GAM run 08-61

by Richard Smith, P.G.

Texas Water Development Board
Groundwater Availability Modeling Section
(512) 936-0877
November 21, 2008

REQUESTOR:

Mr. Jason Coleman with the South Plains Underground Water Conservation District on behalf of Groundwater Management Area 2.

EXECUTIVE SUMMARY:

We ran the groundwater availability model for the southern part of the Ogallala Aquifer for fifty year scenarios with pumping rates based on 1.00, 1.25, 1.50, and 1.75 feet of water level decline per year. In addition, pumping equivalent to average recharge was added to the scenarios and used in the first scenario to verify a constant water level for the fifty year period could be modeled. We produced maps of saturated thickness for each scenario on a decadal basis and tables of the managed available groundwater for each year in each of the seven groundwater conservation districts in Groundwater Management Area 2. The number of inactive cells is directly proportional to the decline rate for each scenario.

DESCRIPTION OF REQUEST:

Mr. Jason Coleman, with the South Plains Underground Water Conservation District, requested a determination of the volume pumped in each year within each of the seven groundwater conservation districts comprising Groundwater Management Area 2 for a time period of fifty years in order to achieve on a yearly basis one foot of drawdown, 1.25 feet of drawdown, 1.50 feet of drawdown , 1.75 feet of drawdown, and a constant water level for the entire 50 year scenario respectively.

METHODS:

To address the request, we completed the following steps:

- used ArcGIS© version 9.1 to calculate the volume for each cell in the southern part of the Ogallala Aquifer groundwater availability model which corresponds to one foot of drawdown, 1.25 feet of drawdown, 1.50 feet of drawdown, and 1.75 feet of drawdown;
- extracted the average recharge from each cell in the model using Groundwater Vistas;
- multiplied the area of each cell (one square mile) by the amount of drawdown, the specific yield, and then added the average recharge per cell;

- created five well files to reflect the respective pumping scenarios, including average recharge as a pumping volume in the constant water level scenario;
- ran the model for a fifty year period for each scenario and exported the results to ArcGIS© version 9.1 to create maps showing on a decade by decade basis the changes in saturated thickness; and
- exported the water budgets by zoned areas representing each groundwater conservation district for each year in the 50 year projection for each scenario and created tables showing the amount of managed available groundwater for each district for each year in each of the five scenarios.

In an effort to determine a starting stress period in the predictive, we compared the total volume of groundwater as computed by the U.S. Geological Survey for 2006 (the latest year) with volumes computed for several stress periods in the initial phase of the predictive cycle of the groundwater availability model run. The volumes computed are for the entire model area and therefore are only approximate. Stress period two has a difference of less than one percent from the United States Geological Survey volume. Therefore, stress period two became the baseline year and stress period three the first year of the new simulation.

Figure 1 shows the location of each of the seven groundwater conservation districts in the analysis.

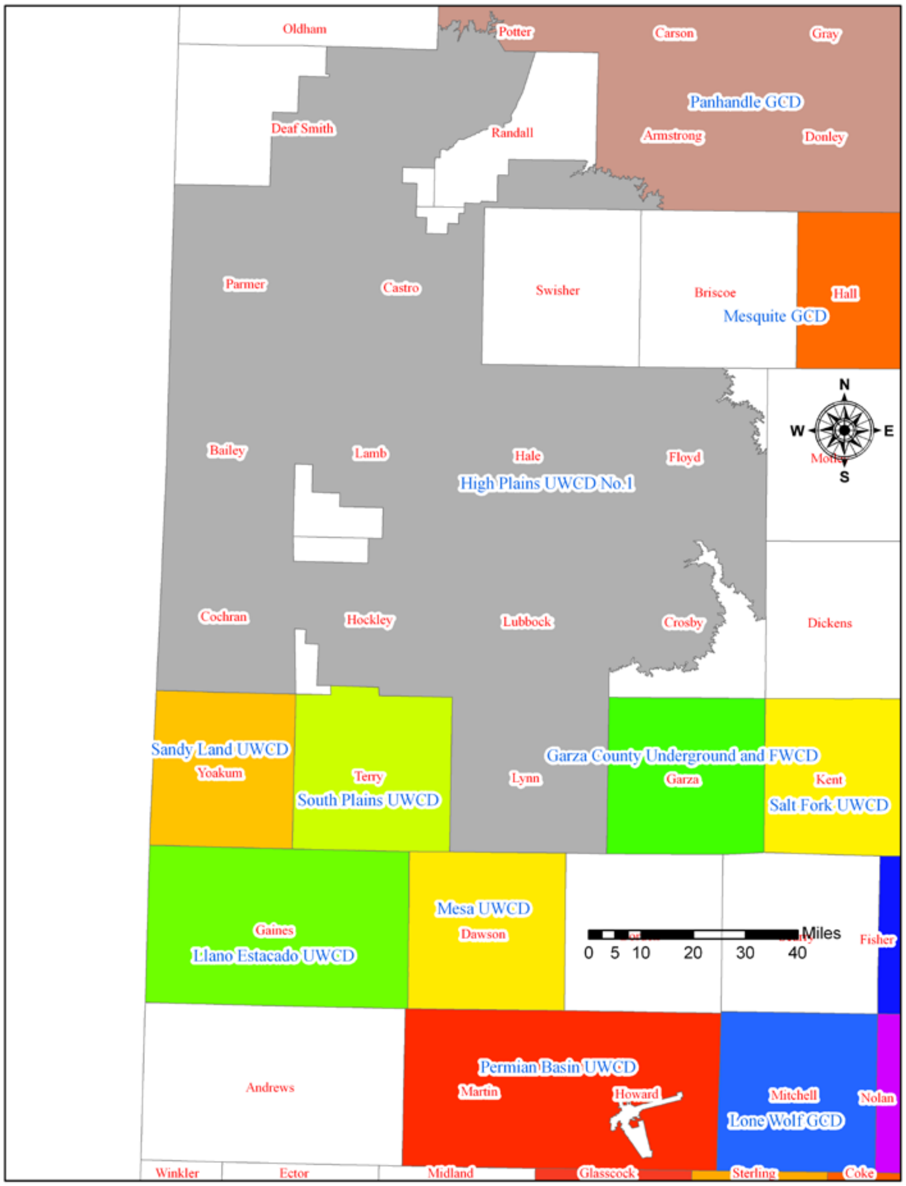


Figure 1: Location of the High Plains, Sandy Land, South Plains, Garza County, Llano Estacado, Mesa, and Permian Basin groundwater conservation districts

PARAMETERS AND ASSUMPTIONS:

- We used version 1.01 of the groundwater availability model for the southern part of the Ogallala Aquifer (Blandford and others, 2003).
- See Blandford and others (2003) for assumptions and limitations of the groundwater availability model for the southern part of the Ogallala Aquifer. Root mean squared error for this model is 47 feet.
- Average recharge used in the groundwater availability model was based on a percentage of precipitation for the 1950 through 1990 period of record. Since this includes the 1950s drought of record, the average recharge used for this analysis is considered a conservative estimate.
- All values in the tables are in acre-feet per year.

RESULTS:

Table 1 shows the managed available groundwater for each of the seven districts comprising Groundwater Management Area 2 using the constant water level scenario. This simply entails pumping the recharge per model cell for the fifty year period. The districts include:

- Garza County Underground and Fresh Water Conservation District,
- High Plains Underground Water Conservation District No 1,
- Llano Estacado Underground Water Conservation District,
- Mesa Underground Water Conservation District,
- Permian Basin Underground Water Conservation District,
- Sandy Land Underground Water Conservation District, and
- South Plains Underground Water Conservation District.

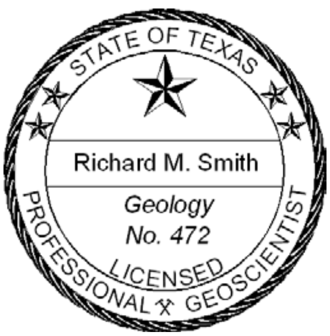
Figures 2 and 3 are the baseline saturated thickness for all scenarios. Figures 4 through 7 present the saturated thickness of the southern part of the Ogallala Aquifer for the constant level scenario, that is, the pumping volume equivalent to recharge per year across the entire aquifer. As expected, there is no difference between the beginning and ending water levels in the simulation. Table 1 provides the pumping volumes for each year in each district. Figures 8 through 17 show the saturated thickness of the southern part of the Ogallala Aquifer with one foot of drawdown per year across the aquifer. Large areas of saturated thickness remain after fifty years. Table 2 provides the pumping volumes for each year in each district. Figures 18 through 27 indicate the saturated thickness across the aquifer with 1.25 feet of drawdown per year and Table 3 provides the pumping volumes for each year in each district. Figures 28 through 37 indicate the saturated thickness across the aquifer with 1.50 feet of drawdown per year, and Table 4 provides the pumping volumes for each year in each district. Figures 38 through 47 show the results of 1.75 feet of drawdown per year, and Table 5 provides the pumping volumes for each year in each district.

Based on an examination of the figures, as expected, the southern part of the Ogallala Aquifer is least impacted with 1.0 foot of drawdown per year and most affected by 1.75

feet of drawdown per year. The one foot scenario actually retains large areas of saturated thickness throughout the region for the entire projected period (see figures 16 and 17). In contrast, the 1.75 feet scenario has large swaths of inactive cells occurring during the course of the simulation. This affects the value for managed available groundwater since as the cells become inactive, they no longer contribute pumping to the model and the available volume decreases.

REFERENCES:

Blandford, T.N., Blazer, D.J., Calhoun, K.C., Dutton, A.R., Naing, T., Reedy, R.C., and Scanlon, B.R., 2003, Groundwater availability of the southern Ogallala Aquifer in Texas and New Mexico—Numerical simulations through 2050: Final Report prepared for the Texas Water Development Board by Daniel B. Stephens & Associates, Inc., 158 p.



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Year	Garza County Underground and FWCD pumping (acre-feet per year)	High Plains UWCD No 1 pumping (acre-feet per year)	Llano Estacado UWCD pumping (acre-feet per year)	Mesa UWCD pumping (acre-feet per year)	Permian Basin UWCD pumping (acre-feet per year)	Sandy Land UWCD pumping (acre-feet per year)	South Plains UWCD pumping (acre-feet per year)
2009	8,778	629,753	90,538	62,176	11,414	41,030	66,406
2010	8,778	629,753	90,538	62,176	11,414	41,030	66,406
2011	8,778	629,753	90,538	62,176	11,414	41,030	66,406
2012	8,778	629,753	90,538	62,176	11,414	41,030	66,406
2013	8,778	629,753	90,538	62,176	11,414	41,030	66,406
2014	8,778	629,753	90,538	62,176	11,414	41,030	66,406
2015	8,778	629,753	90,538	62,176	11,414	41,030	66,406
2016	8,778	629,753	90,538	62,176	11,414	41,030	66,406
2017	8,778	629,753	90,538	62,176	11,414	41,030	66,406
2018	8,778	629,753	90,538	62,176	11,414	41,030	66,406
2019	8,778	629,753	90,538	62,176	11,414	41,030	66,406
2020	8,778	629,753	90,538	62,176	11,414	41,030	66,406
2021	8,778	629,753	90,538	62,176	11,414	41,030	66,406
2022	8,778	629,753	90,538	62,176	11,414	41,030	66,406
2023	8,778	629,753	90,538	62,176	11,414	41,030	66,406
2024	8,778	629,753	90,538	62,176	11,414	41,030	66,406
2025	8,778	629,753	90,538	62,176	11,414	41,030	66,406
2026	8,778	629,753	90,538	62,176	11,414	41,030	66,406
2027	8,778	629,753	90,538	62,176	11,414	41,030	66,406
2028	8,778	629,753	90,538	62,176	11,414	41,030	66,406
2029	8,778	629,753	90,538	62,176	11,414	41,030	66,406
2030	8,778	629,753	90,538	62,176	11,414	41,030	66,406
2031	8,778	629,753	90,538	62,176	11,414	41,030	66,406
2032	8,778	629,753	90,538	62,176	11,414	41,030	66,406
2033	8,778	629,753	90,538	62,176	11,414	41,030	66,406

Table 1: Average recharge per district used in the model to obtain no change in water level throughout the simulation. FWCD is the abbreviation for Fresh Water Conservation District and UWCD I is the abbreviation for Underground Water Conservation District.

Year	Garza County Underground and FWCD pumping (acre-feet per year)	High Plains UWCD No 1 pumping (acre-feet per year)	Llano Estacado UWCD pumping (acre-feet per year)	Mesa UWCD pumping (acre-feet per year)	Permian Basin UWCD pumping (acre-feet per year)	Sandy Land UWCD pumping (acre-feet per year)	South Plains UWCD pumping (acre-feet per year)
2034	8,778	629,753	90,538	62,176	11,414	41,030	66,406
2035	8,778	629,753	90,538	62,176	11,414	41,030	66,406
2036	8,778	629,753	90,538	62,176	11,414	41,030	66,406
2037	8,778	629,753	90,538	62,176	11,414	41,030	66,406
2038	8,778	629,753	90,538	62,176	11,414	41,030	66,406
2039	8,778	629,753	90,538	62,176	11,414	41,030	66,406
2040	8,778	629,753	90,538	62,176	11,414	41,030	66,406
2041	8,778	629,753	90,538	62,176	11,414	41,030	66,406
2042	8,778	629,753	90,538	62,176	11,414	41,030	66,406
2043	8,778	629,753	90,538	62,176	11,414	41,030	66,406
2044	8,778	629,753	90,538	62,176	11,414	41,030	66,406
2045	8,778	629,753	90,538	62,176	11,414	41,030	66,406
2046	8,778	629,753	90,538	62,176	11,414	41,030	66,406
2047	8,778	629,753	90,538	62,176	11,414	41,030	66,406
2048	8,778	629,753	90,538	62,176	11,414	41,030	66,406
2049	8,778	629,753	90,538	62,176	11,414	41,030	66,406
2050	8,778	629,753	90,538	62,176	11,414	41,030	66,406
2051	8,778	629,753	90,538	62,176	11,414	41,030	66,406
2052	8,778	629,753	90,538	62,176	11,414	41,030	66,406
2053	8,778	629,753	90,538	62,176	11,414	41,030	66,406
2054	8,778	629,753	90,538	62,176	11,414	41,030	66,406
2055	8,778	629,753	90,538	62,176	11,414	41,030	66,406
2056	8,778	629,753	90,538	62,176	11,414	41,030	66,406
2057	8,778	629,753	90,538	62,176	11,414	41,030	66,406
2058	8,778	629,753	90,538	62,176	11,414	41,030	66,406

Table 1 (Continued): Decreases in volume indicate increases in inactive cells within the model for that year. FWCD is the abbreviation for Fresh Water Conservation District and UWCD I is the abbreviation for Underground Water Conservation District.

Year	Garza County Underground and FWCD pumping (acre-feet per year)	High Plains UWCD No 1 pumping (acre-feet per year)	Llano Estacado UWCD pumping (acre-feet per year)	Mesa UWCD pumping (acre-feet per year)	Permian Basin UWCD pumping (acre-feet per year)	Sandy Land UWCD pumping (acre-feet per year)	South Plains UWCD pumping (acre-feet per year)
2009	21,930	1,721,098	246,852	147,558	148,059	122,138	151,078
2010	21,930	1,717,026	246,294	147,558	147,102	121,698	151,078
2011	21,930	1,713,056	245,705	147,558	146,171	121,039	151,078
2012	21,930	1,709,500	244,531	147,558	145,195	120,715	150,980
2013	21,930	1,705,314	244,036	147,558	143,769	120,185	150,980
2014	21,930	1,700,958	243,106	147,558	143,171	120,185	150,980
2015	21,930	1,696,807	242,664	147,558	141,599	119,292	150,884
2016	21,930	1,692,174	242,436	147,558	139,952	119,098	150,884
2017	21,930	1,686,778	241,994	147,558	138,549	118,100	150,884
2018	21,930	1,679,597	240,546	147,441	137,784	117,239	150,884
2019	21,930	1,673,312	240,198	147,441	135,638	115,583	150,635
2020	21,930	1,669,038	239,527	147,441	134,510	114,237	150,635
2021	21,930	1,664,392	238,379	147,441	133,398	113,076	150,635
2022	21,930	1,659,194	237,908	147,441	131,888	111,315	150,192
2023	21,930	1,652,894	236,985	147,441	129,840	110,205	150,095
2024	21,930	1,646,679	236,043	147,441	127,664	108,175	149,866
2025	21,813	1,640,298	235,420	146,916	125,963	107,516	149,636
2026	21,813	1,633,252	234,963	146,916	125,029	106,014	149,636
2027	21,813	1,626,208	233,613	146,916	123,793	103,331	149,037
2028	21,813	1,619,191	233,613	146,916	122,746	101,444	148,114
2029	21,813	1,610,183	233,054	146,916	121,064	98,646	147,331
2030	21,699	1,603,313	232,360	146,737	120,010	95,044	146,802
2031	21,566	1,593,093	231,659	146,737	119,124	92,622	146,164
2032	21,566	1,586,542	231,148	146,737	117,624	89,740	145,916
2033	21,566	1,576,615	230,919	146,737	116,672	85,189	145,155

Table 2: Pumping values for a uniform drawdown of one foot across the entire southern part of the Ogallala Aquifer. FWCD is the abbreviation for Fresh Water Conservation District and UWCD I is the abbreviation for Underground Water Conservation District.

Year	Garza County Underground and FWCD pumping (acre-feet per year)	High Plains UWCD No 1 pumping (acre-feet per year)	Llano Estacado UWCD pumping (acre-feet per year)	Mesa UWCD pumping (acre-feet per year)	Permian Basin UWCD pumping (acre-feet per year)	Sandy Land UWCD pumping (acre-feet per year)	South Plains UWCD pumping (acre-feet per year)
2034	21,566	1,568,415	230,257	146,382	115,728	82,748	143,208
2035	21,446	1,555,314	229,236	146,145	114,179	79,121	141,916
2036	21,288	1,544,551	227,782	145,719	112,910	76,893	140,496
2037	21,288	1,535,914	227,341	145,243	111,617	74,052	138,901
2038	21,288	1,522,908	226,114	144,977	110,997	70,090	136,162
2039	21,288	1,509,620	224,539	144,458	110,254	66,771	133,971
2040	21,288	1,499,702	223,106	143,884	108,613	63,345	131,403
2041	21,288	1,488,161	222,003	143,337	107,291	59,669	127,667
2042	21,288	1,475,995	220,612	142,947	106,142	56,081	125,997
2043	21,288	1,464,726	218,404	141,792	105,067	53,723	123,182
2044	21,288	1,452,000	217,153	140,858	103,667	50,191	121,293
2045	21,098	1,440,167	216,272	139,554	102,647	47,754	118,111
2046	21,098	1,427,485	215,935	138,385	101,529	45,091	114,009
2047	21,098	1,426,365	215,677	138,213	101,334	44,435	113,780
2048	21,098	1,425,796	215,449	138,020	101,237	44,435	113,385
2049	21,098	1,424,685	215,449	138,020	101,237	44,205	112,810
2050	21,098	1,423,434	215,449	138,020	101,108	43,496	112,617
2051	21,098	1,422,747	215,449	137,830	100,804	43,396	111,767
2052	21,098	1,422,051	215,449	137,830	100,804	42,795	111,520
2053	21,098	1,420,392	215,449	137,830	100,600	42,350	111,315
2054	21,098	1,419,800	215,345	137,460	100,503	42,150	111,136
2055	21,098	1,417,989	215,345	137,460	100,406	42,000	111,136
2056	21,098	1,416,779	215,345	137,460	100,188	41,832	111,136
2057	21,098	1,416,779	215,345	137,460	100,188	41,832	111,136
2058	21,098	1,416,779	215,345	137,460	100,188	41,832	111,136

Table 2 (Continued): Pumping values for a uniform drawdown of one foot across the entire southern part of the Ogallala Aquifer. Decreases in volume indicate increases in inactive cells within the model. FWCD is the abbreviation for Fresh Water Conservation District and UWCD I is the abbreviation for Underground Water Conservation District.

Year	Garza County Underground and FWCD pumping (acre-feet per year)	High Plains UWCD No 1 pumping (acre-feet per year)	Llano Estacado UWCD pumping (acre-feet per year)	Mesa UWCD pumping (acre-feet per year)	Permian Basin UWCD pumping (acre-feet per year)	Sandy Land UWCD pumping (acre-feet per year)	South Plains UWCD pumping (acre-feet per year)
2009	25,218	1,992,845	285,721	168,905	181,945	142,449	172,246
2010	25,218	1,987,253	285,085	168,905	180,372	141,701	172,246
2011	25,218	1,981,678	283,384	168,905	179,173	140,829	172,124
2012	25,218	1,975,512	282,812	168,905	176,948	140,222	172,124
2013	25,218	1,968,855	281,536	168,905	175,627	139,450	172,004
2014	25,218	1,962,375	281,258	168,905	173,456	138,962	172,004
2015	25,218	1,955,230	280,516	168,905	170,914	137,932	172,004
2016	25,218	1,946,237	278,886	168,759	169,572	136,512	172,004
2017	25,218	1,935,726	278,379	168,759	166,355	134,155	171,726
2018	25,218	1,929,442	277,085	168,759	165,257	132,440	171,726
2019	25,218	1,921,148	275,380	168,759	162,459	130,045	171,211
2020	25,218	1,912,414	274,629	168,759	159,911	128,551	171,090
2021	25,218	1,904,145	273,593	168,357	156,434	126,135	170,837
2022	25,077	1,891,663	272,592	168,158	154,624	124,242	170,583
2023	25,077	1,882,444	271,567	168,158	152,575	121,082	170,029
2024	25,077	1,872,830	270,553	168,158	150,888	117,220	168,606
2025	25,077	1,861,132	269,798	167,950	148,837	113,630	167,597
2026	24,939	1,848,812	268,890	167,950	146,987	109,434	167,384
2027	24,782	1,838,741	268,644	167,950	144,871	104,854	166,397
2028	24,782	1,823,004	267,800	167,537	143,409	99,788	164,720
2029	24,782	1,808,420	266,018	167,057	141,306	95,043	163,009
2030	24,456	1,792,499	263,892	166,908	139,861	89,912	161,138
2031	24,456	1,777,896	262,531	166,407	137,963	86,976	158,029
2032	24,456	1,760,748	261,601	166,017	136,422	81,612	154,824
2033	24,456	1,741,635	259,891	165,308	134,930	76,347	152,682

Table 3: Pumping values for a uniform drawdown of 1.25 feet across the entire southern part of the Ogallala Aquifer. . Decreases in volume indicate increases in inactive cells within the model. FWCD is the abbreviation for Fresh Water Conservation District and UWCD I is the abbreviation for Underground Water Conservation District.

Year	Garza County Underground and FWCD pumping (acre-feet per year)	High Plains UWCD No 1 pumping (acre-feet per year)	Llano Estacado UWCD pumping (acre-feet per year)	Mesa UWCD pumping (acre-feet per year)	Permian Basin UWCD pumping (acre-feet per year)	Sandy Land UWCD pumping (acre-feet per year)	South Plains UWCD pumping (acre-feet per year)
2034	24,456	1,728,233	257,420	164,438	132,860	71,742	146,978
2035	24,456	1,711,242	256,131	163,779	130,949	67,131	145,030
2036	24,456	1,691,533	253,784	162,299	129,339	61,829	141,161
2037	24,242	1,673,151	251,488	161,088	127,400	58,126	136,744
2038	24,242	1,654,946	251,488	159,419	125,749	54,577	132,228
2039	24,242	1,639,988	250,590	158,333	123,814	50,274	127,384
2040	24,242	1,618,309	249,270	155,309	121,430	46,404	123,768
2041	24,029	1,601,463	246,886	153,177	119,631	41,889	118,470
2042	24,029	1,581,962	244,681	152,162	118,075	39,632	114,073
2043	24,029	1,562,816	243,485	151,151	116,620	34,899	109,223
2044	23,618	1,547,078	240,817	148,926	115,112	31,830	104,496
2045	23,618	1,528,497	238,892	147,440	113,977	29,967	101,730
2046	23,392	1,507,352	236,513	145,946	112,170	26,920	98,327
2047	23,392	1,505,804	236,513	145,545	112,036	26,752	97,224
2048	23,392	1,504,191	236,513	145,545	111,904	26,381	96,878
2049	23,392	1,501,247	236,513	145,308	111,650	25,834	96,528
2050	23,392	1,499,381	236,271	144,875	111,395	24,787	96,250
2051	23,179	1,497,670	236,006	144,875	111,143	24,521	95,797
2052	23,179	1,496,818	235,886	144,875	111,022	24,371	95,552
2053	23,179	1,495,344	235,692	144,875	110,779	24,169	95,552
2054	23,179	1,493,788	235,074	144,875	110,491	23,830	94,298
2055	22,970	1,492,129	234,886	144,875	110,225	23,830	93,628
2056	22,970	1,490,238	234,701	144,875	110,091	23,830	93,221
2057	22,970	1,490,238	234,701	144,875	110,091	23,830	93,221
2058	22,970	1,490,238	234,701	144,875	110,091	23,830	93,221

Table 3 (Continued): Pumping values for a uniform drawdown of 1.25 feet across the entire southern part of the Ogallala Aquifer. The year 1999 is the last year of the transient southern part of the Ogallala Aquifer groundwater availability model with pumping volumes that are in the model. Decreases in volume indicate increases in inactive cells within the model. FWCD is the abbreviation for Fresh Water Conservation District and UWCD I is the abbreviation for Underground Water Conservation District.

Year	Garza County Underground and FWCD pumping (acre-feet per year)	High Plains UWCD No 1 pumping (acre-feet per year)	Llano Estacado UWCD pumping (acre-feet per year)	Mesa UWCD pumping (acre-feet per year)	Permian Basin UWCD pumping (acre-feet per year)	Sandy Land UWCD pumping (acre-feet per year)	South Plains UWCD pumping (acre-feet per year)
2009	28,506	2,263,606	324,693	190,250	215,693	162,759	193,414
2010	28,506	2,256,166	323,679	190,250	213,625	161,362	193,414
2011	28,506	2,248,074	321,588	190,250	211,535	160,709	193,268
2012	28,506	2,239,558	320,447	190,250	209,081	159,683	193,268
2013	28,506	2,230,648	319,852	190,250	205,838	158,826	193,124
2014	28,506	2,219,432	318,731	190,076	202,667	157,415	193,124
2015	28,506	2,206,900	316,947	190,076	200,097	154,838	193,124
2016	28,506	2,195,318	315,343	190,076	196,703	152,084	192,817
2017	28,506	2,185,086	313,316	190,076	193,960	149,250	192,395
2018	28,506	2,174,319	312,186	190,076	189,688	146,793	192,085
2019	28,341	2,160,039	310,928	189,626	185,605	143,208	191,530
2020	28,341	2,144,433	309,095	189,398	182,866	140,222	191,225
2021	28,341	2,133,114	307,970	189,398	180,380	135,867	190,100
2022	28,341	2,116,652	307,138	189,398	176,564	130,565	188,752
2023	28,179	2,099,586	306,133	189,160	174,364	124,172	187,689
2024	27,998	2,084,617	305,581	189,160	171,843	118,504	186,393
2025	27,998	2,062,416	302,898	188,157	169,585	111,184	184,575
2026	27,831	2,040,988	300,517	188,157	166,967	105,783	181,754
2027	27,624	2,018,930	298,060	187,565	164,301	99,480	178,011
2028	27,624	1,995,721	297,420	187,179	161,451	93,259	173,632
2029	27,624	1,974,096	295,511	186,135	160,023	85,834	170,492
2030	27,624	1,953,679	292,781	184,633	156,936	80,424	164,674
2031	27,386	1,929,399	289,365	183,473	154,455	73,435	160,551
2032	27,386	1,901,933	287,440	182,051	151,990	67,474	154,145
2033	27,386	1,877,427	286,431	179,418	148,929	61,576	147,965

Table 4: Pumping values for a uniform drawdown of 1.50 feet across the entire southern part of the Ogallala Aquifer. . Decreases in volume indicate increases in inactive cells within the model. FWCD is the abbreviation for Fresh Water Conservation District and UWCD I is the abbreviation for Underground Water Conservation District.

Year	Garza County Underground and FWCD pumping (acre-feet per year)	High Plains UWCD No 1 pumping (acre-feet per year)	Llano Estacado UWCD pumping (acre-feet per year)	Mesa UWCD pumping (acre-feet per year)	Permian Basin UWCD pumping (acre-feet per year)	Sandy Land UWCD pumping (acre-feet per year)	South Plains UWCD pumping (acre-feet per year)
2034	27,386	1,853,548	284,867	177,558	146,632	55,897	142,914
2035	27,136	1,826,656	282,440	174,385	143,301	50,544	135,853
2036	26,899	1,804,430	279,373	172,578	140,753	45,131	130,150
2037	26,899	1,777,334	277,822	170,228	138,179	40,265	124,296
2038	26,440	1,753,458	274,587	168,558	136,928	36,983	117,623
2039	26,440	1,727,137	271,103	166,444	134,639	32,753	114,100
2040	26,208	1,699,731	269,486	163,965	131,650	29,419	107,507
2041	25,733	1,669,276	267,215	161,663	128,939	24,062	101,750
2042	25,043	1,642,415	264,861	158,865	126,635	21,351	97,394
2043	24,662	1,614,600	260,301	157,302	125,111	19,177	94,907
2044	24,204	1,586,749	255,778	156,371	122,534	18,172	90,852
2045	23,427	1,556,134	252,928	154,006	119,940	15,385	85,576
2046	23,281	1,530,854	250,373	152,567	118,714	12,096	81,290
2047	23,281	1,529,200	249,906	152,567	118,110	12,096	81,290
2048	23,281	1,527,056	249,638	152,326	118,110	12,096	81,290
2049	23,281	1,525,212	249,638	152,326	118,110	12,096	80,625
2050	23,281	1,523,001	249,406	152,326	118,110	11,934	80,401
2051	23,281	1,520,395	249,406	152,121	118,110	11,934	79,564
2052	23,281	1,519,145	249,406	152,121	118,110	11,662	79,373
2053	23,043	1,517,060	249,406	152,121	117,487	11,662	78,887
2054	23,043	1,513,544	249,406	151,884	117,334	11,492	78,887
2055	23,043	1,511,318	248,452	151,646	117,185	11,492	78,887
2056	23,043	1,509,109	247,927	151,448	117,185	11,313	78,502
2057	23,043	1,509,109	247,927	151,448	117,185	11,313	78,502
2058	23,043	1,509,109	247,927	151,448	117,185	11,313	78,502

Table 4 (Continued): Pumping values for a uniform drawdown of 1.50 feet across the entire southern part of the Ogallala Aquifer. . Decreases in volume indicate increases in inactive cells within the model. FWCD is the abbreviation for Fresh Water Conservation District and UWCD I is the abbreviation for Underground Water Conservation District.

Year	Garza County Underground and FWCD pumping (acre-feet per year)	High PlainsUWCD No 1 pumping (acre-feet per year)	Llano Estacado UWCD pumping (acre-feet per year)	Mesa UWCD pumping (acre-feet per year)	Permian Basin UWCD pumping (acre-feet per year)	Sandy Land UWCD pumping (acre-feet per year)	South Plains UWCD pumping (acre-feet per year)
2009	31,794	2,535,510	363,785	211,595	249,319	183,070	214,582
2010	31,794	2,524,627	361,694	211,595	246,752	181,353	214,412
2011	31,794	2,513,309	359,426	211,595	243,127	180,296	214,412
2012	31,794	2,501,634	358,445	211,595	239,818	179,028	214,244
2013	31,794	2,488,620	357,223	211,392	234,997	177,305	214,244
2014	31,794	2,472,086	355,262	211,392	231,682	174,176	214,244
2015	31,794	2,456,746	353,011	211,392	227,369	169,898	213,908
2016	31,794	2,441,939	350,649	211,392	223,346	167,204	213,249
2017	31,794	2,423,561	349,720	211,140	216,904	163,382	212,779
2018	31,605	2,405,315	346,924	210,637	212,752	159,022	212,144
2019	31,605	2,390,145	345,651	210,637	209,220	153,124	210,917
2020	31,605	2,370,247	344,150	210,637	204,579	146,286	209,081
2021	31,419	2,346,132	342,434	210,371	201,680	138,987	208,518
2022	31,214	2,322,360	339,821	209,519	198,383	130,331	205,848
2023	31,214	2,295,389	337,647	209,257	195,124	121,092	203,311
2024	30,792	2,265,928	335,062	208,579	191,512	112,899	199,009
2025	30,792	2,237,408	333,688	208,140	186,856	105,262	192,765
2026	30,792	2,210,311	331,330	206,646	185,586	96,574	188,939
2027	30,792	2,183,236	328,042	205,092	180,764	88,760	182,532
2028	30,530	2,148,946	324,793	202,886	178,273	80,861	176,432
2029	30,256	2,112,542	322,432	200,767	174,322	73,133	168,676
2030	30,256	2,083,334	320,173	199,000	170,639	65,123	160,708
2031	30,256	2,048,083	317,270	195,837	166,222	57,424	152,500
2032	29,995	2,016,941	314,534	192,643	162,855	50,873	144,972
2033	29,995	1,985,708	311,623	189,537	159,778	43,494	137,082

Table 5: Pumping values for a uniform drawdown of 1.75 feet across the entire southern part of the Ogallala Aquifer. Decreases in volume indicate increases in inactive cells within the model. FWCD is the abbreviation for Fresh Water Conservation District and UWCD I is the abbreviation for Underground Water Conservation District.

Year	Garza County Underground and FWCD pumping (acre-feet per year)	High Plains UWCD No 1 pumping (acre-feet per year)	Llano Estacado UWCD pumping (acre-feet per year)	Mesa UWCD pumping (acre-feet per year)	Permian Basin UWCD pumping (acre-feet per year)	Sandy Land UWCD pumping (acre-feet per year)	South Plains UWCD pumping (acre-feet per year)
2034	29,488	1,948,515	307,055	186,060	157,965	39,460	131,022
2035	28,971	1,916,811	303,851	183,967	154,022	35,371	123,968
2036	28,971	1,874,772	301,379	181,547	150,223	28,804	113,757
2037	27,947	1,837,675	297,855	177,930	147,978	24,444	108,578
2038	27,218	1,805,506	293,128	175,181	144,444	21,821	105,747
2039	26,702	1,769,424	288,429	174,142	141,769	20,020	101,089
2040	26,269	1,730,578	283,263	171,010	138,074	16,658	94,514
2041	25,974	1,697,032	280,941	168,930	136,130	13,478	89,436
2042	25,294	1,659,078	274,867	167,166	133,239	12,104	83,792
2043	24,038	1,616,628	272,167	164,929	130,288	11,283	80,616
2044	23,551	1,567,381	268,257	162,536	128,256	7,894	76,290
2045	22,714	1,520,574	263,792	159,395	126,331	5,978	70,418
2046	21,746	1,479,202	261,202	158,617	124,167	5,809	64,044
2047	21,746	1,477,190	260,981	158,332	124,167	5,809	63,837
2048	21,746	1,473,254	260,813	158,332	123,810	5,640	63,616
2049	21,486	1,469,126	260,564	158,332	123,810	5,640	63,013
2050	21,486	1,467,080	259,679	157,849	123,810	5,247	62,711
2051	21,486	1,464,874	258,821	157,849	123,810	5,247	62,067
2052	21,224	1,461,338	258,821	157,849	123,640	5,247	61,593
2053	21,224	1,456,591	258,252	157,597	123,461	5,247	61,366
2054	21,224	1,453,879	258,252	157,597	122,949	5,247	61,366
2055	21,224	1,451,842	258,252	156,809	122,949	5,247	60,234
2056	21,055	1,448,898	257,508	156,529	122,767	5,247	59,932
2057	21,055	1,448,898	257,508	156,529	122,767	5,247	59,932
2058	21,055	1,448,898	257,508	156,529	122,767	5,247	59,932

Table 5 (Continued): Pumping values for a uniform drawdown of 1.75 feet across the entire southern part of the Ogallala Aquifer. Decreases in volume indicate increases in inactive cells within the model. FWCD is the abbreviation for Fresh Water Conservation District and UWCD I is the abbreviation for Underground Water Conservation District.

County	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	10 Year Average	5 Year Average
Armstrong	0.42	0.46	0.55	0.49	0.55	0.54	0.72	0.69	0.67	0.55	0.56	0.63
Bailey	-0.53	-0.62	-0.44	-0.43	-0.33	-0.27	-0.25	0.26	-0.15	-0.12	-0.29	-0.11
Castro	-1.76	-1.92	-1.67	-1.79	-1.67	-1.61	-1.33	-1.13	-1.40	-1.21	-1.55	-1.34
Cochran	-0.74	-0.80	-0.72	-0.74	-0.62	-0.62	-0.68	-0.33	-0.64	-0.39	-0.63	-0.53
Crosby	-0.50	-0.56	-0.37	-0.14	-0.08	-0.16	0.07	0.09	-0.54	-0.75	-0.29	-0.26
Dawson	-0.45	-3.50	-2.17	-0.76	-2.43	-1.92	-2.41	0.93	-1.35	-1.22	-1.53	-1.19
Deaf Smith	-0.40	-0.36	-0.26	-0.30	-0.32	-0.42	-0.25	-0.02	-0.24	-0.21	-0.28	-0.23
Floyd	-0.63	-0.78	-0.62	-0.53	-0.39	-0.41	-0.45	-0.15	-0.79	-1.02	-0.58	-0.56
Gaines	-1.50	-3.80	0.20	-1.30	-2.50	-1.20	-3.30	1.00	-0.90	-1.20	-1.45	-1.12
Garza						-2.40	-2.40	2.20	0.20	-1.61	na	-0.80
Hale	-1.56	-1.67	-1.46	-1.43	-1.30	-1.31	-0.94	-0.54	-1.39	-1.51	-1.31	-1.14
Hockley	-0.50	-0.55	-0.41	-0.50	-0.42	-0.46	-0.47	-0.26	-0.61	-0.83	-0.50	-0.53
Howard						0.92	0.54	2.18	0.24	-0.46	na	0.69
Lamb	-1.37	-1.39	-1.24	-1.23	-1.24	-1.20	-1.02	-0.64	-0.93	-0.75	-1.10	-0.91
Lubbock	-0.50	-0.61	-0.50	-0.44	-0.42	-0.35	-0.28	-0.18	-0.71	-1.30	-0.53	-0.56
Lynn	-0.36	-0.52	-0.22	-0.23	-0.06	0.10	0.35	0.99	-0.36	-1.03	-0.13	0.01
Martin						1.32	1.17	1.24	-1.57	0.04	na	0.44
Parmer	-1.64	-1.60	-1.43	-1.45	-1.40	-1.31	-1.12	-0.65	-1.27	-1.14	-1.30	-1.10
Potter	-0.03	-0.01	-0.04	0.29	0.50	-0.04	0.31	0.11	-0.09	-0.12	0.09	0.03
Randall	0.07	0.04	0.02	0.08	-0.04	-0.07	-0.03	0.08	-0.05	-0.18	-0.01	-0.05
Terry	-0.95	-3.13	-1.79	-1.65	-1.38	-1.45	-1.46	1.09	0.33	-1.06	-1.15	-0.51
Yoakum	-0.01	-2.40	-0.90	-1.90	-1.10	-1.40	-1.10	-0.50	-0.90	-0.80	-1.10	-0.94
Yearly Avg.	*-0.68*	*-1.25*	*-0.71*	*-0.73*	*-0.77*	*-0.62*	*-0.65*	0.29	-0.57	*-0.74*		

Table 6: Supplied by Mr. Jason Coleman with the South Plains Underground Water Conservation District, this table shows water level declines and increases within individual counties of Groundwater Management Area 2. Negative values are declines and positive values are increases. The overall average is - 0.64 feet. Blanks indicate data was not analyzed for a particular year and "na" indicates calculating a ten year average was not applicable due to the lack of sufficient data.

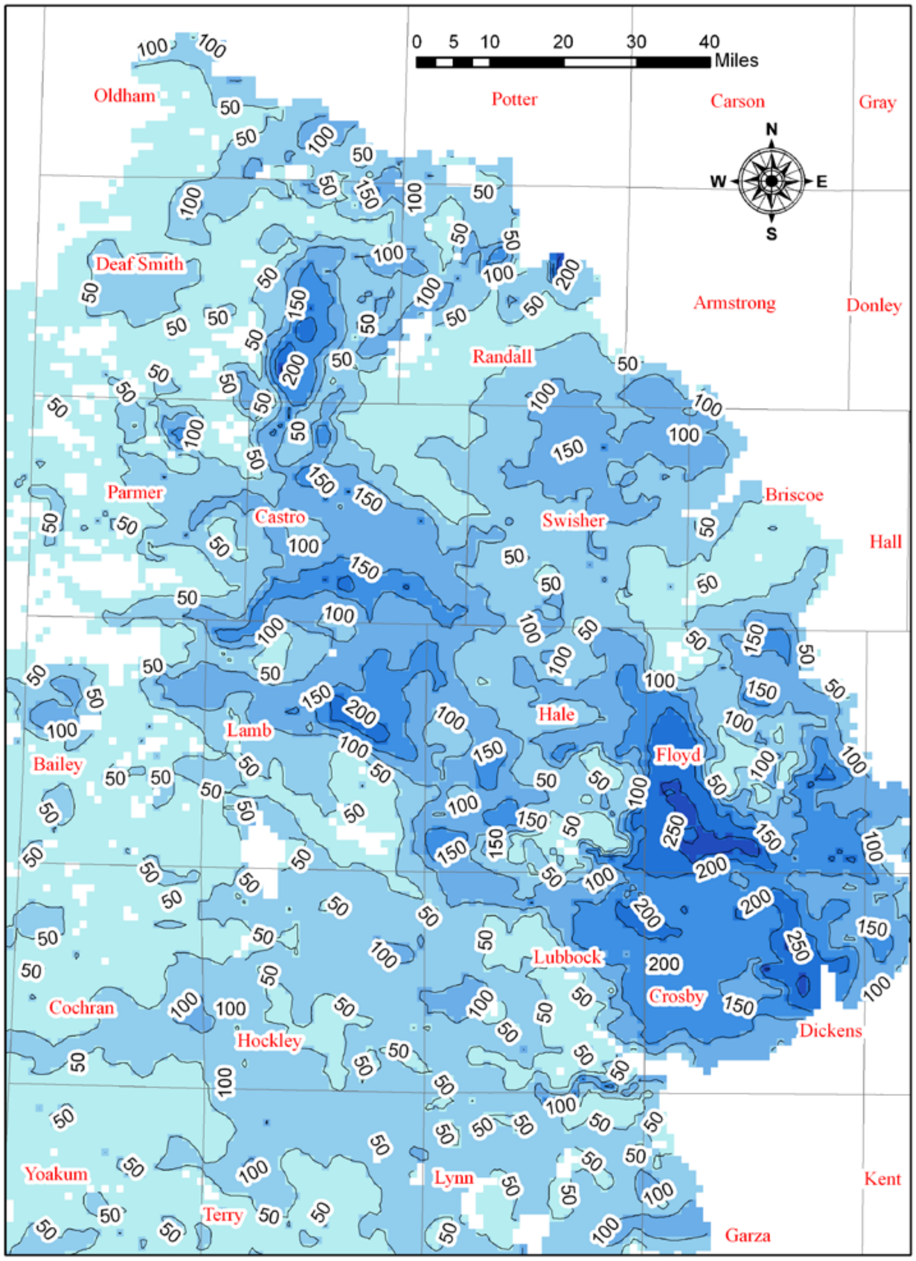

Figure 2: Baseline saturated thickness for the northern half of the southern portion of the Ogallala Aquifer. White areas are inactive cells or outside the model boundary.

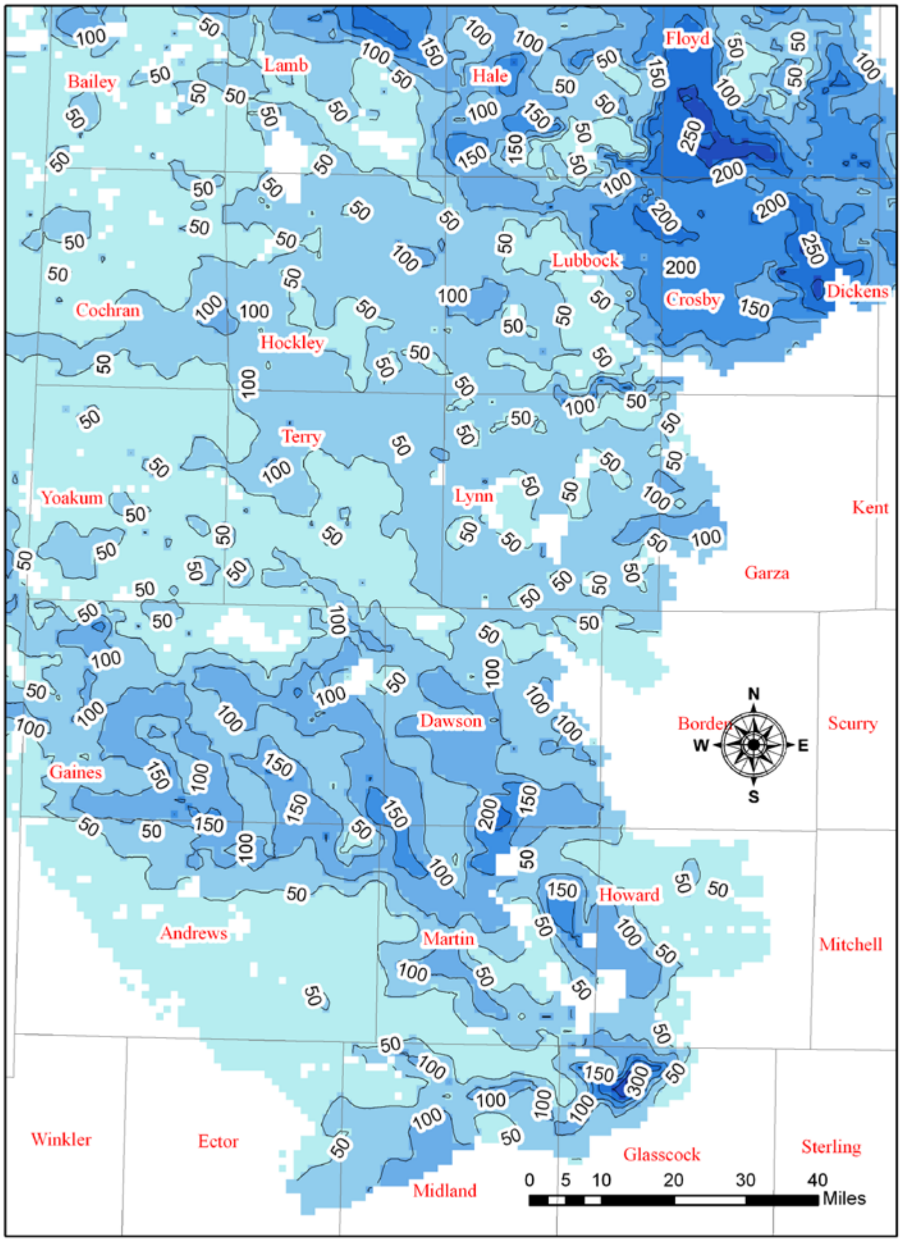

Figure 3: Baseline saturated thickness for the southern half of the southern part of the Ogallala Aquifer. White areas are inactive cells or outside the model boundary.

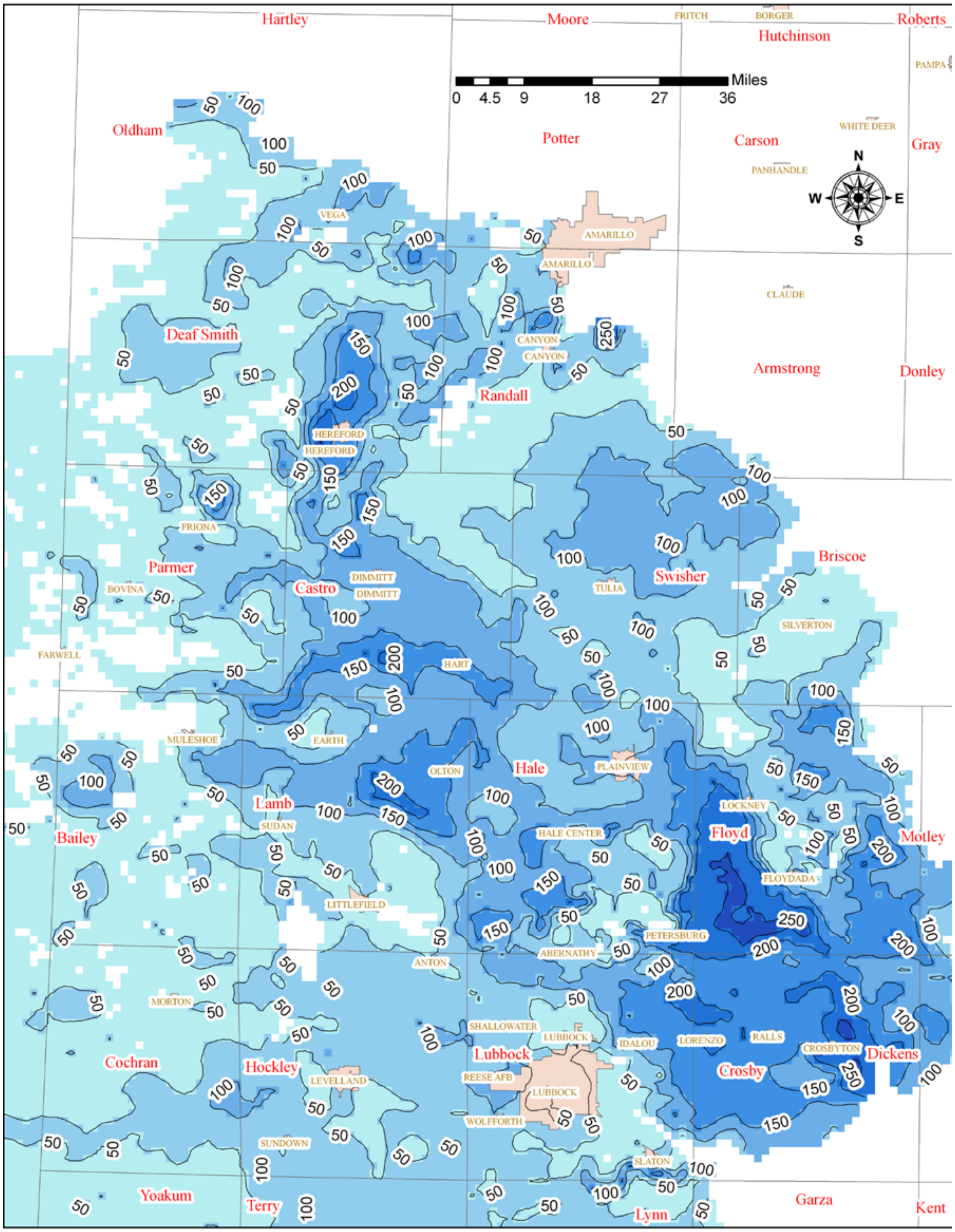

Figure 4: Saturated thickness of the northern half of the southern part of the Ogallala Aquifer in the first stress period (assume year 2009) using recharge as the pumping volume (see Table 1). White areas are inactive cells or outside the model boundary.

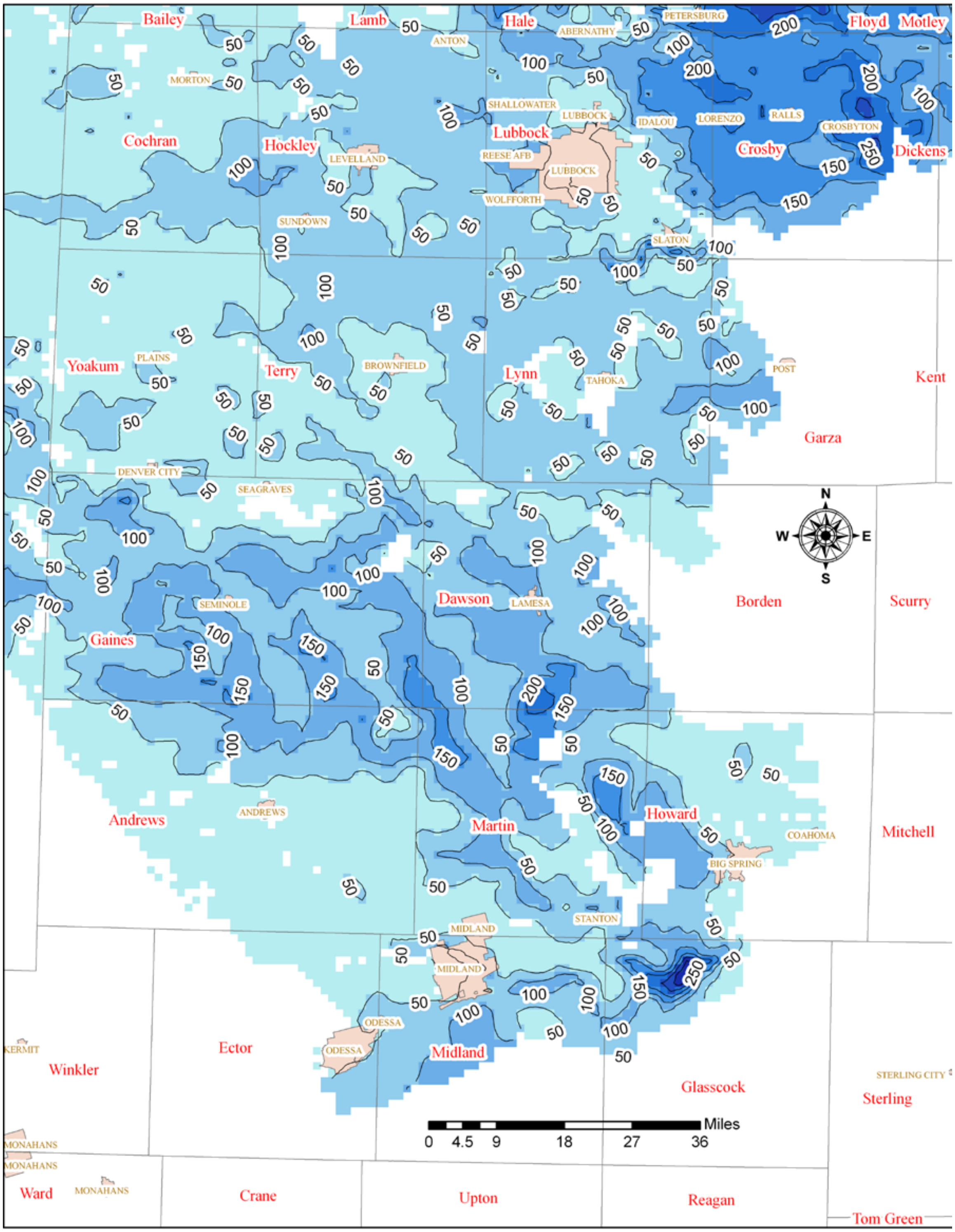

Figure 5: Saturated thickness of the southern half of the southern part of the Ogallala Aquifer in the first stress period (assume year 2009) using recharge as the pumping volume (see Table 1). White areas are inactive cells or outside the model boundary.

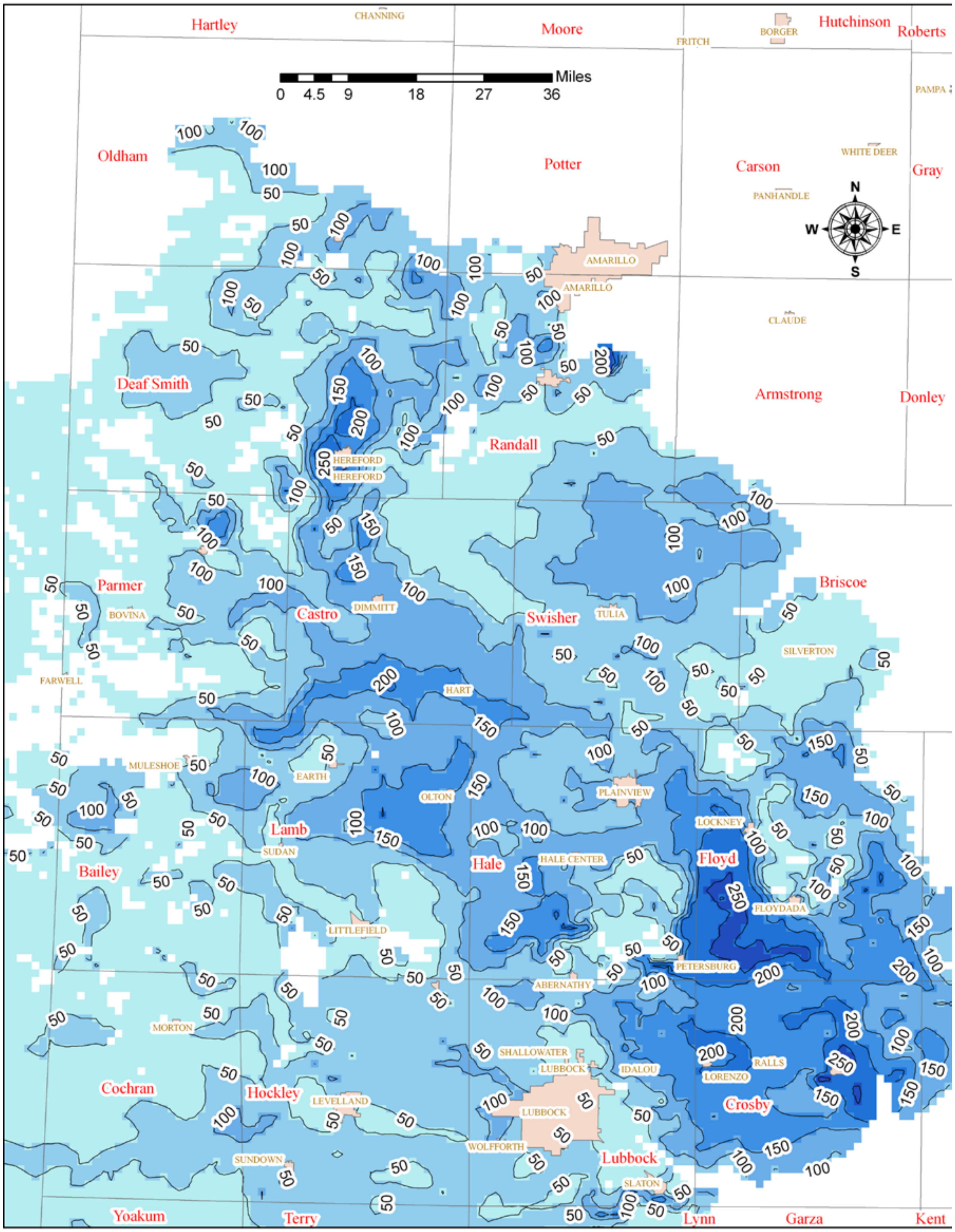

Figure 6: Saturated thickness of the northern half of the southern part of the Ogallala Aquifer in the final stress period (after 50 years) using recharge as the pumping volume (see Table 1). White areas are inactive cells or outside the model boundary.

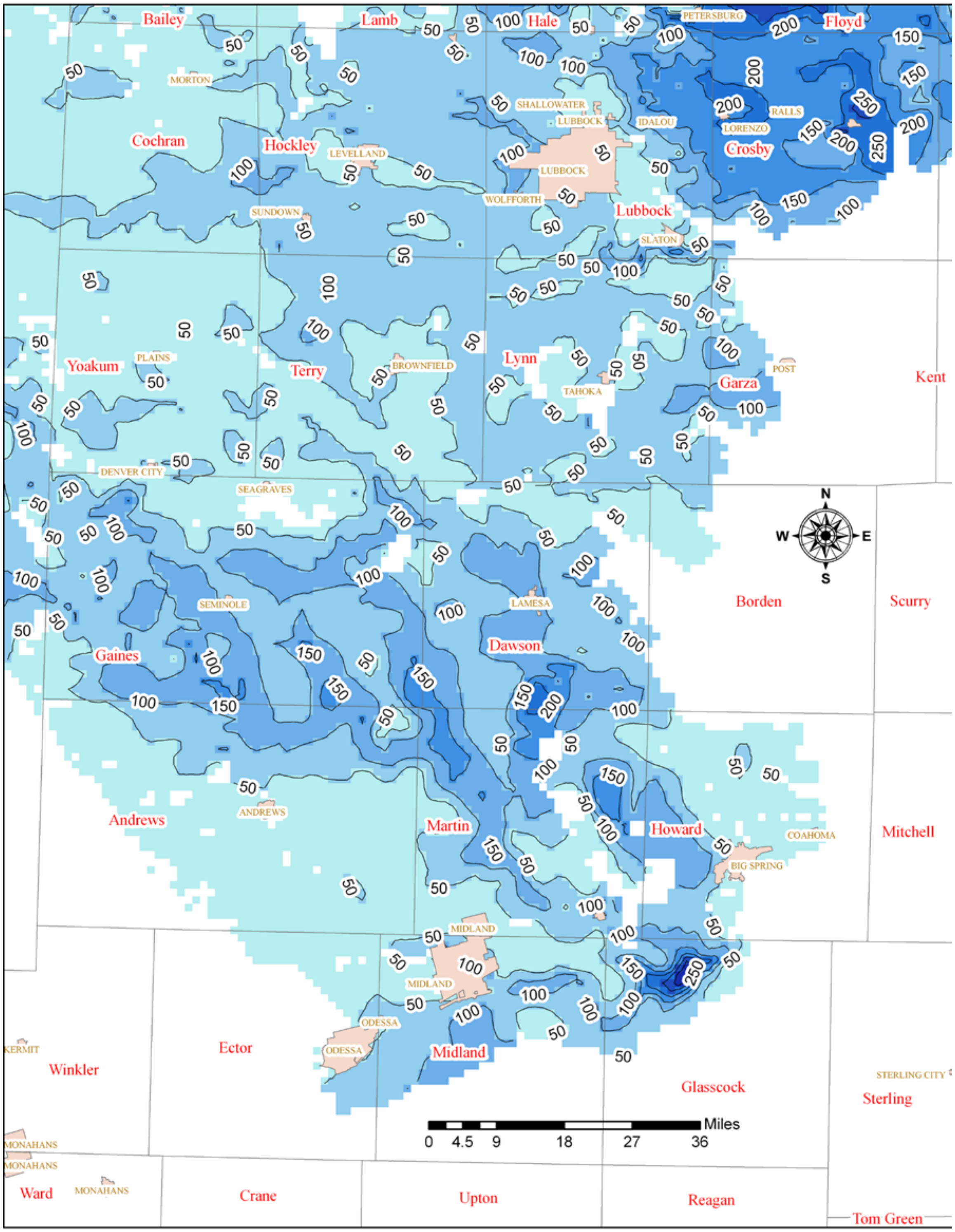

Figure 7: Saturated thickness of the southern half of the southern part of the Ogallala Aquifer in the final stress period (after 50 years) using recharge as the pumping volume (see Table 1). White areas are inactive cells or outside the model boundary.

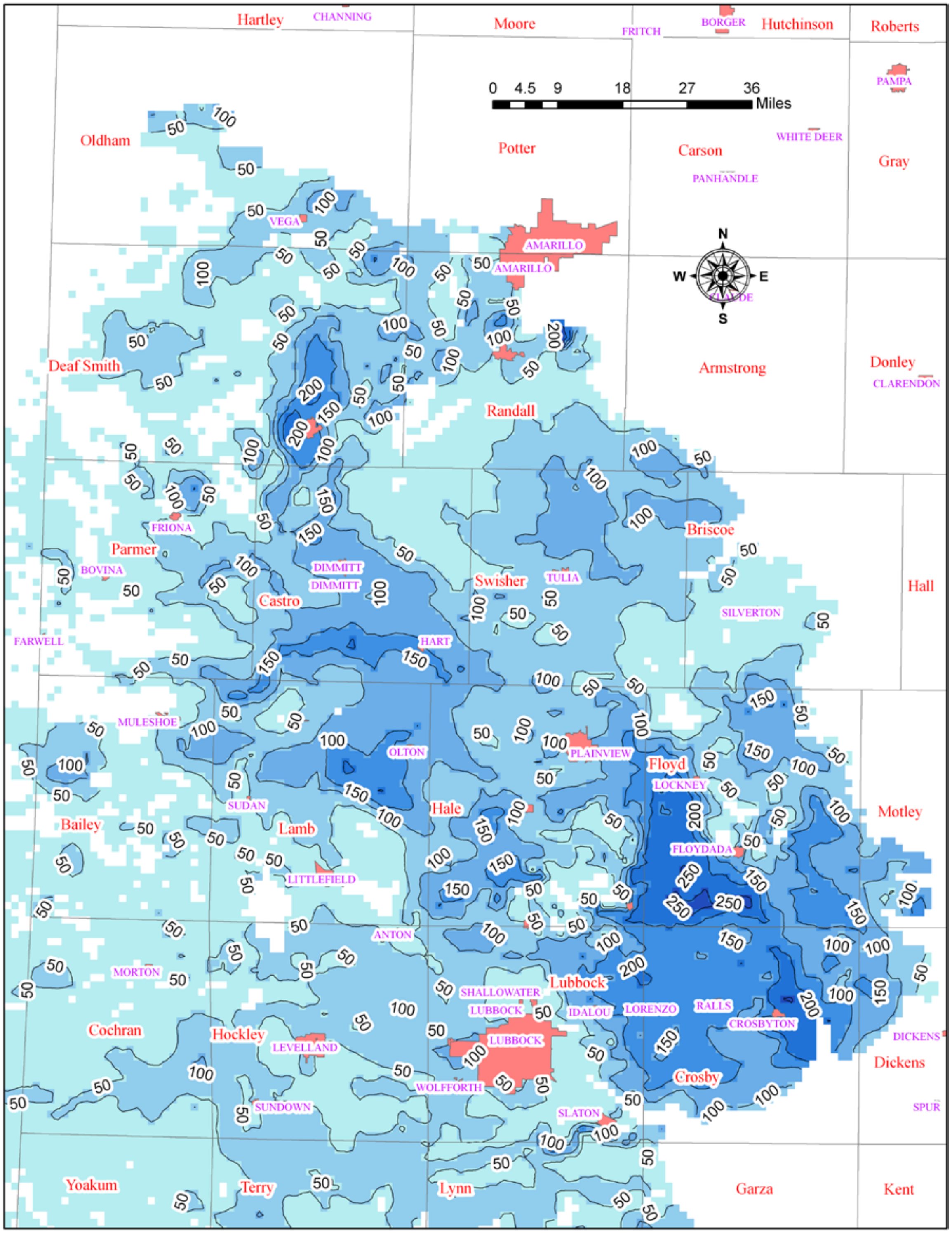

Figure 8: Saturated thickness of the northern half of the southern part of the Ogallala Aquifer after 10 years of pumping at one-foot of decline per year (see Table 2). White areas are inactive cells or outside the model boundary.

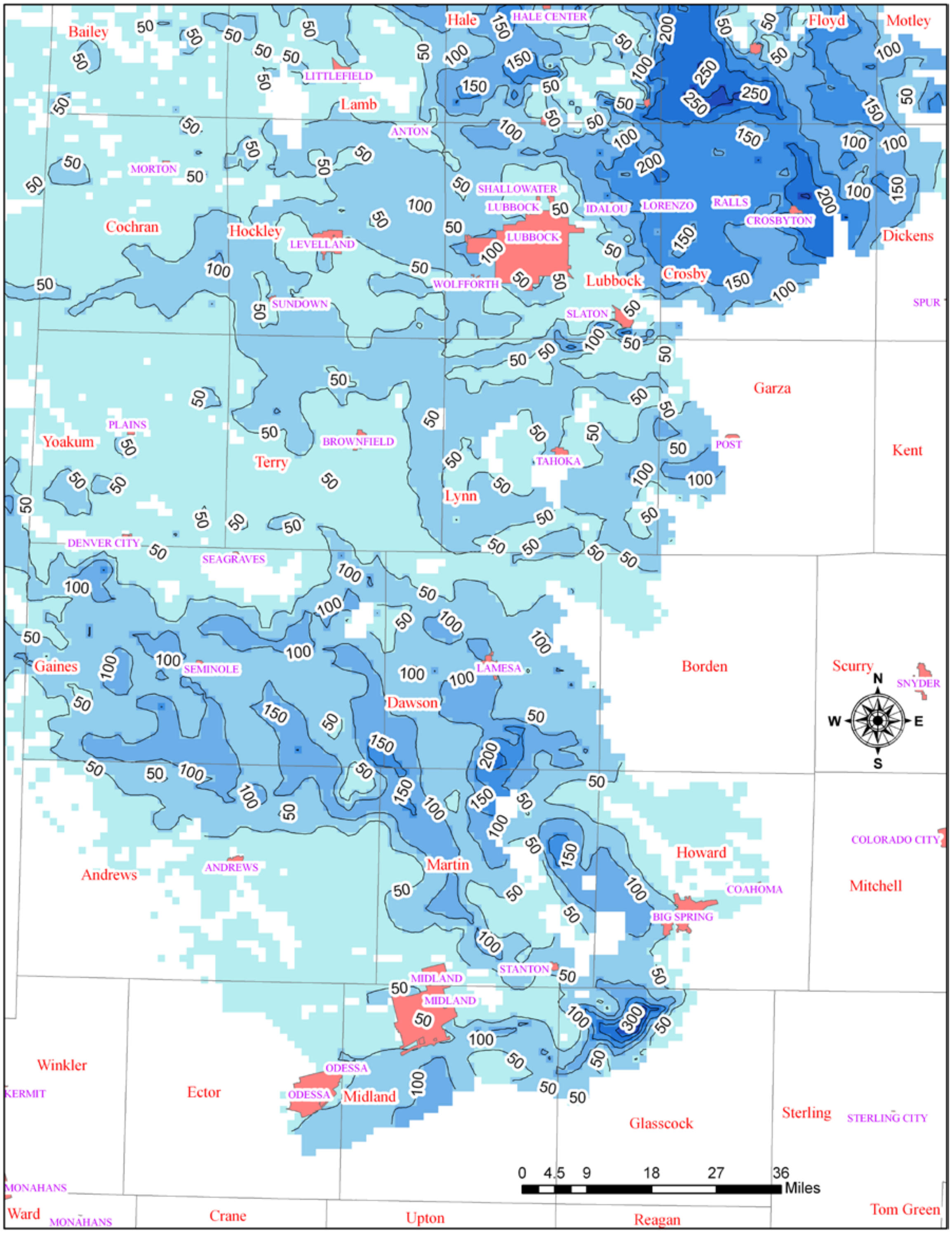

Figure 9: Saturated thickness of the southern half of the southern part of the Ogallala Aquifer after 10 years of pumping at one-foot of decline per year (see Table 2). White areas are inactive cells or outside the model boundary

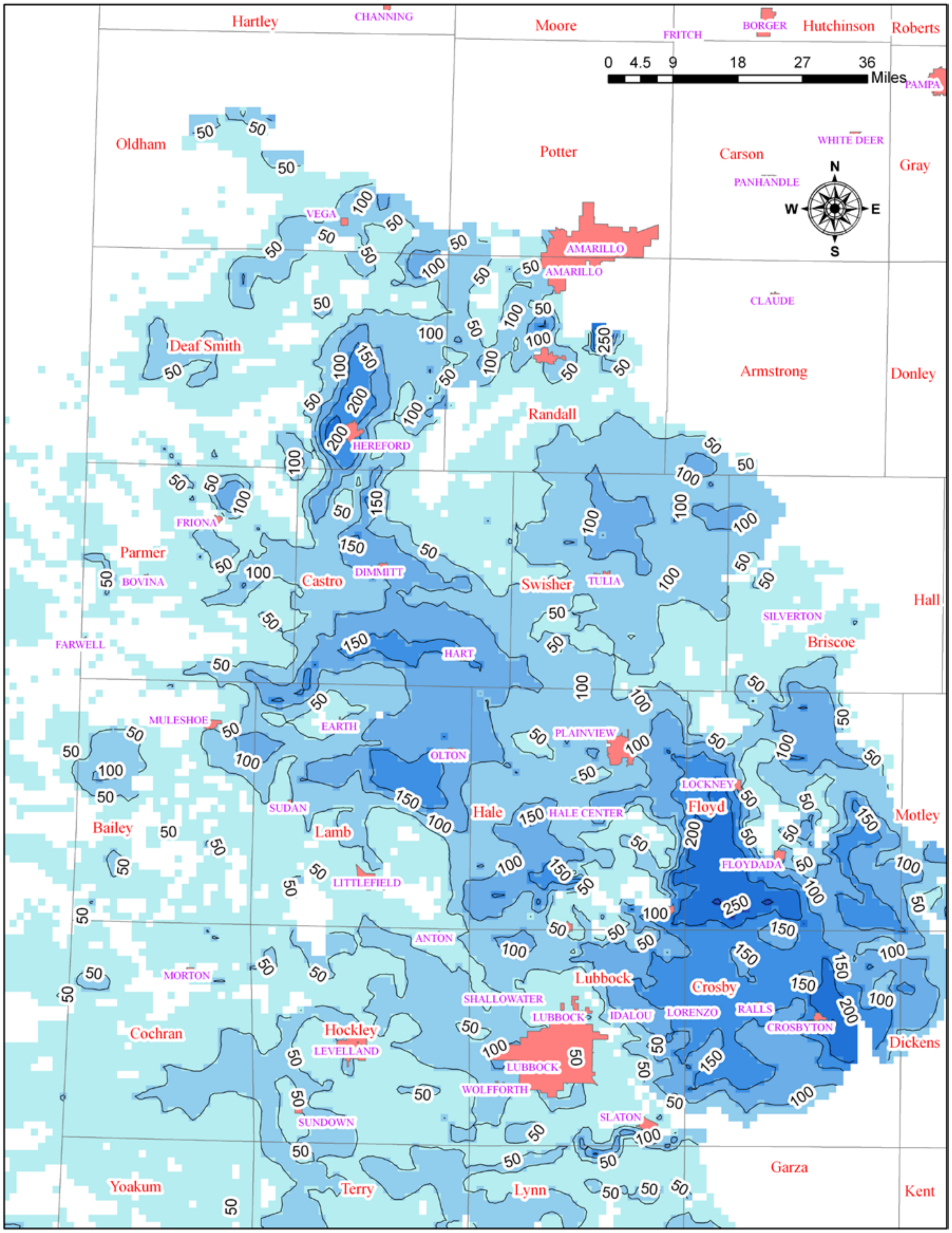

Figure 10: Saturated thickness of the northern half of the southern part of the Ogallala Aquifer after 20 years of pumping at one-foot of decline per year (see Table 2). White areas are inactive cells or outside the model boundary.

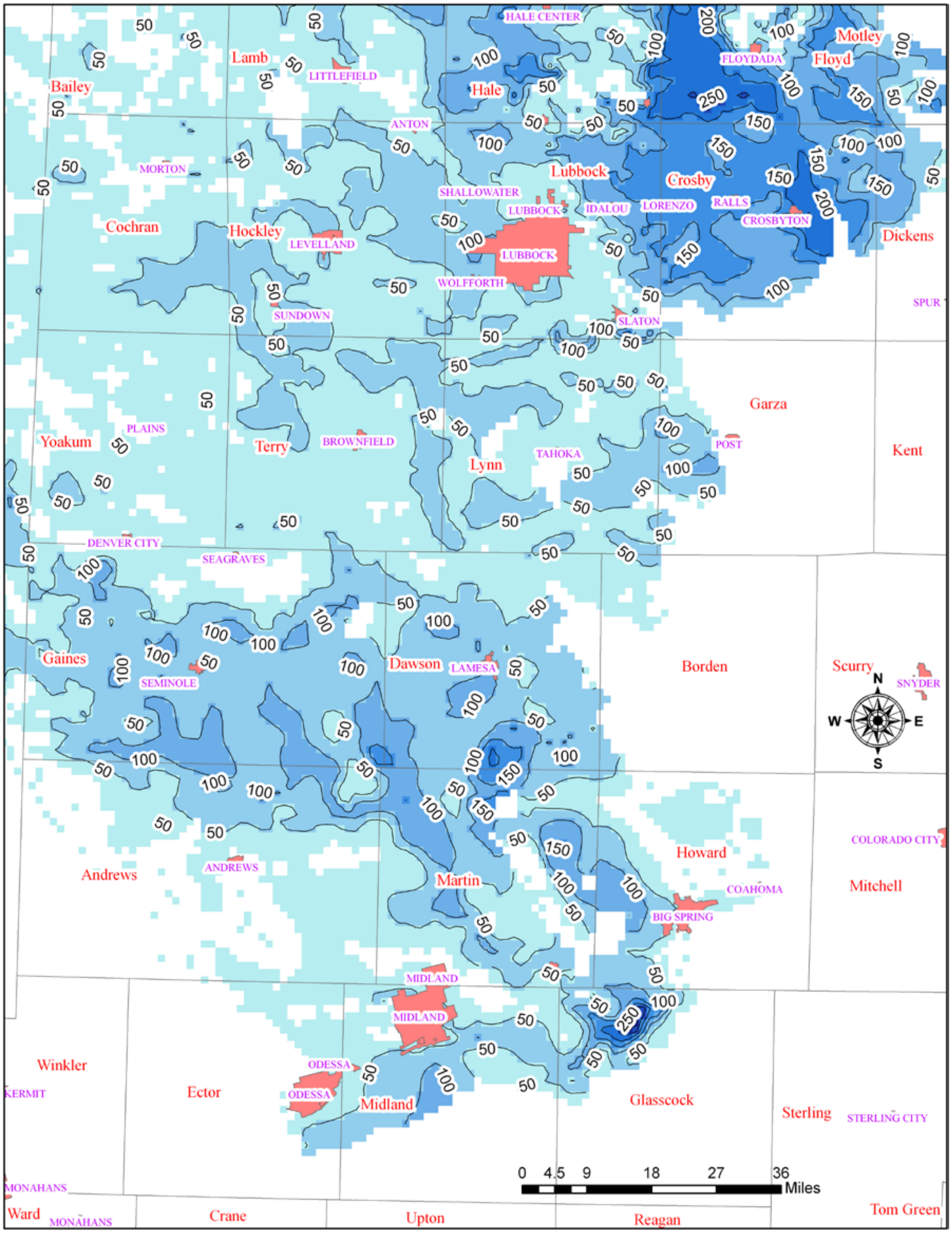

Figure 11: Saturated thickness of the southern half of the southern part of the Ogallala Aquifer after 20 years of pumping at one-foot of decline per year (see Table 2). White areas are inactive cells or outside the model boundary.

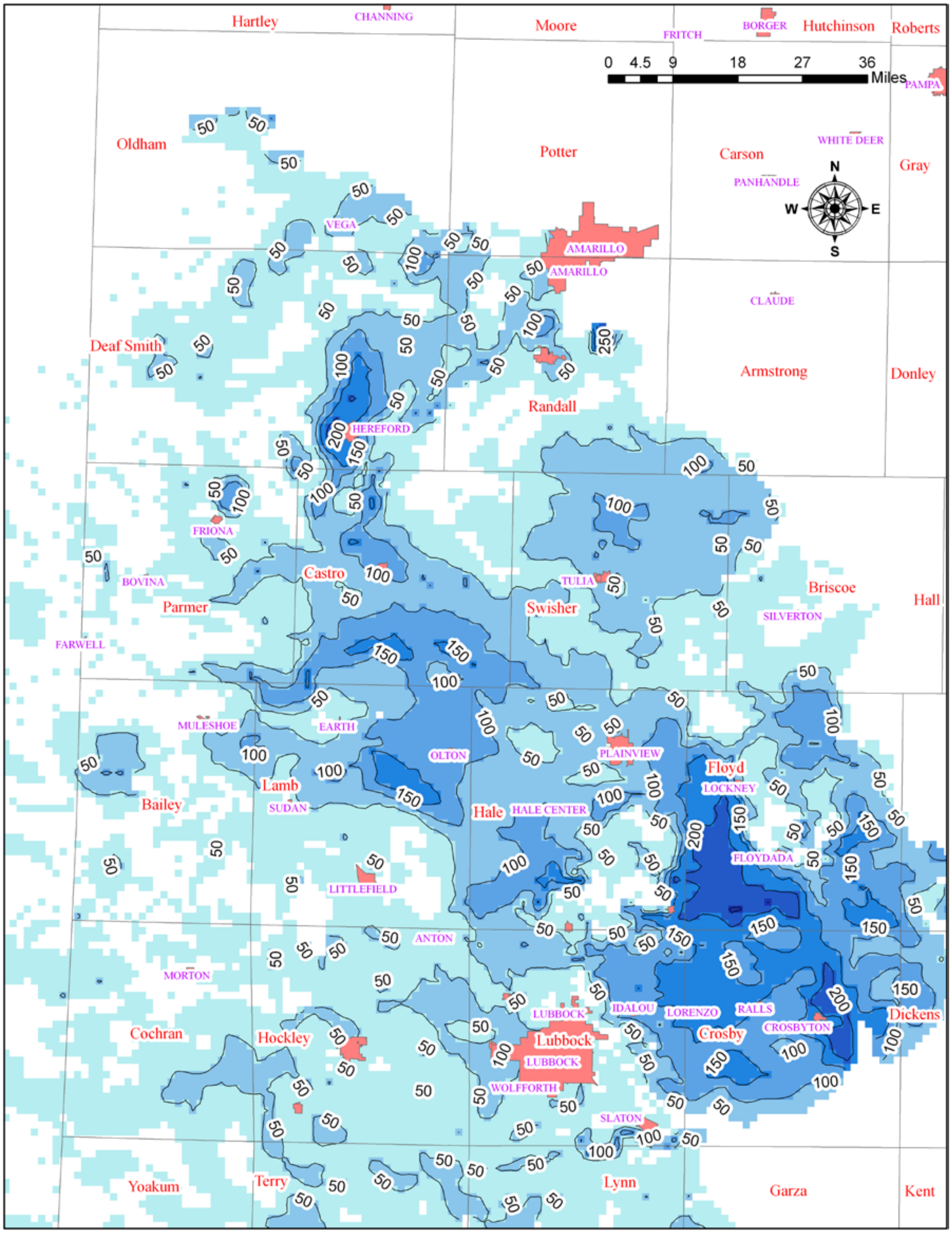

Figure 12: Saturated thickness of the northern half of the southern part of the Ogallala Aquifer after 30 years of pumping at one-foot of decline per year (see Table 2). White areas are inactive cells or outside the model boundary.

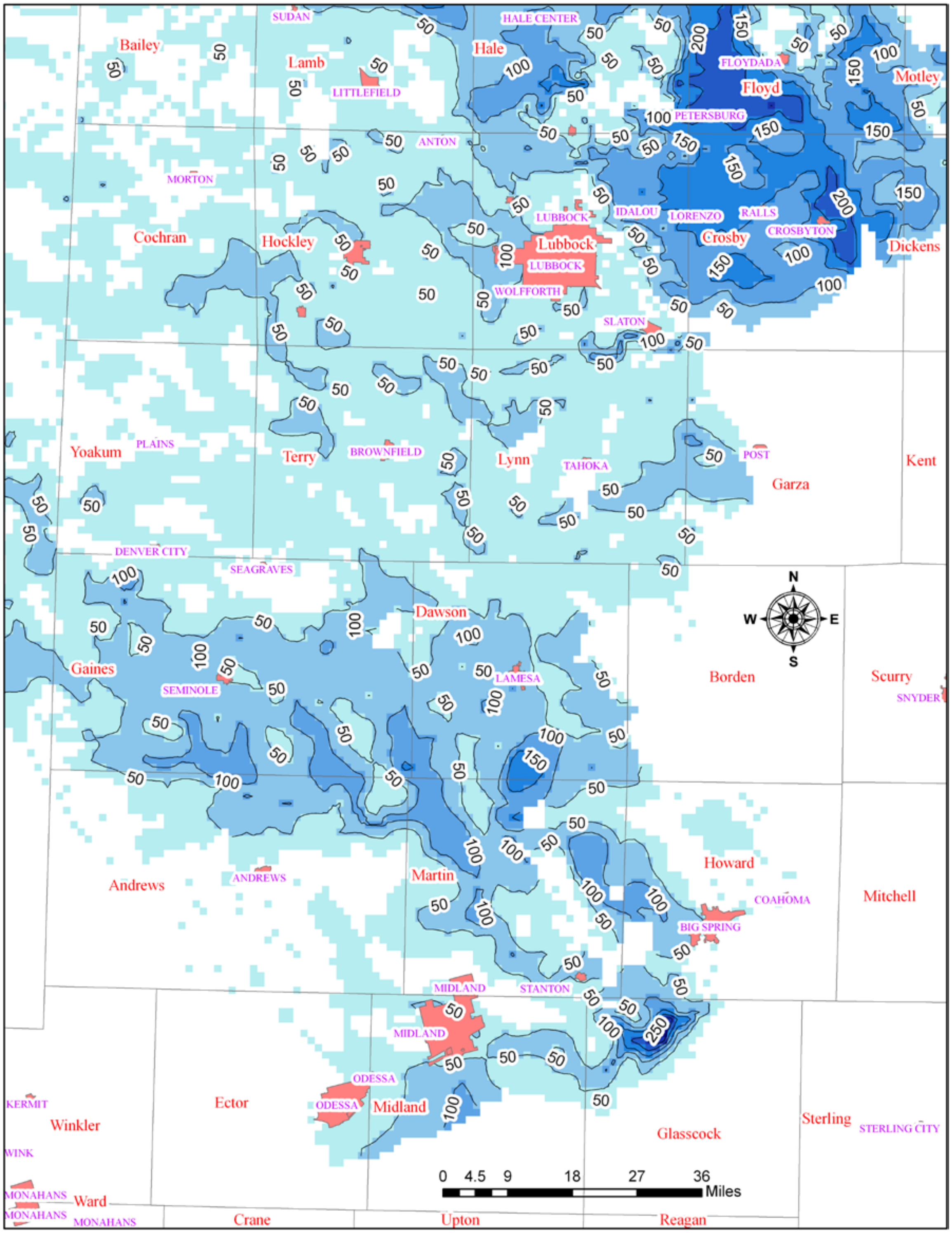

Figure 13: Saturated thickness of the southern half of the Southern Ogallala Aquifer after 30 years of pumping at one-foot of decline per year (see Table 2). White areas are inactive cells or outside the model boundary.

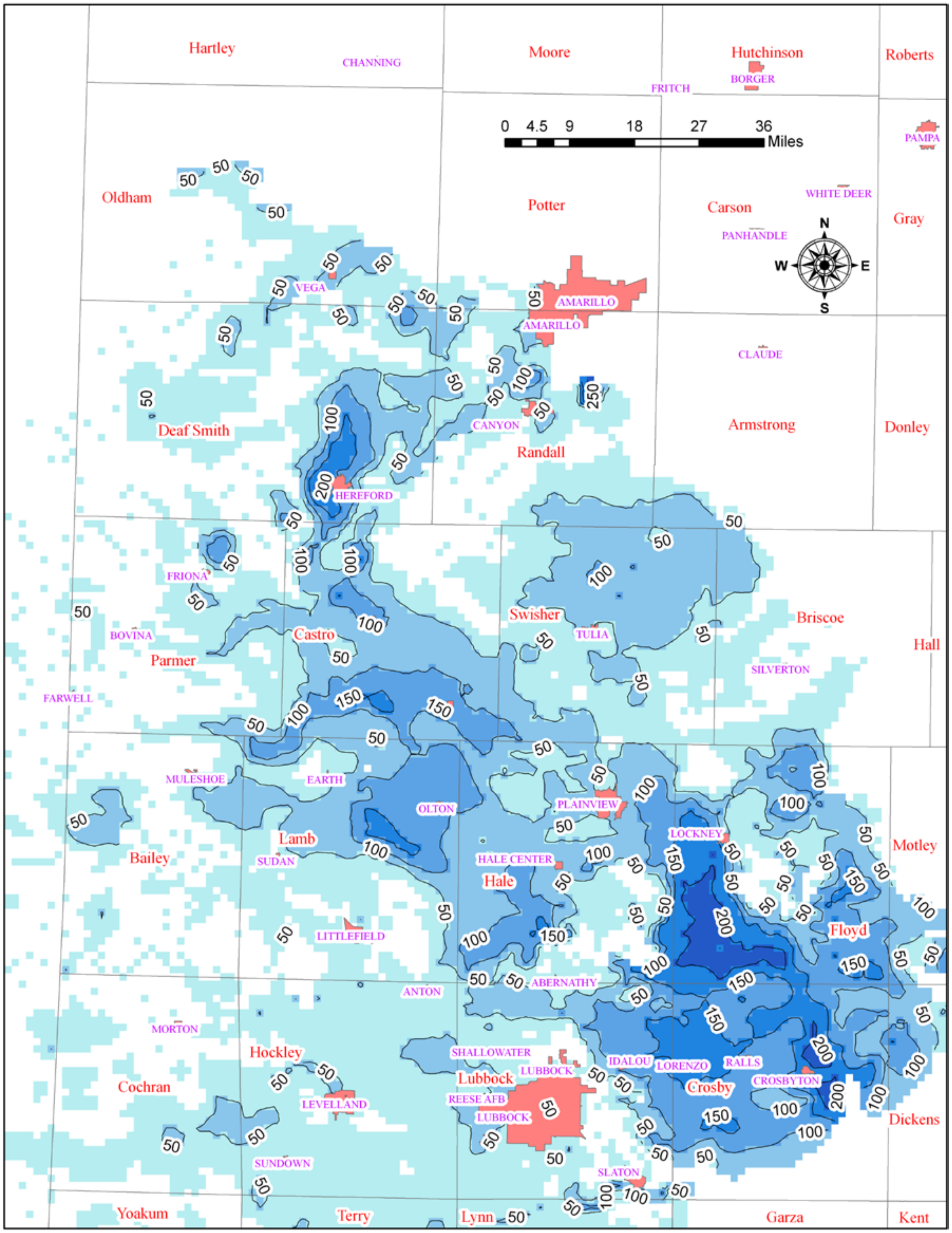

Figure 14: Saturated thickness of the northern half of the Southern Ogallala Aquifer after 40 years of pumping at one-foot of decline per year (see Table 2). White areas are inactive cells or outside the model boundary.

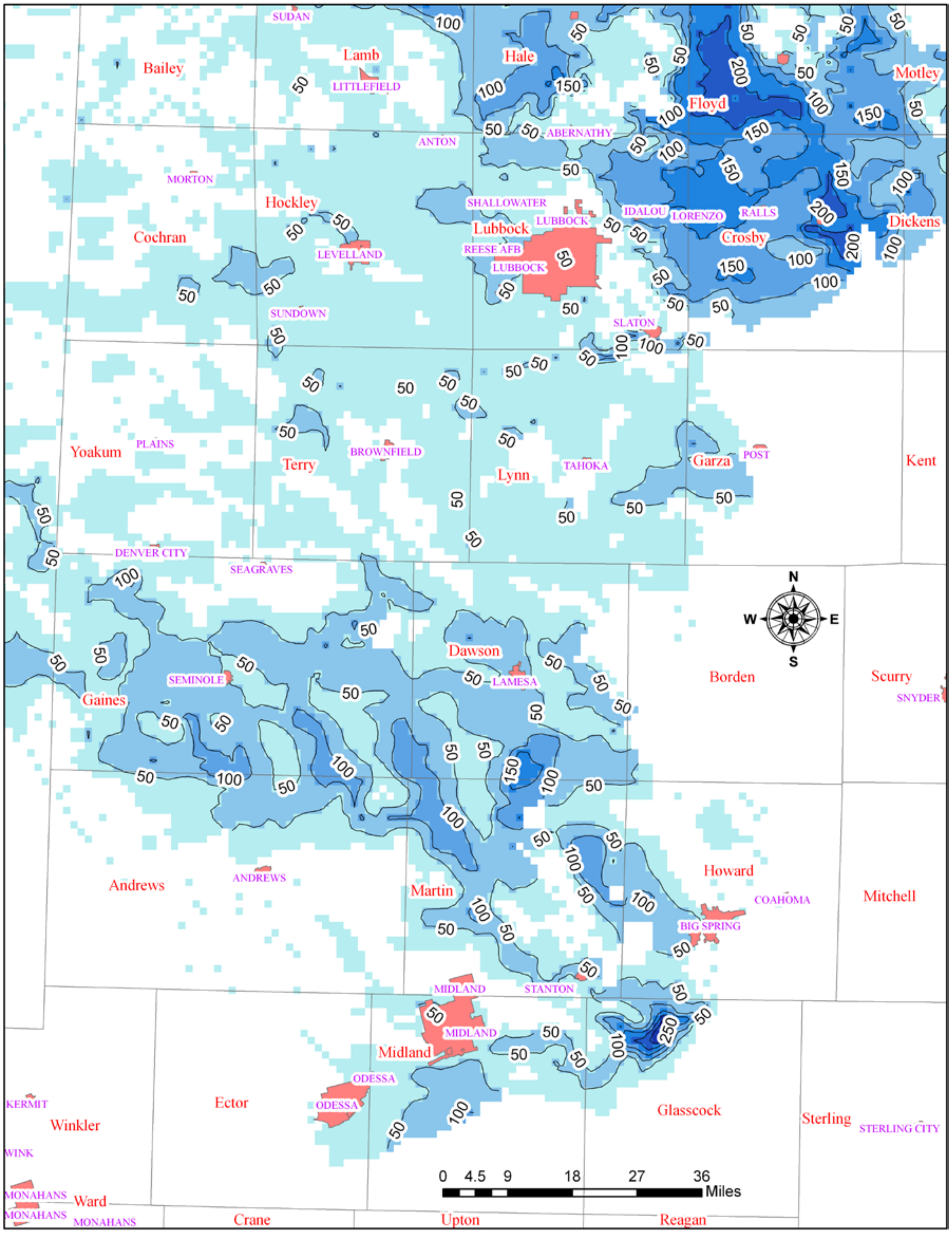

Figure 15: Saturated thickness of the southern half of the Southern Ogallala Aquifer after 40 years of pumping at one-foot of decline per year (see Table 2). White areas are inactive cells or outside the model boundary.

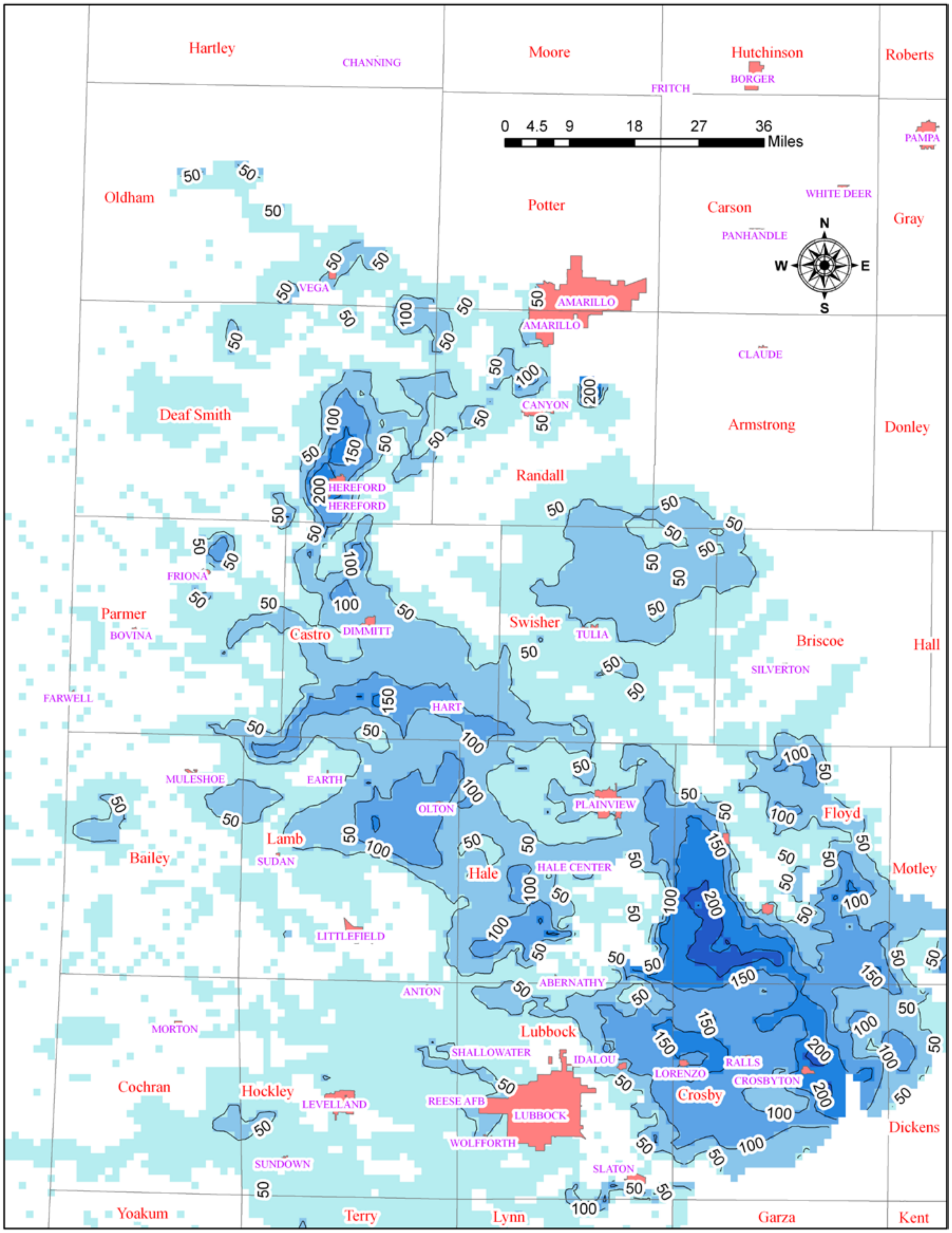

Figure 16: Saturated thickness of the northern half of the Southern Ogallala Aquifer after 50 years of pumping at one-foot of decline per year (see Table 2). White areas are inactive cells or outside the model boundary.

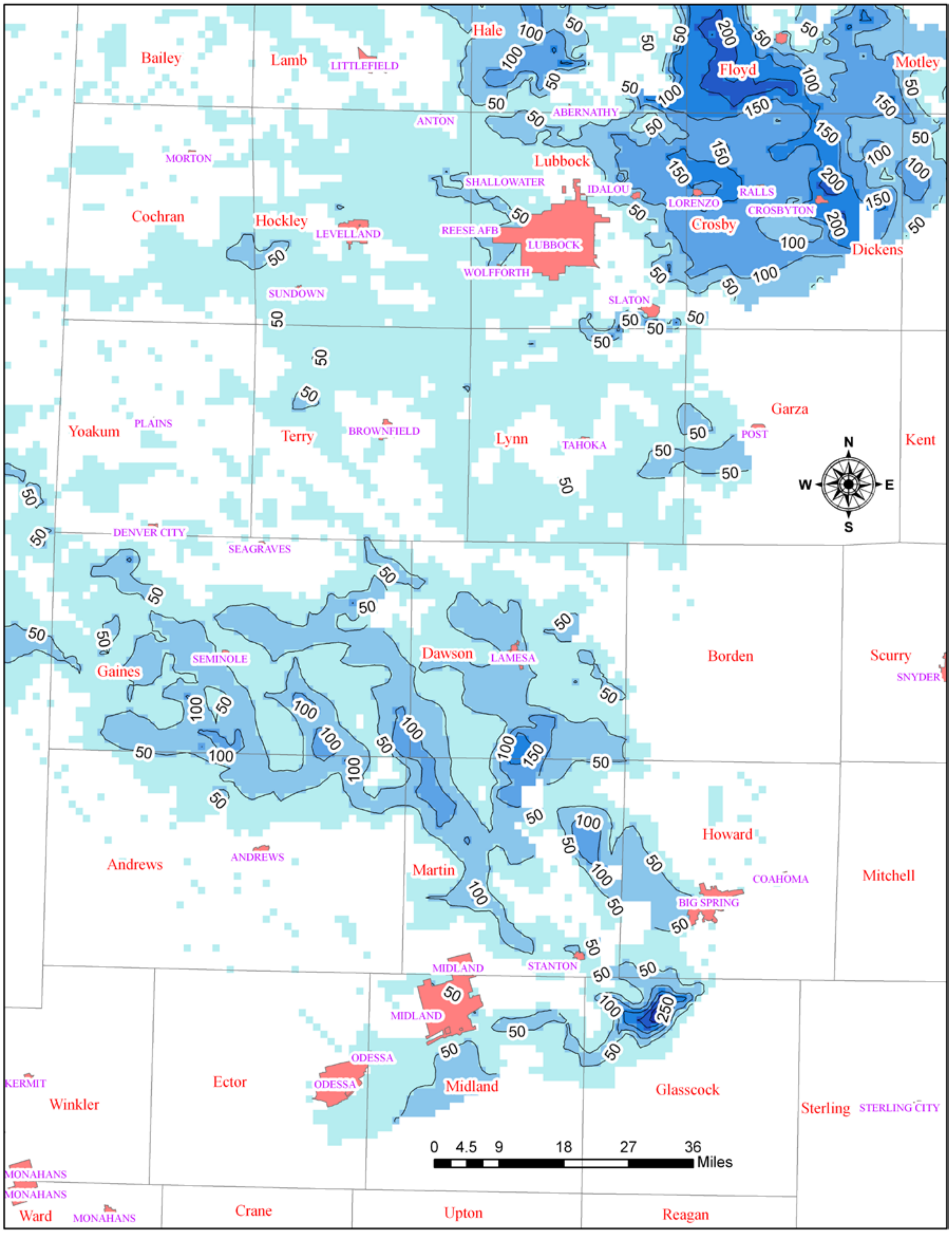

Figure 17: Saturated thickness of the southern half of the Southern Ogallala Aquifer after 50 years of pumping at one-foot of decline per year (see Table 2). White areas are inactive cells or outside the model boundary.

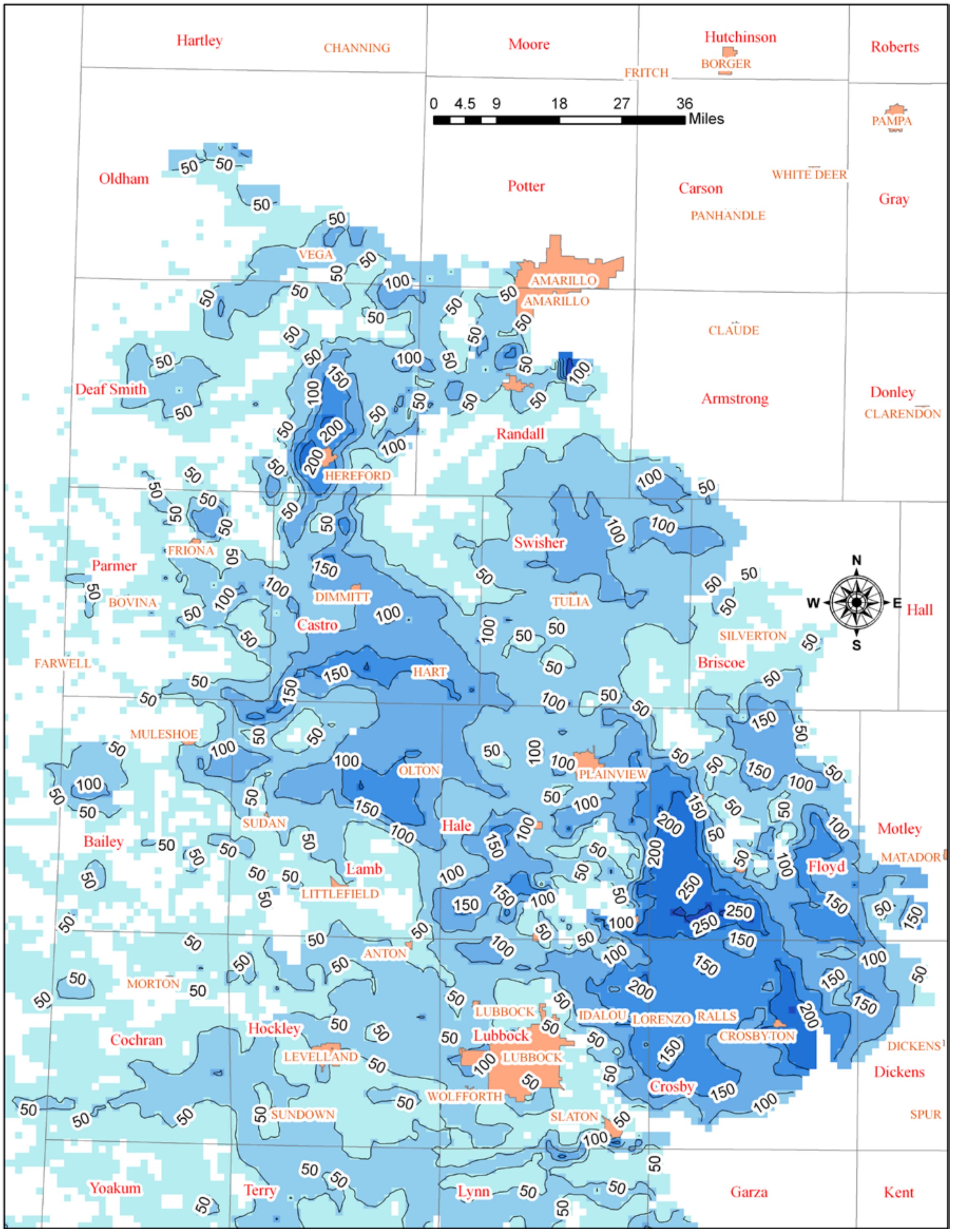

Figure 18: Saturated thickness of the northern half of the Southern Ogallala Aquifer after 10 years of pumping at 1.25 feet of decline per year (see Table 3). White areas are inactive cells or outside the model boundary.

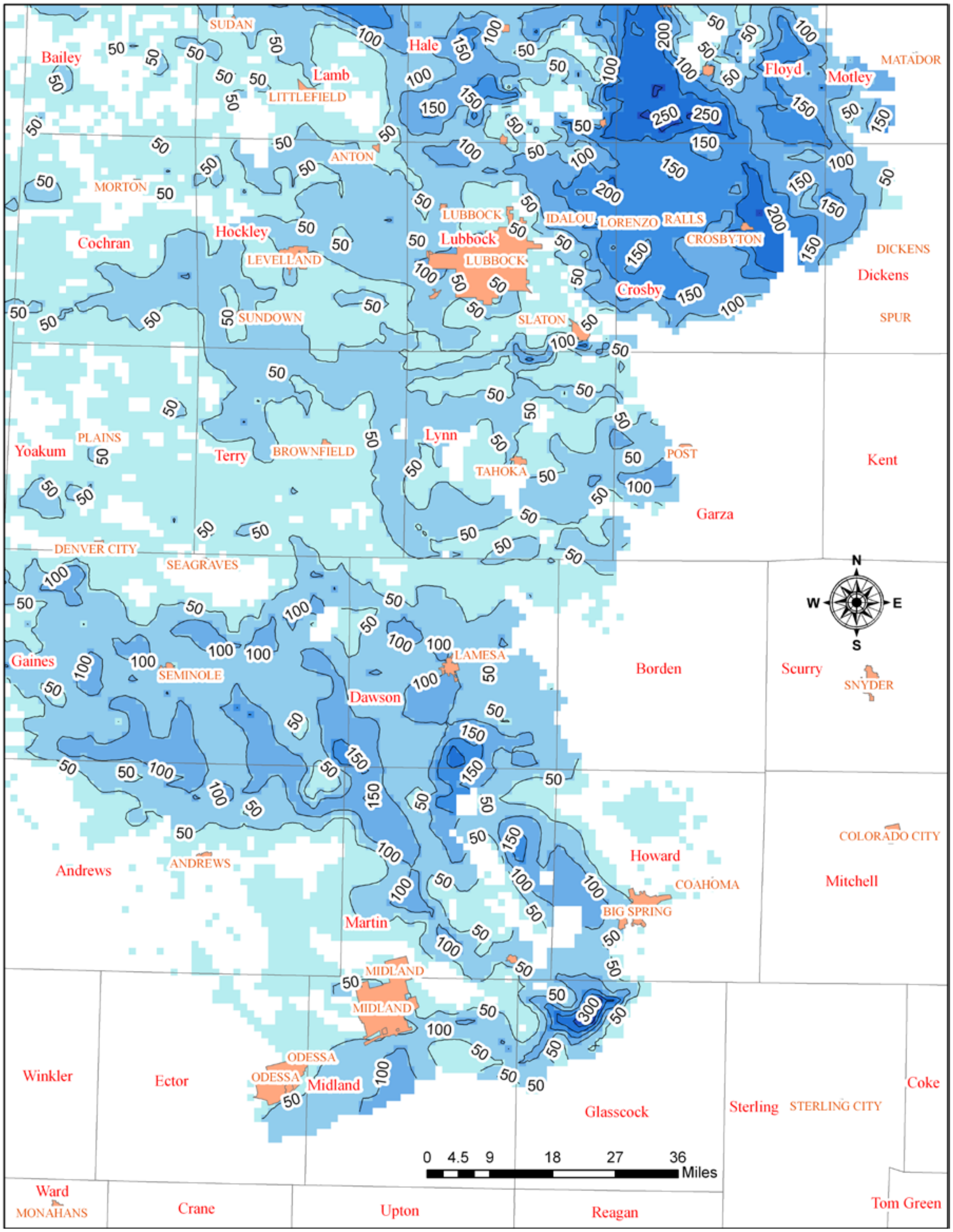

Figure 19: Saturated thickness of the southern half of the Southern Ogallala Aquifer after 10 years of pumping at 1.25 feet of decline per year (see Table 3). White areas are inactive cells or outside the model boundary.

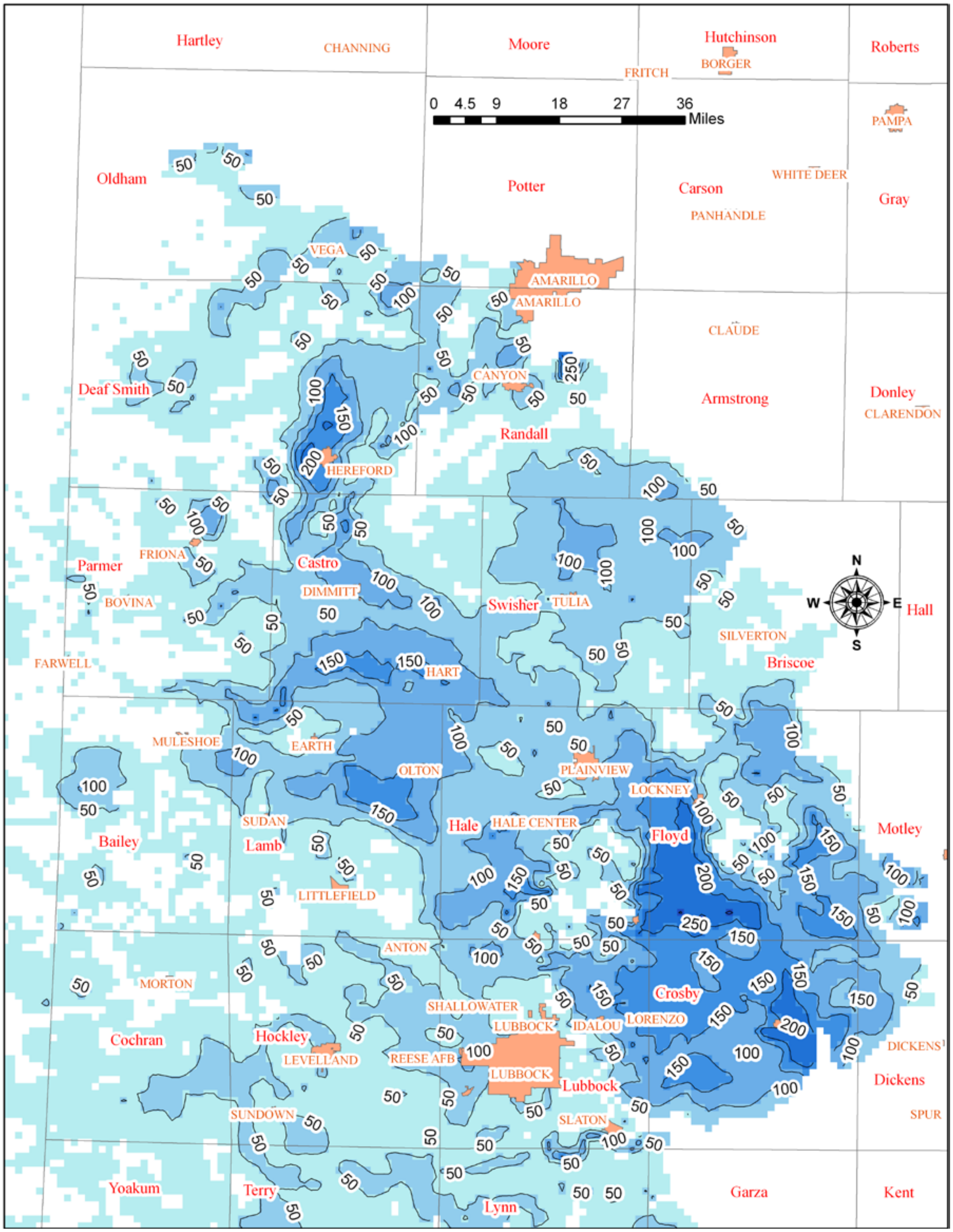

Figure 20: Saturated thickness of the northern half of the Southern Ogallala Aquifer after 20 years of pumping at 1.25 feet of decline per year (see Table 3). White areas are inactive cells or outside the model boundary.

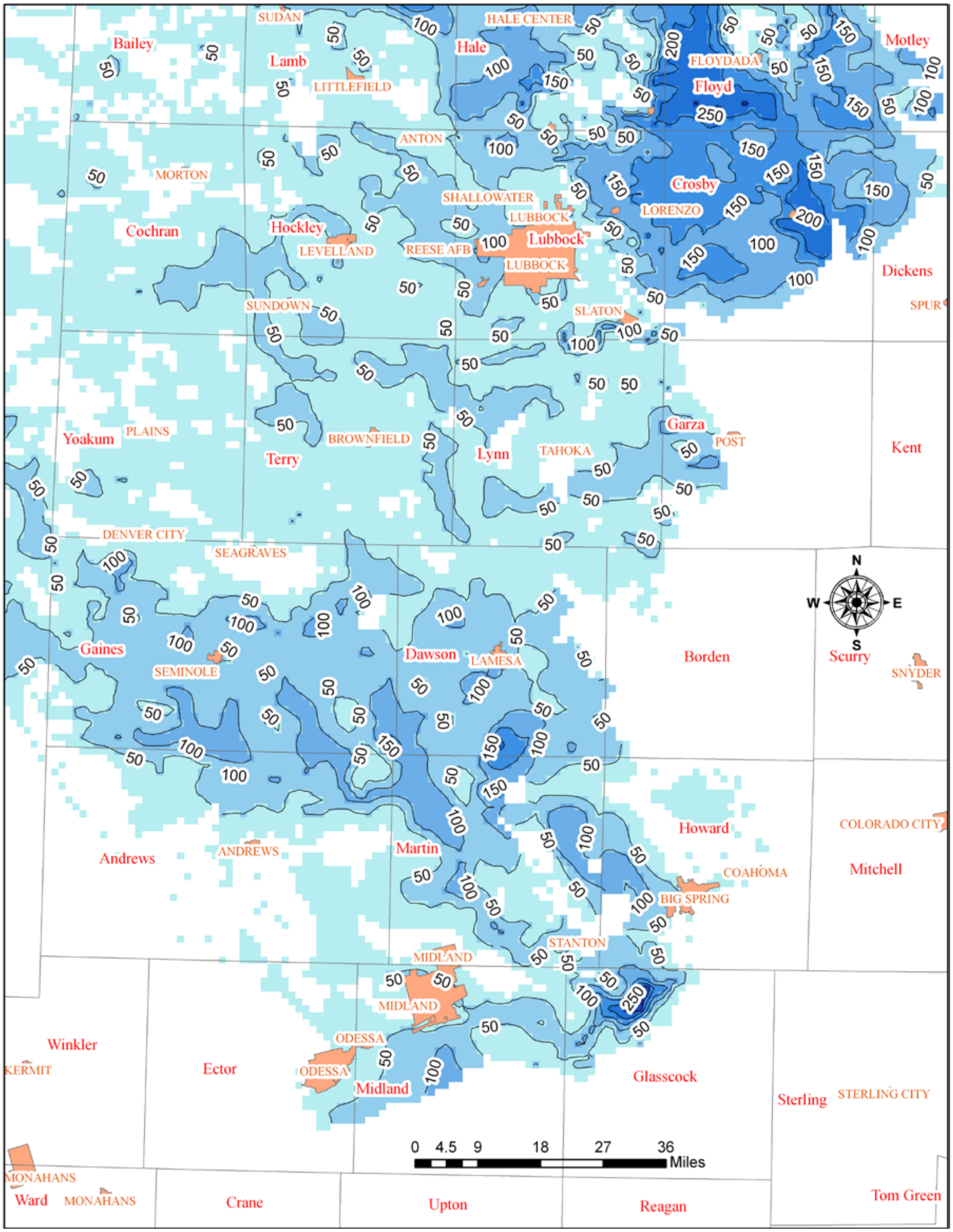

Figure 21: Saturated thickness of the southern half of the Southern Ogallala Aquifer after 20 years of pumping at 1.25 feet of decline per year (see Table 3). White areas are inactive cells or outside the model boundary.

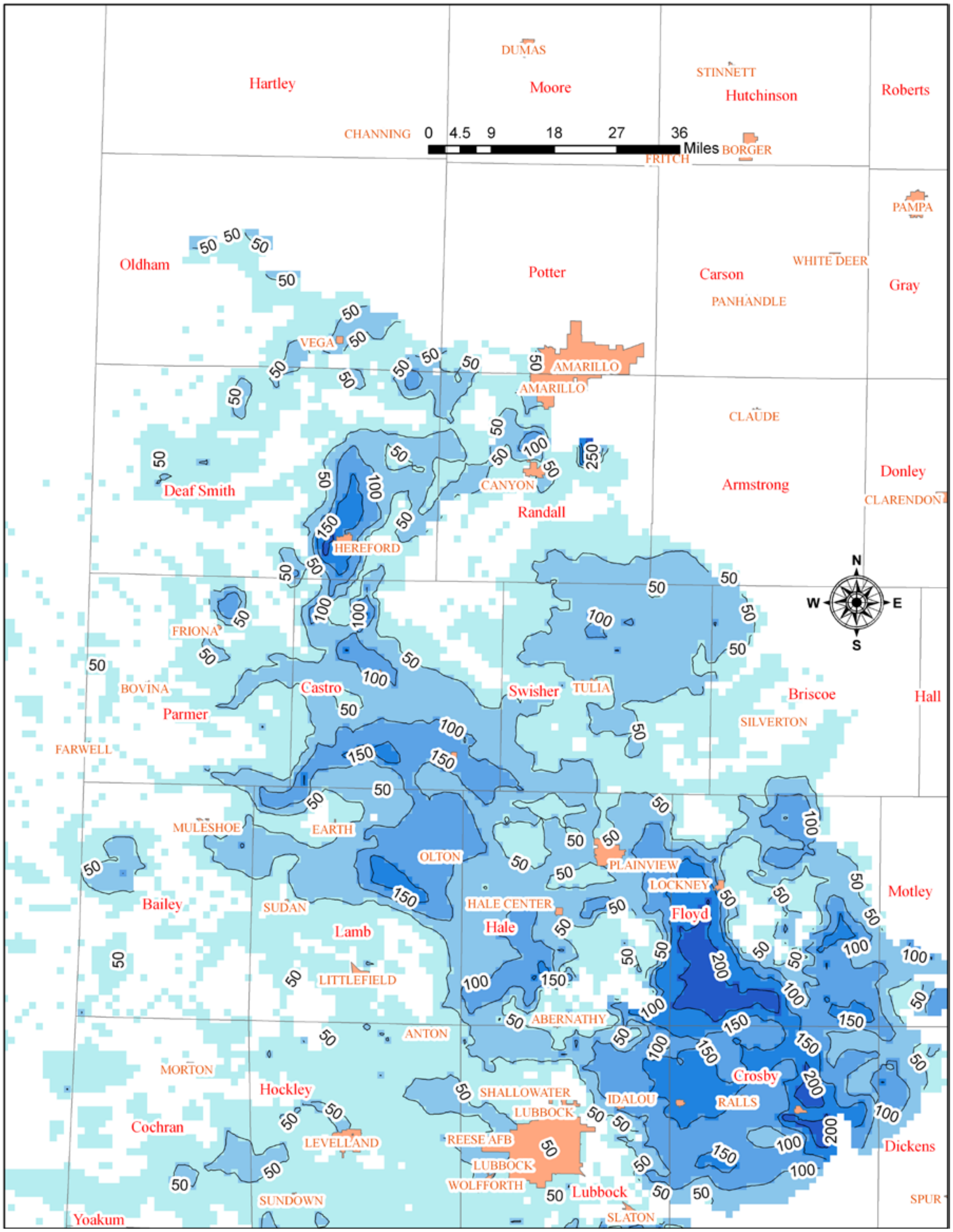

Figure 22: Saturated thickness of the northern half of the Southern Ogallala Aquifer after 30 years of pumping at 1.25 feet of decline per year (see Table 3). White areas are inactive cells or outside the model boundary.

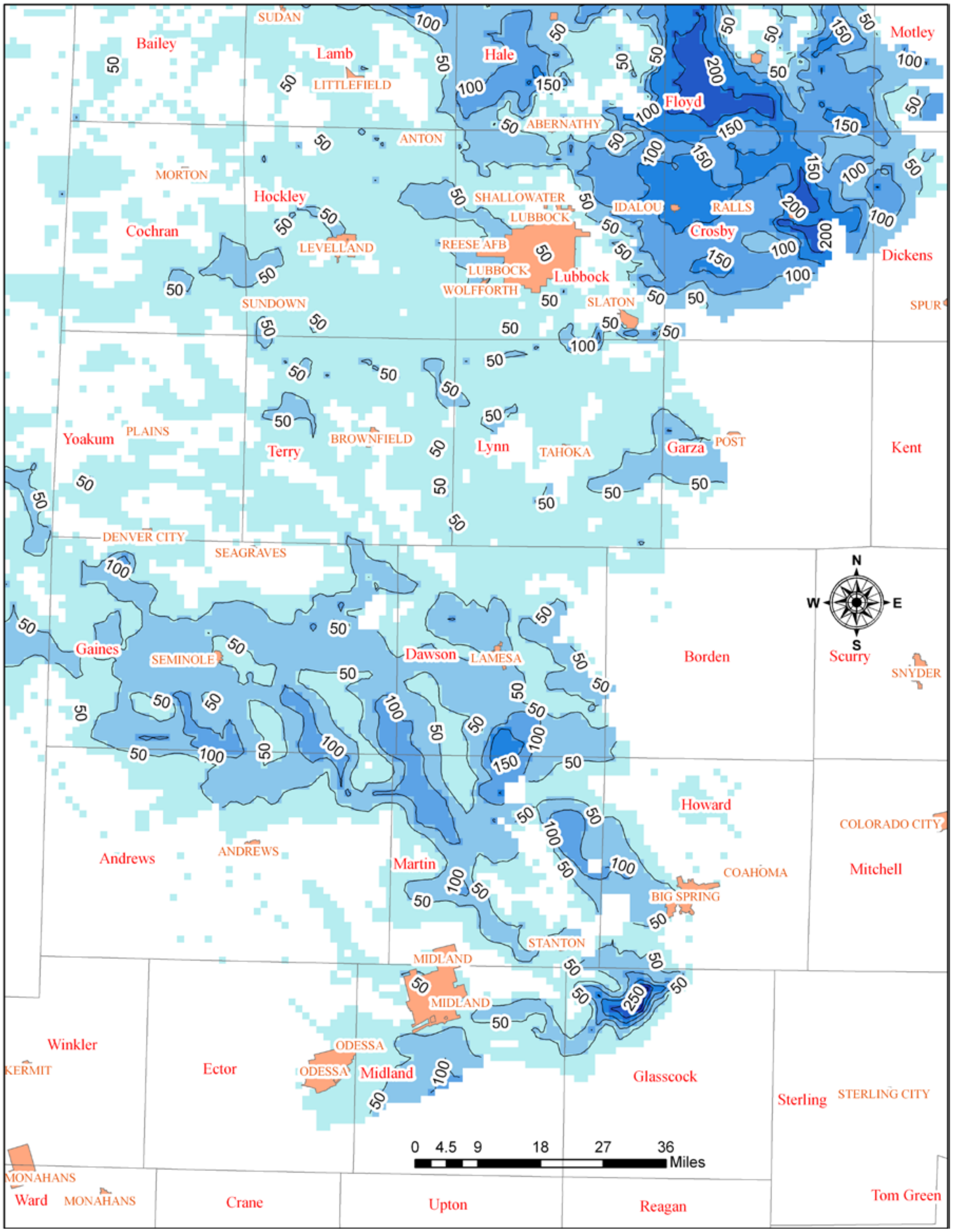

Figure 23: Saturated thickness of the southern half of the Southern Ogallala Aquifer after 30 years of pumping at 1.25 feet of decline per year (see Table 3). White areas are inactive cells or outside the model boundary.

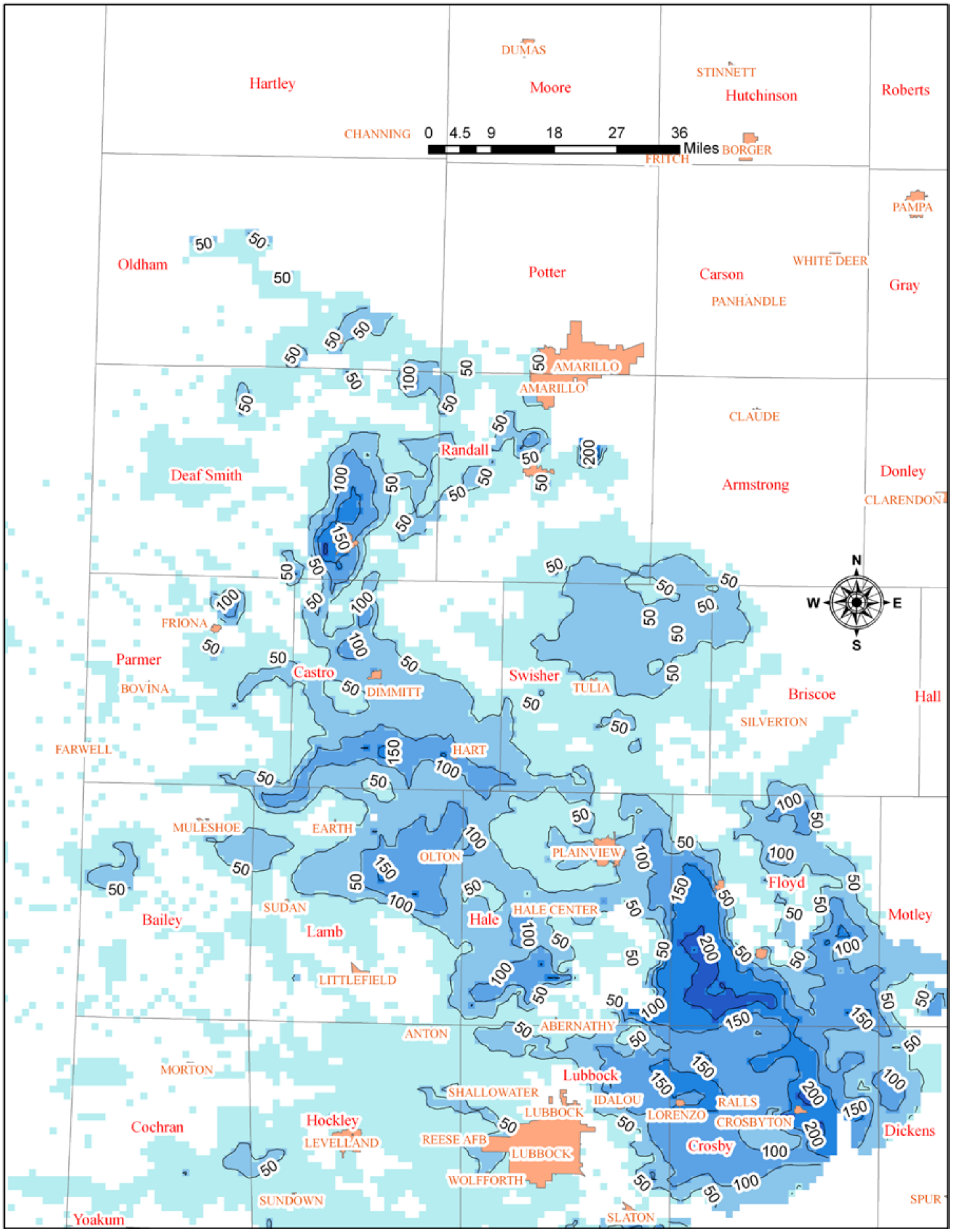

Figure 24: Saturated thickness of the northern half of the Southern Ogallala Aquifer after 40 years of pumping at 1.25 feet of decline per year (see Table 3). White areas are inactive cells or outside the model boundary.

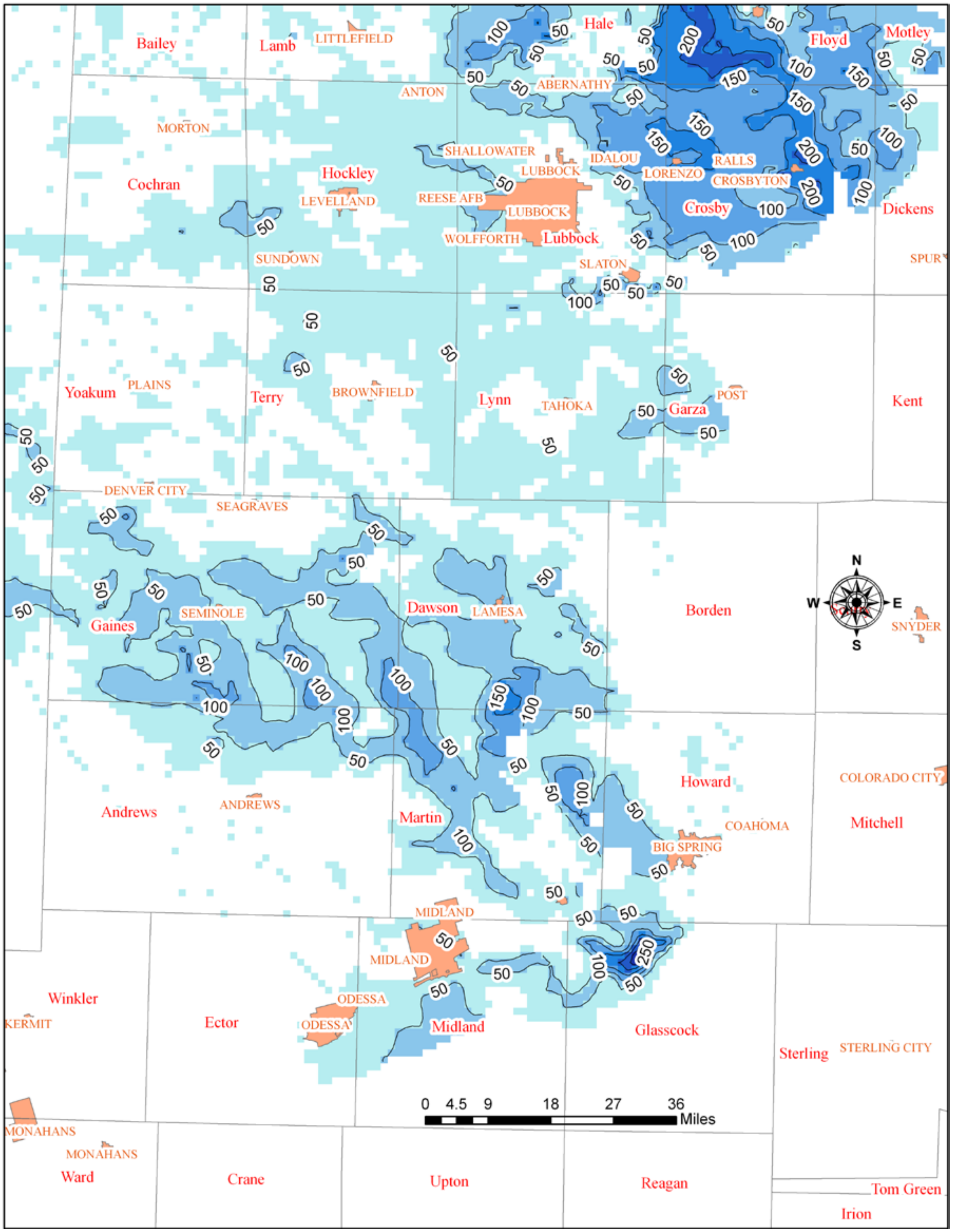

Figure 25: Saturated thickness of the southern half of the Southern Ogallala Aquifer after 40 years of pumping at 1.25 feet of decline per year (see Table 3). White areas are inactive cells or outside the model boundary.

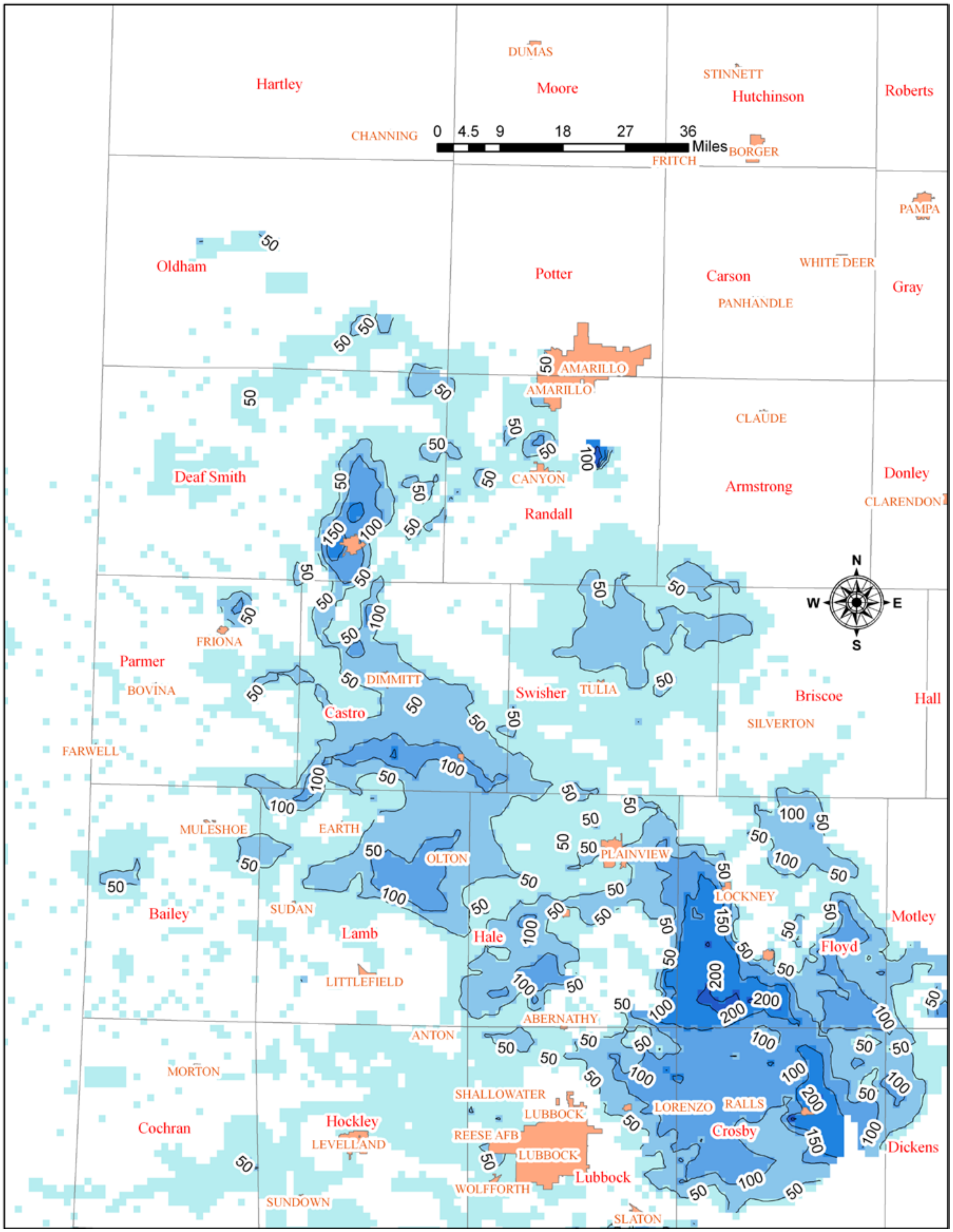

Figure 26: Saturated thickness of the northern half of the Southern Ogallala Aquifer after 50 years of pumping at 1.25 feet of decline per year (see Table 3). White areas are inactive cells or outside the model boundary.

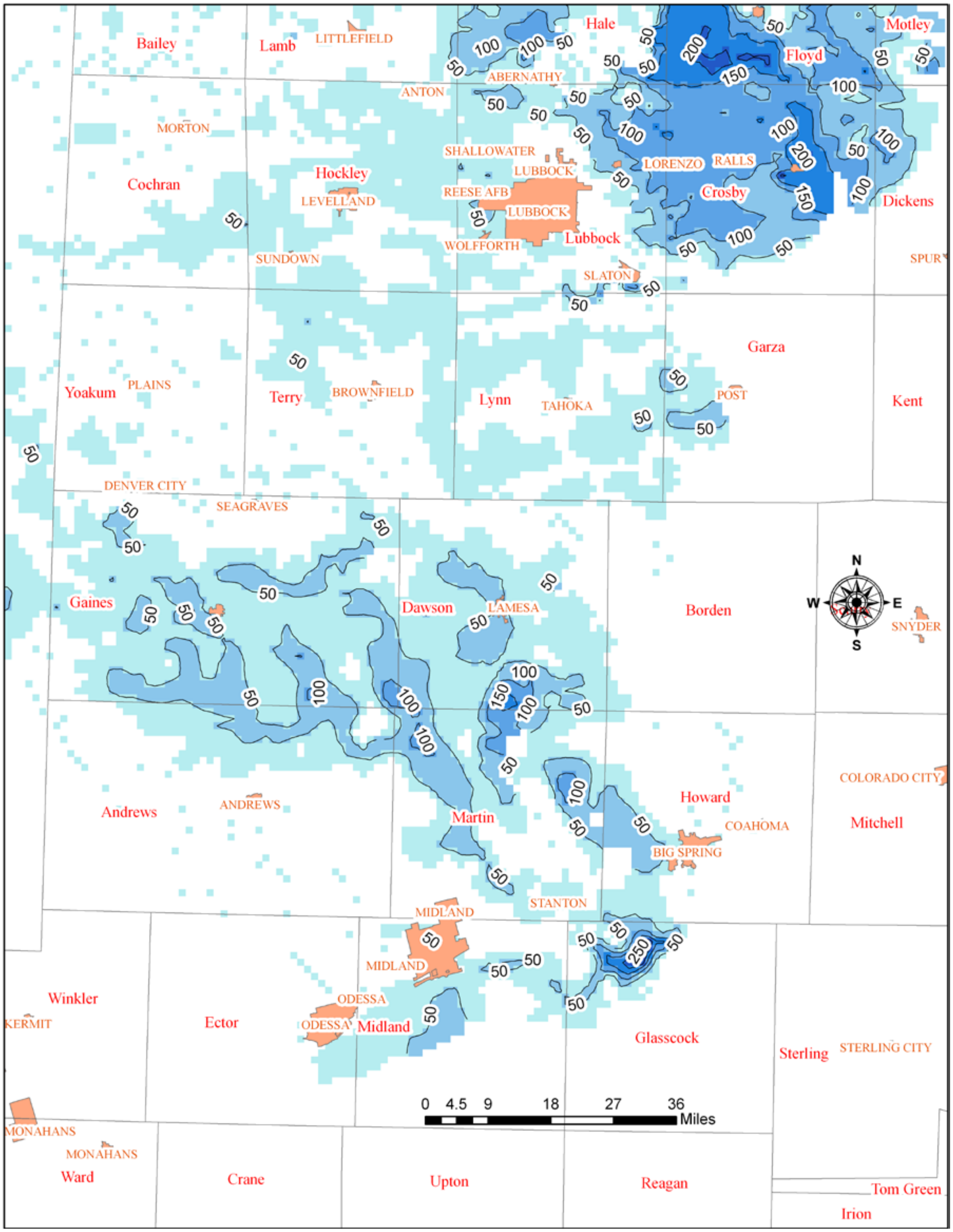

Figure 27: Saturated thickness of the southern half of the Southern Ogallala Aquifer after 50 years of pumping at 1.25 feet of decline per year (see Table 3). White areas are inactive cells or outside the model boundary.

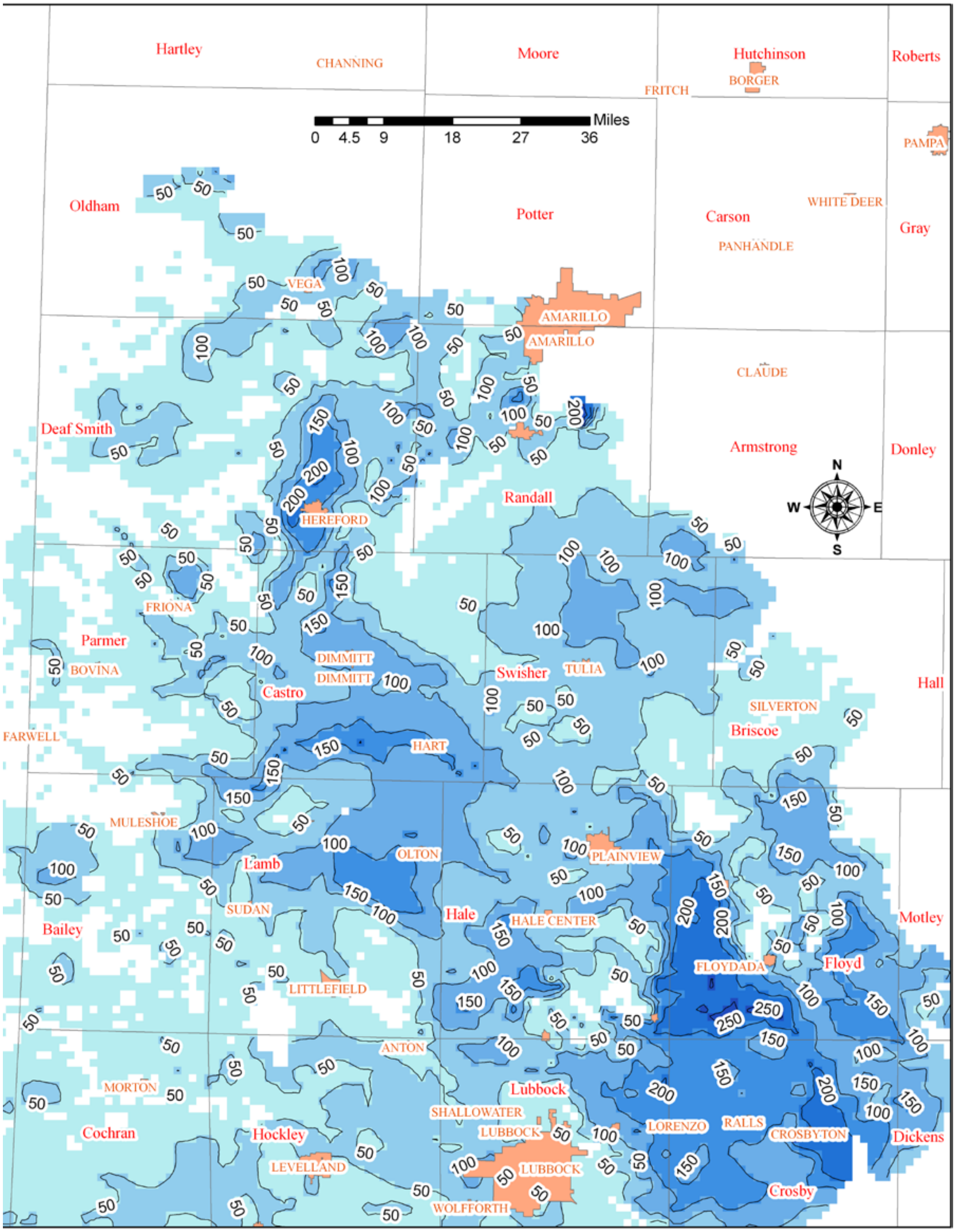

Figure 28: Saturated thickness of the northern half of the Southern Ogallala Aquifer after 10 years of pumping at 1.50 feet of decline per year (see Table 4). White areas are inactive cells or outside the model boundary.

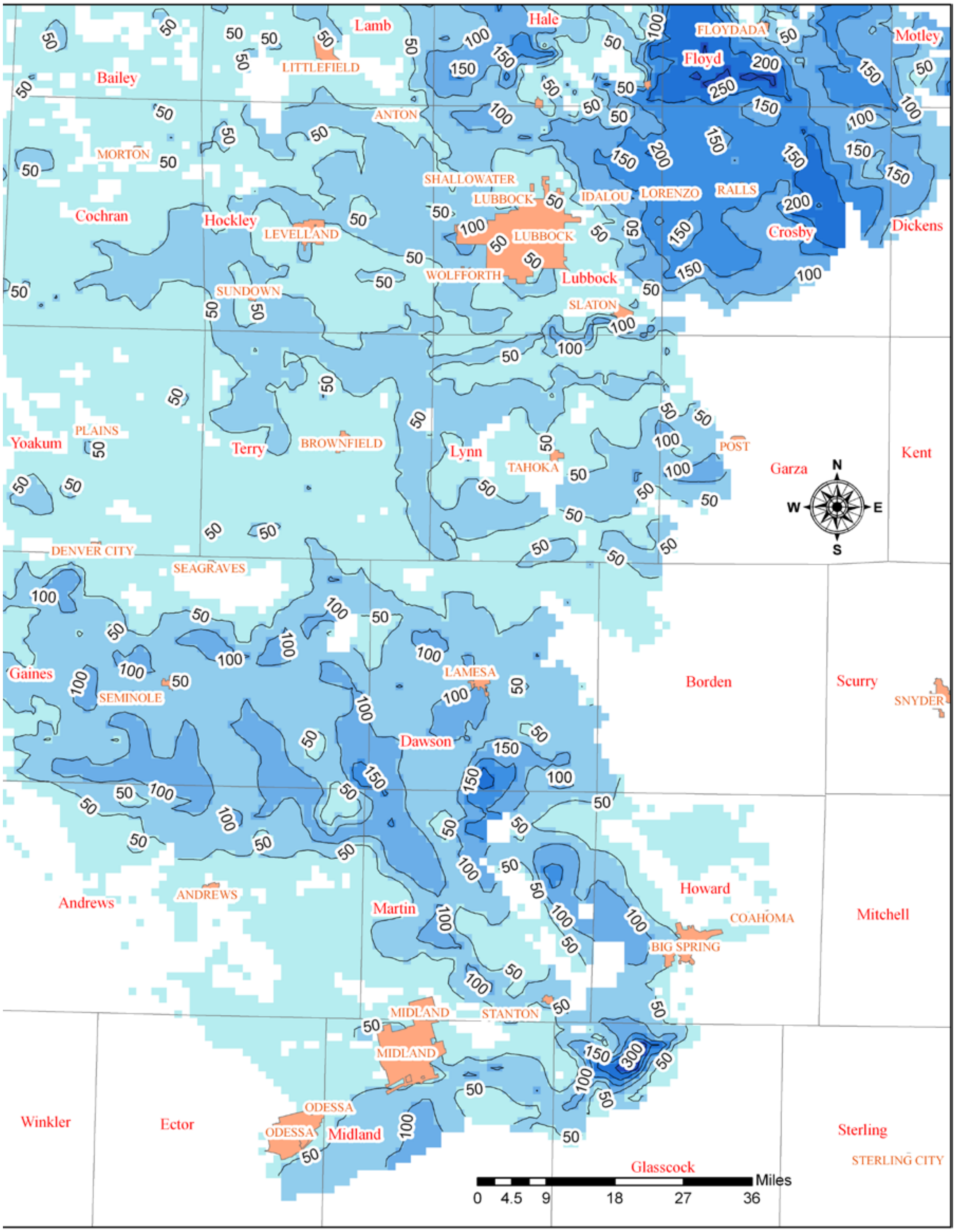

Figure 29: Saturated thickness of the southern half of the Southern Ogallala Aquifer after 10 years of pumping at 1.50 feet of decline per year (see Table 4). White areas are inactive cells or outside the model boundary.

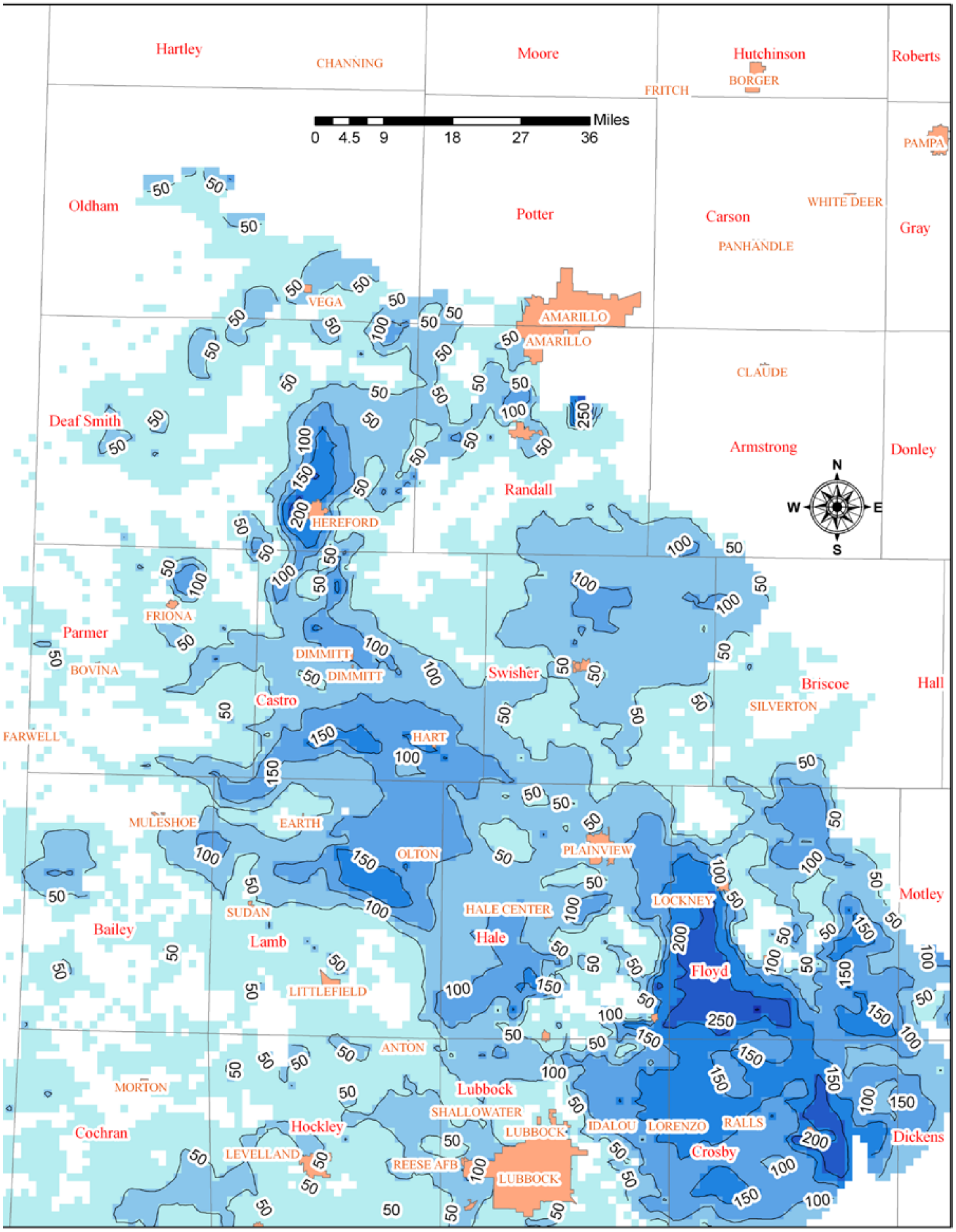

Figure 30: Saturated thickness of the northern half of the Southern Ogallala Aquifer after 20 years of pumping at 1.50 feet of decline per year (see Table 4). White areas are inactive cells or outside the model boundary.

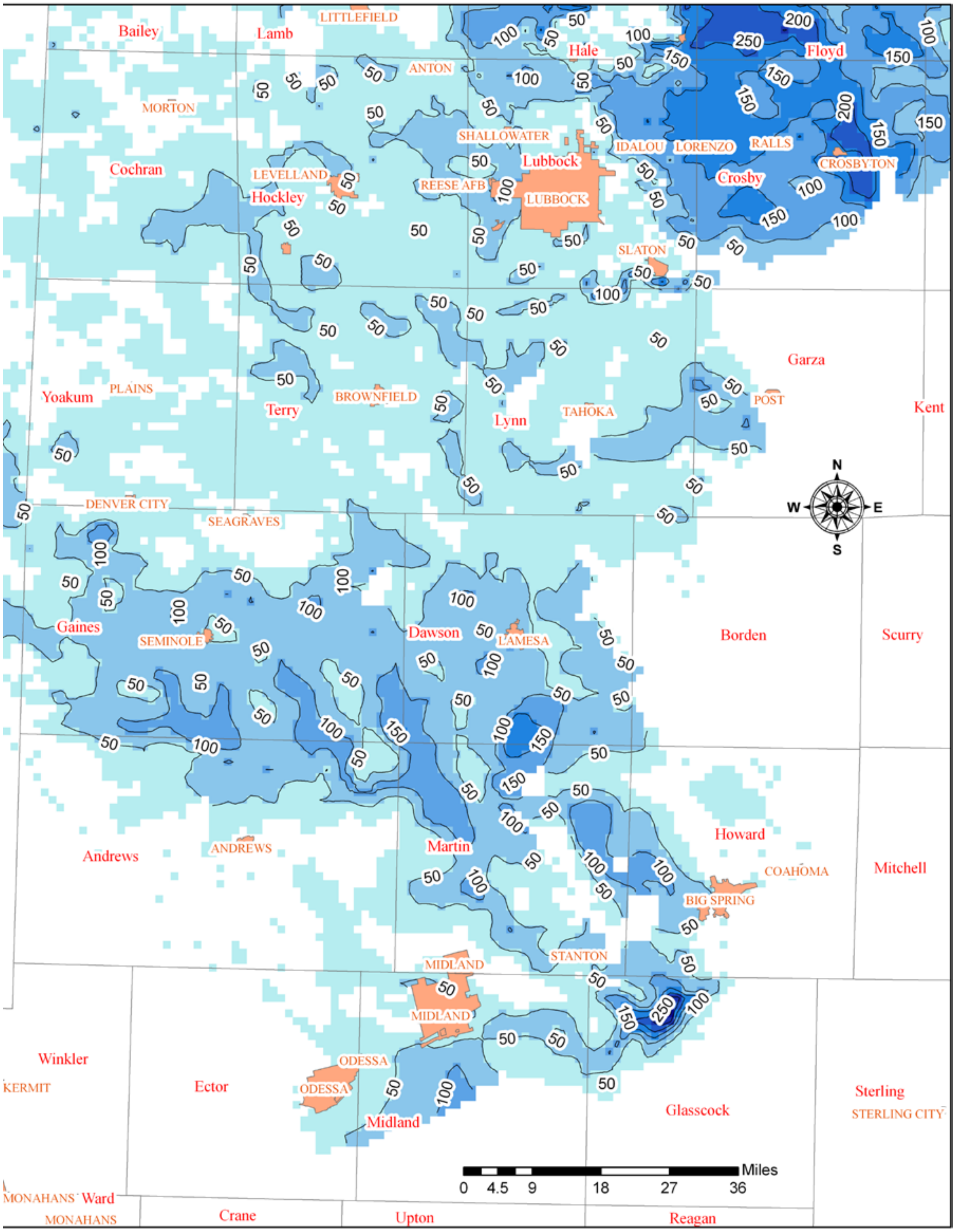

Figure 31: Saturated thickness of the southern half of the Southern Ogallala Aquifer after 20 years of pumping at 1.50 feet of decline per year (see Table 4). White areas are inactive cells or outside the model boundary.

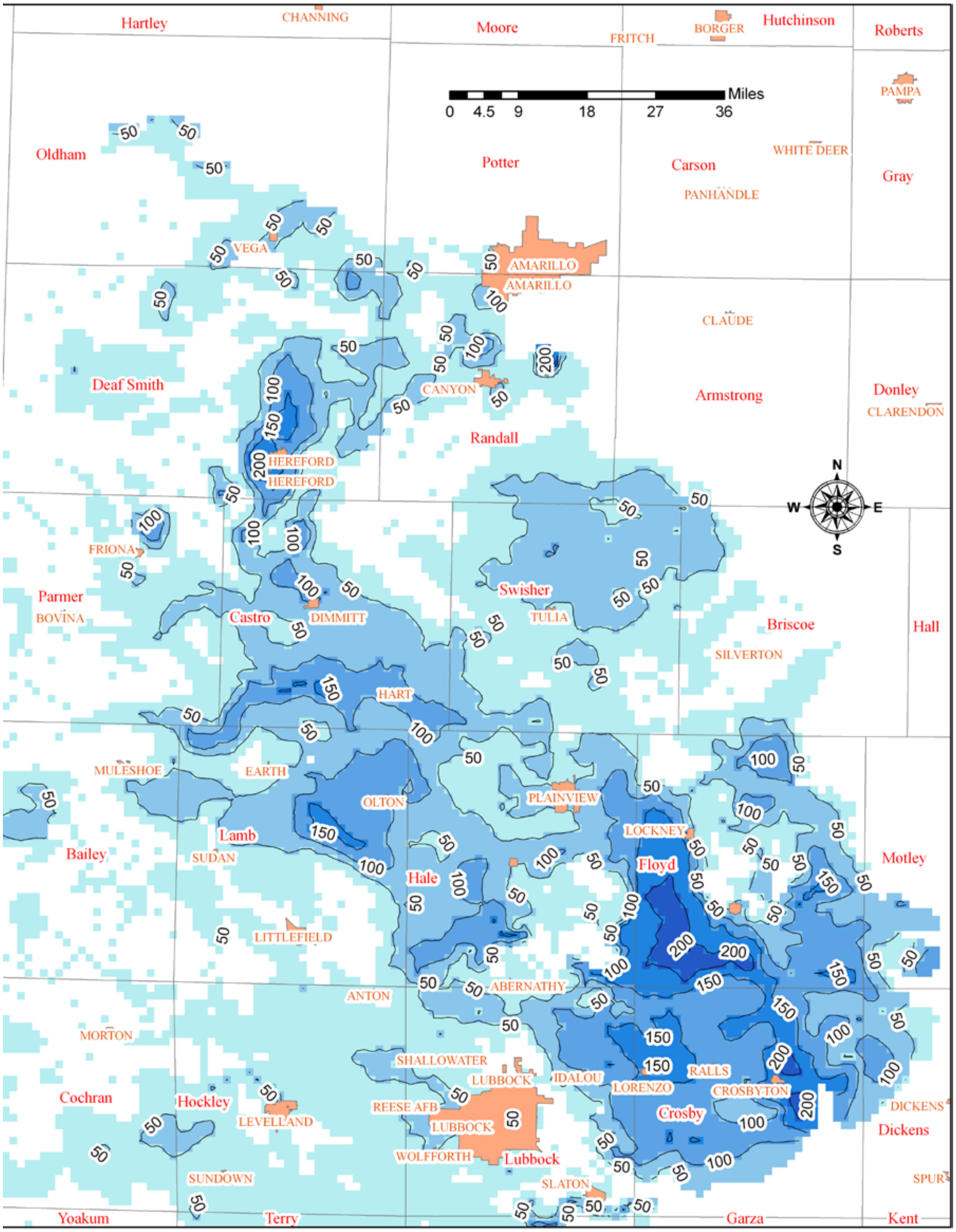

Figure 32: Saturated thickness of the northern half of the Southern Ogallala Aquifer after 30 years of pumping at 1.50 feet of decline per year (see Table 4). White areas are inactive cells or outside the model boundary.

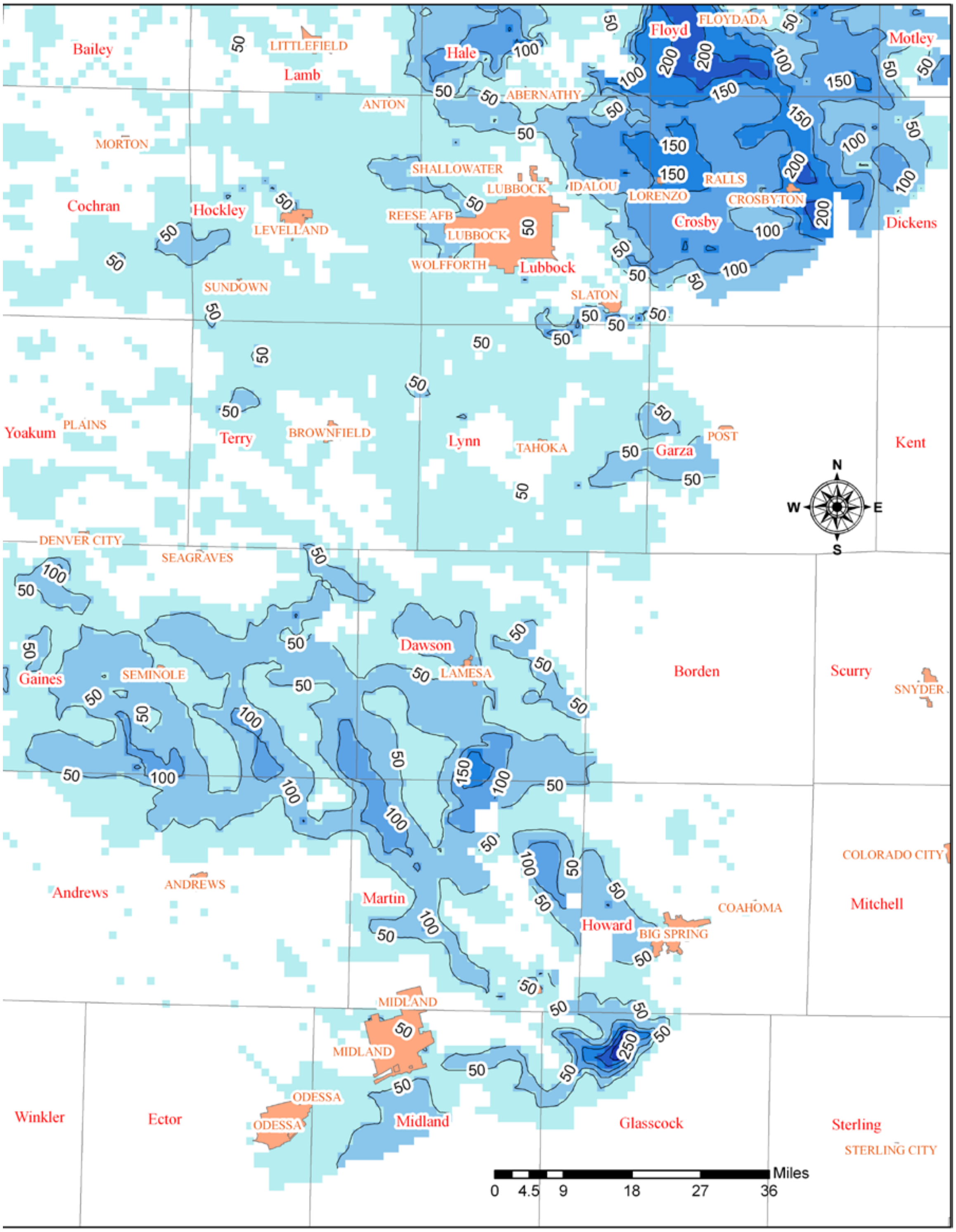

Figure 33: Saturated thickness of the southern half of the Southern Ogallala Aquifer after 30 years of pumping at 1.50 feet of decline per year (see Table 4). White areas are inactive cells or outside the model boundary.

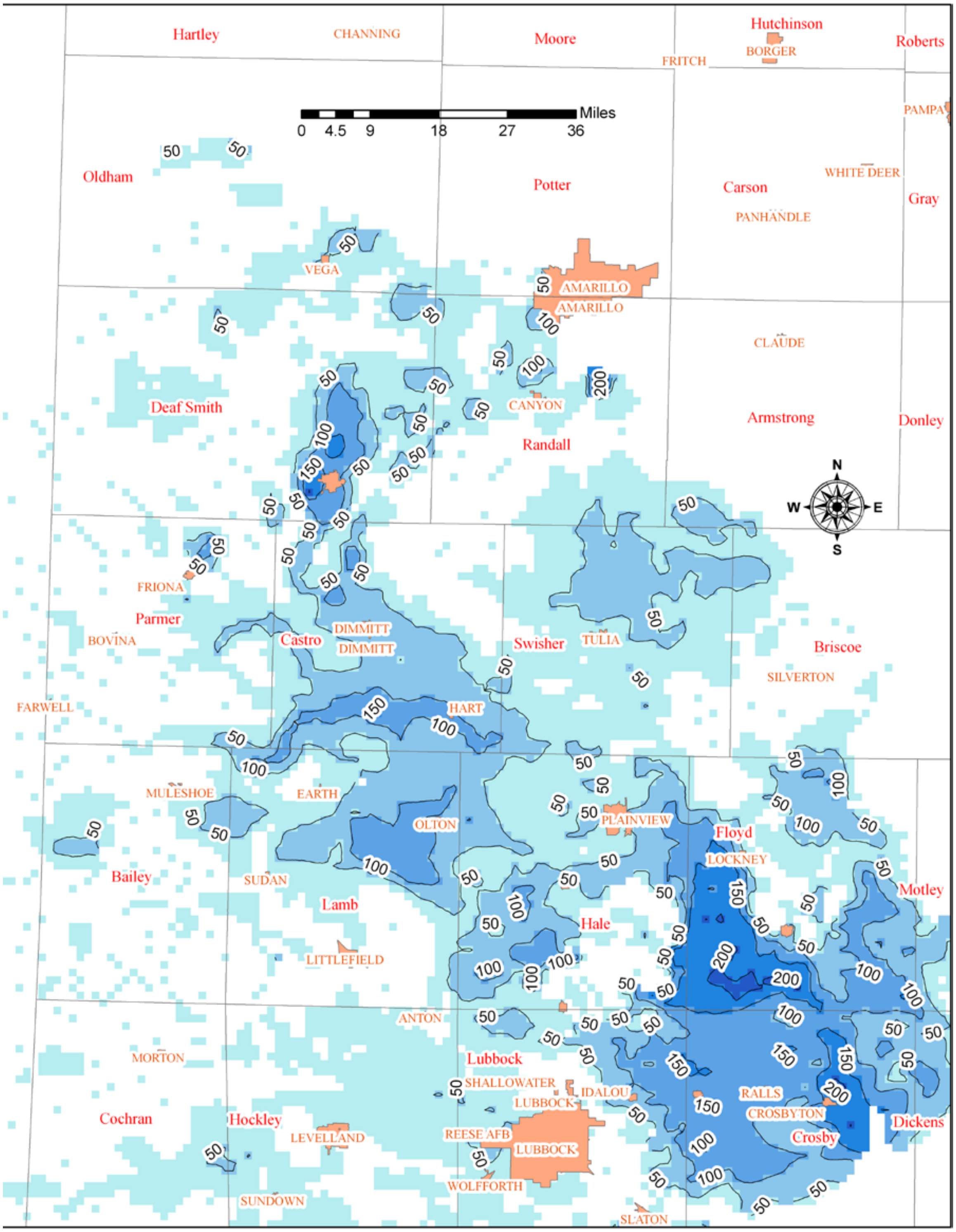

Figure 34: Saturated thickness of the northern half of the Southern Ogallala Aquifer after 40 years of pumping at 1.50 feet of decline per year (see Table 4). White areas are inactive cells or outside the model boundary.

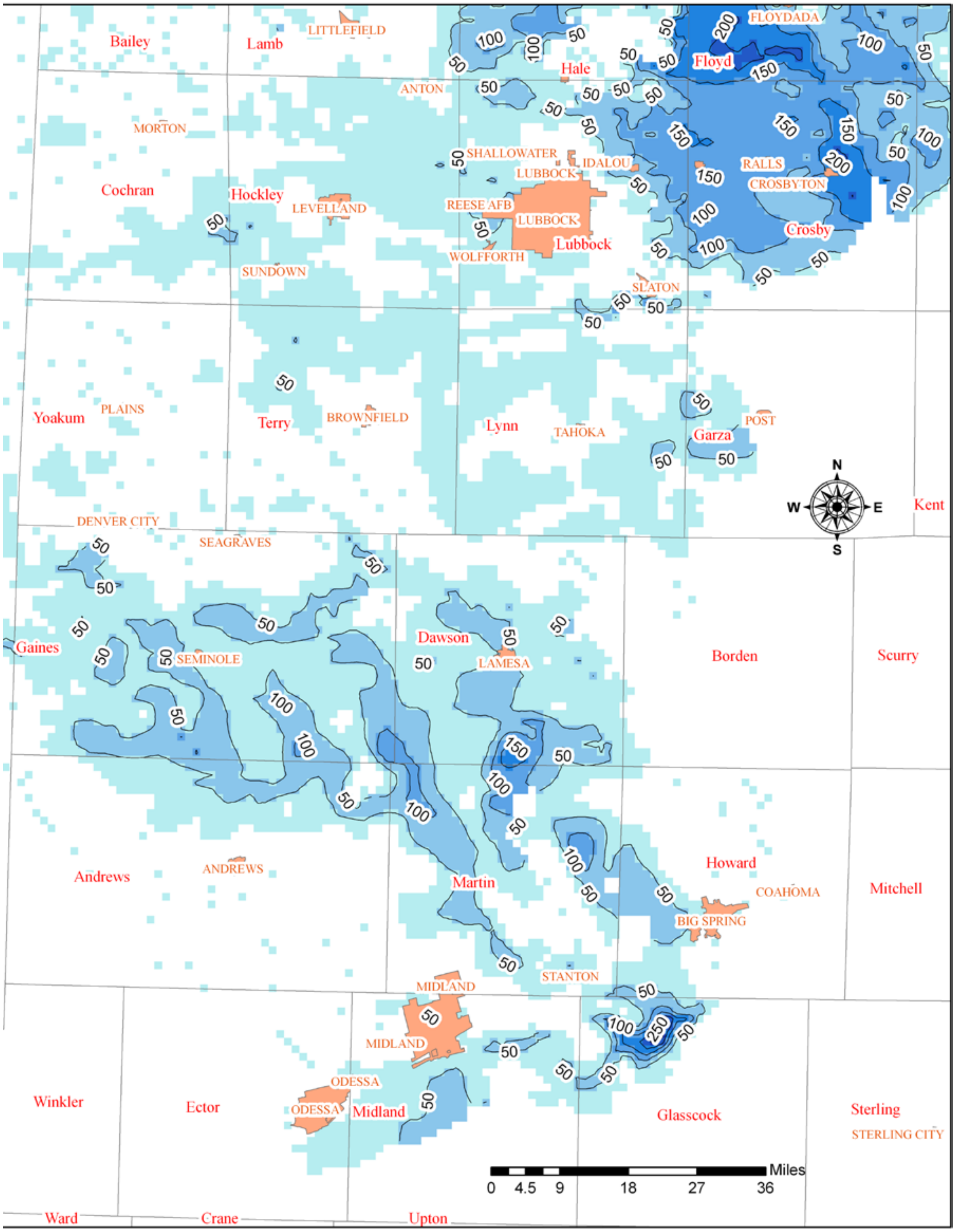

Figure 35: Saturated thickness of the southern half of the Southern Ogallala Aquifer after 40 years of pumping at 1.50 feet of decline per year (see Table 4). White areas are inactive cells or outside the model boundary.

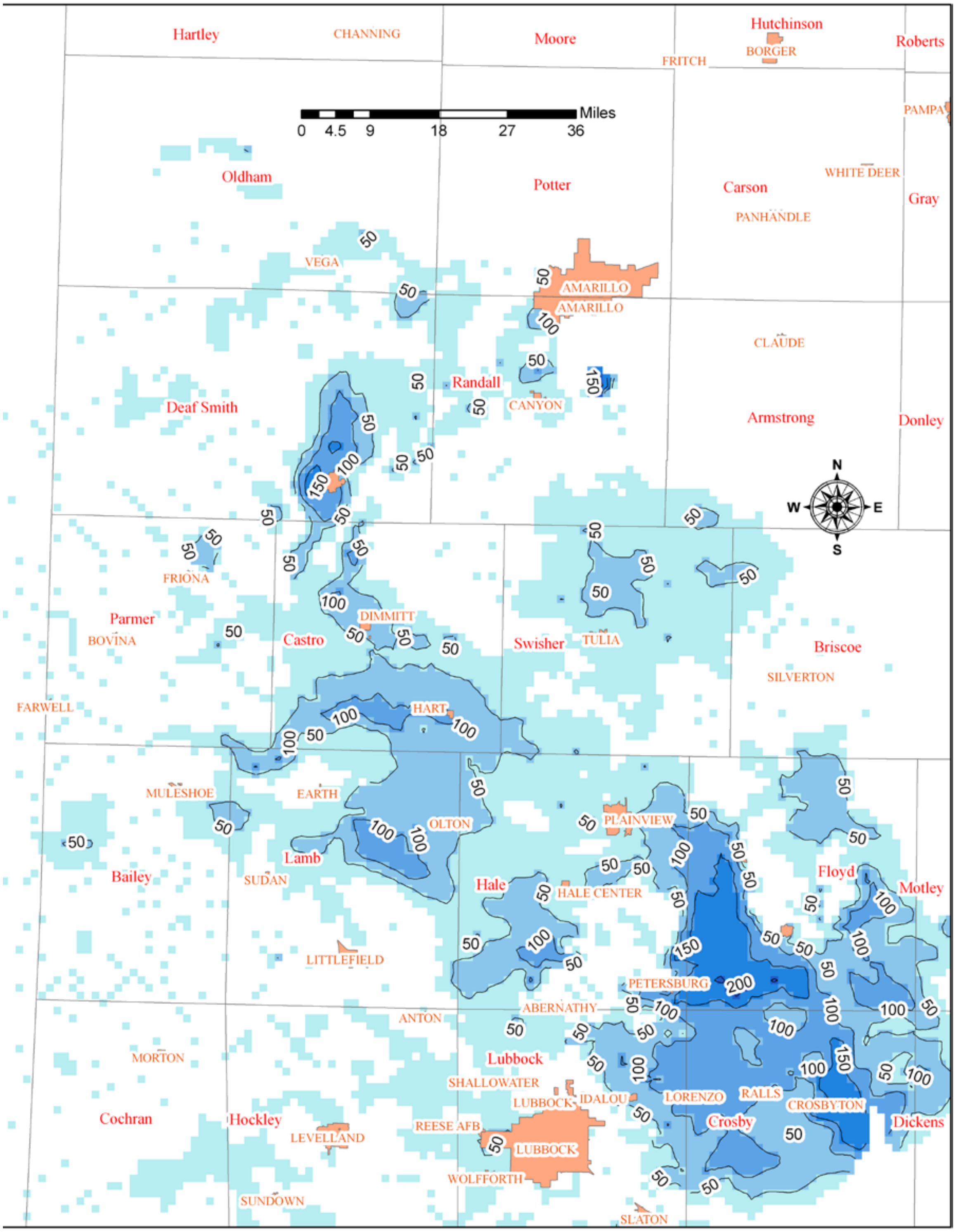

Figure 36: Saturated thickness of the northern half of the Southern Ogallala Aquifer after 50 years of pumping at 1.50 feet of decline per year (see Table 4). White areas are inactive cells or outside the model boundary.

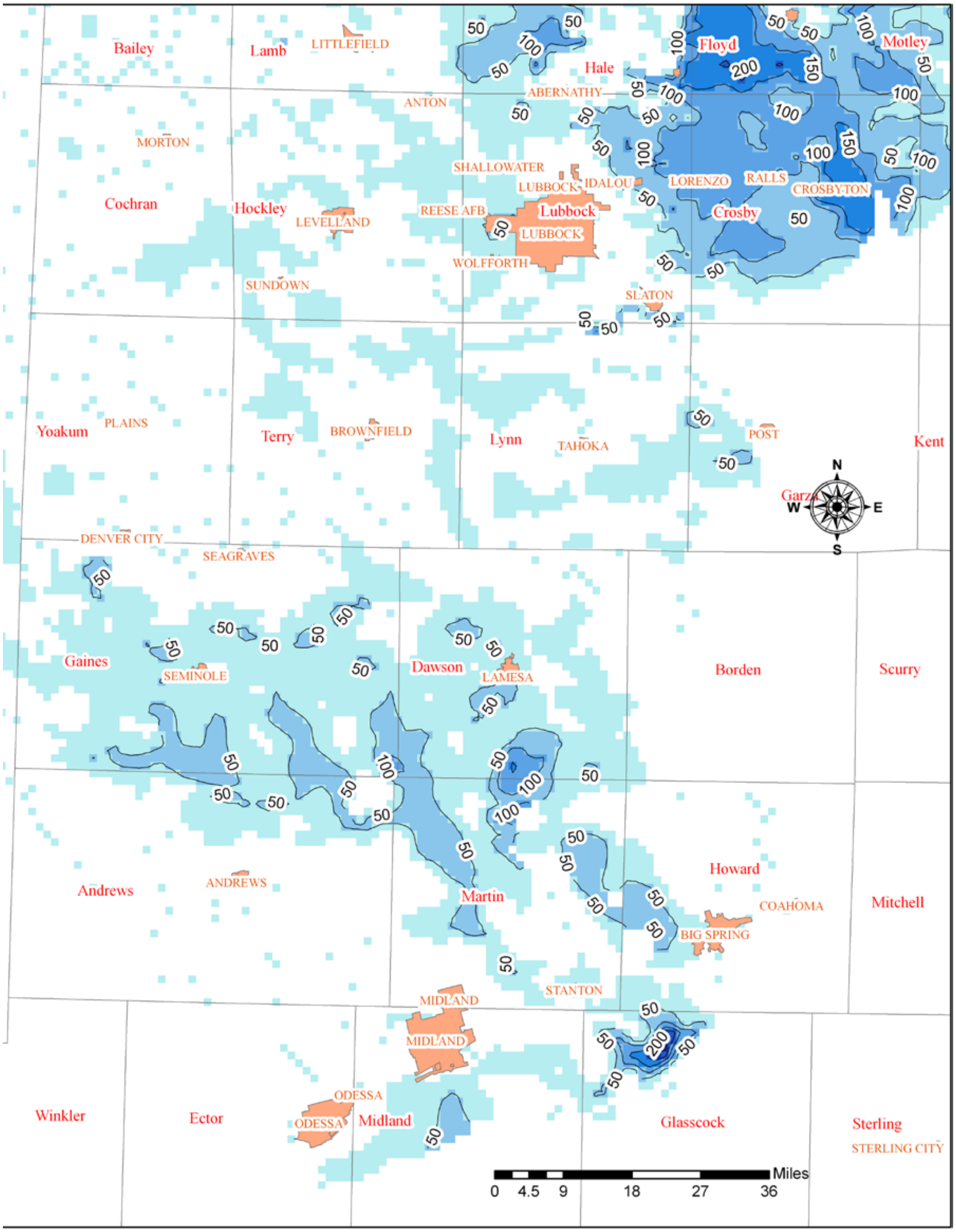

Figure 37: Saturated thickness of the southern half of the Southern Ogallala Aquifer after 50 years of pumping at 1.50 feet of decline per year (see Table 4). White areas are inactive cells or outside the model boundary.

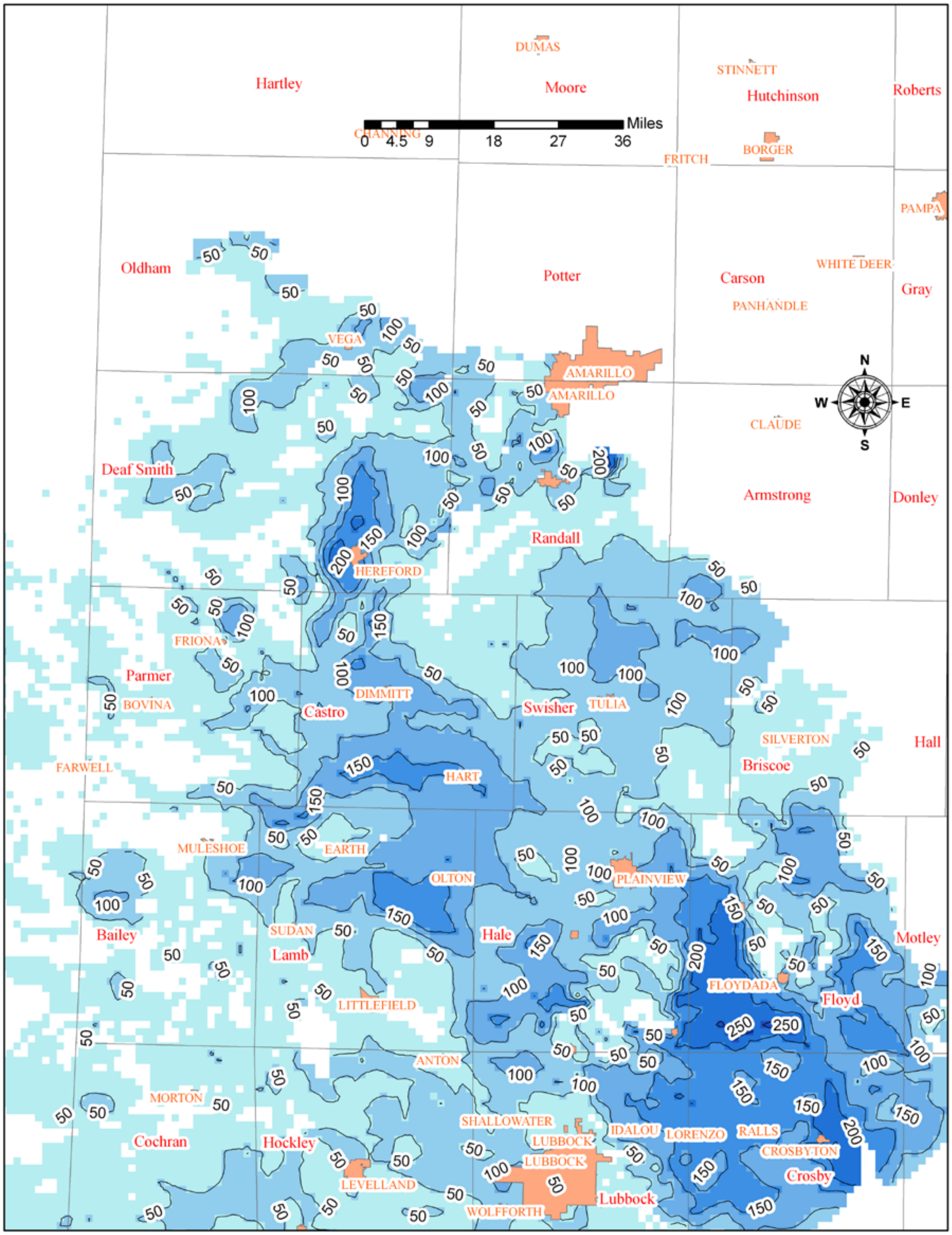

Figure 38: Saturated thickness of the northern half of the Southern Ogallala Aquifer after 10 years of pumping at 1.75 feet of decline per year (see Table 5). White areas are inactive cells or outside the model boundary.

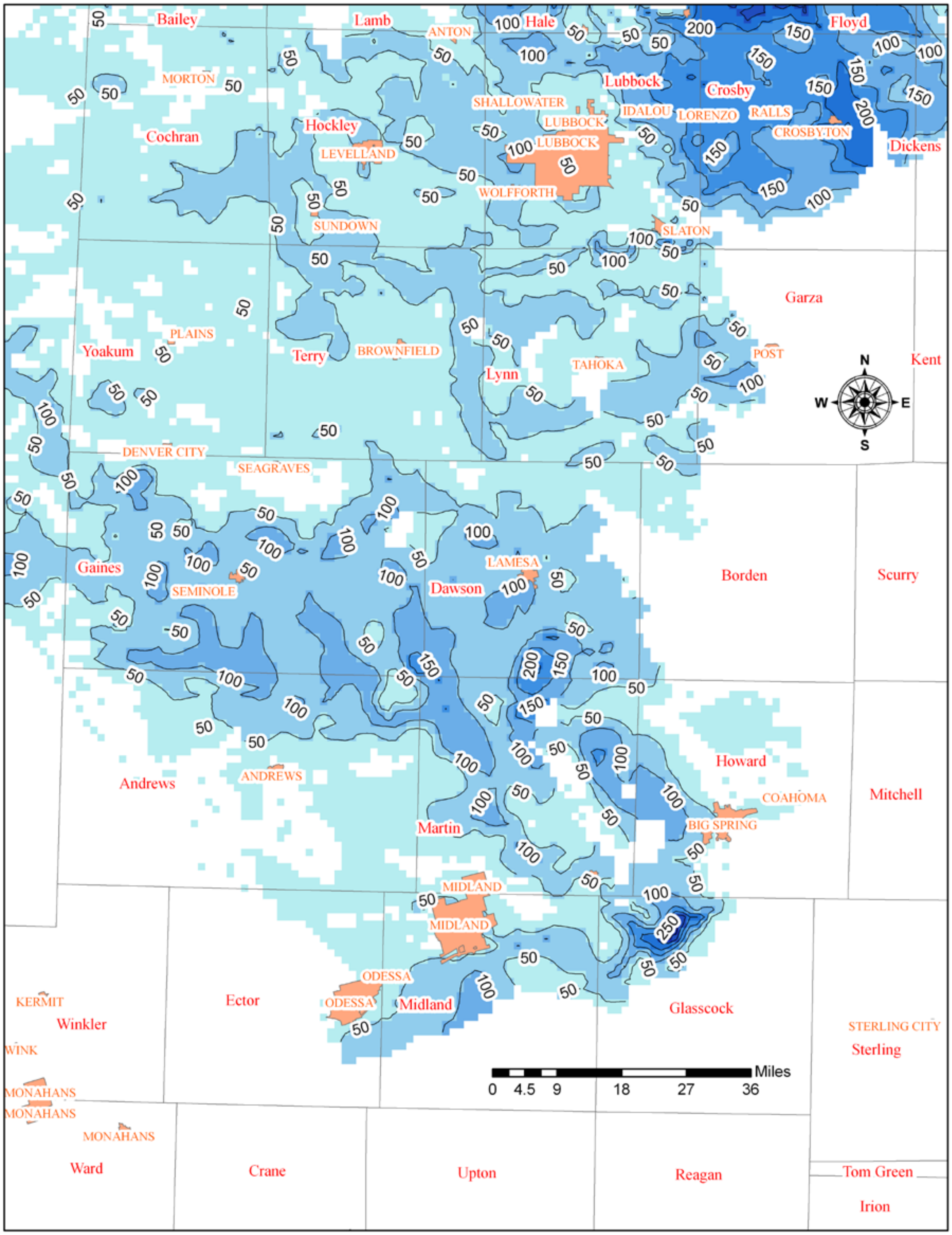

Figure 39: Saturated thickness of the southern half of the Southern Ogallala Aquifer after 10 years of pumping at 1.75 feet of decline per year (see Table 5). White areas are inactive cells or outside the model boundary.

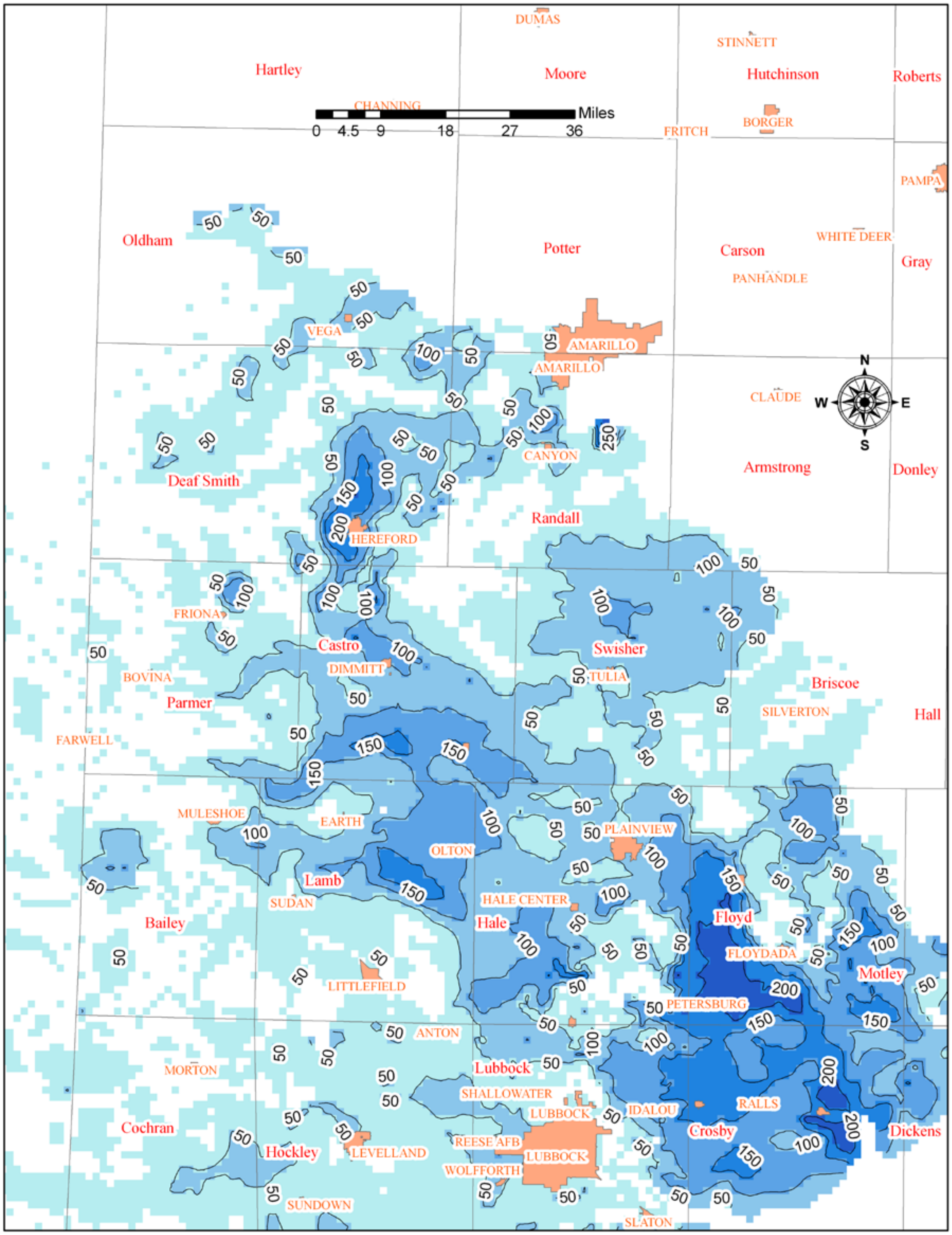

Figure 40: Saturated thickness of the northern half of the Southern Ogallala Aquifer after 20 years of pumping at 1.75 feet of decline per year (see Table 5). White areas are inactive cells or outside the model boundary.

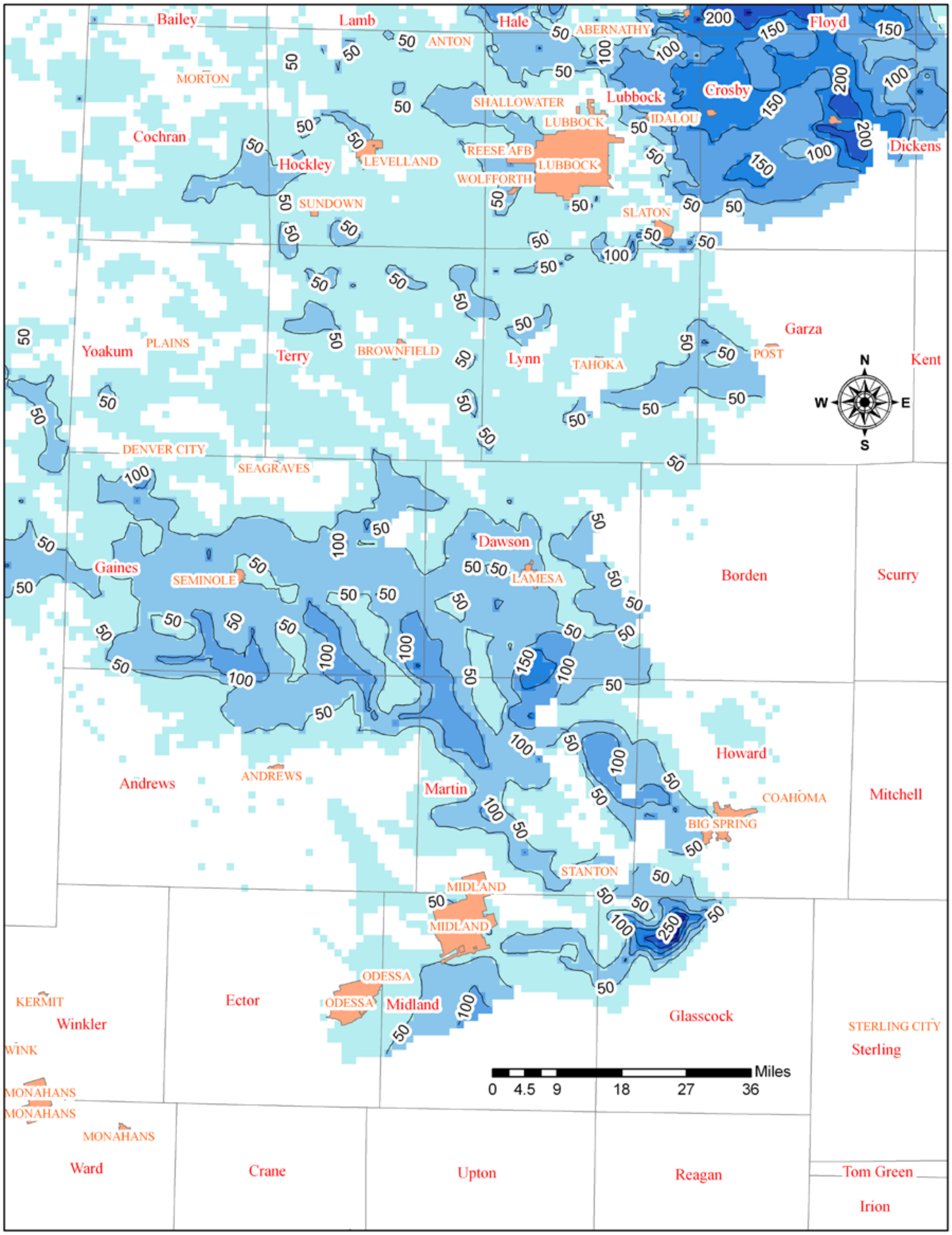

Figure 41: Saturated thickness of the southern half of the Southern Ogallala Aquifer after 20 years of pumping at 1.75 feet of decline per year (see Table 5). White areas are inactive cells or outside the model boundary.

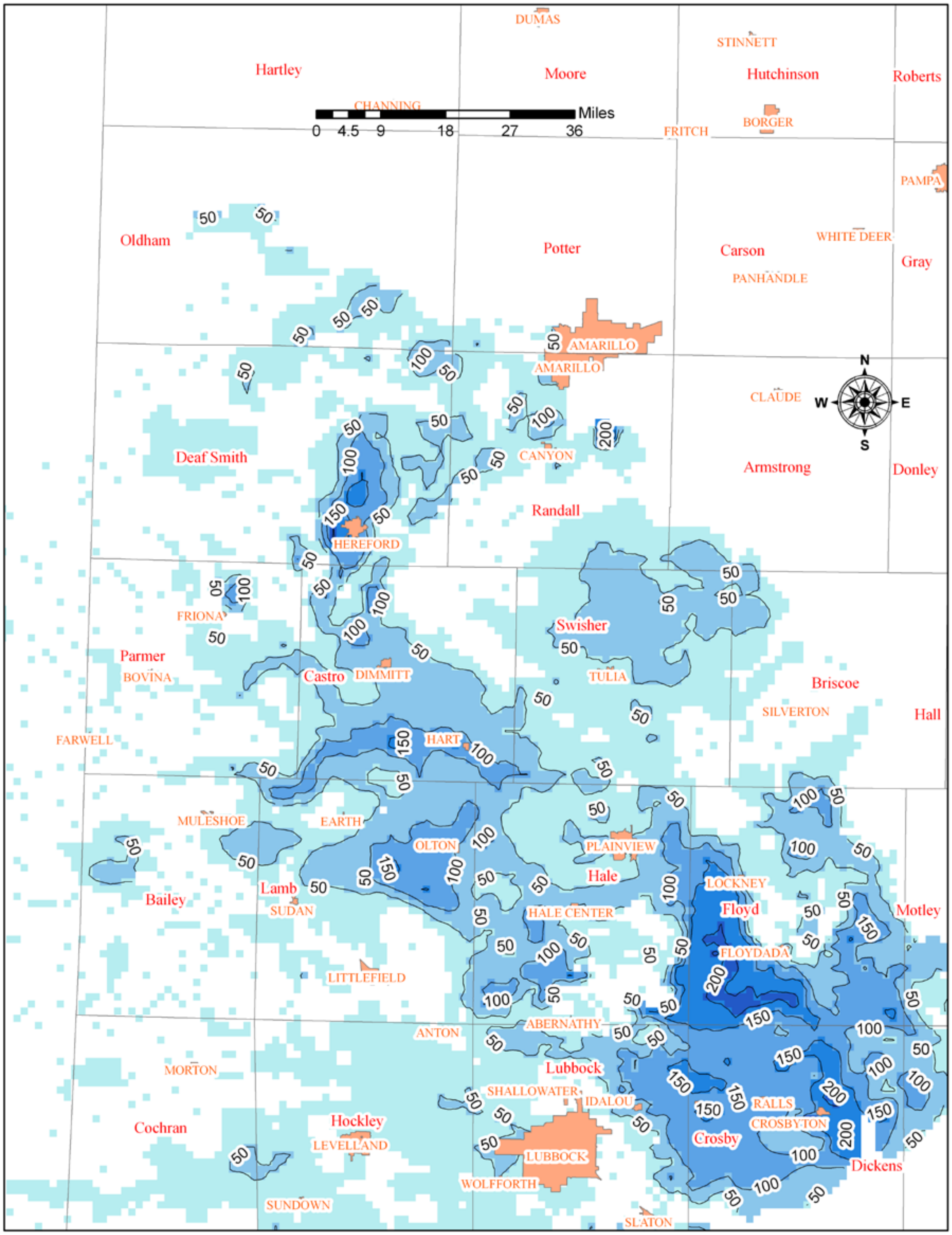

Figure 42: Saturated thickness of the northern half of the Southern Ogallala Aquifer after 30 years of pumping at 1.75 feet of decline per year (see Table 5). White areas are inactive cells or outside the model boundary.

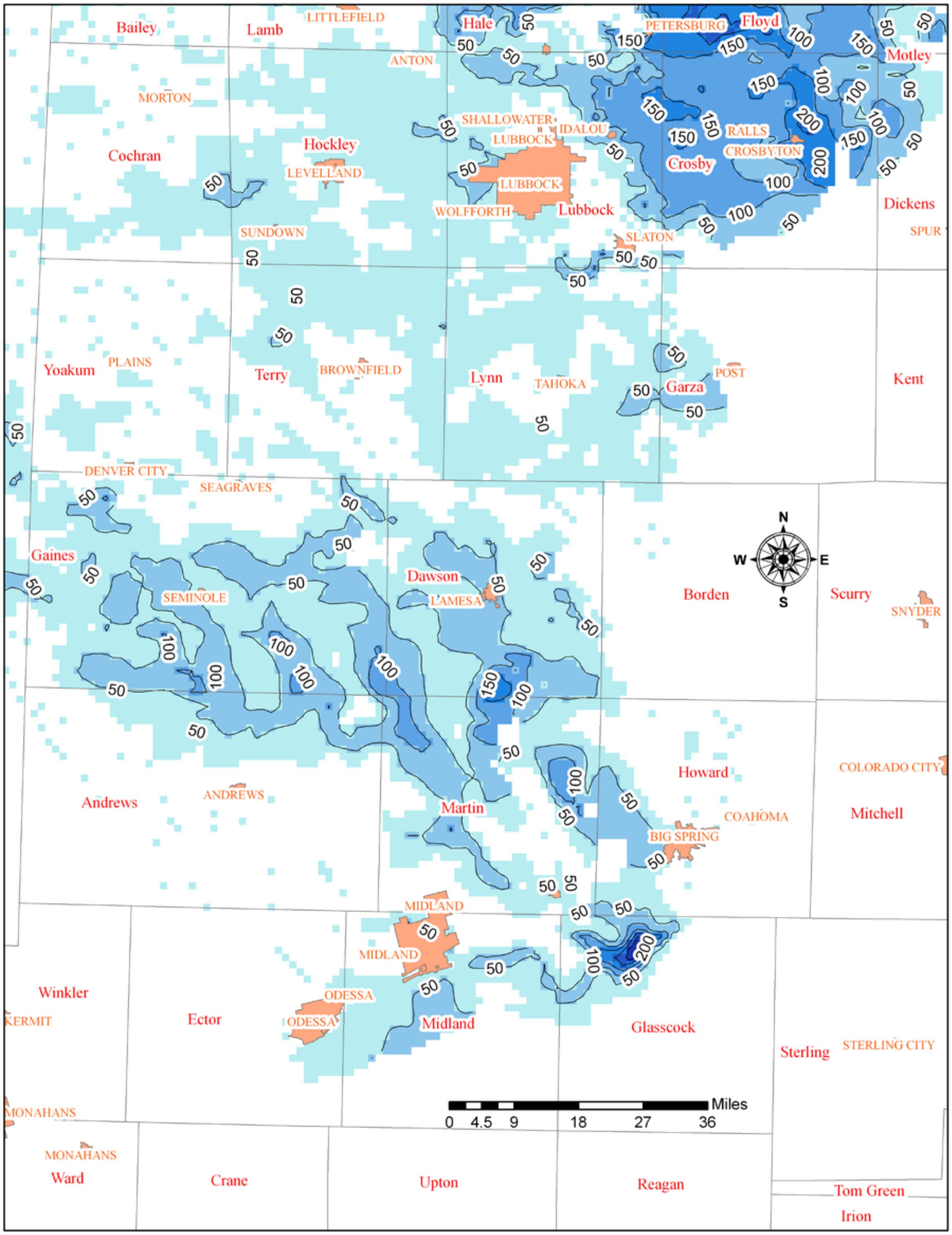

Figure 43: Saturated thickness of the southern half of the Southern Ogallala Aquifer after 30 years of pumping at 1.75 feet of decline per year (see Table 5). White areas are inactive cells or outside the model boundary.

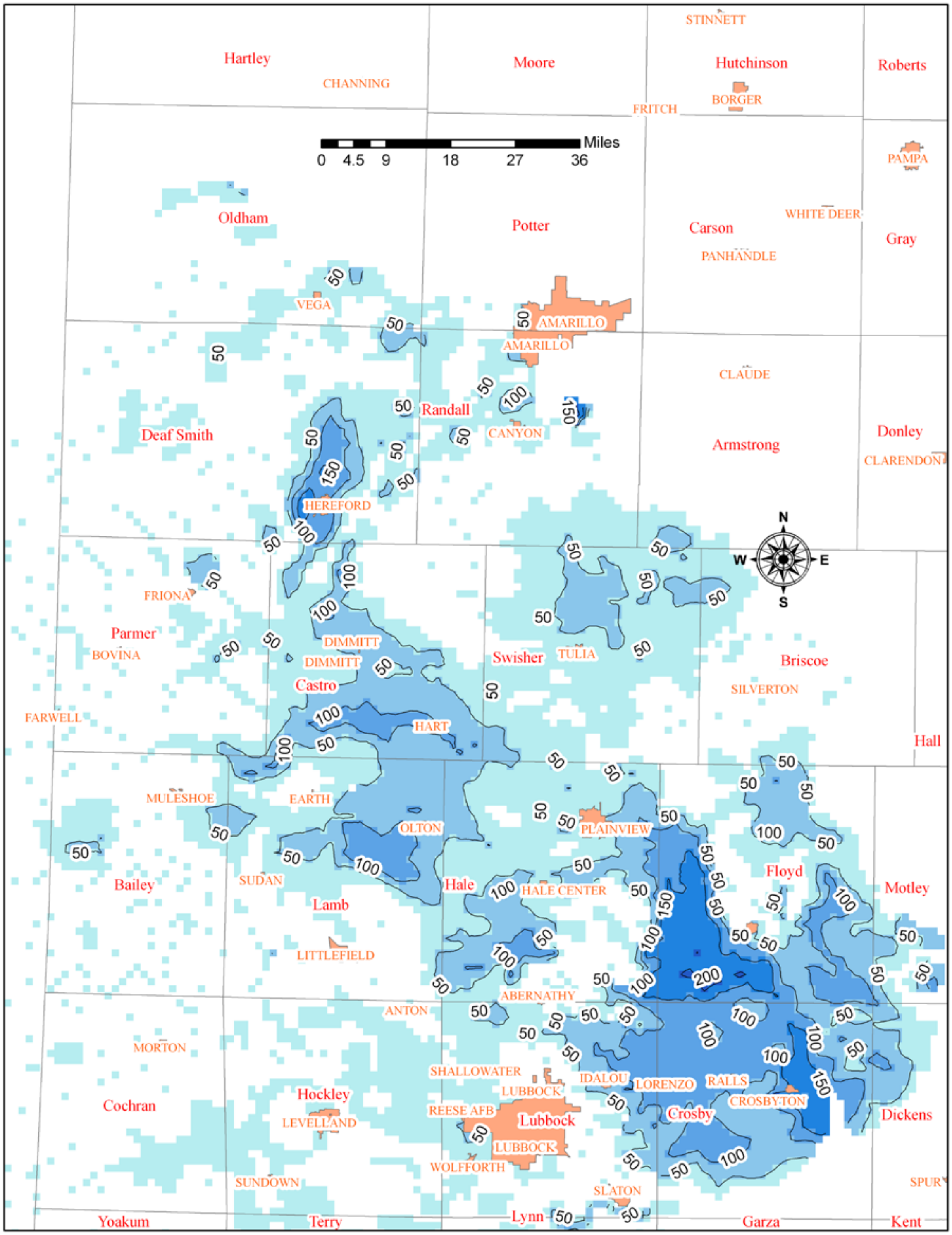

Figure 44: Saturated thickness of the northern half of the Southern Ogallala Aquifer after 40 years of pumping at 1.75 feet of decline per year (see Table 5). White areas are inactive cells or outside the model boundary.

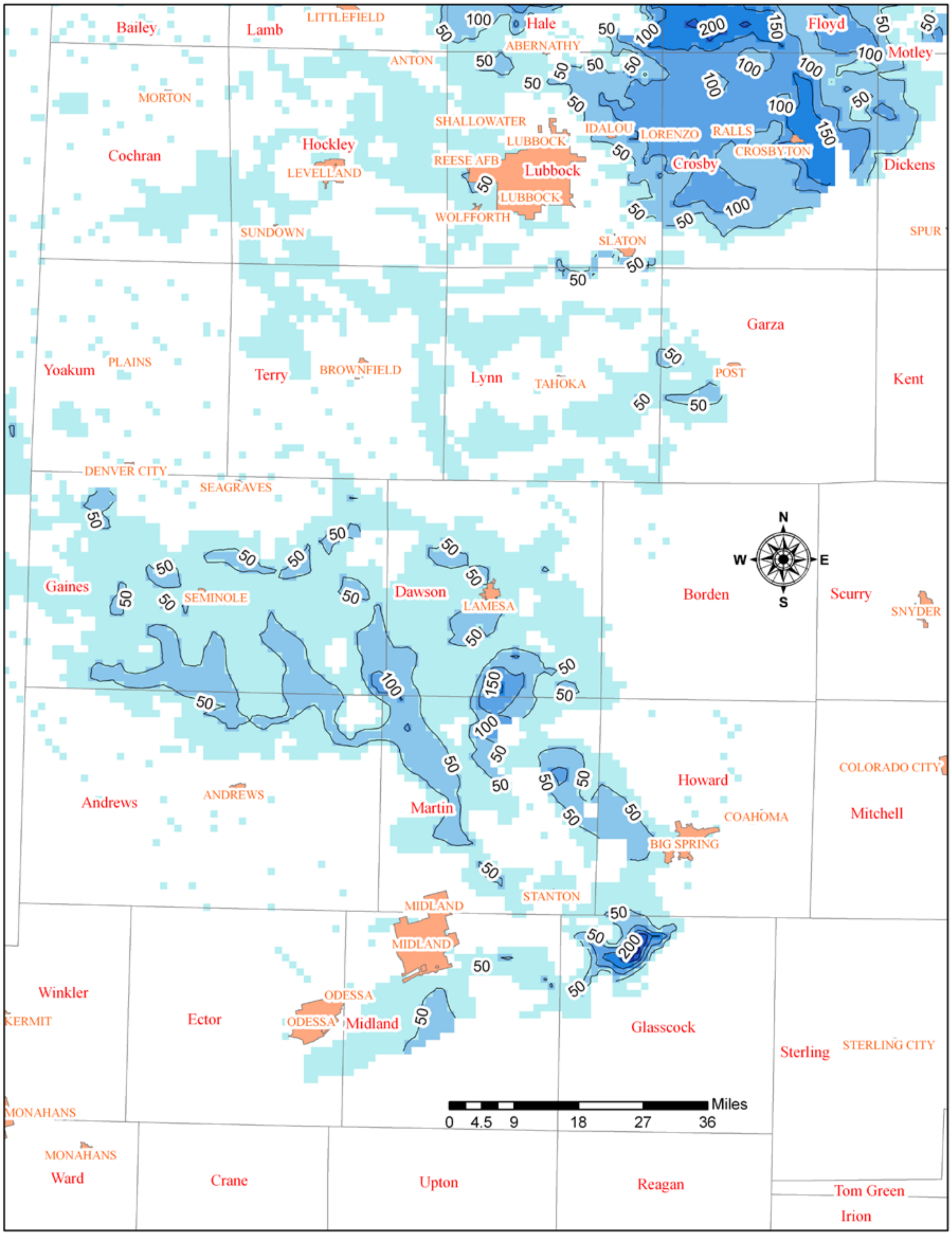

Figure 45: Saturated thickness of the southern half of the Southern Ogallala Aquifer after 40 years of pumping at 1.75 feet of decline per year (see Table 5). White areas are inactive cells or outside the model boundary.

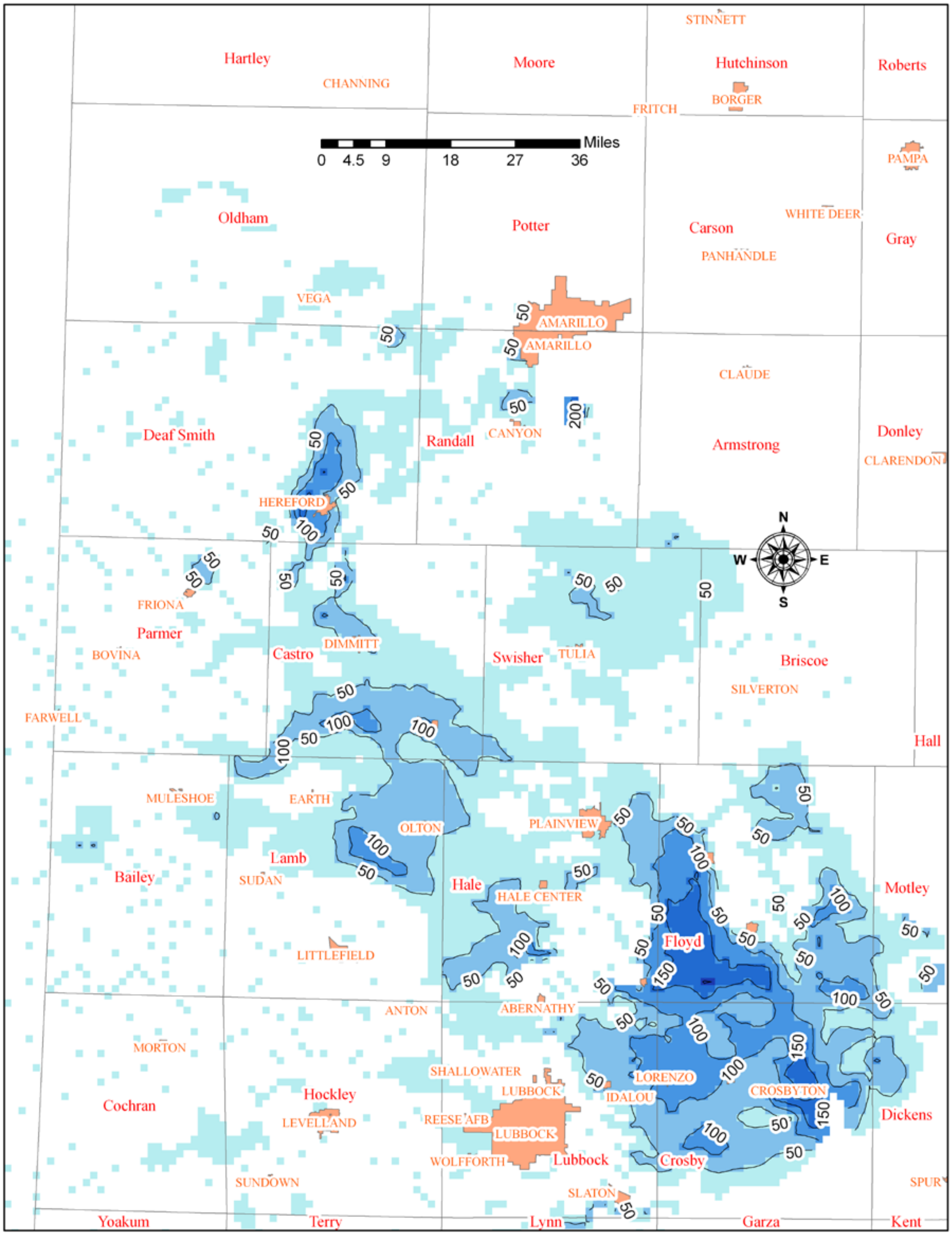

Figure 46: Saturated thickness of the northern half of the Southern Ogallala Aquifer after 50 years of pumping at 1.75 feet of decline per year (see Table 5). White areas are inactive cells or outside the model boundary.

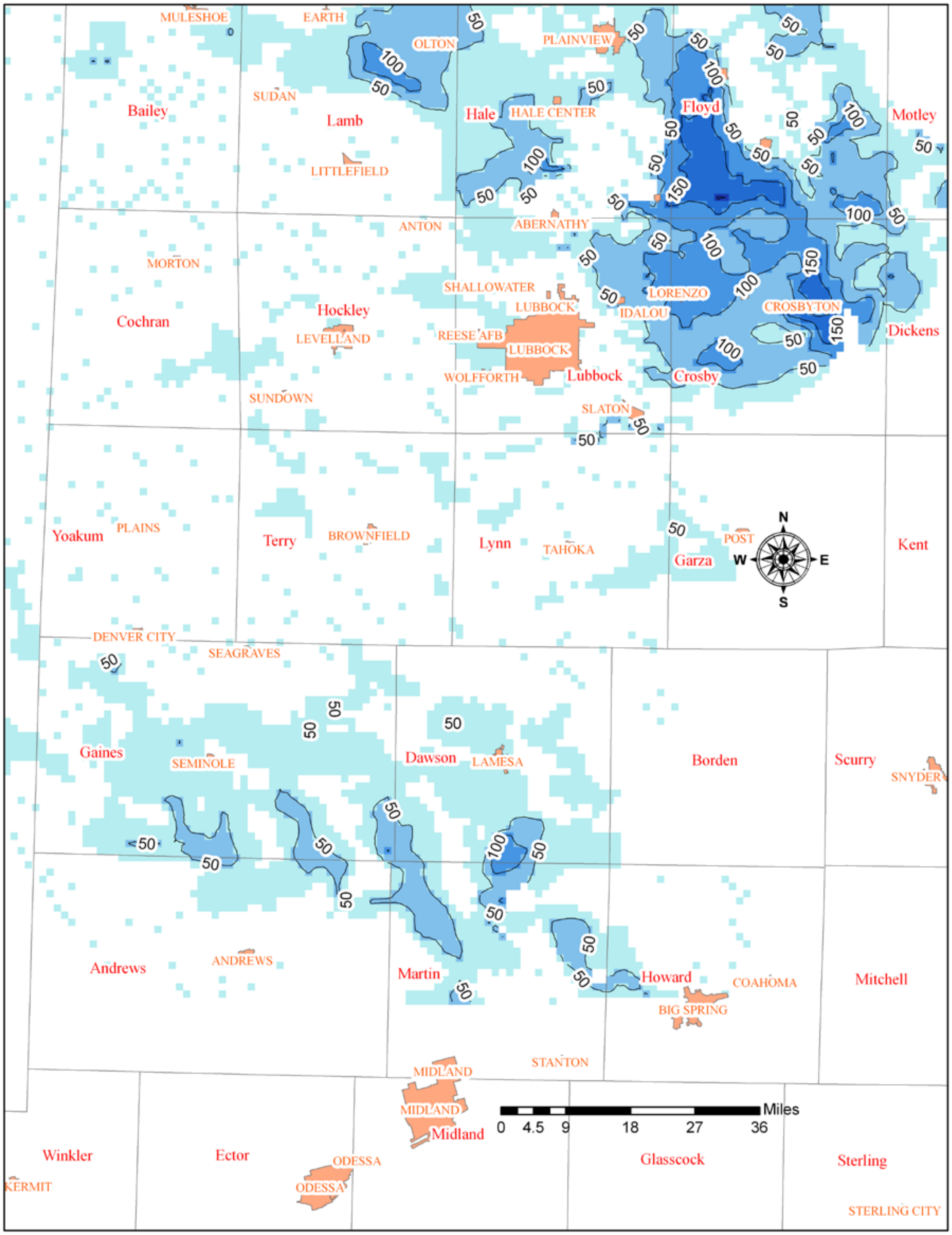

Figure 47: Saturated thickness of the southern half of the Southern Ogallala Aquifer after 50 years of pumping at 1.75 feet of decline per year (see Table 5). White areas are inactive cells or outside the model boundary.