GTA Aquifer Assessment 09-09

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REQUESTOR:

Janet Adams, General Manager of the Jeff Davis County Underground Water Conservation District on behalf of Groundwater Management Area 4.

DESCRIPTION OF REQUEST:

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

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 Marathon Aquifer in the Brewster County Groundwater Conservation District within Groundwater Management Area 4.

DRAFT DESIRED FUTURE CONDITIONS:

- Marathon Aquifer – Four scenarios that allow average water-level declines of 0, 5, 10, and 20 feet over 50 years, respectively.

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, 1978, 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 Marathon Aquifer is located entirely within Groundwater Management Area 4, Brewster County, the Far West Texas Regional Water Planning Group, the Rio Grande River Basin, and the Brewster County Groundwater Conservation District. Therefore, draft annual total pumping was calculated for a single map area (Figure 1). The areal extent of the aquifer was calculated, and this area was 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 of 0, 5, 10, and 20 feet. These volumes were then divided by 50 years to obtain yearly volumes.

Annual effective recharge to the aquifer was calculated by multiplying the outcrop area by the average precipitation (1971 to 2000) and an estimated effective recharge rate.

The calculations were completed in a Microsoft Excel worksheet.

PARAMETERS AND ASSUMPTIONS:

- The entire aquifer extent is assumed to be an outcrop area and calculated as an unconfined aquifer.
- Water level declines of 0, 5, 10, and 20 feet were estimated to be uniform across the aquifer.

- The area was calculated from the TWDB shapefile for the Marathon Aquifer, projected into the groundwater availability modeling (GAM) projection (Anaya, 2001).
- Areas, in acres, were calculated within ArcGIS 9.2.
- Average annual precipitation was used to calculate annual effective recharge volumes.
- The average annual precipitation (1971-2000) for the aquifer map area (Table 1) was determined from the Texas Climatic Atlas (Narasimhan and others, 2008).
- Annual effective recharge from precipitation is estimated to be 2.5 percent of annual precipitation (Muller and Price, 1979; Far West Texas RWPG, 2001).
- 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.
- Specific yield of the aquifer is estimated as 0.03 from information in the Far West Texas Regional Water Plan (Far West Texas RWPG, 2001). This estimate is comparable to other fractured limestone aquifers in Texas (LBG-Guyton Associates, 2003).
- Conditions were assumed to be physically possible across the groundwater management area.

Table 1. Estimated total annual effective recharge volume for the Marathon 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	Marathon	Brewster	Brewster County GCD	1	250,479	14	1.17	2.5	7,327

GMA = groundwater management area GCD = groundwater conservation district 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).

RESULTS:

The annual effective recharge estimate for the Marathon Aquifer is 7,327 acre-feet per year.

The results (Tables 2 and 3) show the draft annual total pumping estimates for the Marathon Aquifer. Water level declines of 0, 5, 10, and 20 feet result in an estimated annual total pumping of 7,327; 8,078; 8,830; and 10,333 acre-feet per year, respectively.

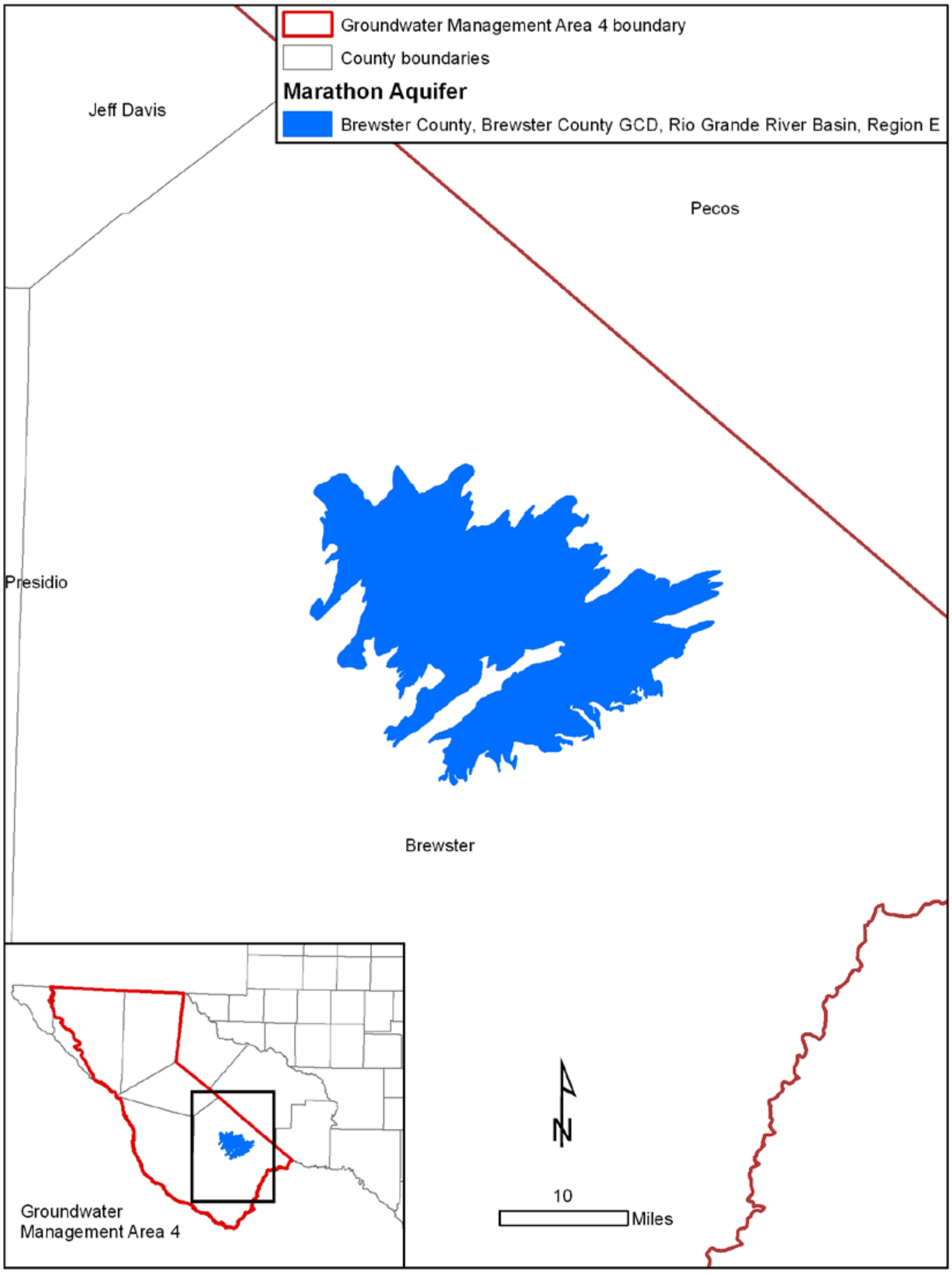

Figure 1. Geographic subdivisions for analyzing draft total pumping for the Marathon Aquifer in Groundwater Management Area 4.
GCD = groundwater conservation district.

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

GMA	Aquifer	County	GCD	Map Area	Estimated specific yield	Areal extent (acres)	Desired total aquifer water level decline (feet)	Estimated total volume from water level decline (acre-feet)	Estimated annual volume from water level decline (acre-feet)	Estimated annual effective recharge[1] (ac-ft/yr)	Estimated annual total volume (ac-ft/yr)
4	Marathon	Brewster	Brewster County GCD	1	0.03	250,479	0	0	0	7,327	7,327
							5	37,572	751	7,327	8,078
							10	75,144	1,503	7,327	8,830
							20	150,287	3,006	7,327	10,333

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

[1] This is the estimated total annual effective recharge volume for the Marathon Aquifer by map areas as shown in Table 1.

The formulas for this table are: specific yield * areal extent * desired total aquifer water level decline = estimated total volume from water level decline. Estimated total volume from water level decline/50 = estimated annual volume from water level decline. Then estimated annual volume from water level decline + estimated annual effective recharge = estimated annual total volume.

Table 3. Estimates of draft annual total pumping for water level declines of 0, 5, 10, and 20 feet in the Marathon Aquifer (see Figure 1).

Map Key	Draft DFC	Aquifer	County	RWPA	River Basin	GCD	GMA	GeoArea	Year	Total Pumping (acre-feet per year)
1	0	Marathon	Brewster	E	Rio Grande	Brewster County GCD	4	n/a	n/a	7,327
1	5	Marathon	Brewster	E	Rio Grande	Brewster County GCD	4	n/a	n/a	8,078
1	10	Marathon	Brewster	E	Rio Grande	Brewster County GCD	4	n/a	n/a	8,830
1	20	Marathon	Brewster	E	Rio Grande	Brewster County GCD	4	n/a	n/a	10,333

Draft DFC = desired future condition based on aquifer water level decline (feet)
RWPA = regional water planning area GMA = groundwater management area GCD = groundwater 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 Marathon 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.

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