GTA Aquifer Assessment 09-12

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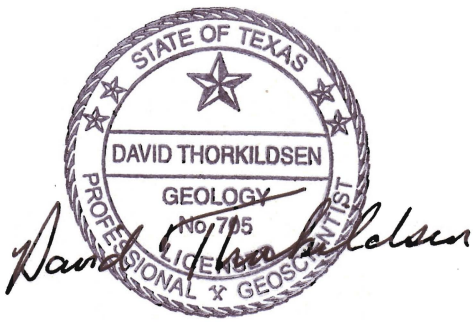

August 31, 2010

REQUESTOR:

Janet Adams, General Manager of Jeff Davis County and Presidio County Underground Water Conservation Districts, acting on behalf of the member groundwater conservation districts of Groundwater Management Area 4.

DESCRIPTION OF REQUEST:

In an email dated 8/14/09, Ms. Janet Adams provided the Texas Water Development Board (TWDB) with draft desired future conditions for all aquifers in Groundwater Management Area 4 and requested that TWDB evaluate the draft desired future condition scenarios.

After reviewing the draft results and on behalf of Brewster County Groundwater Conservation District, Ms. Adams provided the TWDB with additional desired future condition scenarios for the aquifers within Brewster County in an email dated 2/19/10. This aquifer assessment includes all the requested scenarios and estimates the annual total pumping to achieve the draft desired future condition scenarios for the Edwards-Trinity (Plateau) Aquifer in Groundwater Management Area 4.

DRAFT DESIRED FUTURE CONDITIONS:

For the Edwards-Trinity (Plateau) Aquifer:

- Brewster County Groundwater Conservation District — four scenarios that allow an average drawdown of 0, 5, 10, and 20 feet over 50 years, respectively
- Culberson County Groundwater Conservation District — on average a 50-foot drawdown over 50 years
- Jeff Davis County Underground Water Conservation District (UWCD) — on average a 10-foot drawdown over 50 years
- Areas outside conservation district boundaries — on average a 20-foot drawdown over 50 years

METHODS:

For the Edwards-Trinity (Plateau) Aquifer, a simple method of determining groundwater volume based on annual effective recharge and a uniform water-level decline over 50 years was used.

The amount of data available for the Edwards-Trinity (Plateau) Aquifer is considerable; information on effective recharge and specific yield for the aquifer is available from the TWDB Groundwater Availability Model (GAM) (Anaya and Jones, 2004) for the aquifer.

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 over full 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 pumping equals effective recharge plus the change in storage of the aquifer, or:

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

The Edwards-Trinity (Plateau) Aquifer in Groundwater Management Area 4 is located entirely in the Rio Grande River Basin and the Far West Regional Water Planning Area (Region E). County, subcrop/outcrop, and groundwater conservation district boundaries were used to subdivide the aquifer into map areas (Figure 1). The areal extent of each aquifer map area was calculated. These areas were used to calculate estimated annual effective recharge.

The areal extent was multiplied by the estimated aquifer specific yield, and then by uniform water level declines specified in the draft desired future conditions. This volume was then divided by 50 years to obtain a yearly volume. In cases where unconfined and confined conditions existed, those were calculated separately.

Average annual effective recharge to the aquifer was calculated by multiplying each outcrop area by the average precipitation (1971 to 2000) and an effective recharge rate developed for the Edwards-Trinity (Plateau) Aquifer GAM.

The calculations were completed in a Microsoft Excel worksheet.

PARAMETERS AND ASSUMPTIONS:

- The areas for each subdivision were calculated from the TWDB shapefile for the Edwards-Trinity (Plateau) Aquifer, projected into the GAM projection (Anaya, 2001).
- Areas, in acres, were calculated within ArcGIS 9.3.
- Average annual precipitation was used to calculate annual effective recharge volumes.
- The average annual precipitation for each aquifer outcrop map area (Table 1) was determined from the Texas Climatic Atlas (Narasimhan and others, 2008) which is the average for years 1971 through 2000.
- Annual effective recharge from precipitation is estimated to be 2 to 3 percent of annual precipitation (Anaya and Jones, 2004) over the outcrop of the aquifer.
- The estimated average effective recharge for the Edwards-Trinity (Plateau) Aquifer in the analyzed area of Groundwater Management Area 4 is 45,534 acre-feet per year (Table 1).
- Specific yield of the aquifer ranges from 0.2 to 0.005 (Anaya and Jones, 2004).
- The draft annual total pumping estimates are the sum of the annual effective recharge amount and the annual volume of water depleted from the aquifer based on the draft desired future condition.
- Annual volumes are calculated by dividing the total volume by 50 years.
- Water level declines are estimated to be uniform across the aquifer within map areas.
- Conditions were assumed to be physically possible across the groundwater management area.

Table 1. Estimated total annual effective recharge volume for the Edwards-Trinity (Plateau) Aquifer by map area subdivisions (See Figure 1).

GMA	Aquifer	County	GCD	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)
4	Edwards-Trinity (Plateau)	Culberson	none	1	136,285	12	1.0	2	2,726
			Culberson County GCD	3	79,779	13	1.1	2	1,755
		Jeff Davis	Jeff Davis County UWCD	5	337,084	15	1.3	2	8,764
		Brewster	Brewster County GCD	6	978,456	13	1.1	3	32,289
								Total	45,534

GMA = groundwater management area
GCD = groundwater conservation district
ac-ft/yr = acre-feet per year
UWCD = underground water conservation district
The formula for this table is: areal extent (acres) * estimated average annual precipitation (feet) * effective recharge rate = estimated annual effective recharge (ac-ft/yr).

RESULTS:

The results (Tables 2 and 3) show the draft annual total pumping estimates for the Edwards-Trinity (Plateau) Aquifer in Groundwater Management Area 4.

Based on drawdowns of 0, 5, 10, and 20 feet, the Brewster County Groundwater Conservation District has 32,289; 32,778; 33,267; and 34,246 acre-feet per year of draft annual total pumping, respectively.

Based on a 50 foot drawdown, Culberson County Groundwater Conservation District has 2,154 acre-feet per year of draft annual total pumping and based on a 10 foot drawdown, Jeff Davis County Underground Water Conservation District has 9,288 acre-feet per year of draft annual total pumping.

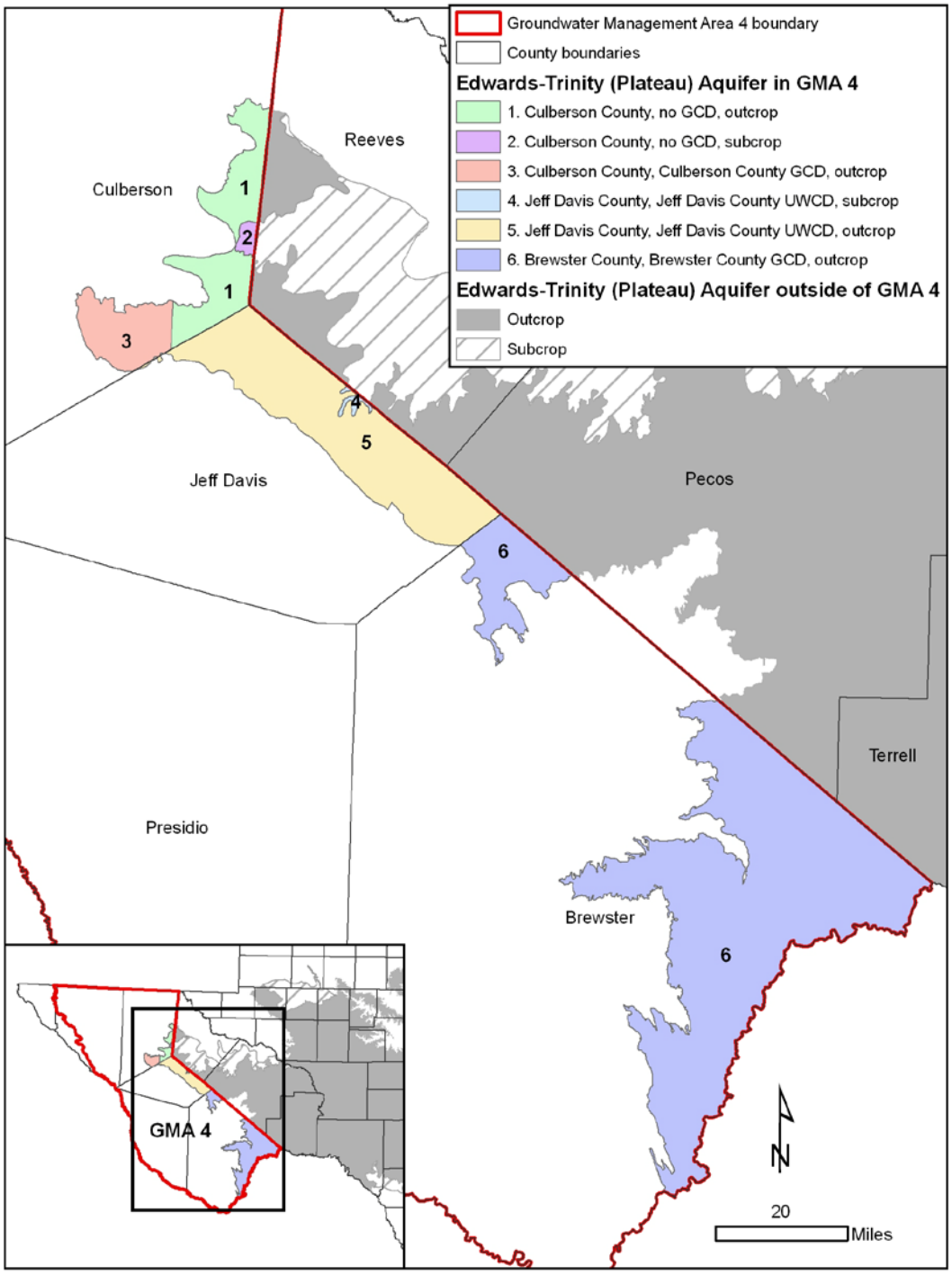

Figure 1. Geographic subdivisions for analyzing draft total pumping for the Edwards-Trinity (Plateau) Aquifer in Groundwater Management Area 4. GMA = groundwater management area, GCD = groundwater conservation district, UWCD = underground water conservation district.

Table 2. Estimates of draft annual total pumping for the Edwards-Trinity (Plateau) Aquifer summarized by map areas (see Figure 1).

GMA	Aquifer	County	GCD	Map Area	Estimated specific yield	Areal extent (acres)	Desired aquifer drawdown (feet)	Estimated total volume from drawdown (acre-feet)	Estimated annual volume from drawdown (acre-feet)	Estimated annual effective recharge[1] (ac-ft/yr)	Estimated annual total volume (ac-ft/yr)
4	Edwards-Trinity (Plateau)	Culberson	none	1	0.005	136,285	20	13,629	273	2,726	2,999
				2	0.2	8,633	20	34,532	691	0	691
			Culberson County GCD	3	0.005	79,779	50	19,945	399	1,755	2,154
		Jeff Davis	Jeff Davis County UWCD	4	0.2	4,687	10	9,374	187	0	187
				5	0.005	337,084	10	16,854	337	8,764	9,101
		Brewster	Brewster County GCD	6	0.005	978,456	0	0	0	32,289	32,289
							5	24,461	489	32,289	32,778
							10	48,923	978	32,289	33,267
							20	97,846	1,957	32,289	34,246

GMA = groundwater management area GCD = groundwater conservation district UWCD = underground water conservation district
ac-ft/yr = acre-feet per year
1 - This is the estimated annual effective recharge volume for the Edwards-Trinity (Plateau) Aquifer by map areas as shown in Table 1.
The formulas for this table are: specific yield * areal extent * desired aquifer drawdown = estimated total volume from drawdown. Estimated total volume from drawdown/50 = estimated annual volume from drawdown. Then estimated annual volume from drawdown + estimated annual effective recharge = estimated annual total volume.

Table 3. Estimates of draft annual total pumping for various drawdown scenarios in the Edwards-Trinity (Plateau) Aquifer (see Figure 1).

Map Key	Draft DFC	Aquifer	County	RWPA	River Basin	GCD	GMA	GeoArea	Year	Outcrop/ Subcrop	Total Pumping (acre-feet per year)
1	20	Edwards-Trinity (Plateau)	Culberson	E	Rio Grande	none	4	n/a	n/a	outcrop	2,999
2	20	Edwards-Trinity (Plateau)	Culberson	E	Rio Grande	none	4	n/a	n/a	subcrop	691
3	50	Edwards-Trinity (Plateau)	Culberson	E	Rio Grande	Culberson County GCD	4	n/a	n/a	outcrop	2,154
4	10	Edwards-Trinity (Plateau)	Jeff Davis	E	Rio Grande	Jeff Davis County UWCD	4	n/a	n/a	subcrop	187
5	10	Edwards-Trinity (Plateau)	Jeff Davis	E	Rio Grande	Jeff Davis County UWCD	4	n/a	n/a	outcrop	9,101
6	0	Edwards-Trinity (Plateau)	Brewster	E	Rio Grande	Brewster County GCD	4	n/a	n/a	outcrop	32,289
6	5	Edwards-Trinity (Plateau)	Brewster	E	Rio Grande	Brewster County GCD	4	n/a	n/a	outcrop	32,778
6	10	Edwards-Trinity (Plateau)	Brewster	E	Rio Grande	Brewster County GCD	4	n/a	n/a	outcrop	33,267
6	20	Edwards-Trinity (Plateau)	Brewster	E	Rio Grande	Brewster County GCD	4	n/a	n/a	outcrop	34,246

Draft DFC = desired future condition based on aquifer drawdown (feet) RWPA = regional water planning area
GMA = groundwater management area GCD = groundwater conservation district UWCD = underground water conservation district
GeoArea = geographic areas defined by unique desired future conditions as specified by a groundwater management area

Limitations:

Additional data are needed to create improved estimates; these estimates are a fundamental interpretation of the requested conditions. This analysis assumes homogeneous and isotropic aquifers; however, conditions for the Edwards-Trinity (Plateau) Aquifer may not behave in a uniform manner. 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.

REFERENCES:

Anaya, R., 2001, GAM technical memo 01-01(rev a): Texas Water Development Board technical memorandum, 2 p.

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