GAM run 05-12

By Richard M. Smith, PG
Texas Water Development Board
Groundwater Availability Modeling Section
(512) 936-0877
April 8,, 2005

REQUESTOR:

Mr. Ray Brady, on behalf of the Hemphill County Groundwater Conservation District

DESCRIPTION OF REQUEST:

Mr. Brady requested that we run the Groundwater Availability Model (GAM) of the northern part of the Ogallala aquifer (Dutton and others, 2001; Dutton, 2004) to estimate the effect of increased pumping from 2006 through 2056 using the following scenarios:

1. estimate the changes in water levels and volumes in storage in Hemphill County by removing one acre-foot per acre per year for a 64 square mile area in the southwest corner of Hemphill County referred to as the "Hemphill Project"(Figure 1) and estimate the effects on stream flow in the Washita River and Gageby Creek;
2. estimate the effect of removing one acre-foot per acre per year for the period 2006 through 2056 from the area in eastern Roberts County referred to as the "Roberts Project" (Figure 2) and estimate the reduction in the volume of water crossing the Roberts/Hemphill county line; and
3. estimate the effect of removing one acre-foot per acre per year from both project areas (Figure 3) for the period 2006 through 2056.

This is the second part of GAM run 04-16 (Smith, 2004).

METHODS:

After running the model (version 2.0) through 2060 for the different scenarios in the request, using projected demand numbers from GAM run 05-09 for areas outside the project areas, we generated water-level maps for 2006, 2010, 2020, 2030, 2040, 2050, and 2056. We calculated saturated thickness by subtracting the bottom elevation of the Ogallala aquifer as included in the GAM (version 2.0) from the GAM calculated water levels. We then used ArcView to generate total volumes for Hemphill County based on the saturated thickness. We took the saturated thickness, on a cell-by-cell basis in the GAM, and multiplied by the area of the cell by the specific yield (0.15).

The Washita River and Gageby Creek are represented in the model as drain cells. We extracted water budgets based on the drain cells corresponding to the Washita River and Gageby Creek to estimate the effects of the various pumpage scenarios.

We estimated flow volumes of water crossing the Roberts/Hemphill county line by zoning the counties and summing the horizontal flow numbers for those model cells on the county boundaries. We estimated water volumes by multiplying the saturated thickness of the county by the specific yield and the appropriate area.

We generated water-level maps for 2006, 2010, 2020, 2030, 2040, 2050, and 2056 to estimate the effect of removing one acre-foot per acre per year from both project areas for the period 2006 through 2056.

PARAMETERS AND ASSUMPTIONS:

- See Dutton and others (2001) and Dutton (2004) for assumptions and limitations of the GAM. Root mean squared error for this model is 32 feet. This error will have more of an effect on model results where the aquifer is thin.
- The recharge in the model represents average climatic conditions for the entire model run of 2001 to 2060.
- We assumed a specific yield of 0.15.
- All pumping outside of the "Roberts" and "Hemphill" project areas represent the demand numbers that the Panhandle Regional Water Planning Group plans to include in their 2006 regional water plan (See GAM run 05-09). We proportionally adjusted the pumping distribution in the predictive run from Dutton and others (2001). To extend this run from 2050 to 2060, we assumed the same distributions for all applicable parameters and continued them annually through 2060.
- The Washita River and Gageby Creek are represented in the model as drains. This assumes groundwater contributes to stream flow when heads are higher than the base of the streams. Drains do not allow streams to contribute to the groundwater system.

RESULTS:

According to the GAM, the volume of water in Hemphill County at the end of the transient period (1998) is 13,400,000 acre-feet and the volume of water for 2056 with the "Hemphill Project" pumping is 11,800,000, a difference of 2,400,000 acre-feet. The change in water levels is significant compared to earlier analyses (compare Figures 4 through 10 and see Smith, 2004).

Groundwater flows from Roberts County into Hemphill County at the end of the transient period (1998). At this time, about 6,000 acre-feet per year flows from Roberts County into Hemphill County (see Smith, 2004). The level of pumping in Roberts County for the "Roberts Project" causes a shift in flow direction in approximately 2018. At that time, flows enter Roberts County from Hemphill County (Table 1 and Figures 11 through 17). Numerous dry cells develop between 2020 and 2030 in Roberts County.

We also ran the model to evaluate the effect of both the "Roberts Project" and the "Hemphill Project" at the same time. The results of this analysis show large numbers of dry cells developing in Roberts and Hemphill Counties after 2020 (Figures 18 through 24).

Both the Washita River and Gageby Creek are represented in the model with drain cells, which assumes they are gaining streams. The minimum value of a drain cell is zero and it cannot show water returning to the aquifer. To determine a baseline, we extracted and summed base flow for the drains representing each of the two watercourses in the year 2000 (Table 2). We also graphed the changes to base flow for the various pumping scenarios (see Figure 25 for the Washita River and Figure 26 for Gageby Creek). The results of the water budget calculation show a general decrease in the base flow in both watercourses. The steepest decline on the Washita River occurs when both the Hemphill and Roberts pumpage scenarios are simulated, closely followed by just the Hemphill scenario.. The Gageby Creek appears to be most impacted by the Hemphill scenario.

REFERENCES:

Dutton, A., 2004, Adjustments of parameters to improve the calibration of the Og-N model of the Ogallala aquifer, Panhandle Water Planning Area: prepared for Freese and Nichols, Inc. and the Panhandle Regional Water Planning Group by the Bureau of Economic Geology, The University of Texas at Austin, 9 p.

Dutton, A., Reedy, R., and Mace, R., 2001, Saturated thickness of the Ogallala aquifer in the Panhandle Water Planning Area–Simulation of 2000 through 2050 withdrawal projections: prepared for the Panhandle Water Planning Group by the Bureau of Economic Geology, The University of Texas at Austin, 54 p.

Smith, R., 2004, GAM Run 04-16: Texas Water Development Board, 4 p.

Table 1: Flow volumes from Roberts County to Hemphill County with the "Roberts Project." Negative values represent flow from Hemphill into Roberts County.

Inflows to Hemphill County from Roberts County		
Year	North of Canadian River (Acre-feet per year)	South of Canadian River (Acre-feet per year)
2006	700	5,150
2010	693	3,070
2020	567	-1,470
2030	483	-3,240
2040	438	-4,330
2050	410	-4,810
2060	384	-4,820

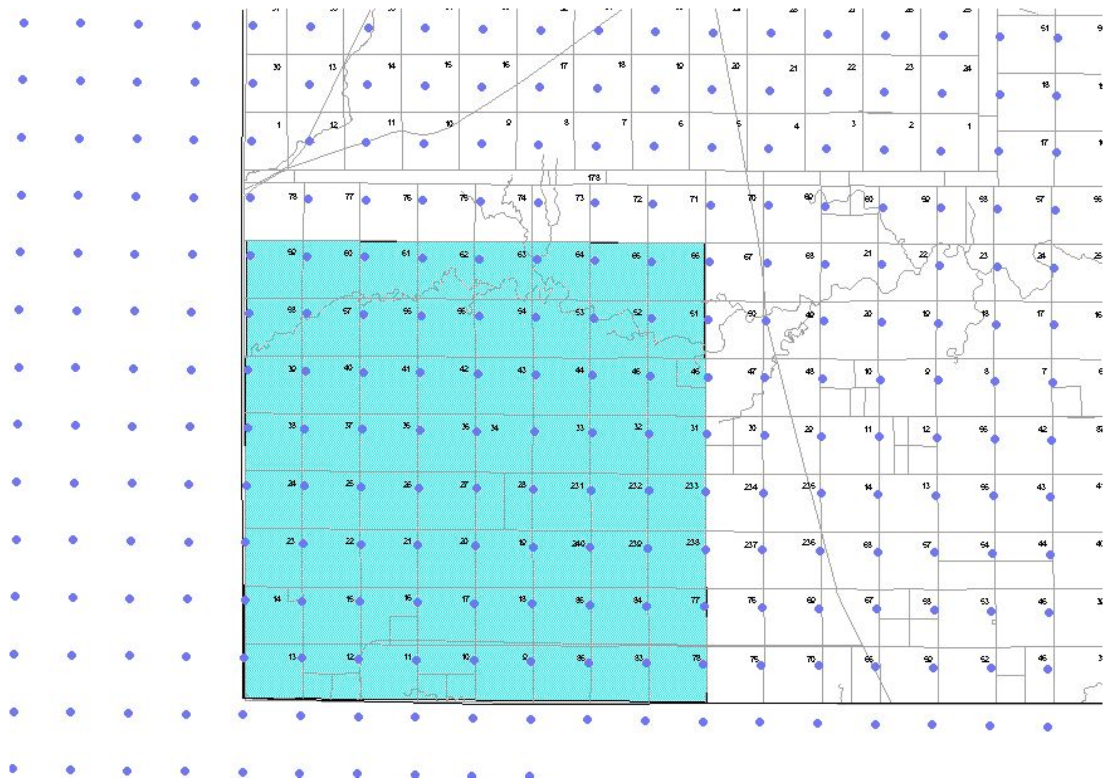

Figure 1: Location of the “Hemphill Project” in the southwest corner of Hemphill County. Proposed pumping for the area equals one acre-foot per acre per year for the period 2006 through 2056. North is at the top of the figure and the shaded area is 8 miles by 8 miles.

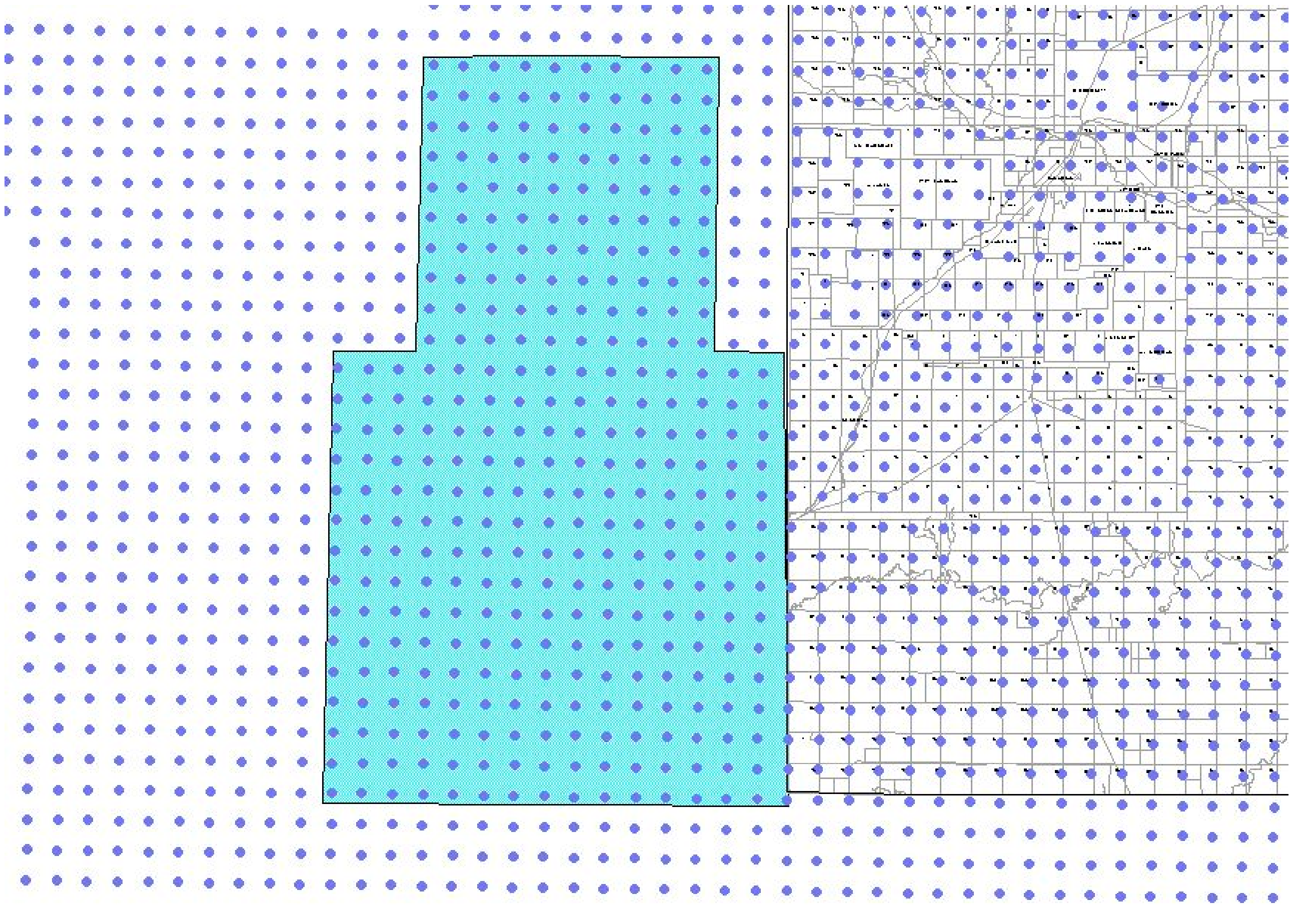

Figure 2: The "Roberts Project" on the east side of Roberts County with proposed pumping of one acre-foot per acre per year for the period 2006 through 2056. North is at the top of the figure and the shaded area is approximately 306 square miles.

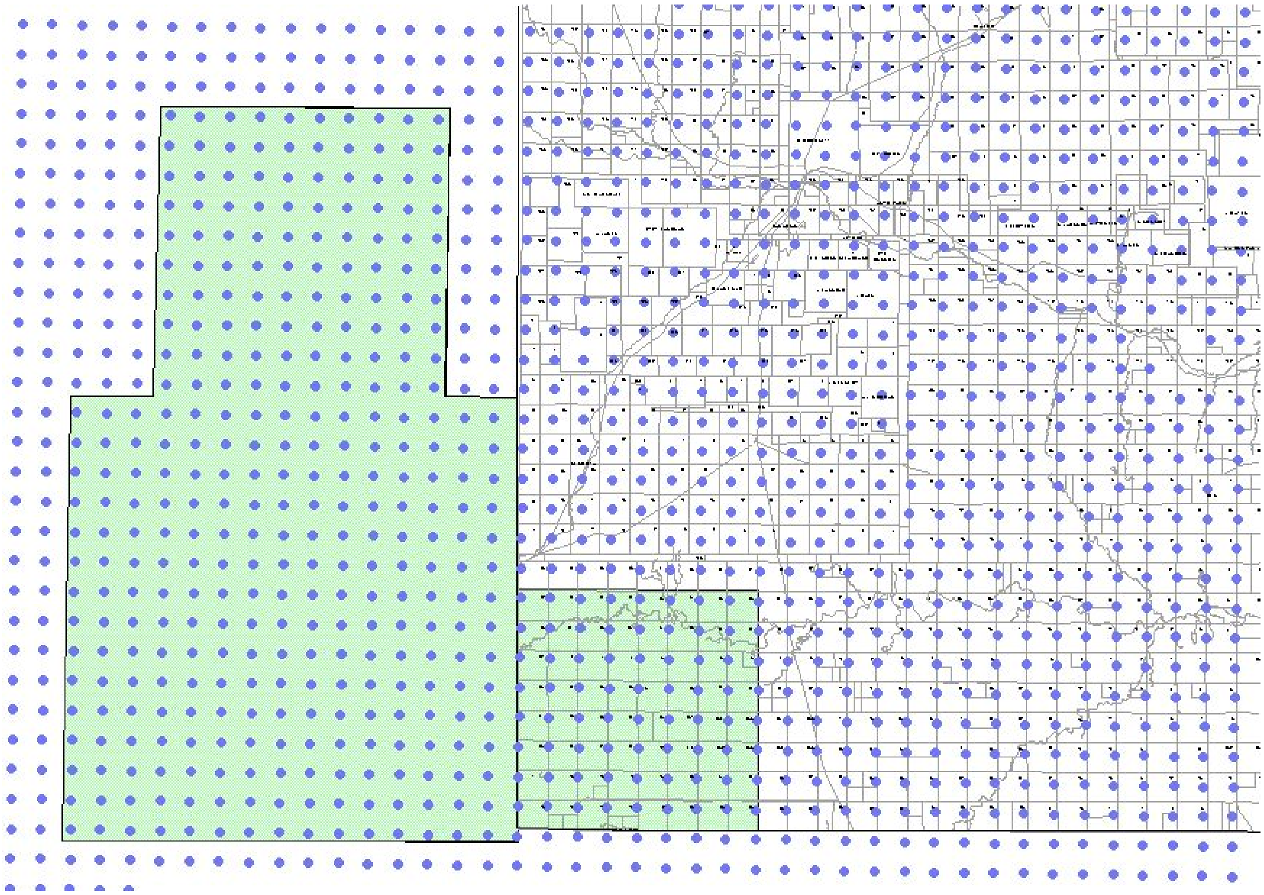

Figure 3: The "Roberts project" and the "Hemphill Project" in relation to one another with proposed pumping of one acre-foot per acre per year for the period 2006 through 2056. North is at the top of the figure and the shaded area is approximately 370 square miles.

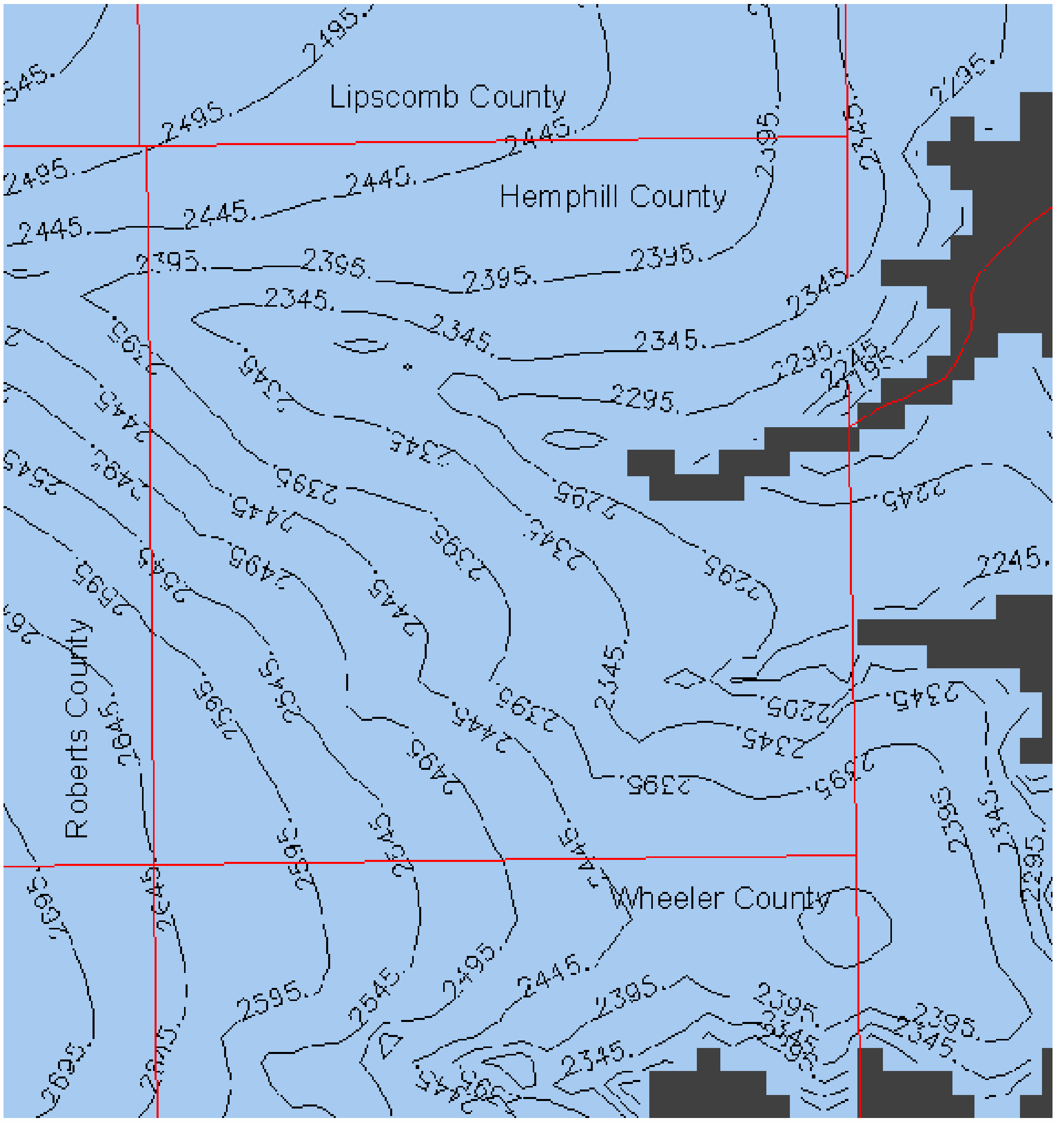

Figure 4: Water-level elevation at the end of the 2006 predictive run with pumping concentrated in the 64 square mile area in the southwest corner of Hemphill County. North is towards the top of the figure, the contour interval is 50 feet, and the dark gray cells are inactive cells in the model.

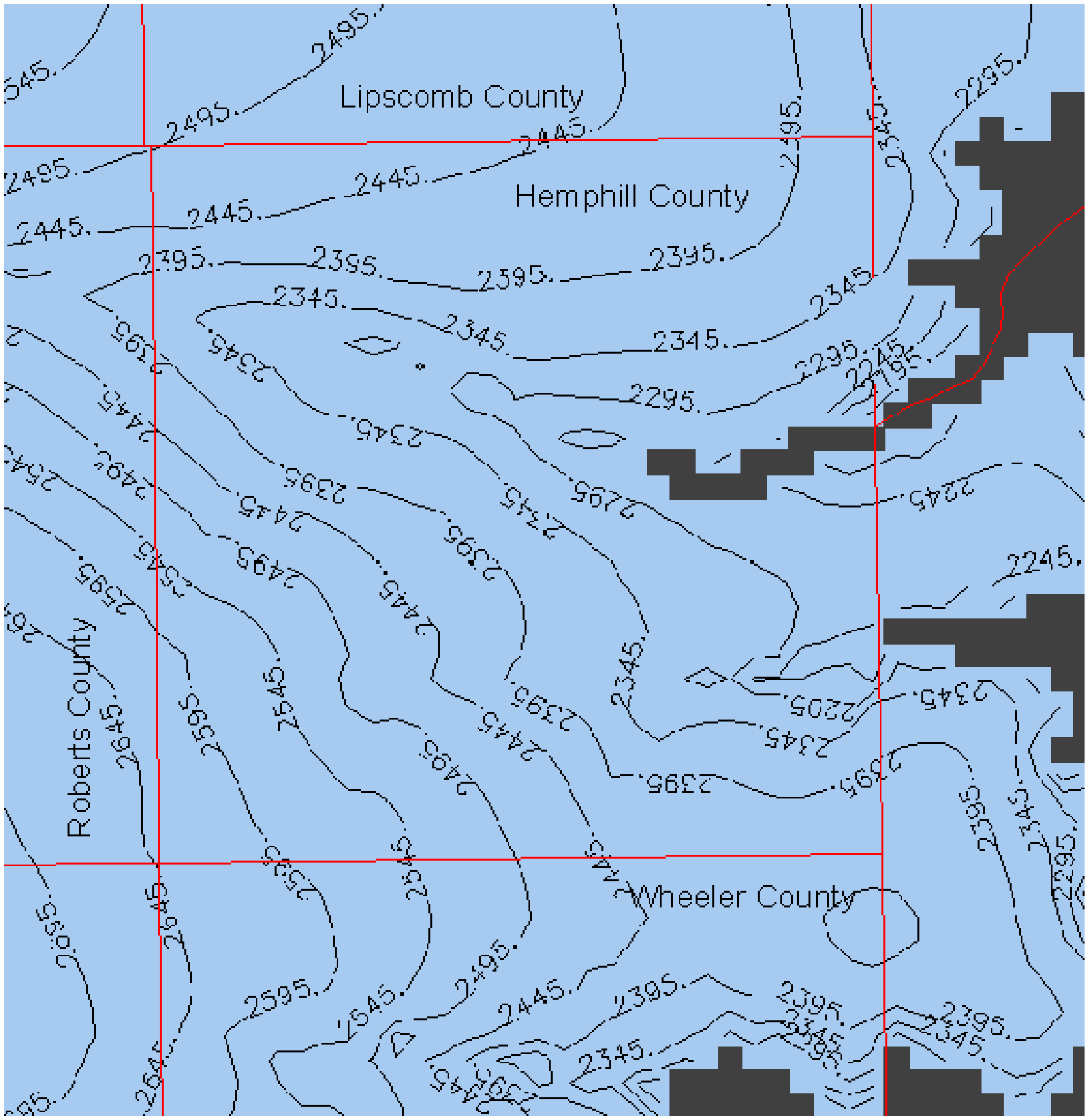

Figure 5: Water-level elevation in 2010 of the predictive run with pumping concentrated in the 64 square mile area in the southwest corner of Hemphill County. North is towards the top of the figure, the contour interval is 50 feet, and the dark gray cells are inactive cells in the model.

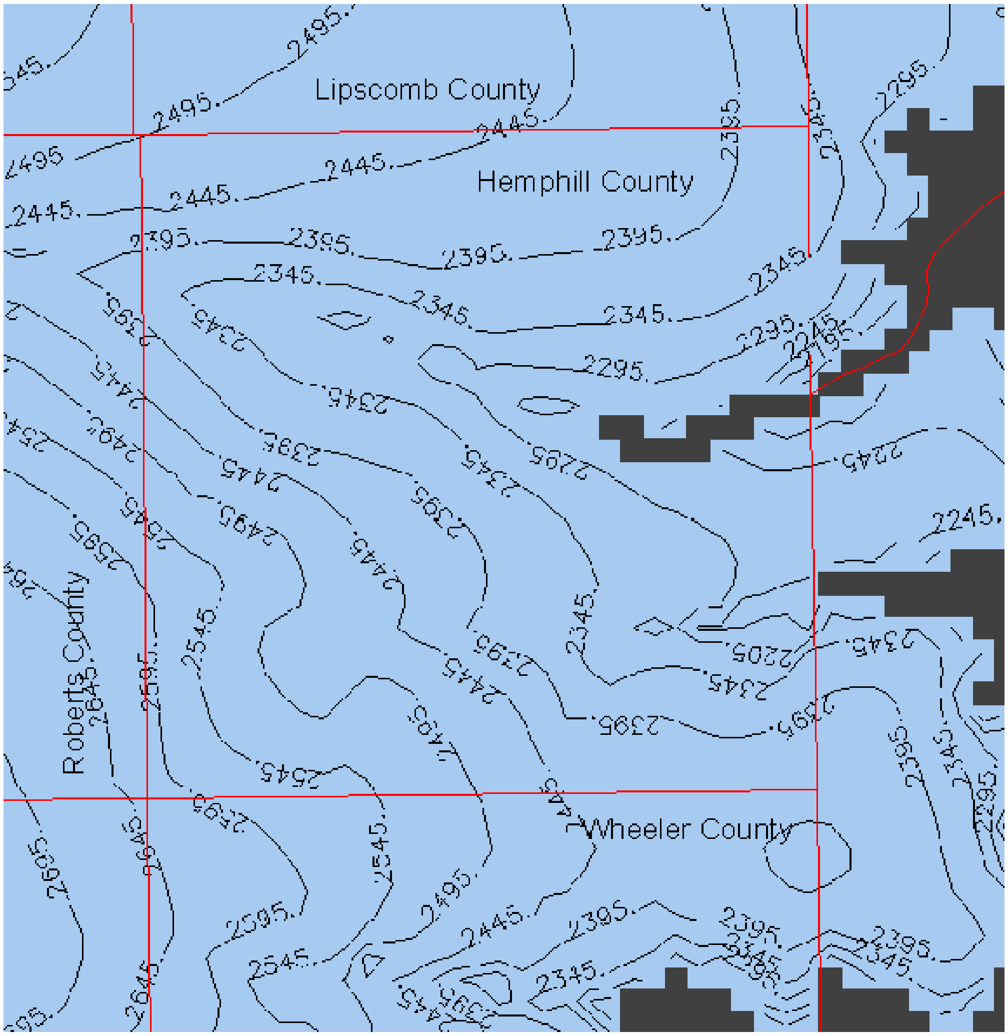

Figure 6: Water-level elevation in 2020 of the predictive run with pumping concentrated in the 64 square mile area in the southwest corner of Hemphill County. North is towards the top of the figure, the contour interval is 50 feet, and the dark gray cells are inactive cells in the model.

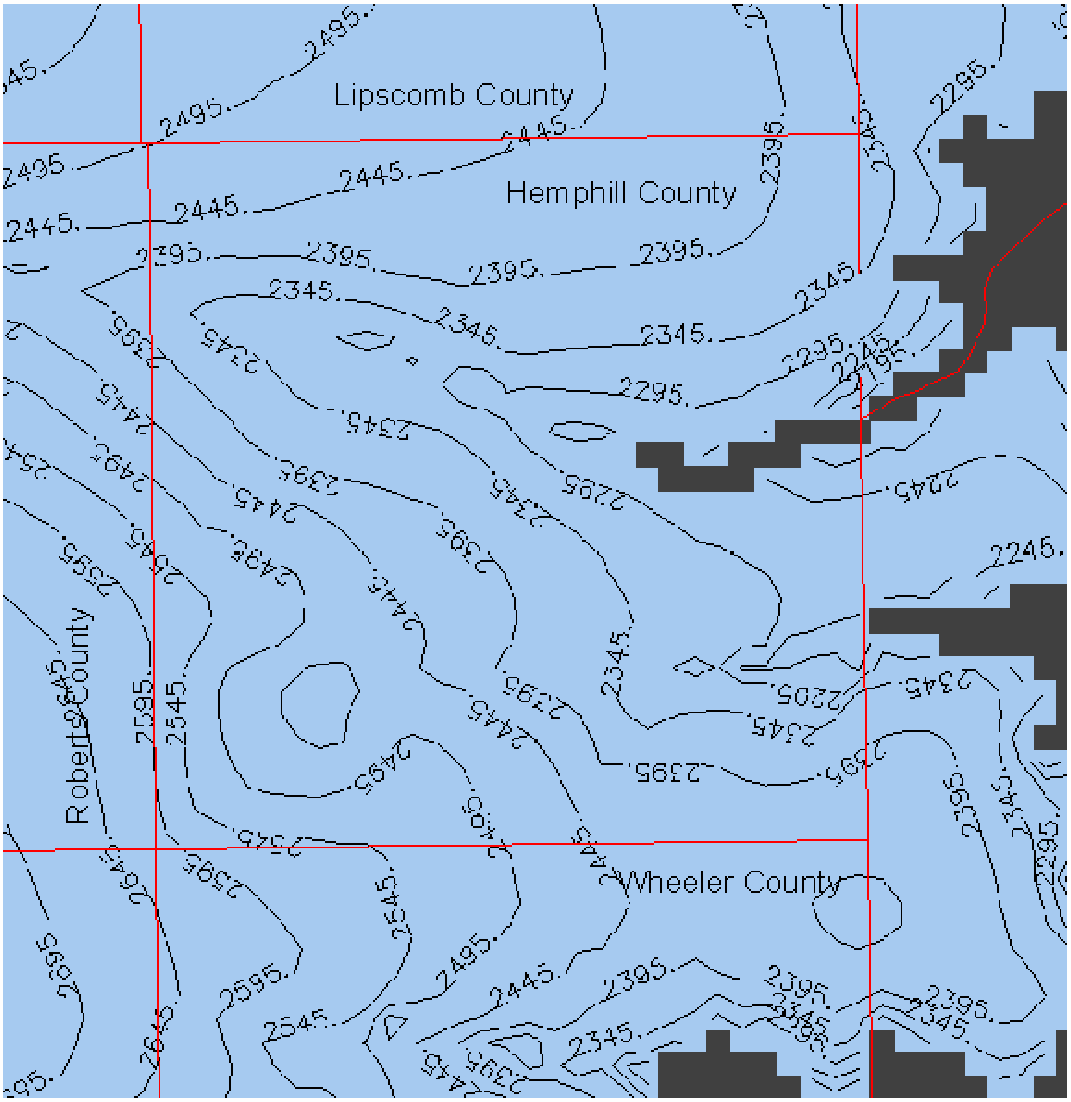

Figure 7: Water-level elevation in 2030 of the predictive run with pumping concentrated in the 64 square mile area in the southwest corner of Hemphill County. North is towards the top of the figure, the contour interval is 50 feet, and the dark gray cells are inactive cells in the model.

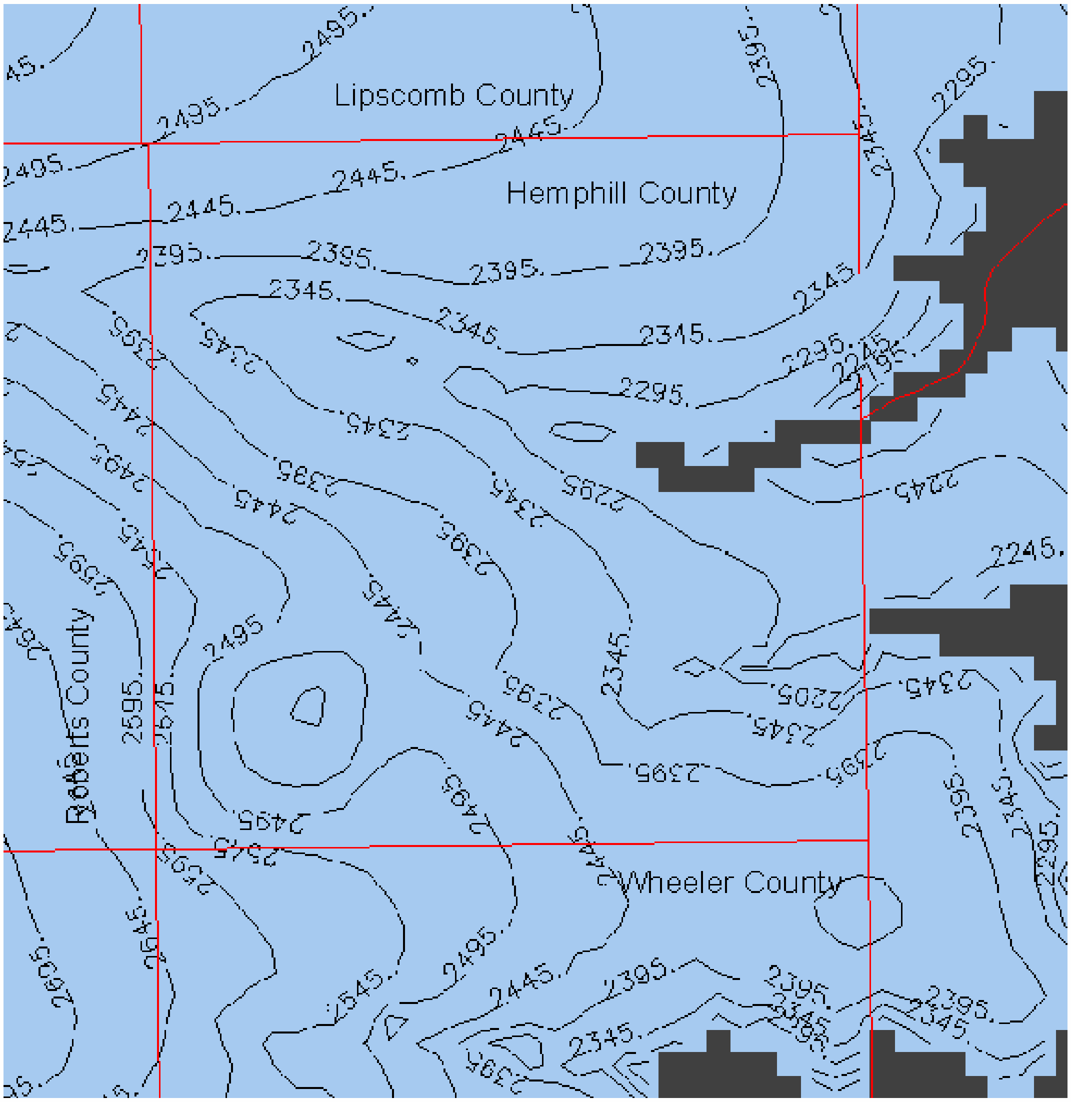

Figure 8: Water-level elevation in 2040 of the predictive run with pumping concentrated in the 64 square mile area in the southwest corner of Hemphill County. North is towards the top of the figure, the contour interval is 50 feet, and the dark gray cells are inactive cells in the model.

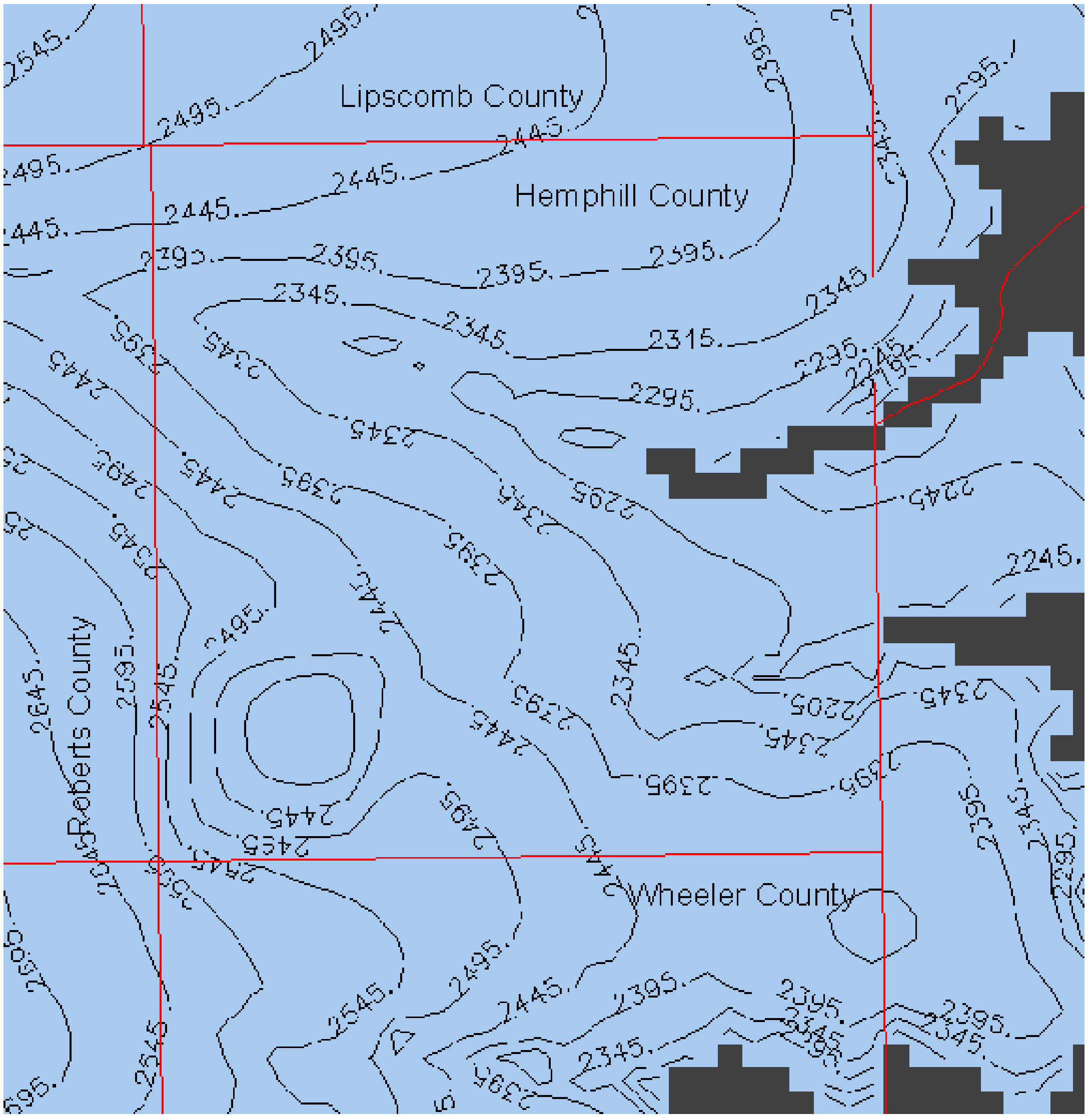

Figure 9: Water-level elevation in 2050 of the predictive run with pumping concentrated in the 64 square mile area in the southwest corner of Hemphill County. North is towards the top of the figure, the contour interval is 50 feet, and the dark gray cells are inactive cells in the model.

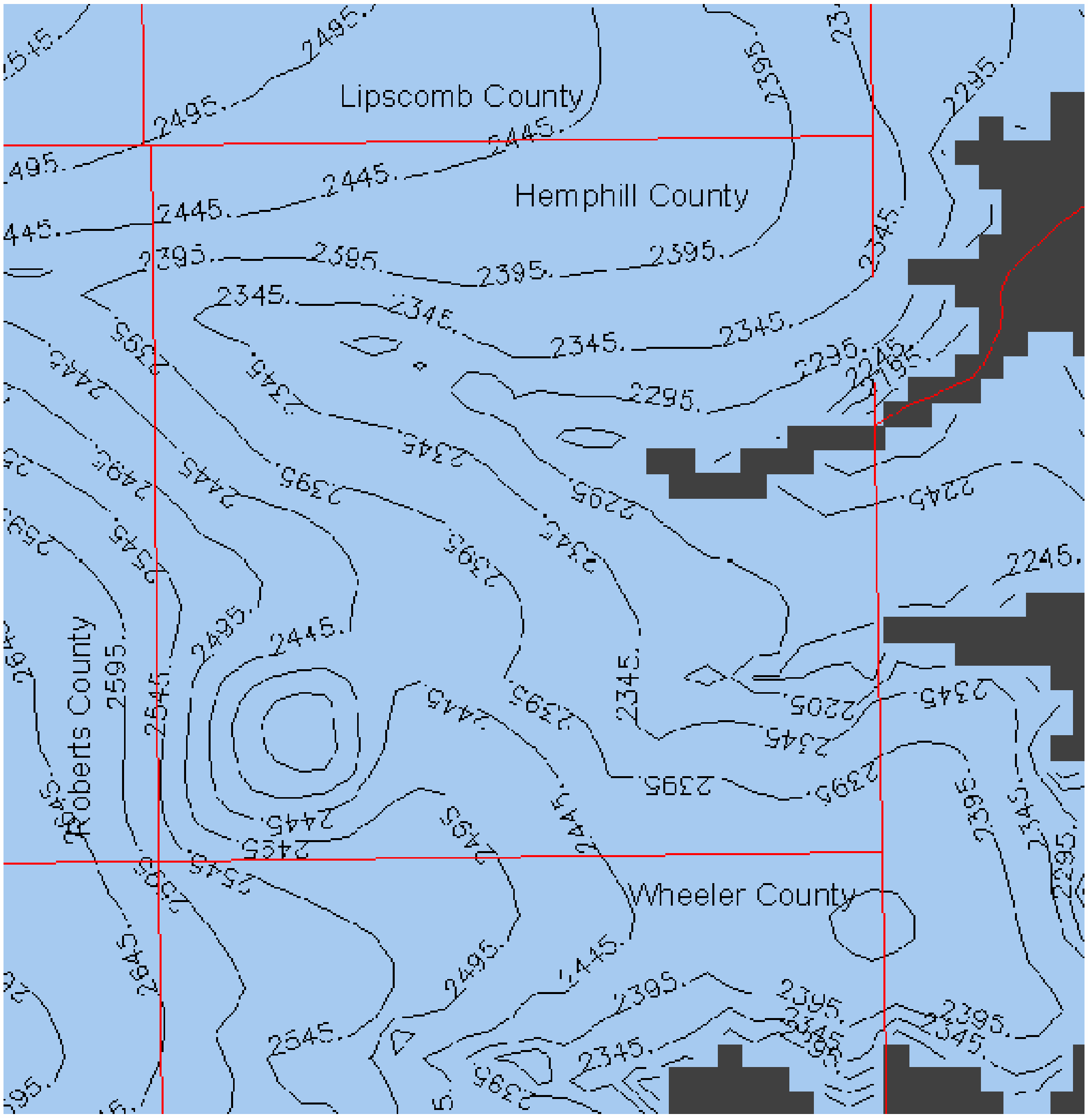

Figure 10: Water-level elevation in 2056 of the predictive run with pumping concentrated in the 64 square mile area in the southwest corner of Hemphill County. North is towards the top of the figure, the contour interval is 50 feet, and the dark gray cells are inactive cells in the model.

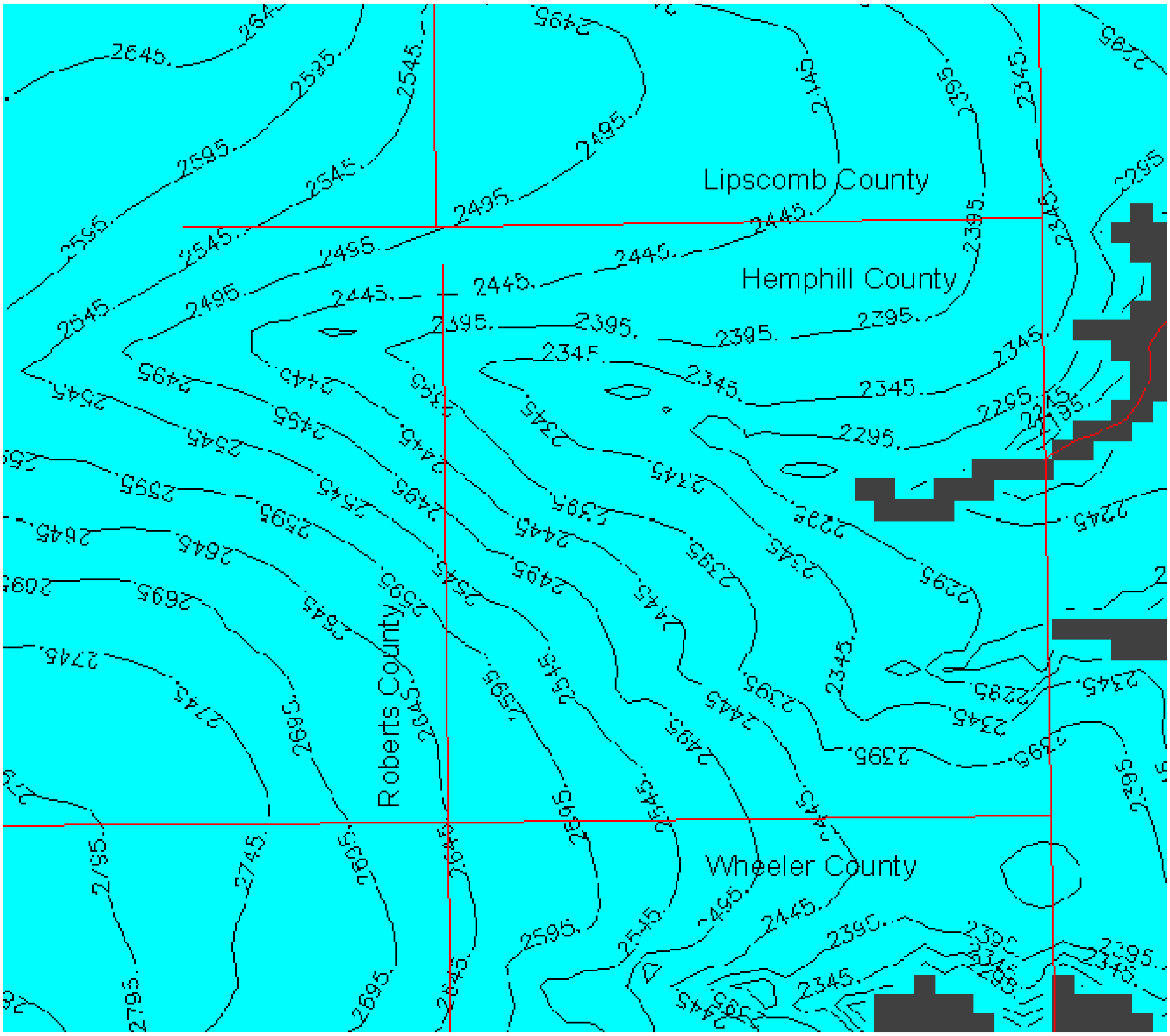

Figure 11: Water-level elevation in 2006 of the predictive run with pumping concentrated in the southeast corner of Roberts County. North is towards the top of the figure, the contour interval is 50 feet, and the dark gray cells are inactive cells in the model.

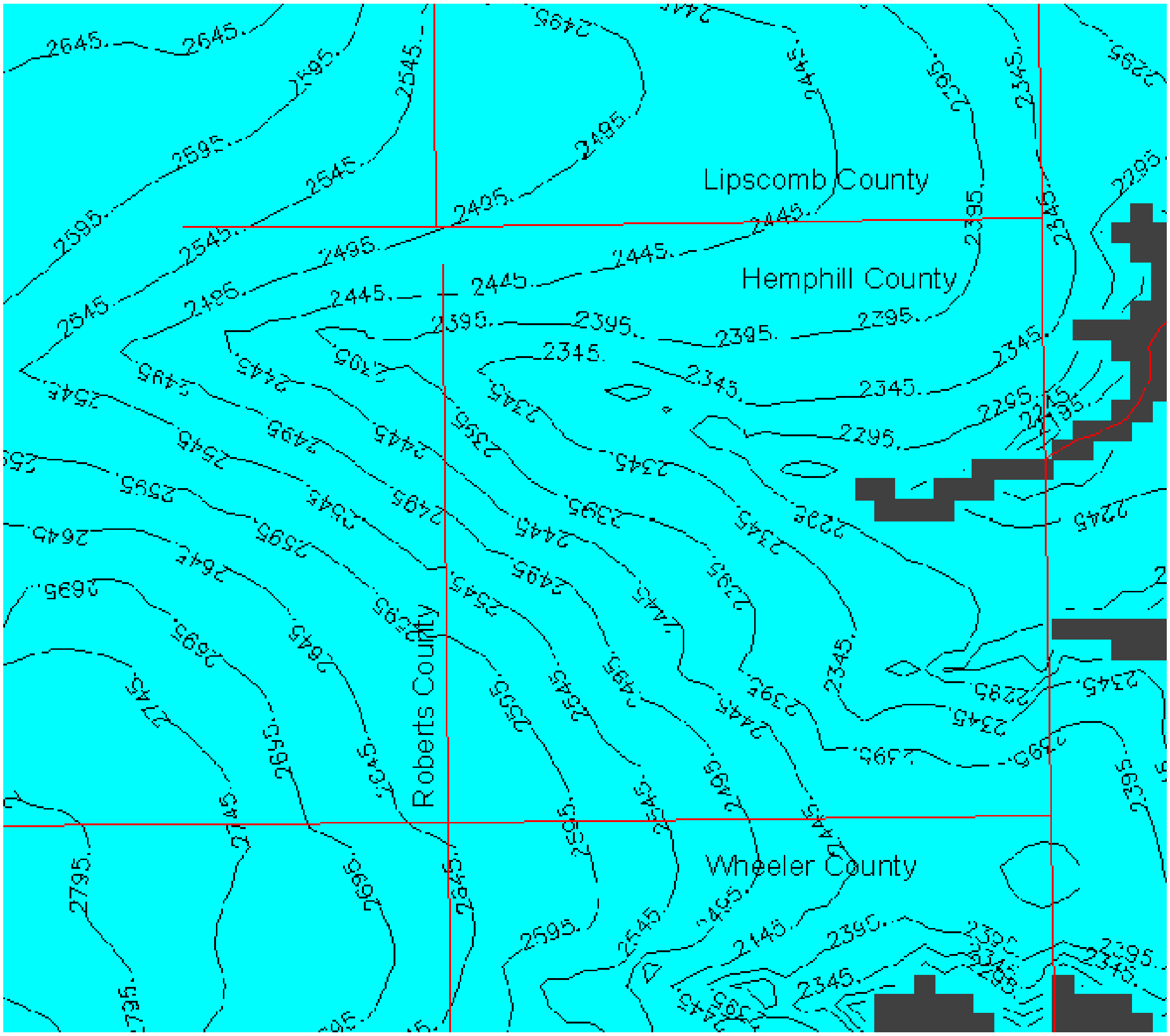

Figure 12: Water-level elevation in 2010 of the predictive run with pumping concentrated in the southeast and east side of Roberts County. North is towards the top of the figure, the contour interval is 50 feet, and the dark gray cells are inactive cells in the model.

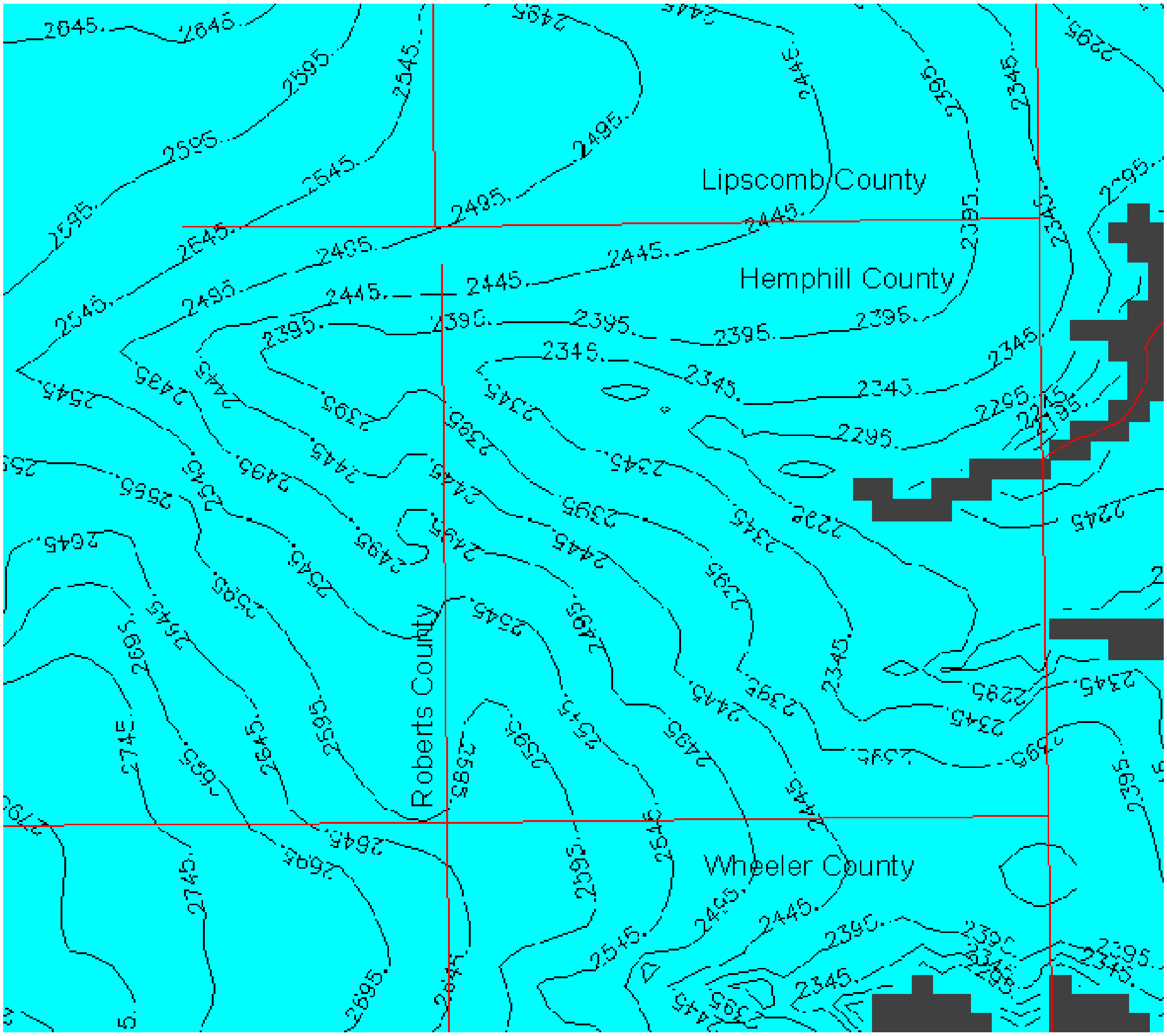

Figure 13: Water-level elevation in 2020 of the predictive run with pumping concentrated in the southeast and east side of Roberts County. North is towards the top of the figure, the contour interval is 50 feet, and the dark gray cells are inactive cells in the model.

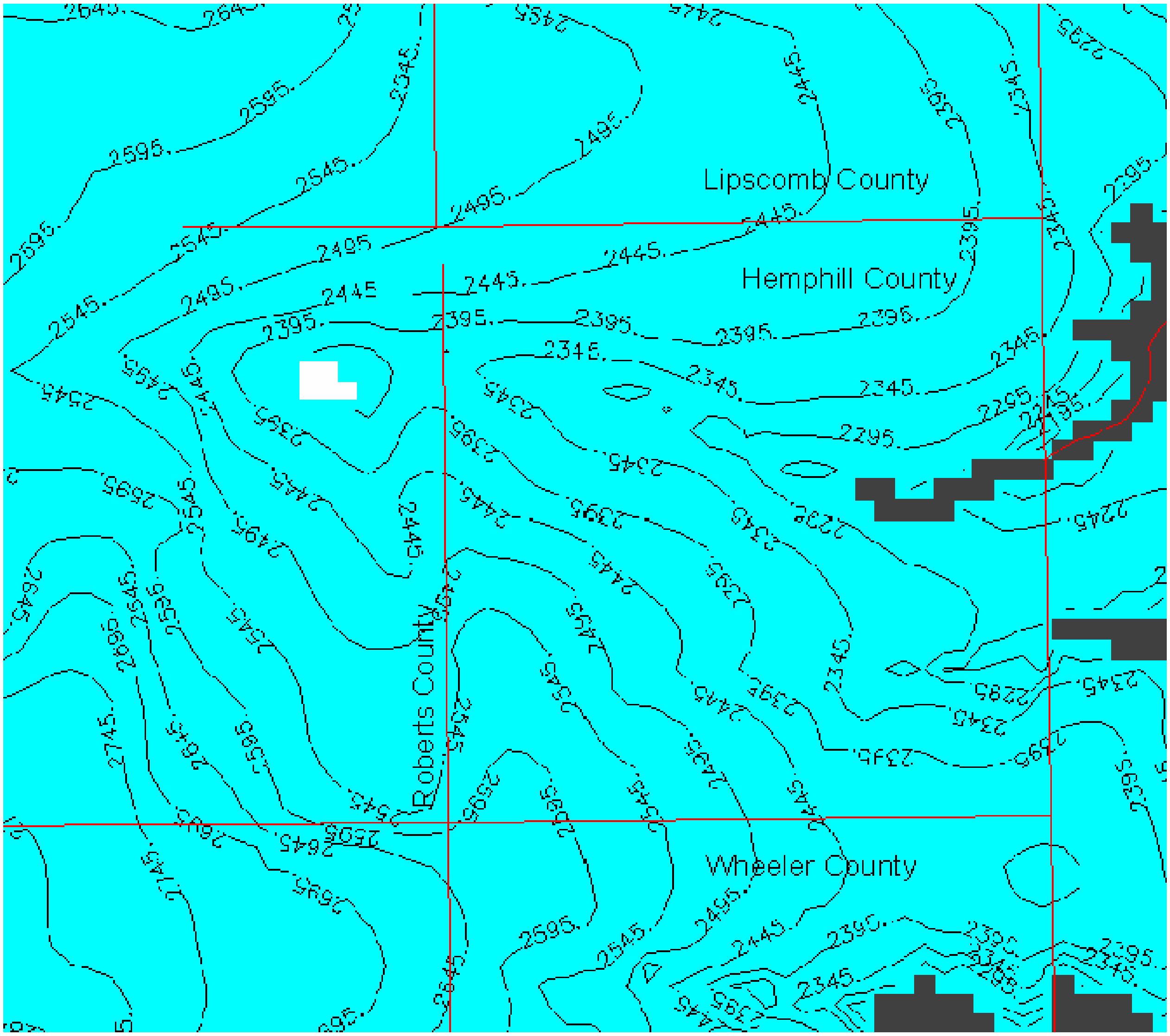

Figure 14: Water-level elevation in 2030 of the predictive run with pumping concentrated in the southeast and east side of Roberts County. North is towards the top of the figure, the contour interval is 50 feet, and the dark gray cells are inactive cells in the model. The white cells are dry cells.

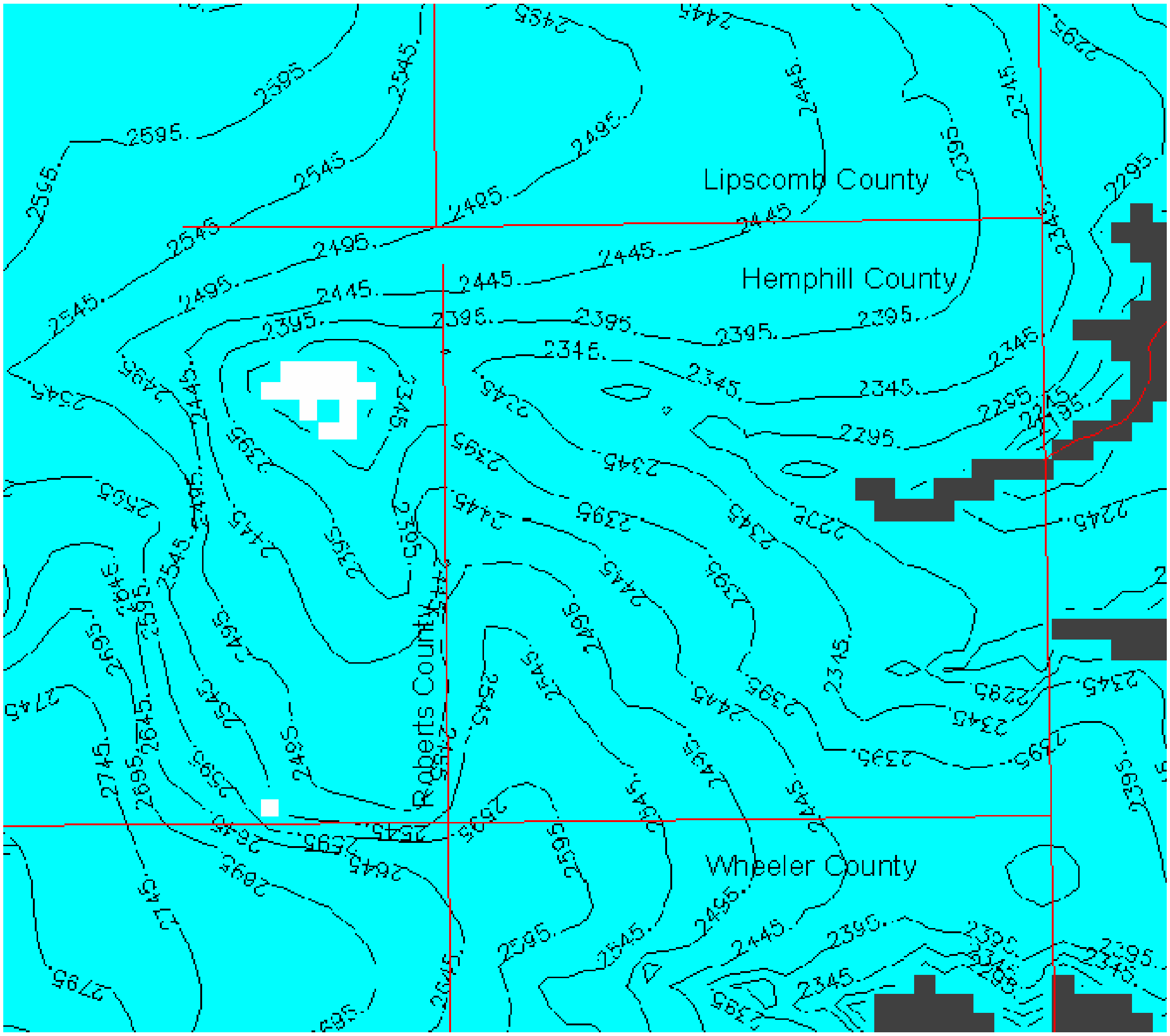

Figure 15: Water-level elevation in 2040 of the predictive run with pumping concentrated in the southeast and east side of Roberts County. North is towards the top of the figure, the contour interval is 50 feet, and the dark gray cells are inactive cells in the model. The white cells are dry cells.

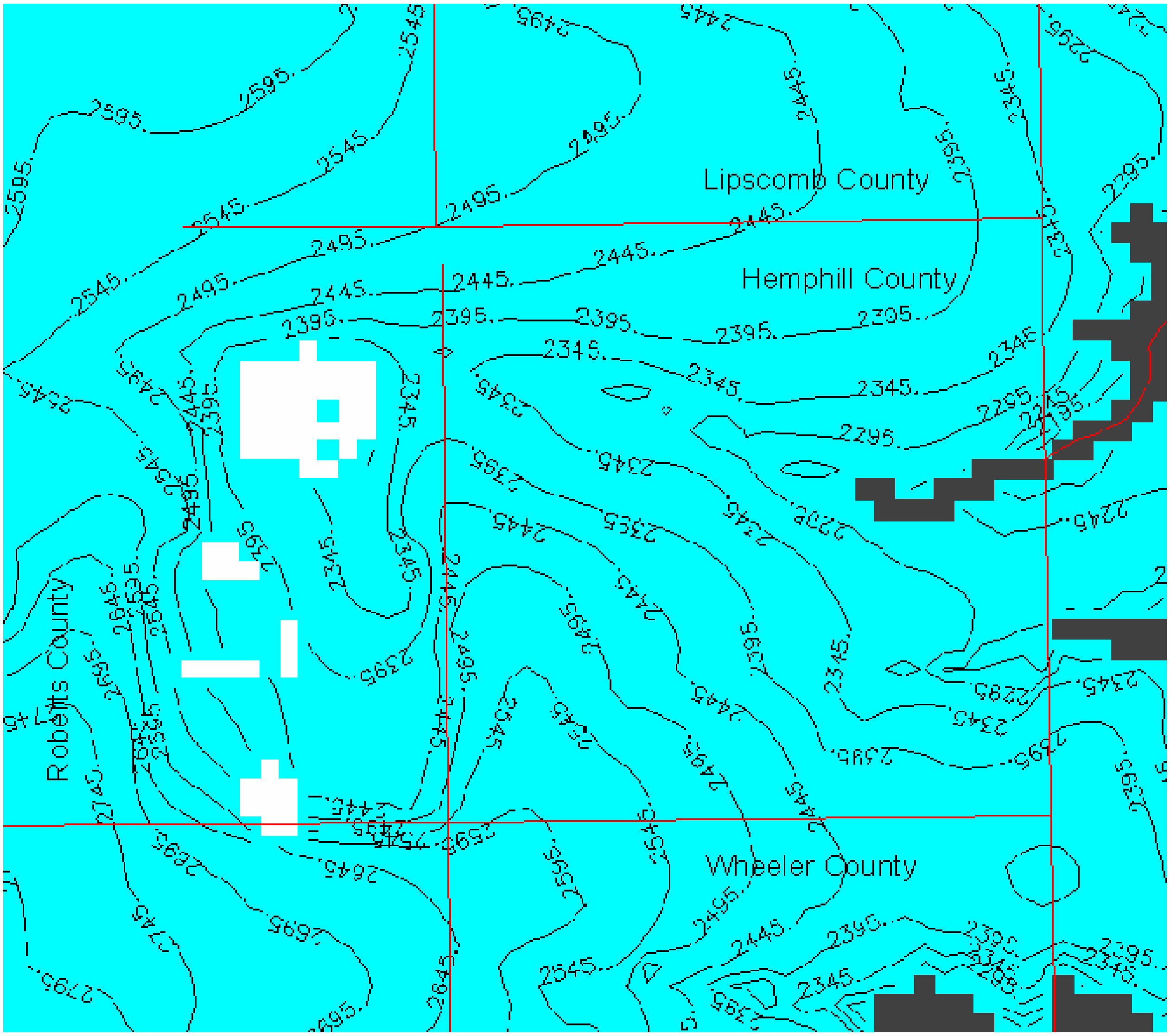

Figure 16: Water-level elevation in 2050 of the predictive run with pumping concentrated in the southeast and east side of Roberts County. North is towards the top of the figure, the contour interval is 50 feet, and the dark gray cells are inactive cells in the model. The white cells are dry cells.

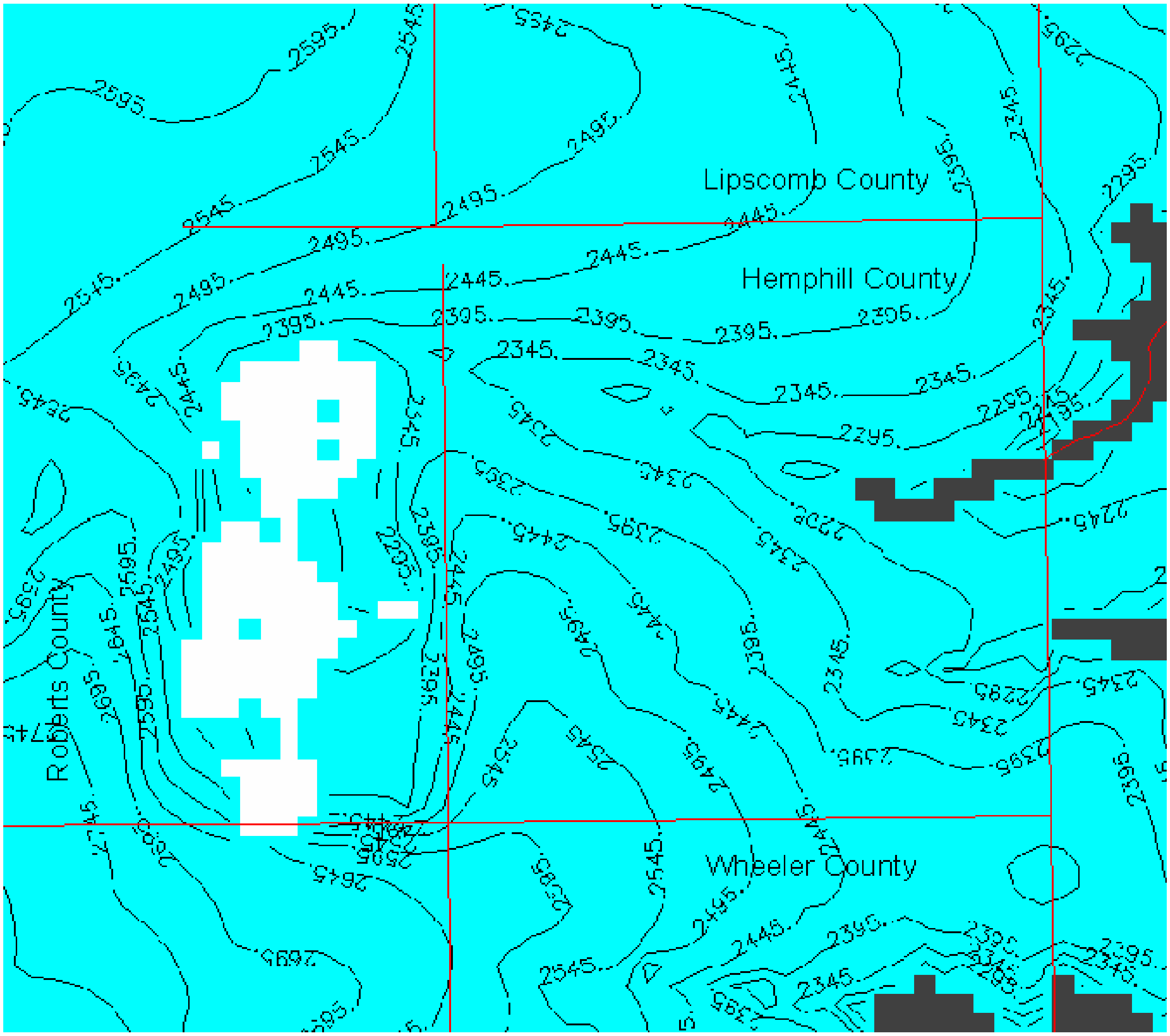

Figure 17: Water-level elevation in 2056 of the predictive run with pumping concentrated in the southeast and east side of Roberts County. North is towards the top of the figure, the contour interval is 50 feet, and the dark gray cells are inactive cells in the model. The white cells are dry cells.

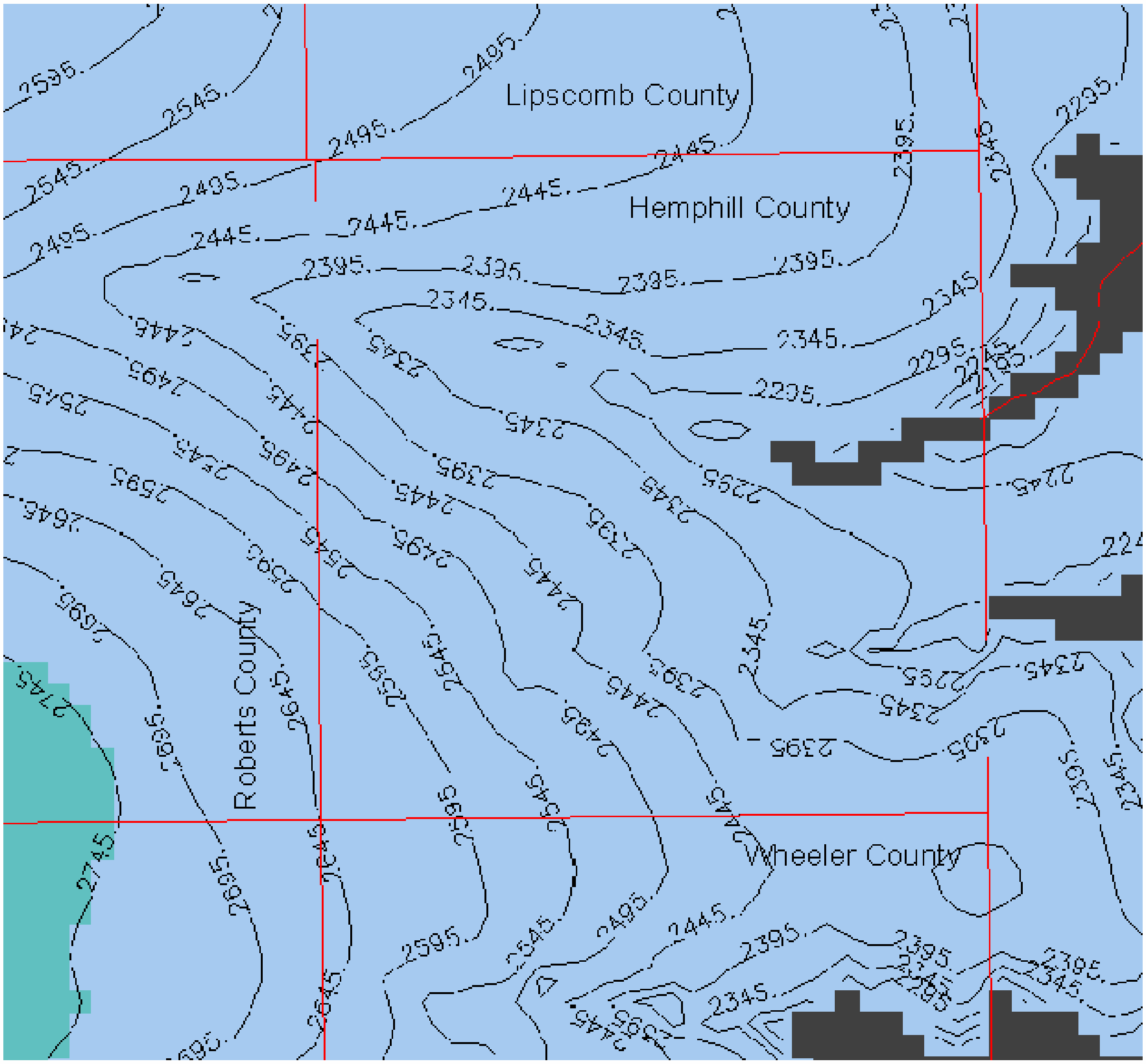

Figure 18: Water-level elevation in 2006 of the predictive run with pumping concentrated in the southeast and east side of Roberts County and the southwest 64 square mile area of Hemphill County. North is towards the top of the figure, the contour interval is 50 feet, and the dark gray cells are inactive cells in the model. The white cells are dry cells.

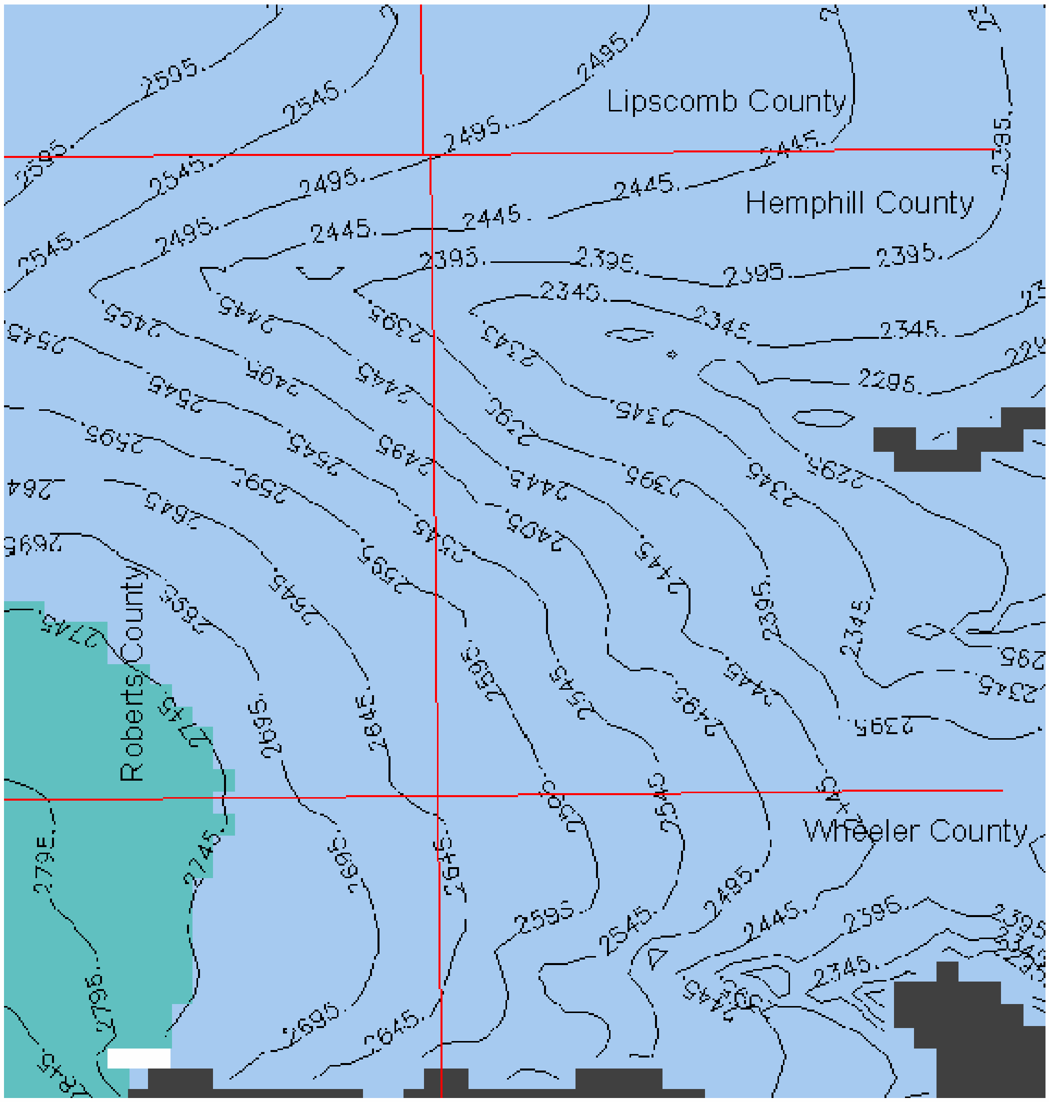

Figure 19: Water-level elevation in 2010 of the predictive run with pumping concentrated in the southeast and east side of Roberts County and the southwest 64 square mile area of Hemphill County. North is towards the top of the figure, the contour interval is 50 feet, and the dark gray cells are inactive cells in the model. The white cells are dry cells.

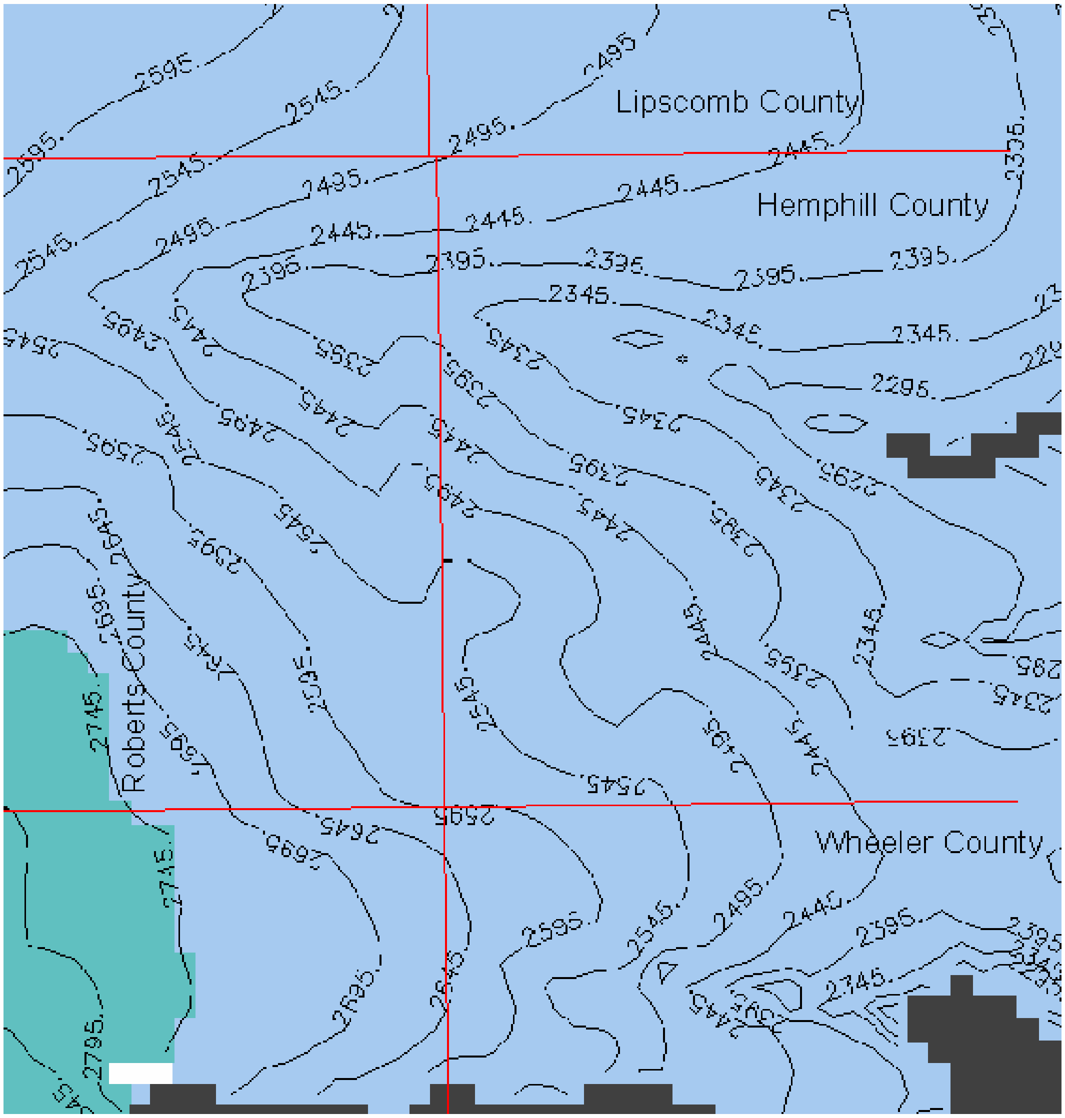

Figure 20: Water-level elevation in 2020 of the predictive run with pumping concentrated in the southeast and east side of Roberts County and the southwest 64 square mile area of Hemphill County. North is towards the top of the figure, the contour interval is 50 feet, and the dark gray cells are inactive cells in the model. The white cells are dry cells.

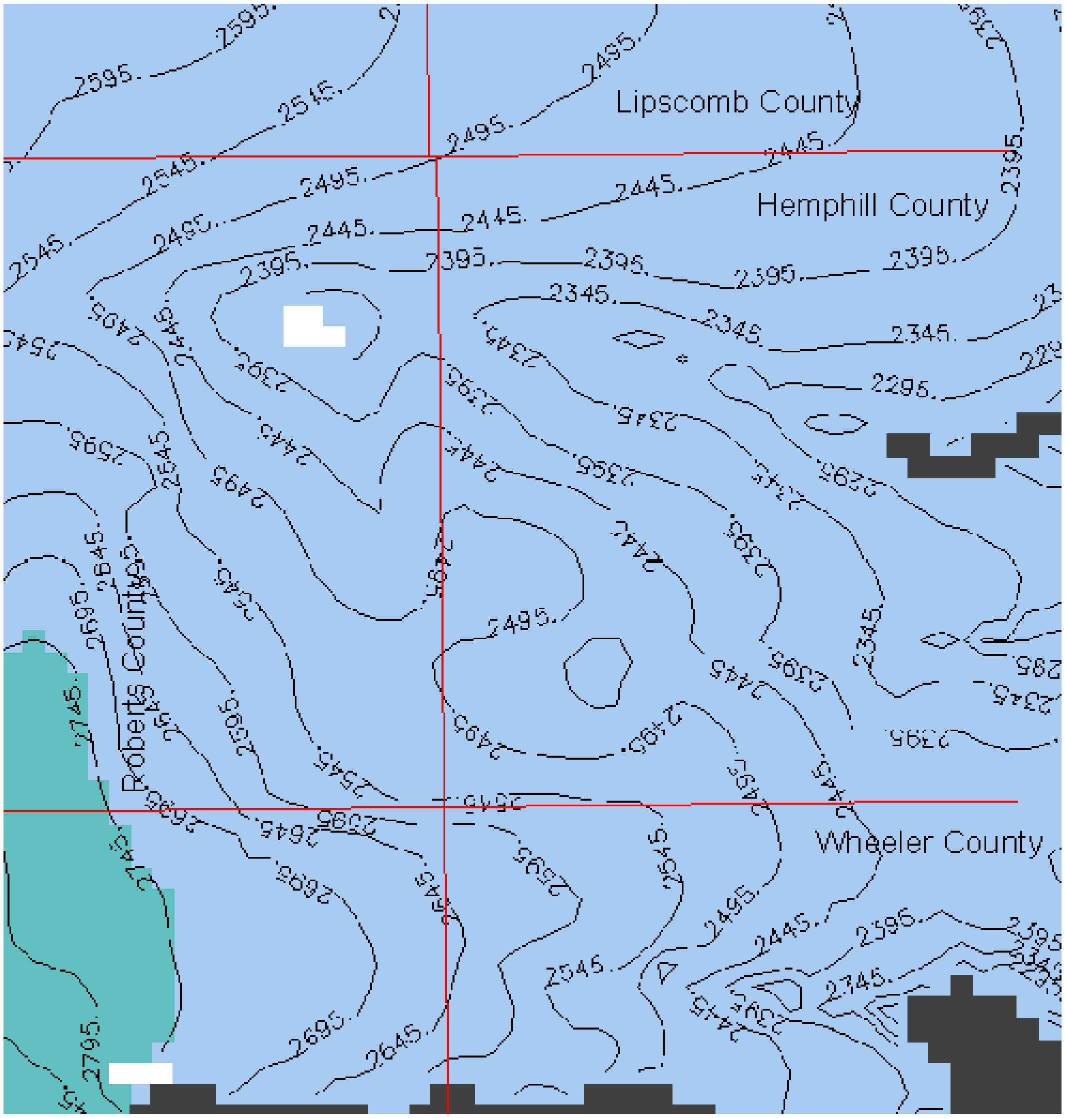

Figure 21: Water-level elevation in 2030 of the predictive run with pumping concentrated in the southeast and east side of Roberts County and the southwest 64 square mile area of Hemphill County. North is towards the top of the figure, the contour interval is 50 feet, and the dark gray cells are inactive cells in the model. The white cells are dry cells.

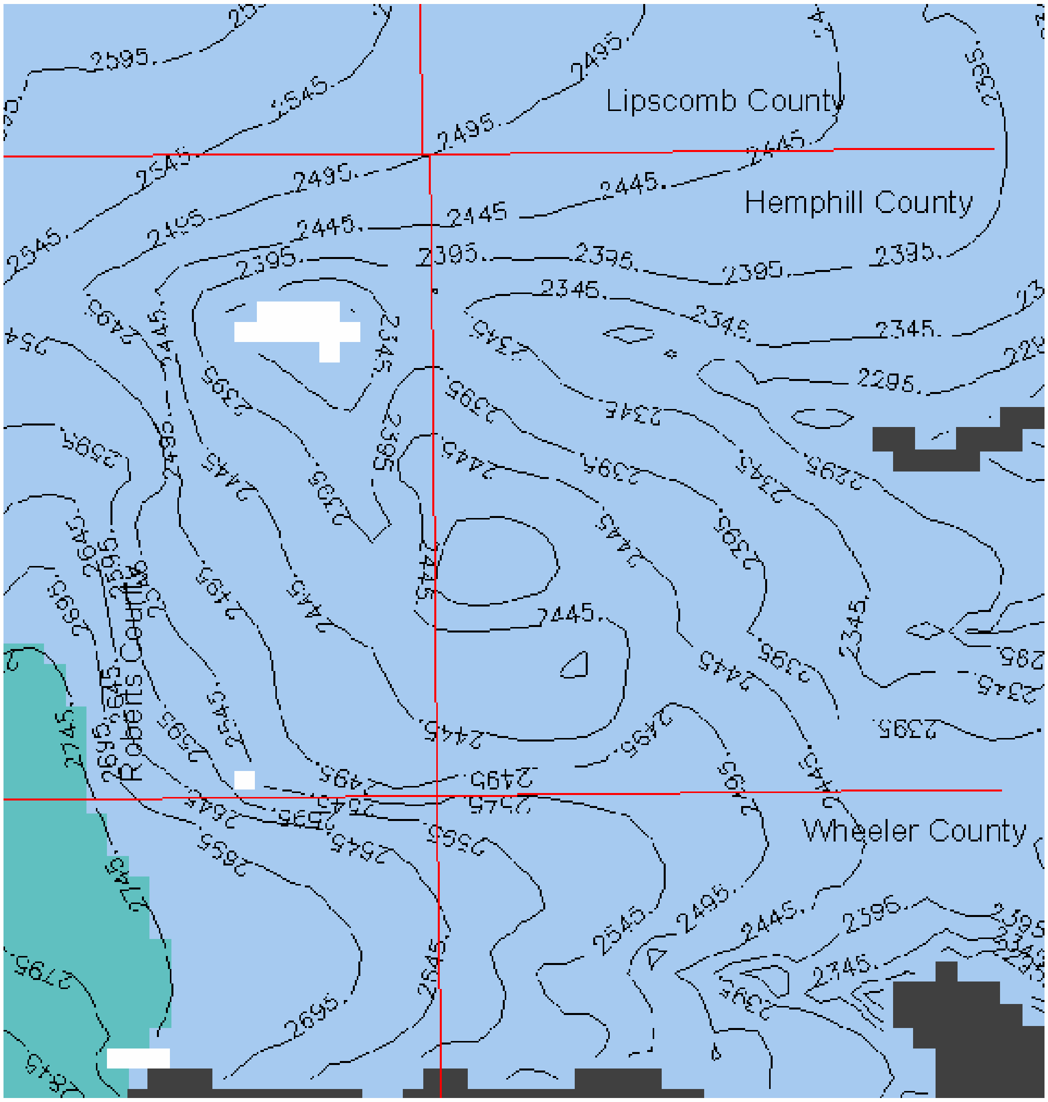

Figure 22: Water-level elevation in 2040 of the predictive run with pumping concentrated in the southeast and east side of Roberts County and the southwest 64 square mile area of Hemphill County. North is towards the top of the figure, the contour interval is 50 feet, and the dark gray cells are inactive cells in the model. The white cells are dry cells.

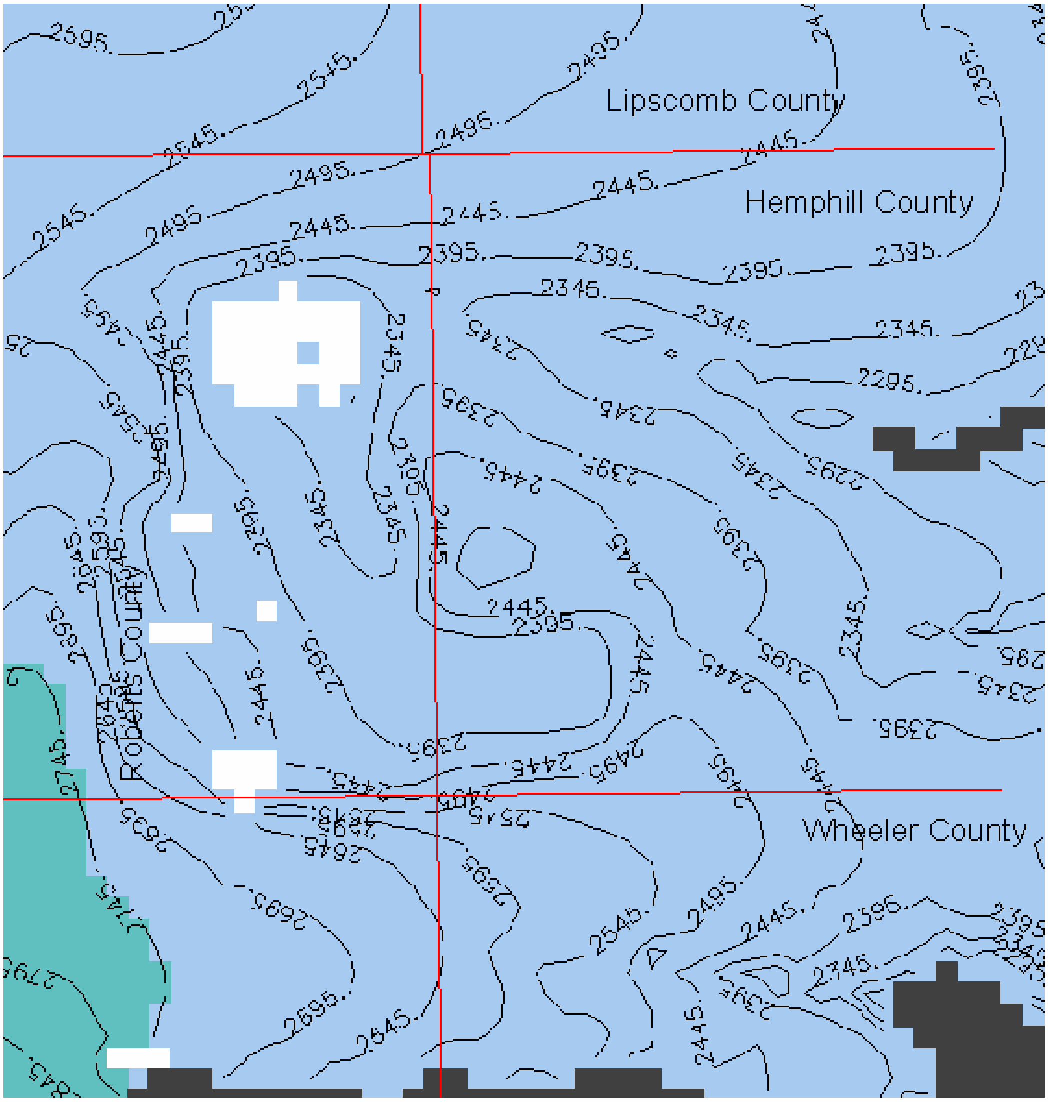

Figure 23: Water-level elevation in 2050 of the predictive run with pumping concentrated in the southeast and east side of Roberts County and the southwest 64 square mile area of Hemphill County. North is towards the top of the figure, the contour interval is 50 feet, and the dark gray cells are inactive cells in the model. The white cells are dry cells.

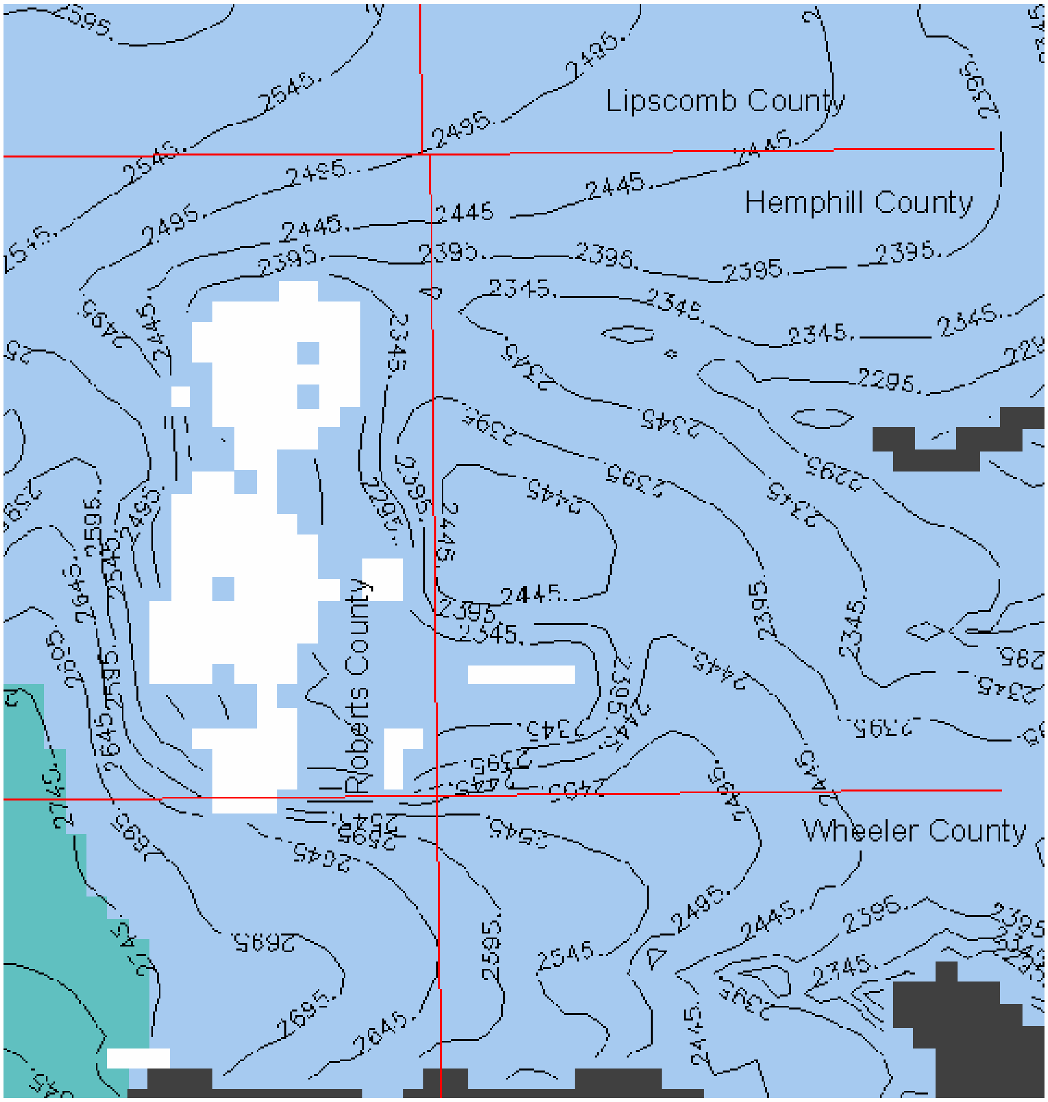

Figure 24: Water-level elevation in 2056 of the predictive run with pumping concentrated in the southeast and east side of Roberts County and the southwest 64 square mile area of Hemphill County. North is towards the top of the figure, the contour interval is 50 feet, and the dark gray cells are inactive cells in the model. The white cells are dry cells.

Table 2. Base flow responses in the Washita River and Gageby Creek from the northern part of the Ogallala aquifer GAM. Reported in acre-feet per year.

Year	Washita River-base	HemphillSW	RobertsSE	Roberts&Hemphill
2000	9,489	9,500	9,497	9,502
2010	9,365	9,161	9,297	8,686
2020	9,220	8,496	9,128	8,017
2030	9,073	7,911	8,916	7,426
2040	8,963	7,384	8,666	6,892
2050	8,860	7,194	8,395	6,675
2060	8,767	7,009	8,119	6,491
	Gageby Creek-base			
2000	3,972	3,975	3,974	3,975
2010	3,928	3,542	3,935	3,939
2020	3,843	3,340	3,882	3,887
2030	3,757	3,276	3,828	3,823
2040	3,681	3,196	3,776	3,743
2050	3,620	3,099	3,726	3,646
2060	3,574	2,992	3,679	3,538

Values in the water budget are probably only accurate to two significant figures.

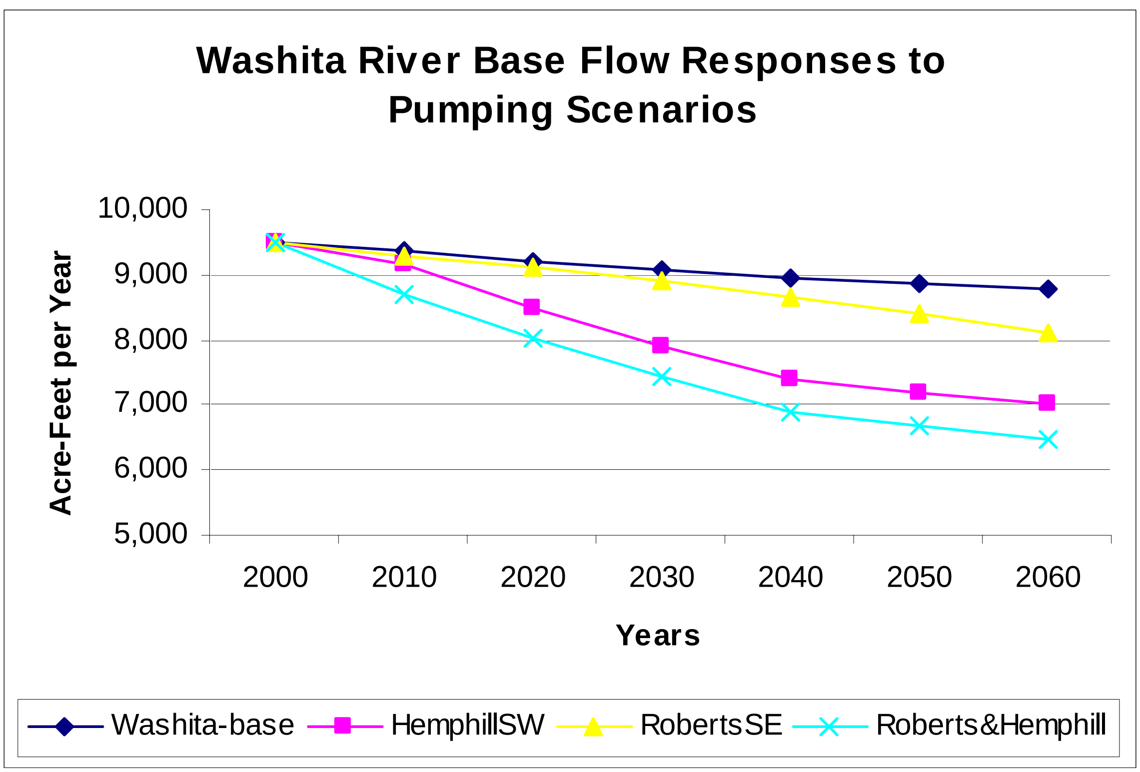

Figure 25. Base flow responses to pumping scenarios for the Washita River.

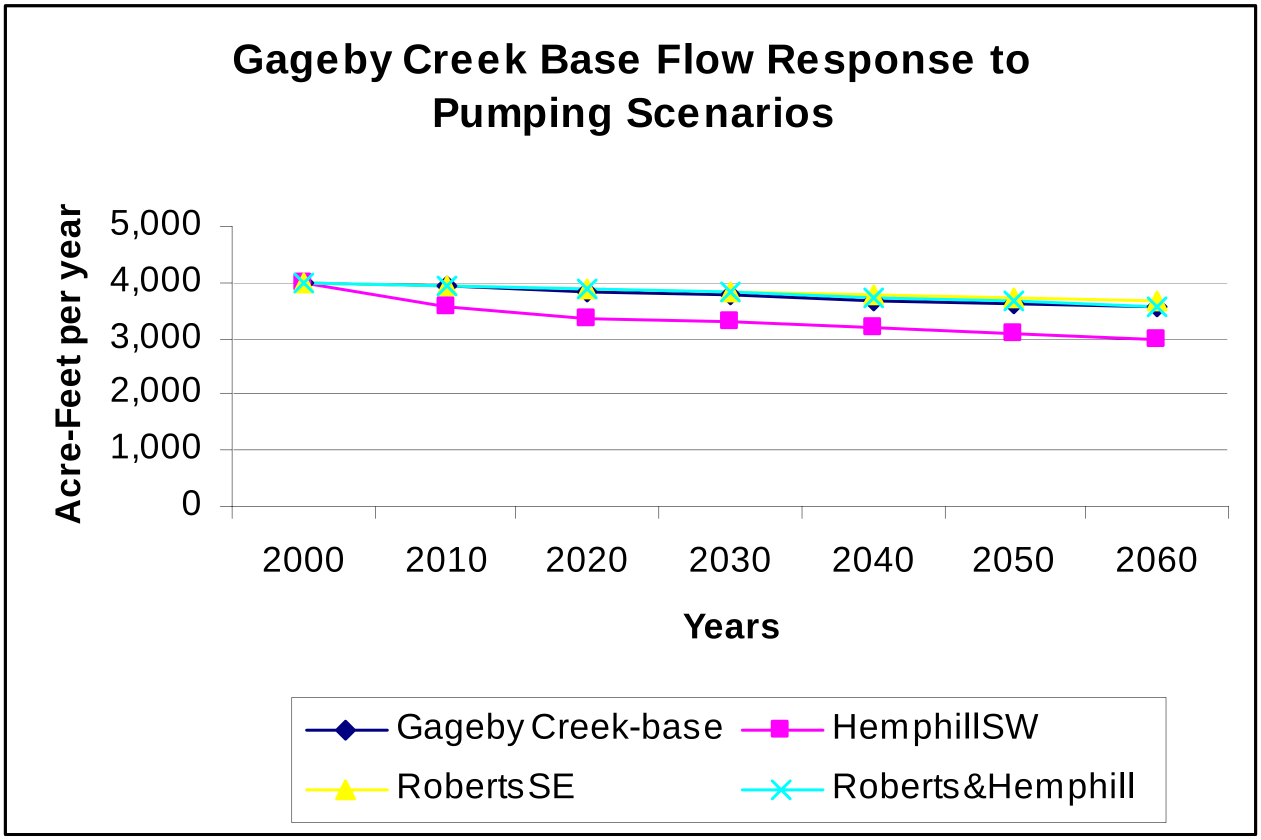

Figure 26: Base Flow Responses for different pumping scenarios on Gageby Creek