GAM run 05-05

by Shirley Wade

Texas Water Development Board
Groundwater Availability Modeling Section
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REQUESTOR:

Gary Westbrook, Post Oak Savannah Groundwater Conservation District (GCD)

DESCRIPTION OF REQUEST:

The Post Oak Savannah GCD requested the following information for the aquifers in their counties:

- model run of the Groundwater Availability Model (GAM) for the central part of the Queen City, Sparta, and Carrizo-Wilcox aquifers (Kelley and others, 2004) showing water levels and drawdowns in Burleson and Milam counties through the year 2050;
- model budgets including outcrop recharge values for each layer;
- information about the interaction between the Brazos River Alluvium and other aquifers; and
- summary description of pumpage from Burleson and Milam counties in the model derived from the 2002 State Water Plan including strategies.

METHODS:

To address the request, we:

- ran the GAM from 2000 to 2050 and queried the budget files for each aquifer layer in Burleson and Milam counties for the year 2050 with long-term average recharge;
- extracted water levels and drawdowns for the model periods representing 2000, 2030, and 2050;
- reviewed two reports on the hydrodynamics of the Brazos River Alluvium aquifer (Cronin and Wilson, 1967; Chowdhury and others, 2004); and
- summarized pumpage by category and user (where possible) as developed from the 2002 State Water Plan demands for the GAMs of the central part of the Carrizo-Wilcox aquifer (Dutton and others, 2003) and the central part of the Queen City and Sparta aquifers (Kelley and others, 2004).

PARAMETERS AND ASSUMPTIONS:

We used the following assumptions in this analysis:
- see Kelley and others (2004) for assumptions and limitations of the GAM. Root mean squared error for this model is 22.0 feet for the Sparta aquifer, 26.5 feet for the Queen City aquifer, 36.3 feet for the Carrizo aquifer, and 30.8 feet for the Simsboro aquifer. This error will have more of an effect on model results where the aquifer is thin ;
- drawdowns are relative to 2000 water levels (positive drawdowns indicate water level decline and negative drawdowns indicate water level rise or rebound);
- pumpage in the model is based on the 2002 State Water Plan;
- long-term average annual recharge is assumed (the modeled water levels under drought-of-record conditions are very similar to results based on average recharge conditions); and
- all flows are in acre-feet per year and water levels are in feet above mean sea level (amsl).

All other parameters and assumptions as described in the final GAM reports also apply (Kelley and others, 2004; Dutton and others, 2003).

RESULTS:

Water budget and recharge

Table 1 shows the water budget for Burleson and Milam counties for 2050.

The average recharge to the Queen City, Sparta, and Carrizo-Wilcox aquifers in Milam County is about 31,600 acre-feet per year. The average recharge for Burleson County is about 13,300 acre-feet per year. Table 1 shows the recharge values by aquifer or layer.

Some groundwater conservation districts also include cross-formational flow in their total recharge estimate. Texas Water Development Board (TWDB) rules concerning groundwater management plan certification define recharge as "The addition of water from precipitation or runoff by seepage or infiltration to an aquifer from the land surface, streams, or lakes directly into a formation or indirectly by way of leakage from another formation." We show infiltration from land surface in the recharge column in Table 1. We also show cross-formational leakage into the aquifers in Table 1 in the columns "upper Z flow in and lower Z flow in."

Water levels and drawdown

We calculated drawdown for a particular year as water level in the year 2000 minus water level for that year. A positive drawdown indicates water level decline. A negative drawdown indicates water level rise or rebound. The model calculated water level surfaces for the year 2000 for the Sparta, Queen City, Carrizo, and Simsboro aquifers are shown in Figures 1 through 4.

Water levels and drawdown for 2030 for the Sparta, Queen City, Carrizo, and Simsboro aquifers are shown in Figures 5 through 12. Water levels and drawdown for 2050 are shown in Figures 13 through 20. The magnitude of drawdown increases, moving downward through the aquifer system. The maximum drawdown in the Sparta aquifer is about 20 feet; whereas, drawdown in the Simsboro aquifer exceeds 200 feet in Burleson County.

Model pumpage summary

The municipal pumpage for Milam County includes several user groups summarized in Table 2. The remainder of the model pumpage is summarized by use category and layer in Table 3. The location of the grid cells for the point pumpage categories (municipal, manufacturing, power, and mining) are shown in Figure 21. It should be noted that Table 1 lists about 1,600 more acre-feet per year in Burleson County than the 2050 total in Table 3. This difference is due to two model cells near the border of Lee and Burleson counties in model layers 6, 7, and 8. The pumpage cells are located in Burleson County, but the pumpage is listed in the database as Bastrop County pumpage (see Figure 21).

Brazos River Alluvium aquifer interaction

The Brazos River Alluvium aquifer receives recharge primarily through precipitation on the flood-plain surface. For the most part, the water discharges from the alluvium mainly through seepage to the Brazos River, evapotranspiration, and wells (Cronin and Wilson, 1967). However, in some locations, water levels in the alluvium are higher than the underlying Sparta aquifer and some groundwater downflow does occur (Cronin and Wilson, 1967; Chowdhury, 2004).

REFERENCES:

Chowdhury, A. H., 2004, Hydraulic interaction between groundwater, Brazos River, and oxbow lakes–Evidence from chemical and isotopic compositions, Brazos River Basin Texas: Lower Brazos River Oxbow Project, Texas Water Development Board.

Cronin, J. G. and Wilson, C. A., 1967, Ground water in the flood-plain alluvium of the Brazos River, Whitney Dam to vicinity of Richmond, Texas: Texas Water Development Board Report 41.

Dutton, A. R., Harden, R., Nicot, J. P., and O' Rourke, D., 2003, Groundwater availability model for the central part of the Carrizo-Wilcox aquifer in Texas: Bureau of Economic Geology, Final report prepared for the Texas Water Development Board.

Kelley, V. A., Deeds, N. E., Fryar, D. G., Nicot, J. P., Jones, T. L., Dutton, A. R., Unger-Holtz, T., and Machin J. L., 2004, Groundwater availability model for the Queen City and Sparta aquifers: Final report prepared for the Texas Water Development Board by INTERA Inc.

Table 1. Flow budget for Burleson and Milam counties based on the GAM for the central part of the Queen City and Sparta aquifers (values in acre-feet per year for average recharge conditions in 2050).

County	Lyr	Change in Storage	X-flow in	X-flow out	upper Z flow in	upper Z flow out	lower Z flow in	lower Z flow out	Wells	Recharge	ET	GHB	Streams	Drains	Total In	Total Out	% diff
									Average Recharge Conditions								
Milam	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	3	-532	531	-889	0	0	86	-914	0	4,086	-549	0	-1,818	0	5,050	-5,049	0
	4	149	55	-370	914	-86	105	-1,438	0	1,226	-70	0	-485	0	2,516	-2,516	0
	5	831	1,549	-3,242	1,438	-105	1	-823	-321	3,926	-1,784	0	-1,470	0	7,750	-7,750	0
	6	3,941	601	-3,137	823	-1	147	-7,380	-468	7,435	-27	0	-1,935	0	13,641	-13,642	0
	7	16,668	4,859	-20,417	7,380	-147	1,569	-18	-21,333	12,497	0	0	-1,057	0	48,718	-48,717	0
	8	4,442	1,539	-5,245	18	-1,569	0	0	-903	2,418	-33	0	-668	0	8,423	-8,424	0
	All	25,499	9,135	-33,300	10,573	-1,909	1,909	-10,573	-23,025	31,587	-2,462	0	-7,434	0	86,097	-86,097	0
Burleson	1	-353	528	-774	0	0	492	-4,765	-420	7,707	-1,089	1,006	-2,254	-78	11,910	-11,909	0
	2	-268	66	-54	4,765	-492	333	-5,013	0	848	-6	0	-179	0	6,090	-6,091	0
	3	-328	1,416	-961	5,013	-333	39	-6,583	-101	4,774	0	0	-2,936	0	12,136	-12,135	0
	4	146	391	-210	6,583	-39	48	-6,868	0	19	0	0	-70	0	7,187	-7,187	0
	5	573	3,720	-6,026	6,868	-48	2	-1,431	-3,656	0	0	0	0	0	11,162	-11,162	0
	6	84	3,776	-1,107	1,431	-2	0	-3,879	**-304	0	0	0	0	0	5,291	-5,291	0
	7	77	13,568	-20,181	3,879	0	3,449	0	**-792	0	0	0	0	0	20,973	-20,973	0
	8	87	5,267	-1,377	0	-3,449	0	0	**-528	0	0	0	0	0	5,354	-5,354	0
	All	18	28,732	-30,691	28,538	-4,363	4,363	-28,538	**-5,801	13,349	-1,095	1,006	-5,439	-78	80,104	-80,102	0

Notes:
** Differs from Table 3 because the pumpage database indicates that the pumping for two cells located in Burleson County on the border with Lee County is Bastrop County manufacturing pumpage.
1.   Layer 1: Sparta aquifer
2.   Layer 2: Weches Formation
3.   Layer 3: Queen City aquifer
4.   Layer 4: Reklaw Formation

5.   Layer 5: Carrizo aquifer
6.   Layer 6: Calvert Bluff Formation
7.   Layer 7: Simsboro aquifer
8.   Layer 8: Hooper Formation
9.   All: sum of layers
10.   **Change in Storage** refers to water that is extracted from storage or added to storage.
           A positive number means water is extracted from storage. A negative number means water is added to storage.
11.   **GHB** refers to flow into or out of the top of the Sparta from younger sediments.
12.   **ET** refers to groundwater extraction due to evapotranspiration.
13.   **X-flow in** refers to lateral flow into the county.
14.   **X-flow out** refers to lateral flow out of the county.
15.   **upper - Z-flow in** refers to flow into the layer from the layer above.
16.   **upper - Z-flow out** refers to flow out of the layer into the layer above.
17.   **lower - Z-flow in** refers to flow into the layer from the layer below.
18.   **lower - Z-flow out** refers to flow out of the layer into the layer below.
19.   **Wells** is for pumping.
20.   A negative sign refers to flow out of the layer in the county.
21.   A positive sign refers to flow into the layer in the county.
22.   The numbers are rounded to the nearest 1 acre-foot. Values in the water budget are probably only accurate to two significant figures.

Table 2. Milam County municipal pumping in the Simsboro aquifer (acre-feet per year).

City	2010	2020	2030	2040	2050
*SAWS	-6,414	-6,142	-6,093	-6,359	-6,931
Thorndale	-140	-136	-136	-136	-139
Rockdale	-1,802	-1,841	-1,942	-2,034	-2,150
Sandow Mines	-6,948	-6,654	-6,600	-6,889	-7,509
Total	**-15,304**	**-14,773**	**-14,771**	**-15,418**	**-16,728**

* San Antonio Water System

Table 3. Model pumping summary by layer and use category per decade based on 2002 State Water Plan demands.

Unit	Layer	Milam County (acre-feet per year)					Burleson County (acre-feet per year)				
		2010	2020	2030	2040	2050	2010	2020	2030	2040	2050
Rural Domestic							Rural Domestic				
Sparta	1	0	0	0	0	0	0	0	0	0	0
Weches	2	0	0	0	0	0	0	0	0	0	0
Queen City	3	0	0	0	0	0	0	0	0	0	0
Reklaw	4	0	0	0	0	0	0	0	0	0	0
Carrizo	5	-112	-112	-113	-112	-112	-1,187	-1,212	-1,212	-1,245	-1,341
Calvert Bluff	6	-149	-150	-150	-150	-149	-22	-23	-23	-23	-25
Simsboro	7	-750	-756	-757	-755	-751	0	0	0	0	0
Hooper	8	-167	-169	-169	-169	-167	0	0	0	0	0
Irrigation							Irrigation				
Sparta	1	0	0	0	0	0	-132	-126	-121	-117	-111
Weches	2	0	0	0	0	0	0	0	0	0	0
Queen City	3	0	0	0	0	0	0	0	0	0	0
Reklaw	4	0	0	0	0	0	0	0	0	0	0
Carrizo	5	-25	-25	-25	-25	-24	0	0	0	0	0
Calvert Bluff	6	0	0	0	0	0	0	0	0	0	0
Simsboro	7	-49	-49	-49	-48	-48	0	0	0	0	0
Hooper	8	-211	-209	-207	-206	-204	0	0	0	0	0
Livestock							Livestock				
Sparta	1	0	0	0	0	0	0	0	0	0	0
Weches	2	0	0	0	0	0	0	0	0	0	0
Queen City	3	0	0	0	0	0	-104	-104	-104	-104	-104
Reklaw	4	0	0	0	0	0	0	0	0	0	0
Carrizo	5	-200	-200	-200	-200	-200	-1,213	-1,213	-1,213	-1,213	-1,213
Calvert Bluff	6	-321	-321	-321	-321	-321	-14	-14	-14	-14	-14
Simsboro	7	-695	-695	-695	-695	-695	0	0	0	0	0
Hooper	8	-410	-410	-410	-410	-410	0	0	0	0	0
Mining							Mining				
Sparta	1	0	0	0	0	0	-24	-18	-15	-13	-13
Weches	2	0	0	0	0	0	0	0	0	0	0
Queen City	3	0	0	0	0	0	0	0	0	0	0

| Unit	Layer	Milam County (acre-feet per year)					Burleson County (acre-feet per year)				
		2010	2020	2030	2040	2050	2010	2020	2030	2040	2050
Reklaw	4	0	0	0	0	0	0	0	0	0	0
Carrizo	5	0	0	0	0	0	0	0	0	0	0
Calvert Bluff	6	0	0	0	0	0	0	0	0	0	0
Simsboro	7	0	0	0	0	0	0	0	0	0	0
Hooper	8	0	0	0	0	0	0	0	0	0	0
Municipal							Municipal				
Sparta	1	0	0	0	0	0	-265	-272	-306	-298	-297
Weches	2	0	0	0	0	0	0	0	0	0	0
Queen City	3	0	0	0	0	0	0	0	0	0	0
Reklaw	4	0	0	0	0	0	0	0	0	0	0
Carrizo	5	0	0	0	0	0	-790	-809	-837	-852	-878
Calvert Bluff	6	0	0	0	0	0	0	0	0	0	0
Simsboro	7	-15,304	-14,773	-14,771	-15,418	-16,728	0	0	0	0	0
Hooper	8	0	0	0	0	0	0	0	0	0	0
Manufacturing							Manufacturing				
Sparta	1	0	0	0	0	0	0	0	0	0	0
Weches	2	0	0	0	0	0	0	0	0	0	0
Queen City	3	0	0	0	0	0	0	0	0	0	0
Reklaw	4	0	0	0	0	0	0	0	0	0	0
Carrizo	5	0	0	0	0	0	-253	-221	-228	-241	-264
Calvert Bluff	6	0	0	0	0	0	0	0	0	0	0
Simsboro	7	0	0	0	0	0	0	0	0	0	0
Hooper	8	0	0	0	0	0	0	0	0	0	0
Power							Power				
Sparta	1	0	0	0	0	0	0	0	0	0	0
Weches	2	0	0	0	0	0	0	0	0	0	0
Queen City	3	0	0	0	0	0	0	0	0	0	0
Reklaw	4	0	0	0	0	0	0	0	0	0	0
Carrizo	5	0	0	0	0	0	0	0	0	0	0
Calvert Bluff	6	0	0	0	0	0	0	0	0	0	0
Simsboro	7	-3,248	-3,248	-3,248	-3,248	-3,248	0	0	0	0	0
Hooper	8	0	0	0	0	0	0	0	0	0	0
Total		-21,641	-21,117	-21,115	-21,757	-23,057	-4,004	-4,012	-4,073	-4,120	-4,260
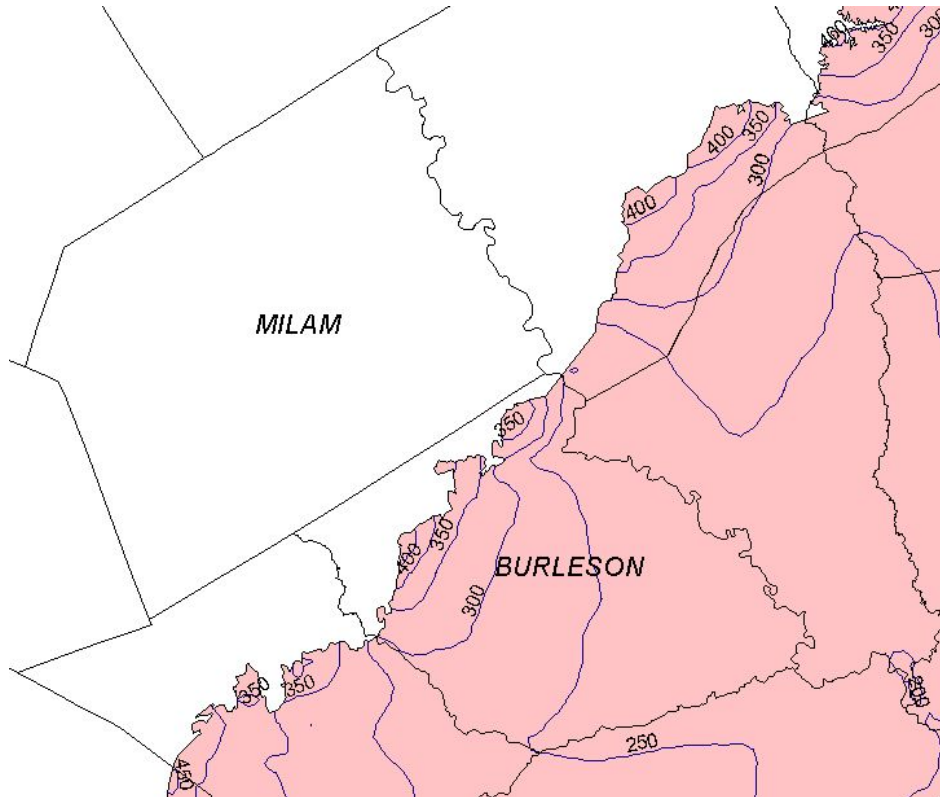
Figure 1. Water–level elevations in the Sparta aquifer for 2000 in feet amsl (contour interval is 50 feet; north is toward the top of the figure).
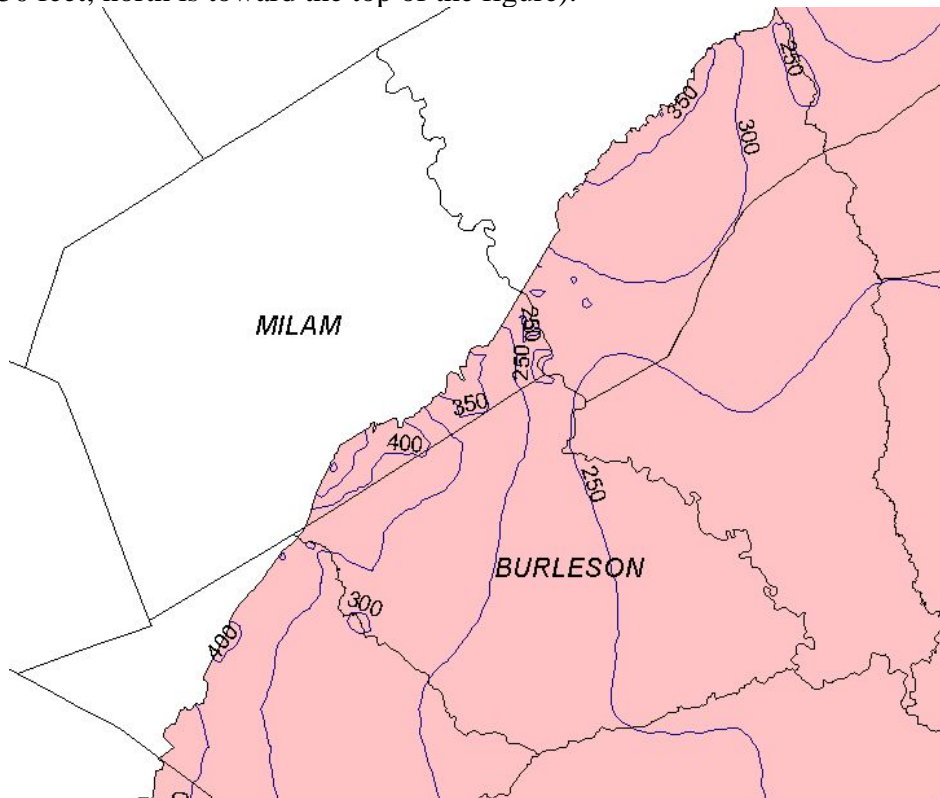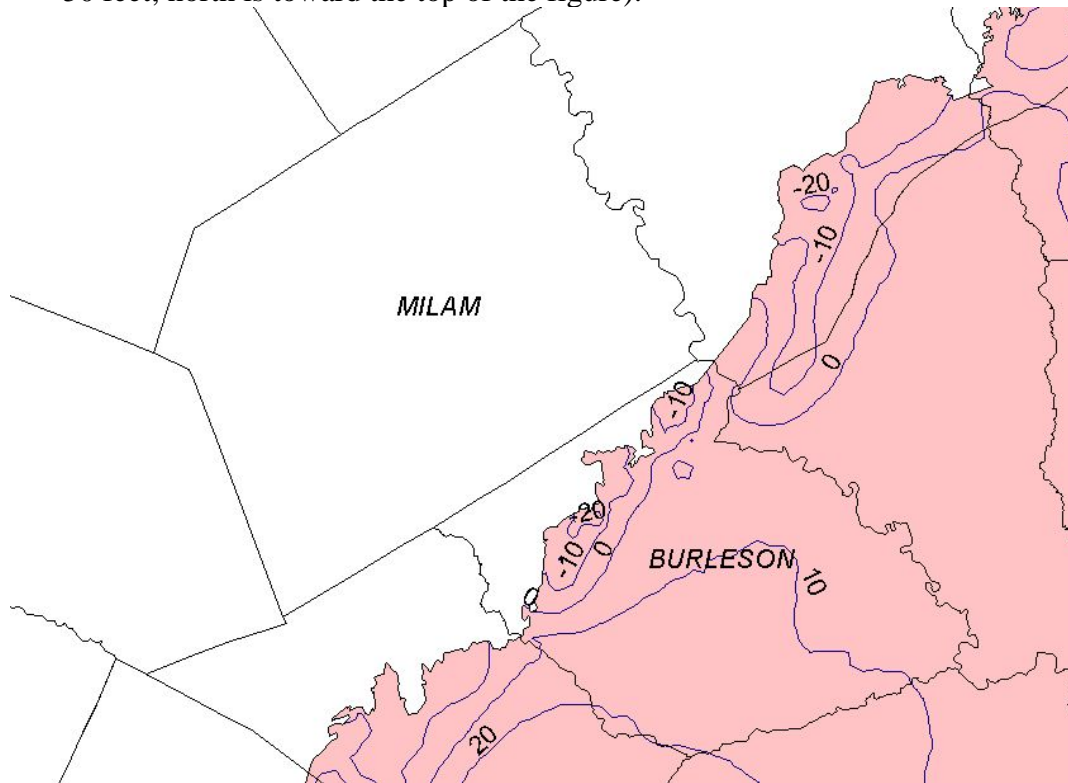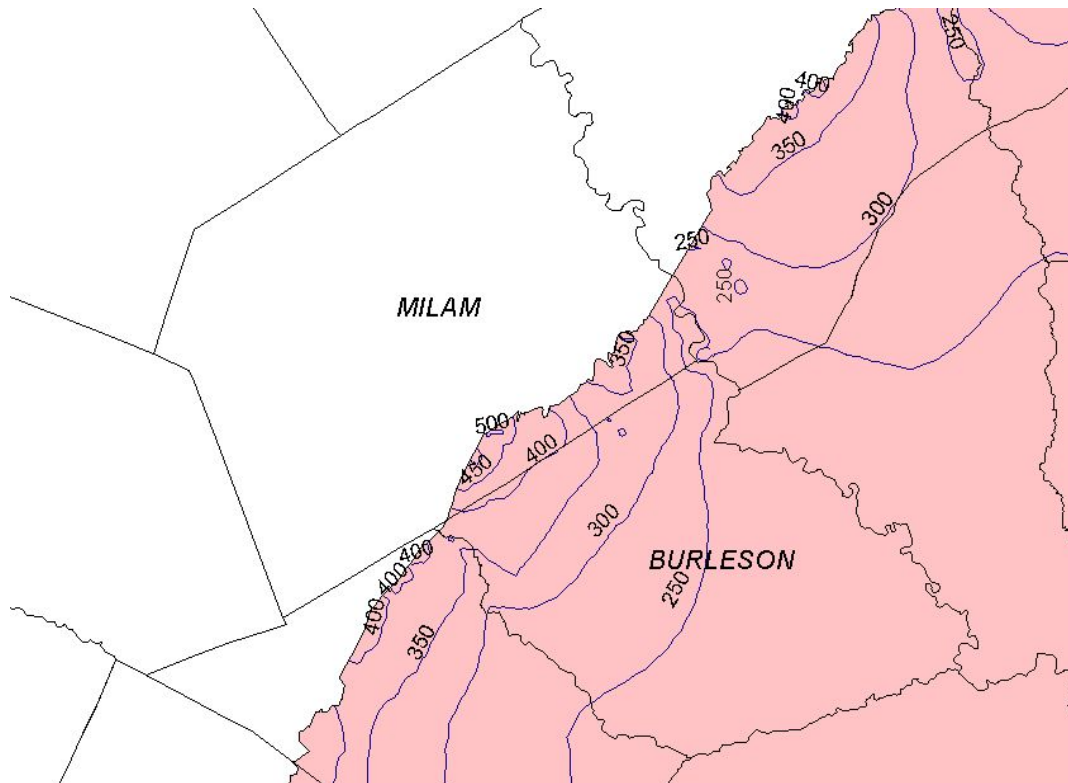

Figure 2. Water–level elevations in the Queen City aquifer for 2000 in feet amsl (contour interval is 50 feet; north is toward the top of the figure).
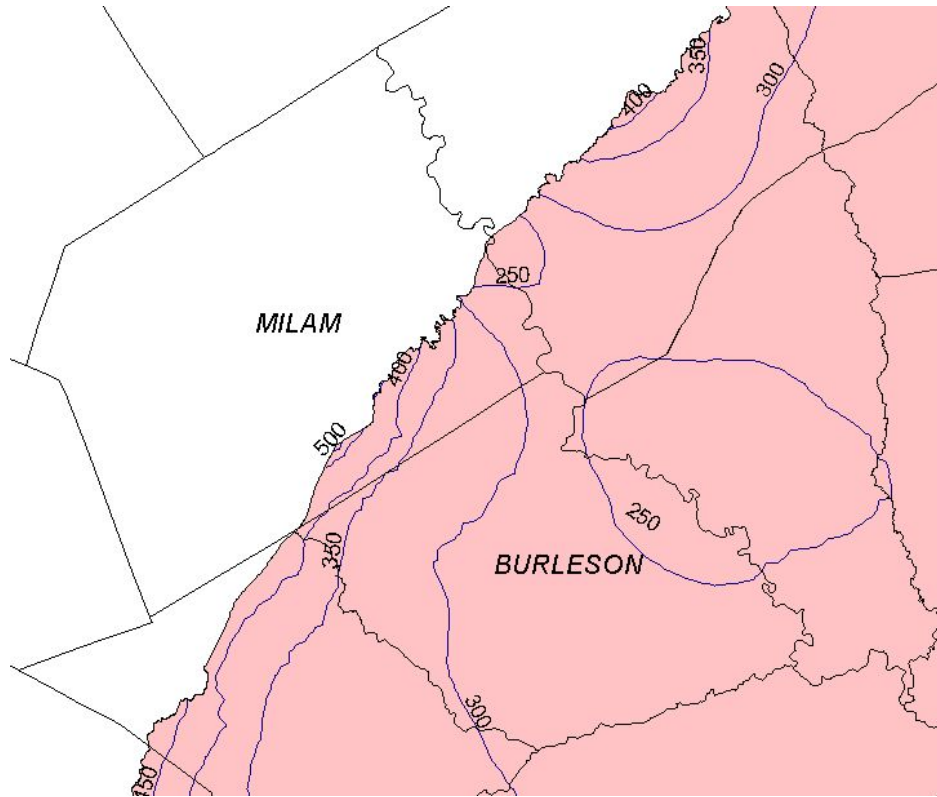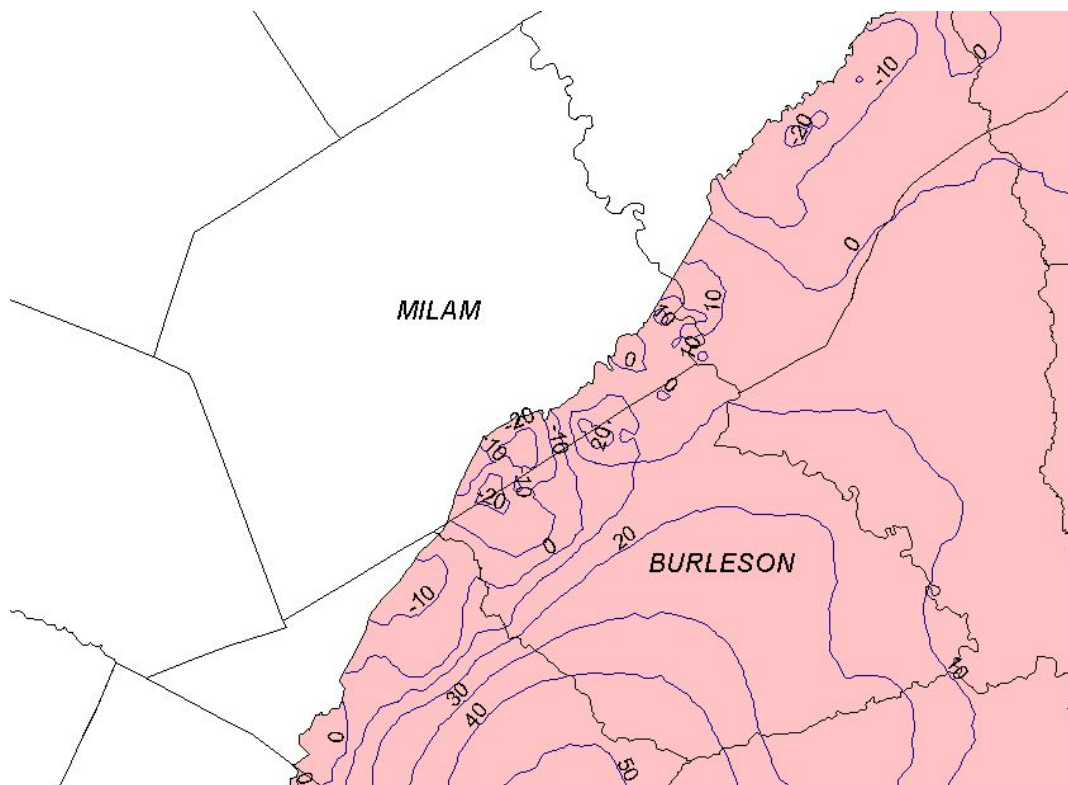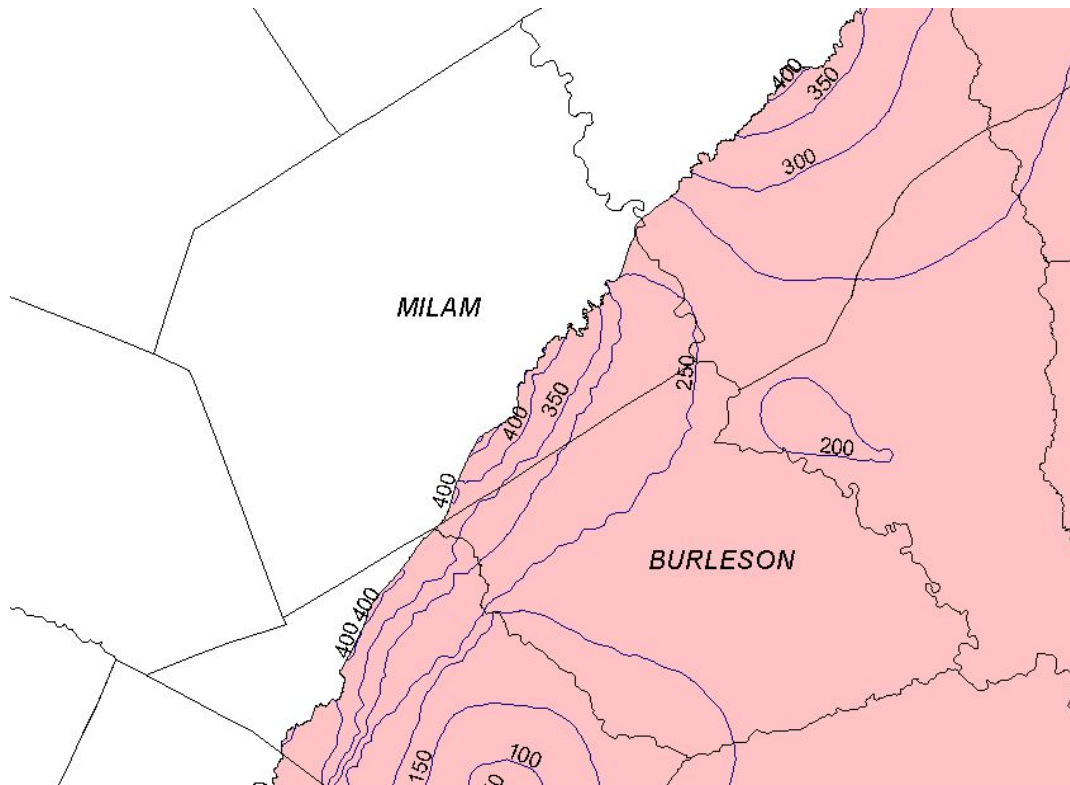
Figure 3. Water–level elevations in the Carrizo aquifer for 2000 in feet amsl (contour interval is 50 feet; north is toward the top of the figure).
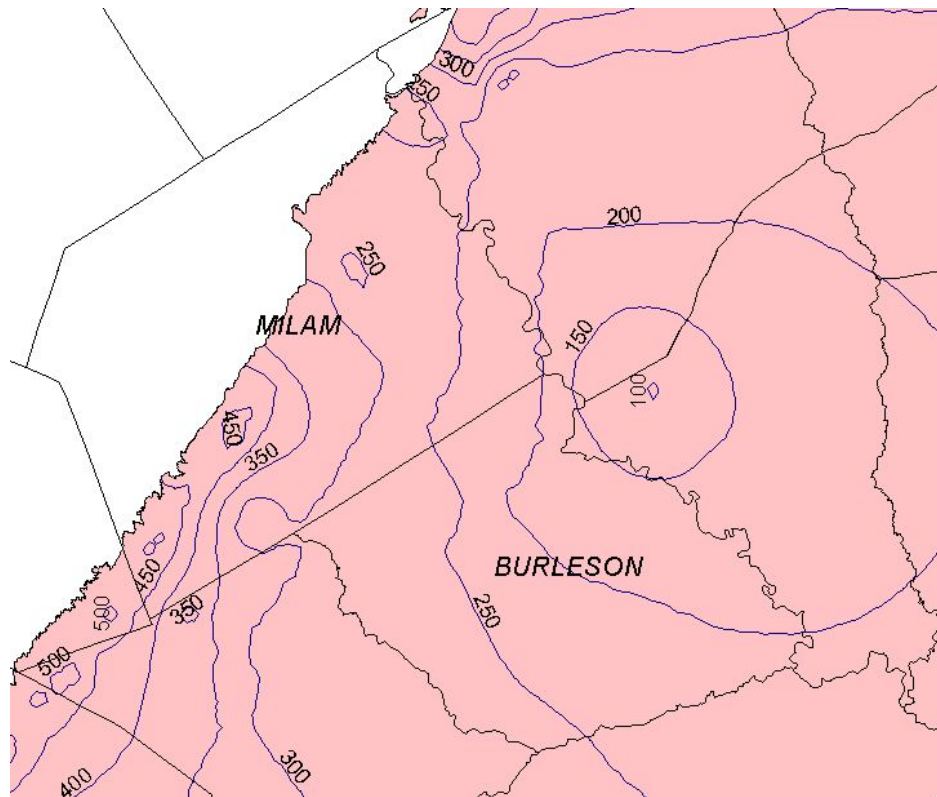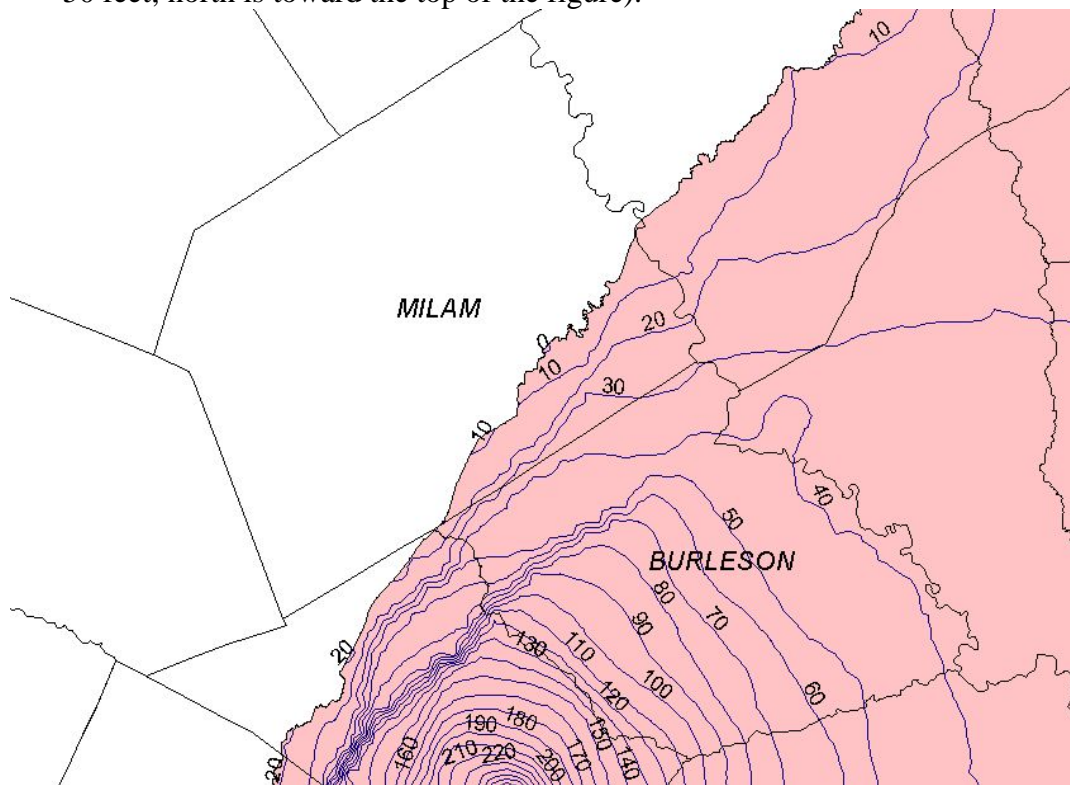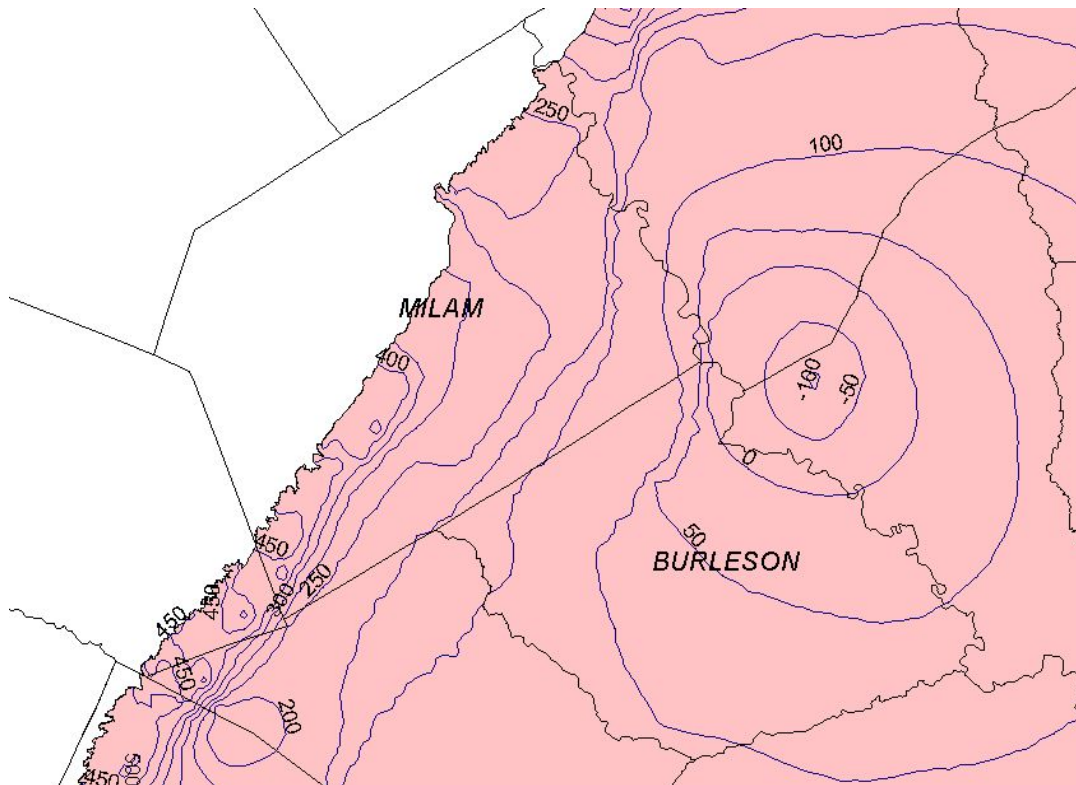

Figure 4. Water–level elevations in the Simsboro aquifer for 2000 in feet amsl (contour interval is 50 feet; north is toward the top of the figure).
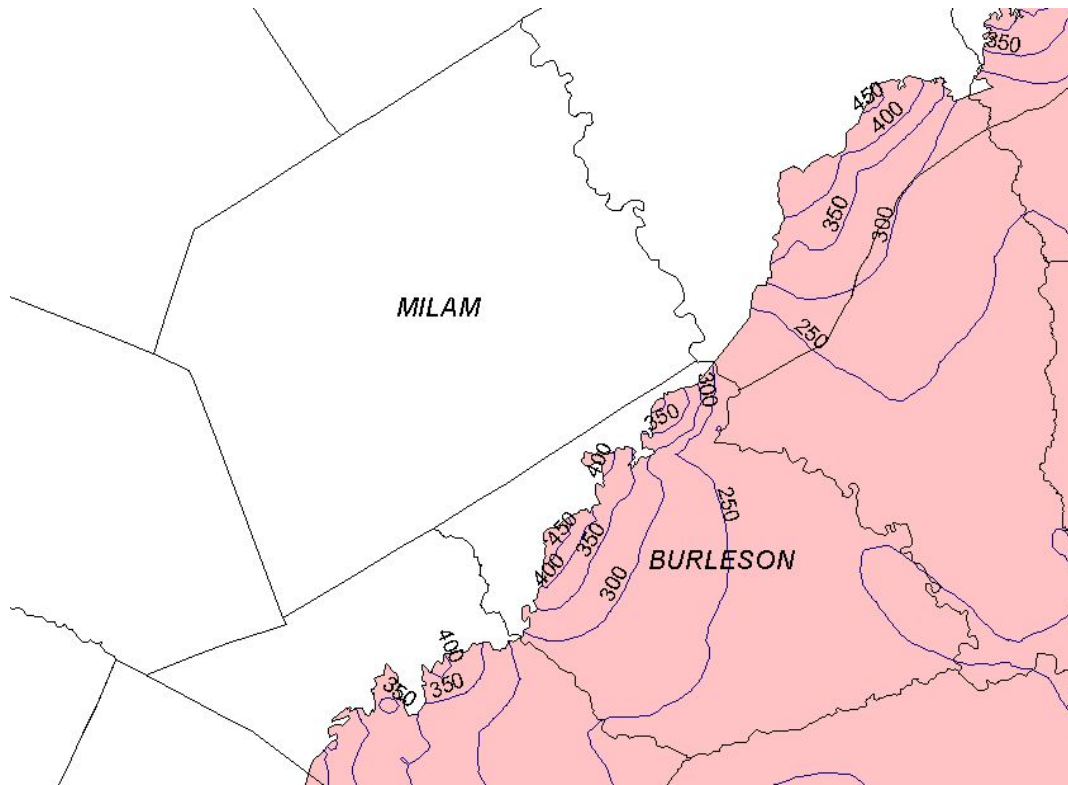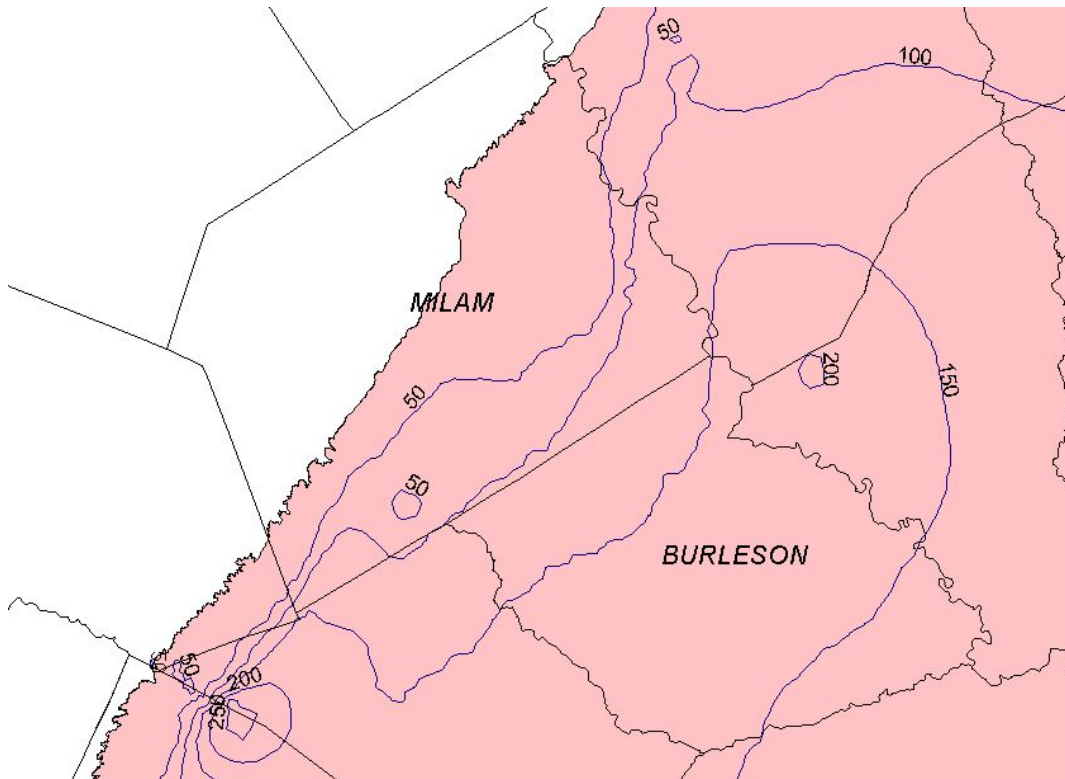
Figure 5. Water–level elevations in the Sparta aquifer for 2030 in feet amsl (contour interval is 50 feet; north is toward the top of the figure).

Figure 6. Drawdown in the Sparta aquifer for 2030 in feet amsl (contour interval is 10 feet; north is toward the top of the figure; positive values indicate water-level declines; negative values indicate water-level rises).
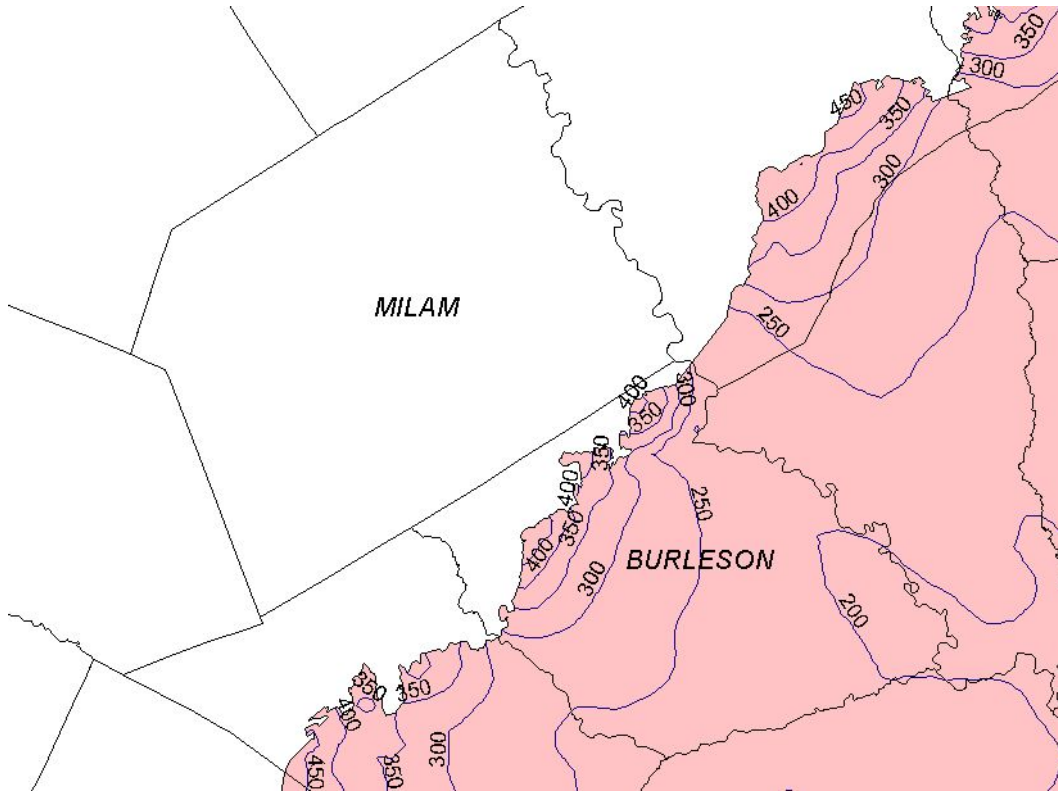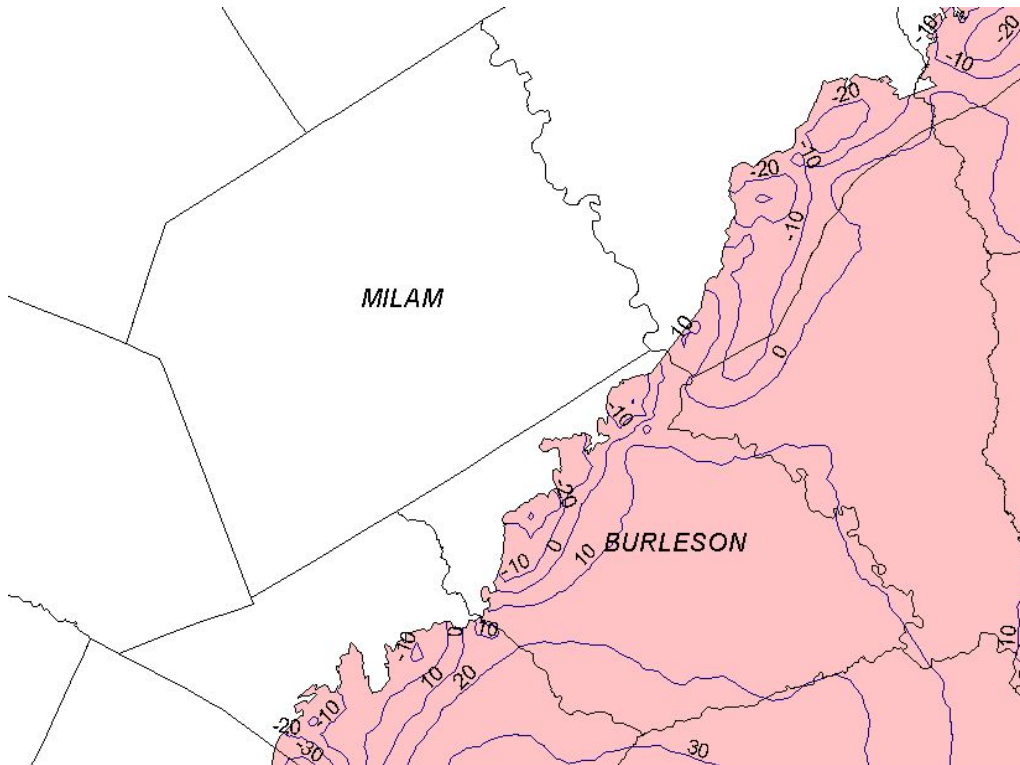
Figure 7.   Water–level elevations in the Queen City aquifer for 2030 in feet amsl (contour interval is 50 feet; north is toward the top of the figure).

Figure 8.   Drawdown in the Queen City aquifer for 2030 in feet amsl (contour interval is 10 feet; north is toward the top of the figure; positive values indicate water-level declines; negative values indicate water-level rises).

Figure 9. Water–level elevations in the Carrizo aquifer for 2030 in feet amsl (contour interval is 50 feet; north is toward the top of the figure).

Figure 10. Drawdown in the Carrizo aquifer for 2030 in feet amsl (contour interval is 10 feet; north is toward the top of the figure; positive values indicate water-level declines; negative values indicate water-level rises).
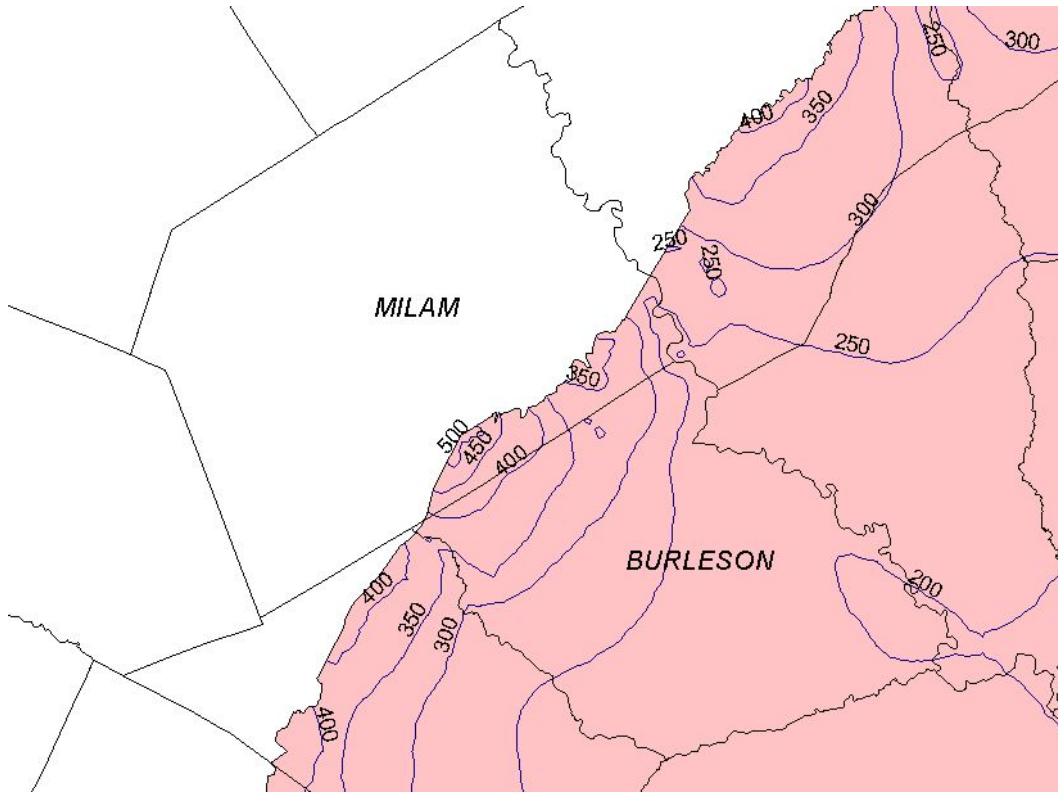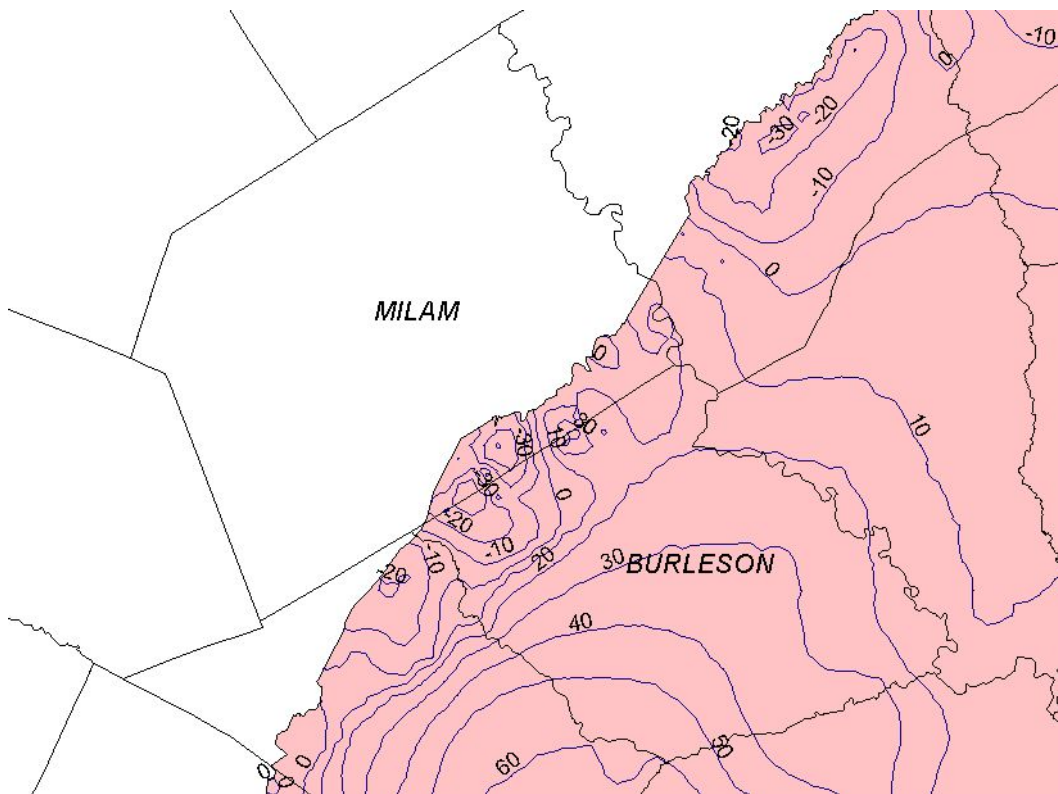
Figure 11. Water–level elevations in the Simsboro aquifer for 2030 in feet amsl (contour interval is 50 feet; north is toward the top of the figure).

Figure 12. Drawdown in the Simsboro aquifer for 2030 in feet amsl (contour interval is 50 feet; north is toward the top of the figure; positive values indicate water-level declines; negative values indicate water-level rises).
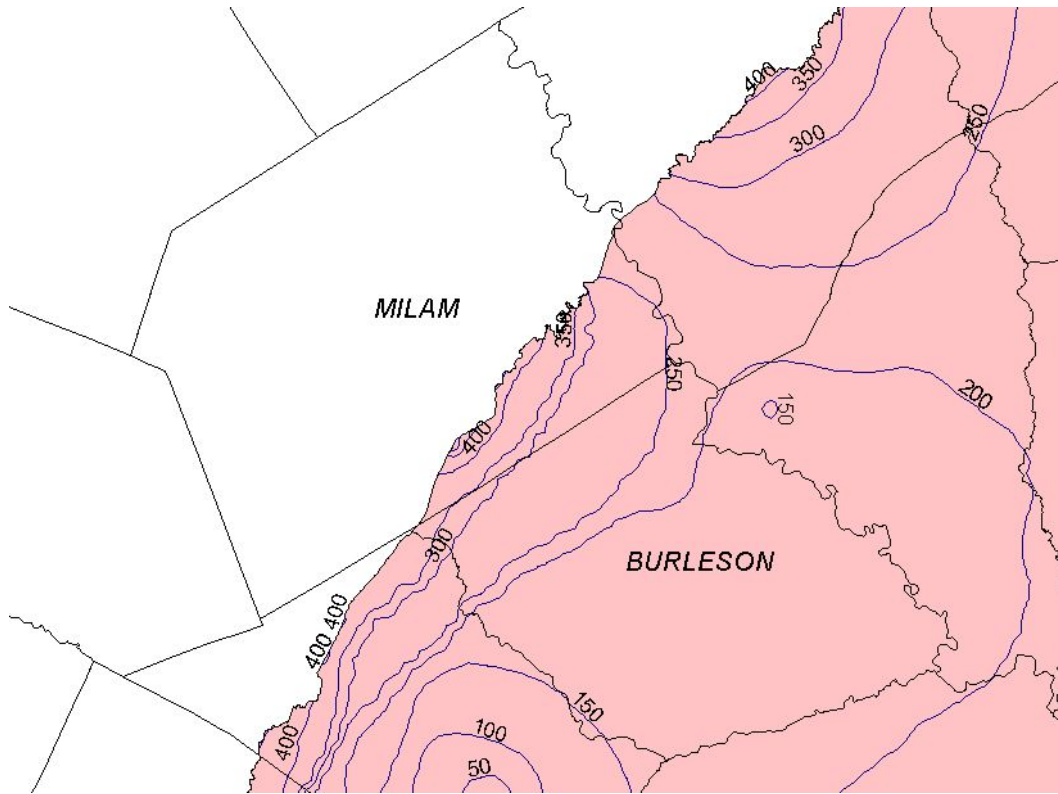
Figure 13. Water–level elevations in the Sparta aquifer for 2050 in feet amsl (contour interval is 50 feet; north is toward the top of the figure).
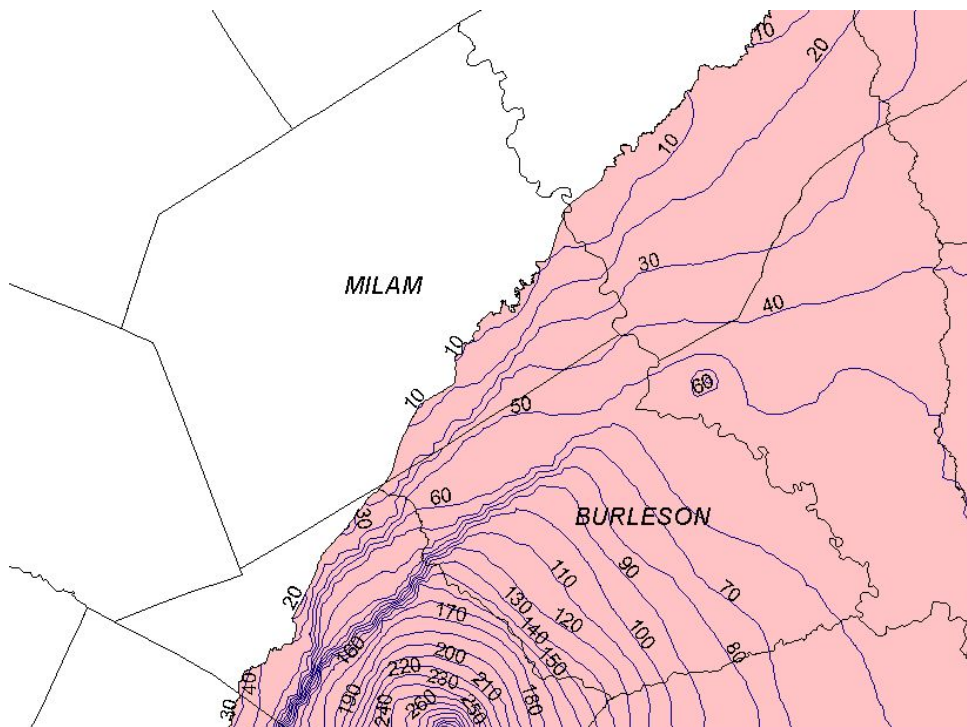

Figure 14. Drawdown in the Sparta aquifer for 2050 in feet amsl (contour interval is 10 feet; north is toward the top of the figure; positive values indicate water-level declines; negative values indicate water-level rises).

Figure 15. Water–level elevations in the Queen City aquifer for 2050 in feet amsl (contour interval is 50 feet; north is toward the top of the figure).

Figure 16. Drawdown in the Queen City aquifer for 2050 in feet amsl (contour interval is 10 feet; north is toward the top of the figure; positive values indicate water-level declines; negative values indicate water-level rises).
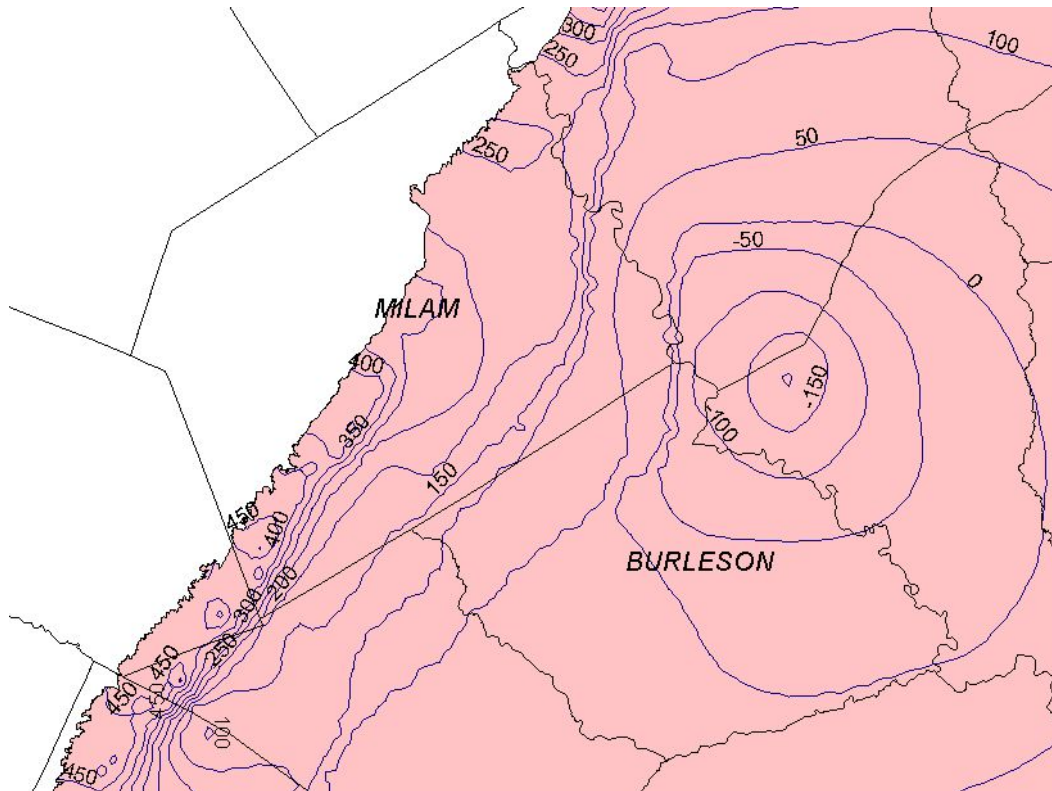
Figure 17. Water–level elevations in the Carrizo aquifer for 2050 in feet amsl (contour interval is 50 feet; north is toward the top of the figure).

Figure 18. Drawdown in the Carrizo aquifer for 2050 in feet amsl (contour interval is 10 feet; north is toward the top of the figure; positive values indicate water-level declines; negative values indicate water-level rises).

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Figure 19. Water–level elevations in the Simsboro aquifer for 2050 in feet amsl (contour interval is 50 feet; north is toward the top of the figure).
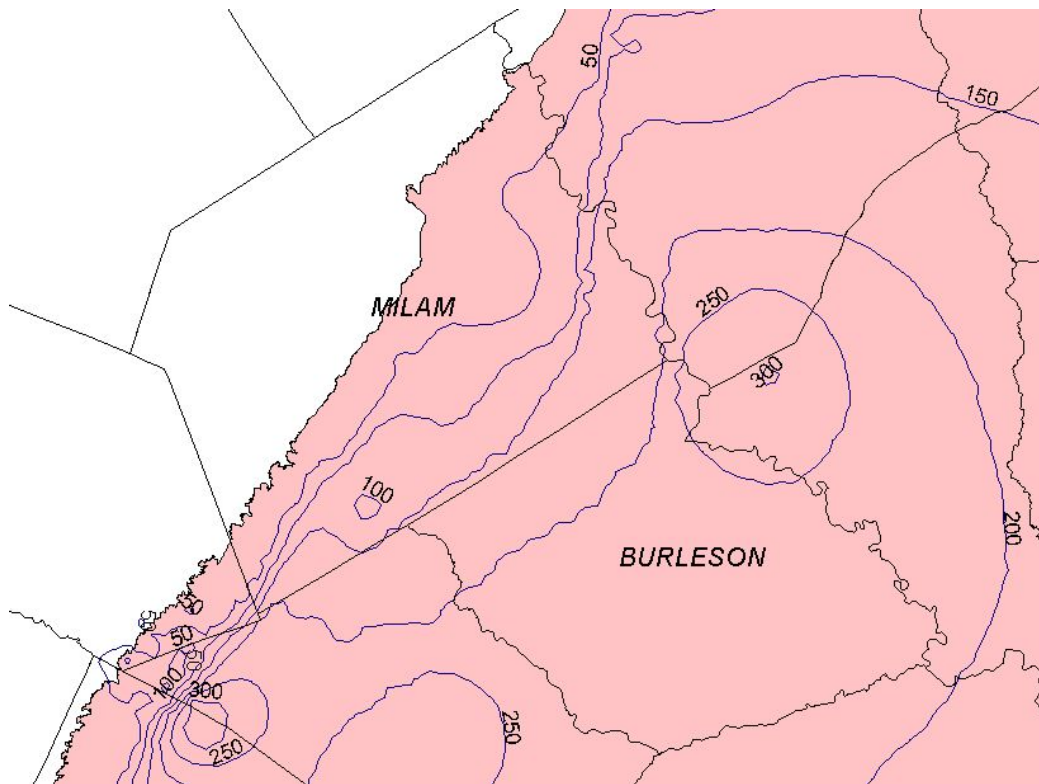

Figure 20. Drawdown in the Simsboro aquifer for 2050 in feet amsl (contour interval is 50 feet; north is toward the top of the figure; positive values indicate water-level declines; negative values indicate water-level rises).
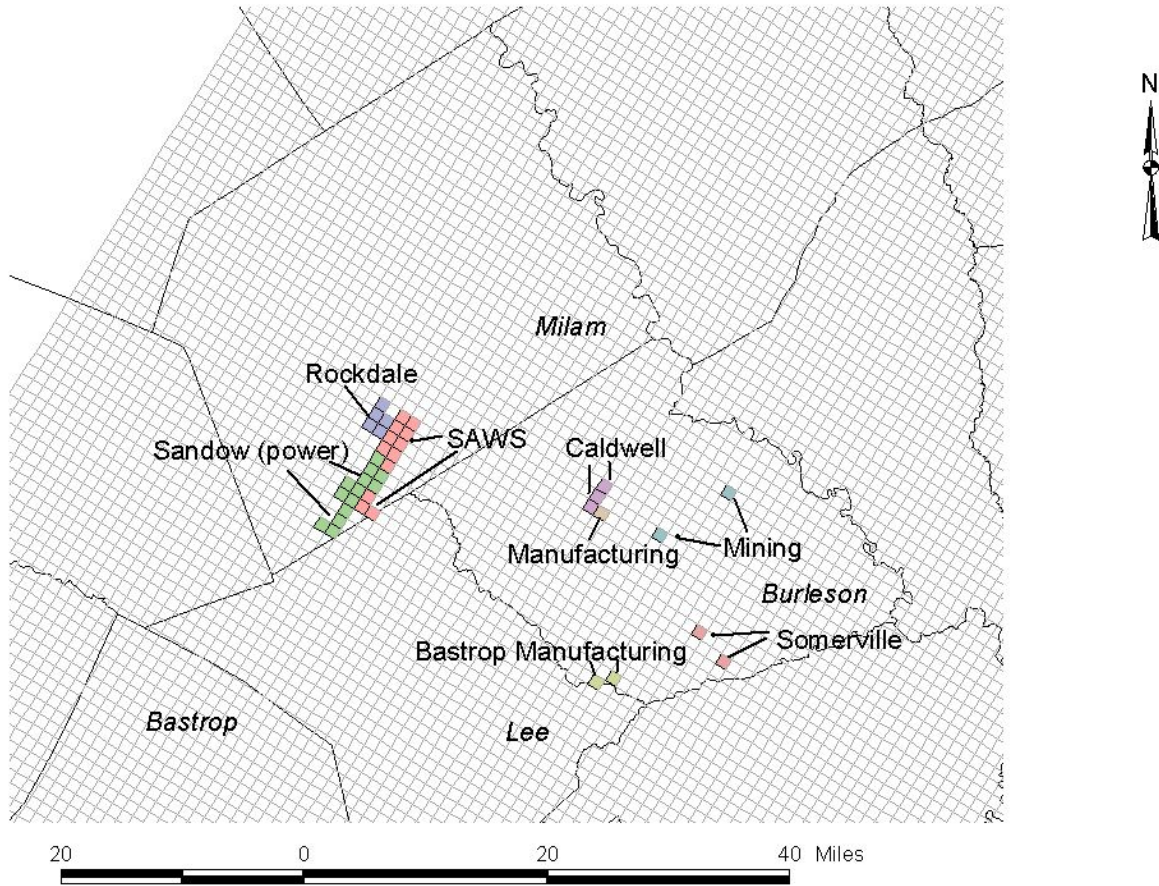
Figure 21. Location of point pumpage in the central part of the GAM for the Queen City and Sparta aquifers for Burleson and Milam counties.