OKLAHOMA Water Resources Board

Water-Level Changes in the Ogallala-Panhandle Aquifer (1982-2022)

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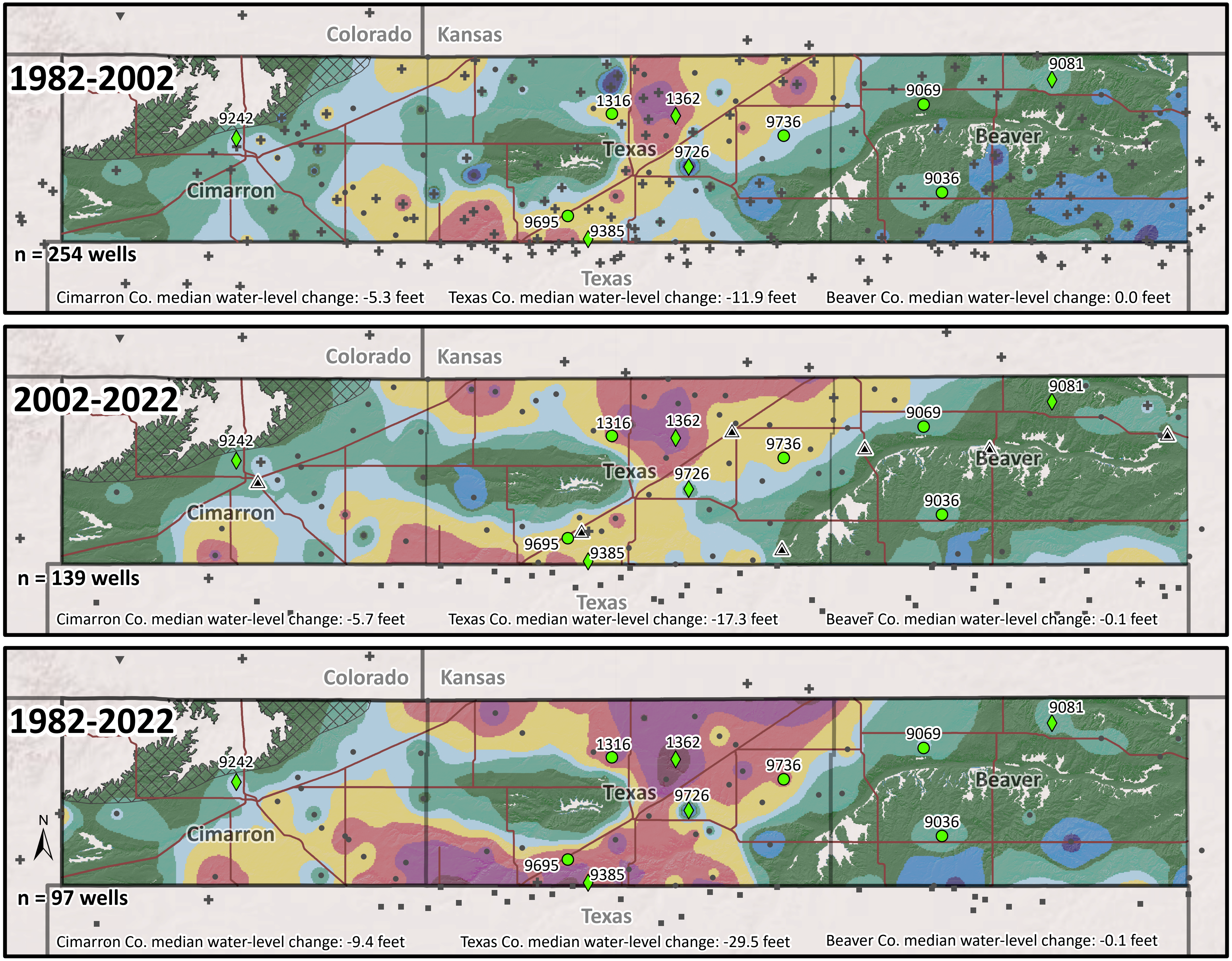

EXPLANATION

- Insufficient data
- Sites highlighted to show variations in trends (Figure 1)
- Oklahoma sites with the longest period of record (Figure 2)
- Climate stations
- Oklahoma Water Resources Board sites
- Colorado Division of Natural Resources sites
- U.S. Geological Survey sites
- Texas Water Development Board sites

Total water-level change, in feet

- -114.4 to -80
- >-80 to -50
- >-50 to -30
- >-30 to -15
- >-15 to -8
- >-8 to -1
- >-1 to 1
- >1 to 8
- >8 to 28.6

0 6 12 24 Miles

0 6 12 24 Kilometers

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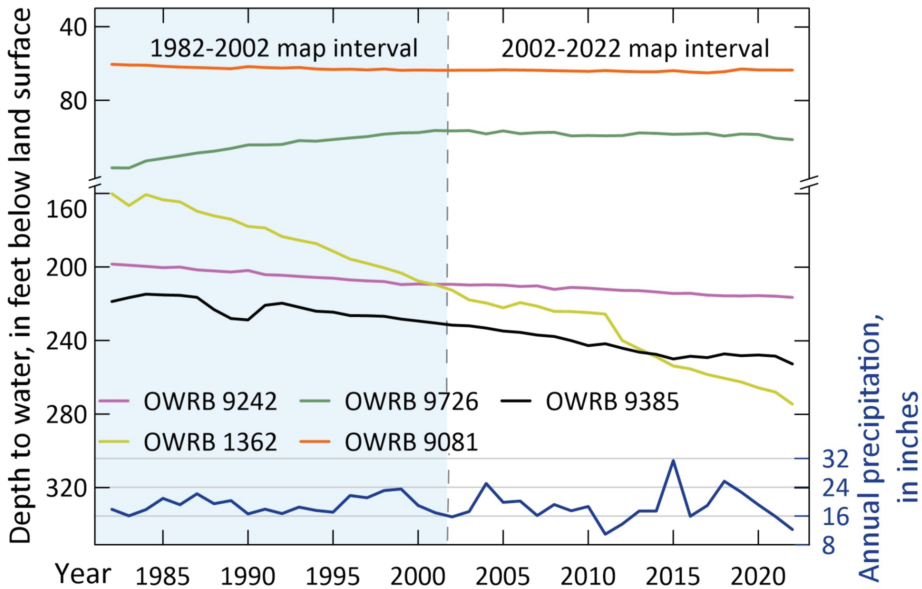


Figure 1: Annual discrete depth-to-water measurements between 1982 and 2022 for five OWRB sites across the Ogallala Panhandle aquifer. Sites were chosen based on spatial distribution, record continuity. and variation in behaviour. Annual precipitation was derived from seven nearby COOP stations (Oklahoma Climatological Survey, 2022).

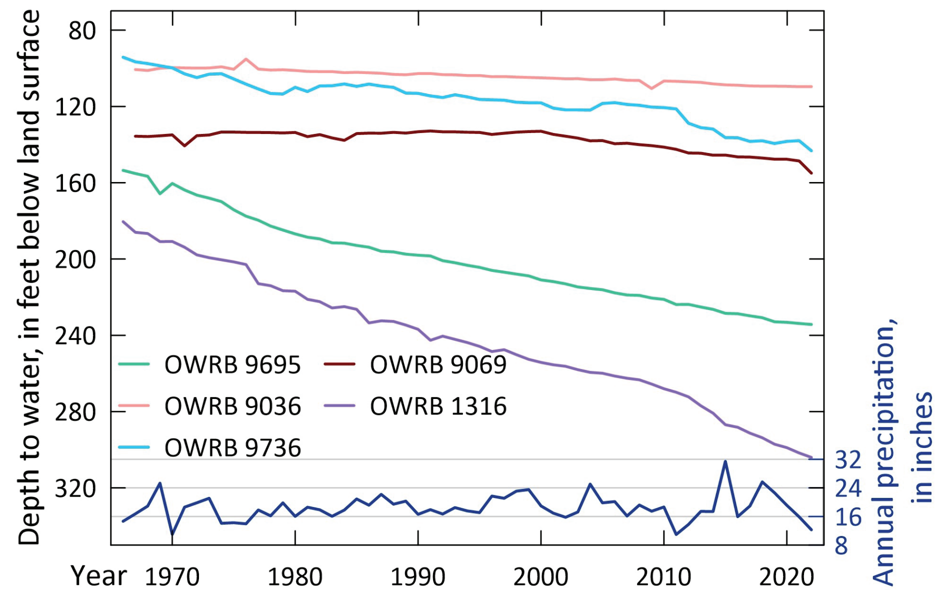


Figure 2: Annual discrete depth-to-water measurements starting in 1966 for OWRB wells with the longest periods of record in the Ogallala Panhandle aquifer which were not included in Figure 1. Annual precipitation was derived from seven nearby COOP stations (Oklahoma Climatological Survey, 2022).

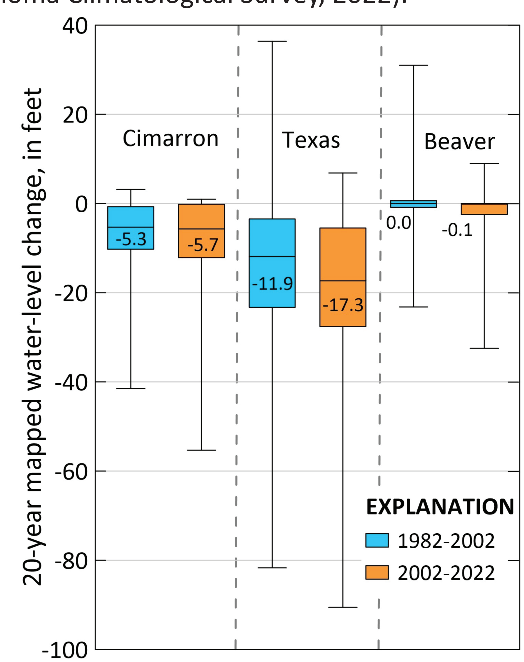
Table 1 (Right): The percent of aquifer area in each range of water-level change from the 1982-2022 water-level change map by county.

County	Percent of aquifer area in each category of 1982-2022 water-level change								
	-114.4 to -80	>-80 to -50	>-50 to -30	>-30 to -15	>-15 to -8	>-8 to -1	>-1 to 1	>1 to 8	>8 to 28.6
Cimarron	0	2.08	9.56	23.04	18.72	18.98	27.63	0	0
Texas	2.43	19.17	27.58	17.66	6.72	11.12	14.15	1.05	0.1
Beaver	0	0.03	0.27	2.21	3.01	25.24	60.53	8.07	0.65

County	Percent of aquifer area in each category of saturated thickness			
	<100	100 to 200	200 to 300	> 300
Cimarron	92.96	7.04	0	0
Texas	38.87	24.46	14.48	22.2
Beaver	60.6	24.03	9.9	5.47

The percent of aquifer area in each range of saturated thickness by county. Saturated thickness was derived from a 2009 map produced for the High Plains aquifer (McGuire et al., 2012).

Figure 3 (Right): Box and whisker plot of water-level change by county and map interval. The statistics were calculated over the set of map cells (each approximately 22.3 acres) in each county which were within the aquifer boundary. The labeled line enclosed in each box denotes the median water-level change, in feet, of each set of map cells.



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Overview

The Oklahoma Water Resources Board (OWRB) has recorded static water-level measurements annually in wells in the Ogallala Panhandle aquifer since the 1960's. These data were used to map and analyze long-term water-level change in the Ogallala aquifer; nearby aquifer water-level data in states adjacent to the Oklahoma Panhandle were also used to interpolate water-level change along the state boundary (Colorado Division of Natural Resources, 2023; Texas Water Development Board, 2023; U.S. Geological Survey, 2023). The period from 1982-2022 had an adequate number of wells with water-level measurements throughout the time period; these data were further split into two intervals from 1982-2002 and 2002-22 to compare the last two 20-year climate cycles (Zotov, 2016).

Water-level change maps were created by interpolating this dataset using methods described in the Methods section of this report. Texas County had the most overall water-level decline, as it contained the only areas with 50 or more feet of decline in the 20-year maps, the only areas with more than 80 feet of decline in the 40-year map, and the highest median decline (Figure 3). Texas County also has the most water use in the state. Areas of greatest water-level increase are more evenly distributed among parts of Texas and Beaver counties and are most prevalent in the 1982-2002 map. All three counties showed greater degrees of water-level decline in 2002-2022 than in 1982-2002, but the median difference was less than half a foot in Cimarron and Beaver counties (Figure 3). The well with the most observed water-level decline from 1982-2022 within the boundary was 114.4 feet in OWRB site 1362 and the well with the most observed increase was 15.3 feet in OWRB site 9726, both in Texas County (Figure 1).

Methods

Water-level measurements were collected from an array of federal and state databases. Only measurements taken between January and March were used to ensure minimal impact from irrigation (McGuire and Strauch, 2013). In addition to one-time measurements, January median water levels derived from hourly or daily readings were also added to the dataset. Water-level measurements reported for pumping wells or those observed as being nearby pumping wells were removed. Water-level graphs for wells with greater than five feet of single-year water-level change were also examined to remove measurements outside the normal range of yearly fluctuation that could have been influenced by unknown external factors such as measurement errors, pumping, or other causes. Five feet of yearly fluctuation was the threshold for this analysis because, of the 9 wells with over 50 years of measurements, 95% of the yearly water-level fluctuations were ± 4.9 feet or less. The resulting dataset of wells measured in 1982, 2002, and 2022 was supplemented with additional wells with comparable measurement intervals and years measured.

Wells measured exactly 20 or 40 years apart were chosen first to supplement the dataset of wells measured in 1982, 2002, and 2022 so as to not bias a record with shorter or longer periods of water-level change. These intervals could be ±10 years from the interval of interest. A well that was not measured in 2002, for example, could still be used to calculate the 1982-2002 water-level change if it was measured across any 20-year interval between 1972-1992 and 1992-2012. The closest interval to the interval of interest was chosen for each well. In the example above, the intervals 1981-2001 or 1983-2003 would be chosen if measurements were available.

In areas that were not sufficiently covered by wells with the desired measurement spacing, ranges within ±10 years were allowed if nearby wells with the exact 20 or 40 years between measurements showed similar water-level changes. More than 95 percent of the wells used in both 20-year maps and more than 92 percent of the wells used in the 40-year map had ranges within ±5 years, however. Priority was given to intervals that could get the closest to 20 or 40 years, with closeness to the dates of interest (within 10 years) getting secondary priority. The interval 1983-2021 would be chosen over 1984-2022 but not over 1983-2022, for example, if 1982 and 2023 measurements were not available for a given well.

Once the full set of water-level measurements was determined, the discrete or January median water levels at the beginning and end of each time interval were subtracted to get interval change in water level for each well. As in similar works, interval change in water-level surfaces were then interpolated between wells using inverse-distance weighting (Esri, 2023; McGuire and Strauch, 2013). These raster surfaces were converted to contours using the Esri Contour tool with 1-foot contours (Esri, 2023) which, based on the processing method in McGuire and Strauch (2013), were manually smoothed and then converted back to rasters using the Topo to Raster tool without drainage enforcement (Esri, 2023) to produce the final map surfaces. This tool increased the water-level change in areas with minimal water-level change (± one foot) along the aquifer boundaries, so the original interpolated areas of ± one foot of water-level change were superimposed over the smoothed rasters along the aquifer boundaries; the non-smoothed rasters were also used for all statistical analyses.

References

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