GEO 327G

GIS & GPS Applications in Earth Science

Assessing Water Table Change of Select Texas Counties in the Ogallala Aquifer from 1998-2018

Mark Lawrence

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Background and Introduction:

The Ogallala Aquifer has been a source of freshwater for many people along the Great Plains of the United States. It underlies 8 states reaching as far north as South Dakota and as far south as the Texas panhandle. This underground sea of water varies in depth depending on the geology of the landscape. The Texas panhandle is one of the areas where the depth of the aquifer is shallowest as well as most prone to drought, receiving an average of 22.2 inches of precipitation per year, so keeping water data on the area is important. Growing up near the panhandle, and working as a ranch hand, it was always interesting to see the heavily irrigated lands which depend on the center-pivot system to keep crops irrigated. The aquifer is a vital source of water that surrounding communities heavily depend on and without it, wouldn't exist. The six-county area of interest is located in a dense agriculture area in the Texas panhandle. The counties of study include: Bailey, Cochran, Hale, Hockley, Lamb, and Lubbock.

Problem:

I am interested in understanding the water table change over the last 20 years. To do this, I would need to find Ogallala aquifer water elevation data ranging over the specified time of interest. I would then have to compare the two separate years (1998 & 2018) by using a spatial analysis tool like the spline tool and a raster calculator like map algebra to determine areas of depletion over twenty years.

Being able to quantify the aquifer depletion would be essential in determining future predictions of water availability and for the area of study. Other studies based off water loss could include effect on agricultural, and urban land-use practices as well as ground water quality, and recharge.

Data Collection:

Texas Political Boundaries were downloaded from the Texas Department of Transportation system (TxDoT), http://gis-txdot.opendata.arcgis.com/

Water table measurements by county were downloaded from the Texas Water Development Board in the groundwater Database (GWDB), https://www.twdb.texas.gov/groundwater/data/gwdbrpt.asp

Ogallala Aquifer shapefile was downloaded from the Texas aquifers in the Texas Water Development Board in the GIS Data section https://www.twdb.texas.gov/mapping/gisdata.asp

General information about the Ogallala Aquifer was attained from the websites listed below to gain a better understanding of the area.

https://www.scientificamerican.com/article/the-ogallala-aquifer/

https://pubs.usgs.gov/fs/2000/0091/report.pdf

Data Pre-Processing:

The Texas shapefile (figure 1) was loaded into ArcMap from the TXDoT website with the North American Datum 1983 coordinate system which is what I'll be working in for the project. From here I selected the counties that are either fully or partially inside the Ogallala Aquifer. I then used the Extract by Mask tool to define a concentrated working area. I then loaded the Texas aquifer shapefile from TWDB and used the attribute table to select the polygons within the Ogallala as seen in Figure 2.

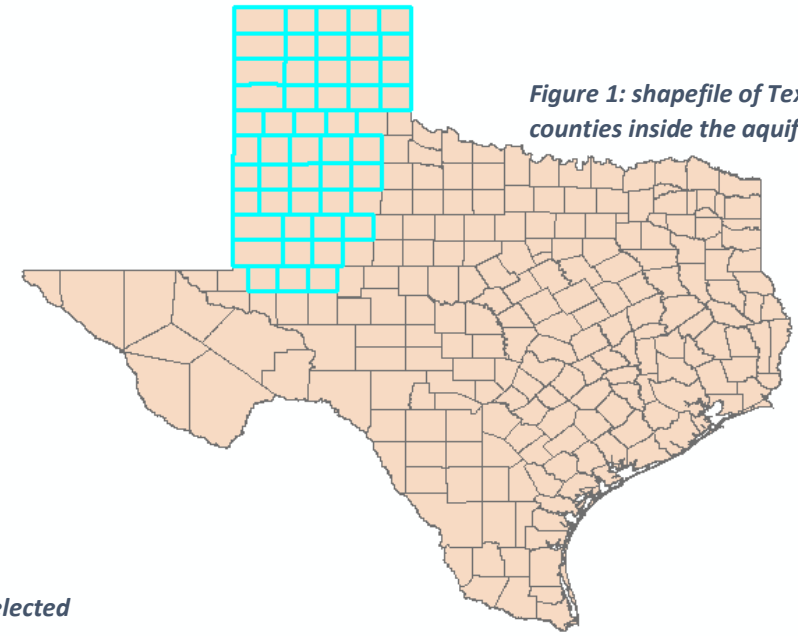
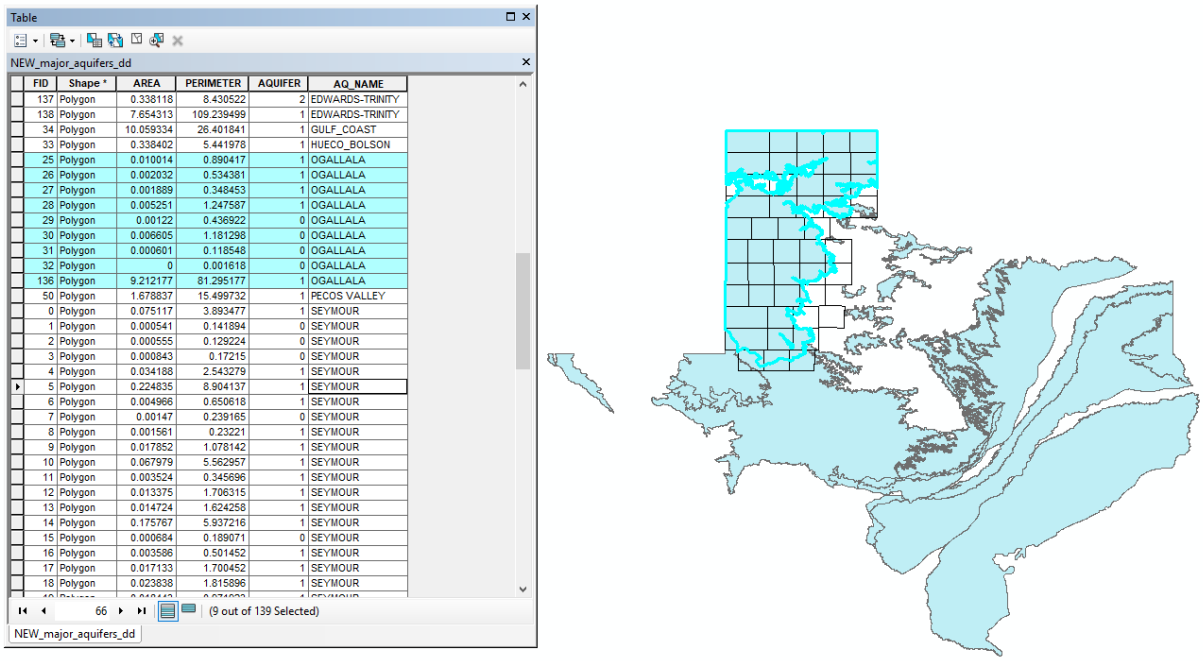


Figure 1: shapefile of Texas with selected counties inside the aquifer.

Figure 2: Ogallala boundary selected from Texas aquifer shapefile.



Table

NEW_major_aquifers_dd

FID	Shape *	AREA	PERIMETER	AQUIFER	AQ_NAME
137	Polygon	0.338118	8.430522	2	EDWARDS-TRINITY
138	Polygon	7.654313	109.239499	1	EDWARDS-TRINITY
34	Polygon	10.059334	26.401841	1	GULF_COAST
33	Polygon	0.338402	5.441978	1	HUECO_BOLSON
25	Polygon	0.010014	0.890417	1	OGALLALA
26	Polygon	0.002032	0.534381	1	OGALLALA
27	Polygon	0.001889	0.348453	1	OGALLALA
28	Polygon	0.005251	1.247587	1	OGALLALA
29	Polygon	0.00122	0.436922	0	OGALLALA
30	Polygon	0.006605	1.181298	0	OGALLALA
31	Polygon	0.000601	0.118548	0	OGALLALA
32	Polygon	0	0.001618	0	OGALLALA
136	Polygon	9.212177	81.295177	1	OGALLALA
50	Polygon	1.678837	15.499732	1	PECOS VALLEY
0	Polygon	0.075117	3.893477	1	SEYMOUR
1	Polygon	0.000541	0.141894	0	SEYMOUR
2	Polygon	0.000555	0.129224	0	SEYMOUR
3	Polygon	0.000843	0.17215	0	SEYMOUR
4	Polygon	0.034188	2.543279	1	SEYMOUR
5	Polygon	0.224835	8.904137	1	SEYMOUR
6	Polygon	0.004966	0.650618	1	SEYMOUR
7	Polygon	0.00147	0.239165	0	SEYMOUR
8	Polygon	0.001561	0.23221	1	SEYMOUR
9	Polygon	0.017852	1.078142	1	SEYMOUR
10	Polygon	0.067979	5.562957	1	SEYMOUR
11	Polygon	0.003524	0.345696	1	SEYMOUR
12	Polygon	0.013375	1.706315	1	SEYMOUR
13	Polygon	0.014724	1.624258	1	SEYMOUR
14	Polygon	0.175767	5.937216	1	SEYMOUR
15	Polygon	0.000684	0.189071	0	SEYMOUR
16	Polygon	0.003586	0.501452	1	SEYMOUR
17	Polygon	0.017133	1.700452	1	SEYMOUR
18	Polygon	0.023838	1.815896	1	SEYMOUR

66 (9 out of 139 Selected)

NEW_major_aquifers_dd

For Aquifer specific data I used the Texas Water Development Boards groundwater database to get well water data specific to the counties of interest. After Selecting “Water Levels by County”, Figure 3 shows the data that is found with the specific selections from the drop-down menus. The data shows the things like the state well number, date of measurement, and water elevation. To extract the data, I clicked on the “Export Drop Down Menu” and then clicked “CSV (comma Delimited)” to export into Excel for manipulation. I did this for each of the counties of interest.

County: Bailey Aquifer: Ogallala View Report
Observation Type: GCD Current Observation Well Coordinate Format: Decimal Degrees
1 of 124 Find | Next

Texas Water Development Board

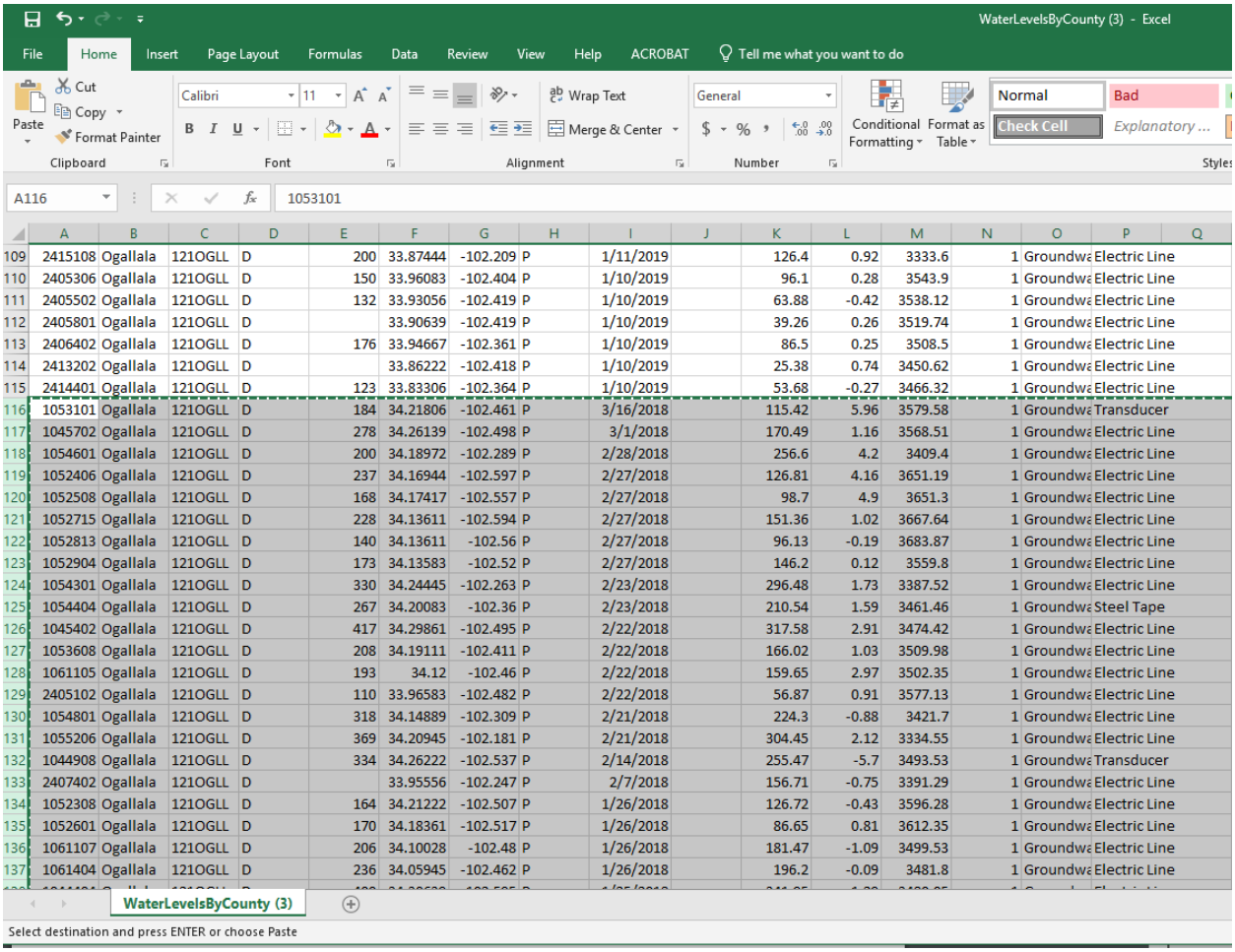
Texas Water Development Board (TWDB) Groundwater Database (GWDB)
Well Water Levels Report
County: Bailey
Aquifer: Ogallala
Observation Type: GCD Current Observation Well

groundwater division

State Well Number	Coordinates	Aquifer	Aquifer Code	Obs Code	Well Depth (ft. below land surface)	Status Code	Date	Time	Water Level (ft. below land surface)	Change value in ( ) indicates rise in level	Water Elevation (ft. above sea level)	Meas #	Measuring Agency	Method	Remark ID	Comments
0948902	34° 17' 15" N 103° 02' 01" W	Ogallala	121OGLL	D	272	P	1/10/1964		117.15		3940.85	1	Texas Water Development Board	Steel Tape		
						P	1/5/1965		121.9	4.75	3936.1	1	Texas Water Development Board	Steel Tape		
						P	1/8/1966		124.31	2.41	3933.69	1	Texas Water Development Board	Steel Tape		
						P	1/7/1967		127.14	2.83	3930.86	1	Texas Water Development Board	Steel Tape		
						P	1/9/1968		130.28	3.14	3927.72	1	Texas Water Development Board	Steel Tape		
						X	1/9/1969					1	Texas Water Development Board		20	
						P	1/14/1970		133.67		3924.33	1	Groundwater Conservation District	Steel Tape		
						P	1/9/1971		133.84	0.17	3924.16	1	Groundwater Conservation District	Steel Tape		
						P	1/2/1972		138.14	4.30	3919.86	1	Groundwater Conservation District	Steel Tape		
						P	1/19/1973		147.2	9.06	3910.8	1	Groundwater Conservation District	Steel Tape		
						P	1/8/1974		140.22	(6.98)	3917.78	1	Groundwater Conservation District	Steel Tape		
						P	1/10/1975		147.57	7.35	3910.43	1	Groundwater Conservation District	Steel Tape		
						P	1/12/1976		146.59	(0.98)	3911.41	1	Groundwater Conservation District	Steel Tape		
						P	1/11/1977		151.51	4.92	3906.49	1	Groundwater Conservation District	Steel Tape		
						P	1/10/1978		153.32	1.81	3904.68	1	Groundwater Conservation District	Steel Tape		
						P	1/9/1979		155.04	1.72	3902.96	1	Groundwater Conservation District	Steel Tape		
						P	12/17/1979		156.53	1.49	3901.47	1	Groundwater Conservation District	Steel Tape		

Figure 3: Ogallala well water data of Bailey county

I then browsed over to the Excel file to manipulate the data because I'm only interested in two years (1998 & 2018). Data from the counties of interest were cut and pasted into two different spreadsheets with one being the 2018 wells and the other being 1998 wells. I then saved these as Comma Separated Values (CSV) files and loaded them into ArcMap. Figure 4 Below shows what the spreadsheets from the groundwater database looked like prior to manipulation.



	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q
109	2415108	Ogallala	121OGLL	D	200	33.87444	-102.209	P	1/11/2019		126.4	0.92	3333.6	1	Groundwa	Electric Line	
110	2405306	Ogallala	121OGLL	D	150	33.96083	-102.404	P	1/10/2019		96.1	0.28	3543.9	1	Groundwa	Electric Line	
111	2405502	Ogallala	121OGLL	D	132	33.93056	-102.419	P	1/10/2019		63.88	-0.42	3538.12	1	Groundwa	Electric Line	
112	2405801	Ogallala	121OGLL	D		33.90639	-102.419	P	1/10/2019		39.26	0.26	3519.74	1	Groundwa	Electric Line	
113	2406402	Ogallala	121OGLL	D	176	33.94667	-102.361	P	1/10/2019		86.5	0.25	3508.5	1	Groundwa	Electric Line	
114	2413202	Ogallala	121OGLL	D		33.86222	-102.418	P	1/10/2019		25.38	0.74	3450.62	1	Groundwa	Electric Line	
115	2414401	Ogallala	121OGLL	D	123	33.83306	-102.364	P	1/10/2019		53.68	-0.27	3466.32	1	Groundwa	Electric Line	
116	1053101	Ogallala	121OGLL	D	184	34.21806	-102.461	P	3/16/2018		115.42	5.96	3579.58	1	Groundwa	Transducer	
117	1045702	Ogallala	121OGLL	D	278	34.26139	-102.498	P	3/1/2018		170.49	1.16	3568.51	1	Groundwa	Electric Line	
118	1054601	Ogallala	121OGLL	D	200	34.18972	-102.289	P	2/28/2018		256.6	4.2	3409.4	1	Groundwa	Electric Line	
119	1052406	Ogallala	121OGLL	D	237	34.16944	-102.597	P	2/27/2018		126.81	4.16	3651.19	1	Groundwa	Electric Line	
120	1052508	Ogallala	121OGLL	D	168	34.17417	-102.557	P	2/27/2018		98.7	4.9	3651.3	1	Groundwa	Electric Line	
121	1052715	Ogallala	121OGLL	D	228	34.13611	-102.594	P	2/27/2018		151.36	1.02	3667.64	1	Groundwa	Electric Line	
122	1052813	Ogallala	121OGLL	D	140	34.13611	-102.56	P	2/27/2018		96.13	-0.19	3683.87	1	Groundwa	Electric Line	
123	1052904	Ogallala	121OGLL	D	173	34.13583	-102.52	P	2/27/2018		146.2	0.12	3559.8	1	Groundwa	Electric Line	
124	1054301	Ogallala	121OGLL	D	330	34.24445	-102.263	P	2/23/2018		296.48	1.73	3387.52	1	Groundwa	Electric Line	
125	1054404	Ogallala	121OGLL	D	267	34.20083	-102.36	P	2/23/2018		210.54	1.59	3461.46	1	Groundwa	Steel Tape	
126	1045402	Ogallala	121OGLL	D	417	34.29861	-102.495	P	2/22/2018		317.58	2.91	3474.42	1	Groundwa	Electric Line	
127	1053608	Ogallala	121OGLL	D	208	34.19111	-102.411	P	2/22/2018		166.02	1.03	3509.98	1	Groundwa	Electric Line	
128	1061105	Ogallala	121OGLL	D	193	34.12	-102.46	P	2/22/2018		159.65	2.97	3502.35	1	Groundwa	Electric Line	
129	2405102	Ogallala	121OGLL	D	110	33.96583	-102.482	P	2/22/2018		56.87	0.91	3577.13	1	Groundwa	Electric Line	
130	1054801	Ogallala	121OGLL	D	318	34.14889	-102.309	P	2/21/2018		224.3	-0.88	3421.7	1	Groundwa	Electric Line	
131	1055206	Ogallala	121OGLL	D	369	34.20945	-102.181	P	2/21/2018		304.45	2.12	3334.55	1	Groundwa	Electric Line	
132	1044908	Ogallala	121OGLL	D	334	34.26222	-102.537	P	2/14/2018		255.47	-5.7	3493.53	1	Groundwa	Transducer	
133	2407402	Ogallala	121OGLL	D		33.95556	-102.247	P	2/7/2018		156.71	-0.75	3391.29	1	Groundwa	Electric Line	
134	1052308	Ogallala	121OGLL	D	164	34.21222	-102.507	P	1/26/2018		126.72	-0.43	3596.28	1	Groundwa	Electric Line	
135	1052601	Ogallala	121OGLL	D	170	34.18361	-102.517	P	1/26/2018		86.65	0.81	3612.35	1	Groundwa	Electric Line	
136	1061107	Ogallala	121OGLL	D	206	34.10028	-102.48	P	1/26/2018		181.47	-1.09	3499.53	1	Groundwa	Electric Line	
137	1061404	Ogallala	121OGLL	D	236	34.05945	-102.462	P	1/26/2018		196.2	-0.09	3481.8	1	Groundwa	Electric Line	

Figure 4: Ogallala well water data exported into a Excel file.

Data Processing:

To display the well data, I loaded in the 1998 and 2018 wells tables I right clicked on "2018_wells.csv" in the table of contents and selected "Display XY Data" from the window and clicked through the warning messages (Figure 5). Figure 6 shows all the points plotted in the counties for 2018 (606 points). 1998 had 473 data points for the same county, this difference is due to more wells being measured today than in the past.

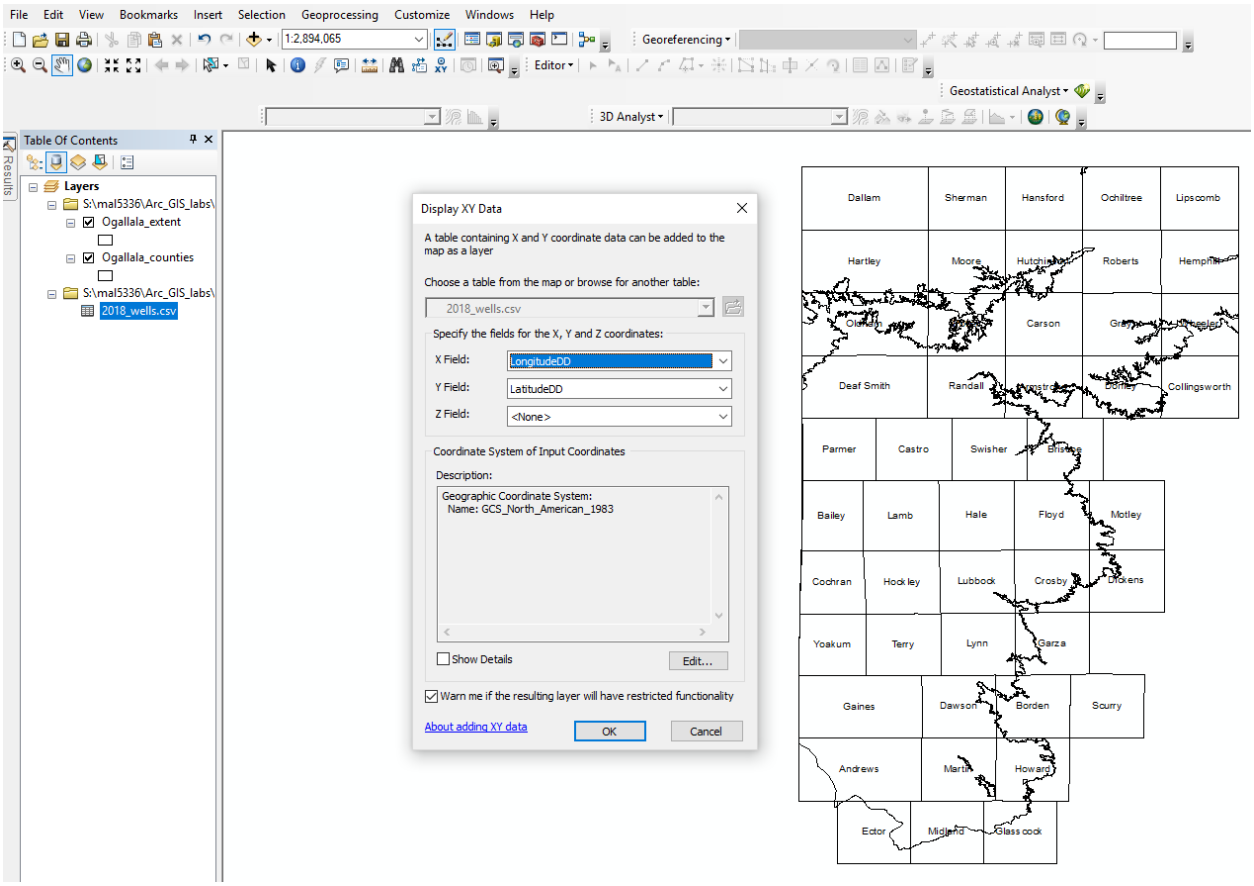


Figure 5: converting 2018 data into XY points

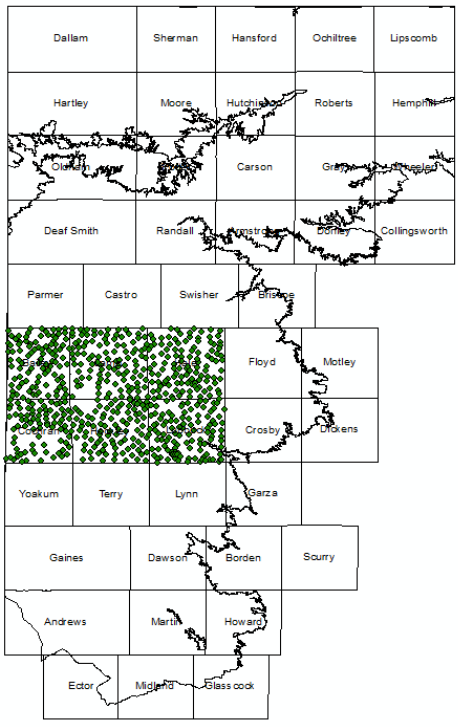


Figure 6: 2018 well water data converting into point data in ArcMap.

At this point I began the Splining process using the Spline (Spatial Analysis) tool to convert points to raster data. I based the Z value off of the water elevation which is the measurement of the water table in feet above sea level. Once the raster was created, I symbolized the data by breaking it up into 10 manual variables 200 feet apart. The values range from 2200 - 4200 ft. above sea level. I then created a splined raster of both the 2018 and 1998 wells. The Maps on Page 8 and 9 are the result of the spline calculator. Notice the decreased water table in 2018.

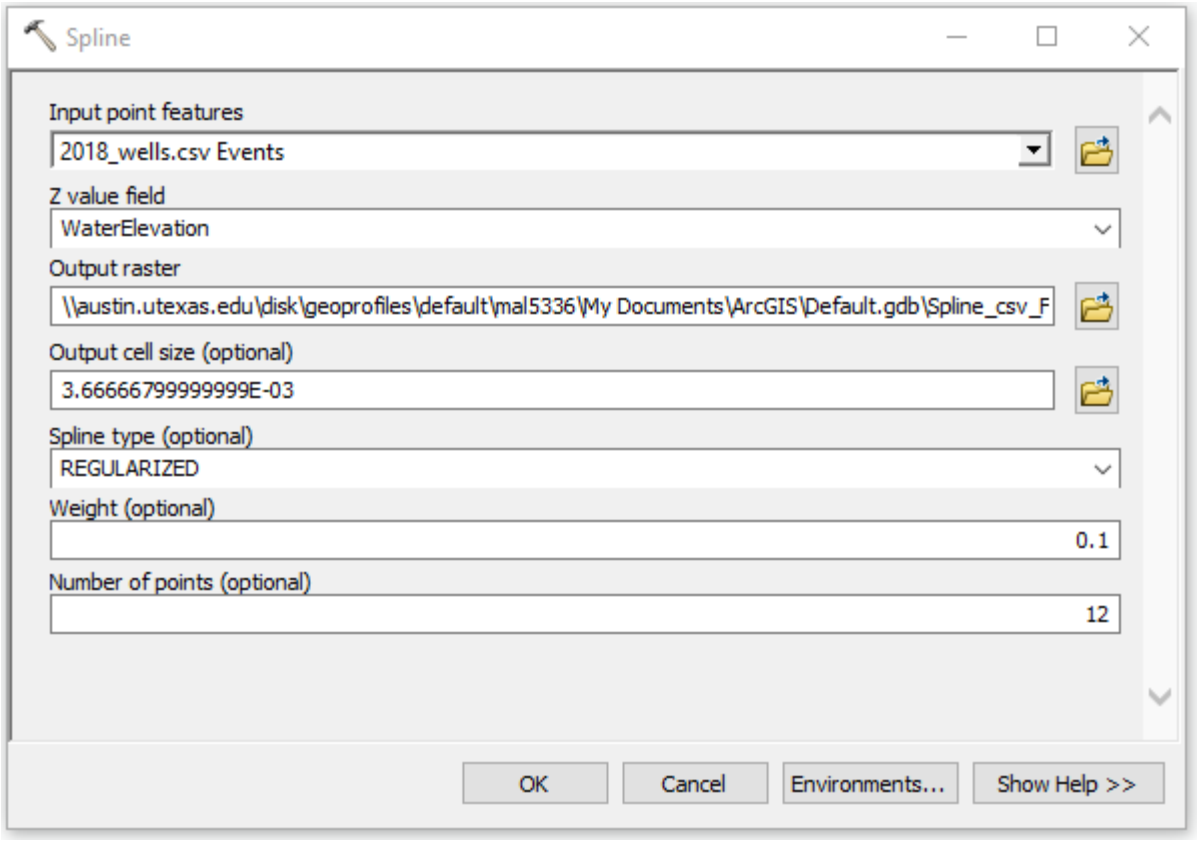
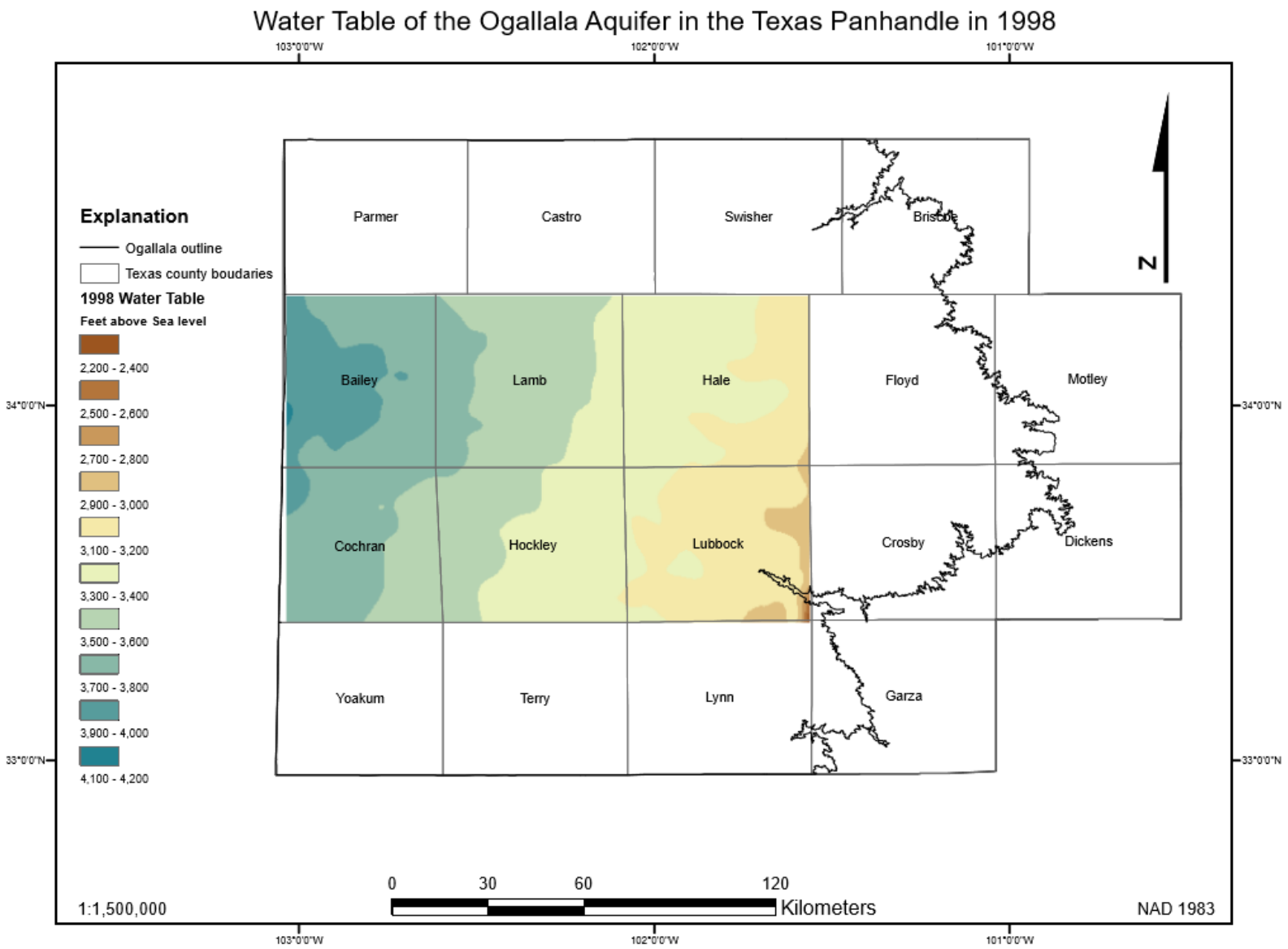
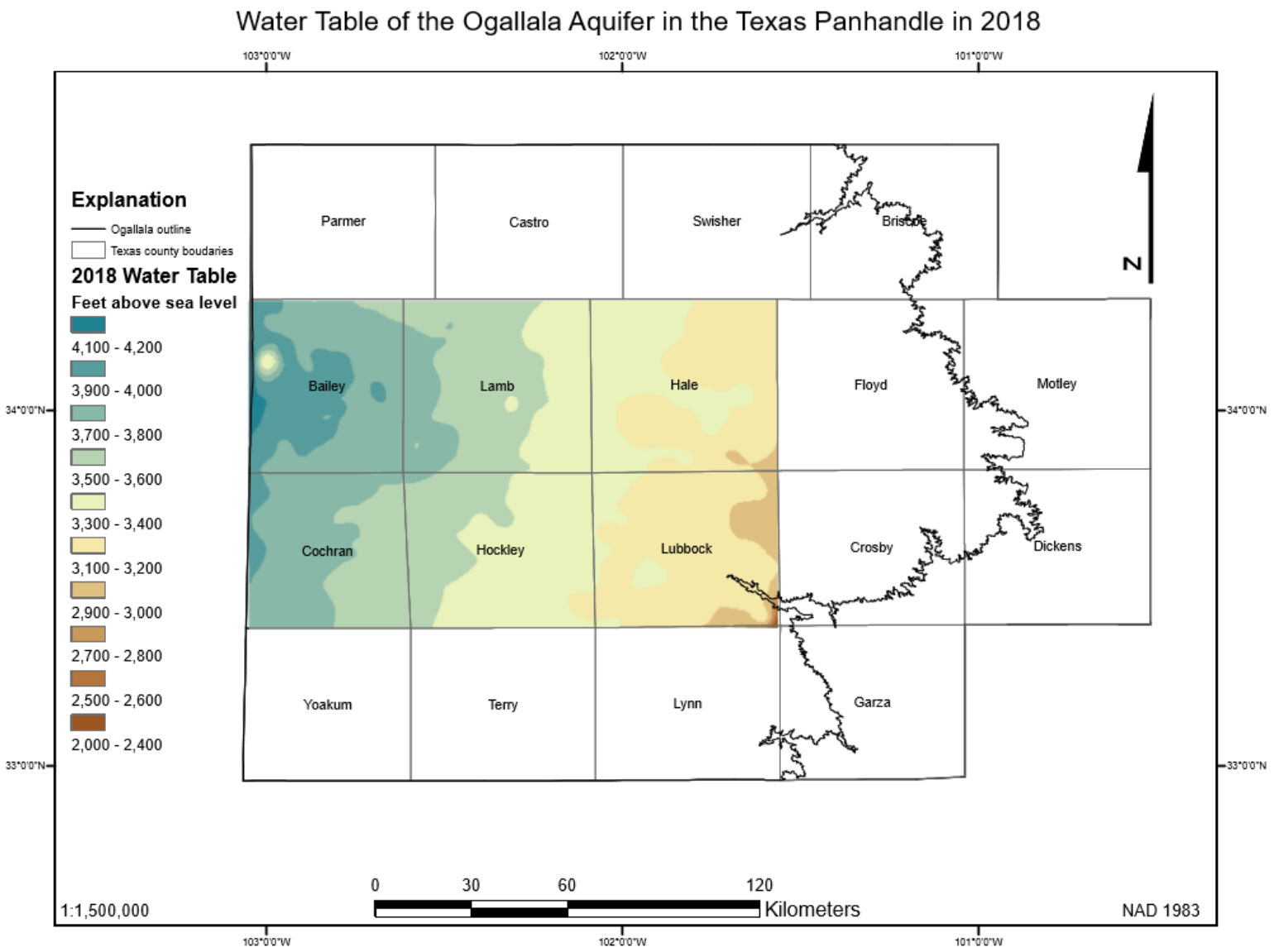


Figure 7: Spline dialogue box that converts my points to a raster



Map 1: Water Table calculation in 1998



Map 2: Water Table calculation in 2018

Now that I have calculated the water tables from 1998 and 2018 we can use the raster calculator tool (spatial analysis) to visualize the difference. The calculation I used is seen in Figure 8. After formatting the symbology, I created Map 3 which shows where water has increased (blue) and where it has decreased (red). Just from the eye test it appears to have dropped some degree.

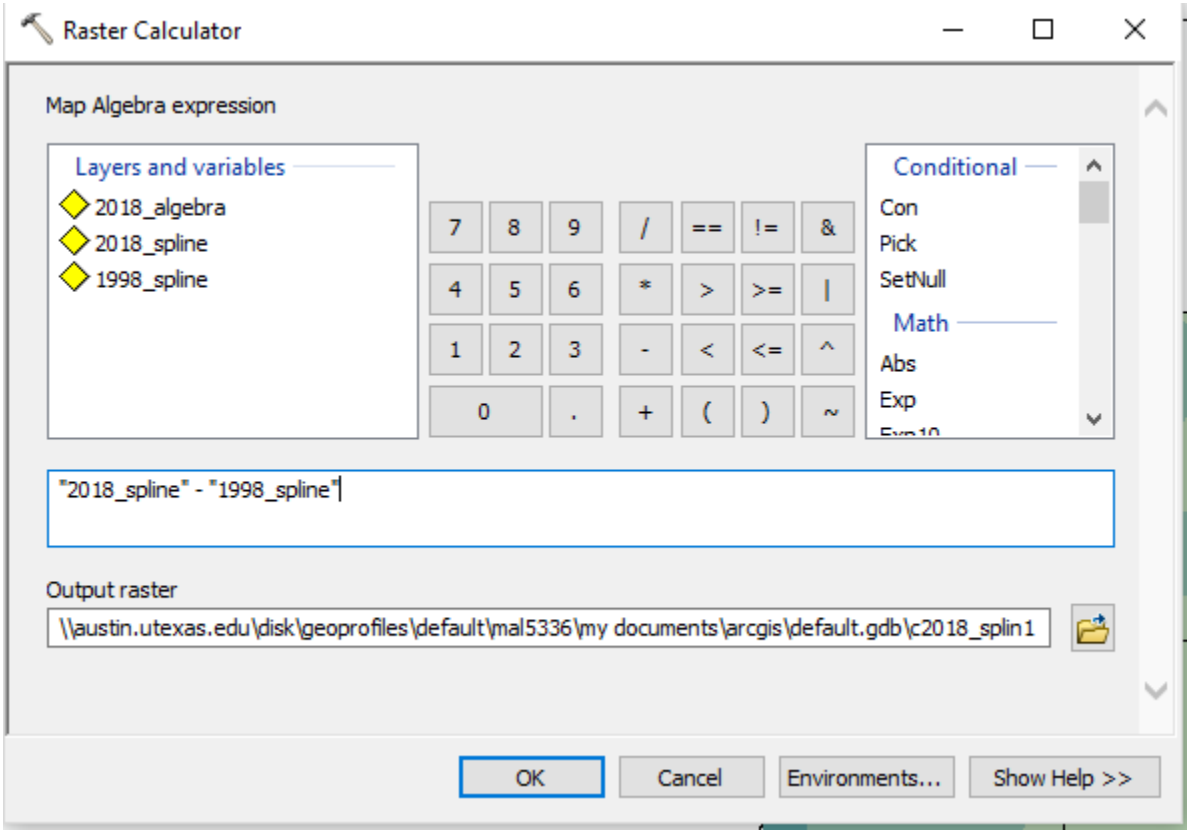
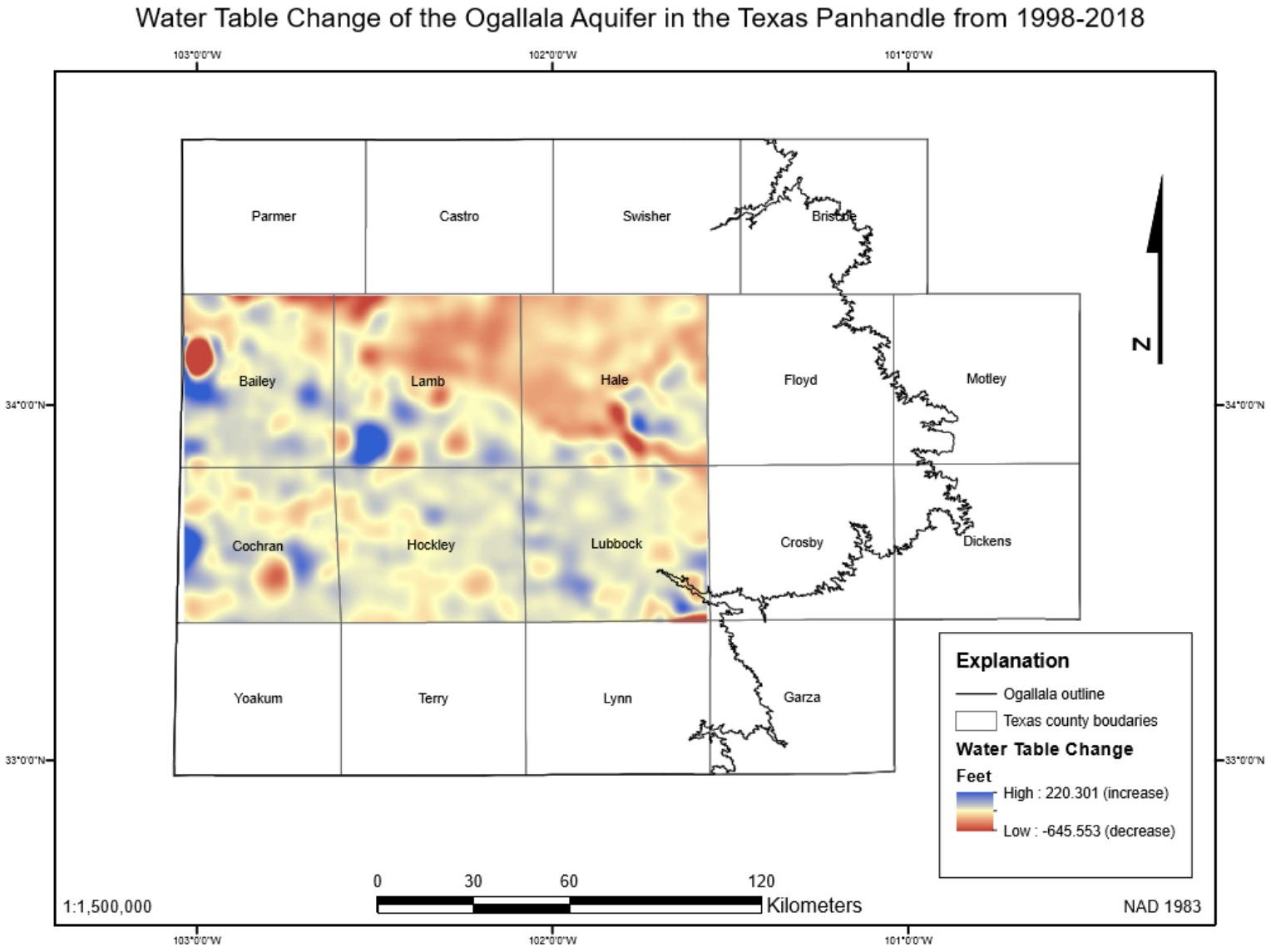


Figure 8: Raster Calculator dialogue box with equation



Map 3: Water Table Difference from 1998-2018

Results:

By looking at the statistics of the Map algebra raster, the average water table loss across the 6-county area is 18.85 feet. This is roughly 0.94 feet of water table drop per year. Much of this can be attributed to agriculture, human consumption, and lack of rainfall to recharge the aquifer loss. According to the Texas Water Development Board the aquifer has a maximum thickness 800 feet in Texas but the average for the entire panhandle is 95 feet. This would mean that in 101 years, with the current rate of depletion per year, the aquifer would run dry for a majority of the area.