of exempt pumping, they may submit it, along with a description of how it was developed, to the Texas Water Development Board for consideration. Once established, the estimates of exempt pumping are subtracted from the total pumping calculation to yield the estimated managed available groundwater for permitting purposes.

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RESULTS:

The estimated total pumping from the Brazos River Alluvium Aquifer in Groundwater Management Area 14 that achieves the adopted desired future condition is approximately 30,853 acre-feet per year. The volumetric calculations to determine total pumping are shown in Table 2. This pumping has been divided 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).

Table 5 contains the estimates of exempt pumping in the Bluebonnet Groundwater Conservation District for domestic and livestock uses. The managed available groundwater for the groundwater conservation district is the difference between the total pumping (Table 4) and the estimated exempt use (Table 5) and is shown in Table 6.

Table 2. Volumetric calculations estimating the annual total pumping for the Brazos River Alluvium Aquifer in the Bluebonnet Groundwater Conservation District summarized by map areas (see Figure 1).

GMA	Aquifer	County	Groundwater Conservation District	Map Area	Estimated specific yield	Areal extent (acres)	Estimated average saturated thickness	Desired percentage of saturated thickness	Desired drained thickness (feet)	Estimated total volume from water level decline (acre-feet)	Estimated annual volume (acre-feet)	Estimated annual effective recharge[1] (ac-ft/yr)	Estimated annual total volume (ac-ft/yr)
14	Brazos River Alluvium	Austin	Bluebonnet GCD	1	0.15	41,013	29	90%	2.9	17,841	357	7,587	7,944
14	Brazos River Alluvium	Grimes	Bluebonnet GCD	2	0.15	27,254	42	90%	4.2	17,170	343	4,769	5,112
14	Brazos River Alluvium	Waller	Bluebonnet GCD	3	0.15	63,032	36	90%	3.6	34,037	681	11,346	12,027
14	Brazos River Alluvium	Washington	N/A	4	0.15	30,580	29	90%	2.9	13,302	266	5,504	5,770
Total											**1,647**	**29,206**	**30,853**

GMA = groundwater management area ac-ft/yr = acre-feet per year

1 - This is the estimated total annual effective recharge volume for the Brazos River Alluvium Aquifer as shown in Table 1.

The formulas for this table are: specific yield * areal extent * desired total aquifer drainded thickness (based on desired saturated thickness) = estimated total volume from water level decline/50 = estimated annual volume from water level decline. Estimated annual volume from water level decline + estimated annual effective recharge = estimated annual total volume.

Table 3. Estimated total pumping by decade for the Brazos River Alluvium Aquifer in Groundwater Management Area 14. 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
Austin	H	Brazos	7,944	7,944	7,944	7,944	7,944	7,944
Grimes	G	Brazos	5,112	5,112	5,112	5,112	5,112	5,112
Waller	H	Brazos	12,027	12,027	12,027	12,027	12,027	12,027
Washington	G	Brazos	5,770	5,770	5,770	5,770	5,770	5,770
		Total	30,853	30,853	30,853	30,853	30,853	30,853

Table 4. Estimated total pumping for the Brazos River Alluvium Aquifer in the Bluebonnet Groundwater Conservation District for each decade between 2010 and 2060. Results are in acre-feet per year.

Groundwater Conservation District	Year					
	2010	2020	2030	2040	2050	2060
Bluebonnet Groundwater Conservation District	25,083	25,083	25,083	25,083	25,083	25,083

Table 5. Estimates of exempt use for the Brazos River Alluvium Aquifer within the Bluebonnet Groundwater Conservation District for each decade between 2010 and 2060. Results are in acre-feet per year.

Groundwater Conservation District	Source	Year					
		2010	2020	2030	2040	2050	2060
Bluebonnet Groundwater Conservation District	TA	110	132	155	179	205	236

Source: TA = Estimated exempt use calculated by TWDB and accepted by the district.

Table 6. Estimates of managed available groundwater for the Brazos River Alluvium Aquifer within the Bluebonnet Groundwater Conservation District for each decade between 2010 and 2060. Results are in acre-feet per year.

Groundwater Conservation District	Year					
	2010	2020	2030	2040	2050	2060
Bluebonnet Groundwater Conservation District	24,973	24,951	24,928	24,904	24,878	24,847

LIMITATIONS:

Managed available groundwater numbers included in this report are the result of subtracting the estimated future exempt use from the estimated total pumping that would achieve the desired future condition adopted by the groundwater conservation districts in the groundwater management area. These numbers, therefore, are the result of (1) using a simplified water budget to estimate the total pumping which achieves the desired future condition and (2) estimating the future exempt use in the area.

The water budget in this analysis was determined to be the best method to calculate a total pumping estimate, 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.

The analysis further assumes that precipitation is the only source of aquifer recharge that 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 precipitation, recharge, and streamflow in developing these total pumping estimates. Those assumptions also need to be considered and compared to actual future data when evaluating achievement of the desired future condition.

In the case of TWDB's estimates of future exempt use, key assumptions were made as to the pattern of population growth relative to the need for domestic wells or supplied water, per capita use from domestic wells, and livestock use of water. In the case of district estimates of future exempt use, including exempt use associated with the exploration of oil and gas, the assumptions are specific to that district. In any case, these assumptions will need to be considered when reviewing future data related to exempt use.

Given these limitations, users of this information are cautioned that the total pumping 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 of using a water budget and the assumptions in this analysis, it is important that the groundwater conservation districts work with the TWDB to refine these managed available groundwater numbers given the reality of how the aquifer responds to the actual amount and location of pumping now and in the future.

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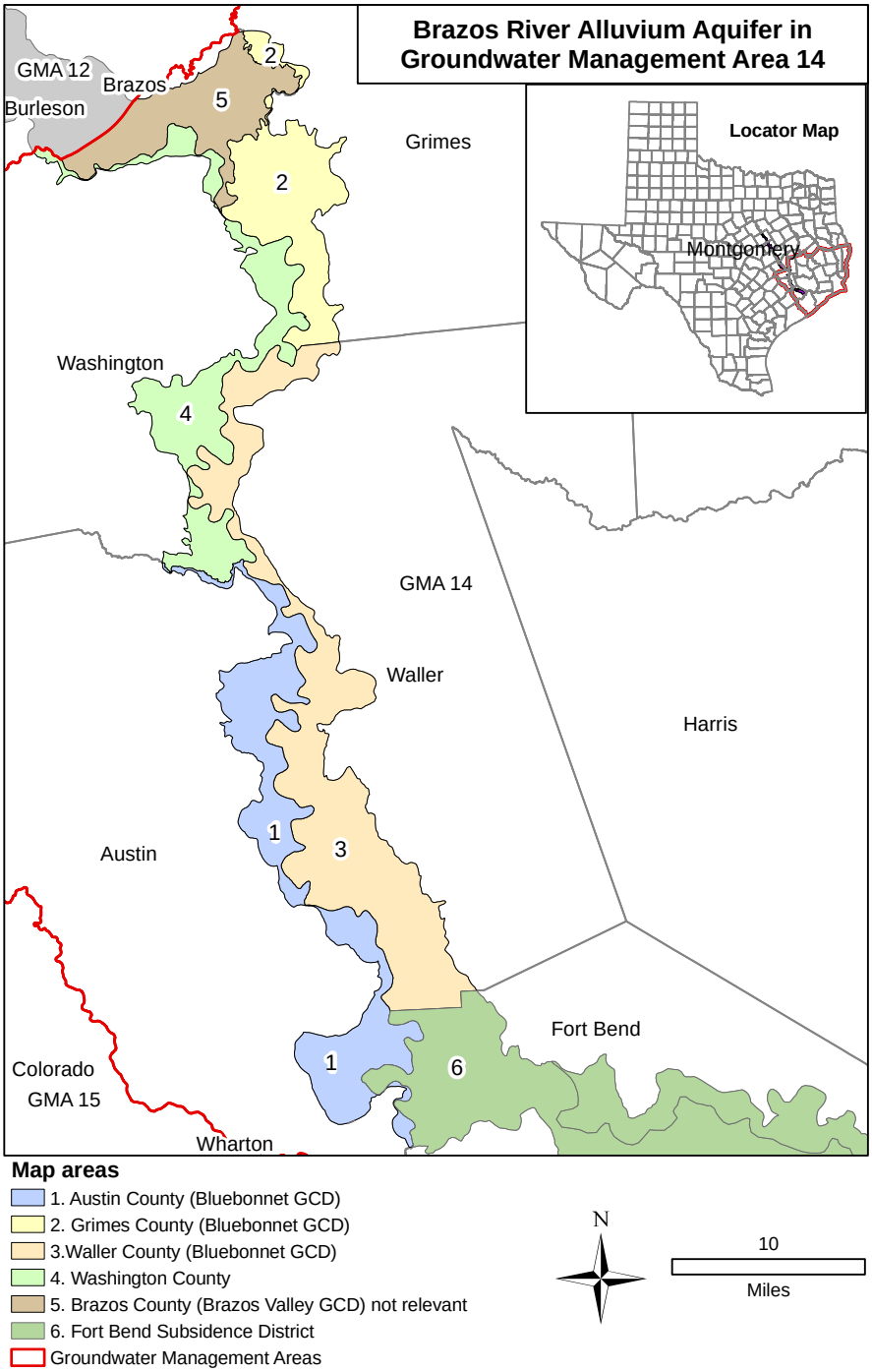

Figure 1. Map showing the map areas for Brazos River Alluvium Aquifer in Groundwater Management Area 14. GCD = Groundwater Conservation District.

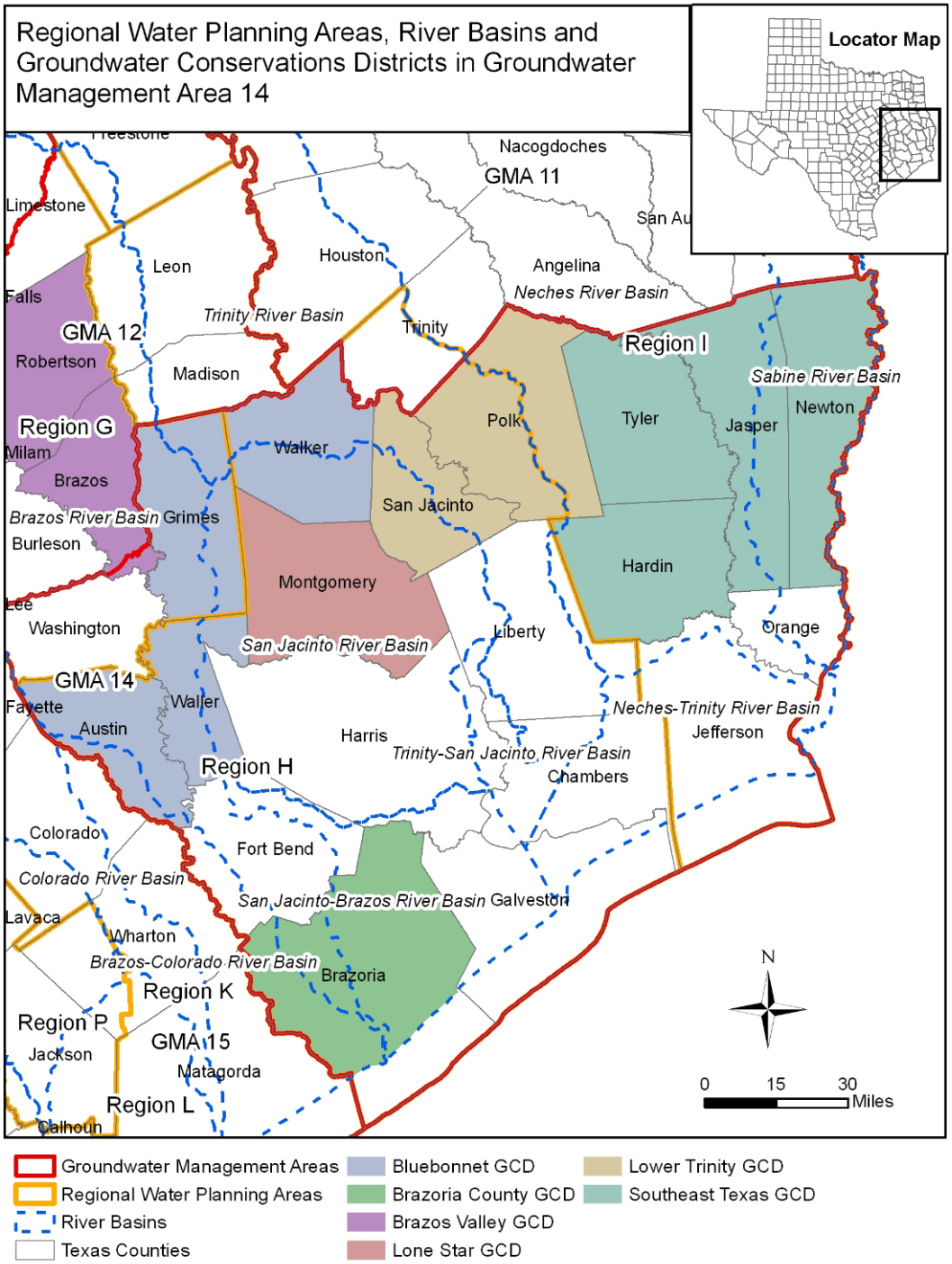

Figure 2. Map showing regional water planning areas, river basins, groundwater conservation districts, and counties in and neighboring the Groundwater Management Area 14. GCD = Groundwater Conservation District