GTA Aquifer Assessment 06-01

by Robert G. Bradley, P.G., and Peter George, P.G.

Texas Water Development Board
Groundwater Technical Assistance Section
(512) 936-0870
June 10, 2008

REQUESTOR:

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

DESCRIPTION OF REQUEST:

Ms. Adams requested estimates of managed available groundwater assuming to look at 10 to 50 feet declines in the water levels for the Capitan Reef Complex, Marathon, Rustler, Presidio-Redford Bolson, Edwards-Trinity (Plateau), and Diablo Plateau aquifers.

METHODS:

Due to limited data on these aquifers, a simple method of determining groundwater volume based on a uniform water-level decline was used. The aquifers were subdivided by county and groundwater conservation district boundaries. The areal extent of each aquifer subdivision was calculated. This area was multiplied by the estimated aquifer storativity, and then by uniform water level declines. In those cases where unconfined and confined conditions existed in the same aquifer, those were calculated separately. The calculations were done in a Microsoft Excel worksheet.

Analytical estimates for the Edwards-Trinity (Plateau) Aquifer were requested due to possible simulation problems with the Groundwater Availability Model (GAM) in the parts of the model covering GMA 4.

PARAMETERS AND ASSUMPTIONS:

- Water level declines of 10, 20, 30, 40, and 50 feet were estimated to be uniform across the aquifer.
- Fifty years is the period used to calculate total volume; then total volume is divided by 50 to get an annual volume that is in turn added to annual recharge estimates.
- Areas were calculated from Texas Water Development Board (TWDB) shapefiles for the Capitan Reef Complex, Marathon, Rustler, Presidio-

Redford Bolson, and Edwards-Trinity (Plateau) aquifers. The area for the Diablo Plateau was calculated using existing mapping data.

- GMA 4 is wholly contained in the Rio Grande River Basin and the Far West Regional Water Planning Group boundaries.
- Recharge was assumed to be only from precipitation and was estimated using reported recharge rates and aquifer extent unless a published recharge volume was available.
- Recharge from precipitation for the eastern flank of the Capitan Reef Complex Aquifer was estimated to be 2,100 ac-ft/yr (Muller and Price, 1979; George and others, 2005).
- Recharge from precipitation for the western flank of the Capitan Reef Complex Aquifer was estimated to be 12,500 ac-ft/yr (Muller and Price, 1979; George and others, 2005).
- Recharge from precipitation for the Capitan Reef Complex Aquifer was areally distributed to each segment of the aquifer.
- Storativity of the Capitan Reef Complex Aquifer was estimated to be 1.0×10^{-3} (0.001) (LBG-Guyton Associates, 2003).
- 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.
- 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).
- Recharge from precipitation for the Marathon Aquifer was estimated to be 7,306 ac-ft/yr based on a recharge estimate of 2.5 percent of annual precipitation as recharge (Far West Texas RWPG, 2001).
- The average annual precipitation for the Marathon Aquifer area was estimated to be 14 inches (NOAA, 2002).
- The specific yield for the Marathon aquifer was estimated to be 0.03 from information in the Far West Texas RWPG (2001). This estimate is comparable to other fractured limestone aquifers in Texas (LBG-Guyton Associates, 2003).
- Recharge from precipitation for the Rustler Aquifer was estimated to be 4,000 ac-ft/yr based on Muller and Price (1979).
- Storativity of the confined Rustler Aquifer was estimated to be 1.0×10^{-4} (0.0001) and the specific yield was estimated to be 0.003 (LBG-Guyton Associates, 2003).
- Storativity of the Presidio-Redford Bolson Aquifer was assumed to be 0.06 based on estimates for other West Texas Bolson aquifers (Beach and others, 2004).
- Recharge to the Presidio-Redford Bolson was estimated to be 3,630 ac-ft/yr (Far West Texas RWPG, 2001).
- Storativity of the Edwards-Trinity (Plateau) Aquifer was estimated to be 5.0×10^{-3} (0.005) (Anaya and Jones, 2004).

- Recharge from precipitation for the Edwards-Trinity (Plateau) Aquifer was estimated to be 7,306 ac-ft/yr based on a recharge estimate of 1.0 percent of annual precipitation as recharge (Far West Texas RWPG, 2001).
- The average annual precipitation for the Edwards-Trinity (Plateau) Aquifer subareas was estimated to be 13 inches in Culberson County and 14 inches in Jeff Davis and Brewster counties (NOAA, 2002).
- The Bone specific yield of Spring-Victorio Peak Aquifer of 0.05 (is used in the the volume estimates for the geologically similar Diablo Plateau Aquifer (LBG-Guyton Associates, 2003).
- Recharge from precipitation for the Diablo Plateau was estimated to be 0.007 feet per year (Mayer and Sharp, 1998).

RESULTS:

Capitan Reef Complex Aquifer estimates are listed in Table 1 and the areas used for the calculations are shown on Figure 1. A 10-foot decline results in an approximate available groundwater volume of 14,703 acre-feet per year and a decline of 50 feet is approximately 15,116 acre-feet per year available from the aquifer.

Marathon Aquifer estimates are listed in Table 2 and the areas used for the estimates are shown on Figure 2. The maximum estimated decline of 50 feet provides 14,820 acre-feet per year

Rustler Aquifer estimates are listed in Table 3 and areas used to analyze volumes are shown on Figure 3. Estimates range from 4,381 acre-feet per year based on a 10 foot decline up to 5,903 acre-feet per year for a decline of 50 feet.

The Presido-Redford Bolson estimates are listed in Table 4 and the areas used for the calculations are shown on Figure 4. A 10 foot decline results in an approximate groundwater volume of 7,293 acre-feet per year and a decline of 50 feet is approximately 21,944 acre-feet per year available from the aquifer.

Spreadsheet estimates of the Edward-Trinity (Plateau) Aquifer show an approximate, total, available groundwater volume of 18,424 acre-feet per year with an estimated 10 foot decline and 24,281 acre-feet available with an average 50 foot decline (Table 5; Figure 5).

Diablo Plateau Aquifer estimates are listed in Table 6 and the areas used for the estimates are shown on Figure 6. The minimum estimated groundwater availability, based on a decline of 10 feet, provides 21,182 acre-feet per year, and 50 feet provides an estimated 71,021 acre-feet per year.

Table 1. Estimated total annual volume available from the Capitan Reef Complex Aquifer by geographic subdivisions (See Figure 1).

GMA	Aquifer	County	GCD	Map Area	Estimated Storativity	Areal Extent (acres)	Assumed Total Aquifer Drawdown (feet)	Estimated Confined Volume (acre-feet)	Estimated Annual Confined Volume (acre-feet)	Estimated Annual Recharge (acre-feet)	Estimated Annual Total Volume (acre-feet)
4	Capitan Reef (confined)	Brewster	Brewster County GCD	7	0.001	72,731	10	727	15	2,100	2,115
					0.001	72,731	20	1,455	29	2,100	2,129
					0.001	72,731	30	2,182	44	2,100	2,144
					0.001	72,731	40	2,909	58	2,100	2,158
					0.001	72,731	50	3,637	73	2,100	2,173
		Culberson	None	2	0.001	61,734	10	617	12	1,740	1,752
					0.001	61,734	20	1,235	25	1,740	1,765
					0.001	61,734	30	1,852	37	1,740	1,777
					0.001	61,734	40	2,469	49	1,740	1,789
					0.001	61,734	50	3,087	62	1,740	1,802
			Culberson County GCD	3	0.001	259,695	10	2,597	52	7,319	7,371
					0.001	259,695	20	5,194	104	7,319	7,423
					0.001	259,695	30	7,791	156	7,319	7,475
					0.001	259,695	40	10,388	208	7,319	7,527
					0.001	259,695	50	12,985	260	7,319	7,579
			None	4	0.001	2,607	10	26	1	73	74
					0.001	2,607	20	52	1	73	75
					0.001	2,607	30	78	2	73	75
					0.001	2,607	40	104	2	73	76
					0.001	2,607	50	130	3	73	76
			None	5	0.001	78,512	10	785	16	2,213	2,228
					0.001	78,512	20	1,570	31	2,213	2,244
					0.001	78,512	30	2,355	47	2,213	2,260
					0.001	78,512	40	3,140	63	2,213	2,276
					0.001	78,512	50	3,926	79	2,213	2,291
		Hudspeth	None	1	0.001	28,862	10	289	6	813	819
					0.001	28,862	20	577	12	813	825
					0.001	28,862	30	866	17	813	831
					0.001	28,862	40	1,154	23	813	837
					0.001	28,862	50	1,443	29	813	842
		Jeff Davis	Jeff Davis County UWCD	6	0.001	12,100	10	121	2	341	343
					0.001	12,100	20	242	5	341	346
					0.001	12,100	30	363	7	341	348
					0.001	12,100	40	484	10	341	351
					0.001	12,100	50	605	12	341	353
		Total			0.001	516,240	10	5,162	103	14,600	14,703
					0.001	516,240	20	10,325	206	14,600	14,806
					0.001	516,240	30	15,487	310	14,600	14,910
					0.001	516,240	40	20,650	413	14,600	15,013
					0.001	516,240	50	25,812	516	14,600	15,116

Table 2. Estimated total annual volume available from the Marathon Aquifer by geographic subdivision (See Figure 2).

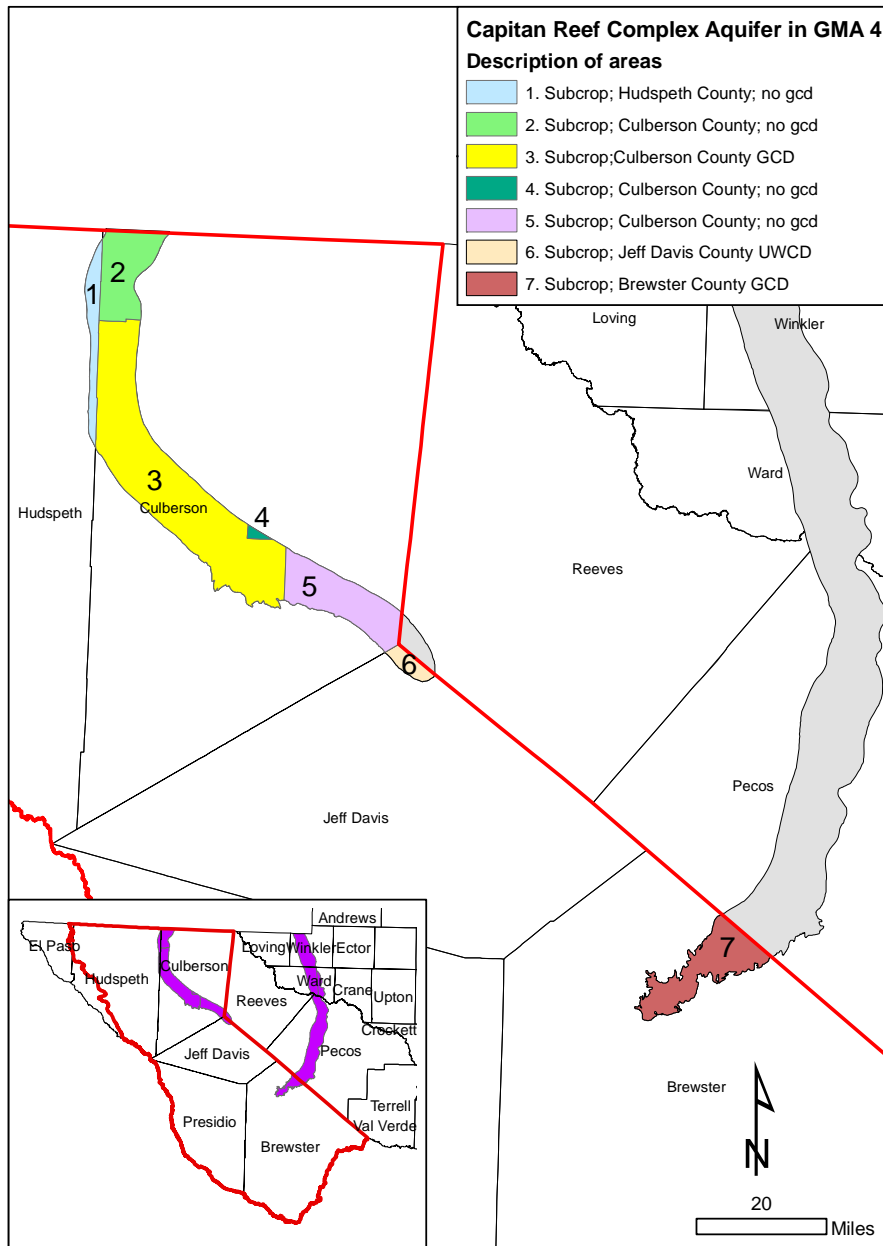| GMA	Aquifer	County	GCD	Map Area	Specific Yield	Areal Extent (acres)	Assumed Total Aquifer Drawdown (feet)	Estimated Confined Volume (acre-feet)	Estimated Annual Confined Volume (acre-feet)	Estimated Annual Recharge (acre-feet)	Estimated Annual Total Volume (acre-feet)
4	Marathon Aquifer	Brewster	Brewster County GCD	1	0.03	250,479	10	75,144	1,503	7,306	8,809
					0.03	250,479	20	150,287	3,006	7,306	10,311
					0.03	250,479	30	225,431	4,509	7,306	11,814
					0.03	250,479	40	300,575	6,011	7,306	13,317
					0.03	250,479	50	375,718	7,514	7,306	14,820

Figure 1. Geographic subdivisions for analyzing the Capitan Reef Complex Aquifer.
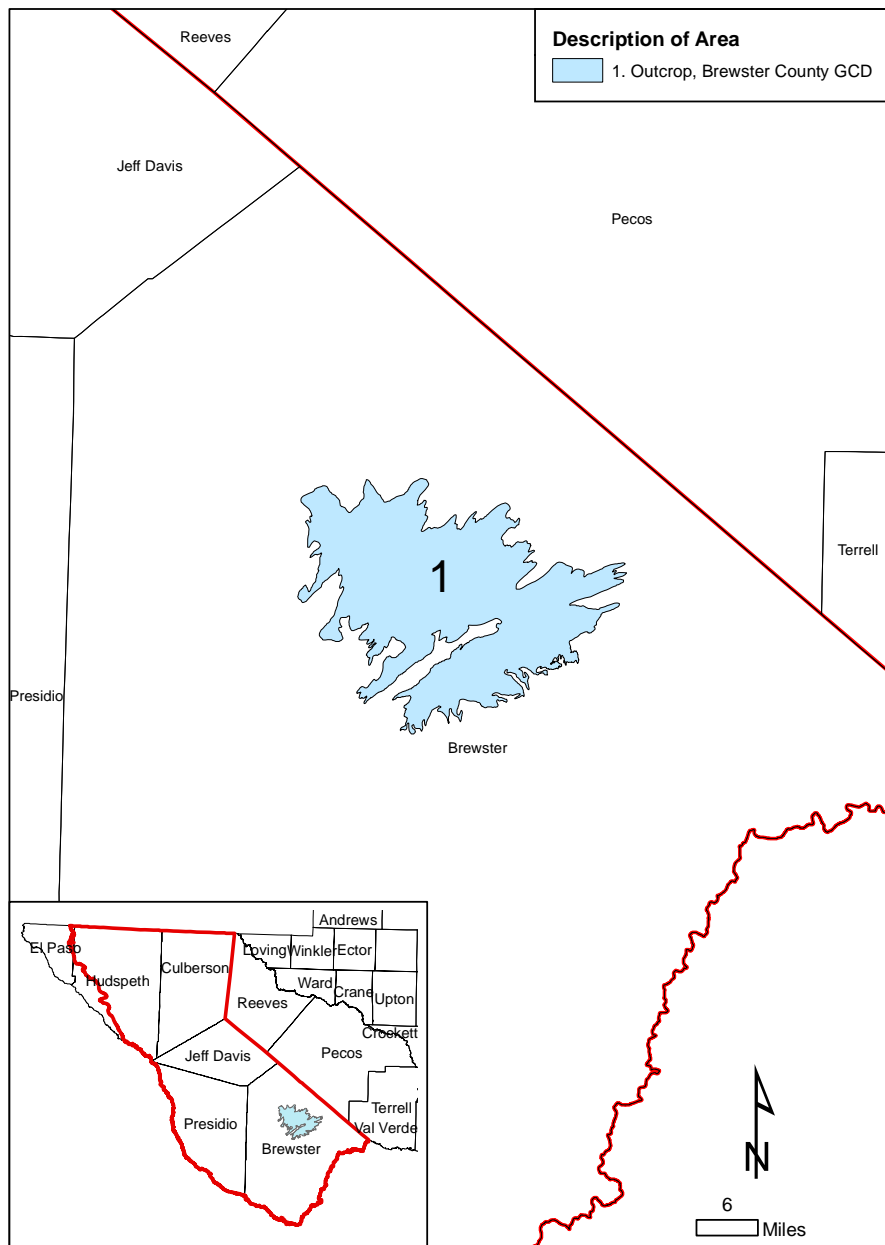
Figure 2. Geographic subdivisions for analyzing the Marathon Aquifer.

Table 3. Estimated total annual volume available from the Rustler Aquifer by geographic subdivision (See Figure 3).

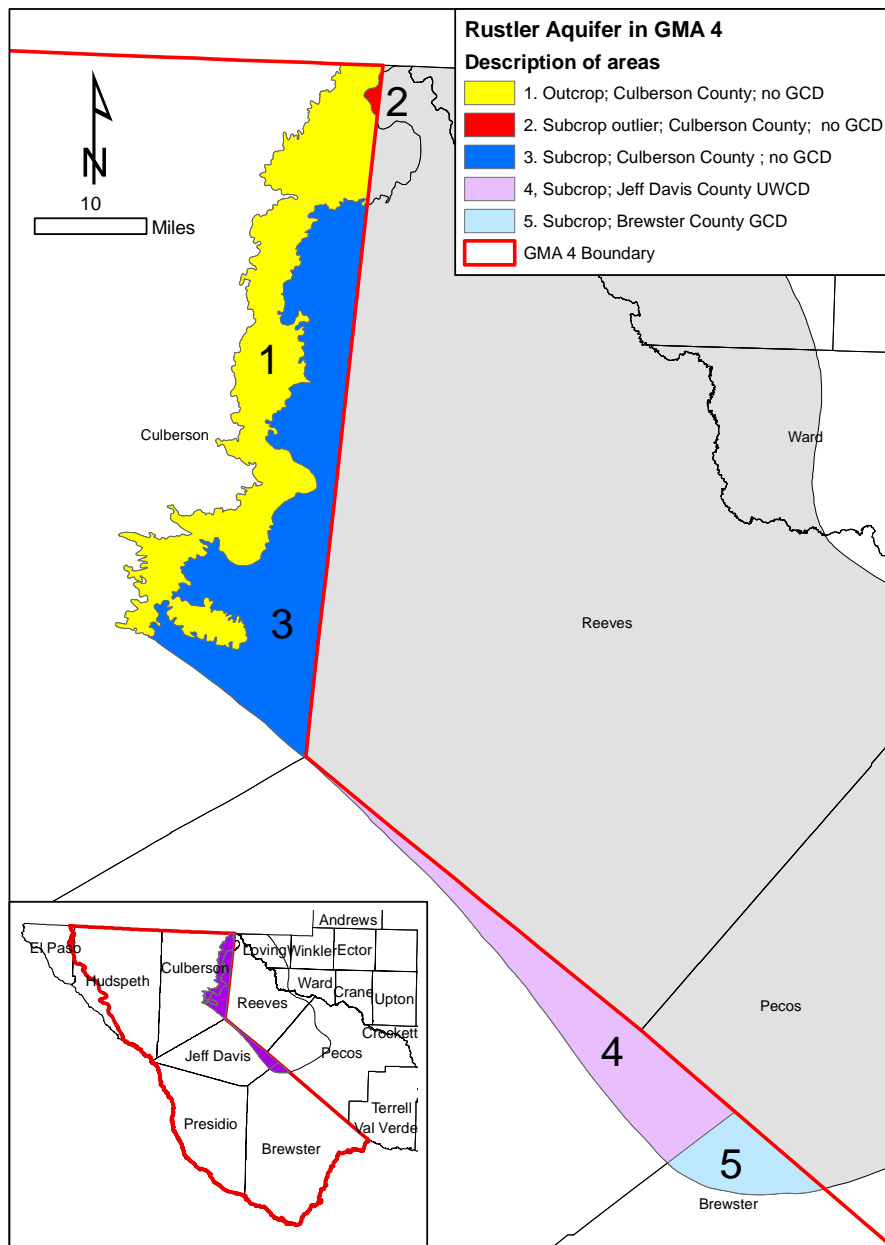| GMA	Aquifer	County	GCD	Map Area	Estimated Storativity	Areal Extent (acres)	Assumed Total Aquifer Drawdown (feet)	Estimated Volume (acre-feet)	Estimated Annual Volume (acre-feet)	Estimated Annual Recharge (acre-feet)	Estimated Annual Total Volume (acre-feet)
4	Rustler (confined)	Brewster	Brewster County GCD	5	0.0001	34,844	10	35	1	267	267
					0.0001	34,844	20	70	1	267	268
					0.0001	34,844	30	105	2	267	269
					0.0001	34,844	40	139	3	267	269
					0.0001	34,844	50	174	3	267	270
		Culberson	None	2	0.0001	1,515	10	2	0	12	12
					0.0001	1,515	20	3	0	12	12
					0.0001	1,515	30	5	0	12	12
					0.0001	1,515	40	6	0	12	12
					0.0001	1,515	50	8	0	12	12
			None	3	0.0001	200,879	10	201	4	1,537	1,541
					0.0001	200,879	20	402	8	1,537	1,545
					0.0001	200,879	30	603	12	1,537	1,550
					0.0001	200,879	40	804	16	1,537	1,554
					0.0001	200,879	50	1,004	20	1,537	1,558
		Jeff Davis	Jeff Davis County UWCD	4	0.0001	101,881	10	102	2	780	782
					0.0001	101,881	20	204	4	780	784
					0.0001	101,881	30	306	6	780	786
					0.0001	101,881	40	408	8	780	788
					0.0001	101,881	50	509	10	780	790
		Total (confined)			0.0001	339,119	10	339	7	1,986	1,992
					0.0001	339,119	20	678	14	1,986	1,999
					0.0001	339,119	30	1,017	20	1,986	2,006
					0.0001	339,119	40	1,356	27	1,986	2,013
					0.0001	339,119	50	1,696	34	1,986	2,020
	Rustler (unconfined)	Culberson	None	1	0.03	183,507	10	55,052	1,101	1,404	2,506
					0.03	183,507	20	110,104	2,202	1,404	3,607
					0.03	183,507	30	165,156	3,303	1,404	4,708
					0.03	183,507	40	220,208	4,404	1,404	5,809
					0.03	183,507	50	275,261	5,505	1,404	6,910
	Total						10	55,730	1,115	4,000	5,115
							20	111,461	2,229	4,000	6,229
							30	167,191	3,344	4,000	7,344
							40	222,921	4,458	4,000	8,458
							50	278,652	5,573	4,000	9,573

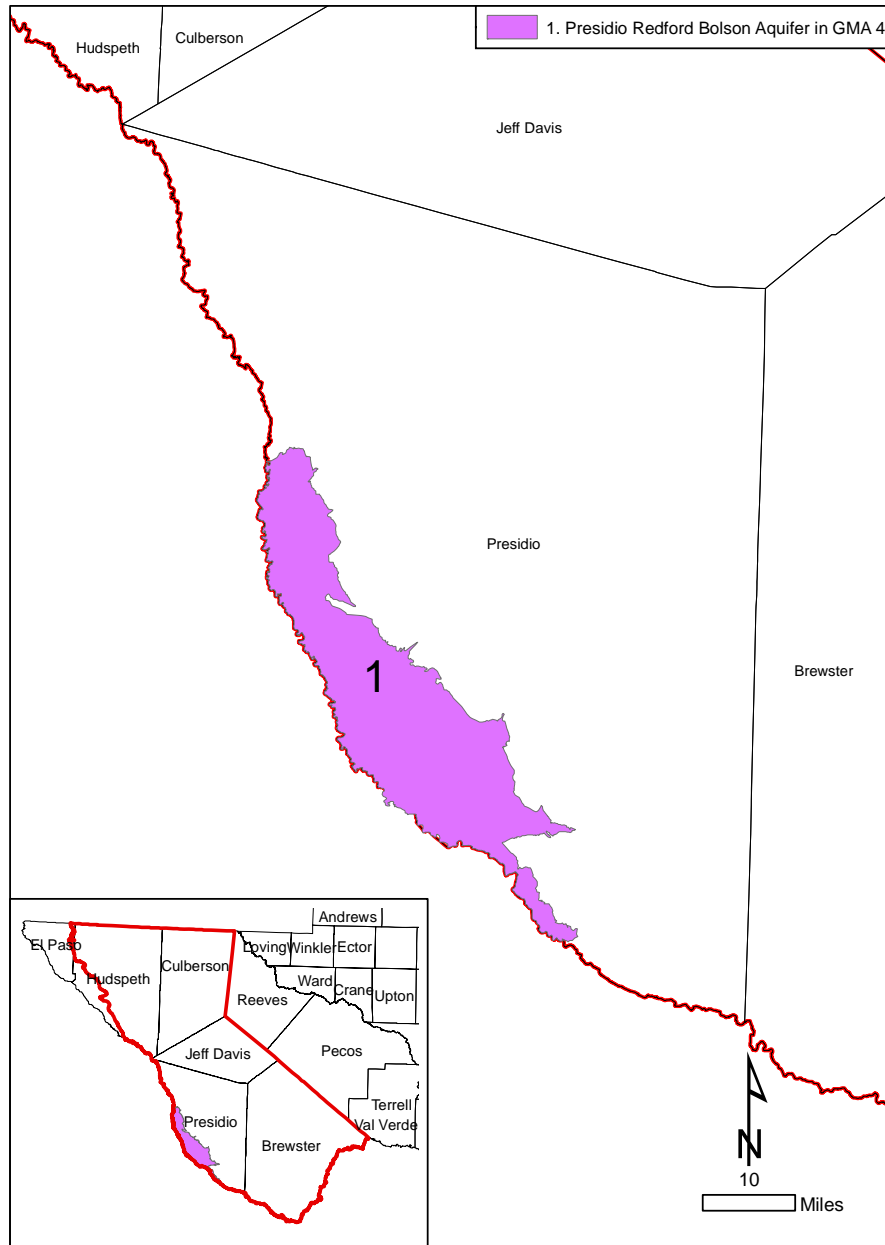Figure 3. Geographic subdivisions for analyzing the Rustler Aquifer.

Table 4. Estimated total annual volume available from the Presidio-Redford Bolson Aquifer by geographic subdivision (See Figure 4).

GMA	Aquifer	County	GCD	Map Area	Estimated Storativity	Areal Extent (acres)	Assumed Total Aquifer Drawdown (feet)	Estimated Volume (acre-feet)	Estimated Annual Volume (acre-feet)	Estimated Annual Recharge (acre-feet)	Estimated Annual Total Volume (acre-feet)
4	Presidio-Redford Bolson (unconfined)	Presidio	Presidio County GCD	1	0.06	305,235	10	183,141	3,663	3,630	7,293
					0.06	305,235	20	366,282	7,326	3,630	10,956
					0.06	305,235	30	549,422	10,988	3,630	14,618
					0.06	305,235	40	732,563	14,651	3,630	18,281
					0.06	305,235	50	915,704	18,314	3,630	21,944

Table 5. Estimated total annual volume available from the Edward-Trinity (Plateau) Aquifer by geographic subdivision (See Figure 5).

GMA	Aquifer	County	GCD	Map Area	Estimated Storativity	Areal Extent (acres)	Assumed Total Aquifer Drawdown (feet)	Estimated Volume (acre-feet)	Estimated Annual Volume (acre-feet)	Estimated Annual Recharge (acre-feet)	Estimated Annual Total Volume (acre-feet)
4	Edwards Trinity (Plateau) Aquifer	Brewster	Brewster County GCD	4	0.005	98,621	10	4,931	99	1,151	1,249
					0.005	98,621	20	9,862	197	1,151	1,348
					0.005	98,621	30	14,793	296	1,151	1,446
					0.005	98,621	40	19,724	394	1,151	1,545
					0.005	98,621	50	24,655	493	1,151	1,644
			Brewster County GCD	5	0.005	879,867	10	43,993	880	10,265	11,145
					0.005	879,867	20	87,987	1,760	10,265	12,025
					0.005	879,867	30	131,980	2,640	10,265	12,905
					0.005	879,867	40	175,973	3,519	10,265	13,785
					0.005	879,867	50	219,967	4,399	10,265	14,664
		Culberson	Culberson County GCD	1	0.005	79,793	10	3,990	80	864	944
					0.005	79,793	20	7,979	160	864	1,024
					0.005	79,793	30	11,969	239	864	1,104
					0.005	79,793	40	15,959	319	864	1,184
					0.005	79,793	50	19,948	399	864	1,263
			None	2	0.005	69,665	10	3,483	70	755	824
					0.005	69,665	20	6,966	139	755	894
					0.005	69,665	30	10,450	209	755	964
					0.005	69,665	40	13,933	279	755	1,033
					0.005	69,665	50	17,416	348	755	1,103
		Jeff Davis	Jeff Davis County UWCD	3	0.005	336,390	10	16,819	336	3,925	4,261
					0.005	336,390	20	33,639	673	3,925	4,597
					0.005	336,390	30	50,458	1,009	3,925	4,934
					0.005	336,390	40	67,278	1,346	3,925	5,270
					0.005	336,390	50	84,097	1,682	3,925	5,606
		Total			0.005	1,464,335	10	73,217	1,464	16,959	18,424
					0.005	1,464,335	20	146,434	2,929	16,959	19,888
					0.005	1,464,335	30	219,650	4,393	16,959	21,352
					0.005	1,464,335	40	292,867	5,857	16,959	22,817
					0.005	1,464,335	50	366,084	7,322	16,959	24,281

Figure 4. Geographic subdivisions for analyzing the Presidio-Redford Bolson.
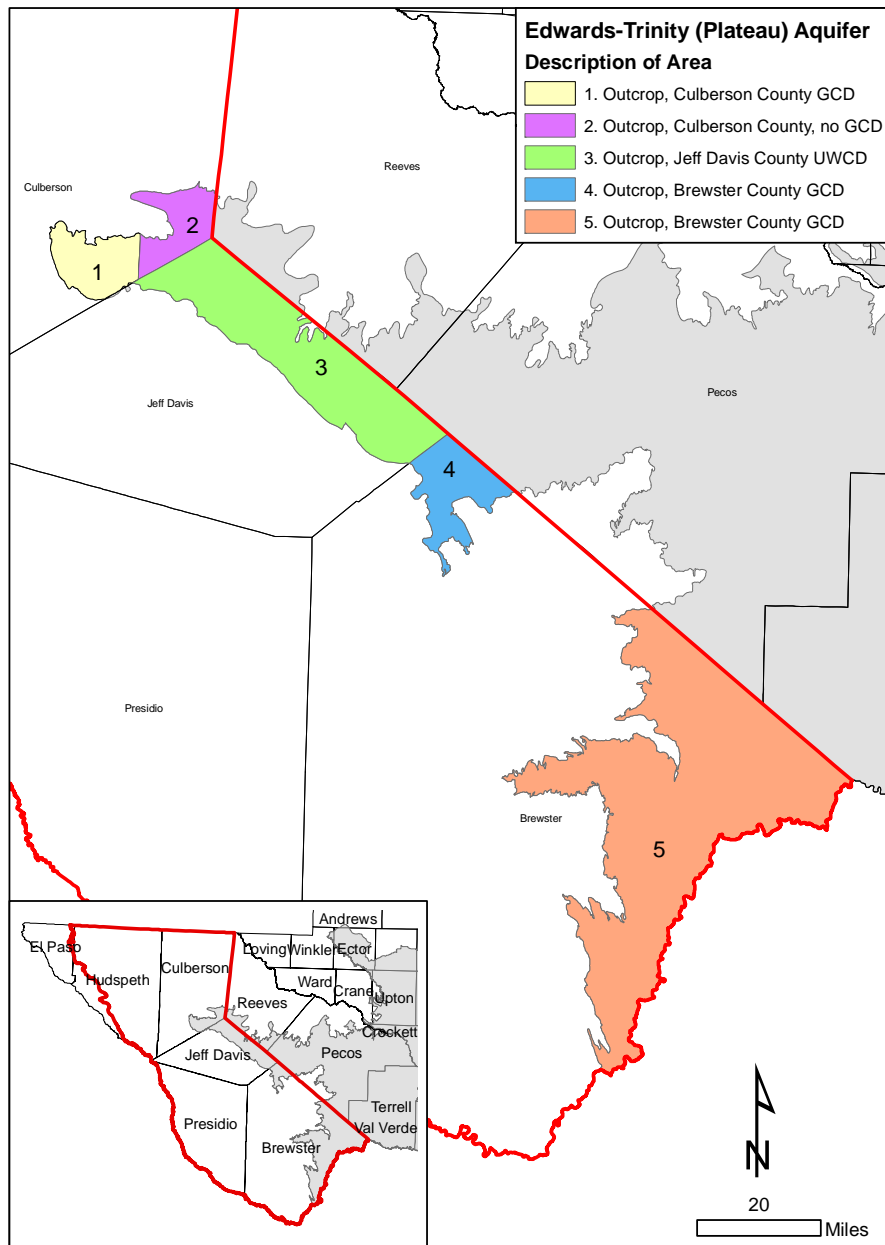
Figure 5. Geographic subdivisions for analyzing the Edwards-Trinity (Plateau) aquifer.

Table 6. Estimated total annual volume available from the Diablo Plateau Aquifer (See Figure 6).

| GMA	Aquifer	County	GCD	Map Area	Estimated Specific Yield	Areal Extent (acres)	Assumed Total Aquifer Drawdown (feet)	Estimated Volume (acre-feet)	Estimated Annual Volume (acre-feet)	Estimated Annual Recharge (acre-feet)	Estimated Annual Total Volume (acre-feet)
4	Diablo Plateau	Culberson	Culberson County GCD	3	0.05	26,996	10	13,498	270	189	459
					0.05	26,996	20	26,996	540	189	729
					0.05	26,996	30	40,494	810	189	999
					0.05	26,996	40	53,993	1,080	189	1,269
					0.05	26,996	50	67,491	1,350	189	1,539
		Hudspeth	Hudspeth County UWCD No. 1	2	0.05	58,398	10	29,199	584	409	993
					0.05	58,398	20	58,398	1,168	409	1,577
					0.05	58,398	30	87,597	1,752	409	2,161
					0.05	58,398	40	116,797	2,336	409	2,745
					0.05	58,398	50	145,996	2,920	409	3,329
			None	1	0.05	1,135,288	10	567,644	11,353	7,947	19,300
					0.05	1,135,288	20	1,135,288	22,706	7,947	30,653
					0.05	1,135,288	30	1,702,931	34,059	7,947	42,006
					0.05	1,135,288	40	2,270,575	45,412	7,947	53,359
					0.05	1,135,288	50	2,838,219	56,764	7,947	64,711
		El Paso	None	4	0.05	25,298	10	12,649	253	177	430
					0.05	25,298	20	25,298	506	177	683
					0.05	25,298	30	37,946	759	177	936
					0.05	25,298	40	50,595	1,012	177	1,189
					0.05	25,298	50	63,244	1,265	177	1,442
		Total			0.05	1,245,980	10	622,990	12,460	8,722	21,182
					0.05	1,245,980	20	1,245,980	24,920	8,722	33,641
					0.05	1,245,980	30	1,868,970	37,379	8,722	46,101
					0.05	1,245,980	40	2,491,960	49,839	8,722	58,561
					0.05	1,245,980	50	3,114,949	62,299	8,722	71,021
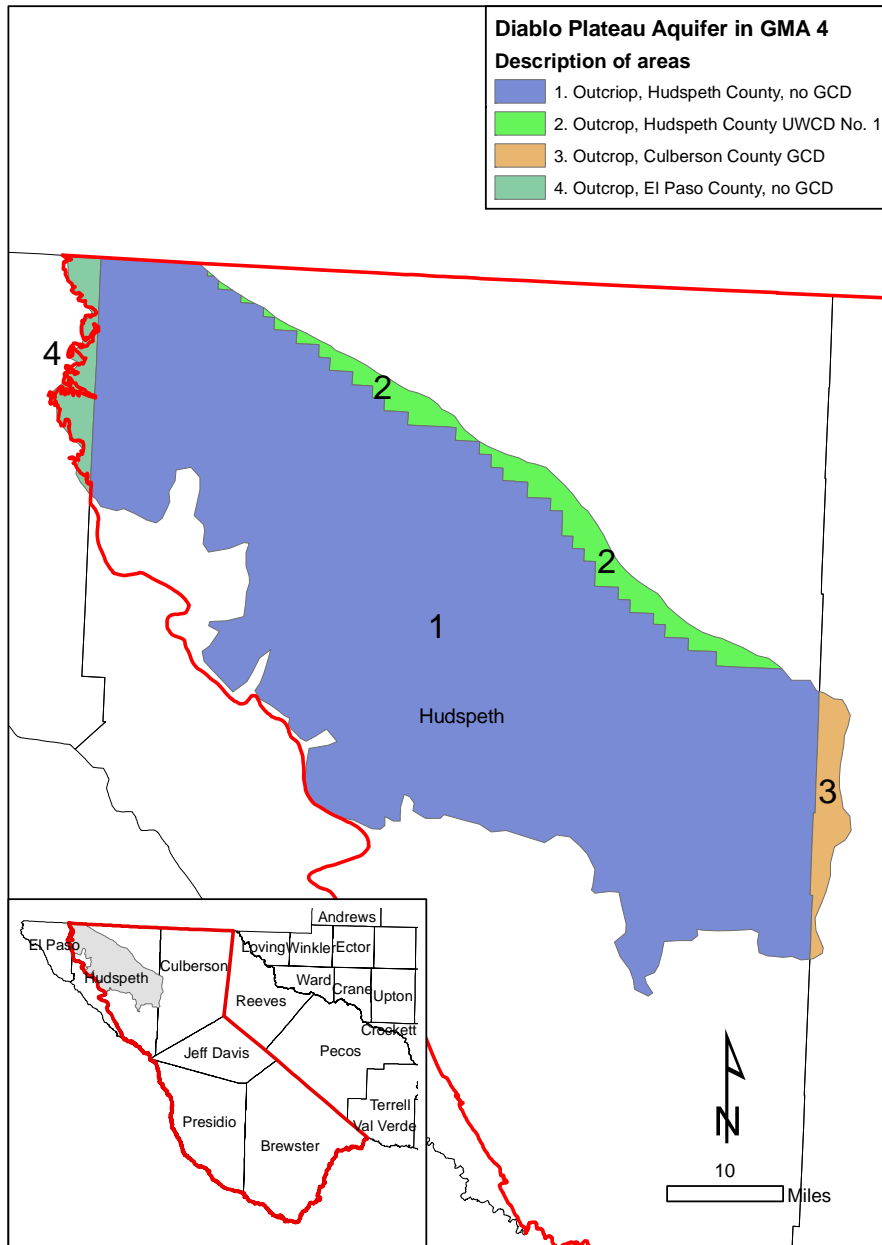
Figure 6. Geographic subdivisions for analyzing the Diablo Plateau
Aquifer.

STIPULATIONS:

Additional data are needed to create improved estimates; however, these estimates are a simplistic interpretation of the requested conditions. These solutions assume homogeneous and isotropic aquifers; however, conditions for the aquifers in GMA 4 typically do not behave in a uniform manner. Recharge is the largest variable; because some of these aquifers are wholly or partially confined, only a small volume is withdrawn from aquifer storage in our approximations. Therefore, the recharge estimates are the most influential variable used in these calculations.

In addition, the drawdown values assumed for the Edwards-Trinity (Plateau) Aquifer may have exceeded the actual saturated thickness for the aquifer. Based on data from the TWDB database, the areas in Culberson, Jeff Davis, and northern Brewster County may only have may have approximately 20 feet or less of saturated thickness.

REFERENCES:

Anaya, R. and Jones, I., 2004, Groundwater Availability Model for the Edwards-Trinity (Plateau) and Cenozoic Pecos Alluvium Aquifer Systems, Texas: Texas Water Development Board GAM Report, 215 p.

Beach, J. A., Ashworth, J. B., Finch, Jr., S. T., Chastain-Howley, A., Calhoun, K., Urbanczyk, K. M., Sharp, J. M., and Olson, J., 2004, Groundwater availability model for the Igneous and parts of the West Texas Bolsons (Wild Horse Flat, Michigan Flat, Ryan Flat and Lobo Flat) aquifers: contract report to the Texas Water Development Board, 208 p.

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

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. 188p.

Mayer, J. M., and Sharp, J. M., Jr., 1998, Fracture control of regional ground-water flow in a carbonate aquifer in a semi-arid region: Geological Society of America Bulletin, v. 110, p. 269-283.

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.

National Oceanic and Atmospheric Administration, 2002, Climatography of the
United States no. 81, monthly station normals of temperature,
precipitation, and heating and cooling degree days, 1971 – 2000: National
Oceanic and Atmospheric Administration, 88 p.
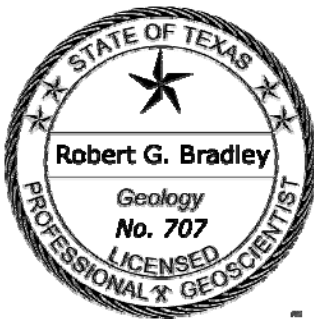
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on June 10, 2008
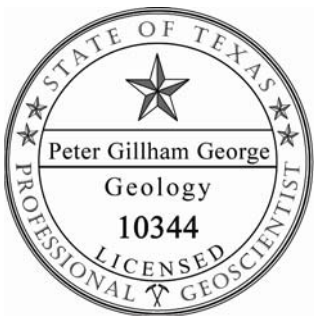
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