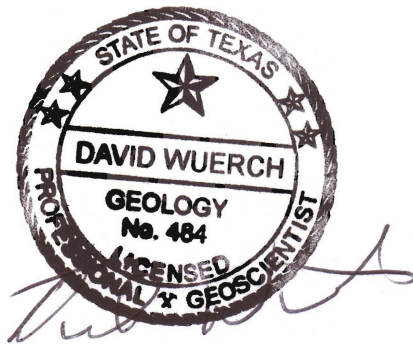# GTA Aquifer Assessment 09-08

by David Wuerch, P.G. and Sarah C. Davidson
Texas Water Development Board
Groundwater Technical Assistance Section
(512) 936-2245

September 21, 2010

REQUESTOR:

Janet Adams, General Manager of Jeff Davis County and Presidio County underground water conservation districts, acting on behalf of Groundwater Management Area 4.

DESCRIPTION OF REQUEST:

Ms. Janet Adams provided the Texas Water Development Board (TWDB) with draft desired future conditions for the Capitan Reef Complex, Marathon, Presidio-Redford Bolson, and Rustler aquifers in Groundwater Management Area 4 and requested that TWDB evaluate the draft desired future conditions. This aquifer analysis estimates the annual total pumping to achieve the draft desired future conditions for the Capitan Reef Complex Aquifer in Groundwater Management Area 4.

DRAFT DESIRED FUTURE CONDITIONS:

- Brewster County Groundwater Conservation District (GCD)—on average a 20-foot drawdown over 50 years
- Culberson County GCD—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:

Due to limited data on the Capitan Reef Complex Aquifer, a simple method of determining groundwater volume based on a uniform water-level decline was used. 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:

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

All of the aquifer within Groundwater Management Area 4 is within the Rio Grande River Basin and the Far West Regional Water Planning Area (Region E). To calculate the total pumping, the aquifer was divided into map areas by county and groundwater conservation district (Figure 1). The areal extent of each aquifer map area was calculated. These areas were used to calculate estimated annual effective recharge.

To determine the volume from storage used to reach the desired water-level drawdown, the areas were multiplied by the estimated aquifer storage coefficient and by the drained saturated thickness necessary to maintain the desired future condition. This volume was then divided by 50 years to obtain a yearly volume.

Annual effective recharge to the aquifer was calculated by distributing existing volumetric recharge estimates evenly across the aquifer areas.

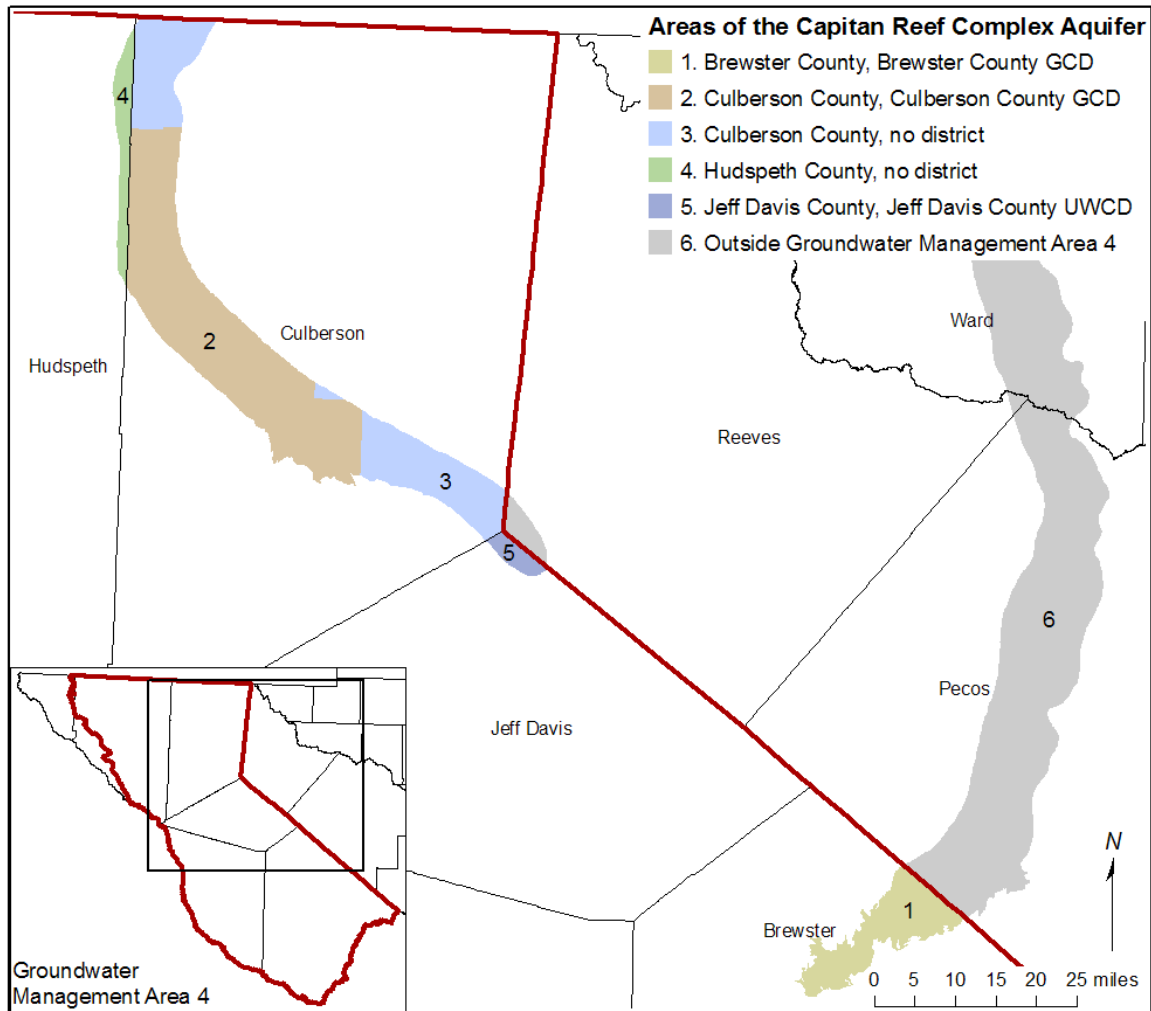The calculations were completed in a Microsoft Excel worksheet.

Figure 1. Map areas for estimating total pumping for the Capitan Reef Complex Aquifer in Groundwater Management Area 4.

PARAMETERS AND ASSUMPTIONS:

- The areas, in acres, for each map area were calculated using the TWDB shapefile for the Capitan Reef Complex Aquifer, projected into the groundwater availability modeling (GAM) projection (Anaya, 2001), within ArcGIS 9.2.
- The Capitan Reef Complex Aquifer is exposed at land surface in the Guadalupe and Apache Mountains in Culberson County and the Glass Mountains in northern Brewster County (Ashworth and Hopkins, 1995).
- The outcrop areas are assumed to be under confined conditions at depth, based on water level data (TWDB, 2008) and from assumptions for

previous investigations (LBG-Guyton Associates, 2003; Far West Texas RWPG, 2001).

- Estimates of storage coefficient in the Capitan Reef Complex Aquifer range from 1.0×10^{-4}–5.0×10^{-2} (0.0001–0.05) (Bjorklund and Motts, 1959; Gates and others, 1978; LBG-Guyton Associates, 2003). The storage coefficient was estimated to be 1.0×10^{-3} (0.001) for these calculations.
- Effective recharge to the aquifer is estimated to be 12,500 acre-feet per year for the portion of the aquifer in Culberson, Jeff Davis, and Hudspeth counties and 2,100 acre-feet per year in Brewster County. These estimates are based on springflow and surface hydrology, groundwater pumpage and water-level changes, and precipitation estimates (Gates and others, 1978; Muller and Price, 1979; Far West Texas RWPG, 2001; George and others, 2005).
- Significant recharge to the aquifer from surface water bodies, such as ephemeral streambeds, has been observed (Bjorklund and Motts 1959), and likely occurs through fractures and karst features (George and others, 2005). However, because there are no existing estimates of the quantity and distribution of these focused inputs to the aquifer, recharge is assumed to occur evenly across the aerial extent of the aquifer.
- 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 of water taken from storage are calculated by dividing the total volume of depletion, based on the draft desired future condition, by 50 years.
- Water-level declines are estimated to be uniform across the aquifer within map areas.
- It is assumed that the water-level declines do not exceed aquifer thickness.
- Conditions were assumed to be physically possible across the groundwater management area.

RESULTS:

The annual effective recharge estimate for the Capitan Reef Complex Aquifer in Groundwater Management Area 4 is 12,500 acre-feet per year for the portion of the aquifer in Culberson, Jeff Davis, and Hudspeth counties and 2,100 acre-feet per year for the portion of the aquifer in Brewster County.

The results (Tables 1 and 2) show the draft annual total pumping estimates for the Capitan Reef Complex Aquifer in Groundwater Management Area 4. Based on the desired future conditions provided, the estimated total pumping volume for

the Capitan Reef Complex Aquifer in Groundwater Management Area 4 is 14,960 acre-feet per year.

Specifically,
- Brewster County GCD has a total of 2,129 acre-feet of annual total pumping;
- Culberson County GCD has a total of 7,580 acre-feet of annual total pumping;
- the area of Culberson County outside of Culberson County GCD has 4,083 acre-feet of annual total pumping;
- Hudspeth County (outside of the GCD) has 825 acre-feet of annual total pumping; and
- Jeff Davis UWCD has a total of 343 acre-feet of annual total pumping.

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

GMA	Aquifer	County	GCD	Map area	Storage coefficient	Areal extent (acres)	Desired total aquifer drawdown (feet)	Estimated total volume from storage (acre-feet)	Estimated annual volume from storage (acre-feet)	Estimated annual effective recharge (ac-ft/yr)	Estimated annual total volume (ac-ft/yr)
4	Capitan Reef (confined)	Brewster	Brewster	1	0.001	72,731	20	1,455	29	2,100	2,129
		Culberson	Culberson	2	0.001	259,695	50	12,985	260	7,320	7,580
			none	3	0.001	142,853	20	2,857	57	4,026	4,083
		Hudspeth	none	4	0.001	28,862	20	577	12	813	825
		Jeff Davis	Jeff Davis	5	0.001	12,100	10	121	2	341	343
							Total	17,995	360	14,600	14,960

GMA = groundwater management area; GCD = groundwater conservation district; ac-ft/yr = acre-feet per year.
The formulas in this table are: storage coefficient * areal extent * desired total aquifer drawdown = estimated total volume from storage
estimated total volume from storage/50 = estimated annual volume from storage
estimated annual volume from storage + estimated annual effective recharge = estimated annual total volume

Table 2. Summary of estimated annual total pumping for the Capitan Reef Complex Aquifer in Groundwater Management Area 4.

Map key	Aquifer	County	RWPA	River basin	GCD	GMA	GeoArea	Year	Total Pumping (acre-feet per year)
1	Capitan	Brewster	E	Rio Grande	Brewster County GCD	4	n/a	n/a	2,129
2	Capitan	Culberson	E	Rio Grande	Culberson County GCD	4	n/a	n/a	7,580
3	Capitan	Culberson	E	Rio Grande	none	4	n/a	n/a	4,083
4	Capitan	Hudspeth	E	Rio Grande	none	4	n/a	n/a	825
5	Capitan	Jeff Davis	E	Rio Grande	Jeff Davis County UWCD	4	n/a	n/a	343

RWPA = regional water planning area, GCD = groundwater conservation district, UWCD = underground water conservation district, GMA = groundwater management area, 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 Capitan Reef Complex Aquifer may not behave in a uniform manner. The analysis further assumes 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.

Ashworth, J.B., and Hopkins, J., 1995, Major and minor aquifers of Texas: Texas Water Development Board Report 345, variously paginated.

Bjorklund, L.J., and Motts, W.S., 1959, Geology and water resources of the Carlsbad area, Eddy County, New Mexico: U.S. Geological Survey Open-File Report 59-9 prepared in cooperation with the New Mexico State Engineer, 322 p.

Far West Texas RWPG (Regional Water Planning Group), 2001, Far west Texas regional water plan: Far West Texas Regional Water Planning Group, variously paginated.

Freeze, R.A., and Cherry, J.A., 1979, Groundwater: Englewood Cliffs, New Jersey, Prentice Hall, Inc., 604.

Gates, J.S., Stanley, W.D., and Ackermann, H.D., 1978, Availability of fresh and slightly saline ground water in the basins of westernmost Texas: United States Geological Survey Open-File Report 78-663, 173 p.

George, P., Mace, R.E., and Mullican, W.F., III, 2005, The hydrogeology of Hudspeth County, Texas: Texas Water Development Board Report 364, 95 p.

LBG-Guyton Associates, 2003, Brackish Groundwater Manual for Texas Regional Water Planning Groups: Texas Water Development Board contract report, 188 p.

Muller, D.A. and Price, R.D., 1979, Ground-water availability in Texas, estimates and projections through 2030: Texas Department of Water Resources Report 238, 77 p.

Theis, C.V., 1940, The source of water derived from wells—Essential factors controlling the response of an aquifer to development: Civil Engineering, v. 10, p. 277–280.

TWDB (Texas Water Development Board), 2008, Groundwater database: Texas Water Development Board, Water Science and Conservation Division. Available online at www.twdb.state.tx.us/gwrd/waterwell/well_info.asp