

Hydrology & Groundwater Resources 2019-2020

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



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Disclaimer: This document is a general information report about the regional hydrology and groundwater resources within the North Plains Groundwater Conservation District. The groundwater resources or hydrological properties of any property can and do vary significantly from those indicated by, or what might be inferred from this document. This document and the information contained within is provided on an "as is" basis. Neither the District Board of Directors nor District Staff make any claims or warranties as to this document's suitability for any use public or private.

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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 ongoing 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.

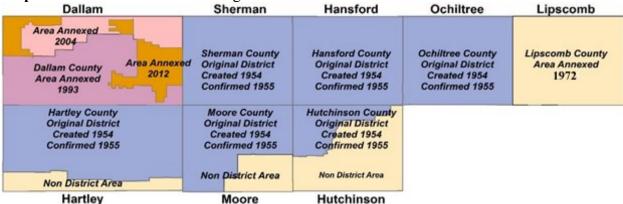


Table 1: County area and percent of each county within the NPGCD.

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 acrefeet 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	From Ogallala Aquifer to Rita Blanca Aquifer	2,909
between each aquifer in the district	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.

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.

^{*}Average is an average of the last five years.

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 <u>select</u> 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
D 11	60
Dallam	69
Hartley	68
Sherman	60
Moore	52
Hansford	67
Hutchinson	25
Ochiltree	48
Lipscomb	45
Total	434

District monitor well under construction

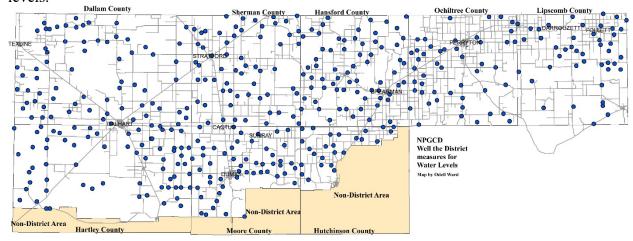


XI. 2020 District Monitor Well Locations and On-line Interactive Maps

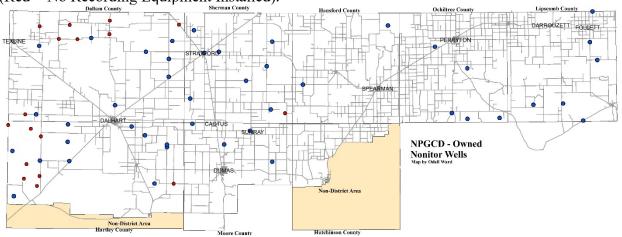
The District maintains a website where data from wells, monitor wells and recording equipment may be viewed. The map is always a work in progress and all data may not yet be available. More data and other map layers may become available as work on the on-line map progresses.

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,

рH,

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	2018	2019	2019	2020	2020
		Number	Average	Number	Average	Number of	Average
		of	Analysis	of	Analysis	Analyses	Analysis
		Analyses	Result	Analyses	Result		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	mg/l	22	217	29	208	18	*Pending
Hardness							

^{*}Due to the 2019-2020 Corvid19 pandemic, scheduled sampling and analyses are delayed.

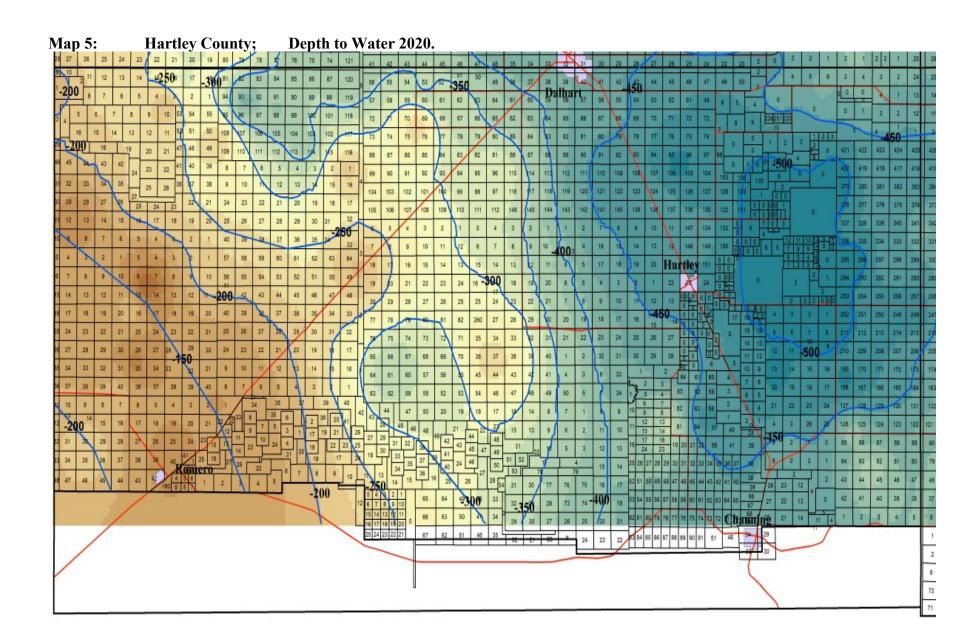
Table 12 shows the average mineral compositions indicated from analyses of well water from within the District. The District samples random wells at the owner's request as well as annually analyzing a subset of wells from the District's monitoring well program. No meaningful conclusions may be drawn 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.

Dallam County; Depth to Water 2020. **Map 4:** Texline74 Dalhart

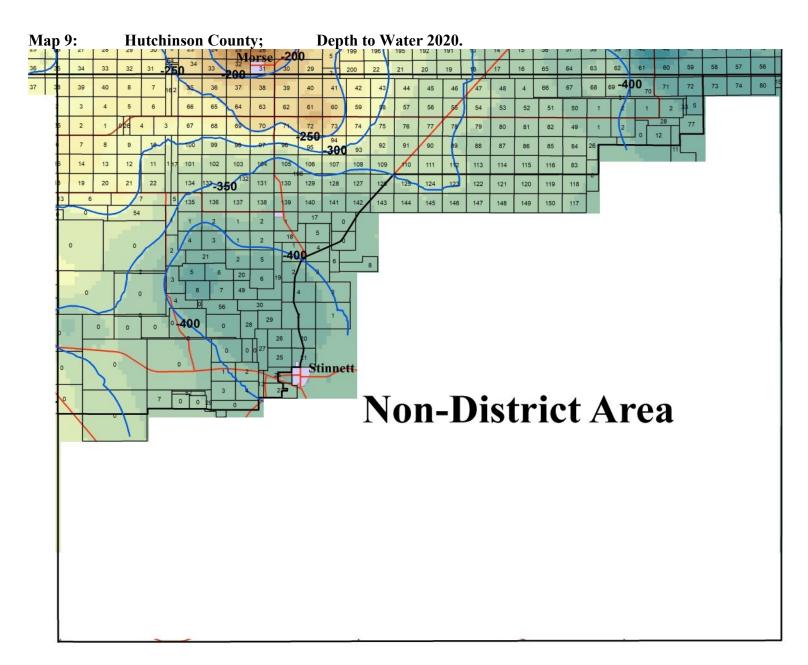


Map 6: Sherman County; Depth to Water 2020. **Texhoma**106 105 76 Stratford177 284 -300 438 -350439 453 452 -350 67

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173	174	175	176	177	178	179	180	181	182	183	184	185	186	187	188	189	6	5	4	14	13	14	15	16	7 56	61	62	63	64	0	
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Map 8: Hansford County; Depth to Water 2020.

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29	68	1	116	125	164	173	212	221	260	269	308	1	42 14	41 14	25	39	138	137	136	135	63	64	65	66	57	man 68	69	70	71	72	3
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26	71	74	119	122	167	170	215	218	263	266	311				61 1	62	163	164	165	166	122	121	120	119	118	117	116	115	114	113	12
25	72	73	120	121	168	169	216	217	264	265	312	- 1	74 1	250 73 1	72 1	71	300	169	168	167	123	124	125	126	127	128	129	130	131	- 40 (133
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6	5 3	4 3	3 3	2 3	1	34	33	32	31	30	29	3 7	200	22	21	20	19	18	17	16	65	64	63	62	61	60	59	58	57	56	55
7 3	3	9 4	0 8	7	192	35	36	37	38	39	40	41	42	43	44	45	46	1	7 48	4	66	67	68	69	70	71	72	73	74	80	5



Map 10: Ochiltree County; Depth to Water 2020.

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7	1		1	12	12	-11	10	9	8	114	107 9			63 48		26 19	-	1101	1102	1103	1104	1105	1106	1107	1108	1109	1110	1111	1112	1113	1114	111
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·0	4		29	30	³¹ -2	³² 50	33	34	35	8	7	6	5		3	Peri	-		-30	1010	1009	1008	1007	1006	1005	1004	1003	1002	1001	1000	999	998
5	5		42	41	40	39	28	37	36	9	10	11	12	13	14	15	16	925	926	927	928	929	930	931	932	933	934	935	936	937	938	939
7	300	0	43	44	15	46	4	48	49	24	28	22	21	20	19	18	17	924	923	922	921	920	919	918	917	916	915	914	913	912	911	910
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12	11	1	57	58	59	60	2	2	1	9	10	11	12	13	14	15	16	836	835	834	833	832	831	830/	829	828	827	826	825	824	823	823
21	22	1	19	20	21	22	4	5	6	24	23	22	21	20	19	18	17/	749	750	754	752	753	754	755	756	757	758	759	60	761	762	76:
24	23	4	18	1	16	15	9	8	7	25	26	27	28	29	30	31	32	748	747	746	745	744	743	142	741	740	739	738	737	736	735	73
	Wa		\leftarrow			400	10	11	12	40	39	38	37	36	35	34	33	661	662	663	664	665	666	68Z	668	669	670	67	672	673	674	67!
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8	7	8	26	25	24	23	14	31	3	56			200		46	47	/	_				577	578	1000	-25	0 581		-10	1000	-	1	044
2	-3		44	45	45	47			32	1	55	54	53	52	51	50	49	673	574	575	576	1		579			582	583	584	585	586	58:
3	12		51	450	49	48	15	16	17	57	58	59	60	61	62	63	64	572	571	570	569	568	567	566	565	564-1		562	561	560	559	558
2	13	1	74	75	76	77/	32 20	19	18	72	1	70	69	68	67	66	65	485	488	487	488	489	490	491	492	493	494	495	496	497	498	499
13	82	V	81	80	79	78	21	22	23	73	74	75	76	77	78	79	80	484	483	482	481	480	479	478	477	476	475	474_	473	472	471	470
02	03	1	104	105	106	107	26	25	24	88	87	86	85	84	83	82	81	397	398	399	400 -	300	402	403	404	405	406	407	408	409	410	411
13	12		111	110	109	108	25	26	27	89	90	91	92	93	94	95	96	396	395	394	393	392	390	390	389	368	387	386	385	384	383	382
40	0	+	184	135	136	137	24	7 6	3	104	103	102	101	100	400	98	97	309	310	31	312	313	314	315	316	317	318	319	320	321	322	323
32	13		-	140	139	138	7	5	2	105	106	107	108	109	110	111	112	308	307	306	305	304	303	302	301	300	299	298	297	296	295	294
43	42		141						1	120	119	118	117	116	115	114	113	221	222	223	224	225	226	227	228	229	230	231	232	233	234	235
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56	55		54	53	50	17	16	19	14	152	151	150	149	148	147	146	145	45	46	Y	48	49	50	51	52	53	54	55	56	57	58	59
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Map 11: Lipscomb County; Depth to Water 2020.

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5	1174	1173	1172	1171	1170	1169	1168	-20 1167	1166	1165	1164	1163	1162	1161	1160	1159	1158	1157	1156	1155	1154	1153	1152	1151	1150	1149	1148	1147	1146	1145
4	1115	1116	1117	1118	1119	1120	1121	1122	1123	1124	1125	1126	1127	1128	1129	1130	1131	1132	1183	1134	1135	1136	1137	1138	1139	1140	1141	1142	1143	1144
37	1086	1085	1084	1083	1082	1081	1080	1079	1078	1077	1076	1075	1074	1073	1072	1071	1070	1069	1068	1067	1066	1065	1064	1063	1062	1061	1060	1059	1058	1057
26	1027	1028	1029	1030	1031	1032	1033	1034	1035	1036	1037	1038	1039	1040	1041	1042	1043	1044	1045	1046	1047	1048	1049	1050	1051	1052	1053	1054	1055	1056
9	998	997	996	995	994	993	992	991	990	989	988	987	986	985	984	983	982	981	980	979	978	977	976	975	974 150	973	972	971	970	969
8	939	940	941	942	943	944	945	946	-200	948	949	950	951	952	953	954	955	956	957	958	959	960	961	962	963	964	965	966	967	968
1	910	909	908	907	906	905	904	903	902	901	900	899	898	897	896	895	894	893	892	891	890	889	888	887	886	885	884	883	882	881
	851	852	853	854	855 150	856	857	858	859	860	861	862	863	864	865	866	867	868	869	870	871	872	873	874	875	876	877	878	879	880
	822	821	820	819	818	817	816	815	814	813	812	811	810	809	808	807	806	805	804	803	100	01-10	10000	799	798	797	796	795	794	793
1	763	764	765	766	767	768	769	770	771	772	773	774	775	776	1	50°8	779	780	781	782	783	784	785	786	V 87	788	789	790	791	792
	734 675	676	677	731	679	729	728	727 682	726 683	725 684	724 685	686	722 687	721 688	720 689	719	718	717 692	716 693	715 694	714	713 696	712	711	710	709	708	-100	706	705
	646	645	644 -	040	642	641	640	639	638	637	636	635	634	633	632	690	630	629	628	627	626	625	624	623	622	621	620	702 619	703 618	617
	587	588	589	590	591	592	593	594	595	596	597	598	599	600	Li 601	9 SCO 602		604	605	606	607	608	609	610	611	612	613	614	615	616
9	558	557	556	555	554	553	552	551	550	549	548	547	546	545	544	543	542	541	540	539	538	537	536	535	534	533	532	531	530	529
8	499	500	501	502	503	504	505	506	507	508	509	510	511	512	513	514	515	516	517	518	519	520	521	522	523	524	525	526	527	528
1	470	469	468	467	466	465	464	463	462	461	460	459	458	457	456	455	454	453	452	451	450	449	448	447	446	445	444	443	442	441
•	411	412	413	414	415	416	417	418	419	420	421	422	423	424	425	426	427	428	429	430	431	432 150	433	434	435	436	437	438	439	440
3	382	381	380	379	378-1	507	376	375	374	373	372	371	370	369	368	367	366	365	364	363	362	361	360	200	358	357	356	355	354	353
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	235	236	237	238	239	240	241	242	243	244	245	246	247	248	249	250	251	252	253	254	255	256	257	258	259	260	261	262	263	264
	206	205	204		0 202	201	200	199	198	197	196	195	194	193	192	191	190	189	188	187	186	185	184	183	182	181	180	179	178	177
	118	148	149	150	151	152	153	154	155	156	157	107	159	160	161	162	163	164	165	166	167	168	169	170	171	172	173	91	175	176
	59	60	61	62	63	113	65	66	67	68	69	70			73	74	75	76	77	99	98 79	97	96	95 82	94	93	92	1	90	88 0
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XIV. Declines (from 2019 Pumping) in Monitor Wells by County

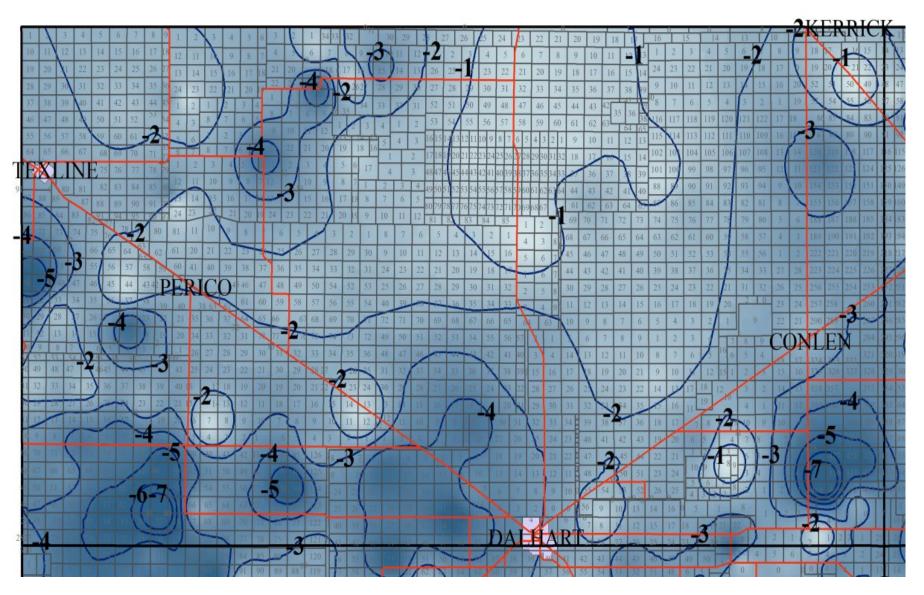
These maps do not include well measurements that indicate rises in water level. Rises may be valid for some specific areas but generally the statistical analyses do not indicate a high level of confidence in that data, therefore it is not used.

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.

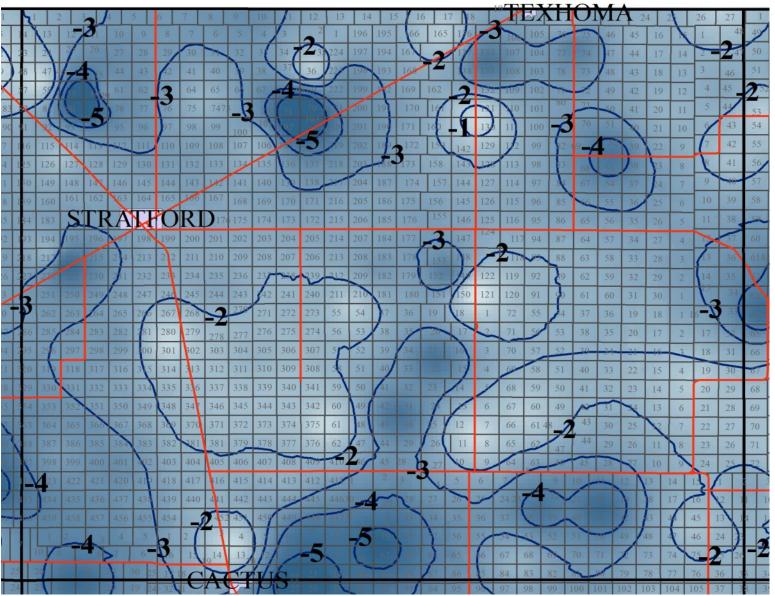
Accuracy: The accuracy of the decline maps is estimated to be +/- 2 feet.

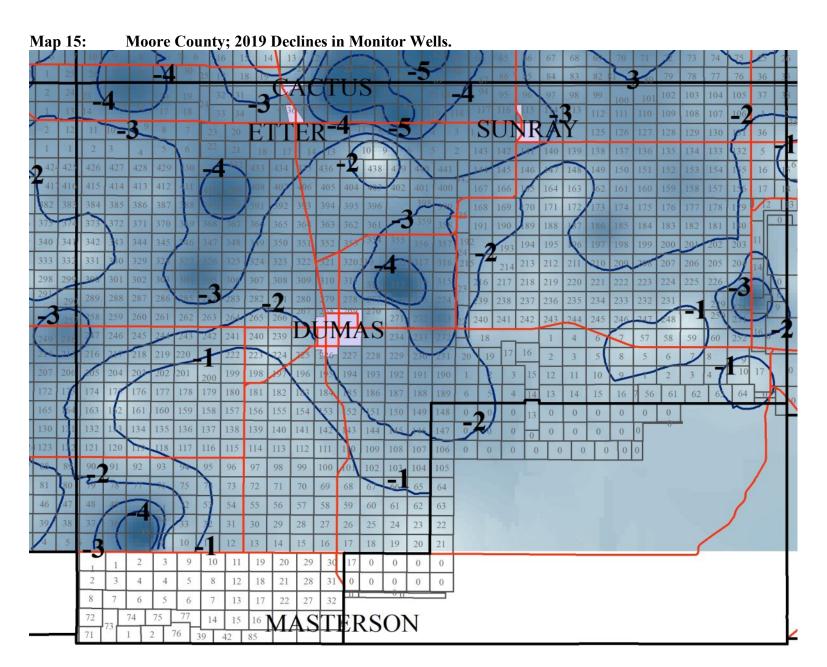
Map 12: Dallam County; 2019 Declines in Monitor Wells.



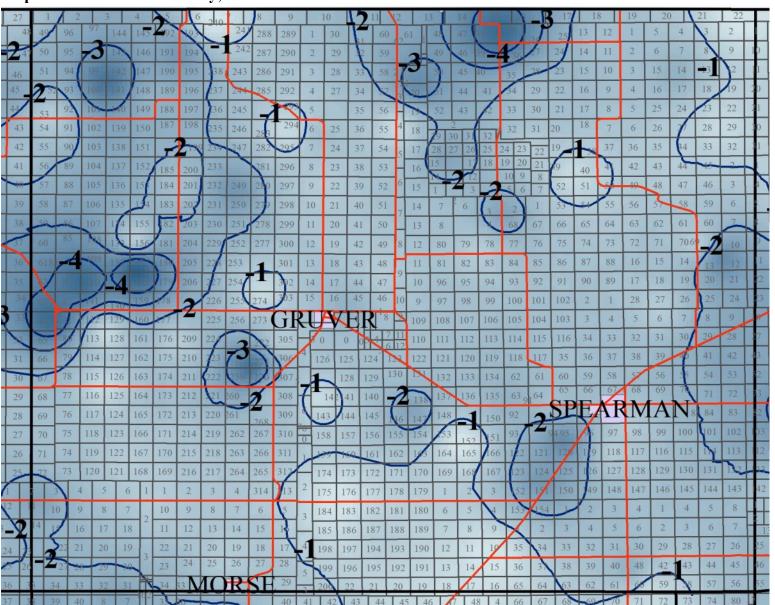
Map 13: Hartley County; 2019 Declines in Monitor Wells. -5 ROMERO 22 84858687888990 CHANNING

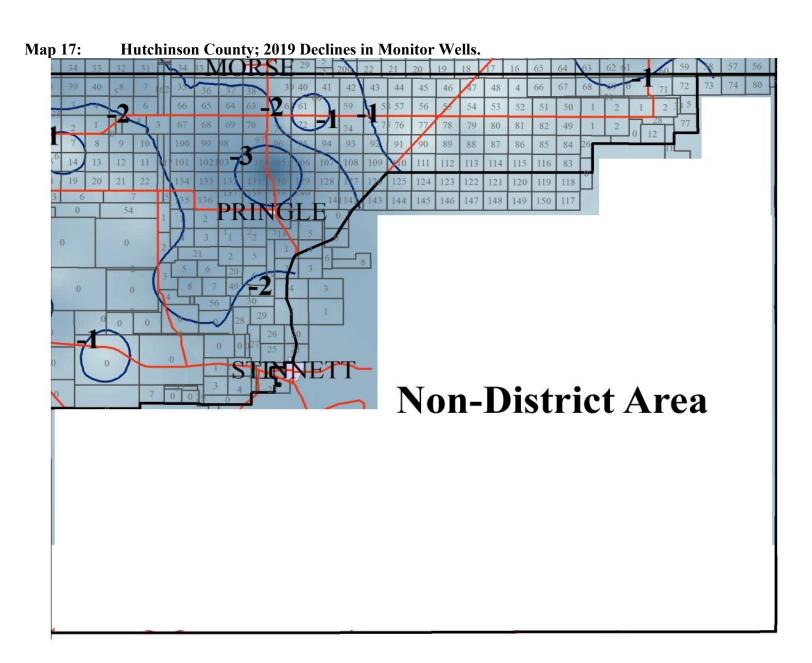
Map 14: Sherman County; 2019 Declines in Monitor Wells.



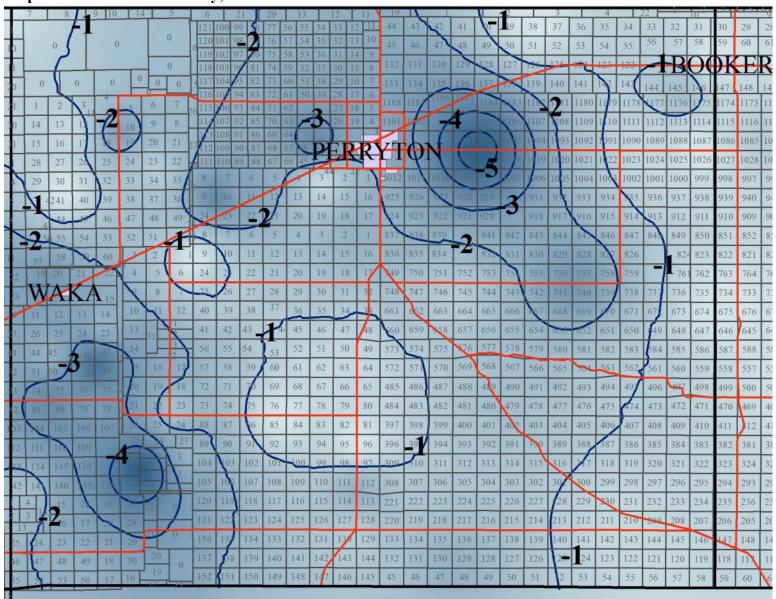


Map 16: Hansford County; 2019 Declines in Monitor Wells.





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



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

		, ,	-3-1		6.1	-	-2-	_0_	100	_				-113	1 13 1					20.	_		- 22	24		16	-	20	30		32	_
3	32	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11/	10	9	1	7	6	5	4	3	2	1
5	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	7	79	80	81		83	14	85	86	87	88
4	B	Ω	h	4F	R	115	114	113	112	111		109	108	107	106	105	104	103	102	101		69	98	97 9	-2		94	13	92	91	90	89
1	145	7	17	140	140	150	151	152	153	154	155)A	R	R	\mathbf{H}	7	ET	T	163	164		106	E	$\overline{\mathbf{A}}$	7	95		72	173	174	175	176
77	1176	1275	1174	1173	1172	1171	1170	1169	1168	1167	1166	1165	1164	1163	1162	1161		1150	1158		1156	115	F	71	L			71	1	1117	1146	114
12	1113	1114	1115	1116	1117	1118	1119	1120	1121	1122	1123	1124		1126		1128		72	1131	1132	1133	1134	1135	1136	1137	51		9	1	1142	1143	1144
89	1088	1087	1086	1085	1084		1082	1081	1080	1079		1077		1075		/	1072	1071	1 70		1068		1066	1065	1064	1063	1062	1061	1000	1059	1058	105
24	1025	1026	1027	1028	1029	1030	1031	1032	1033	1034	1035	1036	1037	1038	103	1040	1041	1042	1043	1044	1045	1046	1047	1048	1049	1050	1051	1052	1053	1054	1055	1056
01	1000	999	998	997	996	995	994	993	992	991	990	989	988	987	986	985	984		982	981	980	979	978	بمبو	976	975	974	973	972	971	970	969
36	937	938	939	940	941	942	943	944	945	946	947	948	949	950	951	52	953	9/4	955	956	957	958	951	960	961	961	963	964	965	166	967	968
13	912	911	910	909	908	907	906	905	904	903	902	901	900	899	898	897	890	895	894	893	892	891	7	889	888	887	886	885	884	883	882	881
1	849	850	851	852	853	854	855	856	857	858	859	860	861	862	863	864	865	866	867	868	869	870	3	872	873	874	875	876	877	878	879	880
2.5	824	823	822	821	820	819	818	817	816	815	814	813	812	811	810	809	808	807	806	805	804	803	802	801	800	799	798	2	796	796	794	793
_/	761	762	763	764	765	766	767	768	769	770	771	772	773	774	775	776	777	778	779	780	781	782	783	784	785	786	787	788	789	790	791	792
Ţ	736	735	734	733	732	731	730	729	728	727	726	725	724	723	722	721	720	719	718	717	716	715	14	713	712	7/1	710	709	708	107	706	705
1	673	674	675	676	677	678	679	680	681	682	683	684	685	686	687	688	689	690	691	692	693	694	695	696	697	698	699	700	70/	702	703	704
49	648	647	646	645	644	643	642	641	640	639	638	637	636	635	634	633	632	631	630	629	628	627	626	625	624	623	622	621	620	619	618	617
84	585	586	587	588	589	590	591	592	593	594	595	596	597	598	599	П	29	C()V	/IR	605	606	607	608	609	610	611	612	613	614	615	616
61	560	559	558	557	556	555	554	553	552	551	550	549	548	547	546	545	544	543	542	541	540	539	538	537	536	535	534	533	532	531	530	529
96	497	498	499	500	501	502	503	504	505	506	507	508	509	510	511	512	513	514	515	516	517	518	519	520	521	522	523	524	525	526	527	528
73	472	471	470	469	468	467	466	465	464	463	462	461	460	459	458	457	456	455	454	453	452	451	450	449	448	447	446	445	444	143	442	441
08	409	410	411	12	413	414	415	416	417	418	419	420	421	422	423	424	425	426	427	428	429	430	431	432	433	434	435	436	437	438	439	440
85	384	383	382	381	380	379	378	377	376	375	374	373	372	371	370	369	368	367	366	365	364	363	362	361	360	359	358	357	356	355	354	353
20	321	322	323	324	325	326	327	328	329	330	331	332	333	334	335	336	337	338	339	340	341	342	343	344	345	346	347	348	349	350	351	352
97	296	295	294	293	292	291	290	289	288	287	286	285	284	283	282	281	280	279	278	277	276	275	274	273	272	271	270	269	268	267	266	26:
32	233	234	235	236	237	238	239	240	241	242	243	244	245	246	247	248	249	250	251	252	253	254	255	256	257	258	259	260	261	Π	50	H
00	208	207	206	205	204	203	202	201	200	199	198	197	196	195	194	193	192	191	190	189	188	187	186	185	184	183	182	181	180	179	178	17
14	145	146	147	148	149	150	151	152	153	154	155	156	157	158	159	160	161	162	163	164	165	166	167	168	169	170	171	172	173	174	175	170
21	120	119	118	11	116	115	114	113	112	111	110	109	108	107	106	105	104	103	102	101	100	99	98	97	96	95	94	93	92	91	90	89
6	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88

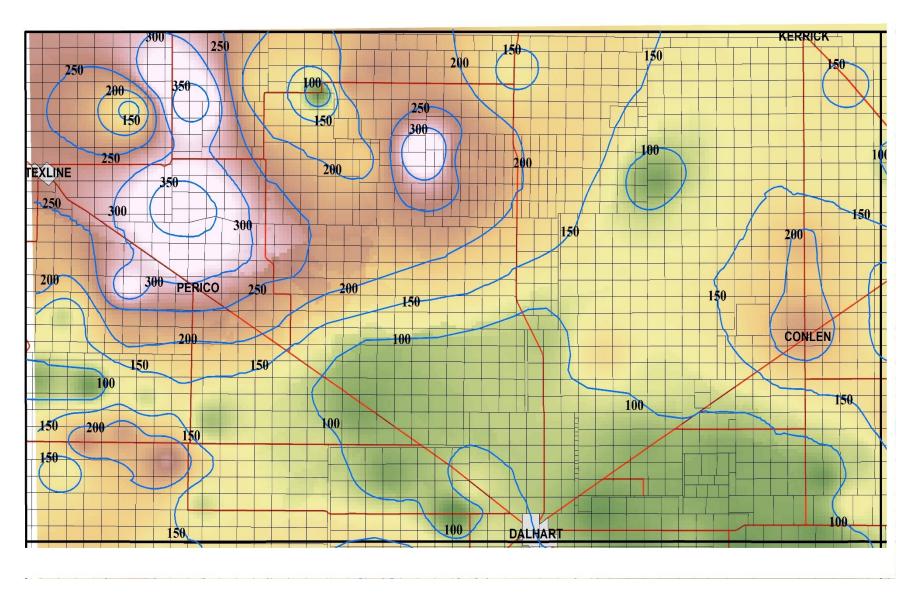
XV. 2018-2020 Estimated (Average) Saturated Thickness of the Ogallala Aquifer by County

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.

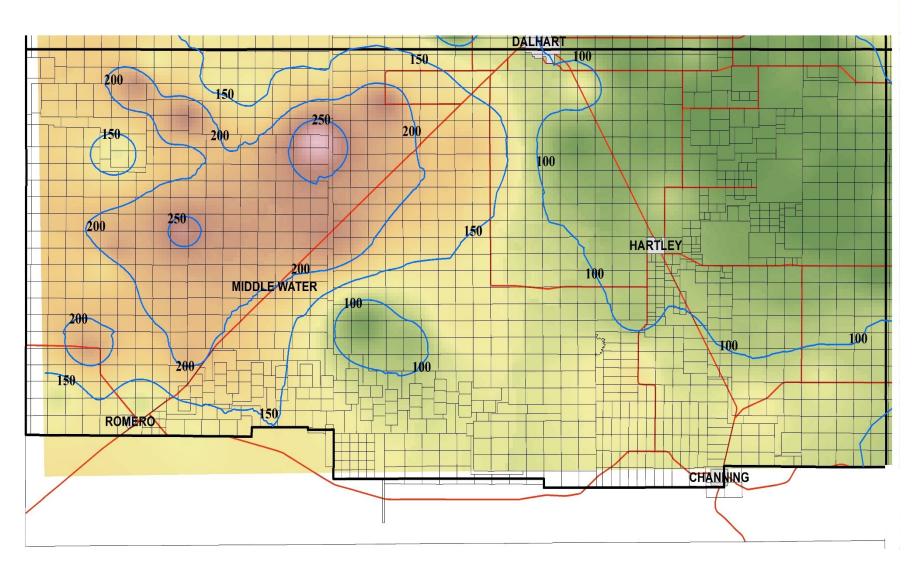
Estimated Saturated Thickness Maps are created every other year. The next set of estimated aquifer thickness maps are scheduled to be created in early Summer of 2021.

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.

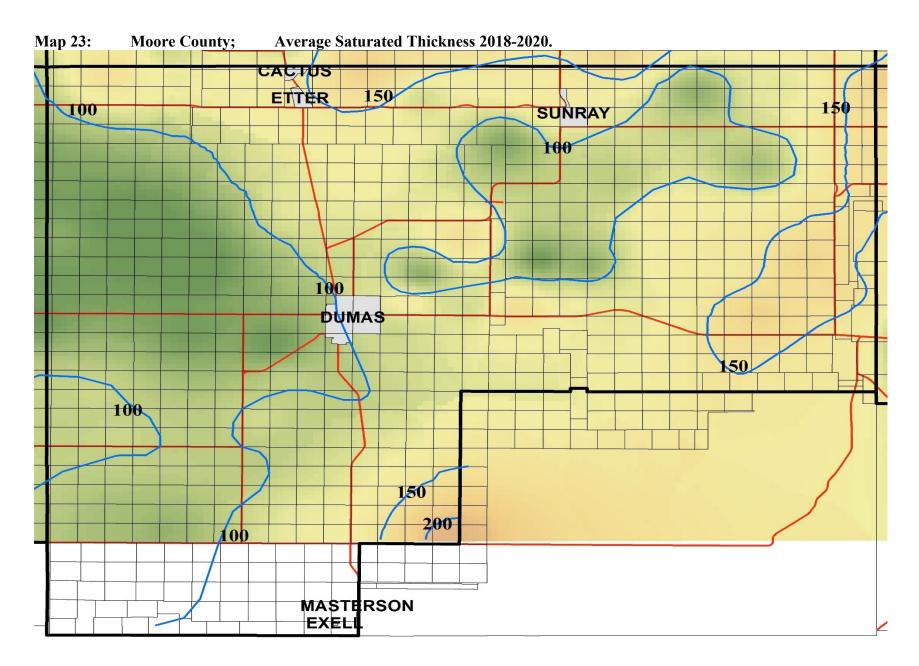


Map 21: Hartley County; Average Saturated Thickness 2018-2020.

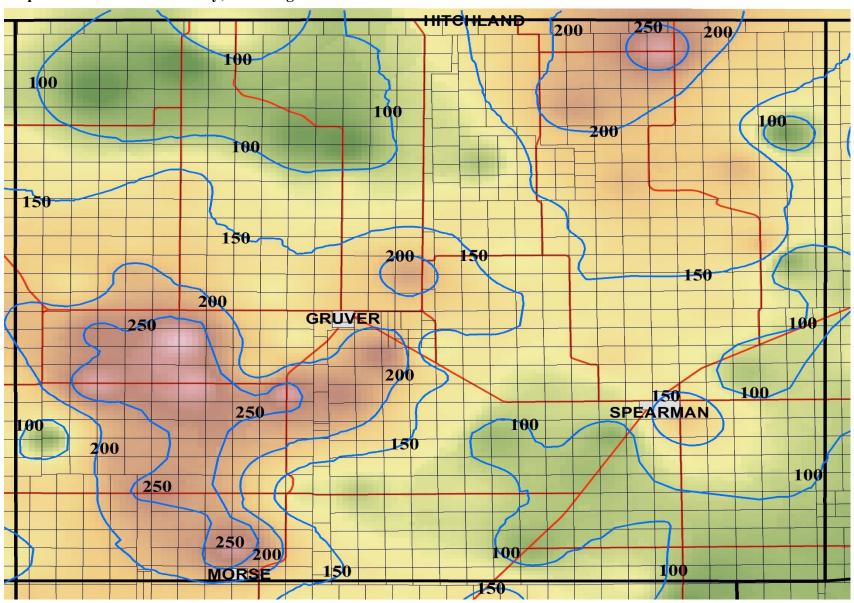


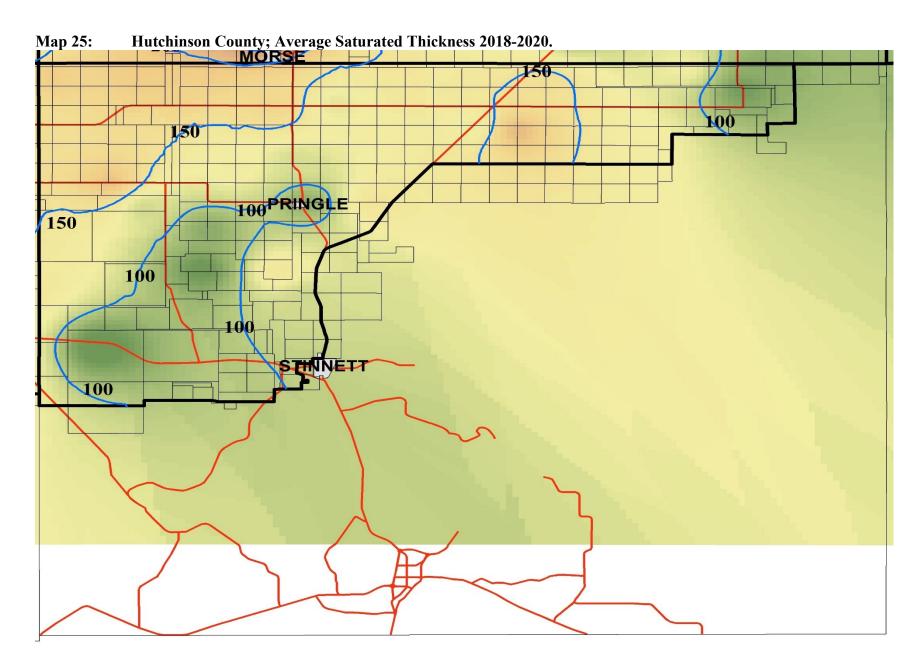
Map 22: Sherman County; Average Saturated Thickness 2018-2020. TEXHOMA STRATFORD

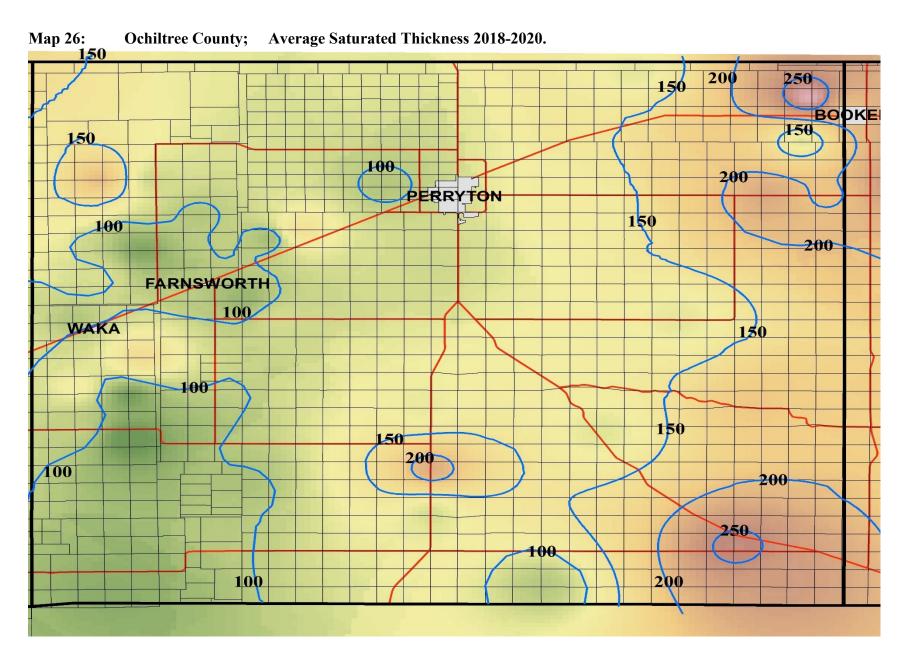
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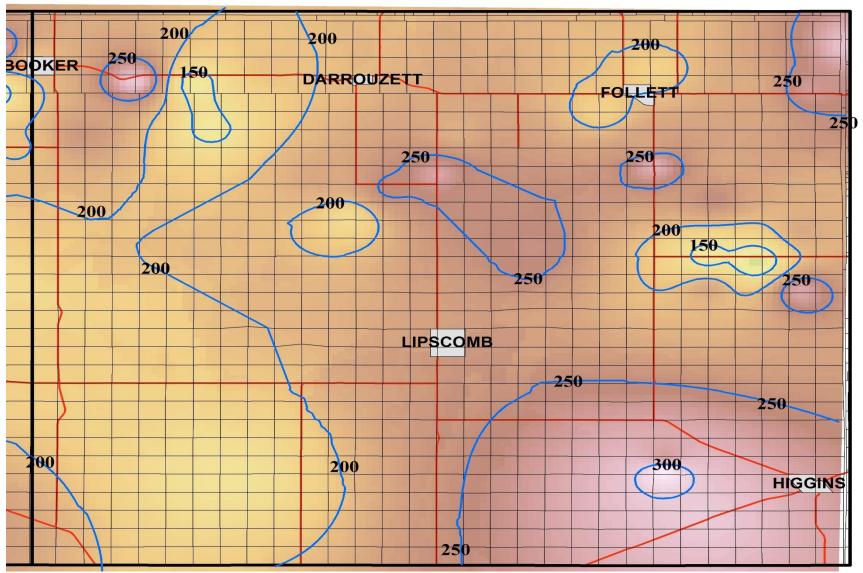
Map 24: Hansford County; Average Saturated Thickness 2018-2020.







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



XVI. Contributors to Hydrology and Groundwater Resources 2019-2020

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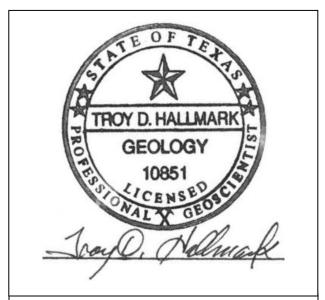
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