Summary of Hydrologic Conditions in Kansas, 2013 Water Year

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The U.S. Geological Survey (USGS) Kansas Water Science Center (KSWSC), in cooperation with local, State, and other Federal agencies, maintains a long-term network of hydrologic monitoring gages in the State of Kansas. These include 195 real-time streamflow-gaging stations (herein gages) and 12 real-time reservoir-level monitoring stations. These data and associated analysis, accumulated for many years, provide a unique overview of hydrologic conditions and help improve our understanding of our water resources.

Real-time streamflow data are verified throughout the year with analysis of regular streamflow measurements made by USGS hydrographers. This information is made available to cooperating agencies as well as other water resource managers and the general public at *http://waterdata.usgs.gov/ks/nwis*. Yearly hydrologic conditions are determined by comparing statistical analyses of current and historical water year (WY) data for the period of record. A water year is defined as the 12-month period from October 1 through September 30 and is designated by the calendar year in which it ends. These analyses are used by local, state, and other Federal agencies in protecting life and property and therefore need to be produced promptly and accurately. Other uses of these data include managing water rights and municipal supply needs, as well as conservation for agricultural, ecological, and recreational uses.

U.S. Geological Survey streamflow-gaging station 06891200, Wakarusa River near Wakarusa, Kansas (photograph by Arin Peters, March 26, 2013).

Statewide Precipitation Overview

Drought conditions began intensifying statewide in 2011, leading to most of Kansas being in either Extreme or Exceptional Drought to start the 2013 water year (U.S. Drought Monitor, 2014) (fig. 1). Although there was some improvement in drought conditions, precipitation during the 2013 water year remained below normal. Above normal precipitation, when it did occur, was localized, leading to flooding in some areas and record low flows in others. The difference in percent of normal precipitation for the 2012 and 2013 water years is shown in figure 2. The central, south-central, and southeast regions generally received normal to above normal precipitation during 2013, whereas much of the rest of the state received below normal (National Oceanic and Atmospheric Administration, 2014); however, the State generally received more precipitation in water year 2013 than in the 2012 water year. Drought conditions in the eastern region were almost completely eliminated by the end of the water year. The western region still had widespread drought, however the intensity lessened throughout all areas according to the Interagency U.S. Drought Monitor (fig. 1).

At the beginning of the 2013 water year, the state was under some level of drought, with almost 45 percent classified as being in Exceptional Drought (designated in table 1 as D4), according to the Interagency U.S. Drought Monitor. By

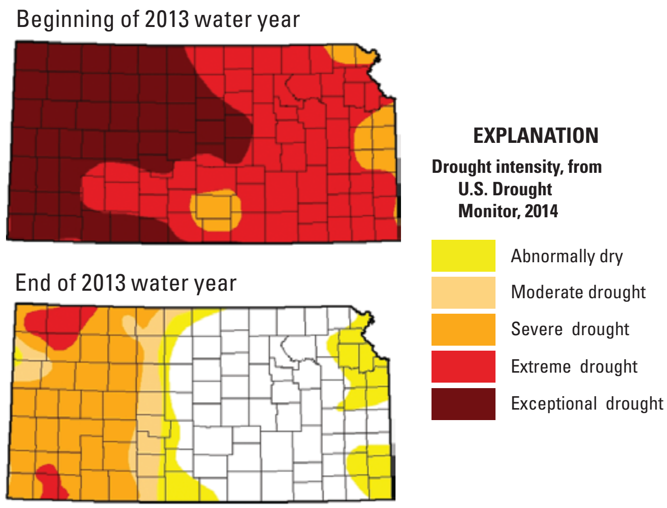

Figure 1. Change in statewide drought coverage and intensity between the beginning and end of the 2013 water year. Source: *http://droughtmonitor.unl.edu/*.

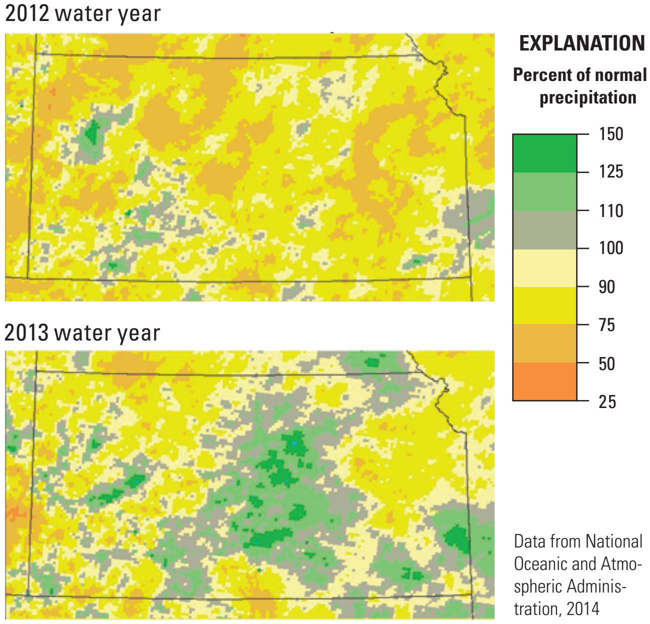

Figure 2. Comparison of statewide percent of normal (1981–2010) precipitation for the 2012 and 2013 water years. Source: *http://water.weather.gov*.

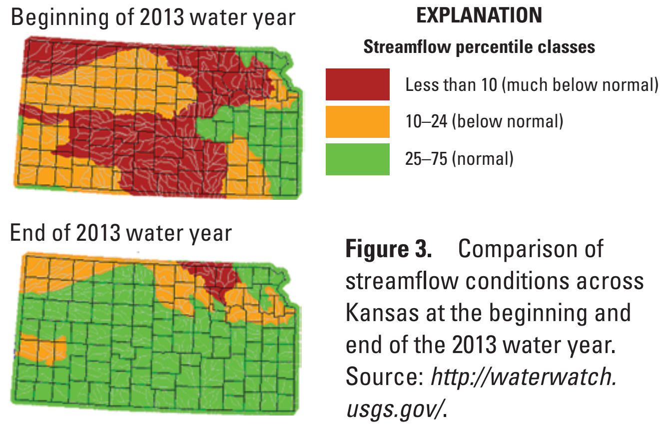

Figure 3. Comparison of streamflow conditions across Kansas at the beginning and end of the 2013 water year. Source: *http://waterwatch.usgs.gov/*.

the end of the 2013 water year, there were no areas of Extreme Drought, and only 54 percent was considered to be in any level of drought condition.

Streamflow Overview

Streamflow conditions, relative to the full period of equivalent record, varied a great deal spatially and temporally during the 2013 water year. The year was characterized by localized flooding in some areas, and record low flows at other locations. As the drought conditions generally improved, streamflows generally increased. The water year started out with streamflows being much below normal, with most parts of the state having streamflows lower than the 25th percentile, and large areas less than the 10th percentile (fig. 3). Only a small portion of the eastern region was in the normal range of flow (25–75th percentile). By the end of the water year, most of the state was in the normal range of streamflow with only the extreme north-central region being much below normal.

Watershed Runoff

Runoff, or flow per unit area, is a good indicator of precipitation and streamflow conditions for a given basin (Langbein and Iseri, 1960). Quarterly maps of drainage basin runoff can provide insight into the variability of hydrologic conditions throughout a water year including development or improvement of drought conditions (fig. 4). At the beginning of the water year, much of Kansas was in the below normal (less than 10 percent) to much below normal (10–24 percent) range for runoff. Several parts of the state were reporting some of the lowest runoff values on record, and this persisted for some regions into the 3rd quarter of the 2013 water year. Conditions remained fairly constant through the second quarter of the 2013 water year with some improvement in extreme eastern Kansas. Starting in the 3rd quarter, conditions improved across much of the eastern one-half of the state. By the end of the 2013 water year most of the state was in the normal to much above normal range (between 25 and 90 percent), with only parts of the northwestern region still reporting conditions below the 10th percentile (U.S. Geological Survey, 2014b).

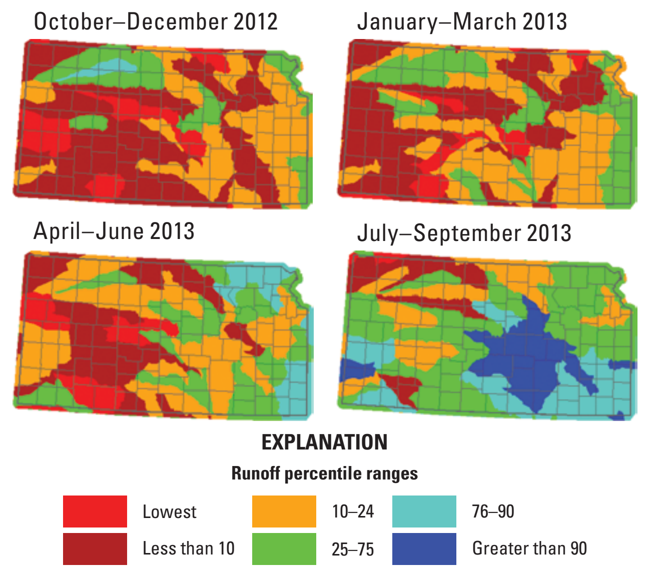

Figure 4. Quarterly runoff percentiles by watershed, 2013 water year. Source: *http://waterwatch.usgs.gov/*.

Table 1. Percent area coverage of drought conditions in the State of Kansas at the beginning and end of the 2013 water year. Data from U.S. Drought Monitor, 2014.

	None	D0–D4 Abnormally dry	D1–D4 Moderate drought	D2–D4 Severe drought	D3–D4 Extreme drought	D4 Exceptional drought
Start of 2013 water year	0	100	100	100	93.25	44.73
End of 2013 water year	46.14	53.86	40.28	31.94	3.96	0

Flooding and Record-High Streamflows

Although substantial widespread flooding did not occur during the 2013 water year, flooding did occur at a few locations. (fig. 5). One peak of record streamflow (for sites with 30 or more years of record) took place during the 2013 water year. The gage at Delaware River near Muscotah (06890100) had its highest instantaneous discharge in 43 years of record (35,600 ft^3/s) on May 29, 2013, following an intense precipitation event in the area (fig. 6*B*). For the first one-half of the water year, the flow at the gage was well below the 25th percentile of streamflow. Rainfall in the spring and the flooding event at the end of May brought the cumulative discharge during the year above the 75th percentile where it stayed for the rest of the water year (U.S. Geological Survey, 2014b) (fig. 6*A*).

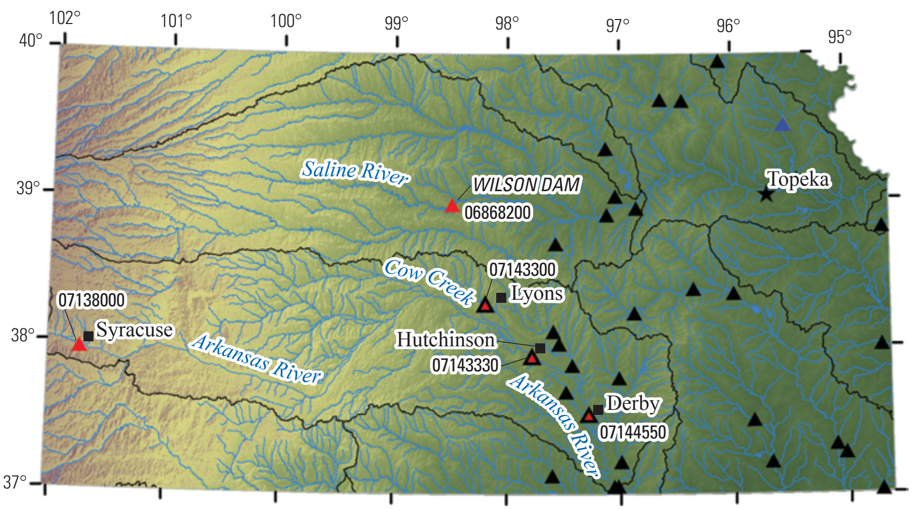

Figure 5. Locations of streamflow sites recording extreme hydrologic conditions in the 2013 water year.

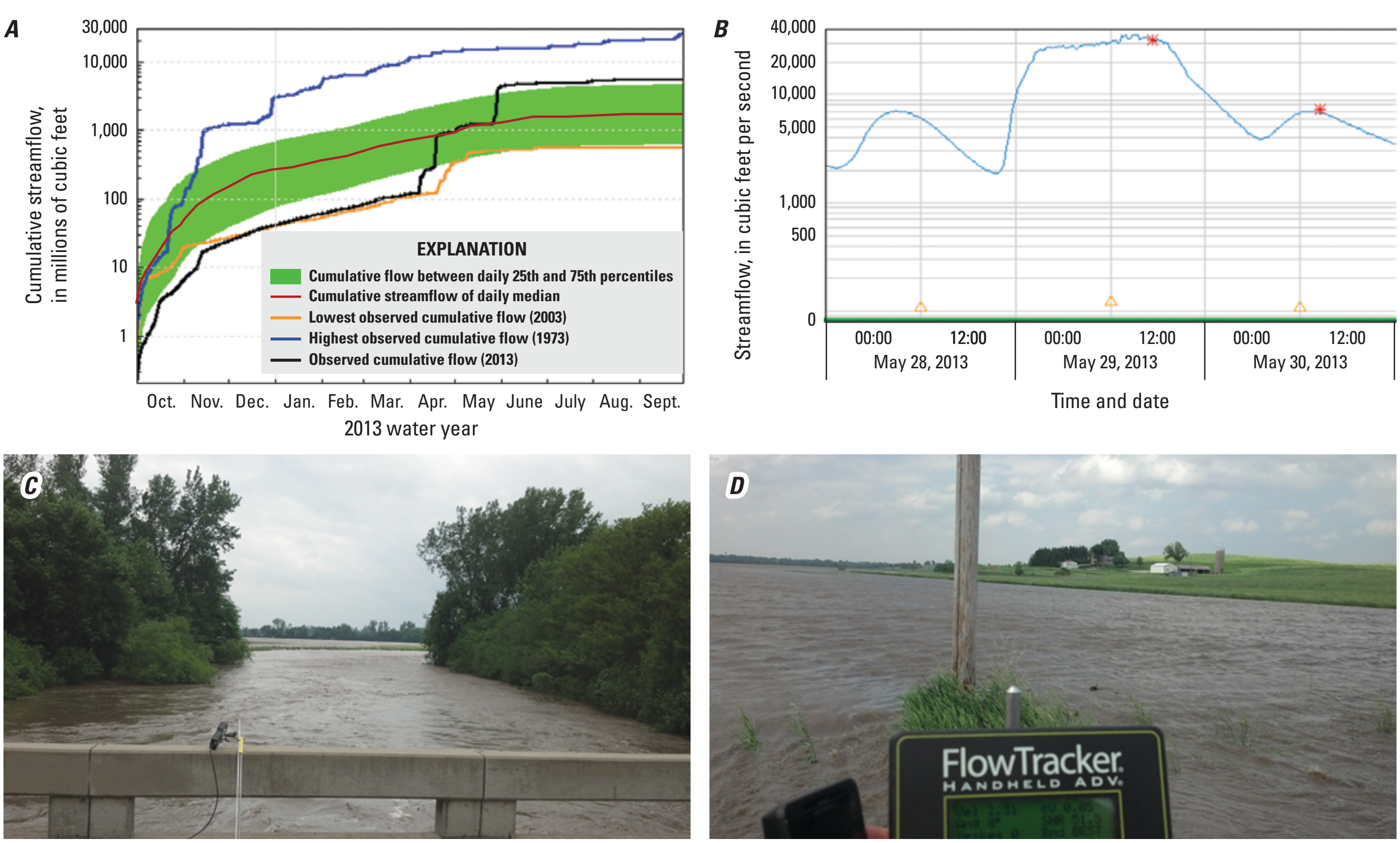

Figure 6. *A*, Time-series plot of cumulative discharge at U.S. Geological Survey streamflow-gaging station 06890100, which shows the relative dry start to the year and the trend to above average flow for the second half of the water year (source: *http://waterwatch.usgs.gov/*). *B*, Hydrograph showing the peak of record instantaneous discharge on May 29, 2013, Delaware River near Muscotah (06890100) (source: *http://waterdata.usgs.gov/ks/nwis*). *C*, Streamflow under the bridge, and *D*, overflow, during the May 29th flooding event at the gage. Photographs by Arin Peters, May 29, 2013.

Table 2. Record low 7-day average streamflows for five gaging stations in Kansas, 2013 water year. All streamflow discharge values are given in cubic feet per second.

Station number and name		Years of record	2013 water year	Previous low record (year)
06868200	Saline River at Wilson Dam, Kansas	50	0.98	1.16 (1968)
07138000	Arkansas River at Syracuse, Kansas	97	0	0.06 (1974)
07143300	Cow Creek near Lyons, Kansas	65	0.05	0.14 (1946)
07143330	Arkansas River near Hutchinson, Kansas	53	32.7	33.4 (1981)
07144550	Arkansas River near Derby, Kansas	44	76.4	82.9 (2012)

New Record-Low Streamflows

In 2013, record-low 7-day average discharges occurred at five gaging stations with more than 30 years of record (table 2; fig. 5). The Arkansas River at Syracuse gage had a daily mean flow of zero ft^3/s on several occasions during the 2013 water year, for the first time in its 97-year history (U.S. Geological Survey, 2014a) (fig. 7*A*). The site also set a new record 7-day average low flow (U.S. Geological Survey, 2014b).

Reservoirs

Major reservoirs throughout Kansas are managed primarily by the Tulsa and Kansas City districts of the U.S. Army Corps of Engineers as well as the U.S. Department of the Interior, Bureau of Reclamation. These reservoirs have many uses and purposes including water supply, flood mitigation, power generation, fish and wildlife management, water quality enhancement, and recreation. Managing reservoir operations requires real-time data on the streamflow into and downstream of the reservoir, as well as the level and contents of the reservoir itself. For federal reservoirs, the USGS collects and provides that data.

At the beginning of the 2013 water year, most reservoirs were still at low levels from the 2011–12 drought. All Federal reservoirs monitored by the USGS began the water year with the water level below the top of the conservation pool, or the level at which a reservoir is considered full. Because Kansas generally receives most of its yearly precipitation during the warm season (National Oceanic and Atmospheric Administration, 2014), the reservoirs did not fill up again until the spring of 2013. Early spring precipitation began filling the reservoirs statewide, but some did not fill the conservation pool until late summer, and by year end a few were still below conservation pool elevation.

Perry and Clinton Lakes in the northeast region are a good illustration of the extent to which precipitation and runoff were localized. The dams of these reservoirs are separated by a mere 14 miles, but their hydrologic conditions differed greatly in 2013. Perry Lake near Perry (06890898)on the Delaware River began the 2013 water year at 82 percent full. This means the water level was at an elevation at which the reservoir contents (volume) equaled 82 percent of the contents when the water level is at conservation pool elevation (U.S. Army Corps of Engineers, 2014b). The reservoir filled up, or reached conservation pool elevation by the end of May, and ended the 2013 water year at 105 percent full (fig. 8*A*). Clinton Lake near Lawrence (06891478) on the Wakarusa River started the water year at 85 percent and only declined, ending the 2013 water year at 80 percent (fig. 8*B*). In March of 2013, Clinton Lake came within 0.05 ft of the record low lake level (U.S. Army Corps of Engineers, 2014a). Heavy rainfall occurred on several occasions in the drainage basin that feeds Perry Lake, providing much needed inflow to fill the reservoir. The drainage basin that feeds Clinton Lake, however, missed much of the precipitation required to reach the conservation pool elevation.

Cheney Reservoir, located on the North Fork of the Ninnescah River in the south-central region is a primary water supply for the Wichita metropolitan area (U.S. Bureau of Reclamation, 2014). At the beginning of the 2013 water year, it was only 68 percent full, but heavy rains in May and August filled the reservoir once again for the first time since the spring of 2011. At the end of the 2013 water year, the reservoir was 99 percent full. Low levels in the Cheney Reservoir are evident at the beginning of the 2013 water year and the subsequent recovery and filling of the reservoir through the summer is shown in figure 8*C*.

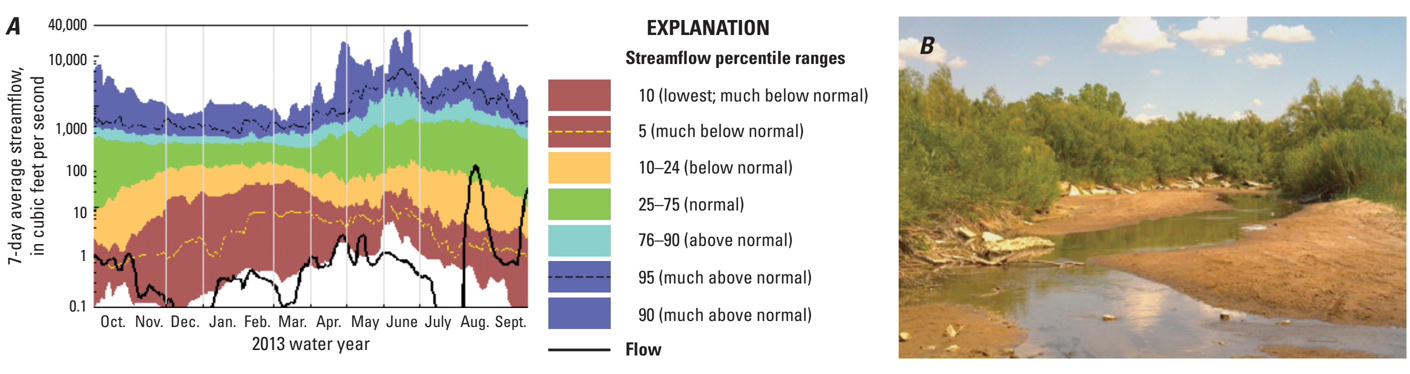

Figure 7. *A*, The Arkansas River near Syracuse, Kansas, recorded the lowest 7-day average streamflow in 97 years of record in July of 2013 (source: *http://waterwatch.usgs.gov/*). *B*, Arkansas River at extremely low flow (photograph by Travis See, July 2012).

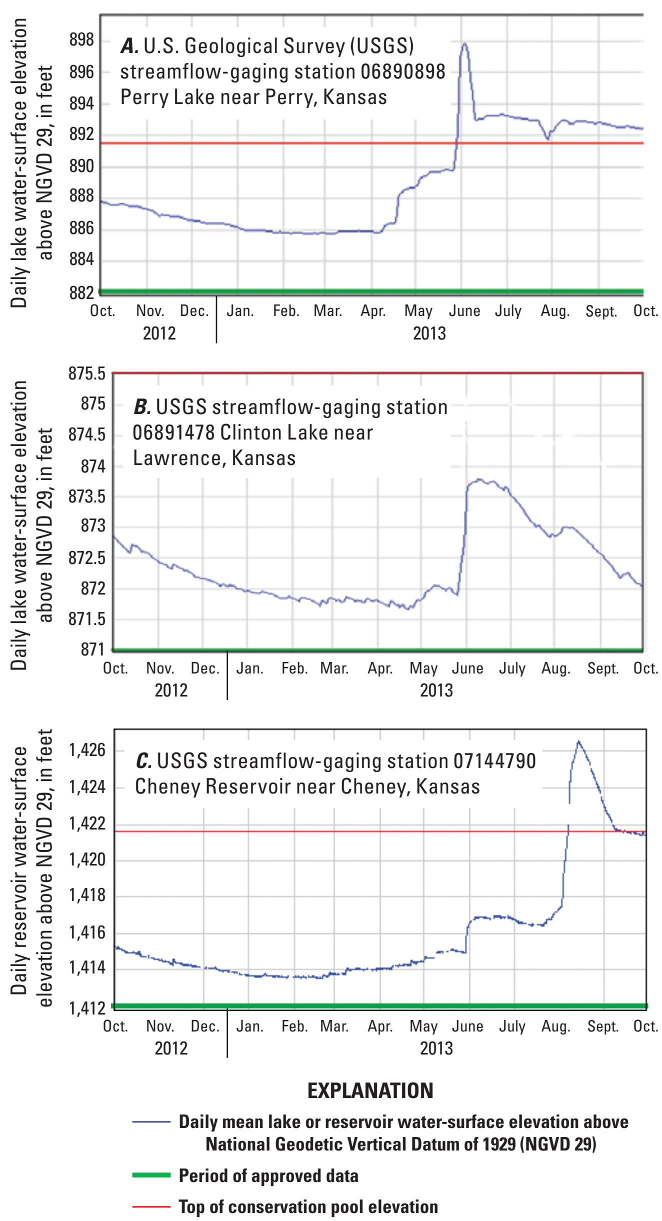

Figure 8. Water-surface elevations of *A and B*, Perry Lake and Clinton Lake in northeast Kansas; and *C*, Cheney Reservoir in south-central Kansas, during the 2013 water year. Source: *http://waterdata.usgs.gov/ks/nwis*.

Water-Quality Monitoring

The USGS carries out scientific investigations of water resources and collects water-quality data from streams, reservoirs, and groundwater. Water-quality investigations primarily are funded by cooperative partnerships with local, State, tribal and other Federal agencies to inform water-resource issues and policies. In addition to cooperative partnerships, water-quality data are collected as part of national USGS hydrologic networks. Some important water-quality issues being addressed by scientific investigations are related to transport of sediment and nutrients. Problems caused by sediment include degraded water quality and aquatic habitat, loss of water-storage capacity in reservoirs, and transport of contaminants associated with sediment such as nutrients. Excessive nutrients contribute to degraded water quality and can lead to problematic algal blooms (U.S. Environmental Protection Agency, 2009).

The number and types of sites where water-quality data are collected change from year to year depending on specific requirements of current projects. During water year 2013, water-quality data were collected from 32 stream sites, 1 reservoir, and 80 groundwater sites in Kansas. Discrete water samples were collected from all sites. Constituents analyzed in samples varied, but all sites included nutrients, carbon, major ions, trace elements, suspended sediment, pesticides, organic wastewater and household compounds, and fecal indicator bacteria. Continuous, real-time water-quality monitors were operated at 18 stream sites, 1 reservoir, and 3 groundwater sites. Continuous monitors typically measured water temperature, dissolved oxygen, pH, specific conductance, and turbidity. At selected sites continuous measurements also included chlorophyll, dissolved organic matter, and nitrate plus nitrite. Continuous water-quality monitors also are used in combination with discrete sample data to develop regression models for computing real-time concentrations for additional constituents of interest. Continuous water-quality data are available at *http://nrtwq.usgs.gov/ks/*.

Continuous, Real-Time Nitrate Monitoring

The USGS operated continuous, real-time nitrate monitors at nine sites in Kansas during water year 2013. The availability of reliable nitrate sensors has made it possible to measure rapidly changing nitrate concentrations that can affect human and aquatic health but often are missed using discrete sampling methods (Pellerin and others, 2013). In Kansas, measurements from nitrate sensors are being used along with other continuous water-quality data to characterize sources and transport of nutrients in urban and agricultural watersheds. The information helps inform decisionmakers on important water management topics such as appropriate treatment for municipal water supply. For example, to meet future water demands, the City of Wichita operates the Aquifer Storage and Recovery project to artificially recharge the *Equus* Beds aquifer. During high streamflows, water is diverted from the Little Arkansas River, treated, and stored in the aquifer. The maximum nitrate concentration allowed in treated drinking water is 10 milligrams per liter (U.S. Environmental Protection Agency, 2009). Continuous nitrate monitoring provides real-time data to help determine treatment needs during recharge operations (fig. 9). In addition, continuous, real-time nitrate information helps characterize nutrient sources and transport, identifies times and conditions when water-quality criteria are not being met, and helps document effects of implemented management practices.

Significance of Water Year 2013

Although 2013 was not a record year for drought or flooding statewide, it was unique in that extreme conditions did occur, on both ends of the hydrologic spectrum, sometimes at the same gaging stations. Several locations had record low flows in the fall of 2012 only to flood in the summer of 2013. The gaging stations at Cow Creek near Lyons (07143300), Arkansas River near Hutchinson (07143330), and Arkansas River near Derby (07144550), all had record low 7-day average streamflows after 65, 53, and 44 years of record, respectively, before flooding in August of 2013 (figs. 5 and 10).

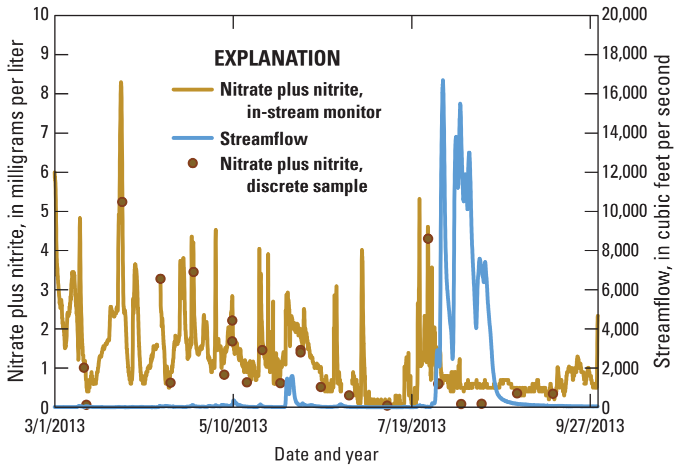

Figure 9. Continuous nitrate plus nitrite and streamflow data from the Little Arkansas River near Sedgwick, Kansas, March through September 2013. Continuous, in-stream monitors measure variability often missed by discrete samples. The monitor measures nitrate and nitrite, but nitrite is usually negligible.

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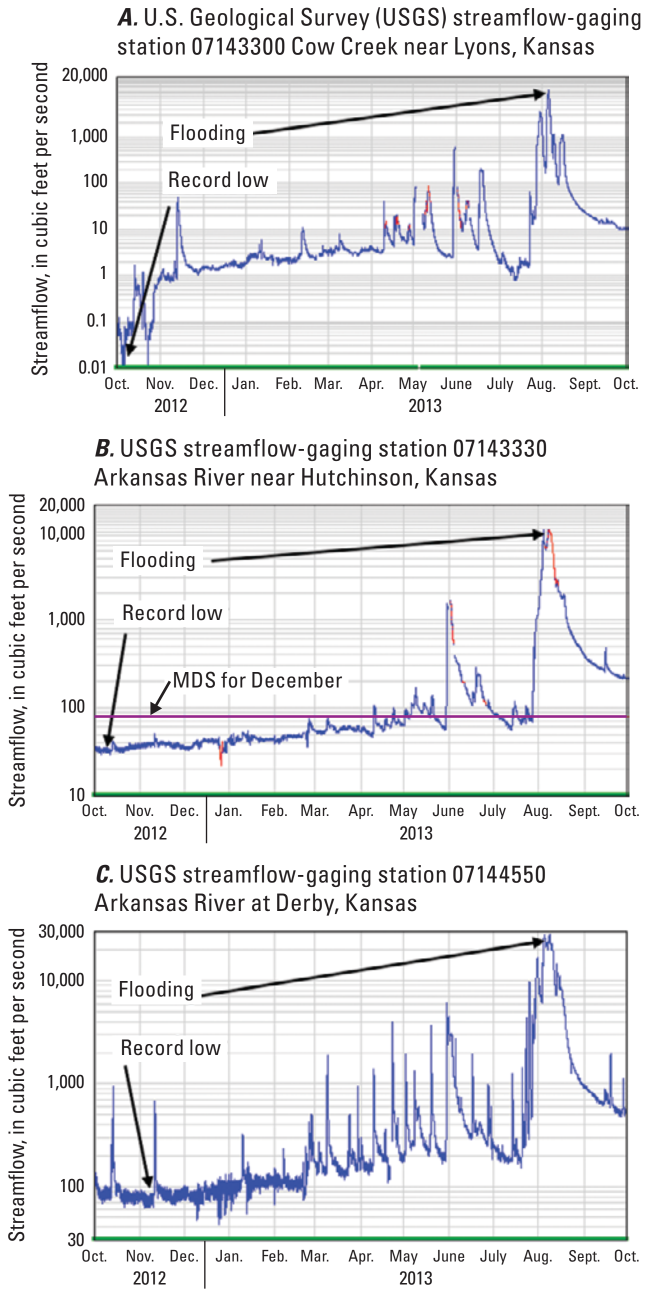

Figure 10. Hydrographs of the three gages that recorded record low 7-day average streamflows and flooding in the 2013 water year. *A*, Cow Creek near Lyons, Kansas recorded 0.05 cubic feet per second (ft^3/s) in October 2012 and flooded in August 2013. *B*, The Arkansas River near Hutchinson, Kansas recorded 32.7 ft^3/s in October 2012 and flooded in August 2013. *C*, The Arkansas River near Derby, Kansas recorded 76.4 ft^3/s in November 2012 and flooded in August 2013. Source: *http://waterdata.usgs.gov/ks/nwis*.

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