GAM run 05-09

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Groundwater Availability Modeling Section
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REQUESTOR:

Mr. Stefan Schuster with Freese and Nichols, Inc. on behalf of the Panhandle Regional Water Planning Group

DESCRIPTION OF REQUEST:

Mr. Schuster requested that we run the Groundwater Availability Model (GAM) for the northern part of the Ogallala aquifer for the period 2010 to 2060 and (1) provide maps of water levels for 2010, 2020, 2030, 2040, 2050, and 2060; (2) calculate saturated thicknesses; and (3) compute aquifer volumes for each county. He wanted this information for 2010, 2020, 2030, 2040, 2050, and 2060 using the groundwater demands he provided us that were from the Panhandle Regional Water Planning Group for their 2006 regional water plan (Schuster's demands). We also provided water budgets for each county.

METHODS:

We used the Groundwater Availability Model (GAM) for the northern part of the Ogallala aquifer (the original model [Dutton and others, 2001] with the updates [Dutton, 2004]) and Schuster's demands. We proportionally adjusted predictive pumping in the GAM by category in each county to equal Schuster's demands. The predictive run in the original GAM only extends to 2050. To get to 2060, we took the adjusted pumping for 2050, proportionally adjusted this pumping by category in each county to equal Schuster's demands for 2060, and then linearly interpolated between 2050 and 2060.

Once we ran the GAM, we extracted the water levels and contoured them in PMWIN to generate the water-level maps for each decade.

We calculated saturated thickness by subtracting the bottom of the Ogallala aquifer as included in the GAM from the GAM calculated water levels. We then used ArcView to generate total volumes for each county based on the saturated thickness for each decade. We took the saturated thickness, on a cell-by-cell basis in the GAM, and multiplied by the area of the cell and the specific yield (0.15).

We extracted water budgets from the model for each county and decade.

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 53 ft. This error will have more of an effect on model results where the aquifer is thin.
- Recharge represents average conditions for the predictive period.
- Assumed a uniform specific yield of 0.15 across aquifer.

RESULTS:

Figures 1 through 6 show GAM predicted water levels based on Schuster's demands. Note that the white areas in these figures represent inactive cells in the GAM. As the predictive run progresses, more white appears in the GAM. These white areas represent parts of the GAM that are going dry because the aquifer can not continue to support the pumping. In the GAM, once a part of the model goes dry, it stays dry, and the pumping is "shut off." This can result in water levels rising in nearby areas once the pumping in the area is stopped. This also results in less pumping in the model because the pumping has been stopped in these areas. In reality, the aquifer will probably not go dry because pumping will become uneconomical before the aquifer goes dry in any particular area. However, the GAM is suggesting that these areas may experience water supply problems sometime in the next 50 years.

Table 1 shows the volume of groundwater in the Ogallala aquifer for each county in the Panhandle Regional Water Planning Area through 2060. Each county shows a decline in volume between 2010 and 2060. Note that the rate of decline is less in some counties, probably because of the GAM going dry in those counties. For example, the volume of groundwater in Dallam County initially decreases by about 3,000,000 acre-ft between 2010 and 2020 but only decreases by about 700,000 acre-ft between 2050 and 2060. This is because much of the production area in Dallam County has gone dry because it could not sustain pumping. Note that Oldham and Randall counties are only partially in the GAM for the northern part of the Ogallala aquifer. Volumes for the rest of the Ogallala aquifer are in GAM run 03-22.

Table 2 shows the water budget for each county through 2060. The pumpage for a county may be less than Schuster's demands due to the model going dry in places.

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.

Table 1: Volume of groundwater in the Ogallala aquifer for counties in the Panhandle Regional Water Planning Area.

		Volumes are in acre-feet					
County	2000	2010	2020	2030	2040	2050	2060
Dallam	15,700,000	12,300,000	10,300,000	9,090,000	7,790,000	6,890,000	6,210,000
Sherman	17,300,000	15,000,000	12,700,000	10,100,000	8,590,000	7,040,000	5,490,000
Hansford	18,500,000	17,300,000	16,200,000	15,200,000	14,200,000	13,300,000	12,500,000
Ochiltree	19,100,000	18,200,000	17,400,000	16,600,000	15,900,000	15,300,000	14,700,000
Lipscomb	18,600,000	18,500,000	18,400,000	18,300,000	18,200,000	18,100,000	18,000,000
Hartley	20,500,000	18,300,000	16,300,000	14,700,000	13,600,000	13,000,000	12,500,000
Moore	10,500,000	8,750,000	7,060,000	5,560,000	4,400,000	3,570,000	2,970,000
Hutchinson	9,590,000	8,900,000	8,220,000	7,610,000	7,080,000	6,660,000	6,300,000
Roberts	23,900,000	23,400,000	22,800,000	22,300,000	21,900,000	21,400,000	20,800,000
Hemphill	13,700,000	13,700,000	13,600,000	13,600,000	13,500,000	13,500,000	13,500,000
Oldham	444,000	436,000	430,000	425,000	419,000	415,000	411,000
Potter	2,790,000	2,680,000	2,530,000	2,410,000	2,340,000	2,260,000	2,190,000
Carson	13,500,000	12,500,000	11,600,000	10,700,000	9,980,000	9,320,000	8,730,000
Gray	11,400,000	11,100,000	10,800,000	10,500,000	10,300,000	10,000,000	9,810,000
Wheeler	6,650,000	6,600,000	6,550,000	6,510,000	6,480,000	6,450,000	6,420,000
Randall	1,560,000	1,450,000	1,360,000	1,280,000	1,220,000	1,170,000	1,130,000
Armstrong	3,610,000	3,540,000	3,480,000	3,420,000	3,370,000	3,320,000	3,280,000
Donley	5,290,000	5,130,000	4,990,000	4,860,000	4,740,000	4,650,000	4,570,000
Collingsworth	74,000	73,900	73,800	73,700	73,600	73,500	73,400

Values reported to three significant digits.

Table 2: Water budgets for selected counties in the Panhandle Regional Water Planning Area (values in acre-feet per year).

County	Year	Stor_IN	Stor_Out	X-In	X-Out	Wells	Springs	Recharge	Total_In	Total_Out	%Diff
Dallam	2010	-361	277,543	21,801	-27,167	-291,798	0	20,711	319,468	-319,468	-0.02
	2020	-499	221,364	21,549	-24,736	-236,457	0	18,699	261,612	-261,612	-0.01
	2030	-973	179,439	21,130	-21,969	-195,370	0	17,692	218,010	-218,848	-0.06
	2040	-1,870	121,582	19,537	-19,705	-135,837	0	16,518	157,638	-157,638	-0.03
	2050	-1,962	88,042	17,860	-17,692	-102,297	0	15,764	121,582	-121,582	-0.05
	2060	-2,029	65,738	16,435	-16,015	-79,238	0	14,925	97,266	-97,266	-0.1
Sherman	2010	0	271,674	33,875	-15,764	-300,183	0	7,874	315,275	-315,275	0
	2020	0	264,127	33,121	-12,577	-294,313	0	7,832	306,890	-306,890	0.01
	2030	0	240,649	31,444	-9,894	-271,674	0	7,706	281,736	-281,736	0.01
	2040	0	200,401	28,593	-7,261	-231,426	0	7,412	238,134	-238,134	0
	2050	-37	159,315	25,323	-5,299	-188,662	0	7,052	193,693	-193,693	0
	2060	-84	126,613	21,969	-3,933	-153,445	0	6,582	157,638	-157,638	-0.01
Hansford	2010	0	126,613	9,056	-19,118	-134,160	-1,585	7,446	155,961	-155,961	0
	2020	0	124,098	8,016	-19,705	-131,644	-1,115	7,446	152,607	-152,607	0
	2030	0	118,228	7,261	-19,621	-124,936	-652	7,446	145,899	-145,899	0
	2040	0	103,974	6,465	-18,950	-111,520	-221	7,437	131,644	-131,644	-0.02
	2050	-19	89,719	5,752	-18,028	-98,104	0	7,412	116,551	-116,551	-0.01
	2060	0	83,179	5,165	-17,022	-91,396	0	7,387	109,005	-109,005	0
Ochiltree	2010	0	97,266	12,997	-15,177	-109,005	0	8,972	124,098	-124,098	-0.01
	2020	0	92,235	14,003	-13,835	-106,489	0	8,972	120,744	-120,744	0
	2030	0	85,527	14,590	-12,829	-101,458	0	8,972	114,874	-114,874	-0.01
	2040	0	73,788	14,674	-12,242	-90,558	0	8,972	103,135	-103,135	-0.01
	2050	0	62,804	14,338	-11,739	-79,993	0	8,972	92,235	-92,235	0
	2060	0	57,437	13,835	-11,236	-74,794	0	8,972	86,365	-86,365	-0.01

Table 2: Continued.

County	Year	Stor_IN	Stor_Out	X-In	X-Out	Wells	Springs	Recharge	Total_In	Total_Out	%Diff
Lipscomb	2010	-17	11,404	4,721	-17,105	-15,848	0	20,459	44,440	-44,440	0
	2020	0	11,236	4,478	-17,189	-15,596	0	20,459	44,105	-44,105	-0.01
	2030	0	10,481	4,285	-17,273	-14,925	0	20,459	43,183	-43,183	-0.01
	2040	-56	9,056	4,125	-17,357	-13,416	0	20,459	41,673	-41,673	-0.01
	2050	-142	7,848	4,000	-17,525	-11,991	0	20,459	40,332	-40,332	-0.02
	2060	-78	7,236	3,899	-17,692	-11,320	0	20,459	39,577	-39,577	-0.02
Hartley	2010	-96	266,643	9,643	-7,018	-273,351	-12,913	16,938	293,475	-293,475	-0.02
	2020	-184	238,134	9,056	-4,612	-247,357	-11,571	16,518	264,127	-264,127	-0.03
	2030	-391	156,799	8,284	-4,243	-166,023	-10,314	15,428	181,116	-181,116	-0.02
	2040	-835	102,297	7,580	-3,455	-110,682	-9,223	14,674	124,098	-124,098	-0.06
	2050	-948	61,965	7,060	-2,700	-71,105	-8,469	14,087	83,095	-83,263	-0.11
	2060	-566	48,633	6,825	-2,188	-58,863	-7,823	13,919	69,344	-69,428	-0.1
Moore	2010	-79	178,600	15,177	-3,228	-192,855	-5,392	7,555	201,240	-201,240	-0.01
	2020	-114	169,377	10,733	-2,960	-180,277	-4,201	7,370	187,824	-187,824	0
	2030	-212	139,191	8,117	-2,599	-147,576	-3,312	6,943	154,284	-154,284	-0.01
	2040	-200	99,781	5,828	-2,071	-107,328	-2,750	6,490	112,359	-112,359	-0.01
	2050	-275	71,775	4,000	-1,778	-77,393	-2,323	6,054	81,754	-81,837	-0.01
	2060	-193	54,922	2,826	-1,384	-59,869	-2,004	5,727	63,474	-63,474	0
Hutchinson	2010	0	84,688	9,475	-12,913	-82,005	-15,177	15,848	109,843	-109,843	0.01
	2020	-108	75,884	8,888	-14,758	-71,692	-14,003	15,680	100,620	-100,620	0.01
	2030	0	68,841	8,175	-15,848	-63,894	-12,829	15,596	92,235	-92,235	0.01
	2040	-242	54,922	7,471	-16,183	-49,807	-11,571	15,512	77,897	-77,897	-0.01
	2050	-390	46,034	6,792	-17,189	-40,164	-10,397	15,345	68,170	-68,170	0
	2060	-634	37,816	6,163	-18,195	-31,192	-9,140	15,177	59,114	-59,114	0.01

Table 2: Continued.

County	Year	Stor_IN	Stor_Out	X-In	X-Out	Wells	Springs	Recharge	Total_In	Total_Out	%Diff
Roberts	2010	0	66,744	22,556	-6,088	-62,552	-8,972	24,065	114,036	-114,036	0
	2020	0	63,558	23,730	-6,708	-62,049	-7,739	24,065	112,359	-112,359	0
	2030	-25	55,257	24,400	-7,312	-56,179	-6,264	24,065	104,812	-104,812	-0.01
	2040	-52	49,136	24,400	-7,764	-52,071	-4,788	24,065	98,104	-98,104	-0.01
	2050	-381	72,027	25,071	-7,974	-78,148	-2,968	23,981	121,582	-121,582	-0.01
	2060	-14	69,176	25,910	-8,075	-79,070	-1,551	23,981	119,905	-119,905	0
Hemphill	2010	-1	5,048	14,422	-1,618	-4,905	-23,310	31,360	51,148	-51,148	0
	2020	0	4,763	14,254	-1,652	-4,939	-22,975	31,360	50,729	-50,729	0.01
	2030	0	4,310	14,171	-1,652	-4,855	-22,639	31,360	50,226	-50,226	0.02
	2040	-2	3,857	14,171	-1,618	-4,771	-22,388	31,360	49,723	-49,723	0
	2050	-8	3,438	14,171	-1,576	-4,704	-22,220	31,360	49,304	-49,304	0.01
	2060	-14	3,086	14,171	-1,543	-4,637	-21,969	31,360	48,968	-48,968	0
Oldham	2010	-9	499	2,314	-193	-592	-2,935	914	3,731	-3,731	-0.1
	2020	-1	550	2,281	-192	-680	-2,876	914	3,748	-3,748	-0.09
	2030	0	584	2,239	-192	-721	-2,826	914	3,740	-3,740	-0.03
	2040	-101	384	2,205	-196	-352	-2,851	906	3,497	-3,497	-0.06
	2050	-48	380	2,180	-199	-357	-2,859	906	3,438	-3,438	-0.08
	2060	-22	378	2,155	-205	-364	-2,851	906	3,438	-3,438	-0.08
Potter	2010	-309	10,481	533	-5,291	-6,851	-2,608	3,564	15,093	-15,093	-0.04
	2020	-489	14,254	485	-5,559	-10,481	-2,381	3,480	18,950	-18,950	-0.03
	2030	-620	9,056	323	-5,509	-5,383	-2,222	3,438	13,751	-13,751	-0.06
	2040	-454	7,337	127	-5,501	-3,874	-2,096	3,429	11,907	-11,907	-0.06
	2050	-376	7,152	101	-5,467	-3,949	-1,996	3,429	11,739	-11,823	-0.05
	2060	-392	6,591	84	-5,366	-3,463	-1,970	3,388	11,152	-11,152	-0.05

Table 2: Continued.

County	Year	Stor_IN	Stor_Out	X-In	X-Out	Wells	Springs	Recharge	Total_In	Total_Out	%Diff
Carson	2010	-136	110,682	6,507	-3,505	-119,905	-1,459	8,469	125,775	-124,936	0.01
	2020	-508	95,589	6,800	-3,388	-105,651	-1,333	8,469	110,682	-110,682	0.01
	2030	-62	89,719	6,792	-3,379	-100,620	-1,266	8,385	104,812	-104,812	0.02
	2040	-83	80,077	6,792	-3,320	-90,558	-1,207	8,385	95,589	-95,589	0
	2050	-87	68,505	6,725	-3,228	-79,154	-1,140	8,335	83,598	-83,598	0.01
	2060	-117	62,887	6,599	-3,144	-73,452	-1,073	8,276	77,729	-77,729	0.02
Gray	2010	-81	35,049	1,752	-10,062	-31,695	-11,404	16,435	53,245	-53,245	0.03
	2020	-46	34,211	1,719	-10,481	-30,773	-11,068	16,435	52,322	-52,322	0.03
	2030	-29	31,947	1,702	-10,481	-28,761	-10,733	16,435	50,058	-50,058	0.02
	2040	-29	28,844	1,677	-10,314	-26,077	-10,481	16,435	46,872	-46,872	0.04
	2050	-61	25,826	1,643	-9,894	-23,730	-10,230	16,435	43,937	-43,937	0
	2060	-49	23,813	1,593	-9,475	-22,304	-9,978	16,351	41,757	-41,757	0.01
Wheeler	2010	-45	6,037	2,868	-4,587	-8,804	-20,208	24,652	33,540	-33,624	-0.07
	2020	-219	5,853	2,792	-4,528	-8,720	-19,872	24,652	33,288	-33,288	-0.08
	2030	-140	4,469	2,708	-4,494	-7,312	-19,872	24,568	31,779	-31,779	-0.11
	2040	-175	3,790	2,608	-4,503	-6,649	-19,621	24,568	30,941	-30,941	-0.02
	2050	-226	3,128	2,507	-4,528	-5,978	-19,537	24,568	30,186	-30,270	-0.08
	2060	-159	2,750	2,423	-4,545	-5,710	-19,369	24,568	29,767	-29,767	-0.11
Randall	2010	-45	10,146	353	-708	-21,466	-1,090	855	23,310	-23,310	0.01
	2020	-66	10,649	368	-653	-23,059	-835	847	24,568	-24,568	0.02
	2030	-155	8,720	349	-480	-21,801	-690	809	23,143	-23,143	0.02
	2040	-398	6,750	387	-270	-20,376	-641	775	21,717	-21,717	0.02
	2050	-694	5,358	406	-231	-18,615	-680	756	20,208	-20,208	0.02
	2060	-390	4,763	377	-206	-18,112	-692	750	19,369	-19,369	0.01

Table 2: Continued.

County	Year	Stor_IN	Stor_Out	X-In	X-Out	Wells	Springs	Recharge	Total_In	Total_Out	%Diff
Armstrong	2010	-11	6,272	594	-2,952	-5,752	-2,658	4,511	11,404	-11,404	0.01
	2020	-1	6,113	523	-2,960	-5,677	-2,507	4,511	11,152	-11,152	-0.02
	2030	-5	5,719	471	-2,926	-5,358	-2,406	4,503	10,733	-10,733	-0.01
	2040	-19	5,006	413	-2,859	-4,721	-2,314	4,494	9,894	-9,894	0.01
	2050	-39	4,478	353	-2,759	-4,293	-2,239	4,494	9,307	-9,307	-0.01
	2060	-41	4,142	307	-2,658	-4,075	-2,172	4,494	8,972	-8,972	-0.01
Donley	2010	-35	16,518	3,572	-1,627	-20,543	-12,158	14,254	34,295	-34,295	-0.02
	2020	-23	15,428	3,421	-1,585	-20,040	-11,404	14,254	33,121	-33,037	0.01
	2030	-16	13,919	3,270	-1,551	-19,034	-10,817	14,254	31,360	-31,444	-0.06
	2040	-22	11,571	3,111	-1,526	-17,105	-10,314	14,254	28,928	-28,928	-0.02
	2050	-71	9,307	2,943	-1,509	-15,093	-9,894	14,254	26,497	-26,497	0.01
	2060	-48	8,192	2,809	-1,493	-14,171	-9,475	14,254	25,239	-25,239	-0.04
Collingsworth	2010	0	8	1,526	0	-3	-1,786	252	1,786	-1,786	-0.03
	2020	0	10	1,509	0	-5	-1,761	252	1,769	-1,769	-0.03
	2030	0	8	1,484	0	-6	-1,736	252	1,744	-1,744	-0.1
	2040	0	10	1,459	0	-7	-1,719	252	1,727	-1,727	0
	2050	0	10	1,442	0	-8	-1,694	252	1,702	-1,702	0
	2060	0	8	1,425	0	-9	-1,677	252	1,685	-1,685	-0.05

1. Stor In – Water going into storage
2. Stor Out – Water coming out of storage
3. X-In – Water moving horizontally into the county
4. X-Out – Water moving horizontally out of the county
5. Wells – pumpage from wells
6. Spring – spring flow
7. Recharge – recharge to the county
8. Total_In – total water into the county
9. Total_Out –total water out of the county
10. %Diff – percent difference between Total_In and Total_Out

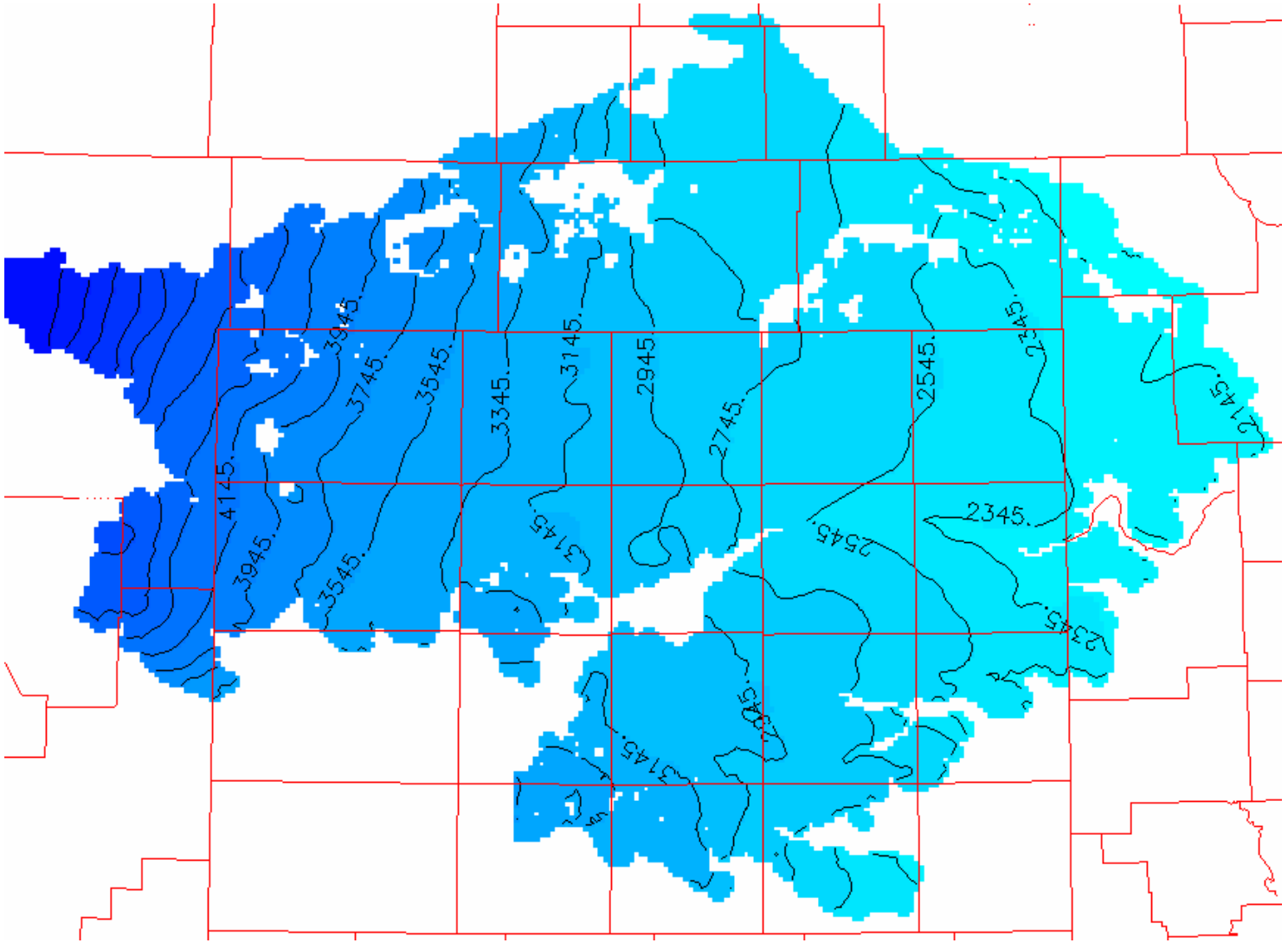

Figure 1: Simulated water levels in the northern part of the Ogallala aquifer in 2010.

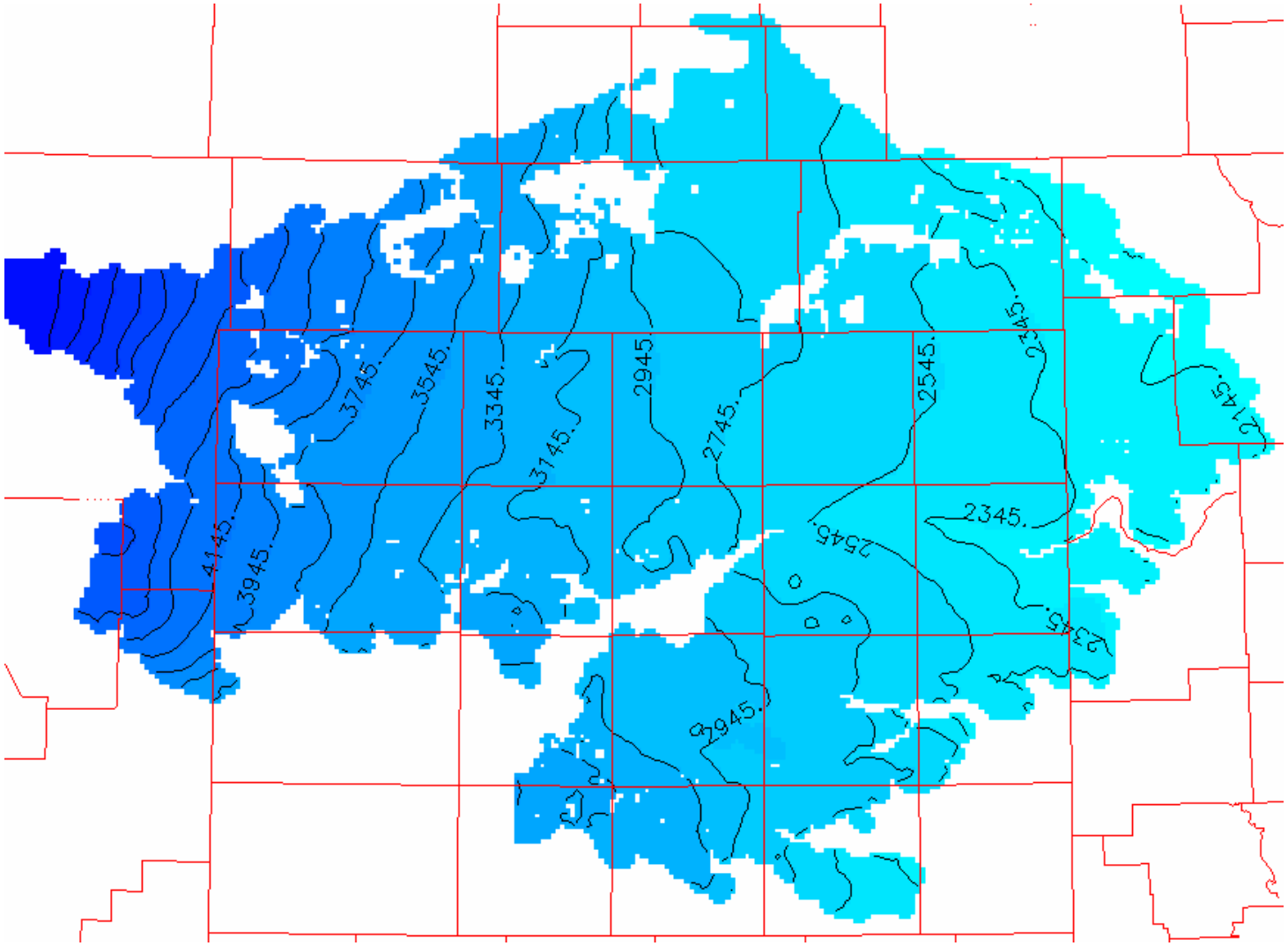

Figure 2: Simulated water levels in the northern part of the Ogallala aquifer in 2020.

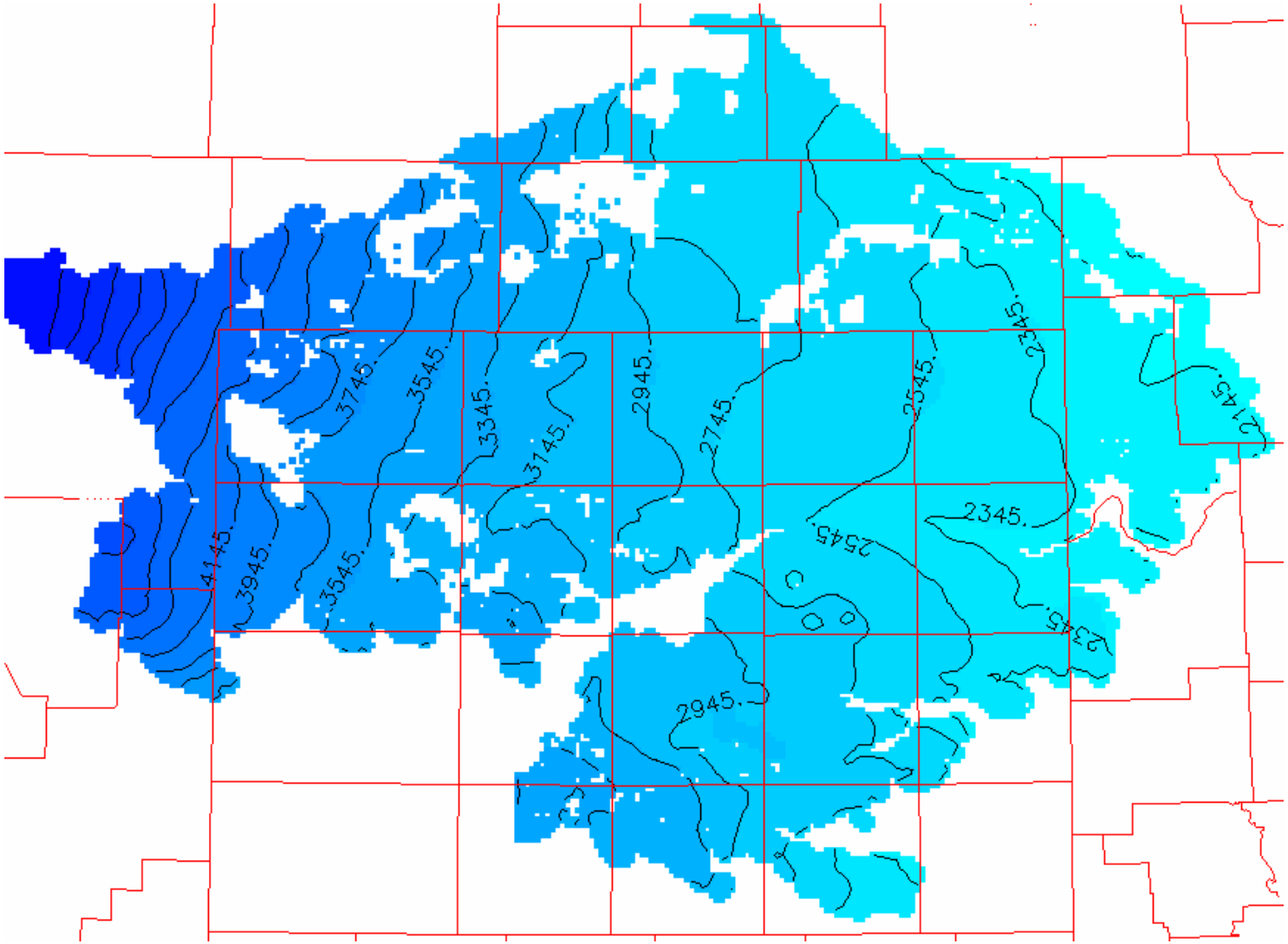

Figure 3: Simulated water levels in the northern part of the Ogallala aquifer in 2030.

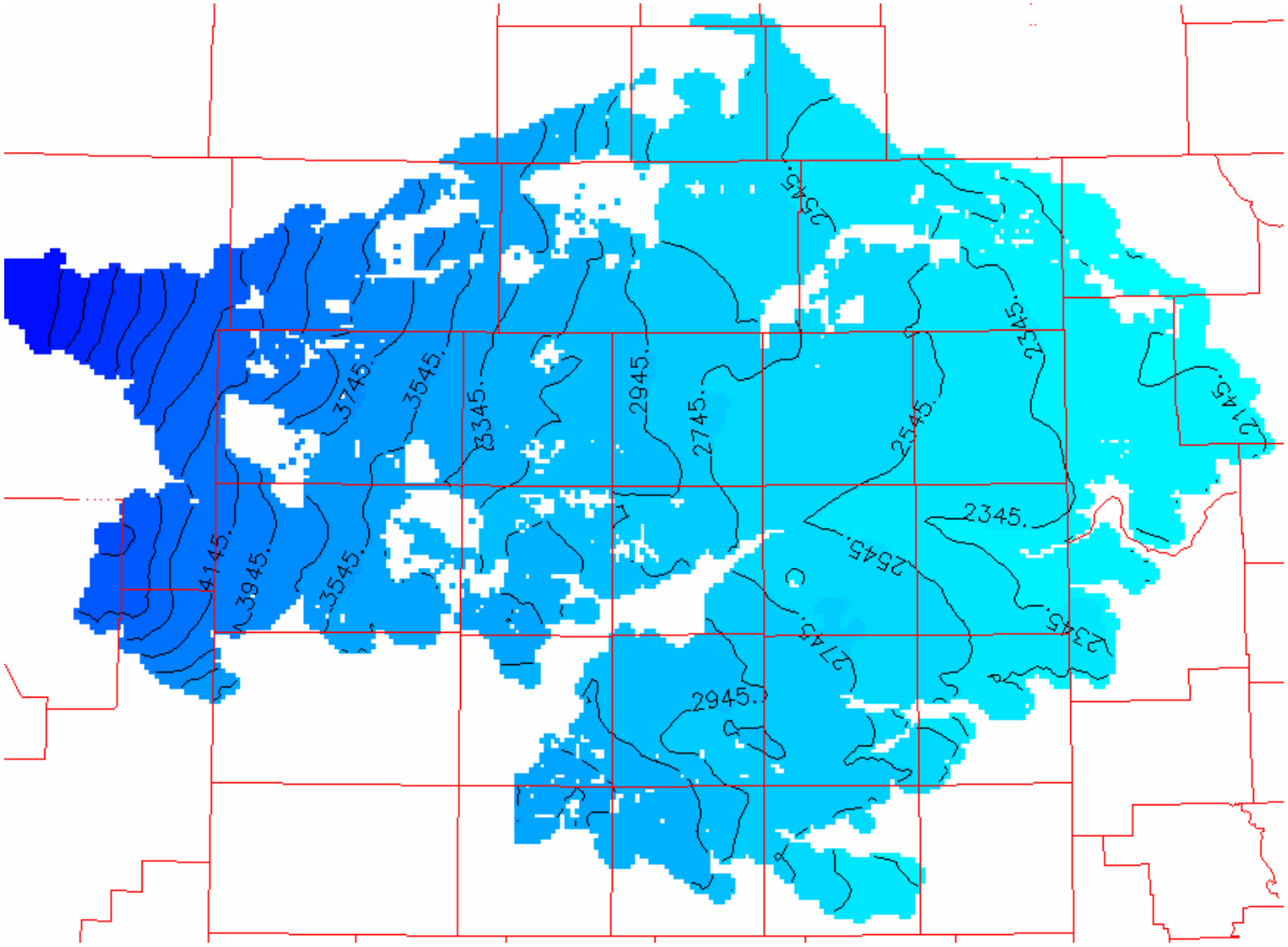

Figure 4: Simulated water levels in the northern part of the Ogallala aquifer in 2040.

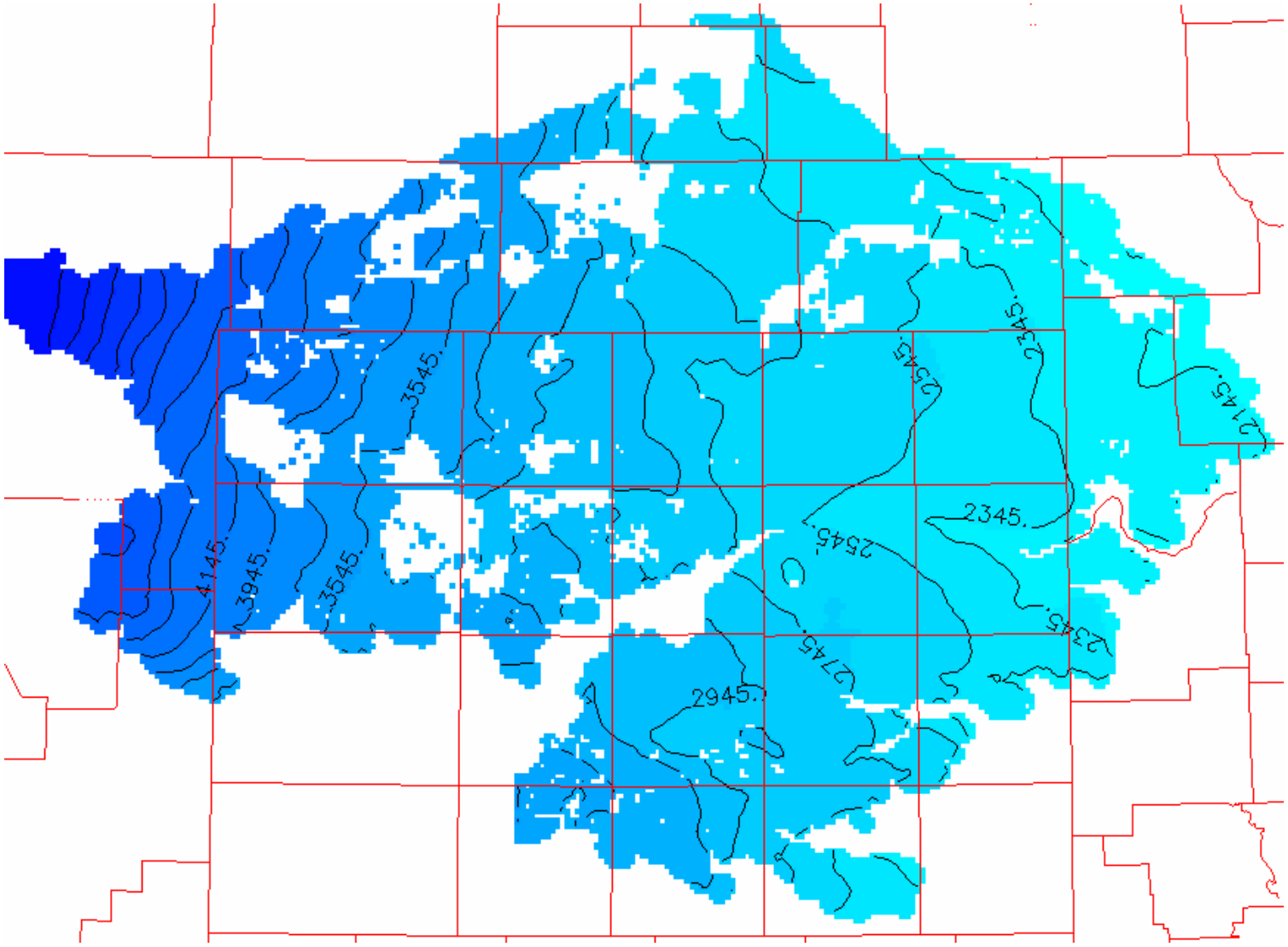

Figure 5: Simulated water levels in the northern part of the Ogallala aquifer in 2040.

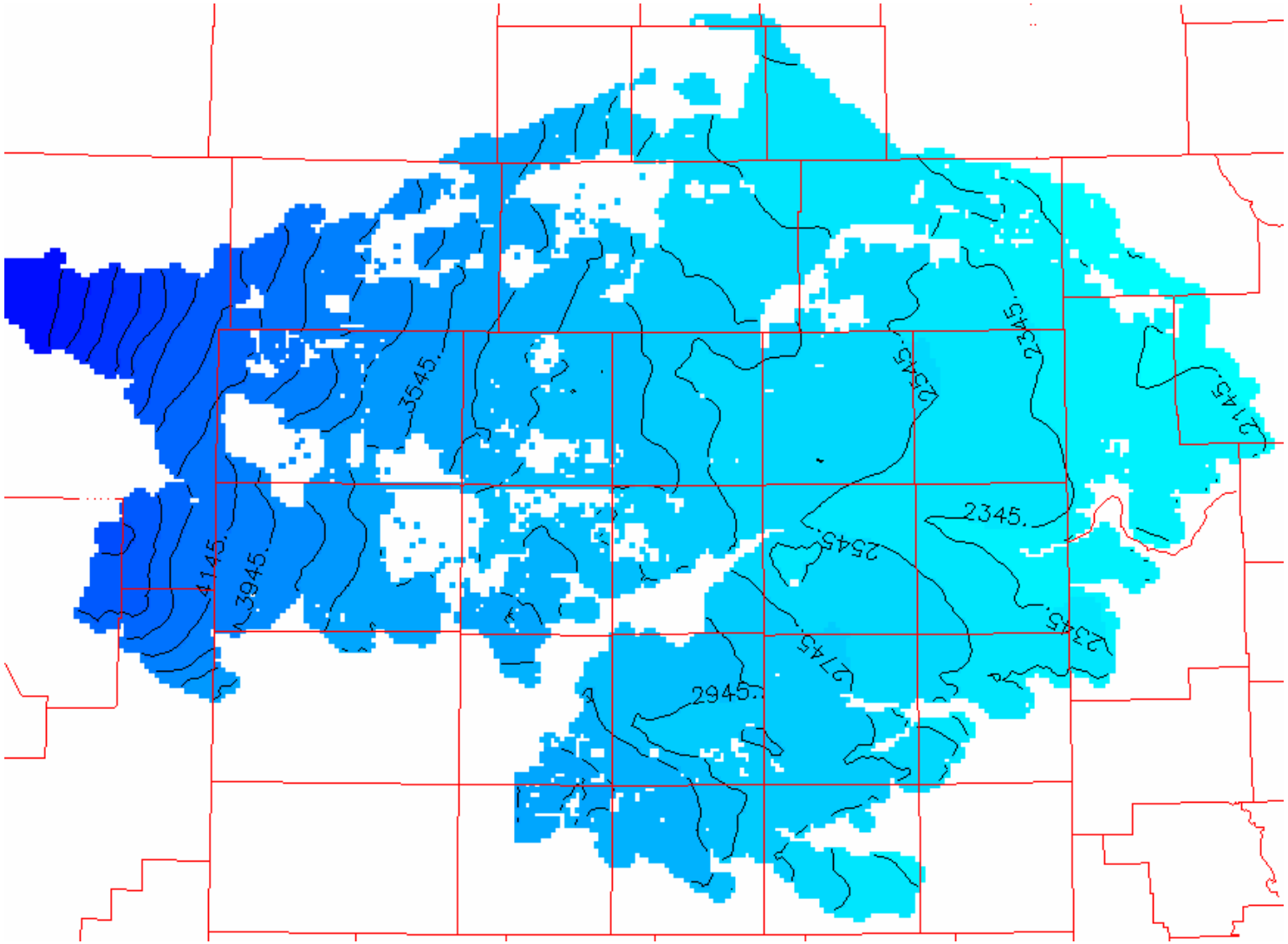

Figure 6: Simulated water levels in the northern part of the Ogallala aquifer in 2060.