

# GAM Task 10-031: Supplement to GAM Task 10-005

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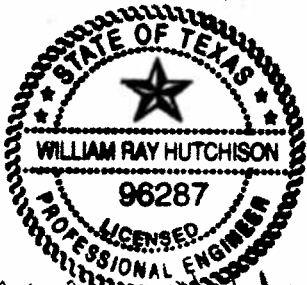
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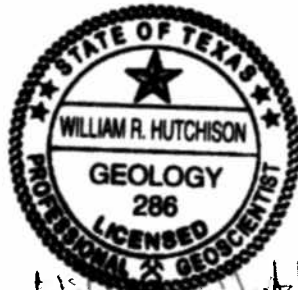
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January 25, 2011



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The seals appearing on this document were authorized by William R. Hutchison, P.E. 96287, P.G. 286 and Mohammad Masud Hassan, P.E. 95699 on January 25, 2011.

## **DESCRIPTION OF TASK:**

This report presents additional results associated with the analysis described in GAM Task 10-005. The simulations used as part of this task include four of the seven pumping scenarios (GAM Task 10-005) of the Trinity Aquifer that range from current estimated pumping representing 2008 to about twice the estimated 2008 level of pumping. Each scenario included running 387 50-year simulations. The 387 50-year simulations were developed based on tree-ring precipitation estimates from 1537 to 1972 for the Edwards Plateau (Cleaveland, 2006). The results were used to evaluate averaged water budgets per county and to develop contour maps of average drawdown in water levels for each scenario.

## **METHODS:**

The seven pumping scenarios in GAM Task 10-005 (Hutchison, 2010) ranged from no pumping in the Trinity Aquifer (Scenario 1), to 2008 levels of pumping (about 60,000 acre-feet in Scenario 4) to about twice the pumping experienced in 2008 (about 120,000 acre-feet in Scenario 7) as summarized below:.

- Scenario 1 = 0 acre-feet per year
- Scenario 2 = 20,000 acre-feet per year
- Scenario 3 = 40,000 acre-feet per year
- Scenario 4 = 60,000 acre-feet per year (2008 conditions)
- Scenario 5 = 80,000 acre-feet per year
- Scenario 6 = 100,000 acre-feet per year
- Scenario 7 = 120,000 acre-feet per year

Table 1 summarizes the estimated pumping by county and by aquifer in 2008. These estimates were provided by groundwater conservation districts in Groundwater Management Area 9.

Table 1. Estimated 2008 pumping as provided by the groundwater conservation districts in Groundwater Management Area 9

<b>County</b>	<b>Edwards Group of the Edwards-Trinity (Plateau) Aquifer</b>	<b>Upper Trinity Aquifer</b>	<b>Middle Trinity Aquifer</b>	<b>Lower Trinity Aquifer</b>	<b>Total Pumping (County)</b>
Bandera	631	288	3567	515	<b>5,000</b>
Bexar	0	693	14110	197	<b>15,000</b>
Blanco	0	77	1,477	0	<b>1,554</b>
Comal	0	398	5,788	0	<b>6,186</b>
Hays	0	416	4,800	449	<b>5,665</b>
Kendall	315	300	6,060	325	<b>7,000</b>
Kerr	1,035	213	6,263	5,534	<b>13,045</b>
Medina	0	0	500	1000	<b>1,500</b>
Travis	0	551	4,967	0	<b>5,518</b>
<b>Total pumping (aquifer)</b>	<b>1,981</b>	<b>2,936</b>	<b>47,532</b>	<b>8,020</b>	<b>60,468</b>

#### **PARAMETERS AND ASSUMPTIONS:**

- See GAM Task 10-005 (Hutchison, 2010) for additional information of the assumptions used for recharge, starting conditions, and pumping for the 387 50 year simulations.
- The recently updated Hill Country portion of the Trinity Aquifer developed by Jones and others (2009) was used for these simulations. See Mace and others (2000) and Jones and others (2009) for details on model construction, recharge distribution, discharge, assumptions, and limitations of the model.
- Pumping scenarios 4, 5, 6, and 7 were used as described above
- The model has four layers: layer 1 represents the Edwards Group of the Edwards-Trinity (Plateau) Aquifer, layer 2 represents the Upper Trinity Aquifer, layer 3 represents the Middle Trinity Aquifer, and layer 4 represents the Lower Trinity Aquifer.
- The rivers, streams, and springs were simulated in the model using MODFLOW's Drain package. MODFLOW's Drain package was also used to simulate spring discharge along bedding contacts of the Edwards Group (Plateau) and the Upper

Trinity Aquifer in the northwestern parts of the model area. This resulted in the assignment of numerous drain cells along this outcrop contact.

- The model was run with MODFLOW-96 (Harbaugh and McDonald, 1996).
- Drawdowns were calculated by subtracting the final water levels at the end of the 50 year simulations from the 2008 initial conditions..

## **RESULTS:**

Summary tables of all groundwater budget results (by county and aquifer are presented in Appendix A. Because each scenario consisted of 387 50-year simulations, the groundwater budget results are expressed in terms of average of all 387 simulations for each scenario.

Figures 1 through 4 show the contour maps of the average drawdown for the Trinity Aquifer within Groundwater Management Area 9. In scenario 4 the drawdown is a maximum of about 14.5 feet to a minimum of 3.3 feet water rise in elevation compared to 2008 starting water level elevations. In scenario 5, 6 and 7 the drawdown ranges from:

- zero feet to 54.6 feet,
- zero feet to 74.0 feet, and
- zero feet to 87.9 feet respectively.

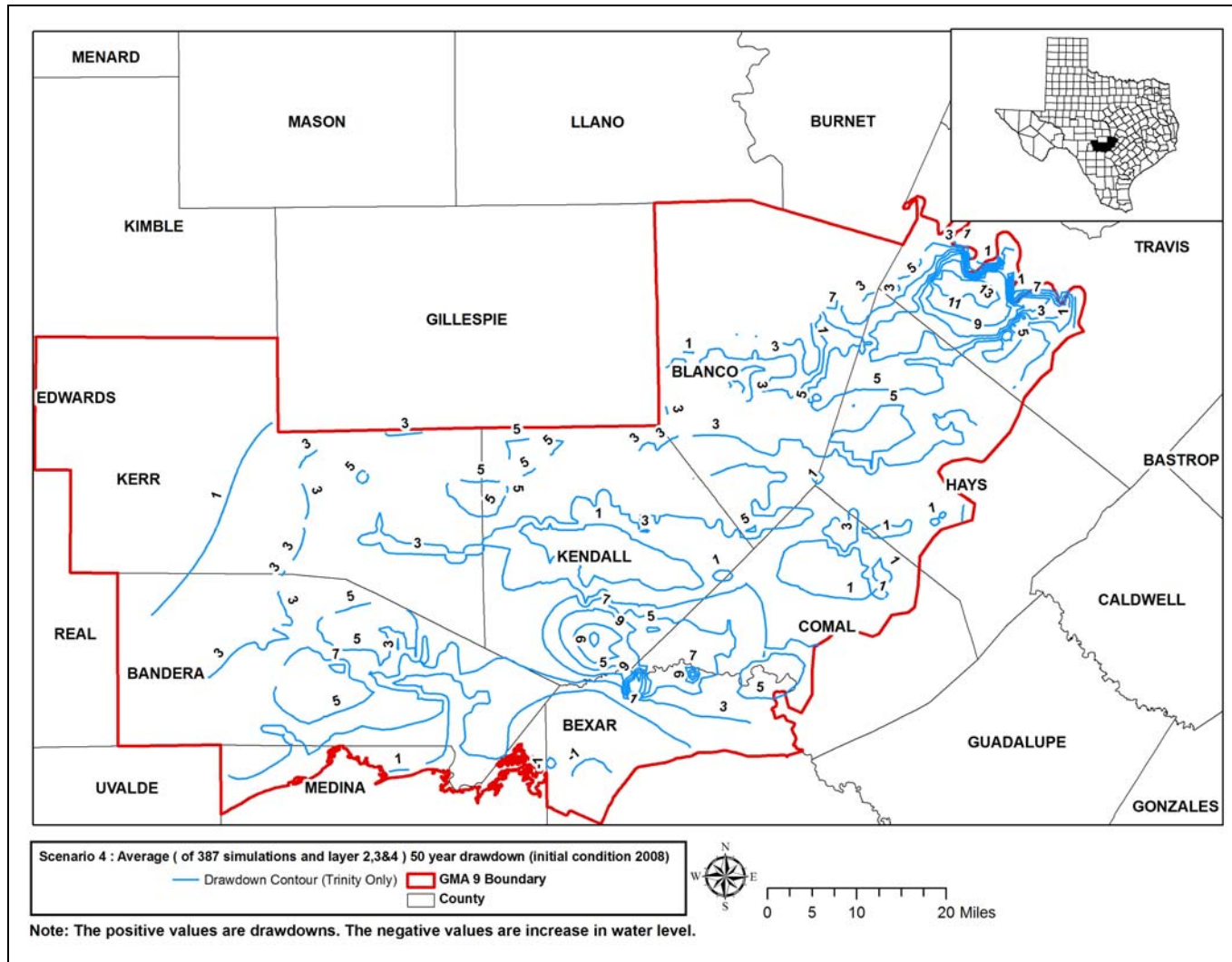


Figure 13: Average water level drawdown contour map for scenario 4 for Groundwater Management Area (GMA) 9 using 2008 water levels for the calculation.

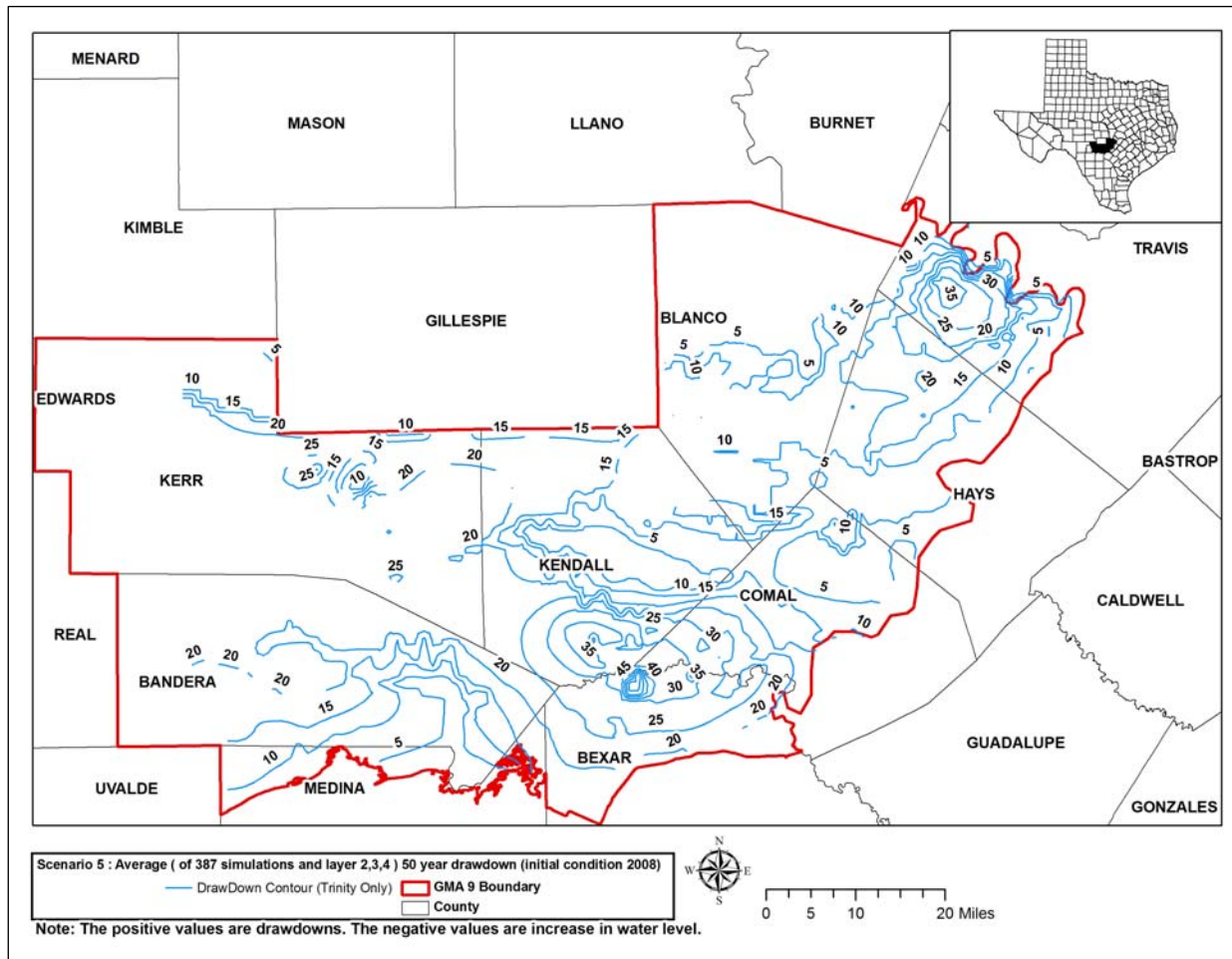


Figure 14: Average water level drawdown contour map for scenario 5 for Groundwater Management Area (GMA) 9 using 2008 water levels for the calculation.

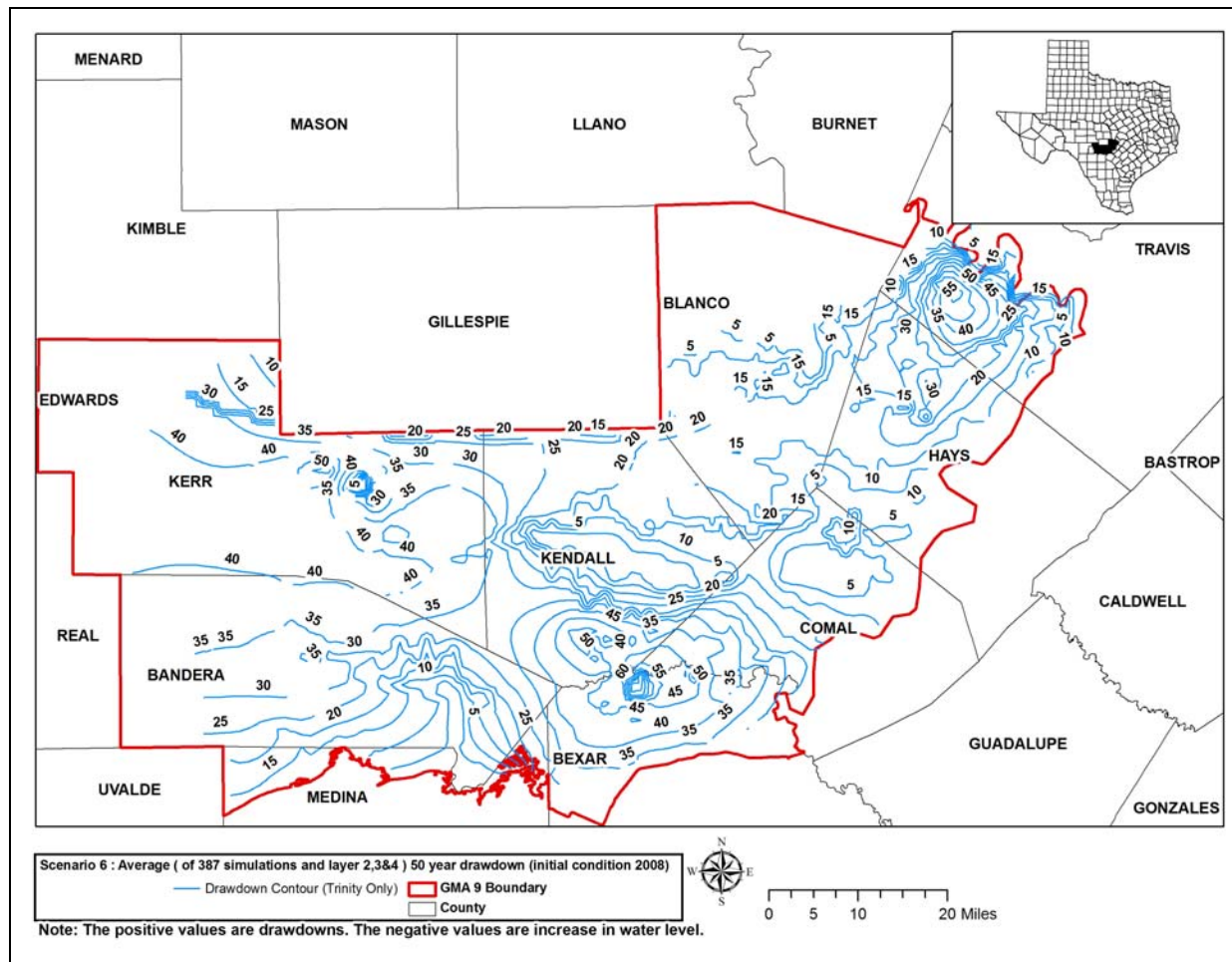


Figure 15: Average water level drawdown contour map for scenario 6 for Groundwater Management Area (GMA) 9 using 2008 water levels for the calculation.

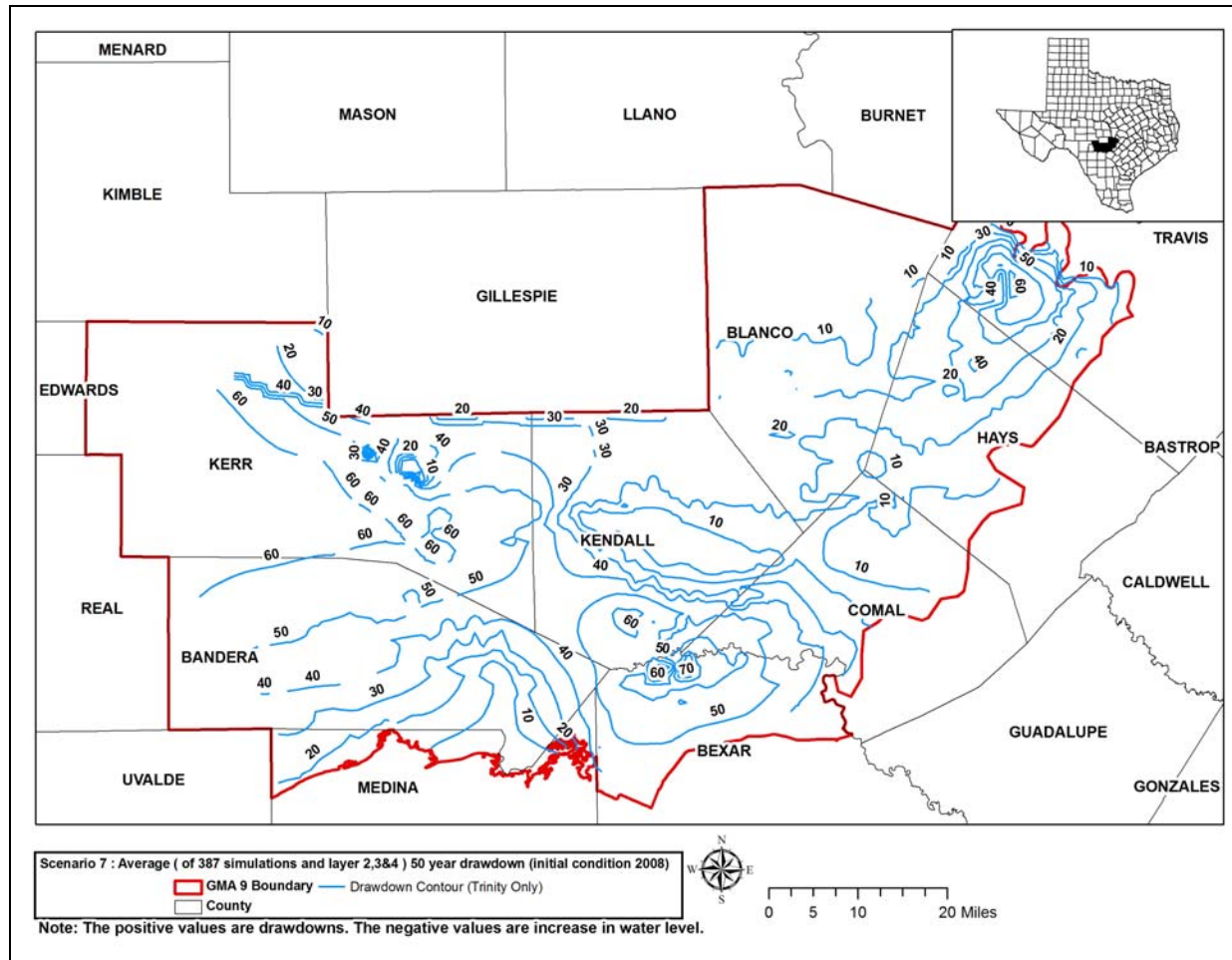


Figure 16: Average water level drawdown contour map for scenario 7 for Groundwater Management Area (GMA) 9 using 2008 water levels for the calculation.



**REFERENCES:**

Hutchison, William R., 2010. Draft GAM Task 10-005. Texas Water Development Board unpublished report.

Chowdhury, Ali H., 2010. Draft GAM Runs 09-011, 09-012, and 09-24. Texas Water Development Board unpublished report.

Cleaveland, Malcolm K., 2006. Extended Chronology of Drought in the San Antonio Area. Report to the Guadalupe-Blanco River Authority.

Harbaugh, A.W. and McDonald, M.G., 1996, User's documentation for the U.S. Geological Survey modular finite-difference ground-water flow model: U.S. Geological Survey Open-File Report 96-485

Hutchison, W.R., 2010, Draft GAM Runs 09-011, 09-012, and 09-24 Supplement. Texas Water Development Board unpublished report.

Jones, I.C., Anaya, R. and Wade, S., 2009, Groundwater Availability Model for the Hill Country portion of the Trinity Aquifer System, Texas, Texas Water Development Board unpublished report, 193 p.

Mace, R.E., Chowdhury, A.H., Anaya, R., and Way, S-C., 2000, Groundwater availability of the Trinity Aquifer, Hill Country Area, Texas—Numerical simulations through 2050: Texas Water Development Board Report 353, 119 p.

# **Appendix A**

## **Water budgets per county for:**

**Bandera County**

**Bexar County**

**Blanco County**

**Comal County**

**Hays County**

**Kendall County**

**Kerr County**

**Medina County**

**Travis County**

Table: Bandera County (Edward Aquifer. 2008 to 2060)				
INFLOW	Scen 4	Scen 5	Scen 6	Scen 7
RECHARGE FROM PRECIPITATION	9,604	9,460	9,435	9,405
INFLOW FROM KERR COUNTY	3,422	3,392	3,386	3,383
TOTAL INFLOW	13,026	12,852	12,821	12,788
OUTFLOW				
PUMPING	626	626	626	626
OUTFLOW TO SURFACE WATER	11,678	11,568	11,560	11,535
OUTFLOW TO TRINITY AQUIFER	707	704	704	703
TOTAL OUTFLOW	13,011	12,898	12,890	12,864
TOTAL INFLOW- TOTAL OUTFLOW	15	-46	-69	-76
STORAGE CHANGE	15	-45	-68	-75
MODEL ERROR	0	-1	-1	-1

Table: Bandera County (Trinity Aquifer. 2008 to 2060)				
INFLOW	Scen 4	Scen 5	Scen 6	Scen 7
RECHARGE FROM PRECIPITATION	31,787	31,310	31,227	31,129
INFLOW FROM KENDALL COUNTY	5,686	5,391	5,165	4,906
INFLOW FROM KERR COUNTY	7,415	6,655	6,070	5,459
INFLOW FROM EDWARD AQUIFER	707	704	704	703
TOTAL INFLOW	45,595	44,060	43,166	42,197
OUTFLOW				
PUMPING	4,373	5,831	7,290	8,746
OUTFLOW TO SURFACE WATER	21,680	19,892	18,672	17,436
OUTFLOW TO EDWARD AQUIFER (BALCONES FALT ZONE)	1,118	807	543	217
OUTFLOW TO OTHER AREA	470	381	324	237
OUTFLOW TO BEXAR COUNTY	1,742	1,754	1,775	1,779
OUTFLOW TO MEDINA COUNTY	16,295	15,870	15,579	15,033
TOTAL OUTFLOW	45,678	44,535	44,183	43,448
TOTAL INFLOW- TOTAL OUTFLOW	-83	-475	-1,017	-1,251
STORAGE CHANGE	-82	-475	-1,018	-1,251
MODEL ERROR	-1	0	1	0

Table: Bexar County (Trinity Aquifer. 2008 to 2060)				
INFLOW	Scen 4	Scen 5	Scen 6	Scen 7
RECHARGE FROM PRECIPITATION	41,294	40,673	40,566	40,439
INFLOW FROM BANDERA COUNTY	1,742	1,754	1,775	1,779
INFLOW FROM COMAL COUNTY	10,621	11,273	11,896	12,446
INFLOW FROM KENDALL COUNTY	10,392	10,086	9,844	9,480
INFLOW FROM MEDINA COUNTY	4,831	5,788	6,688	7,583
<b>TOTAL INFLOW</b>	<b>68,880</b>	<b>69,574</b>	<b>70,769</b>	<b>71,727</b>
OUTFLOW				
PUMPING	14,922	19,897	24,872	29,682
OUTFLOW TO SURFACE WATER	10,412	10,285	10,214	10,139
OUTFLOW TO EDWARD AQUIFER (BALCONES FALT ZONE)	33,705	30,389	27,484	24,436
OUTFLOW TO OTHER AREA	9,878	9,216	8,638	8,028
<b>TOTAL OUTFLOW</b>	<b>68,917</b>	<b>69,787</b>	<b>71,208</b>	<b>72,285</b>
<b>TOTAL INFLOW- TOTAL OUTFLOW</b>	<b>-37</b>	<b>-213</b>	<b>-439</b>	<b>-558</b>
STORAGE CHANGE	-37	-209	-434	-554
MODEL ERROR	0	-4	-5	-4

Table: Blanco County (Trinity Aquifer. 2008 to 2060)				
INFLOW	Scen 4	Scen 5	Scen 6	Scen 7
RECHARGE FROM PRECIPITATION	23,316	22,966	22,906	22,834
INFLOW FROM OTHER AREA	1,796	1,761	1,731	1,696
INFLOW FROM KENDALL COUNTY	2,738	2,704	2,690	2,670
<b>TOTAL INFLOW</b>	<b>27,850</b>	<b>27,431</b>	<b>27,327</b>	<b>27,200</b>
OUTFLOW				
PUMPING	1,545	2,060	2,575	3,090
OUTFLOW TO SURFACE WATER	17,127	16,380	15,928	15,419
OUTFLOW TO COMAL COUNTY	3,799	3,683	3,597	3,487
OUTFLOW TO HAYS COUNTY	5,434	5,482	5,532	5,558
<b>TOTAL OUTFLOW</b>	<b>27,905</b>	<b>27,605</b>	<b>27,632</b>	<b>27,554</b>
<b>TOTAL INFLOW- TOTAL OUTFLOW</b>	<b>-55</b>	<b>-174</b>	<b>-305</b>	<b>-354</b>
STORAGE CHANGE	-46	-164	-297	-344
MODEL ERROR	-9	-10	-8	-10

Table: Comal County (Trinity Aquifer. 2008 to 2060)				
INFLOW	Scen 4	Scen 5	Scen 6	Scen 7
RECHARGE FROM PRECIPITATION	39,793	39,195	39,092	38,969
INFLOW FROM SURFACE WATER	0	0	0	959
INFLOW FROM BLANCO COUNTY	3,799	3,683	3,597	3,487
INFLOW FROM KENDALL COUNTY	7,799	7,823	7,855	7,822
TOTAL INFLOW	51,391	50,701	50,544	51,237
OUTFLOW				
PUMPING	5,716	7,622	9,527	11,380
OUTFLOW TO SURFACE WATER	5,492	3,044	1,055	0
OUTFLOW TO EDWARD AQUIFER (BALCONES FALT ZONE)	15,384	14,796	14,315	13,803
OUTFLOW TO OTHER AREA	8,208	8,202	8,232	8,254
OUTFLOW TO BEXAR COUNTY	10,621	11,273	11,896	12,446
OUTFLOW TO HAYS COUNTY	6,016	5,958	5,890	5,809
TOTAL OUTFLOW	51,437	50,895	50,915	51,692
TOTAL INFLOW- TOTAL OUTFLOW	-46	-194	-371	-455
STORAGE CHANGE	-47	-192	-370	-452
MODEL ERROR	1	-2	-1	-3

Table: Hays County (Trinity Aquifer. 2008 to 2060)				
INFLOW	Scen 4	Scen 5	Scen 6	Scen 7
RECHARGE FROM PRECIPITATION	24,363	23,997	23,934	23,859
INFLOW FROM BLANCO COUNTY	5,434	5,482	5,532	5,558
INFLOW FROM COMAL COUNTY	6,016	5,958	5,890	5,809
TOTAL INFLOW	35,813	35,437	35,356	35,226
OUTFLOW				
PUMPING	5,397	7,196	8,985	10,620
OUTFLOW TO SURFACE WATER	19,490	18,462	17,658	16,837
OUTFLOW TO EDWARD AQUIFER (BALCONES FALT ZONE)	2,610	1,782	1,073	412
OUTFLOW TO OTHER AREA	2,417	2,330	2,252	2,180
OUTFLOW TO TRAVIS COUNTY	5,951	5,863	5,770	5,624
TOTAL OUTFLOW	35,865	35,633	35,738	35,673
TOTAL INFLOW- TOTAL OUTFLOW	-52	-196	-382	-447
STORAGE CHANGE	-51	-195	-382	-447
MODEL ERROR	-1	-1	0	0

Table: Kendall County (Edwards Aquifer. 2008 to 2060)				
INFLOW	Scen 4	Scen 5	Scen 6	Scen 7
RECHARGE FROM PRECIPITATION	5,446	5,364	5,350	5,333
INFLOW FROM KERR COUNTY	101	101	101	101
TOTAL INFLOW	5,547	5,465	5,451	5,434
OUTFLOW				
PUMPING	311	311	311	311
OUTFLOW TO SURFACE WATER	4,879	4,833	4,838	4,820
OUTFLOW TO OTHER AREA	217	216	216	215
OUTFLOW TO TRINITY AQUIFER	153	153	153	152
TOTAL OUTFLOW	5,560	5,513	5,518	5,498
TOTAL INFLOW- TOTAL OUTFLOW	-13	-48	-67	-64
STORAGE CHANGE	-13	-47	-66	-65
MODEL ERROR	0	-1	-1	1

Table: Kendall County (Trinity Aquifer. 2008 to 2060)				
INFLOW	Scen 4	Scen 5	Scen 6	Scen 7
RECHARGE FROM PRECIPITATION	52,346	51,559	51,424	51,262
INFLOW FROM OTHER AREA	4,087	4,048	4,034	4,009
INFLOW FROM KERR COUNTY	3	0	0	0
INFLOW FROM EDWARD AQUIFER	153	153	153	152
TOTAL INFLOW	56,589	55,760	55,611	55,423
OUTFLOW				
PUMPING	6,688	8,919	11,147	13,376
OUTFLOW TO SURFACE WATER	23,405	21,129	19,477	17,704
OUTFLOW TO BANDERA COUNTY	5,686	5,391	5,165	4,906
OUTFLOW TO BEXAR COUNTY	10,392	10,086	9,844	9,480
OUTFLOW TO BLANCO COUNTY	2,738	2,704	2,690	2,670
OUTFLOW TO COMAL COUNTY	7,799	7,823	7,855	7,822
OUTFLOW TO KERR COUNTY	0	223	404	619
TOTAL OUTFLOW	56,708	56,275	56,582	56,577
TOTAL INFLOW- TOTAL OUTFLOW	-119	-515	-971	-1,154
STORAGE CHANGE	-118	-511	-971	-1,153
MODEL ERROR	-1	-4	0	-1

Table: Kerr County (Edward Aquifer. 2008 to 2060)				
INFLOW	Scen 4	Scen 5	Scen 6	Scen 7
RECHARGE FROM PRECIPITATION	35,483	34,950	34,858	34,748
INFLOW FROM OTHER AREA	973	969	971	968
<b>TOTAL INFLOW</b>	<b>36,456</b>	<b>35,919</b>	<b>35,829</b>	<b>35,716</b>
<b>OUTFLOW</b>				
PUMPING	1,034	1,034	1,034	1,034
OUTFLOW TO SURFACE WATER	26,268	26,040	26,036	25,977
OUTFLOW TO BANDERA COUNTY	3,422	3,392	3,386	3,383
OUTFLOW TO KENDALL COUNTY	101	101	101	101
OUTFLOW TO TRINITY AQUIFER	5,494	5,473	5,470	5,466
<b>TOTAL OUTFLOW</b>	<b>36,319</b>	<b>36,040</b>	<b>36,027</b>	<b>35,961</b>
<b>TOTAL INFLOW- TOTAL OUTFLOW</b>	<b>137</b>	<b>-121</b>	<b>-198</b>	<b>-245</b>
<b>STORAGE CHANGE</b>	<b>137</b>	<b>-121</b>	<b>-198</b>	<b>-245</b>
<b>MODEL ERROR</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>

Table: Kerr County (Trinity Aquifer. 2008 to 2060)				
INFLOW	Scen 4	Scen 5	Scen 6	Scen 7
RECHARGE FROM PRECIPITATION	16,952	16,697	16,653	16,601
INFLOW FROM OTHER AREA	7,962	7,905	7,923	7,827
INFLOW FROM KENDALL COUNTY	0	223	404	619
INFLOW FROM EDWARD AQUIFER	5,494	5,473	5,470	5,466
<b>TOTAL INFLOW</b>	<b>30,408</b>	<b>30,298</b>	<b>30,450</b>	<b>30,513</b>
<b>OUTFLOW</b>				
PUMPING	12,001	13,544	15,302	16,428
OUTFLOW TO SURFACE WATER	11,063	10,863	10,826	10,746
OUTFLOW TO BANDERA COUNTY	7,415	6,655	6,070	5,459
OUTFLOW TO KENDALL COUNTY	3	0	0	0
<b>TOTAL OUTFLOW</b>	<b>30,482</b>	<b>31,062</b>	<b>32,198</b>	<b>32,633</b>
<b>TOTAL INFLOW- TOTAL OUTFLOW</b>	<b>-74</b>	<b>-764</b>	<b>-1,748</b>	<b>-2,120</b>
<b>STORAGE CHANGE</b>	<b>-74</b>	<b>-762</b>	<b>-1,748</b>	<b>-2,118</b>
<b>MODEL ERROR</b>	<b>0</b>	<b>-2</b>	<b>0</b>	<b>-2</b>

Table: Medina County (Trinity Aquifer. 2008 to 2060)				
INFLOW	Scen 4	Scen 5	Scen 6	Scen 7
RECHARGE FROM PRECIPITATION	6,084	5,993	5,977	5,958
INFLOW FROM BANDERA COUNTY	16,295	15,870	15,579	15,033
TOTAL INFLOW	22,379	21,863	21,556	20,991
OUTFLOW				
PUMPING	1,405	1,873	2,341	2,810
OUTFLOW TO SURFACE WATER	6,275	6,243	6,232	6,217
OUTFLOW TO EDWARD AQUIFER (BALCONES FALT ZONE)	7,998	6,486	5,185	3,619
OUTFLOW TO OTHER AREA	1,874	1,503	1,175	844
OUTFLOW TO BEXAR COUNTY	4,831	5,788	6,688	7,583
TOTAL OUTFLOW	22,383	21,893	21,621	21,073
TOTAL INFLOW- TOTAL OUTFLOW	-4	-30	-65	-82
STORAGE CHANGE	-6	-31	-66	-84
MODEL ERROR	2	1	1	2

Table: Travis County (Trinity Aquifer. 2008 to 2060)				
INFLOW	Scen 4	Scen 5	Scen 6	Scen 7
RECHARGE FROM PRECIPITATION	11,194	11,026	10,997	10,963
INFLOW FROM HAYS COUNTY	5,951	5,863	5,770	5,624
TOTAL INFLOW	17,145	16,889	16,767	16,587
OUTFLOW				
PUMPING	5,375	7,120	8,714	9,890
OUTFLOW TO SURFACE WATER	7,419	6,466	5,748	5,201
OUTFLOW TO EDWARD AQUIFER (BALCONES FALT ZONE)	1,327	969	657	354
OUTFLOW TO OTHER AREA	3,079	2,513	2,001	1,547
TOTAL OUTFLOW	17,200	17,068	17,120	16,992
TOTAL INFLOW- TOTAL OUTFLOW	-55	-179	-353	-405
STORAGE CHANGE	-43	-166	-341	-393
MODEL ERROR	-12	-13	-12	-12