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Natural Resource Stewardship and Science

Water Quality Monitoring for Knife River Indian Villages National Historic Site

2013 Data Report

Natural Resource Data Series NPS/KNRI/NRDS—2020/1257

ON THE COVER

Water quality monitoring equipment on the Knife River in June 2013 at Knife River Indian Villages National Historic Site, North Dakota.

Photograph courtesy of the United State Geological Survey

Water Quality Monitoring for Knife River Indian Villages National Historic Site

2013 Data Report

Natural Resource Data Series NPS/KNRI/NRDS—2020/1257

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Abstract

The Northern Great Plains Inventory and Monitoring Network (NGPN) began monitoring water quality in the Knife River at Knife River Indian Villages National Historic Site (KNRI) in 2013, with the assistance of the U.S. Geological Survey (USGS). This report summarizes the data collected during the 2013 ice-free season (April 4 through October 17) for streamflow, water temperature, dissolved oxygen, specific conductance, and pH.

2013 was a wet year and discharge on the Knife River peaked at 5330 cubic feet per second in early June. There was considerable seasonal variation in all water quality measures. A summary of our results can be found in Descriptive Statistics Summary tables for the ice-free season (Table 3 in Results section) and for each month (Table 4 in Results section). Notably, dissolved oxygen concentrations dropped below 5 mg/ L, a North Dakota state water quality standard, 34 times during September 2013, although that is less than 1% of all records. Water temperature also exceeded state standards a few times in July.

NGPN's collaboration with USGS supported real-time and archived access to this data through the USGS National Water Information System Website, where it remains available to the public.

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Acknowledgments

Thank you to the staff of the USGS North Dakota Water Science Center for their attention to the details of data collection, reporting, and the transfer of data to NGPN.

Introduction

Knife River Indian Villages National Historic Site (KNRI) was established in 1974 with a mission to commemorate the culture and history of the Northern Great Plains Indian peoples and to preserve, study, and interpret the historic and archeological resources of the site. KNRI sits on 1,758 acres of upland mixed-grass prairie and riparian forests, at the confluence of the Knife and the Missouri River. The Knife River originates in the Badlands of west-central North Dakota and flows about 200 miles (193 km) until it reaches the Missouri River (Figure 1). KNRI is in a semi-arid region that averaged 19 inches of precipitation annually from 1995-2015, but extreme variation in temperature and precipitation is common in this region.

The Knife River flows through about 3 miles of the park and many of the archeological sites are on or close to the banks of the river (National Park Service 2013). In this area, river flow tends to peak between March and May, while annual low flows occur in November and December (NPS 1997).

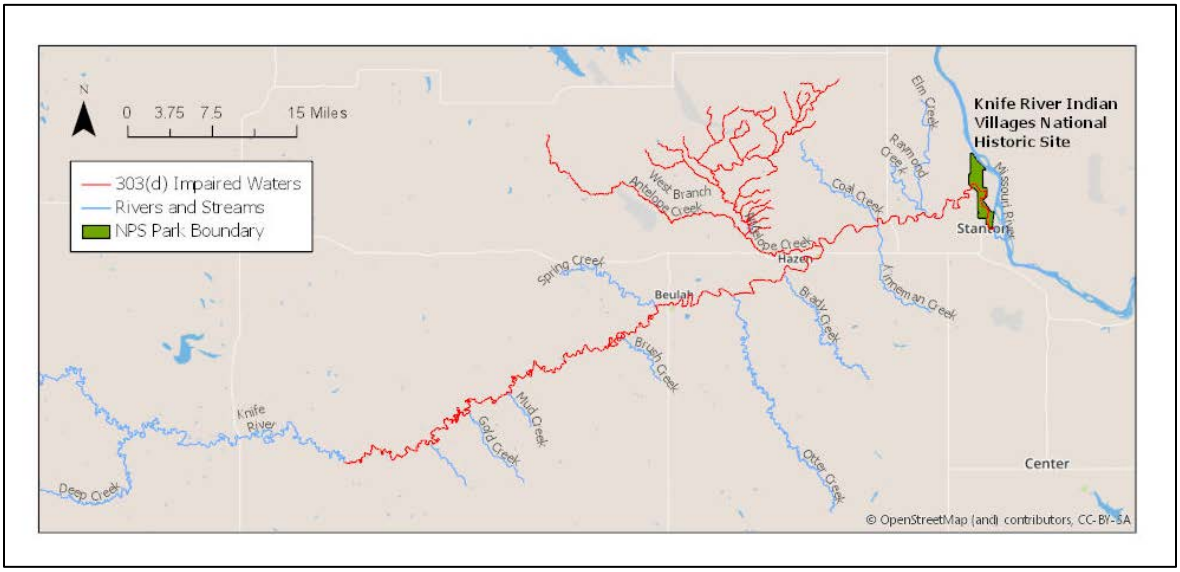


Figure 1. Map of the Knife River Indian Villages National Historic Site and the Knife River in North Dakota. The stretch of the river running through the monument, is listed as impaired under 303(d) criteria (indicated in red) for fecal coliform.

The Knife River is designated as a Class II water in North Dakota. Class II waters are similar to Class I which are defined as "water suitable for propagation or protection, or both, of resident fish species and other aquatic biota and for swimming, boating and other water recreation" but for Class II additional treatment may be required to meet drinking water requirements (NDDEQ 2019). The stretch of the Knife River that runs through KNRI is listed as an impaired waterway under section 303(d) of the Clean Water Act and is listed for *Escherichia coli* (ND Department of Health 2019). Fecal coliform concentrations were found to be as high as 2419 CFU / 100 ML in 2011, which is almost ten times the maximum concentration for recreation (Tronstad 2013). The source of the *E. coli* and fecal coliform is not known, but livestock feeding operations, agriculture, and failing septic

systems are likely contributors. For more details and current impairment information visit the North Dakota Department of Environmental Quality website.

The Knife River is characterized by a large amount of organic matter (Tronstad 2013) and a high sediment load. In one study, the Knife River was found to transport 1690 tons of sand per day and 270 tons of clay and silt (Berkas 1995). Riverbank erosion is a continued threat to archeological resources in the park (National Park Service 2013).

The Northern Great Plains Inventory & Monitoring Network (NGPN) began monitoring water quality at KNRI in 2013 to better understand current conditions and changes over time in the Knife River. The monitoring is conducted at the gaging station at Knife River Indian Villages National Historic Site, ND (Monitoring Location 06340590; Figure 2) in collaboration with the United States Geological Survey (USGS). The objective is to determine the status and long-term trends of core water quality parameters during the ice-free season. NGPN plans to repeat water quality monitoring at KNRI every three years, starting in 2013 (Wilson et al. 2014), conducting in-depth analysis of status and trends after 3 to 5 cycles of sampling.

NGPN's core water quality parameters include streamflow, dissolved oxygen, pH, specific conductivity, and water temperature (Table 1; Wilson et al. 2014). These parameters are measured every 15 minutes throughout the ice-free season (typically April to October), and results are made available in real-time on the USGS National Water Information System Website.

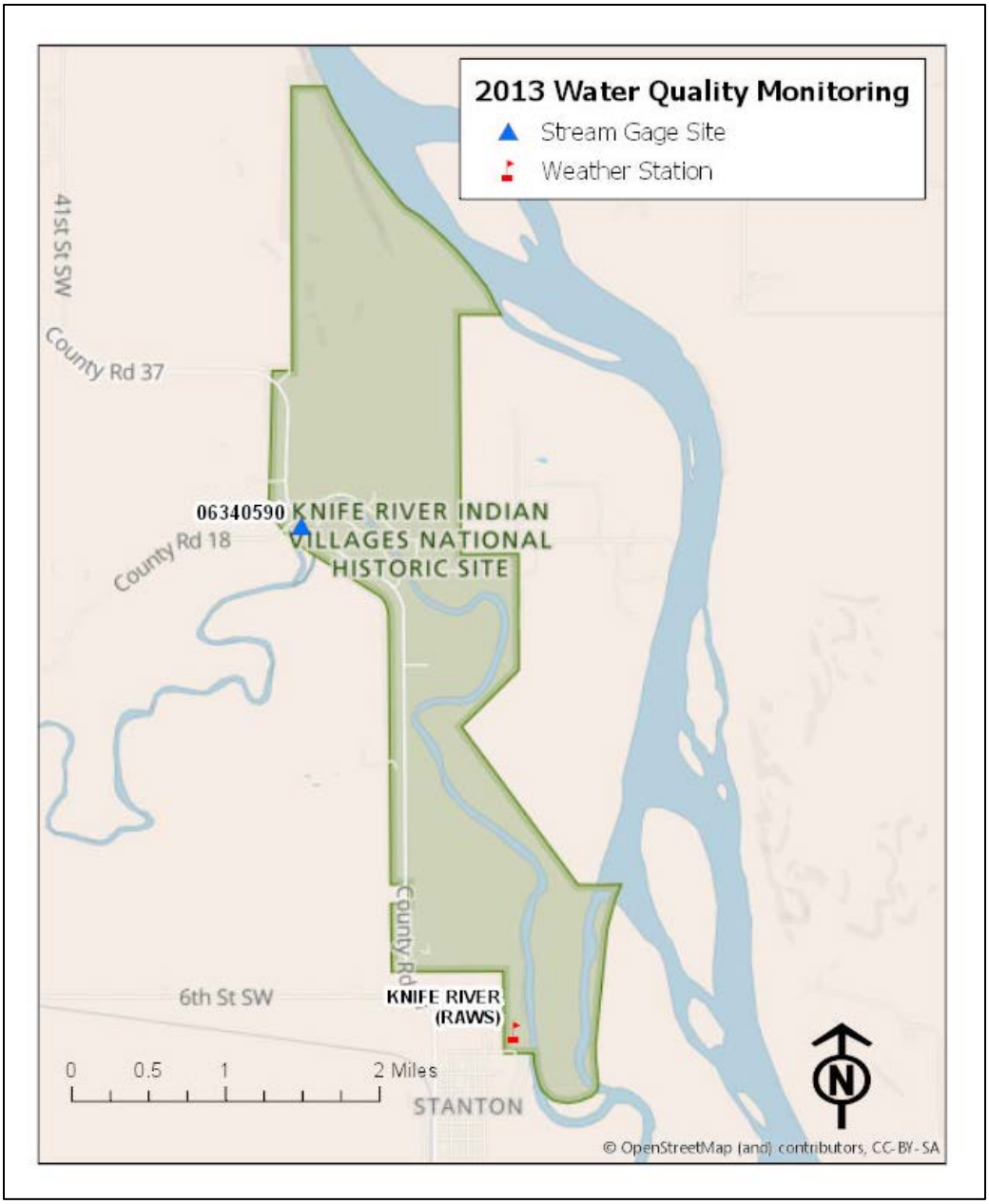


Figure 2. Map of Knife River Indian Villages National Historic Site and water quality monitoring location (blue triangle) and nearby weather station (red flags). Climate data in this report are taken from the Knife River RAWS weather station.

Table 1. Water quality parameters measured as part of the Northern Great Plains Inventory & Monitoring Water Quality Program and associated state standards for North Dakota class II waters (NDDEQ 2019).

Water Quality Parameter	Description	ND state standards applicable to warm water fisheries designations
Water temperature (°C)	Water temperature is affected by solar radiation, air temperature, rainfall, flow dynamics, stream shading, in-stream bed material and reflectance and land use/cover in the watershed.	• 29.44°C • The maximum increase shall not be greater than five degrees 2.78°C above natural background conditions.
Dissolved Oxygen (mg/L)	Dissolved oxygen level is a measure of the amount of oxygen in the water column and an important indicator of a water body's ability to support aquatic life.	• 5 mg/l as a daily minimum • up to 10% of representative samples collected during any 3-year period may be less than this value provided that lethal conditions are avoided
Specific Conductance (µS/cm)	Specific conductivity is a measure of the water's ability to conduct electricity. Specific conductivity is typically proportional to the dissolved major ions in the water such as calcium, magnesium, sodium, and sulfate.	No criteria
pH	The pH of the stream is a measure of the hydrogen ion concentration in the water. Different organisms flourish within different ranges of pH.	• 6.0 - 9.0 • up to 10% of representative samples collected during any 3-year period may exceed this range, provided that lethal conditions are avoided.

Methods

The NGPN Water Quality Monitoring Protocol (Wilson et al. 2014) sets out the methods used for sampling water quality and streamflow. The general approach is briefly described below. For more detail, please see Wilson et al. 2014 (available at https://www.nps.gov/im/ngpn/water-quality.htm).

Data Collection

Water quality data are collected at a real-time USGS stream gage (ID number 06340590) inside the park, at around 1640 ft. elevation. Water quality and streamflow are measured every 15 minutes throughout the ice-free season. Monitoring at KNRI began in 2013 and will be repeated in 2016, 2019, and every three years thereafter. Program funding currently limits monitoring to a cycle of one year of monitoring, followed by two years without.

In 2013, NGPN partnered with the USGS North Dakota Water Science Center to have USGS staff collect water quality and streamflow data at KNRI. The USGS deployed a continuous, multi-parameter sonde at the bridge along the Knife River on April 5, 2013 (Figure 3) and visited the gaging station every 3–4 weeks for equipment maintenance (Table 2). This instrument recorded dissolved oxygen, pH, specific conductivity, and water temperature every 15 minutes, while the gage simultaneously measured stream stage (or gage height) and discharge, a measure of streamflow.

Figure 3. A sonde device is used to measure water quality on the Knife River in 2013 at Knife River Indian Villages National Historic Site (right panel). The United States Geological Survey Knife River gaging station (06340590) is set up for real-time data transmission via satellite (left panel). Photographs courtesy of NPS.

Satellite telemetry transmitted the water data to the Water Science Center in near real-time (https://waterdata.usgs.gov/monitoring-location/06340590/). The USGS staff reviewed the real-time data daily to verify the accurate transfer of provisional field data and to identify sensor malfunctions or erroneous data. Access to the real-time data allowed them to recognize problems recording

equipment malfunction, sedimentation, electrical disruption, debris, or vandalism. If disruptions occurred, the USGS staff scheduled additional site visits and minimizing the loss of data.

During each site visit, USGS staff conducted a site inspection and a side-by-side comparison with the in-the-water sonde and an independent field sonde. They serviced and calibrated the sensors as needed. Calibration included pre- and post-calibration checks to quantify fouling errors and equipment drift – data critical to correction and grading of the final data. On October 17, 2013, the USGS removed the multi-parameter sonde from the Knife River (Table 2).

Quality assurance and quality control was conducted by USGS staff following established USGS guidelines (Wagner et al. 2006). NGPN received the final corrected (approved) data in February of 2014 from the USGS, and used AQUARIUS Workstation by Aquatic Informatics (http://aquaticinformatics.com/) and R (R Core Team 2019) to store and analyze water data. Water year reports are provided by USGS and the text can be found in Appendix A. Figures were generated in R and daily mean values were calculated from 15-minute interval data. In the case where there were missing data due to instrument error, means were generated by excluding the missing values and the maximum and minimum were left blank. Means were not calculated for days where all time steps were missing (i.e. the instrument didn't collect any data that day).

Climate data were downloaded from the RAWS Knife River Climate Station. The data were accessed and graphed using the web-based tool Climate Analyzer.

Table 2. Field journal for 2013 Water Quality Sampling at Knife River Indian Villages National Historic Site.

Date	Notes
April 4, 2013	Instrument installed ~ 11 am. Heavy debris.
April 17, 2013	Replaced YSI monitor
April 24, 2013	Checked meter, it was clean
May 6, 2013	Cleaned monitor tied probe vert to fence post.
May 16, 2013	Serviced monitor. Sensor fouling with mud / silt.
June 6, 2013	Probe was silted in /buried in sand. Could not remove because of high water.
June 10, 2013	Old probe was buried in sand and couldn't be retrieved. Installed new probe hanging from bridge.
June 17, 2013	Sensor fouling with mud / silt. Probe was cleaned and orifice line was reinstalled deeper.
July 15, 2013	Pipe had mud, but probe was fairly clean the fouling was bugs, mud and silt. Serviced YSI probe.
August 20, 2013	Light debris, serviced monitor. Sensor fouling was mud / silt
September 17, 2013	Light algae, mud, and light debris in channel. Serviced YSI probe.
October 17, 2013	Light algae & mud. Removed sensor 9:12 AM

Results

The water quality monitoring season (ice-free) on the Knife River at KNRI lasted from April 4, 2013 to November 17, 2013. The discharge of the Knife River increased from April to June and then declined in fall (Figure 4). The maximum recorded discharge was on June 3, 2013 at 5330 cubic feet per second and the minimum was recorded on August 28, 2013 at less than 60 cubic feet per second (Appendix A). This seasonal pattern of increased flow in the spring is typical but in comparison to the past years, May and June 2013 was wetter than average (Figure 5). In 2013, it rained and snowed 18.94 inches with total monthly precipitation peaking in May (Figure 5).

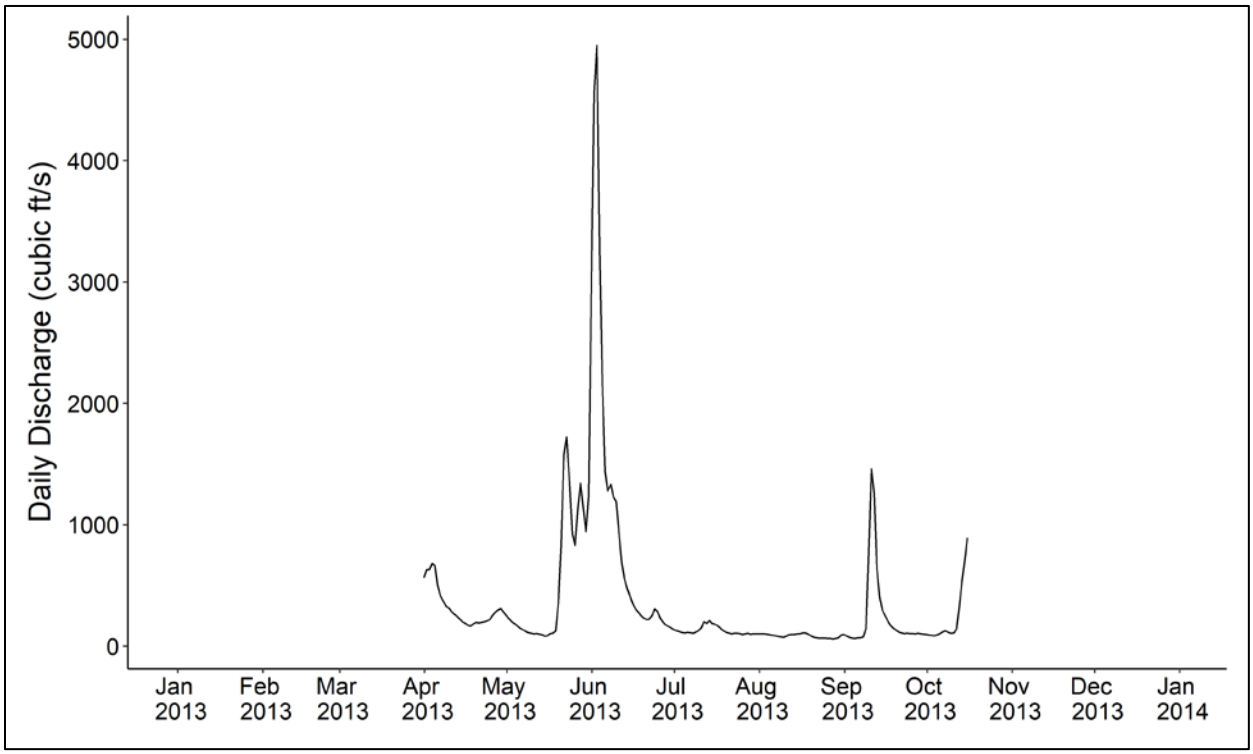
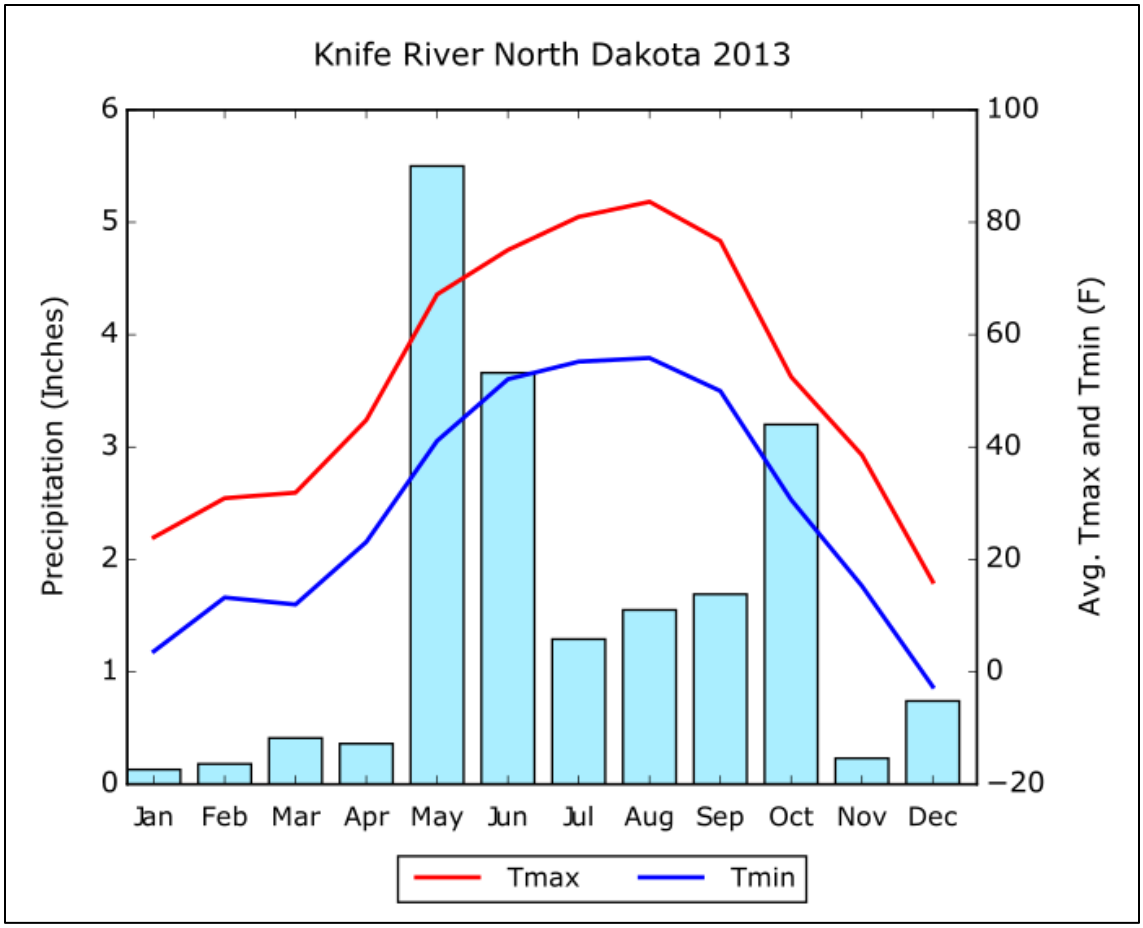
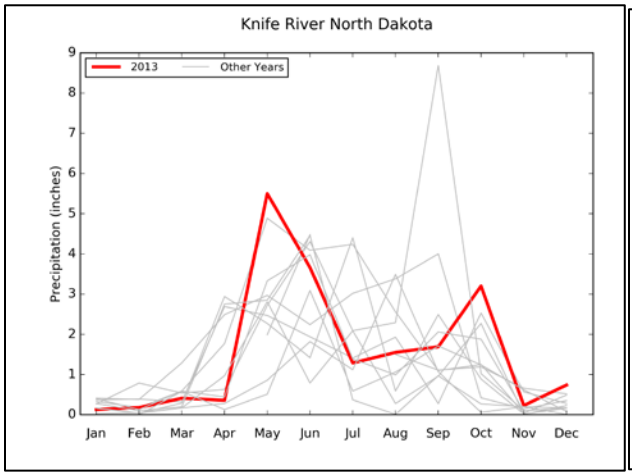


Figure 4. Daily mean discharge (black line) in 2013 on the Knife River Knife River Indian Villages National Historic Site, USGS Gaging Station 06340590.





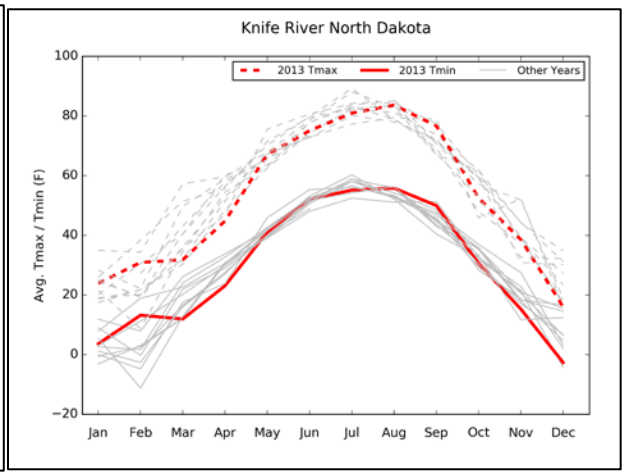


Figure 5. Total monthly precipitation (light blue) and average monthly minimum (blue) and maximum (red) temperature for 2013 in Knife River Indian Villages National Historic Site (top panel). A comparison of 2013 precipitation (bottom left) and temperature (bottom right) in Knife River Indian Villages National Historic Site compared to the period of record. Climate data are from Knife River RAWS climate station. The data were accessed and graphed using the web-based tool Climate Analyzer.

During the ice-free season at KNRI, we collected over 16,000 water quality measurements in the Knife River (Table 3). We found mean water temperature of 18°C, dissolved oxygen concentrations of 8.7 mg/L, specific conductance of 1818, and pH of 8 (Table 3). There was, however, variation across months in all parameters (Table 4). Mean water temperature in April was 7°C and increased to a mean of close to 24°C in July before declining back to 9.8°C in October (Table 4, Figure 6). Maximum water temperature exceeded the North Dakota water quality standard of 29.4°C six times in July (Table 4).

Table 3. Summary of descriptive statistics for water temperature, dissolved oxygen, specific conductance, and pH measured for the ice-free sampling period at Knife River Indian Villages National Historic Site in the Knife River from April 2013 to October 2013. Percent exceedance is the proportion of samples that exceed the respective state regulatory threshold described in Table 1 (water temperature max. limit is 29.4°C; dissolved oxygen ≥ 5.0 mg/L and pH range is <6.0 or >9.0).

Descriptive Statistic	**Water Temperature (°C)**	**Dissolved Oxygen (mg/L)**	**Specific Conductance (µS/cm)**	**pH**
Mean	18.2	8.65	1818.38	8.08
Standard Deviation	6.28	1.29	261.47	0.14
Median	19.9	8.6	1890	8.1
Minimum	0.1	4.8	761	7.6
Maximum	29.5	11.9	2240	8.4
Number of Points	16405	13587	16211	16399
Number of Points below or above standard	6 (above)	34 (below)	NA	0 (above) 0 (below)
% Exceedance	0.04%	0.25%	NA	0%

Table 4. Monthly summary of descriptive statistics and percent exceedances for core water quality parameters for the ice-free sampling period at Knife River Indian Villages National Historic Site in the Knife River from April 2013 to October 2013. Percent exceedance is the proportion of samples that exceed the respective state regulatory threshold described in Table 1 (water temperature max. limit is 29.4°C; dissolved oxygen ≥ 5.0 mg/L and pH range is <6.0 or >9.0).

Dates	Descriptive Statistic	Water Temperature (°C)	Dissolved Oxygen (mg/L)	Specific Conductivity (µS/cm)	pH
April 5 -30, 2013	Number of measurements	1440	644	1440	1440
	Mean	7.29	10.69	1445.93	8.32
	Standard Deviation	3.93	0.78	307.25	0.1
	Median	7	10.9	1560	8.4
	Minimum	0.1	8.9	761	8.1
	Maximum	15.7	11.8	1830	8.5
	% Exceedance	0	0	-	0
May, 2013	Number of measurements	2878	1806	2684	2873
	Mean	14.68	8.68	1772.66	8.19
	Standard Deviation	3.35	1.02	306.42	0.19
	Median	14.4	8.7	1920	8.3
	Minimum	6.2	6.4	894	7.6
	Maximum	23.2	10.7	2050	8.4
	% Exceedance	0	0	-	0
June, 2013	Number of measurements	1915	1915	1915	1915
	Mean	22.35	8.02	1925.77	8.25
	Standard Deviation	1.85	0.75	154.89	0.12
	Median	22.1	7.8	1930	8.3
	Minimum	18.5	6.9	1570	8
	Maximum	27.3	9.8	2200	8.4
	% Exceedance	0	0	-	0
July, 2013	Number of measurements	2880	2819	2880	2880
	Mean	23.71	8.31	2001.28	8.41
	Standard Deviation	2.76	1	87.89	0.09
	Median	23.7	8.2	2020	8.4
	Minimum	16.7	6.6	1830	8.3
	Maximum	29.5	11.9	2220	8.7
	% Exceedance	0.21%	0	-	0

Table 4 (continued). Monthly summary of descriptive statistics and percent exceedances for core water quality parameters for the ice-free sampling period at Knife River Indian Villages National Historic Site in the Knife River from April 2013 to October 2013. Percent exceedance is the proportion of samples that exceed the respective state regulatory threshold described in Table 1 (water temperature max. limit is 29.4°C; dissolved oxygen ≥ 5.0 mg/L and pH range is <6.0 or >9.0).

Dates	Descriptive Statistic	Water Temperature (°C)	Dissolved Oxygen (mg/L)	Specific Conductivity (µS/cm)	pH
August, 2013	Number of measurements	2879	2193	2879	2880
	Mean	22.96	8.15	1888.16	8.4
	Standard Deviation	2.51	0.87	120.03	0.07
	Median	22.9	8	1900	8.4
	Minimum	17.2	6.4	1570	8.2
	Maximum	29.1	10	2110	8.5
	% Exceedance	0	0	-	0
September, 2013	Number of measurements	2877	2675	2877	2877
	Mean	18.64	8.38	1666.13	8.34
	Standard Deviation	3.47	1.42	247.55	0.16
	Median	18.8	8.4	1770	8.4
	Minimum	11.2	4.8	1010	7.9
	Maximum	27.8	11.6	1970	8.6
	% Exceedance	0	1.27%	-	0
October 1 - 16, 2013	Number of measurements	1536	1535	1536	1534
	Mean	9.78	10.36	1924.98	8.38
	Standard Deviation	2.45	0.54	90.64	0.07
	Median	9.6	10.3	1900	8.4
	Minimum	4.5	9	1710	8.2
	Maximum	15.9	11.7	2240	8.5
	% Exceedance	0	0	-	0

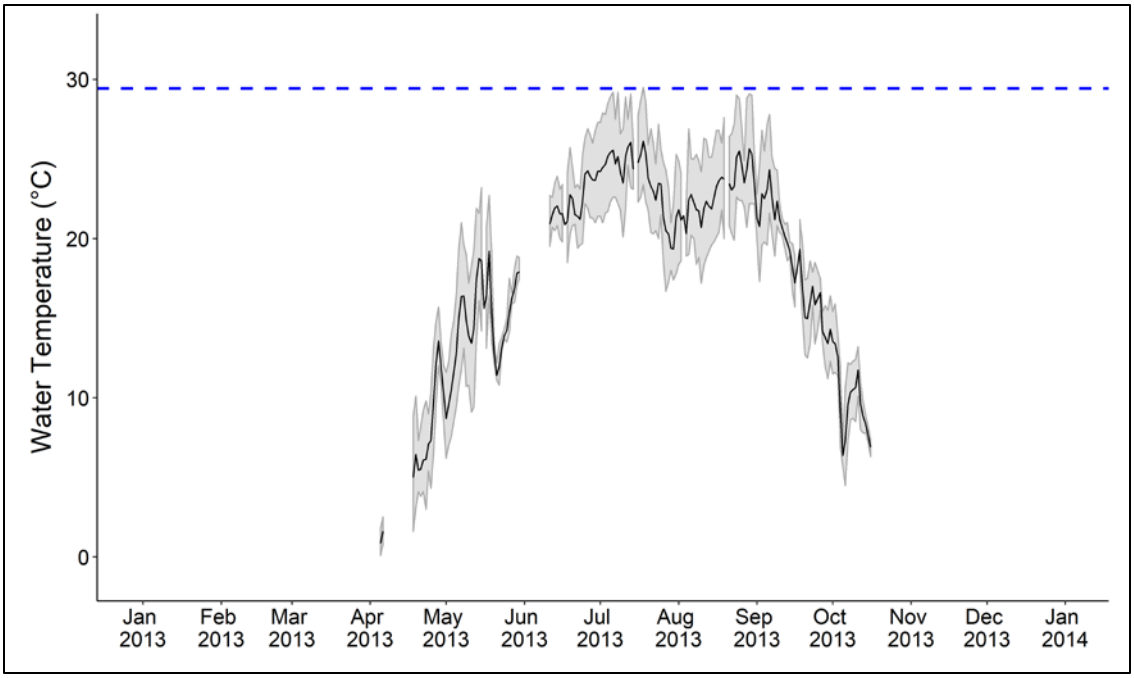


Figure 6. Daily mean water temperature (black line) collected on the Knife River at Knife River Indian Villages National Historic Site in 2013. The sonde was in the water from April 5, 2013 through October 16, 2013. The gray ribbon shows the daily maximum and minimum water temperature for the same period. The dashed blue line indicates one of the North Dakota state water quality standards (see Table 1 for more details). The periods where the instrument did not collect data are indicated by gaps in the record.

Dissolved oxygen also displayed seasonal variation (Table 3, Figure 7). The highest mean dissolved oxygen concentrations were in the spring and fall, averaging greater than 10 mg/L in April and October. Dissolved oxygen was found below one of the North Dakota state water quality criteria (Table 1). Dissolved oxygen concentrations measured below 5 mg/ L in the Knife River 34 times during September 2013 (Table 3, Figure 7).

Specific conductance of the Knife River was highly variable throughout the year (Table 3, Figure 8), but showed a less predictable seasonal pattern than temperature or dissolved oxygen concentrations. The pH of the Knife River ranged between 7.6 and 8.4 (Figure 9) and was never outside the range of the North Dakota state standards of 6.0 -9.

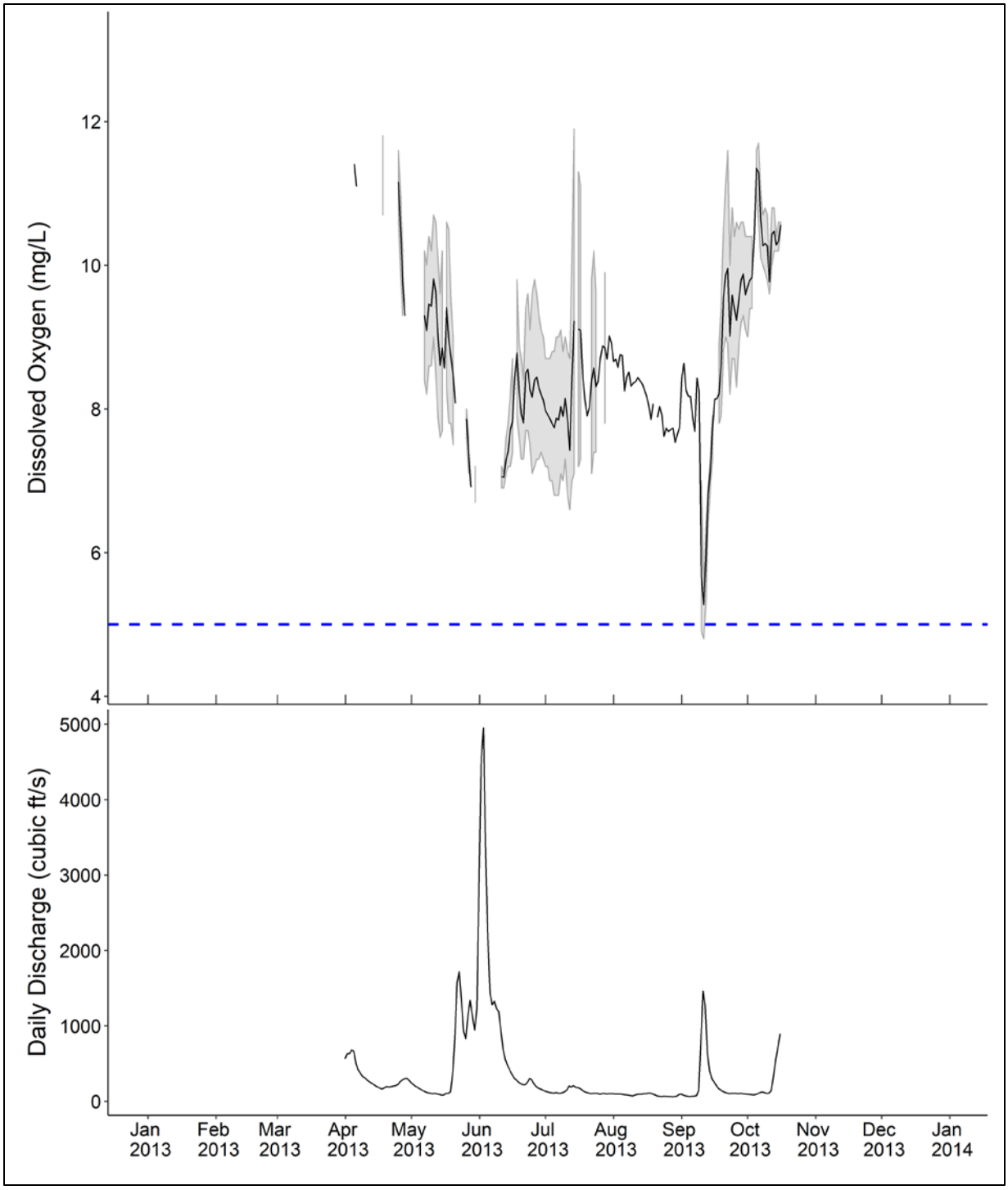


Figure 7. Daily mean dissolved oxygen concentrations (top) and daily discharge (bottom) of the Knife River in 2013 at Knife River Indian Villages National Historic Site. The gray ribbon shows the daily maximum and minimum dissolved oxygen for the same period. The dashed blue line indicates one of the North Dakota state water quality standards (see Table 1 for more details). The periods where the instrument did not collect data are indicated by gaps in the record.

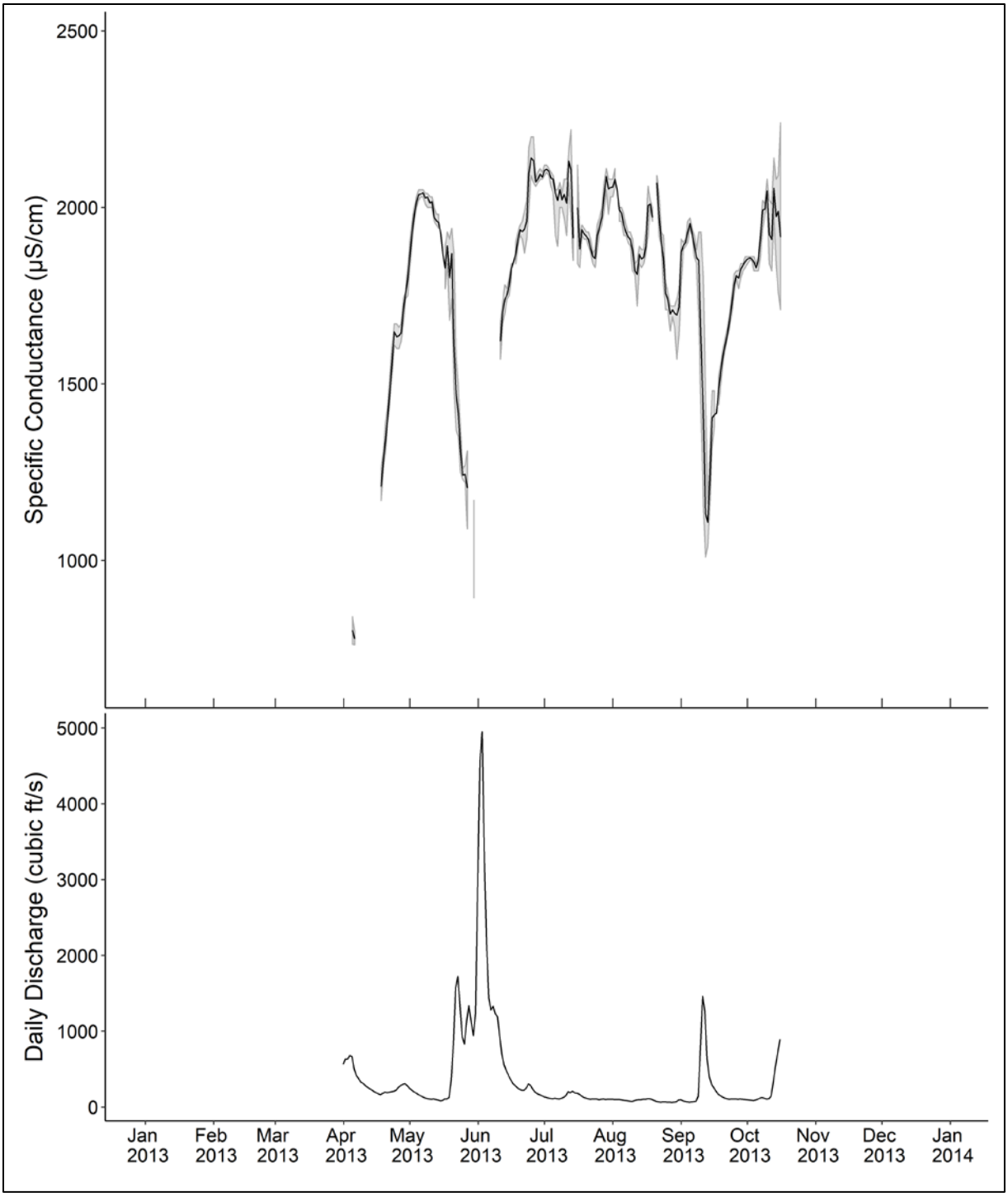


Figure 8. Daily mean specific conductance (top) and daily discharge (bottom) of the Knife River in 2013 at Knife River Indian Villages National Historic Site. The gray ribbon shows the daily maximum and minimum specific conductivity for the same period. The periods where the instrument did not collect data are indicated by gaps in the record.

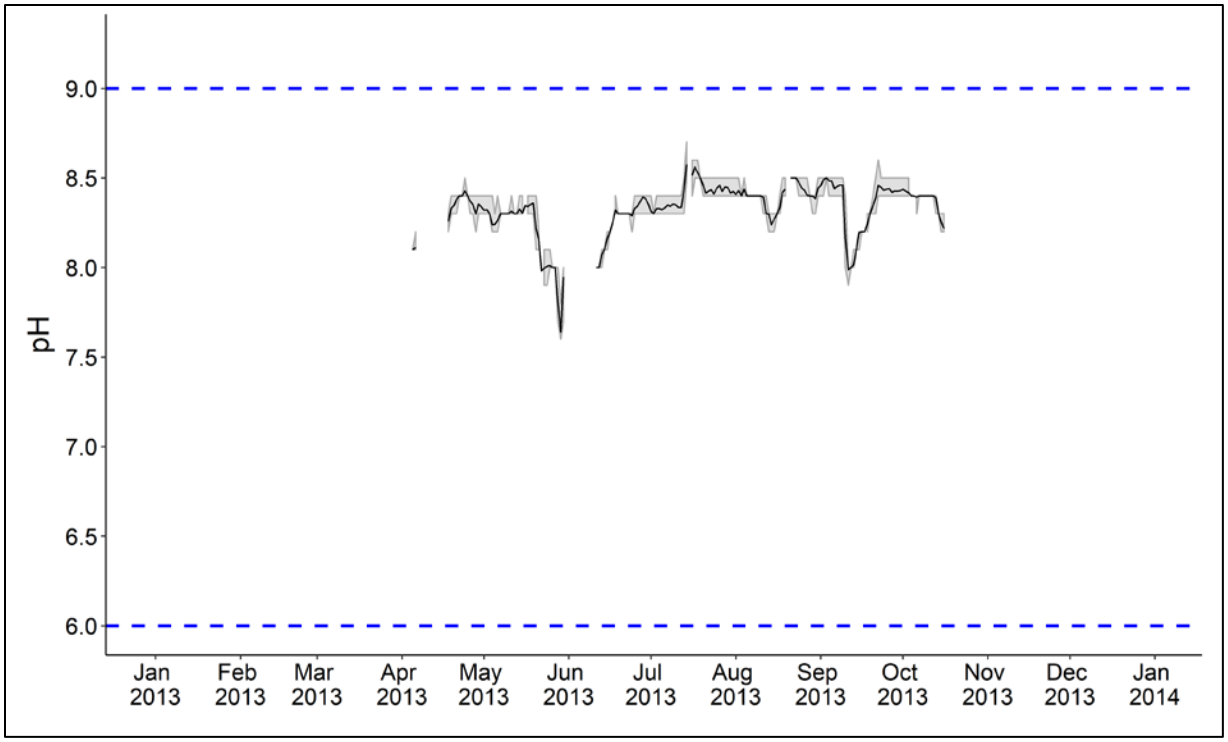


Figure 9. Daily mean pH (black line) of the Knife River at Knife River Indian Villages National Historic Site in 2013. Measurements were taken from from April 5, 2013 through October 16, 2013. The gray ribbon shows the daily maximum and minimum pH for the same period. The dashed blue lines indicate the North Dakota state water quality standards (see Table 1 for more details). The periods where the instrument did not collect data are indicated by gaps in the record.

Further Analysis

This Data Report is intended to provide a basic review of the data collected during the 2013 water quality monitoring season at Knife River Indian Villages National Historic Site. All data included in this report is available upon request from the Northern Great Plains Inventory and Monitoring Network, as well as in the archives found on the USGS National Water Information System for site 06340590.

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Appendix A. USGS Water Data Quality Report for Knife River 06340590, 2013

Water-Data Report 2013
06340590 KNIFE RIVER NR STANTON, ND

Cannonball, Heart, and Knife Basin
Knife Subbasin

LOCATION.—Lat 47°21'29", long 101°23'50" referenced to North American Datum of 1927, in SW1/4 SW1/4 sec.21, T.145N., R.84 W., Mercer County, ND, Hydrologic Unit 10130201, on left bank, 10 ft downstream from county bridge, and 2.4 mi north of Stanton.

DRAINAGE AREA—Not determined.

SURFACE-WATER RECORDS

PERIOD OF RECORD.—DAILY DISCHARGE—April to Octobr 2013 (discontinued).

PERIOD OF RECORD.—DAILY GAGE HEIGHT—April to October 2013 (discontinued).

GAGE.—Water stage recorder. Datum of gage is 1,640 ft above North American Vertical Datum of 1988, from topographic map.

REMARKS.—Records good except for estimated daily discharges, which are poor.

REGULATION.—Slight regulation by Lake Ilo 81 mi upstream, capacity, 7,130 acre-ft.

EXTREMES FOR CURRENT YEAR.—Maximum discharge, 5,330 ft^3/s, June 3, gage height, 16.84 ft; minimum daily discharge, 59 ft^3/s, August 28.

WATER-QUALITY RECORDS

PERIOD OF DAILY RECORD.—

WATER TEMPERATURE: April to October 2013 (discontinued).

SPECIFIC CONDUCTANCE: April to October 2013 (discontinued).

pH: April to October 2013 (discontinued)

DISSOLVED OXYGEN: April to october 2013 (discontinued).

INSTRUMENTATION.—Multiparameter water-quality monitor.

REMARKS.—Records rated as follows:

WATER TEMPERATURE: rated good: April 4-October 16.

SPECIFIC CONDUCTANCE: Rated good: April 4-May 20, June 10-October 16. Rated fair: May 21-June 9.

pH: Rated good: April4-October 16.

DISSOLVED OXYGEN: Rated good: April 29-October 16. Rated poor: April 4-April 28.

EXTREMES FOR CURRENT YEAR.—

WATER TEMPERATURE: Maximum recorded, 29.5°C, July 18; minimum recorded, 0.0°C, April 4,15.

SPECIFIC CONDUCTANCE: Maximum recorded, 2340 microsiemens, July 15; minimum recorded, 761 microsiemens, April 6.

pH: Maximum recorded, 8.7 units, July 14; minimum recorded, 7.6 units, May 29.

DISSOLVED OXYGEN: Maximum recorded, 12.4 milligrams per liter, April 9; minimum recorded, 4.8 milligrams per liter, September 11.

The Department of the Interior protects and manages the nation's natural resources and cultural heritage; provides scientific and other information about those resources; and honors its special responsibilities to American Indians, Alaska Natives, and affiliated Island Communities.

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National Park Service
U.S. Department of the Interior

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