Hydrology & Groundwater Resources 2019-2020

NORTH PLAINS GROUNDWATER Conservation District

Thirteen Edition 2020

District & Aquifer Information
Aquifer Recharge
Annual Groundwater Production
Groundwater Production & G.A.M. Comparison
Water Table Levels & Declines
Water Quality Analyses
Average Depth to Water Maps
Average Groundwater Decline Maps
Average Saturated Thickness Maps

Photo by Dale Hallmark

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I. Introduction

The North Plains Groundwater Conservation District (NPGCD or District), manages the groundwater resources in all or part of eight counties in the Northern Texas Panhandle and is governed by an elected seven-member Board of Directors. The Board established the District's mission, "maintaining our way of life through conservation, protection, and preservation of our groundwater resources" and achieves this mission through the development of long-range management plans, creating and enforcing rules, being actively involved in regional and state water planning, undertaking conservation demonstrations projects and providing public outreach and education programs.

To further advance its management strategies the District promotes new conservation management methods and technologies, cooperates with private, corporate and government entities to promote the conservation, protection and preservation of the area's critically important groundwater resources. The District manages and operates information collection programs, undertakes scientific investigations and offers well testing and water quality analysis services as part of its on-going efforts to monitor aquifer conditions.

Information collected by the District and other agencies is broadly summarized in this "Hydrology and Groundwater Resources" report. District's staff prepared maps for this report showing the District boundaries, estimated depth to water, estimated average annual water level declines, estimated aquifer saturated thickness and maps showing District monitor well locations. This report summarizes the number of active and inactive wells, the number of new wells drilled, measured annual groundwater production, and provides a broad overview of general water quality.

II. Definitions

Cretaceous- A geological period corresponding to 65-144 million years ago.

DFC- (Desired Future Condition) a goal set by the District Board of Directors specifying the condition that an Aquifer will be in at a specified time in the future.

GAM- (Groundwater Availability Model) a predictive numerical computer model of Aquifers that the Texas Water Development Board maintains and operates.

Heterogeneous- Consisting of dissimilar elements or parts; not homogeneous.

Jurassic- A geological period corresponding to 144-208 million years ago.

Inter-formational Flow- A flow of water from one formation into another formation.

Intra-formational Flow- A flow of water from one part of a formation into another part of the same formation.

MAG- (Managed Available Groundwater) a groundwater volume results of a GAM based on specified DFC's.

Permian- A geological period corresponding to 245-286 million years ago.

Pliocene- A geological period corresponding to 2.5 to 5.3 million years before the present.

Recharge- The process whereby water is added to an aquifer either through natural or artificial means. Recharge normally refers to rainfall infiltrating an aquifer through a recharge zone.

Red-Bed- a geological strata consisting primarily of red to orange clays and silts in place below the base of the Ogallala Aquifer.

Saturated Thickness - The distance from the top of an aquifer to the base of the aquifer where the pore spaces are filled with water.

Triassic- A geological period corresponding to 208-245 million years ago.

Unconformably (Unconformity) - the surface between successive strata representing a missing interval in the geologic time record.

III. District Boundaries

The North Plains Groundwater Conservation District is in the Texas Panhandle, north of the city of Amarillo and North of the Canadian River. The District consists of approximately 7,390 square miles which includes all of Dallam, Hansford, Lipscomb, Ochiltree and Sherman counties, as well as part of Hartley, Hutchinson and Moore counties.

The original (1954/1955) area of the District included part of Hartley, Moore and Hutchinson counties and all of Sherman, Hansford and Ochiltree counties. Other areas have annexed into the District over time.

Map 1: District boundaries including areas that annexed into the District over time.

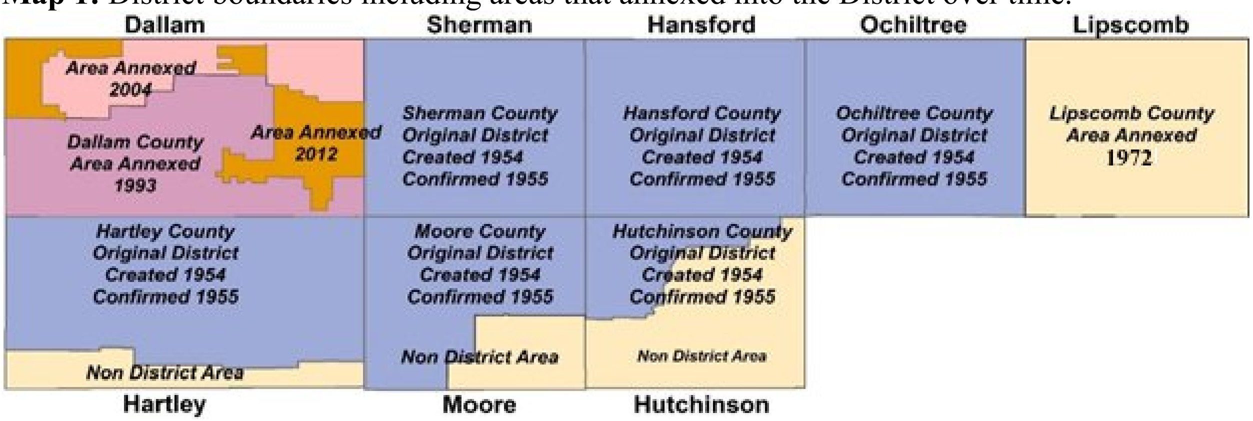


Table 1: County area and percent of each county within the NPGCD.

County	County Area (Sq. Mi.)	Estimated Area in District (Sq. Mi.)	Approximate Number of Acres	Percent of County in the District
Dallam	1505	1505	963,200	100 %
Hansford	907	907	580,480	100 %
Hartley	1463	1244	796,160	83.56 %
Hutchinson	894	278	177,920	30.55 %
Lipscomb	934	934	597,760	100 %
Moore	914	699	447,360	76.51 %
Ochiltree	907	907	580,480	100 %
Sherman	916	916	586,240	100 %
Totals	**8440 Sq. Mi.**	**7390 Sq. Mi.**	**4,729,600 Acres**	

IV. General Geology and Hydrology

Ogallala Aquifer

The Ogallala Aquifer extends from the northern United States into the Texas Panhandle and West Texas and is the primary source of water within the District. The aquifer consists of sands, gravel, silts, and clay sediments that were deposited as part of ancient river systems from about three million to about six million years ago during the Neogene geologic period. An ancient land surface separates the Ogallala from much older strata below of the Permian, Triassic, Jurassic, and Cretaceous geologic periods which range in age from 65 million years to 286 million years. This ancient land surface is called an unconformity and represents between six million years and 65 million years of missing geologic strata in the area.

South of the District, the Canadian River has totally or partially eroded through the Ogallala along much of its length and separates the North Plains from the South Plains. Water-bearing units of Cretaceous and Jurassic ages combine to form the Rita Blanca (a minor aquifer) in the western part of Dallam and Hartley counties. Underlying these aquifers and much of the Ogallala are Triassic age (Dockum Aquifer) sediments and Red Bed strata. The Dockum is a minor, confined to semi-confined aquifer located under Dallam, Hartley and far western Sherman and Moore counties. The water bearing strata is generally locally referred to as the Santa Rosa. For this document, the Ogallala Aquifer is considered to consist of the Ogallala formation and any underlying, potable water-bearing geologic units hydraulically connected with it.

Red Bed (Base of the Aquifer)

Throughout much of the District, the Ogallala aquifer is underlain by "Red Bed". The geology consists of mixed deposits of reddish to orange clay, sands and gravel. The reddish color is caused by staining from the oxides of iron containing minerals. In some areas, the red bed may be absent and in other areas may be several hundred feet thick.

V. Aquifer Thickness or Saturated Material

Saturated thickness maps depict the vertical distance from the water level to the bottom of the aquifer. The saturated thickness of the Ogallala Aquifer ranges from less than 10 feet to over 300 feet and has an estimated average thickness (Table 2) of 148 feet. Saturated thicknesses are calculated every other year and use data from District monitor wells. Other calculation methods will give differing results.

Table 2: 2019-2020 Estimated average aquifer thickness by county (District Area only).

Dallam	Hartley	Sherman	Moore	Hansford	Hutchinson	Ochiltree	Lipscomb
161 ft.	129 ft.	137 ft.	115 ft.	158 ft.	128 ft.	134 ft.	225 ft.

Next scheduled update: Summer of 2021.

VI. Aquifer Recharge, Inflows and Outflows

Surface water and precipitation provide minimal annual recharge to the Ogallala aquifer especially when compared to aquifer withdrawals. District-wide average recharge estimates vary slightly but tend to be below one third of an inch per year. Other inflows and outflows, from and to streams and lateral inflows and outflows tend to be somewhat equal. Some areas of the District however may experience significant local recharge.

The recharge information below (Tables 3,4 and 5) are from the Texas Water Development Board's (TWDB) Groundwater Availability Model Run 17-008. The GAM run was requested by the District for use in the 2018 District Management Plan.

Table 3: Summarized recharge, inflows and out flows to the Ogallala Aquifer. All values are in acre-feet per year rounded to the nearest acre-foot.

Management Plan requirement	Aquifer or confining unit	Results
Estimated annual amount of recharge from precipitation to the district	Ogallala Aquifer	137,029
Estimated annual volume of water that discharges from the aquifer to springs and any surface-water body including lakes, streams, and rivers	Ogallala Aquifer	26,368
Estimated annual volume of flow into the district within each aquifer in the district	Ogallala Aquifer	50,186
Estimated annual volume of flow out of the district within each aquifer in the district	Ogallala Aquifer	94,559
Estimated net annual volume of flow between each aquifer in the district	From Ogallala Aquifer to Rita Blanca and Dockum Aquifers	3,807

TABLE 4: Summarized inflows and outflows to the Dockum Aquifer. All values are in acre-feet per year rounded to the nearest acre-foot.

Management Plan requirement	Aquifer or confining unit	Results
Estimated annual amount of recharge from precipitation to the district	Dockum Aquifer	49
Estimated annual volume of water that discharges from the aquifer to springs and any surface-water body including lakes, streams, and rivers	Dockum Aquifer	0
Estimated annual volume of flow into the district within each aquifer in the district	Dockum Aquifer	4,097
Estimated annual volume of flow out of the district within each aquifer in the district	Dockum Aquifer	2,293
Estimated net annual volume of flow between each aquifer in the district1	From Dockum Aquifer to Ogallala and Rita Blanca Aquifers	1,997

TABLE 5: Summarized inflows and outflows to the Rita Blanca Aquifer. All values are in acre-feet per year rounded to the nearest acre-foot.

Management Plan requirement	Aquifer or confining unit	Results
Estimated annual amount of recharge from precipitation to the district	Rita Blanca Aquifer	0
Estimated annual volume of water that discharges from the aquifer to springs and any surface-water body including lakes, streams, and rivers	Rita Blanca Aquifer	0
Estimated annual volume of flow into the district within each aquifer in the district	Rita Blanca Aquifer	902
Estimated annual volume of flow out of the district within each aquifer in the district	Rita Blanca Aquifer	229
Estimated net annual volume of flow between each aquifer in the district	From Ogallala Aquifer to Rita Blanca Aquifer	2,909
	From Dockum Aquifer to Rita Blanca Aquifer	555

VII. Annual Groundwater Production and Modeled Available Groundwater

The District requires all owners of non-exempt water wells to annually report groundwater production. Table 6 show the groundwater volumes reported to the District from 2015 through 2019. Over the last five years, groundwater withdrawals in the district averaged 1.49 million acre-feet per year. The eastern four counties' (Hansford, Hutchinson, Lipscomb, and Ochiltree) groundwater production averaged 355.8 thousand acre-feet per year; while the western four counties' (Dallam, Hartley, Moore, and Sherman) production averaged 1.14 million acre-feet per year. The east and west pumping averaged 25%, and 75% respectively of the total groundwater production.

Groundwater withdrawals for 2019 in the district totaled 1.421 million acre-feet. The east counties pumped 356 thousand acre-feet (25%) while the west counties pumped 1.065 million acre-feet (75%). 2019 district-wide production is 5.2% below average for the past five years. The east counties pumped about average and west counties pumped about 7% below average.

Table 6: Groundwater production reported to the District, 2015-2019 (Acre-feet).

County	2015	2016	2017	2018	*2019	*Average
Dallam	297,000	339,200	312,300	349,900	303,200	320,300
Hartley	332,700	391,600	376,000	422,600	349,200	374,400
Moore	156,700	185,700	173,100	200,600	157,700	174,800
Sherman	251,700	285,300	265,100	312,000	255,400	273,900
Hansford	148,800	170,400	146,700	190,800	162,300	163,900
Hutchinson	57,700	67,700	63,600	75,500	68,400	66,600
Lipscomb	39,400	42,300	44,200	44,200	43,400	42,700
Ochiltree	77,400	81,400	77,300	95,500	81,800	82,700
West	**1,038,100**	**1,201,800**	**1,126,500**	**1,285,100**	**1,065,500**	**1,143,400**
East	**323,300**	**361,800**	**331,800**	**406,000**	**355,900**	**355,800**
Total	**1,361,400**	**1,563,600**	**1,458,300**	**1,691,100**	**1,421,400**	**1,499,200**

*2019 Production data are provisional and subject to changes.
*Average is an average of the last five years.

Modeled Available Groundwater (MAG)

Texas law requires groundwater conservation districts to adopt aquifer desired future conditions (DFC's), create a 50-year management plan and adopt rules to achieve those DFC's. In adopting DFC's, creating management plans and adopting rules Texas law also requires districts to use estimates of modeled available groundwater (MAG) from the Texas Water Development Board (TWDB). The MAG's are also used to monitor the progress in attaining the District's DFC's. The table below show the average groundwater production from 2015-2019 and the District's combined current MAG amounts for the Ogallala, Rita Blanca and Dockum aquifers.

Table 7: Average annual groundwater production from 2014-2018 and 2018 groundwater production compared to the current estimated Modeled Available Groundwater from the Ogallala, Rita Blanca and Dockum aquifers (GAM RUN 16-029 MAG).

County	2020 MAG	2019 Production	2019 Percent Difference between MAG and Production	Average Production 2015-2019	Average Percent Difference between MAG and Production 2015-2019
Dallam	401,663	303,200	-24.51%	320,300	-20.26%
Hartley	409,187	349,200	-14.66%	374, 400	-8.50%
Moore	219,654	157,7600	-28.21%	174,800	-20.42%
Sherman	398,183	255,400	-35.86%	273,900	-31.21%
Hansford	275,016	162,300	-40.99%	163,800	-40.44%
Hutchinson	62,803	68,400	8.91%	66,600	6.05%
Lipscomb	266,809	43,400	-83.73%	42,700	-84.00%
Ochiltree	243,778	81,800	-66.44%	82,700	-66.08%
West	**1,428,687**	**1,065,500**	**-25.42%**	**1,143,400**	**-19.97%**
East	**848,406**	**355,900**	**-58.05%**	**355,800**	**-58.06%**
Total	**2,277,093**	**1,421,400**	**-37.58%**	**1,499,200**	**-34.16%**

VIII. Depth to Water, Average Declines Based on Groundwater Production and Declines Observed in District Monitor Wells

Changes in the water table, calculated from monitor well measurements vary from rises in the water level to declines that may locally exceed 8-12 feet per year. Each county in the District have areas experiencing little or no decline as well as areas of much greater decline. Declines are caused predominately by agricultural pumping and are influenced primarily by surface recharge of the aquifer and lateral flows into and out of the aquifer.

Recharge is affected by rainfall, surface runoff, evaporation and plant uptake, depth to water, soil porosity and the geologic substrata present. An aquifer characteristic that affects the speed an aquifer refills and consequently how much water a well can produce is intra-formational flow. Intra-formational flow is the flow of water from one part of an aquifer into another part of the same aquifer.

Table 8: 2019 Average yearly county declines in water levels calculated from groundwater production reports.

County	Average Annual Feet of Decline
Dallam	2.02
Hansford	1.83
Hartley	2.95
Hutchinson	2.36
Lipscomb	0.41
Moore	2.49
Ochiltree	0.91
Sherman	2.96

Average declines in water level are calculated values (Table 8) created using reported annual groundwater production and an estimated aquifer specific yield of 18 percent.

Average county declines and average declines observed in monitor wells differ because District monitor wells are predominately located near areas of high pumping. This bias in monitor well location tends to cause an over estimation of declines when used to calculate county averages.

***Table 9:** 2019-2020, Average depth to water and comparisons of average declines in **select** District water level monitor wells.

County	Avg. Depth to Water (Feet)	2020 Avg. Well Decline (Feet)	2019 Avg. Well Decline (Feet)	Current 5-Year Avg. Well Decline (Feet)	Previous 5-Year Avg. Well Decline (Feet)	Current 10-Year Avg. Well Decline (Feet)	Previous 10-Year Avg. Well Decline (Feet)
Dallam	282	2.58	2.61	2.63	2.82	2.74	3.19
Hansford	302	1.71	1.70	1.69	1.68	1.70	1.64
Hartley	364	3.05	3.08	3.12	3.24	3.19	3.56
Hutchinson	350	1.47	1.47	1.46	1.45	1.46	1.41
Lipscomb	162	0.49	0.49	0.49	0.44	0.44	0.43
Moore	358	2.34	2.34	2.33	2.31	2.32	2.08
Ochiltree	333	1.18	1.14	1.11	0.97	1.03	0.78
Sherman	313	2.48	2.45	2.43	2.37	2.37	2.32
District-wide	**308**	**1.91**	**1.91**	**1.91**	**1.91**	**1.91**	**1.93**

**The information in Table 9 is derived from statistical analyses of monitor well hydrographs created from current and historical information. The statistical analyses (indicating both rises and declines) may indicate the quality of information collected from some wells is less than optimal. Such data may be included in the calculations of declines and depth to water as it represents the best or in some cases the only information available.*

IX Active Production Wells within the District

District records indicate that there are over 15,800 well permits that have been issued since the District was created in 1955. Currently there are 10,680 large active wells which include wells varying in production between 18 GPM to over 1,000 GPM. During 2020, the District issued 189 permits of all types from January through the end of April.

Table 10: Summary of wells in the District and recent new well permits.

County	Active Production Wells	Capped Wells	Small Registered Wells	2019 Permits Issued	2020 Permits Issued Through April 2020
Dallam	2606	243	701	67	59
Hansford	905	439	257	28	6
Hartley	2664	142	387	43	86
Hutchinson	393	145	116	17	5
Lipscomb	289	68	238	7	0
Moore	1313	352	459	32	7
Ochiltree	558	238	267	13	5
Sherman	1952	325	287	64	21
Total	**10680**	**1952**	**2712**	**271**	**189**

*Well count totals may vary slightly over time due to differing database query techniques and as any errors are corrected.

X. District Monitor Wells

Typical District Monitor Well

The District monitors declines in groundwater levels by maintaining a network of water-level monitoring wells. Currently the District measures 434 wells (Table 11). Monitor wells are measured annually beginning in January and measurements are complete by mid-March. The information collected is analyzed, used to create maps and plays a vital role in making reasonable long-term management decisions based on the best available scientific data.

As part of its water level monitoring program, the District may drill or install water level monitoring equipment in wells (up to ten wells) annually. The drilled wells are non-production wells dedicated solely to data collection which provide information of more accuracy, reliability, and consistency than other types of wells the District monitors. They are also readily available, if needed, for conducting aquifer tests that cannot be conducted using other well types.

Table 11: 2020 Water level monitor wells by county.

County	Number of Monitor Wells
Dallam	69
Hartley	68
Sherman	60
Moore	52
Hansford	67
Hutchinson	25
Ochiltree	48
Lipscomb	45
Total	**434**

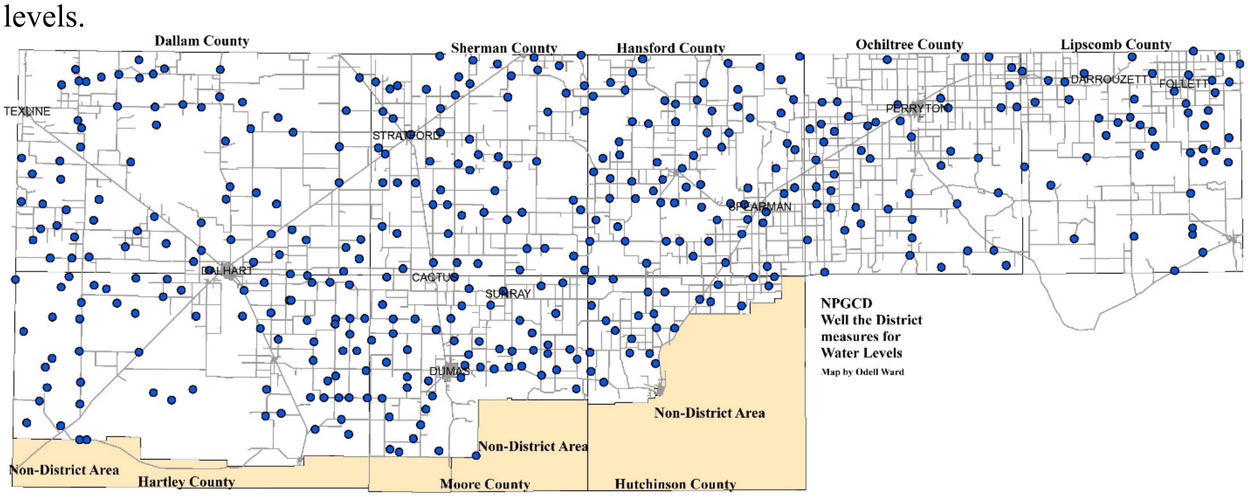
District monitor well under construction

XI. 2020 District Monitor Well Locations and On-line Interactive Maps

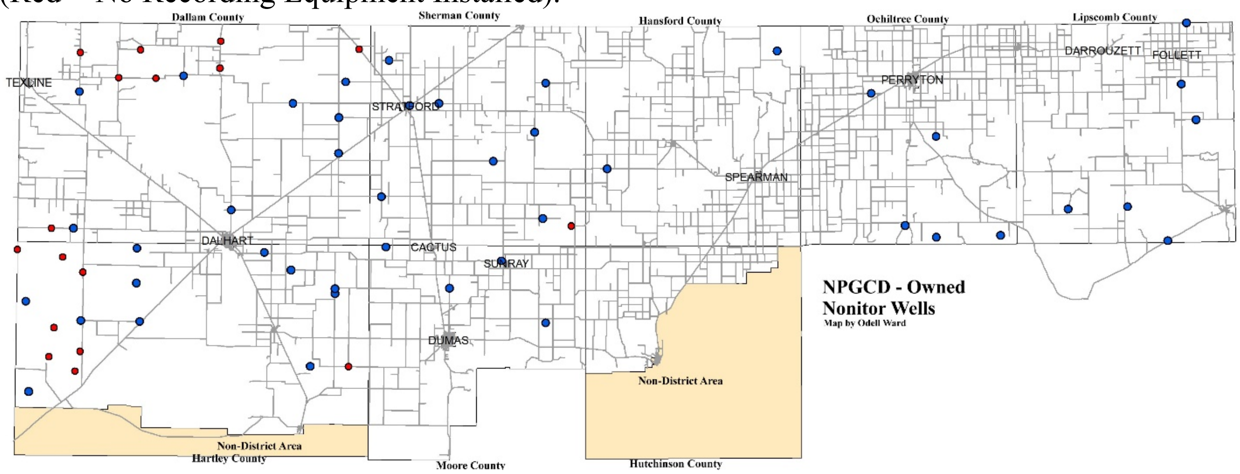
The District maintains a website where data from wells, monitor wells and recording equipment may be viewed. The map is always a work in progress and all data may not yet be available. More data and other map layers may become available as work on the on-line map progresses.

http://map.northplainsgcd.org/

Map 2: 2020 map of private well locations from which the District annually measures water levels.



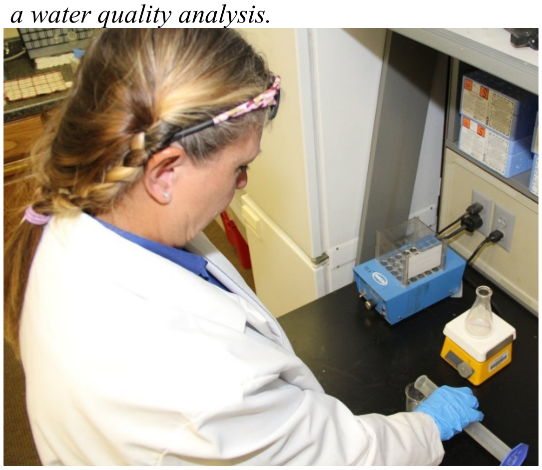
Map 3: 2020 District-owned water level monitor wells with and without recording equipment. (Red = No Recording Equipment Installed).



XII. Water Quality

The District's goals for groundwater is that future water supplies are of sufficient quantity and also of excellent quality. The District monitors groundwater chemistry by analyzing samples from select wells within the District and performing water quality analyses upon request from area residents.

District Natural Resource Specialist performing a water quality analysis.



The District may analyze water samples for the following parameters as necessary:
Total Hardness,
Chloride,
Conductivity,
Fluoride,
Iron,
Nitrate,
pH,
Sodium,
Sulfate,
Total Dissolved Solids,
The Presence or Absence of Coliform Bacteria.

Groundwater within the District is considered excellent although it is "hard" water and contains considerable calcium and some magnesium carbonate (hardness) (Table 12). The District also performs analyses to indicate the presence or absence of coliform bacteria. In the rare instance an analysis indicates the presence of coliform bacteria, the contamination source is often located within a few yards of the sampled well. Normally a well that tests positive for coliform bacteria can be decontaminated by eliminating the contaminate source, chlorinating the well, pipes and water storage equipment and then purging the well, pipes and water storage equipment.

Table 12: Typical mineral analyses from wells within the District.

Parameter	Units	2018 Number of Analyses	2018 Average Analysis Result	2019 Number of Analyses	2019 Average Analysis Result	2020 Number of Analyses	2020 Average Analysis Result
Sulfate	mg/l	32	50.8	29	44.68	16	*Pending
Nitrate	mg/l	22	11.14	29	1.653	16	*Pending
Total Iron	mg/l	22	0.234	29	.0433	16	*Pending
Chlorides	mg/l	22	60.77	29	30.57	16	*Pending
Fluoride	mg/l	22	.0466	29	.661	16	*Pending
Total Hardness	mg/l	22	217	29	208	18	*Pending

**Due to the 2019-2020 Corvid19 pandemic, scheduled sampling and analyess are delayed.*

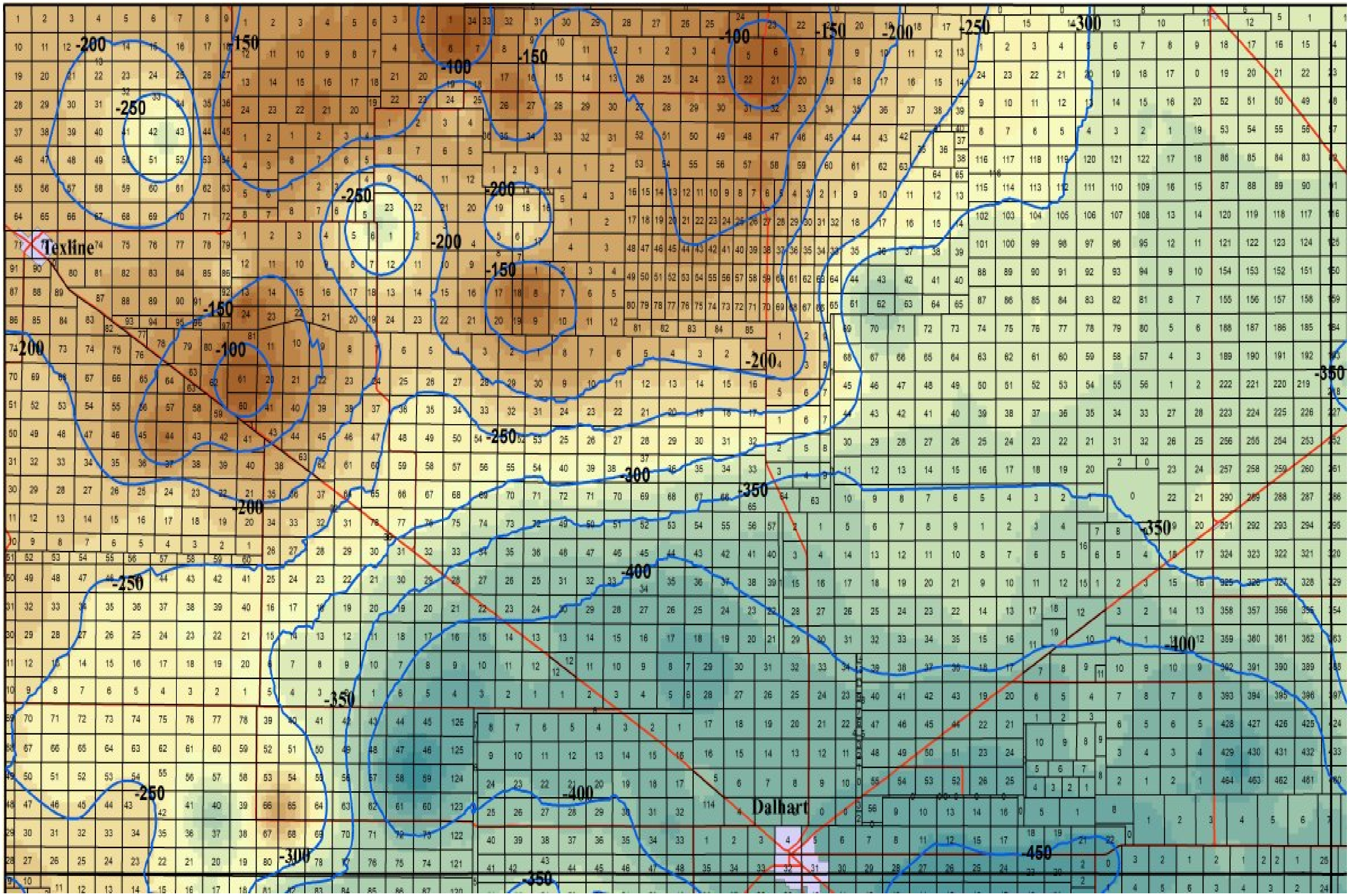
Table 12 shows the average mineral compositions indicated from analyses of well water from within the District. The District samples random wells at the owner's request as well as annually analyzing a subset of wells from the District's monitoring well program. No meaningful conclusions may be drawn from the above table about potential changes in water quality over time as the values are not all from the same set of wells. District residents may request a groundwater analysis by contacting the District. In most instances the analyses are free to District residents.

XIII. 2020 Depth to Water from Land Surface

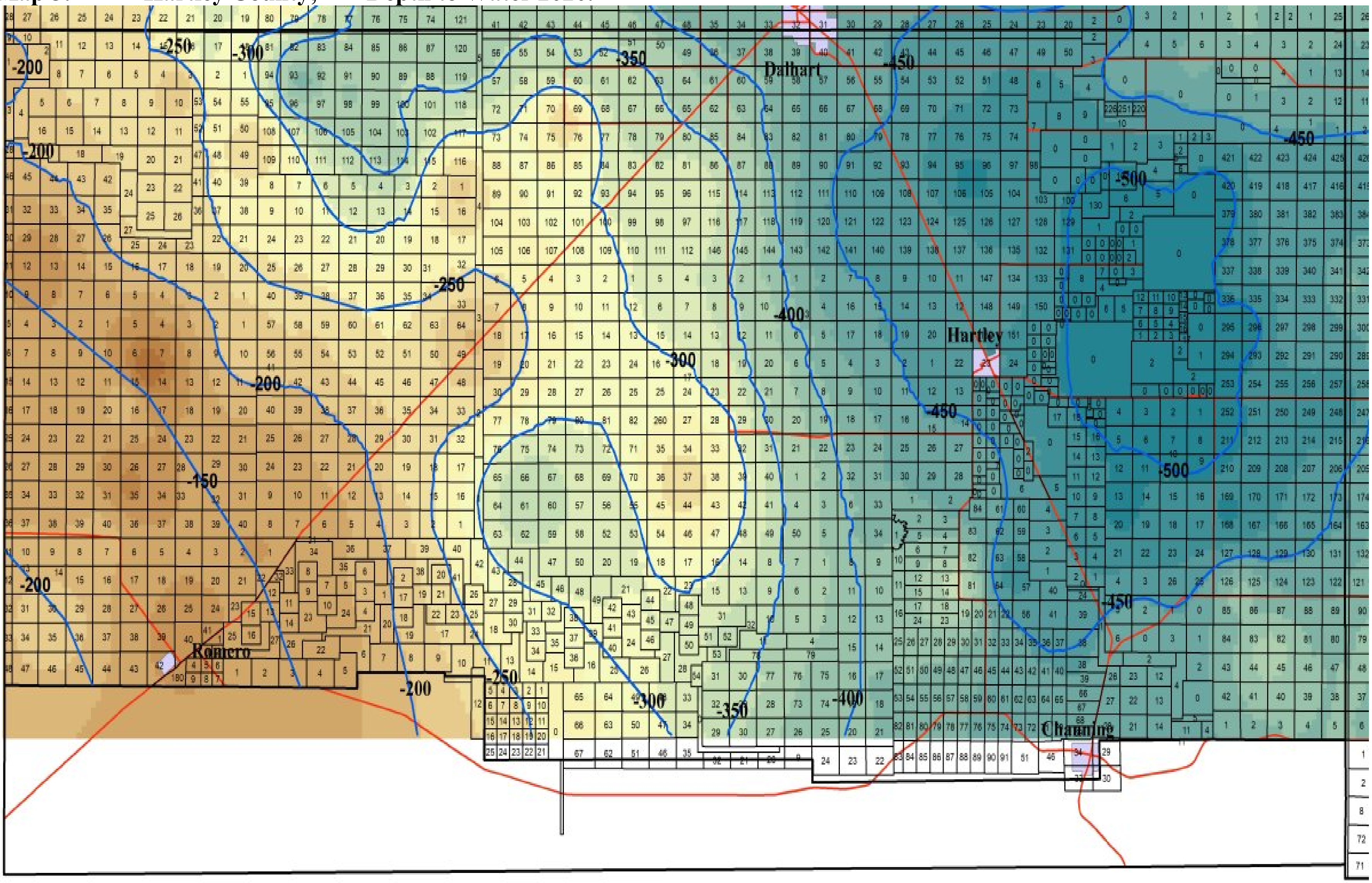
Maps depicting depth to water below land surface are created from statistical analyses of current and historical water level measurements. The most recent water level measurements were measured in January and February of 2020. Those water level measurements represent the depth to water at the end of the 2019 agricultural pumping season and prior to the beginning of the 2020 pumping season. It would be valid to title the maps either 2019 or 2020 Depth to Water.

Accuracy: The accuracy of the depth to water is estimated to be equal to the contour interval, +/- 50 feet.

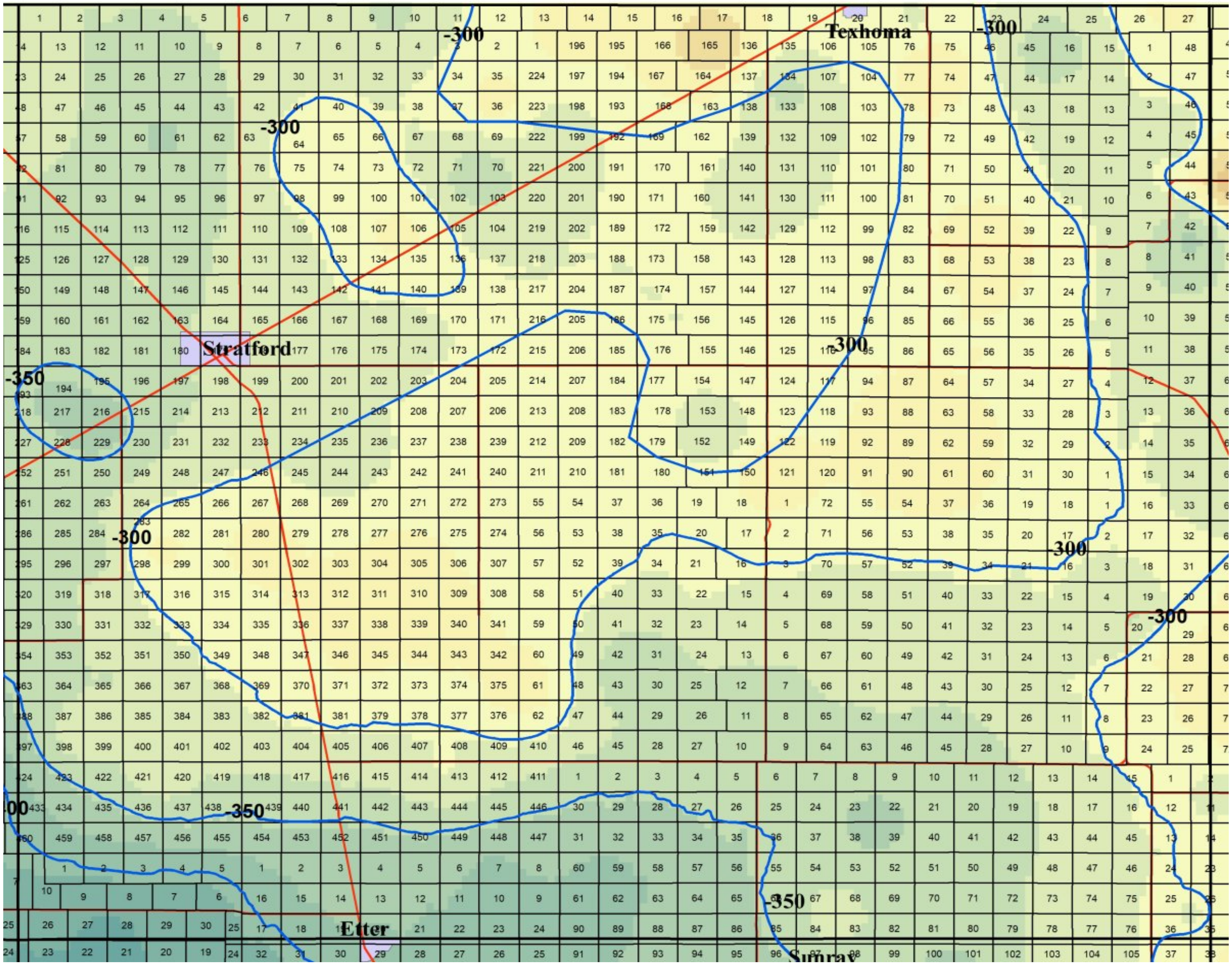
Map 4: Dallam County; Depth to Water 2020.



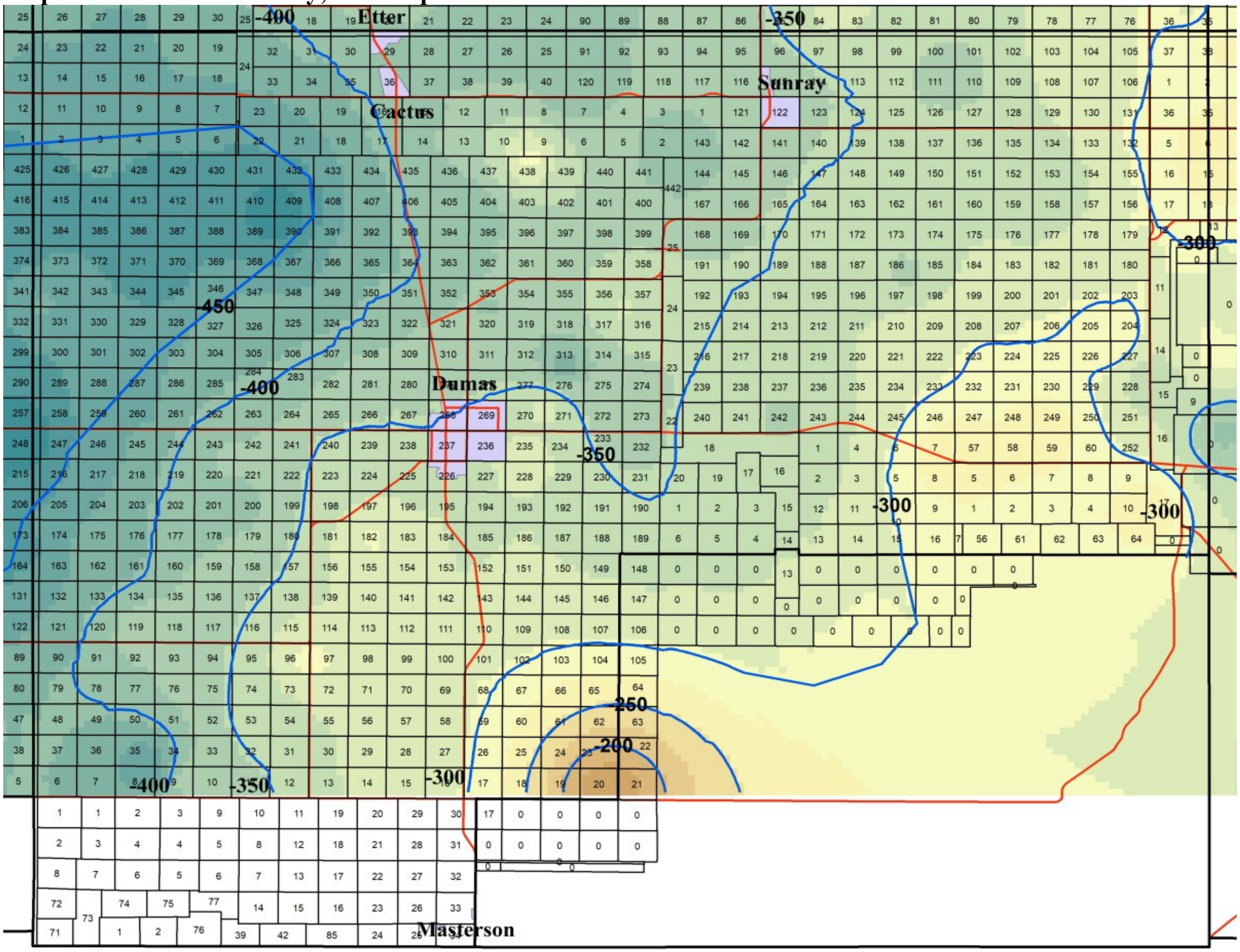
Map 5: Hartley County; Depth to Water 2020.



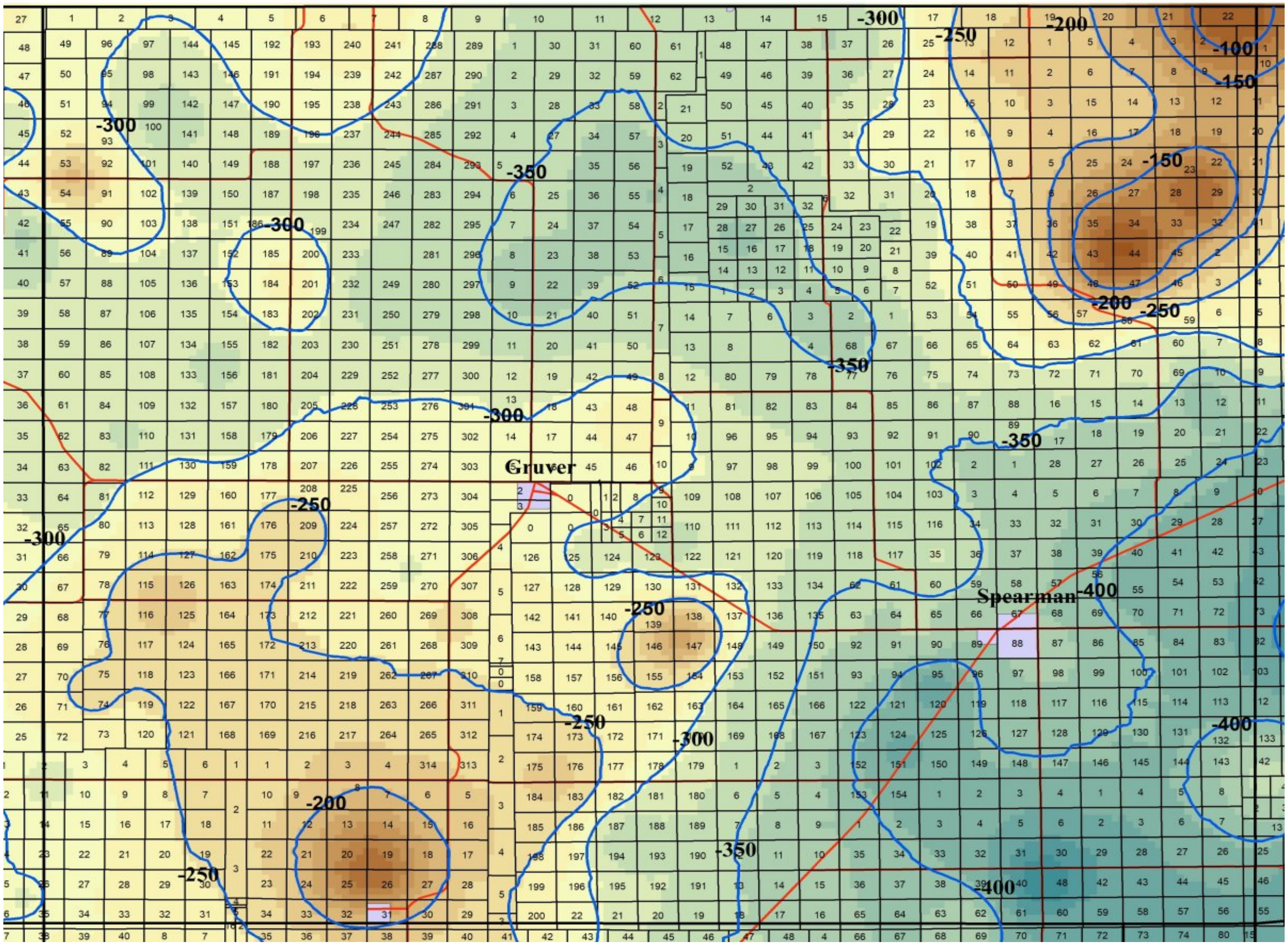
Map 6: Sherman County; Depth to Water 2020.



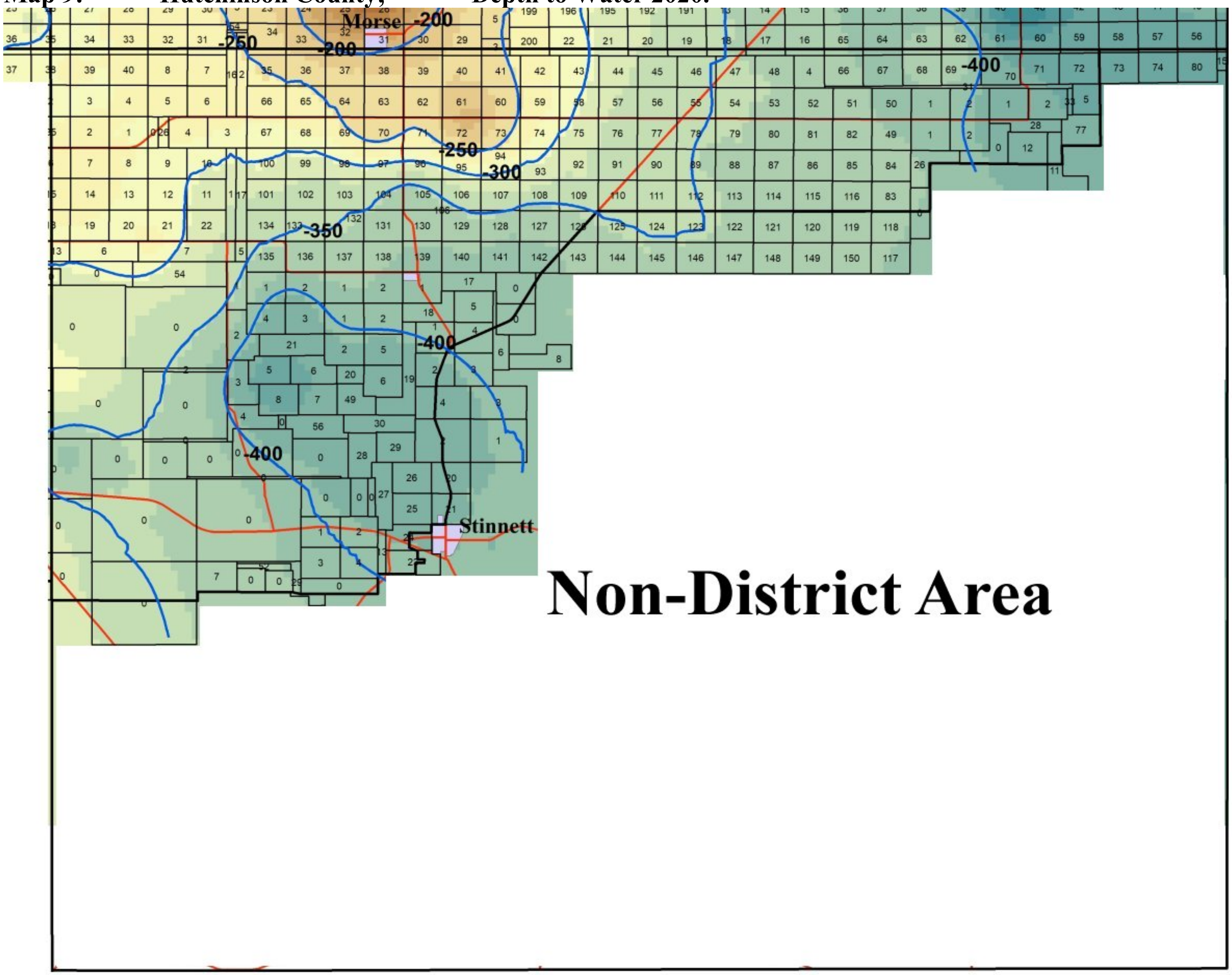
Map 7: Moore County; Depth to Water 2020.



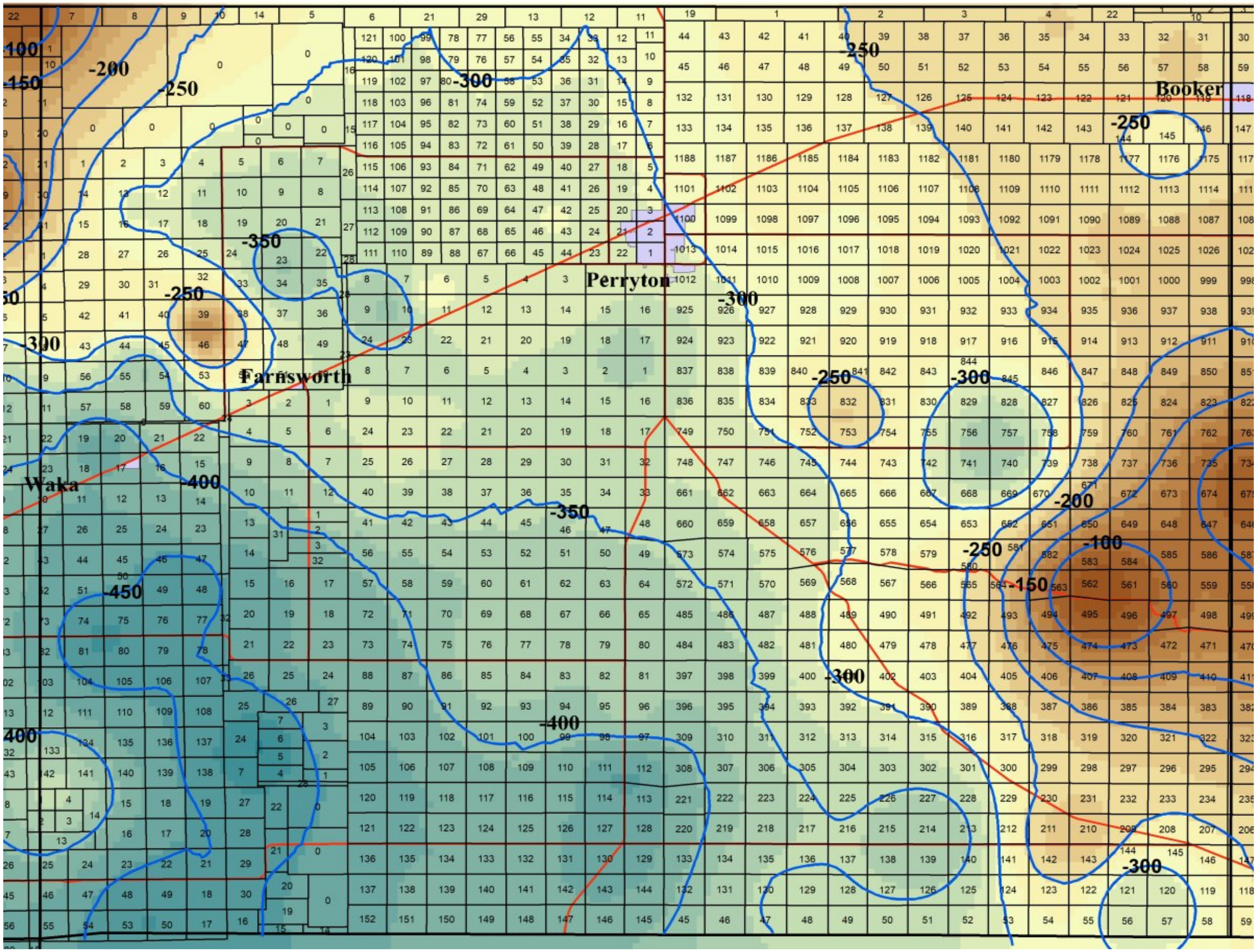
Map 8: **Hansford County; Depth to Water 2020.**



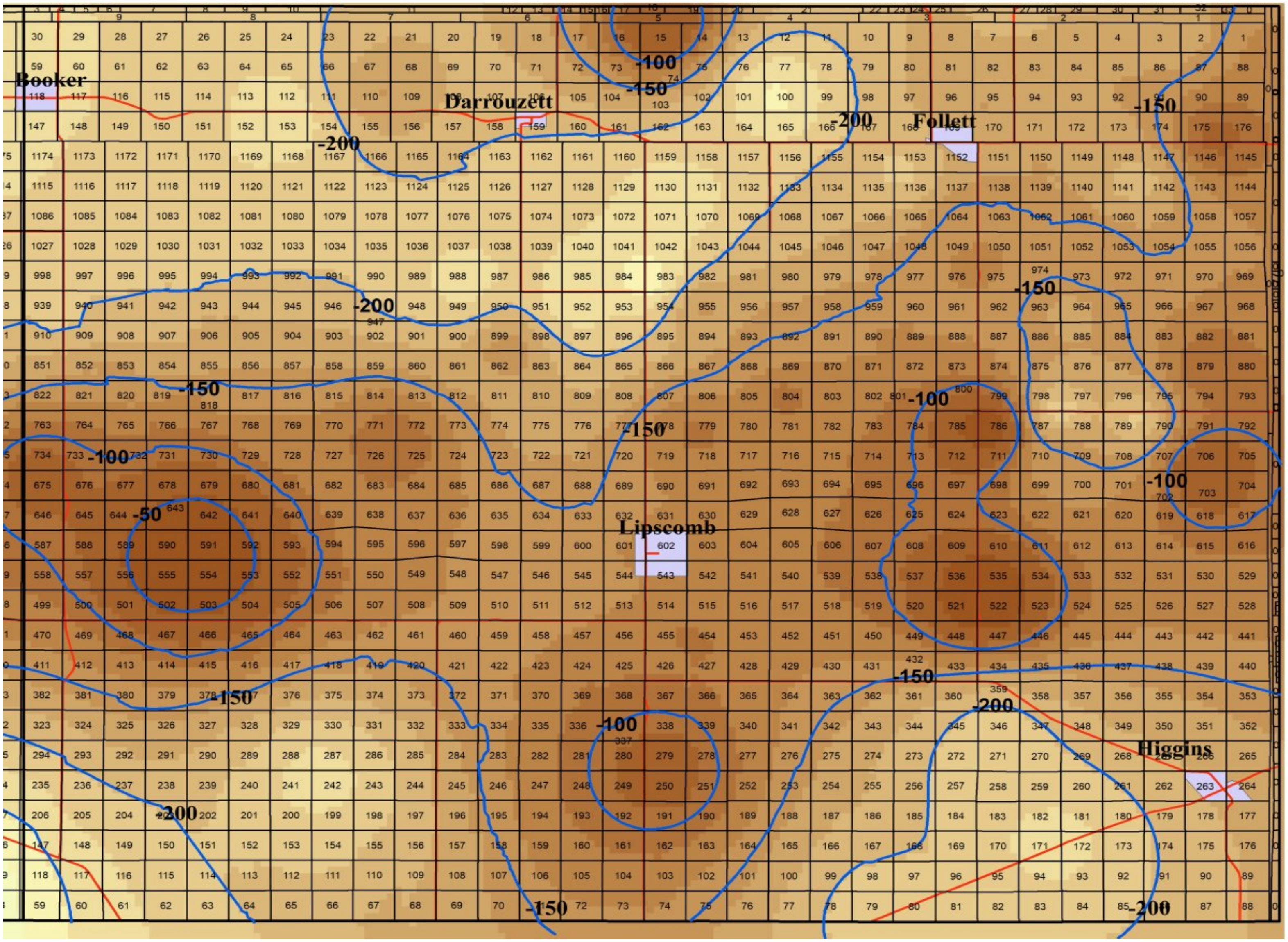
Map 9: Hutchinson County; Depth to Water 2020.



Map 10: Ochiltree County; Depth to Water 2020.



Map 11: Lipscomb County; Depth to Water 2020.



XIV. Declines (from 2019 Pumping) in Monitor Wells by County

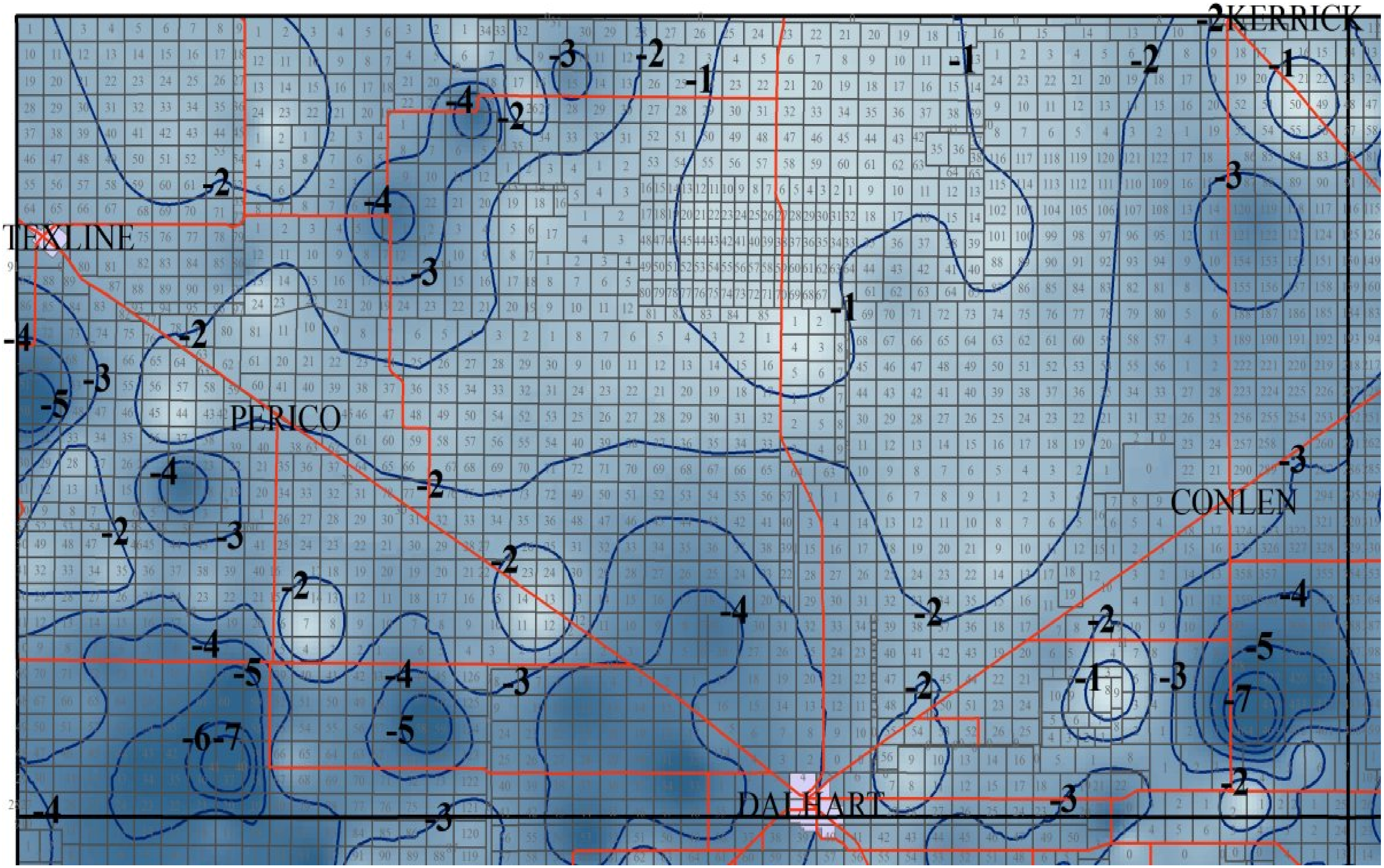
These maps do not include well measurements that indicate rises in water level. Rises may be valid for some specific areas but generally the statistical analyses do not indicate a high level of confidence in that data, therefore it is not used.

Maps depicting declines in monitor wells are created from a statistical analysis of current and historical water level measurements. The most recent water level measurements were taken in January and February of 2020. The declines represent declines resulting predominantly from the 2019 agricultural pumping season.

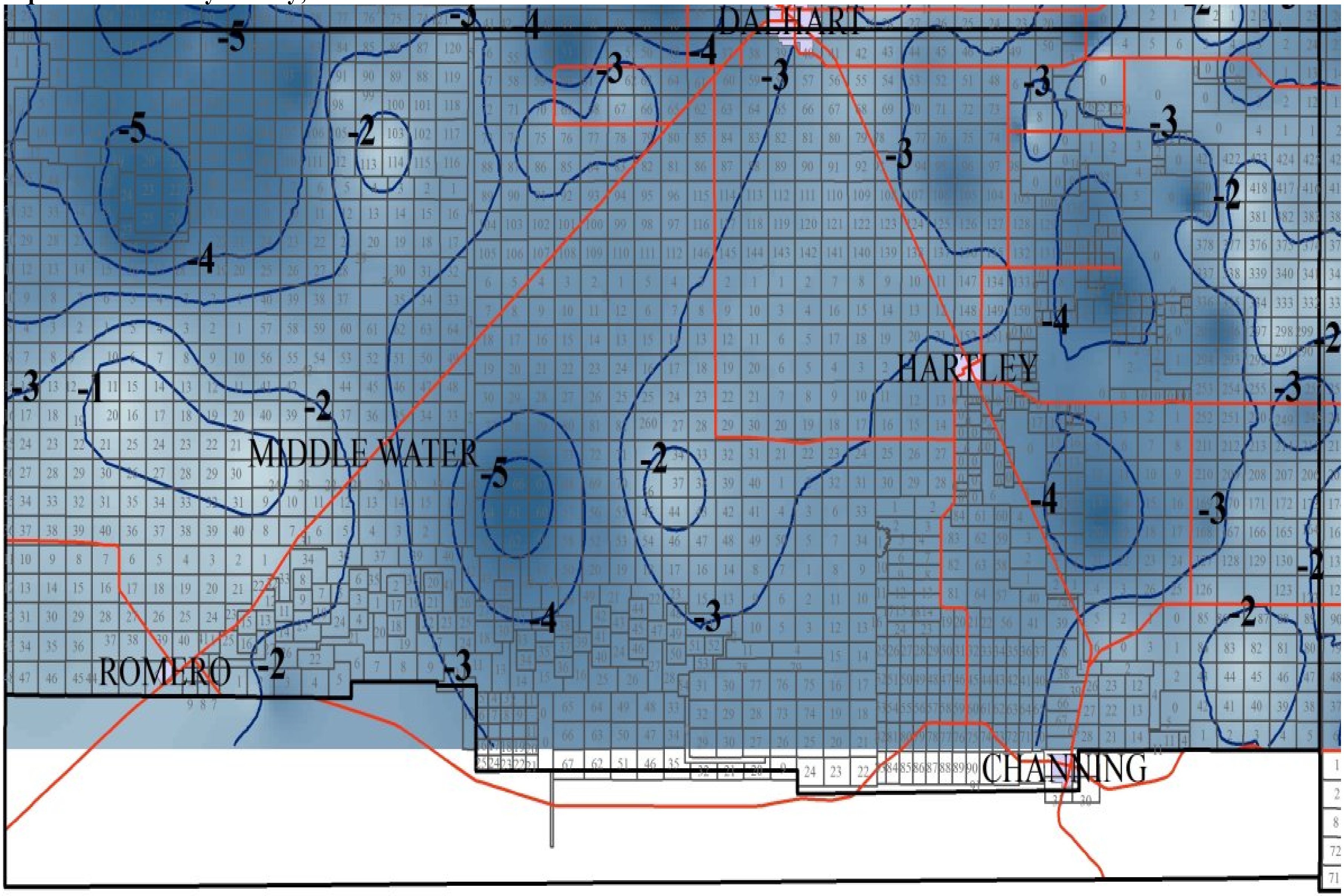
Declines are calculated using water level measurements taken from District monitor wells which are located primarily in high pumping areas. Consequently, these wells tend to show higher declines than what a true county-average-decline would show.

Accuracy: The accuracy of the decline maps is estimated to be +/- 2 feet.

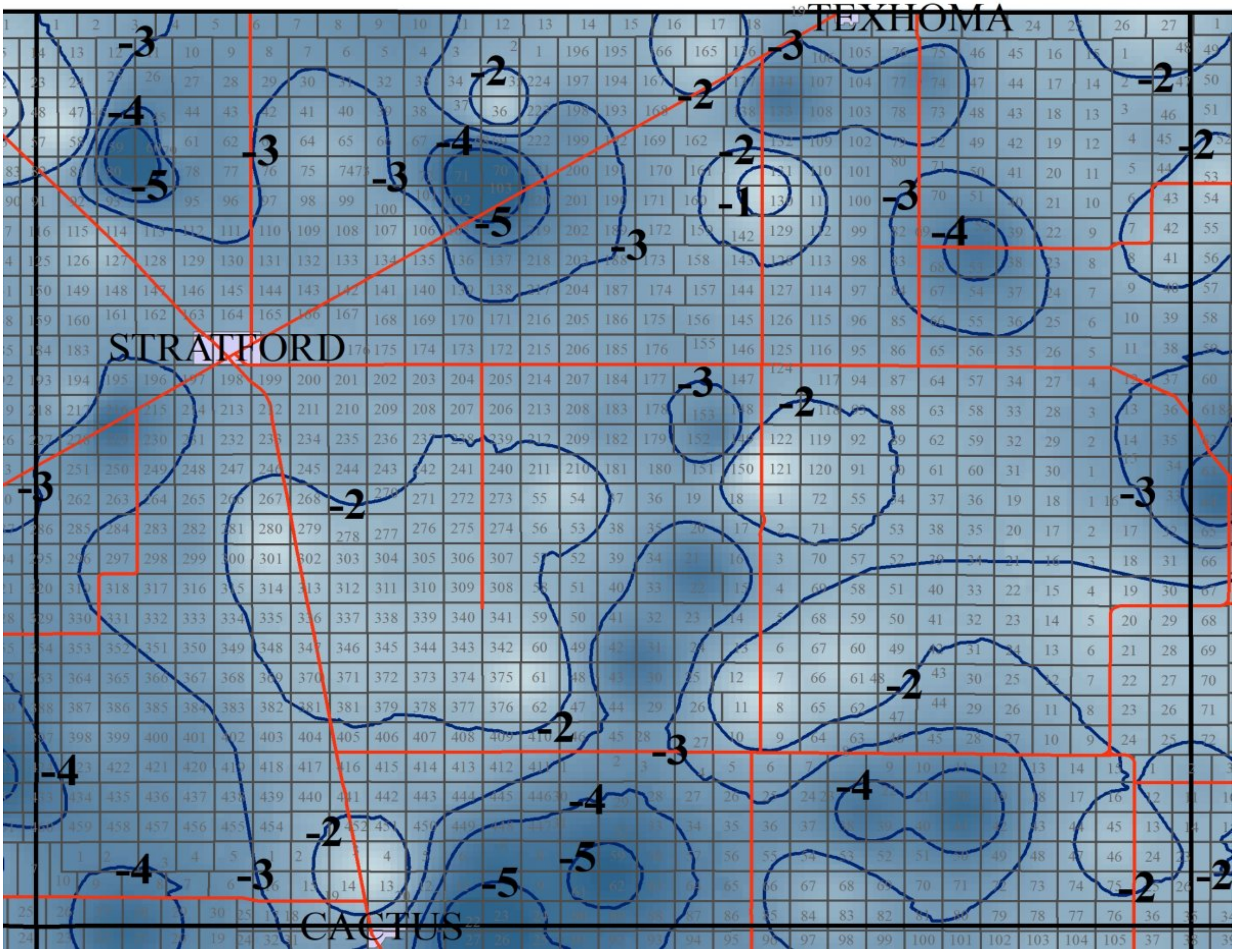
Map 12: Dallam County; 2019 Declines in Monitor Wells.



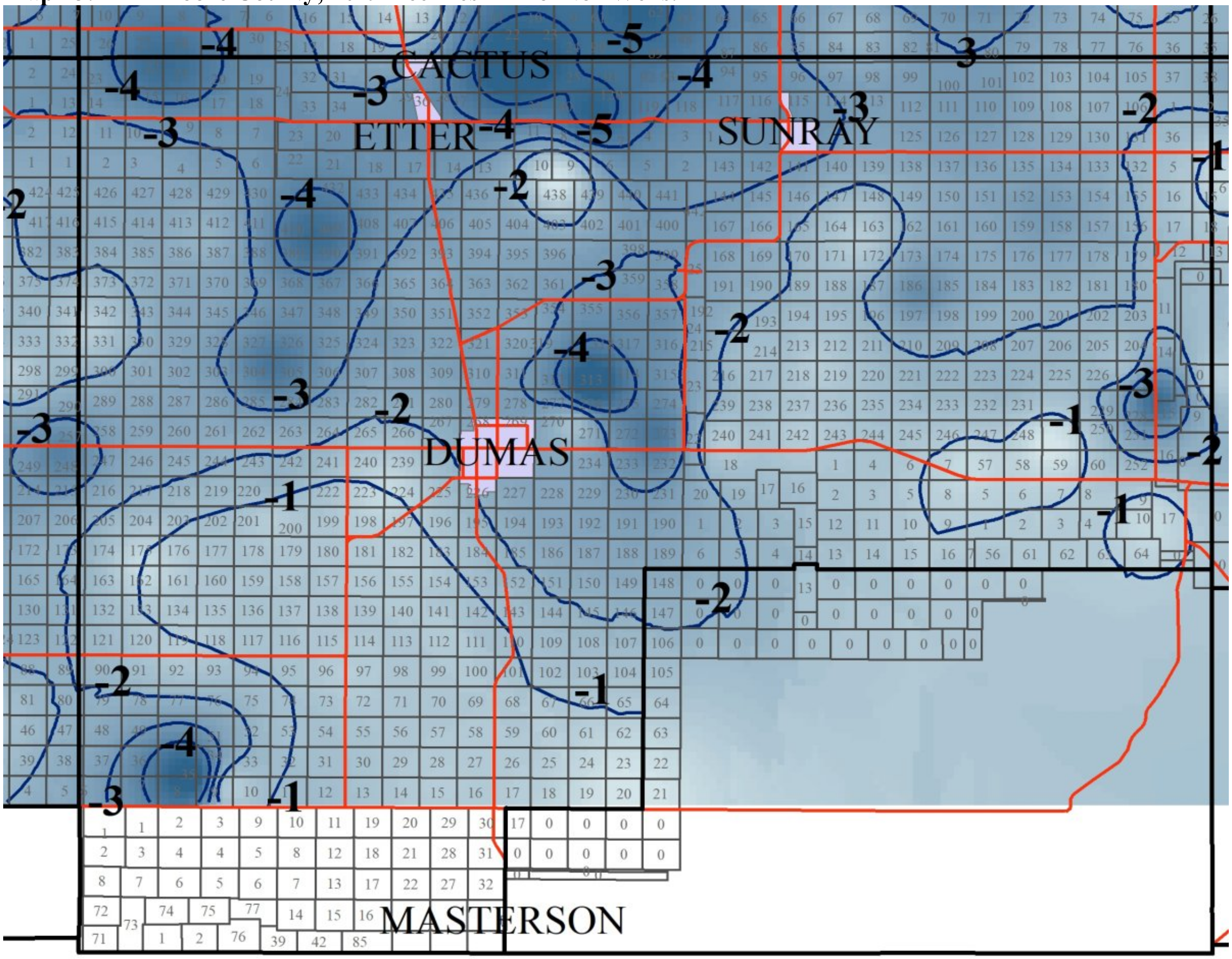
Map 13: **Hartley County; 2019 Declines in Monitor Wells.**



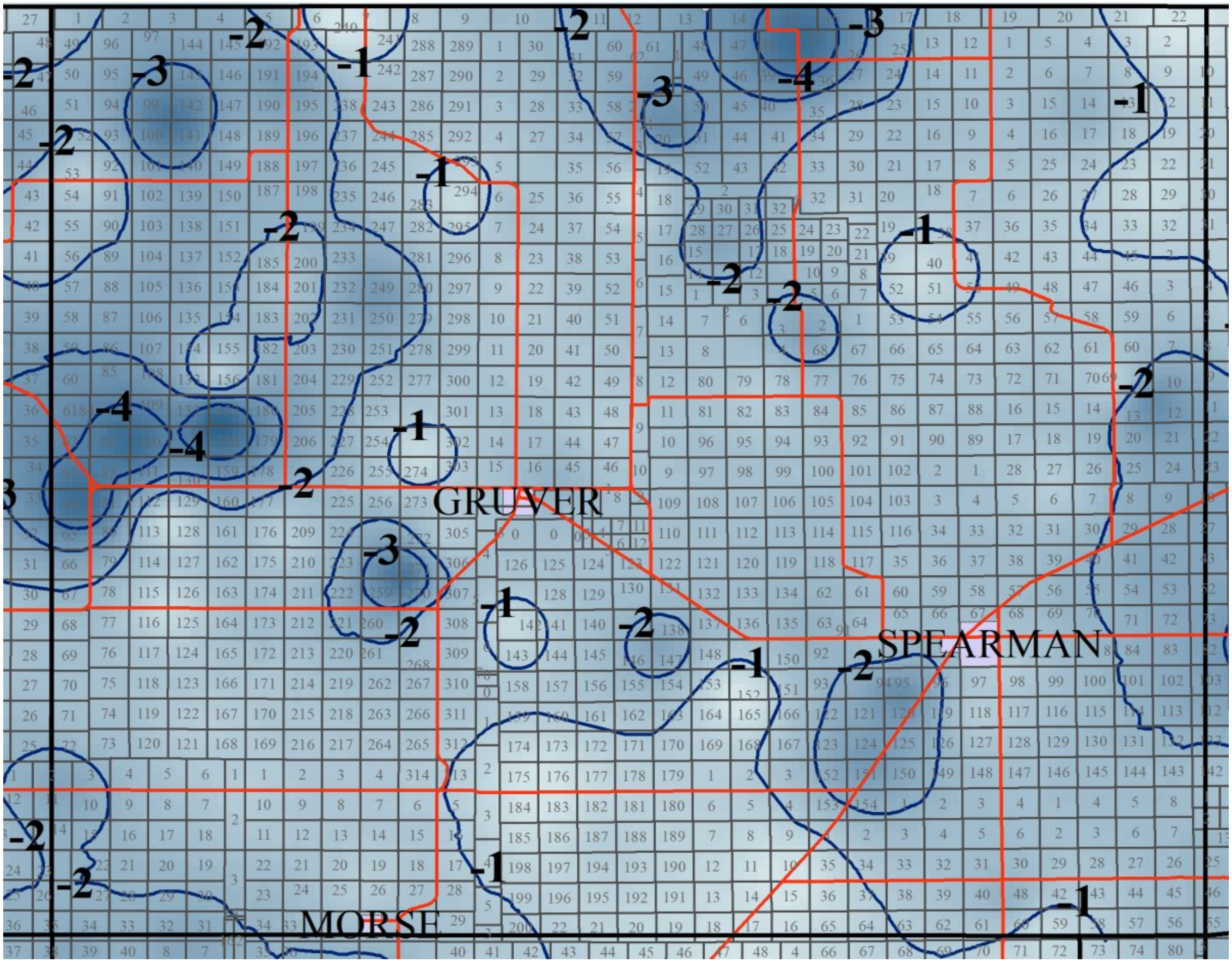
Map 14: **Sherman County; 2019 Declines in Monitor Wells.**



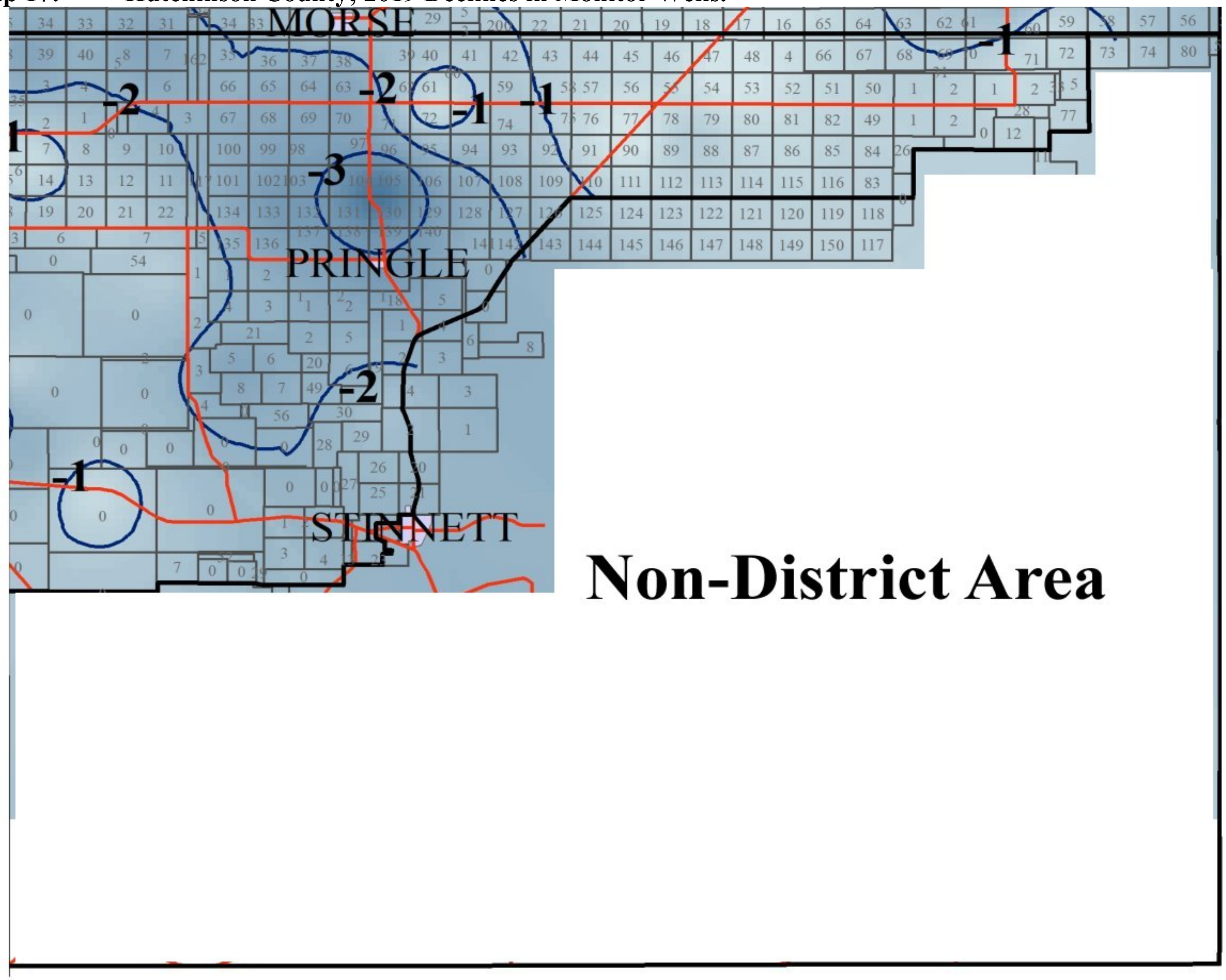
Map 15: **Moore County; 2019 Declines in Monitor Wells.**



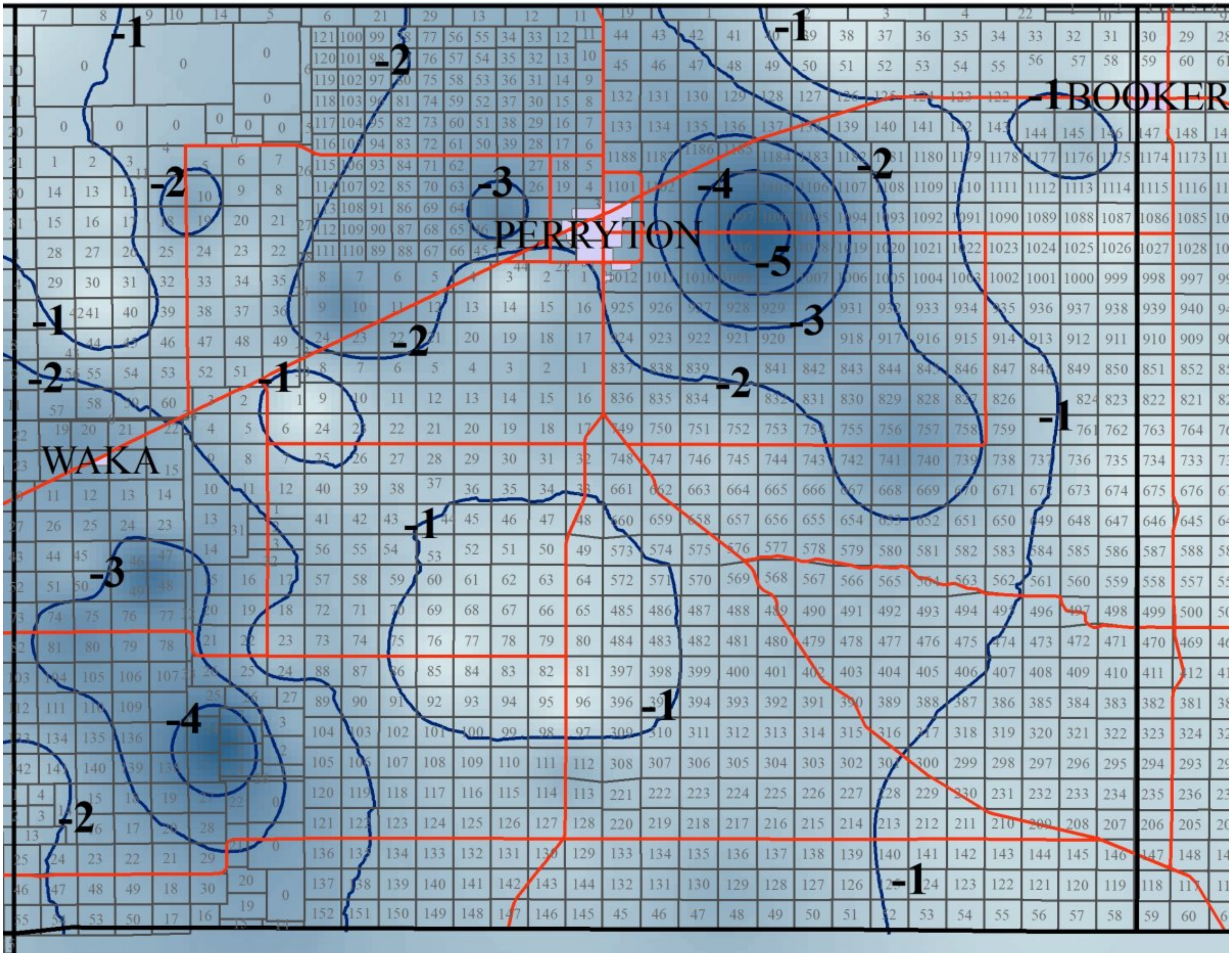
Map 16: Hansford County; 2019 Declines in Monitor Wells.



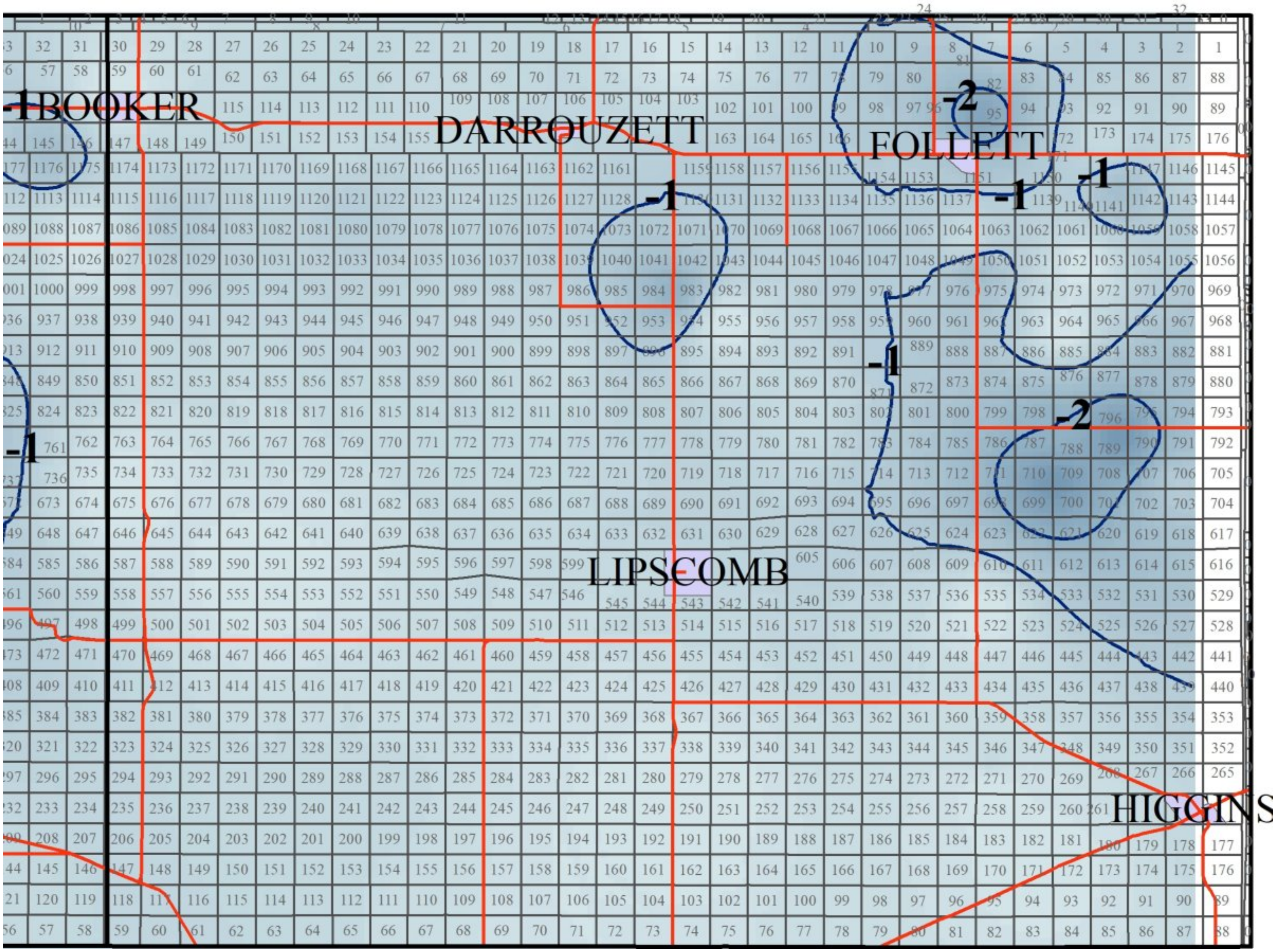
Map 17: Hutchinson County; 2019 Declines in Monitor Wells.



Map 18: Ochiltree County; 2019 Declines in Monitor Wells.



Map 19: Lipscomb County; 2019 Declines in Monitor Wells.



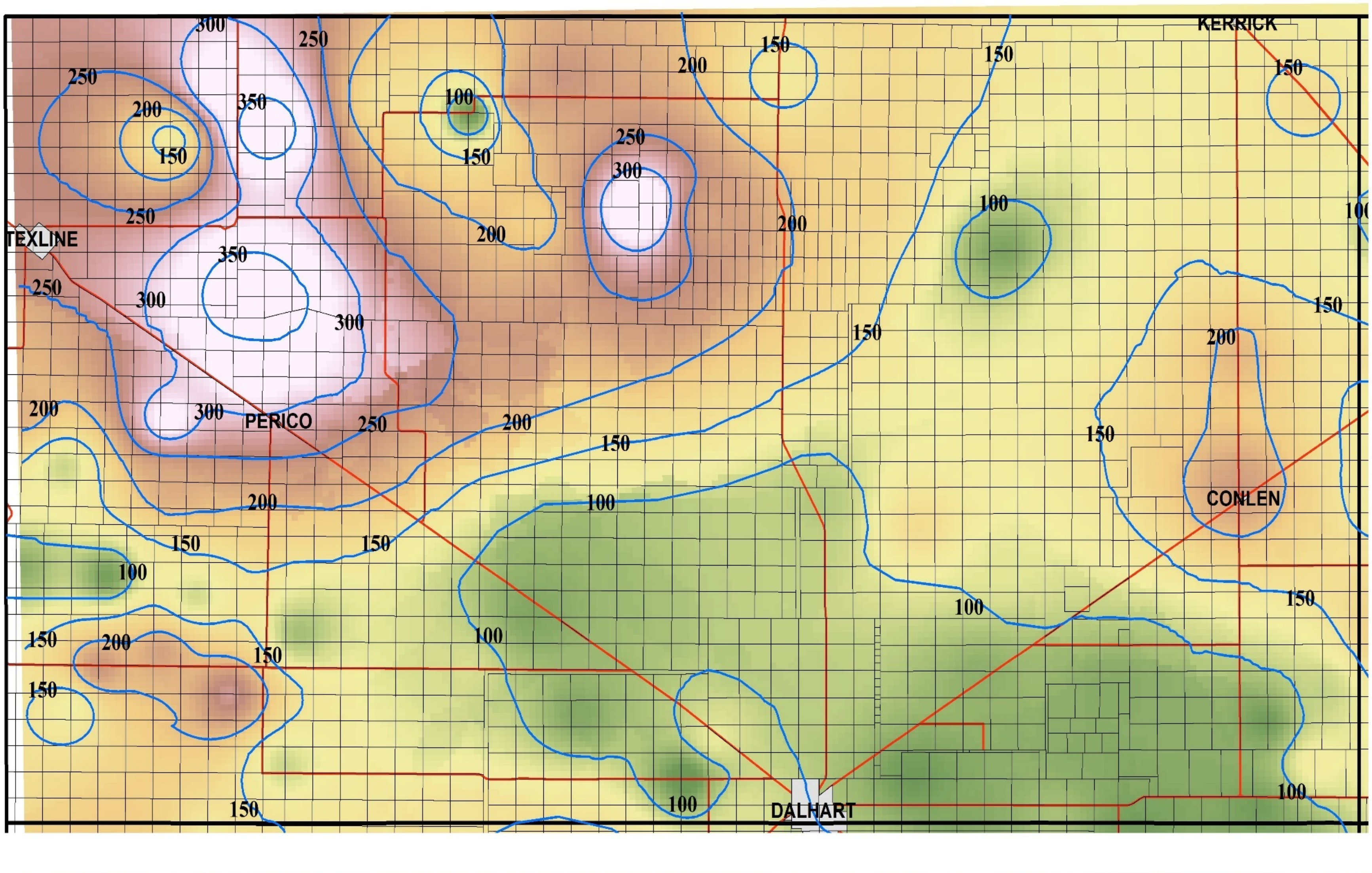
XV. 2018-2020 Estimated (Average) Saturated Thickness of the Ogallala Aquifer by County

Maps depicting estimated aquifer saturated thickness are created using geographical information mapping software and result from subtracting the base of the aquifer elevation layer from the water level elevation layer. The water level elevation layer is created from a statistical analysis of current and historical water level measurements. The most recent water measurements used for saturated Thickness maps were taken in January, February, and March of 2019. Those water level elevations represent the water level elevations at the end of the 2018 pumping season and the beginning of the 2019 pumping season. The Saturated Thickness maps represent the saturated thickness at the beginning of 2019 and is considered reasonably accurate for at least a three-year period.

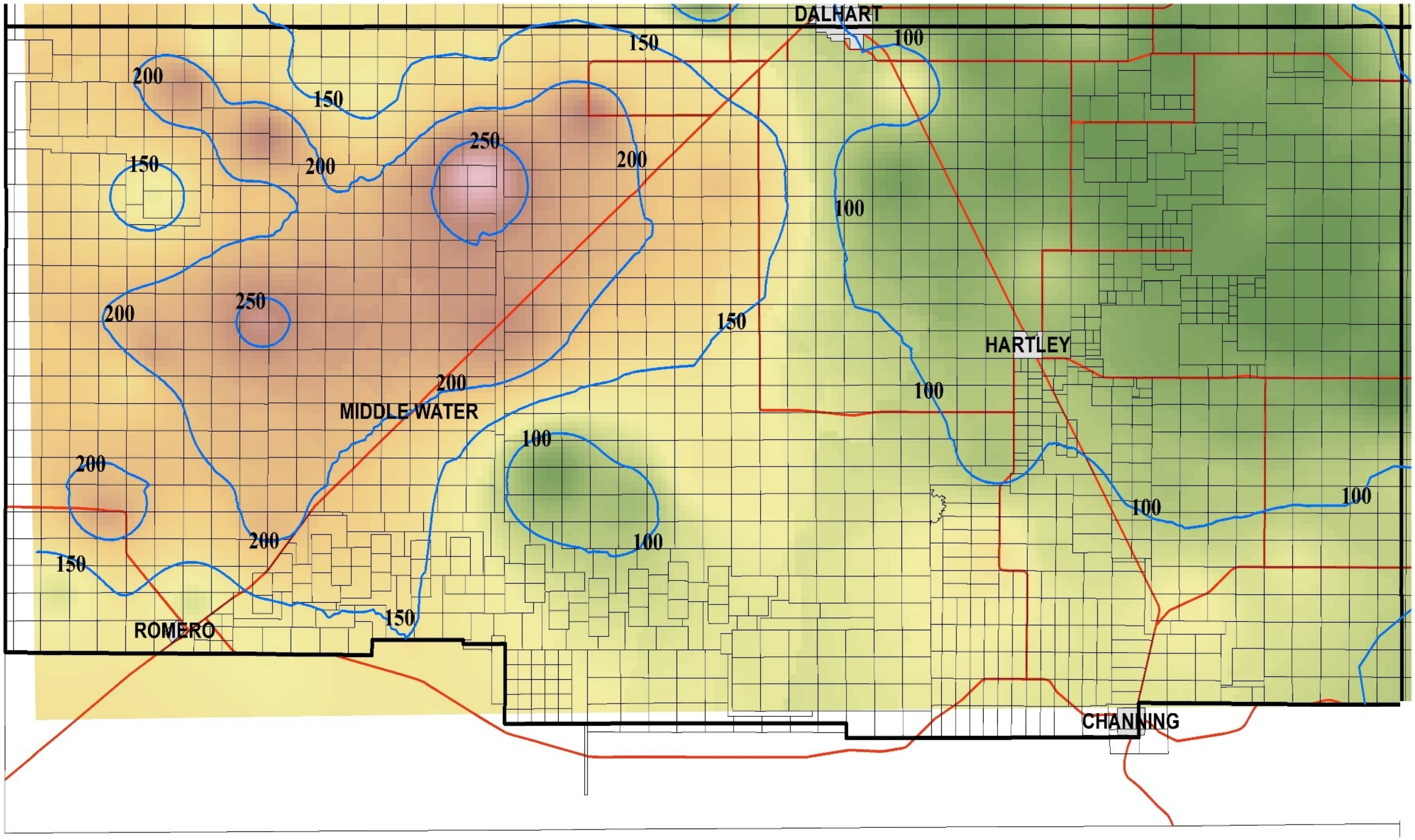
Estimated Saturated Thickness Maps are created every other year. The next set of estimated aquifer thickness maps are scheduled to be created in early Summer of 2021.

Accuracy: Map accuracy is estimated to be equal to +/- 50 feet. In some areas data may have been included from the Rita Blanca or the Dockum Aquifers due to the uncertainty in delineating those boundaries. Inclusion of such data may increase the value of the saturated thickness of the Ogallala above what may be encountered in the field.

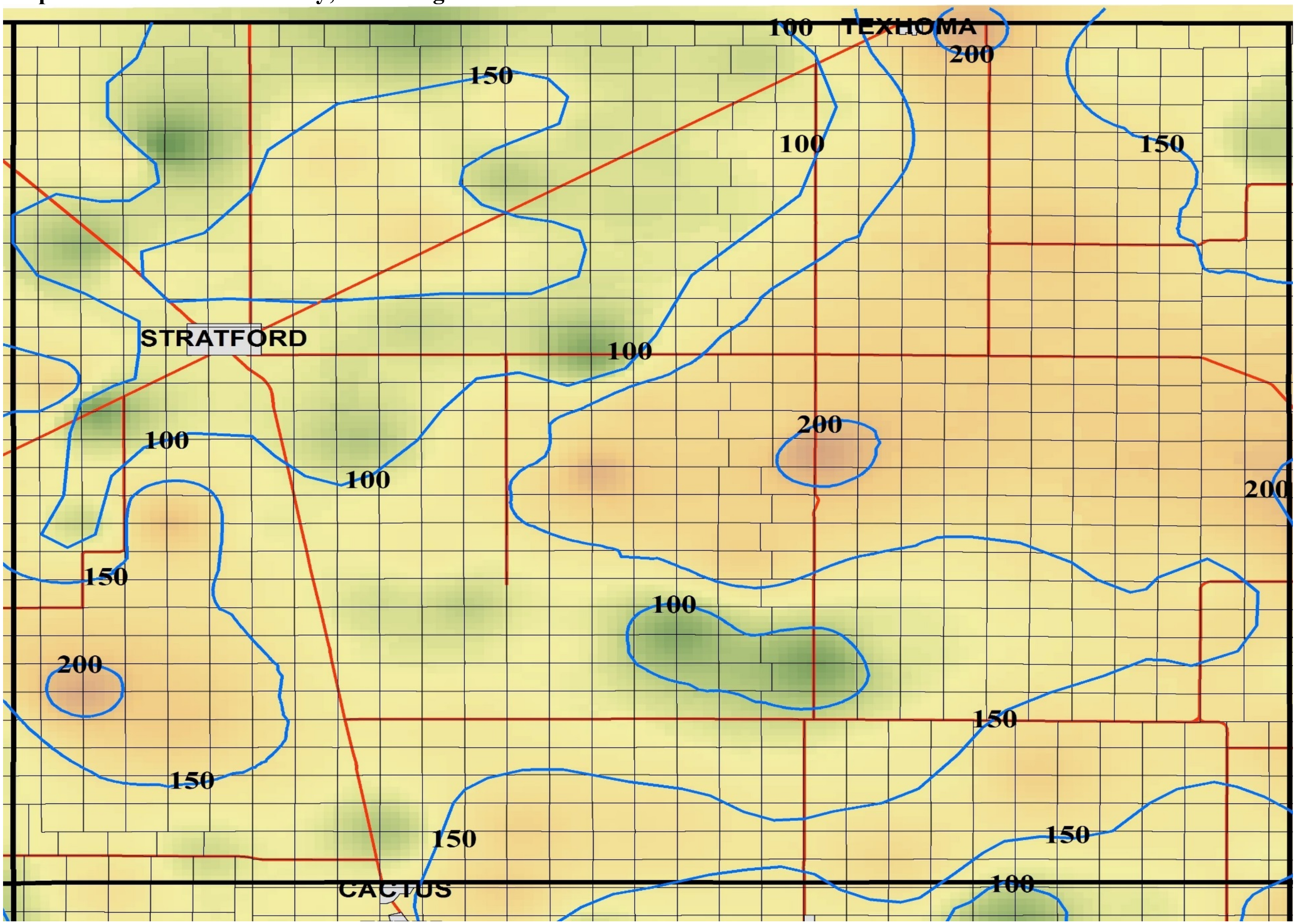
Map 20: Dallam County; Average Saturated Thickness 2018-2020.



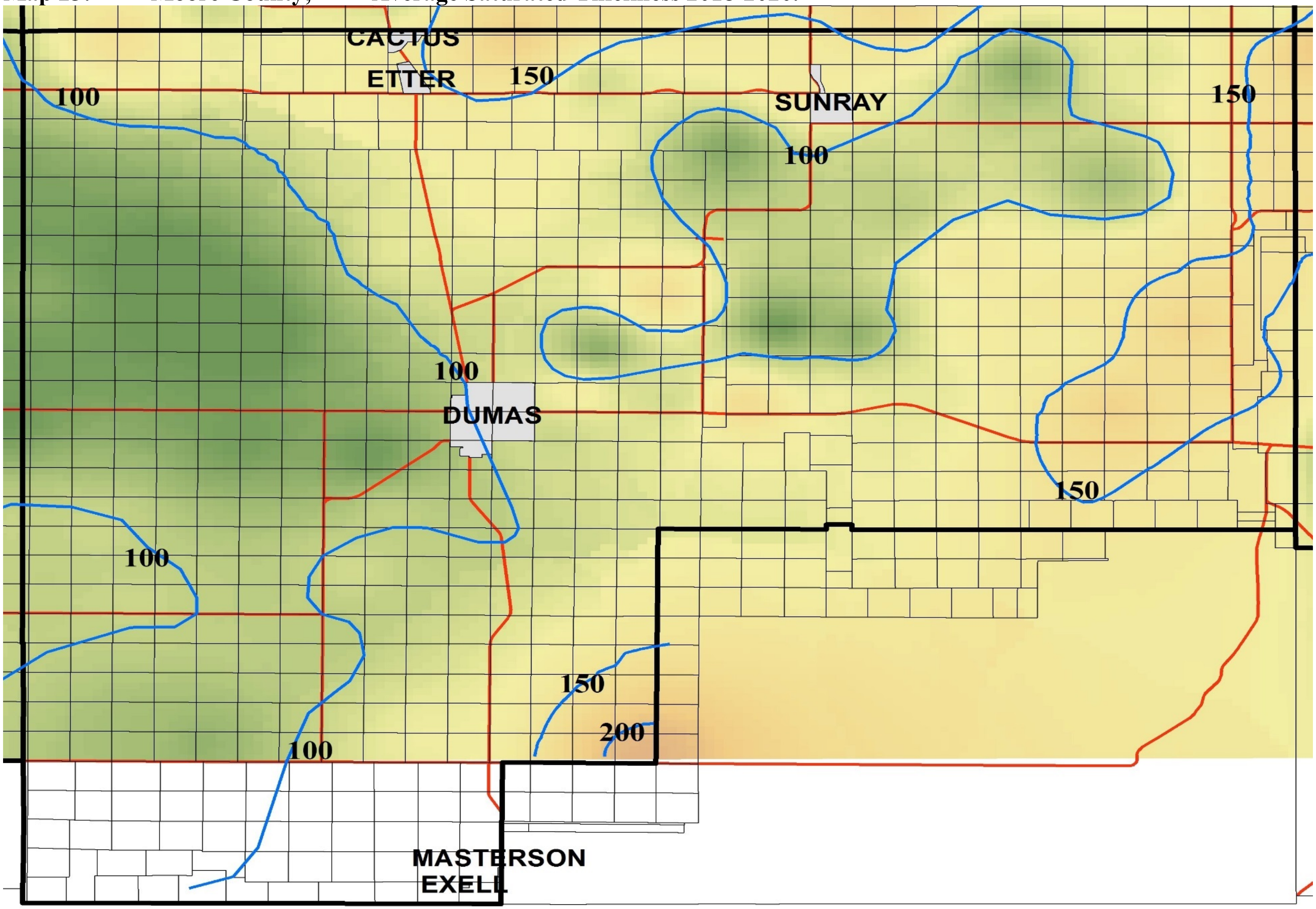
Map 21: Hartley County; Average Saturated Thickness 2018-2020.



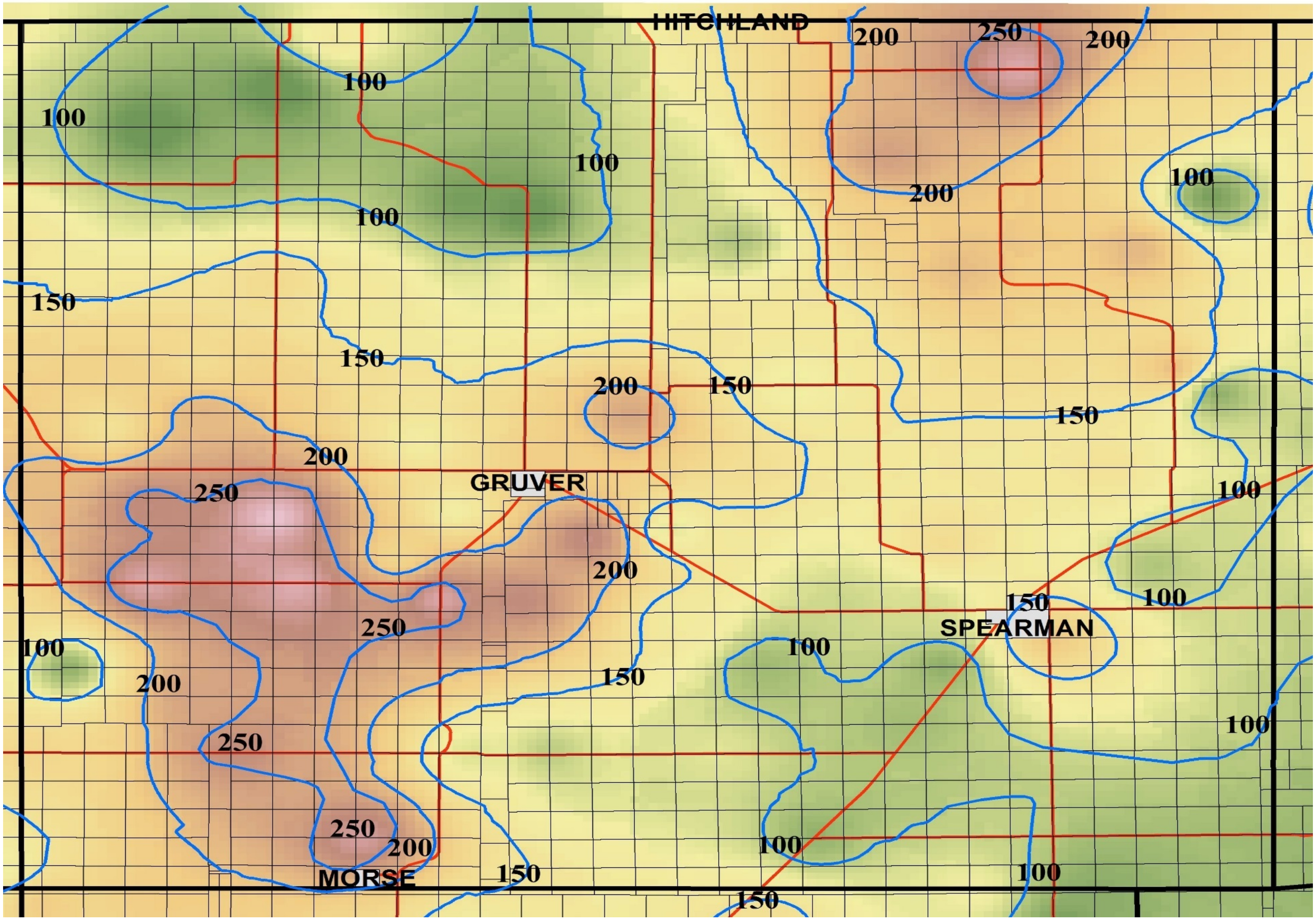
Map 22: Sherman County; Average Saturated Thickness 2018-2020.



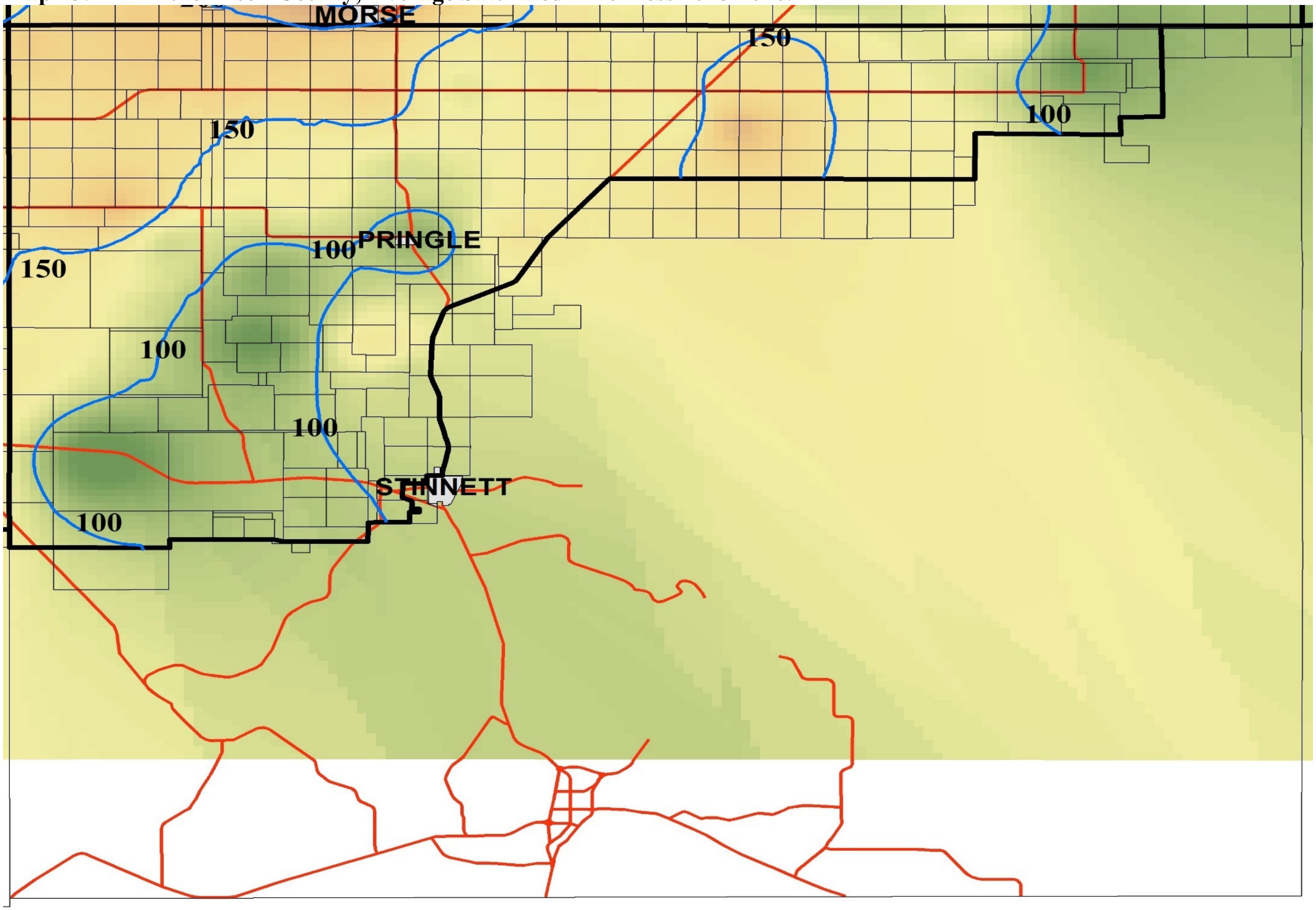
Map 23: Moore County; Average Saturated Thickness 2018-2020.



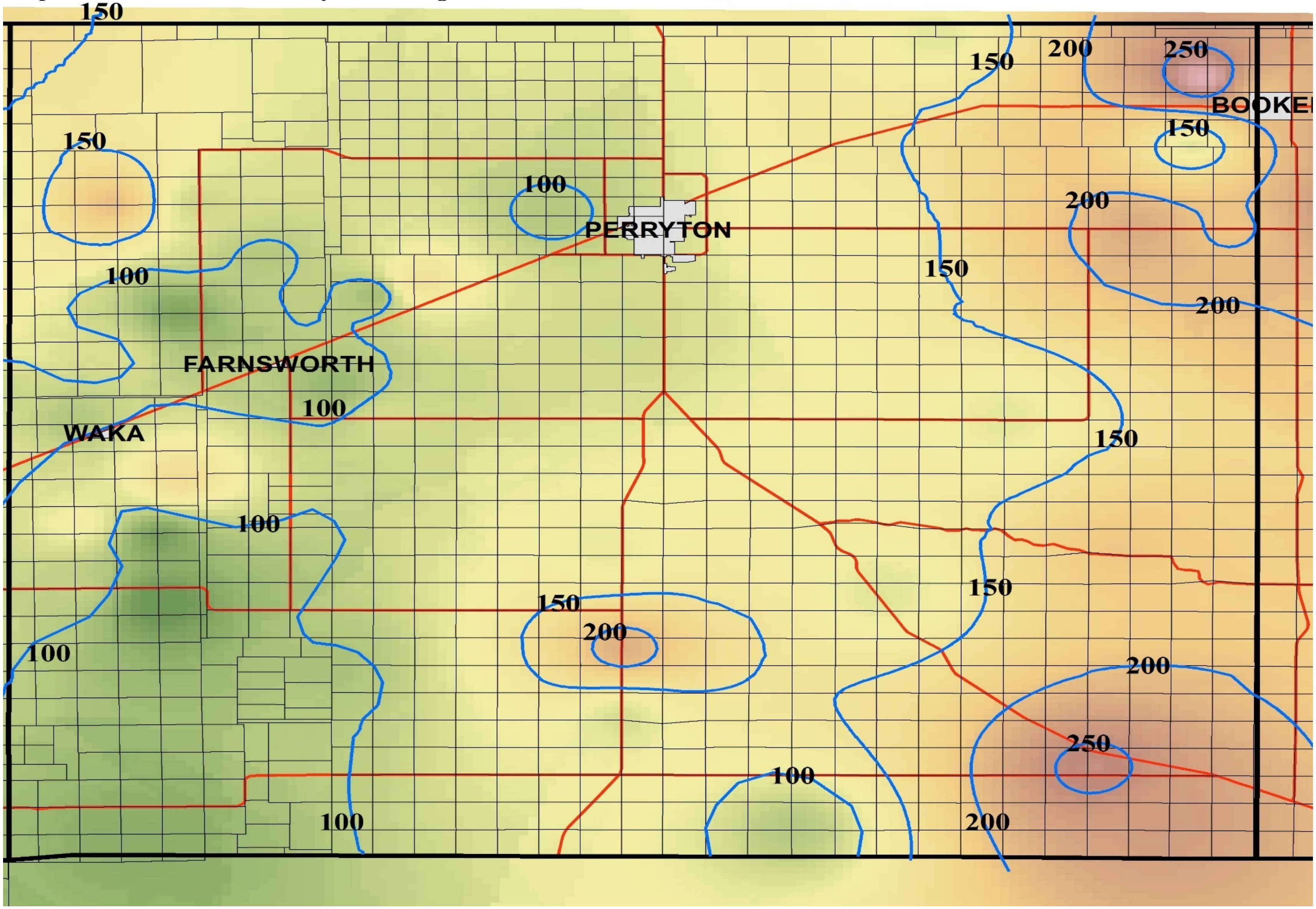
Map 24: **Hansford County;** **Average Saturated Thickness 2018-2020.**



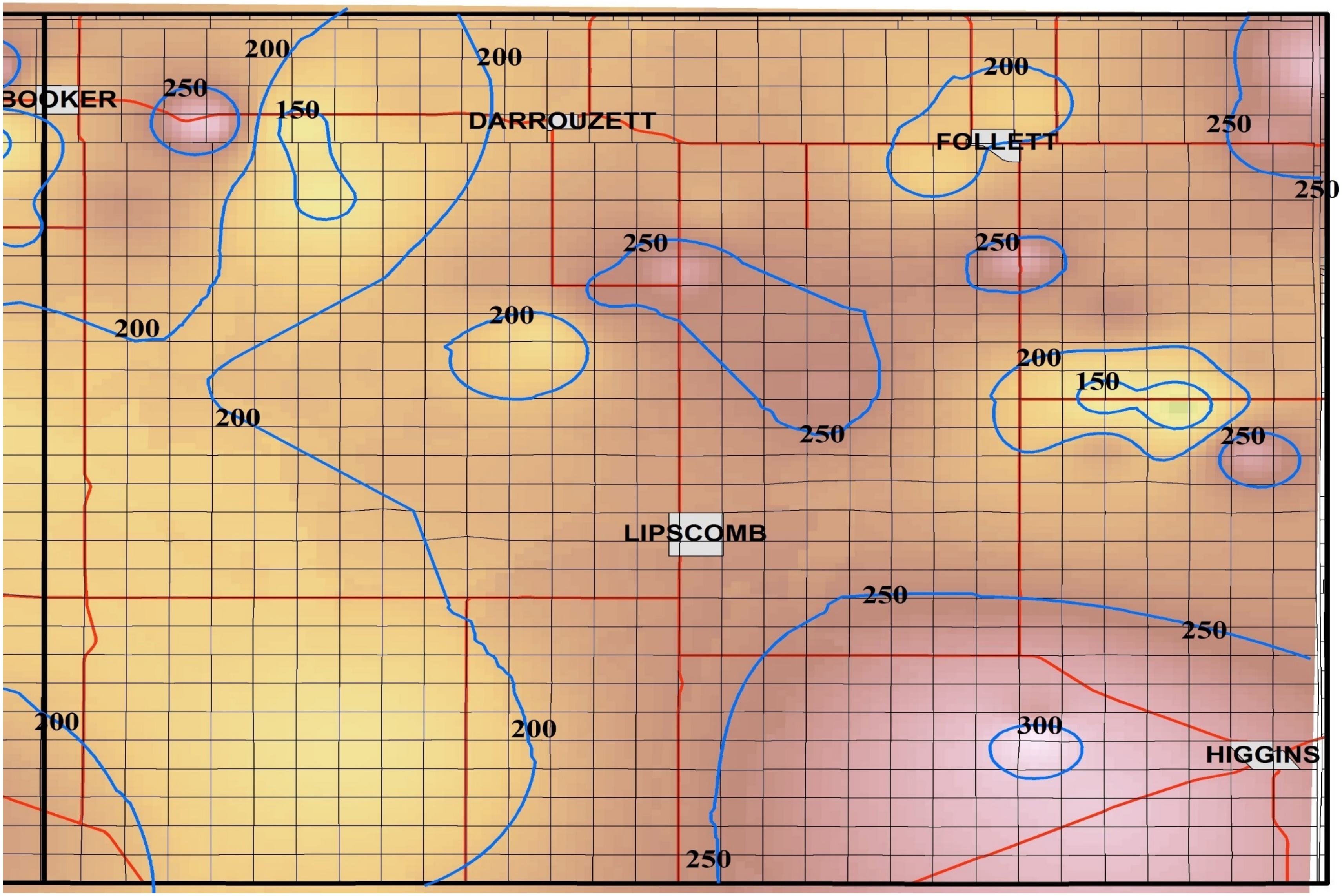
Map 25: **Hutchinson County; Average Saturated Thickness 2018-2020.**



Map 26: Ochiltree County; Average Saturated Thickness 2018-2020.



Map 27: Lipscomb County; Average Saturated Thickness 2018-2020.



XVI. Contributors to Hydrology and Groundwater Resources 2019-2020

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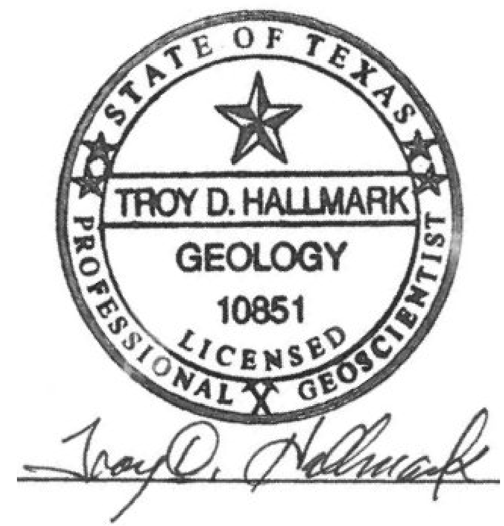

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