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The High Plains Aquifer: Can We Make It Last?

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Nearly a third of the United States' irrigated crops depend on one massive but dwindling water source: the High Plains aquifer. Declining water levels in the High Plains aquifer and responses to those declines are resource challenges that necessitate input from geoscientists.

The High Plains aquifer, which underlies parts of eight states from South Dakota to Texas, consists of several interconnected aquifers, including the Ogallala aquifer. Unequally distributed, most of the southern two-thirds is in serious decline; water levels have dropped >150 ft since pre-development in areas of Texas and Kansas (Fig. 1; McGuire, 2014). Roughly 19.6 million acre-feet were pumped in 2005, primarily for irrigation (McGuire, 2009), a quantity that exceeds the basin-wide average annual inflow of the Colorado River (Bureau of Reclamation, 2011). In 2013, three times more water was pumped from the aquifer in Kansas than the estimated natural recharge rate (Buchanan et al., 2015). Kansas warns that without changes, "70% of the aquifer [in Kansas] will be depleted within 50 years" (Kansas Water Office and Kansas Department of Agriculture, 2015). Water quality also impairs the aquifer in some regions (Whittemore, 2012).

The High Plains aquifer is the source for a highly productive region of corn, alfalfa, soybeans, wheat, sorghum, and cotton (Cruse et al., 2016). Crops support the numerous cattle feedlots and large dairies that overlie the High Plains aquifer. Meatpacking, milk processing, ethanol plants, and domestic users also rely on the aquifer. It supports the region's economy and the U.S. food supply. Can the aquifer's use be slowed and its life extended? The aquifer's availability to future generations depends on decisions by policy makers, water managers, and especially irrigators. The geoscience community is continually improving its knowledge of its current and projected future conditions, information essential for its sound management.

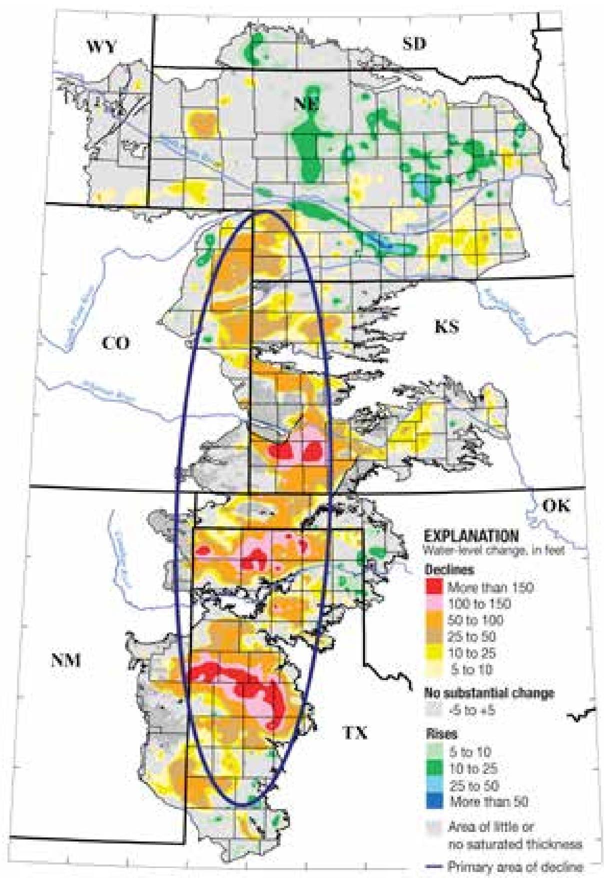

Figure 1. Water level changes in the High Plains aquifer from pre-development (about 1950) to 2013, with primary area of declines circled. Modified from McGuire (2014).

In Kansas, Colorado, and Texas, states with large aquifer declines, regulators gave irrigators the right to pump far more water than the aquifer can sustain. In Kansas and Colorado, water right permits are governed by seniority. When there is not enough water to meet the needs of all water right holders, priority is given to those who own the oldest, most senior rights, a system summarized as "first in time, first in right." However, both states accept regional groundwater declines, allowing more use to get the economic benefits of the aquifer, a management approach sometimes called "planned depletion." Texas governs groundwater by the rule of capture, which gives landowners the right to use groundwater beneath their property. Local groundwater conservation districts manage the High Plains aquifer in Texas, and most districts require well meters and annual water use reports from well owners. Because water rights have legal standing,

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regulators in these states have limited ways to cut back on use. Thus, future conservation rests mostly with individual water right owners, who will make decisions about reducing their use.

THE TECHNOLOGY POTENTIAL

States encourage locally developed efforts to conserve the aquifer supply. Texas requires groundwater conservation districts that share a common aquifer to set "desired future condition" aquifer goals. Once these goals are set, the Texas Water Development Board (TWDB) uses groundwater availability models to estimate how much groundwater can be pumped to achieve the goals (TWDB, 2016). In Colorado, the Republican River Water Conservation District (RRWCD) encourages landowners to enroll irrigated acres into USDA programs for conversion to dryland acres, in exchange for payments. The RRWCD charges farmers an annual water use fee of US$14.50 per irrigated acre, which helps fund payments for fallowing acres (D. Daniels[1], 2016, personal commun.).

Precise water management has the potential for irrigators to maintain crop yields and revenues on less water by using efficient irrigation systems and optimizing when to water. Kansas is testing this approach at "water technology farms" (Kansas Water Office, 2016). The Texas Water Plan has an irrigation water savings goal of 639,000 acre feet annually by 2020 through implementing more efficient irrigation systems and methods (TWDB, 2016).

Irrigation systems improve efficiencies, with more water taken up by the crop and less lost to evaporation, surface runoff, or deep percolation. Inefficient flood irrigation (gravity flow down furrows) has largely given way to more efficient center pivots (large circular sprinklers). Highly efficient subsurface or mobile drip irrigation is gaining popularity. Soil moisture probes in fields with data accessible on a smart phone or tablet allow farmers to monitor moisture in the crop root zone and apply water at the most effective times. Precise crop water management is a big shift from the typical pattern of turning on an irrigation system in the spring and turning it off at the end of the growing season.

More efficient irrigation does not necessarily result in water conservation, a common assumption. The adoption of more efficient irrigation systems in Kansas led to more irrigated acres of water-intensive crops (Perry, 2006). More efficient irrigation systems can operate with lower-capacity wells. Many farmers invest in more efficient systems when their well capacities decline to be able to continue irrigation of the same type of crops (Peterson and Golden, 2005). When well capacities declined in the past, producers abandoned wells and switched to dryland farming; new systems allow irrigation to continue from lower-yielding wells. In effect, it allows operators to drain the aquifer more completely. Unless irrigation is done with real conservation, not just the limits of the well capacity, new technologies could exacerbate aquifer declines.

Aquifer data is critical to conservation efforts. It provides a strong foundation for policy makers, water managers, and water users to evaluate options and add confidence to their decisions. It also allows evaluation of the impact of decisions, which may range from business as usual to cutbacks in water use. Data on Kansas water wells, annual water use by water right, irrigation systems, and water levels in a network of 1,400 wells in the High Plains aquifer goes back several decades. The data is publically available online, with tools for mapping of water level trends in a well or area of interest (www.kgs.ku.edu/HighPlains/index.shtml). The data is a powerful resource for understanding the aquifer and modeling future aquifer conditions. Colorado, Texas, and other states also collect and post data online and are rapidly expanding their water databases and models. The U.S. Geological Survey uses the state data to report on the entire High Plains aquifer conditions. Information transparency with the public builds trust and increases awareness.

Widespread conservation may hinge on voluntary, collective commitments to goals that extend the water resource further into the future. In a 99 mi^2 area of northwestern Kansas, irrigators entered into a voluntarily proposed, but mandatory once adopted, five-year conservation plan with reductions of water use by 20%. Now in its fourth year, reports are encouraging; irrigators are staying within the reduced water use levels and reasonable crop yields are being achieved, while extending the life of the aquifer significantly (Golden, 2015; Butler et al., 2016). Whether that commitment happens over a wider area remains to be seen.

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[1] D. Daniels is general manager of the Republican River Water Conservation District in Colorado.