



Water Quality Monitoring for Agate Fossil Beds National Monument

2020 Data Report

Natural Resource Data Series NPS/AGFO/NRDS—2022/1362





ON THIS PAGE

Upstream view of the Niobrara River from the gage station at Agate Fossil Beds National Monument, Nebraska, in August 2020.

Photograph courtesy of KA McLaughlin, RE Woodruff & KRW, of the USGS, at Station 06454100.

ON THE COVER

Photograph of the Niobrara River at Agate Fossil Beds National Monument, Nebraska.

Photograph courtesy of National Park Service, 2017.

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Abstract

The Northern Great Plains Inventory and Monitoring Network (NGPN) began monitoring water quality in the Niobrara River at Agate Fossil Beds National Monument (AGFO) in 2014 with the assistance of the U.S. Geological Survey (USGS). This report summarizes the data collected during the 2020 ice-free season (March 31 to November 3) for streamflow, water temperature, dissolved oxygen, specific conductance, and pH. NGPN's collaboration with USGS supported real-time and archived access to this data through the [Niobrara River at Agate, Nebr. - USGS Water Data for the Nation](#) where it remains available to the public.

A summary of our 2020 results can be found in Descriptive Statistics Summary tables for the ice-free season (Table 3) and for each month (Table 4). All water quality parameters in the Niobrara River showed seasonal variability, correlating with precipitation and temperature patterns recorded at AGFO. Of note, water temperatures in 2020 exceeded Nebraska state thresholds for cold water fisheries in 8.72% of samples. This segment of the Niobrara River is now listed by the state of Nebraska as having impaired aquatic life beneficial uses. While dissolved oxygen exceedances of the standard reached 18% of all samples in 2014 (Ashton, 2020), no samples exceeded the Nebraska dissolved oxygen thresholds in 2020.

Acknowledgements

We would like to acknowledge Wyoming-Montana Water Science Center USGS staff including Ray Woodruff and crew for collecting the water quality data; AGFO park staff; Nebraska Department of Energy and the Environment staff for background information; Nebraska Games and Parks Commission staff for background information; Isabel Ashton for providing the R code; and Stephanie Rockwood, Isabel Ashton, and Theresa Schaffner for providing much of the background information and template for this report. Thanks to Myles Cramer for reviewing this report.

Introduction

Agate Fossil Beds National Monument (AGFO) lies in the unglaciated high plains of northwest Nebraska, approximately sixty-five miles southeast and downstream of the Niobrara River headwaters in Wyoming. The park consists of 2,700 acres of short-grass prairie, bisected from west to east by the Niobrara River with wetlands expanding from the river to meet upland prairie terraces (Dibner et al 2020). Approximately four miles of the perennial spring-fed river flow through Agate Fossil Beds National Monument (Bowles et al 2013). Beneath the prairie surface, AGFO is home to a world-renowned concentration of Miocene fossils. These fossil beds were once a part of the James H. Cook Agate Springs Ranch which became a gathering place for the Oglala Lakota people led by Chief Red Cloud (NPS 2017). Agate Fossil Beds National Monument was established in 1965 to protect, display, and interpret the Miocene epoch fossils and related geologic phenomena found within the park; to protect and curate the Cook-Red Cloud Native American artifact collection; and to preserve the short-grass prairie and Niobrara riparian ecotone (National Park Service 2008, 2017).

Across Nebraska, the Niobrara River is a prominent natural feature and an important agricultural, recreational, cultural, and ecological resource. Protecting the water quality in the Niobrara River within AGFO is a high regional priority for the National Park Service (Wilson et al. 2014). The Niobrara River supports a riparian corridor dominated by native species such as bulrush (*Scirpus spp.*), broad-leaved cattail (*Typha latifolia*), and willow (*Salix spp.*) (Licht 2002). However, the spread and dominance of non-native yellow flag iris (*Iris pseudacorus*) along the stretch of the river flowing through AGFO has replaced native riparian plant species, thereby altering the overall riparian habitat (Spaak 2016). The NPS has been monitoring aquatic vegetation and wildlife in the park since 1979, and there has been a notable decline in species richness. In 1989, the Niobrara River in AGFO had 7 native fish species and one non-native species present. By 2011, only three fish species were recorded, including the non-native northern pike (*Esox lucius*) (Pegg and Pope 2008). In addition to species decline, observations of the Niobrara River show that the river channel in AGFO is deeper and narrower, when compared to non-infested river locations upstream, due to the increased bank stability caused by the mats of yellow flag iris. This alteration to flow regimes can alter the function of the river, further impacting the aquatic vegetation and wildlife species (Spaak 2016).

The stretch of the Niobrara River that runs through AGFO is designated as a Coldwater Class B stream for aquatic life by the Nebraska Department of Environment and Energy (NDEE, formerly the Nebraska Department of Environmental Quality). This stretch of the Niobrara is defined as a water known to support non-reproductive populations of trout and important native fish species (NDEE 2019). In Nebraska, surface waters with a Coldwater Class B designation must have appropriate ranges for pH, temperature, toxic substances, total ammonia, dissolved oxygen, and streamflow (NDEE 2019, Dibner et al. 2020). The Niobrara River also has a recreation use (where *E. coli* bacteria is a pollutant of concern) and an agriculture use (where conductivity, nitrate, and selenium are of concern) as well as meeting minimum aesthetic standards: no noxious odors, floating solids, or algal blooms. Impairment of this stretch of the Niobrara River's aquatic life use is due to low dissolved oxygen, as first reported in the 2016 Nebraska Integrated Water Quality Report (Figure 1). This reach (NE-WY border to Whistle Creek NI 4-50000) was listed as EPA Category 5 in the 2016,

2018, and 2020 Nebraska Integrated Water Quality Reports, indicating that the designated waterbody uses were impaired and it does not have a total maximum daily load (TMDL) to address this impairment. A previous aquatic community assessment determined the aesthetics use was being met, and chronic water quality standards were not assessed due to the state's monitoring protocol. Stretches of the river downstream from the park are impaired under section 303(d) of the Clean Water Act for the recreation use due to *E. coli* bacteria concentrations and for the aquatic life use due to elevated temperature (Figure 1). For more details and current impairment information visit the Nebraska Department of Environment and Energy [website](#).

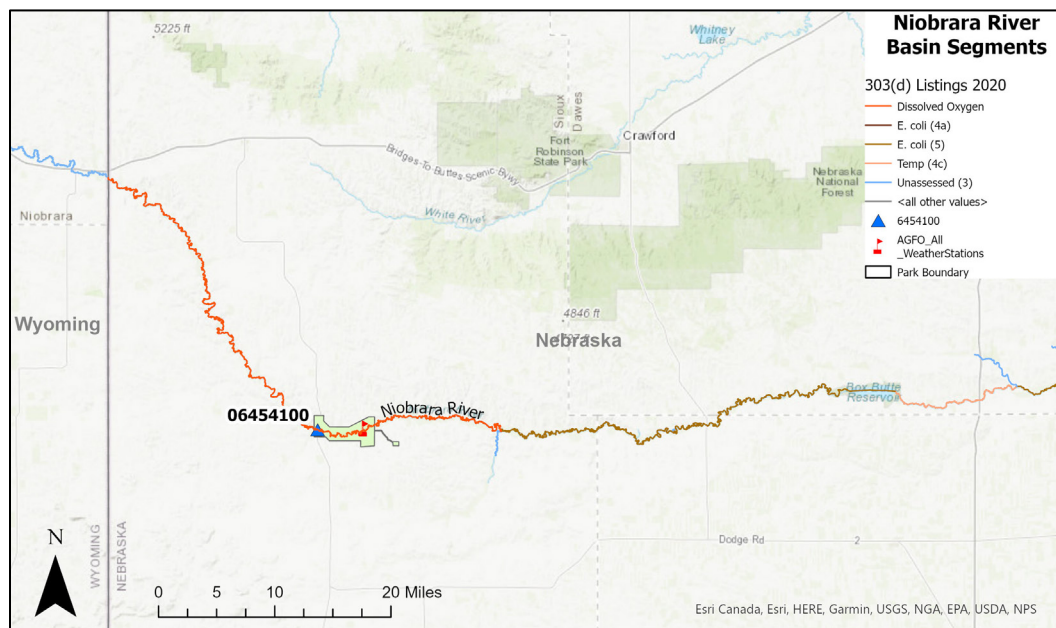


Figure 1. Map of the western Niobrara River Basin in Nebraska and Agate Fossil Beds National Monument. The stretch of the river through AGFO was first listed as impaired in 2016 under 303(d) criteria for dissolved oxygen. Other segments downstream are impaired for *E. coli* and temperature.

The Northern Great Plains Inventory & Monitoring Network (NGPN) began monitoring water quality at AGFO in 2014 (Wilson et al. 2014) to better understand current conditions and changes over time in the Niobrara River. The monitoring is conducted at the gaging station at Agate Fossil Beds National Monument, NE (Monitoring Location 06454100; Figure 2) in collaboration with the United States Geological Survey (USGS) and Nebraska Department of Natural Resources (NE DNR). 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 AGFO every three years, and an in-depth analysis of status and trends will be conducted after 3 to 5 cycles of sampling (Wilson et al. 2014).

NGPN's core water quality parameters include streamflow, dissolved oxygen (DO), pH, specific conductivity, and water temperature (Table 1; Wilson et al. 2014). Most water quality parameters (DO, pH, specific conductivity, and water temperature) are measured every 15 minutes throughout the ice-free season (typically March to November), and results are available in real-time on the

[USGS National Water Information System Website](https://water.usgs.gov/nwis/). The gaging and resulting streamflow measurements are managed by Nebraska Department of Natural Resources, and the data is available on the [NeDNR Stream Gaging \(nebraska.gov\)](https://nebraska.gov/nebraska-dnr/stream-gaging) website.

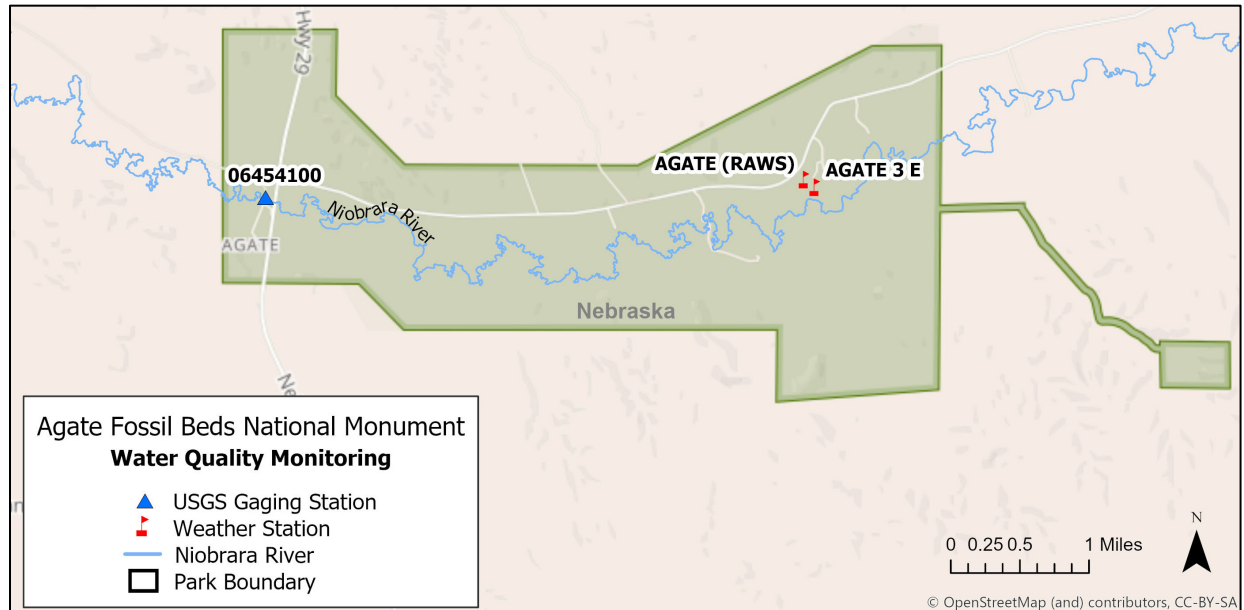


Figure 2. Map of Agate Fossil Beds National Monument and water quality monitoring location (06454100, blue triangle) and nearby weather stations (red flags). Climate data in this report is taken from the Agate 3 E weather station.

Table 1. Water quality parameters measured as part of the Northern Great Plains Inventory & Monitoring Network Water Quality Program and associated state standards for the Niobrara River at Agate Fossil Beds (NEE 2019).

Water Quality Parameter	Description	NE state standards applicable to cold water fisheries designations (class B)
Water temperature (°C)	Water temperature is affected by solar radiation, air temperature, rainfall, flow dynamics, physiography of the waterbody, stream shading, land use/cover, and land development in the watershed. Water temperature monitoring indicates response to daily and annual climatic variations and may track short-term drought or long-term climate changes. Water temperature can indicate changes in water use, source, and flow dynamics. Aquatic organisms are dependent on specific temperature ranges for their optimum health and survival.	• The temperature of a receiving water is not to be increased by a total of more than 3°C from natural background outside the mixing zone. • For cold waters, the maximum limit is 22°C.
Dissolved Oxygen (mg/L)	The DO level, a measure of the amount of oxygen in the water column, is considered an important indicator of a waterbody's ability to support aquatic life. The DO in rivers and streams typically declines as temperature increases and as flow decreases; DO also responds to photosynthesis, resulting in natural variation during the day and additional natural variation through the season. The DO in water can vary over extended periods of time due to changes in the landscape or climate.	• One-day minimum of not less than 5.0 mg/L for coldwater fish early-life stages. This criterion applies from April 1 through June 30. • One-day minimum of not less than 4.0 mg/L for all life stages other than coldwater fish early-life stages. This criterion applies from July 1 through March 31. • Seven-day mean minimum of not less than 5.0 mg/L. This criterion applies from July 1 through March 31. • Seven-day mean of not less than 6.5 mg/L for coldwater fish early-life stages. This criterion applies from April 1 through June 30. • Thirty-day mean of not less than 6.5 mg/L. This criterion applies from July 1 through March 31.
Specific Conductance (µmhos/cm)	Specific conductance, a measured concentration of the water's ability to conduct electricity, typically is proportional to the dissolved major ions in the water such as calcium, magnesium, sodium, and sulfate. A change in specific conductance indicates a change in the concentration(s) of major ions. Small changes in specific conductance are common through the day and through the seasons.	• Conductivity not to exceed 2,000 umhos/cm. This criterion applies between April 1 and September 30.
pH	The pH is a measure of the hydrogen ion concentration in a solution. The pH in surface waters typically ranges from 6.5 to 8.5. pH may be influenced by watershed vegetation, hydrology, geology, and soils. Different organisms flourish within different ranges of pH.	• Maintained between 6.5 and 9.0, unless pH values outside this range are due to natural conditions.

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 06454100) inside the park, at around 4405 ft. elevation. Water quality and streamflow are measured every 15 minutes throughout the ice-free season. Monitoring at AGFO began in 2014 and will be repeated every three years thereafter. Program funding currently limits monitoring to a cycle of one year of monitoring, followed by two years without.

In 2020, NGPN partnered with the USGS Wyoming-Montana Water Science Center to have USGS staff collect water quality and streamflow data at AGFO. The USGS deployed a continuous, multi-parameter sonde at the gage (Figure 3) on March 31, 2020 and visited the gaging station every 3–4 weeks for equipment maintenance. This instrument recorded dissolved oxygen, pH, specific conductivity, and water temperature every 15 minutes. The stream gage is managed by Nebraska Department of Natural Resources, and measures stream stage (or gage height, measured in feet). Visits to the gage are made twice every month throughout the year. During the visits, discharge is measured directly, and a stage-discharge relationship is developed from the stage data interspersed with discrete discharge measurements.

Satellite telemetry was used to transmit the water data to the Water Science Center in near real-time (<https://waterdata.usgs.gov/monitoring-location/06454100/>). 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 such as recording equipment malfunction, sedimentation, electrical disruption, debris, or vandalism. If disruptions occurred, the USGS staff scheduled additional site visits to minimize the loss of data.

During each site visit, the 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 the correction and grading of the final data. On November 4, 2020, the USGS removed the multi-parameter sonde from the Niobrara River.

Quality assurance and quality control was conducted by the USGS staff following established USGS guidelines (Wagner et al. 2006). NGPN received the final corrected (approved) data in December of 2021 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). We calculated the proportion of records that exceeded Nebraska environmental regulatory thresholds (Table 1).



Figure 3. A sonde device is used to measure water quality in the Niobrara River at Agate Fossil Beds National Monument. The United States Geological Survey Niobrara River gaging station (06454100) is set up for real-time data transmission via satellite. Photographs courtesy of KA McLaughlin, RE Woodruff & KRW, of the USGS, at Station 06454100.

Discharge data was provided by Nebraska Department of Natural Resources. Nebraska staff visited the gage monthly throughout the year to record discharge data, provide maintenance, and inspect the site. 15-minute stage data was collected from a Sutron Satlink High Dynamic Range (HDR) Data Collection Platform (DCP) bubbler with kilopounds per square inch (KPSI) submersible pressure transducer. QA procedures were followed, and approved data was available via the Nebraska surface water gaging website. Water year reports are also available for the site by year. The 2020–2021 hydrographic reports by water years from the station are found in Appendix B.

Climate data were downloaded from the Agate 3 E (250030) National Weather Service Cooperator Observer Program station. The data were accessed and graphed using the web-based tool [Climate Analyzer](#).

Table 2. Field journal for 2020 Water Quality Sampling at Agate Fossil Beds National Monument.

Date	Notes
March 31, 2020	Initial installation and calibration of sonde. Cross-section performed.
May 12, 2020	Sonde serviced. Cross-section performed. Erroneous pH and specific conductance values were deleted. SC fouling correction applied.
June 12, 2020	Sonde serviced. Cross-section performed. Minor pH fouling correction applied May 12-June 12 th . Drift correction applied May 12 th -June 12 th .
July 7, 2020	Sonde serviced. Cross-section performed. DCP orifice was out of water and was lowered to staff gage. Data from June 29 th -July 7 th was deleted.
August 5, 2020	Sonde serviced. Cross-section performed. Minor pH fouling correction applied July 7 th to August 5 th . SC fouling correction applied.
September 10, 2020	Sonde serviced. DO sensor malfunctioned Sept 8 th -10 th . DO sensor replaced on Sept. 10 th . Cross-section performed. Erroneous pH and specific conductance values were deleted. pH fouling detected on Sept 5 th and fouling correction applied. SC drift correction also applied. Water temperature value associated with sonde service was deleted as well as two values from August associated with fouling.
November 4, 2020	Sonde removed from water. Cross-section performed. DO drift correction applied for data from Sept. 10 th -Nov. 4 th . DO data rated good. Stage data rated good. A 0.02 ft correction was applied between September and November. pH unit drift correction applied. pH data rated good. Specific conductance rated good except for August 13 th -24 th which was poor due to fouling. Water temperature record rated excellent.

Results

The water quality monitoring season (ice-free) on the Niobrara River at AGFO lasted from March 31 to November 4, 2020. Discharge measurements were made using a DCP stage recorder which recorded measurements year-round showing high spring flow with a steady drop throughout the monitoring season, with late season spikes (Figure 4, [NeDNR Stream Gaging \(nebraska.gov\)](https://nebraska.gov/ne-dnr/stream-gaging)). The gage was maintained by Nebraska DNR.



Figure 4. Daily mean discharge (black line) during water quality sampling season on the Niobrara River at Agate Fossil Beds National Monument from March 31 to November 4, 2020, at USGS Gaging Station 06454100 (NE DNR).

According to the USGS Water-Year Summary for 2020 (Appendix A [USGS Water-Year Summary for Site USGS 06454100](https://www.water.usgs.gov/publications/water-year-summary/)), maximum recorded gage height occurred on April 1 at a height of 4.35 ft. Stage was recorded at 4.39 ft on the date on the sonde installation (March 31, 2020). Calculated discharge corresponded to 27 cfs on March 31–April 1 (NE DNR). Peak discharge occurred outside the 2020 water quality sampling season at 37 cfs on March 10. 2020 was a relatively dry year at Agate. All months had below average precipitation when compared to the 30-year period from 1981–2010 (Figure 5). Most of the precipitation fell in May through July with October also receiving high rainfall. Streamflow, as measured by discharge, affects water quality parameters. Low flow or extremely high flow conditions can have deleterious effects on water quality, so comparison of water quality parameters to streamflow conditions is recommended (Dodds 2004, Mosley 2015).

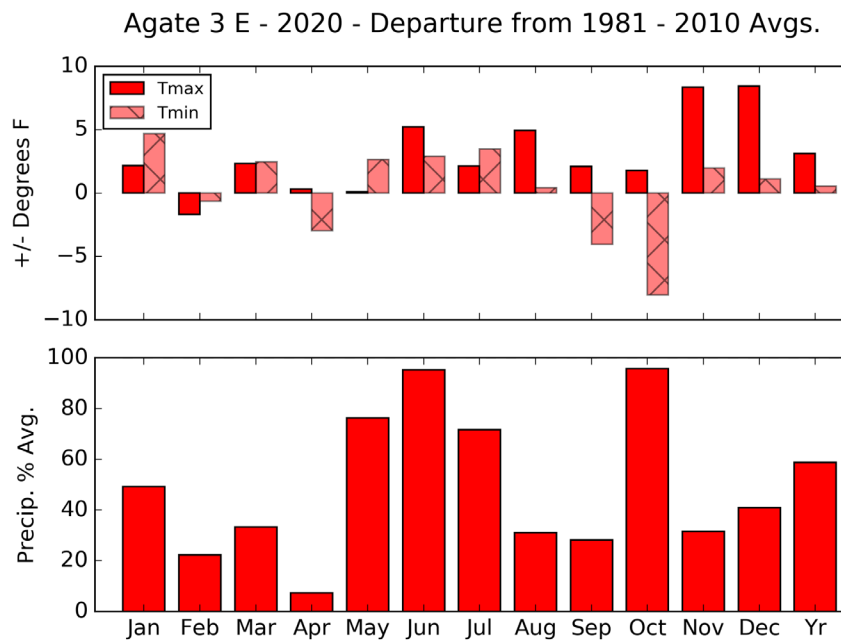
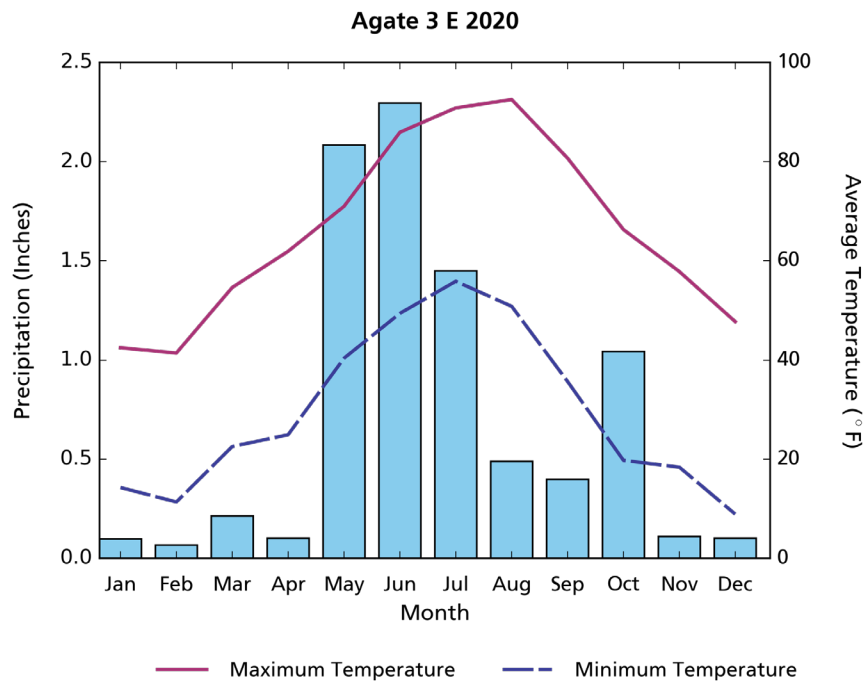


Figure 5. The top panel shows total monthly precipitation (light blue bars), average monthly minimum temperature (dashed blue line), and average monthly maximum temperature (solid red line) for the 2020 calendar year in Agate Fossil Beds National Monument. The bottom panel shows monthly departures from 1981–2010 average temperature and precipitation for the 2020 calendar year in Agate Fossil Beds National Monument. Climate data are from the Agate 3 E weather station (250030). The data were accessed and graphed using the web-based tool Climate Analyzer.

Flow is dictated by precipitation events but can also be affected by land use including ditching, irrigation withdrawals, regulation, and increased water demand by plants. Dibner 2020 states that a river's flow regime is unique and must be compared to itself over time while putting it in the broader regional context. If streamflow trends are consistent with regional trends, then broader environmental change may be at play. The flow record is disjointed at Agate, and regional gages are limited. USGS has a discharge record from 1957–1991 at Agate. Years later, the state of Nebraska took over the gage, recording streamflow from 2006 to present. Trend analysis on the Niobrara's River flow is outside the scope of this report.

During the ice-free season at AGFO, we collected over 20,000 water quality measurements in the Niobrara River (Table 3). We found mean water temperature of 14.66°C, dissolved oxygen concentrations of 8.12 mg/L, specific conductance of 398.45 $\mu\text{S}/\text{cm}$, and pH of 8.11 (Table 3). There was, however, variation across months in all parameters (Table 4).

Mean water temperatures for the summer months of June, July, and August were around 19–20°C (Table 4). The Nebraska water quality standard is 22°C (Table 1), temperatures above that temperature violate state standards. Water temperature at Agate was exceeded from May through August 2020, with the highest temperature occurring in July at 26.2°C (Table 4). Overall, 8.72% of the recorded temperatures in 2020 were above the state threshold for cold water fisheries (Table 3, Figure 6).

Dissolved oxygen displayed seasonal variation (Table 4, Figure 8), with higher concentrations typically recorded in colder months. Fortunately, the Niobrara River in 2020 did not show any dissolved oxygen problems, with no violations of state standards. Mean dissolved oxygen values for the year were 8.12 mg/L (Table 3) and between 6 and 8 mg/L during the summer months (Table 4, Figure 7). Mean dissolved oxygen concentrations remained above state threshold (5 mg/L) even during the summer months of June, July, and August.

Specific conductance of the Niobrara River stayed relatively constant between 367 and 471 $\mu\text{S}/\text{cm}$ with a yearly average of 398 $\mu\text{S}/\text{cm}$ (Table 3, Figure 9), well below the state standard of 2,000 $\mu\text{S}/\text{cm}$. Thus, exceedance rate of the standard was 0% (Table 3).

The pH of the Niobrara River remained within the state threshold of 6.5–9.0, with an annual mean of 8.11 (Table 3). There was some seasonal variability and pH was only slightly higher during the spring months. The pH was well under the state standard of 9.0, with no exceedances for the year (Figure 10, Table 4).

Table 3. Summary of descriptive statistics for water temperature, dissolved oxygen, specific conductance, and pH measured for the ice-free sampling period on the Niobrara River at Agate Fossil Beds National Monument from March 31 to November 4, 2020, at USGS Gaging Station 06454100. Percent exceedance is the proportion of samples that exceed the respective state regulatory threshold described in Table 1 (water temperature max. limit is 22.0°C; dissolved oxygen $\geq$ 5.0 mg/L; specific conductance $\leq$ 2,000 μ S/cm; and pH range is 6.5–9.0).

Descriptive Statistic	Water Temperature (°C)	Dissolved Oxygen (mg/L)	Specific Conductance (μ S/cm)	pH
Number of Measurements	21014	20892	20093	21040
Mean	14.66	8.12	398.45	8.11
Standard Deviation	5.94	1.42	14.92	0.11
Median	15.8	8.0	394	8.1
Minimum	.1	5.4	367	7.8
Maximum	26.2	11.6	471	8.4
Number of Points below or above standard	1832 (above)	0 (below)	0 (above)	0 (above/below)
% Exceedance	8.72%	0%	0%	0%

Table 4. Monthly summary of descriptive statistics and percent exceedances for core water quality parameters for the ice-free sampling period on the Niobrara River at Agate Fossil Beds National Monument from March 31 to November 3, 2020, at USGS Gaging Station 06454100. Percent exceedance is the proportion of samples that exceed the respective state regulatory threshold described in Table 1 (water temperature max. limit is 22.0°C; dissolved oxygen $\geq$ 5.0 mg/L; pH range is 6.5–9.0; and specific conductance thresholds and exceedances are not reported).

Dates	Descriptive Statistic	Water Temperature (°C)	Dissolved Oxygen (mg/L)	Specific Conductivity (μ S/cm)	pH
31-Mar-20	Number of measurements	52	54	53	54
	Mean	10.37	9.51	381.13	8.26
	Standard Deviation	1.08	0.5	1.65	0.05
	Median	10.55	9.6	380	8.3
	Minimum	7.6	8.5	379	8.2
	Maximum	11.6	10.1	384	8.3
	% Exceedance	0	0	0	0

Table 4 (continued). Monthly summary of descriptive statistics and percent exceedances for core water quality parameters for the ice-free sampling period on the Niobrara River at Agate Fossil Beds National Monument from March 31 to November 3, 2020, at USGS Gaging Station 06454100. Percent exceedance is the proportion of samples that exceed the respective state regulatory threshold described in Table 1 (water temperature max. limit is 22.0°C; dissolved oxygen $\geq$ 5.0 mg/L; pH range is 6.5–9.0; and specific conductance thresholds and exceedances are not reported).

Dates	Descriptive Statistic	Water Temperature (°C)	Dissolved Oxygen (mg/L)	Specific Conductivity (μ S/cm)	pH
Apr-20	Number of measurements	2880	2880	2880	2880
	Mean	8.97	9.29	389.75	8.25
	Standard Deviation	3.86	1.05	3.99	0.05
	Median	9.5	9.2	390	8.3
	Minimum	0.1	7.2	380	8.1
	Maximum	17.6	11.4	401	8.4
	% Exceedance	0	0	0	0
May-20	Number of measurements	2973	2973	2964	2973
	Mean	14.84	7.96	397.03	8.13
	Standard Deviation	3.58	1.02	7.1	0.11
	Median	14.9	7.9	397	8.1
	Minimum	6.1	5.9	379	7.9
	Maximum	23.2	10.6	423	8.4
	% Exceedance	1.41	0	0	0
Jun-20	Number of measurements	2878	2879	2795	2879
	Mean	19.35	6.92	396.32	8.04
	Standard Deviation	2.79	0.7	5.59	0.1
	Median	19.5	6.9	395	8
	Minimum	11.7	5.4	385	7.8
	Maximum	25.5	8.6	414	8.2
	% Exceedance	17.1	0	0	0

Table 4 (continued). Monthly summary of descriptive statistics and percent exceedances for core water quality parameters for the ice-free sampling period on the Niobrara River at Agate Fossil Beds National Monument from March 31 to November 3, 2020, at USGS Gaging Station 06454100. Percent exceedance is the proportion of samples that exceed the respective state regulatory threshold described in Table 1 (water temperature max. limit is 22.0°C; dissolved oxygen $\geq$ 5.0 mg/L; pH range is 6.5–9.0; and specific conductance thresholds and exceedances are not reported).

Dates	Descriptive Statistic	Water Temperature (°C)	Dissolved Oxygen (mg/L)	Specific Conductivity (μ S/cm)	pH
Jul-20	Number of measurements	2975	2976	2919	2975
	Mean	20.43	6.9	390.96	8.05
	Standard Deviation	2.41	0.83	5.63	0.11
	Median	20.4	6.7	391	8
	Minimum	14.2	5.5	379	7.8
	Maximum	26.2	8.9	419	8.3
	% Exceedance	27.53	0	0	0
Aug-20	Number of measurements	2951	2975	2177	2975
	Mean	19.42	7.19	384.49	8.05
	Standard Deviation	2.3	0.75	4.66	0.11
	Median	19.2	7	385	8
	Minimum	12.4	6	367	7.9
	Maximum	24.4	9.1	393	8.3
	% Exceedance	16.23	0	0	0
Sep-20	Number of measurements	2877	2727	2877	2876
	Mean	13.87	8.37	399.6	8.16
	Standard Deviation	3.06	0.74	8.75	0.07
	Median	14.2	8.4	401	8.2
	Minimum	6.7	6.3	382	8
	Maximum	20.2	10.2	417	8.3
	% Exceedance	0	0	0	0

Table 4 (continued). Monthly summary of descriptive statistics and percent exceedances for core water quality parameters for the ice-free sampling period on the Niobrara River at Agate Fossil Beds National Monument from March 31 to November 3, 2020, at USGS Gaging Station 06454100. Percent exceedance is the proportion of samples that exceed the respective state regulatory threshold described in Table 1 (water temperature max. limit is 22.0°C; dissolved oxygen $\geq$ 5.0 mg/L; pH range is 6.5–9.0; and specific conductance thresholds and exceedances are not reported).

Dates	Descriptive Statistic	Water Temperature (°C)	Dissolved Oxygen (mg/L)	Specific Conductivity (μ S/cm)	pH
Oct-20	Number of measurements	2972	2972	2972	2972
	Mean	7.23	9.82	422.88	8.11
	Standard Deviation	3.98	1.01	16.6	0.06
	Median	7.7	9.8	424	8.1
	Minimum	0.1	8	398	8
	Maximum	14	11.6	471	8.3
	% Exceedance	0	0	0	0
November 1–3, 2020	Number of measurements	456	456	456	456
	Mean	5.16	10.38	425.86	8.09
	Standard Deviation	1.04	0.35	10.78	0.03
	Median	5	10.3	421.5	8.1
	Minimum	3.2	9.7	411	8
	Maximum	7.4	11.1	441	8.1
	% Exceedance	0	0	0	0

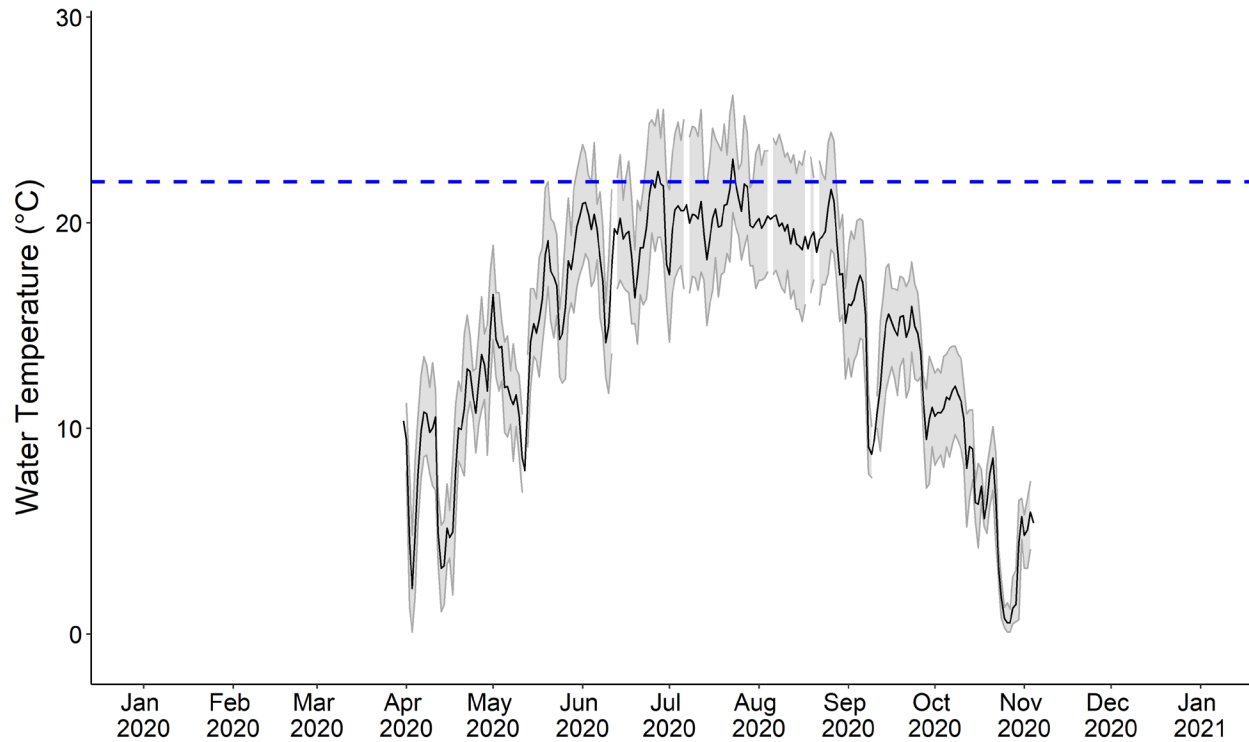


Figure 6. Daily mean water temperature (black line) collected on the Niobrara River at Agate Fossil Beds National Monument from March 31 to November 3, 2020, at USGS Gaging Station 06454100. The gray ribbon shows the daily maximum and minimum water temperature for the same period. The dashed blue line indicates one of the Nebraska 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.

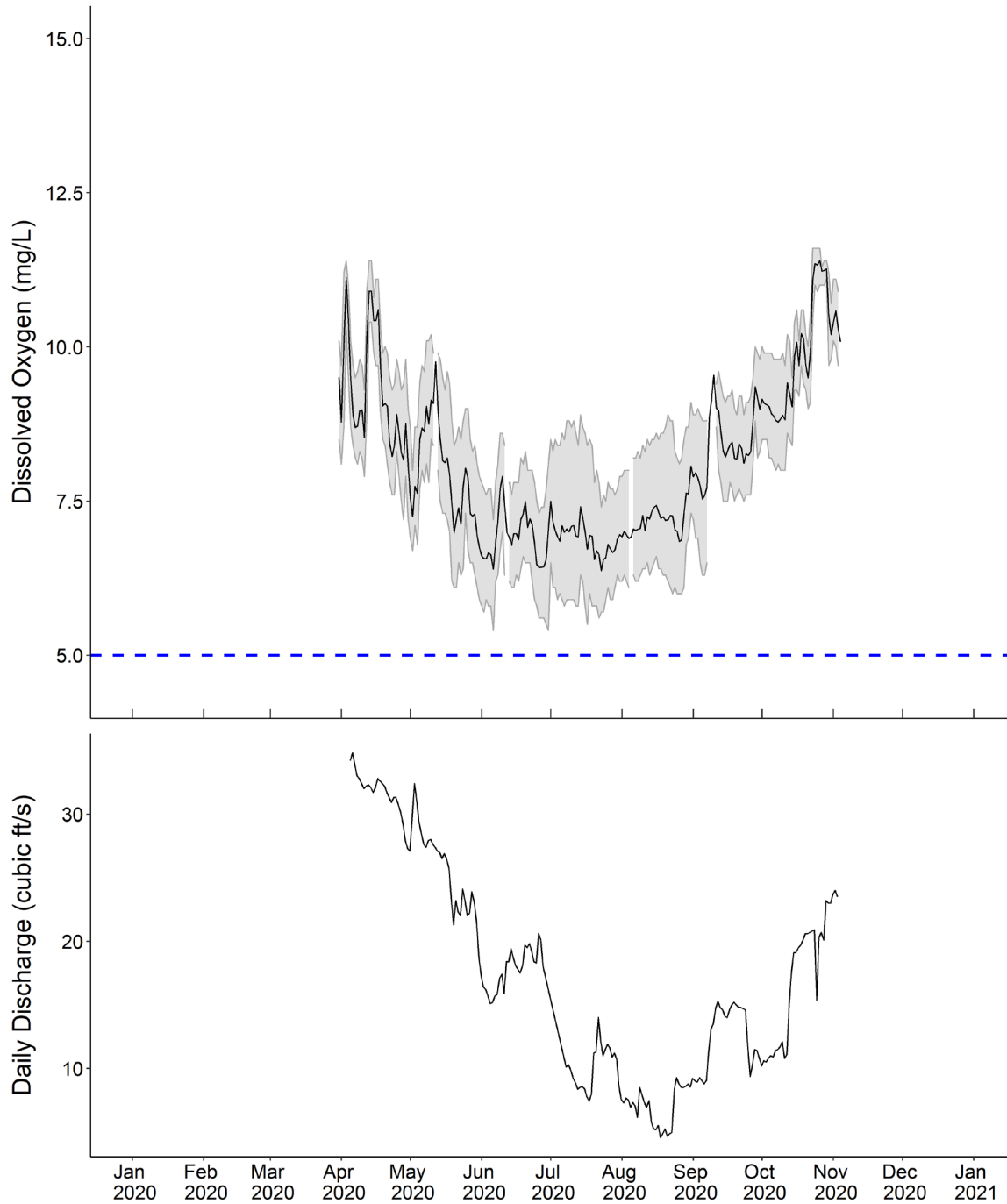


Figure 7. Daily mean dissolved oxygen concentrations (black line; top graph) and daily discharge (bottom) of the Niobrara River at Agate Fossil Beds National Monument from March 31 to November 3, 2020, at USGS Gaging Station 06454100. The gray ribbon shows the daily maximum and minimum dissolved oxygen for the same period. The dashed blue line indicates one of the Nebraska 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.

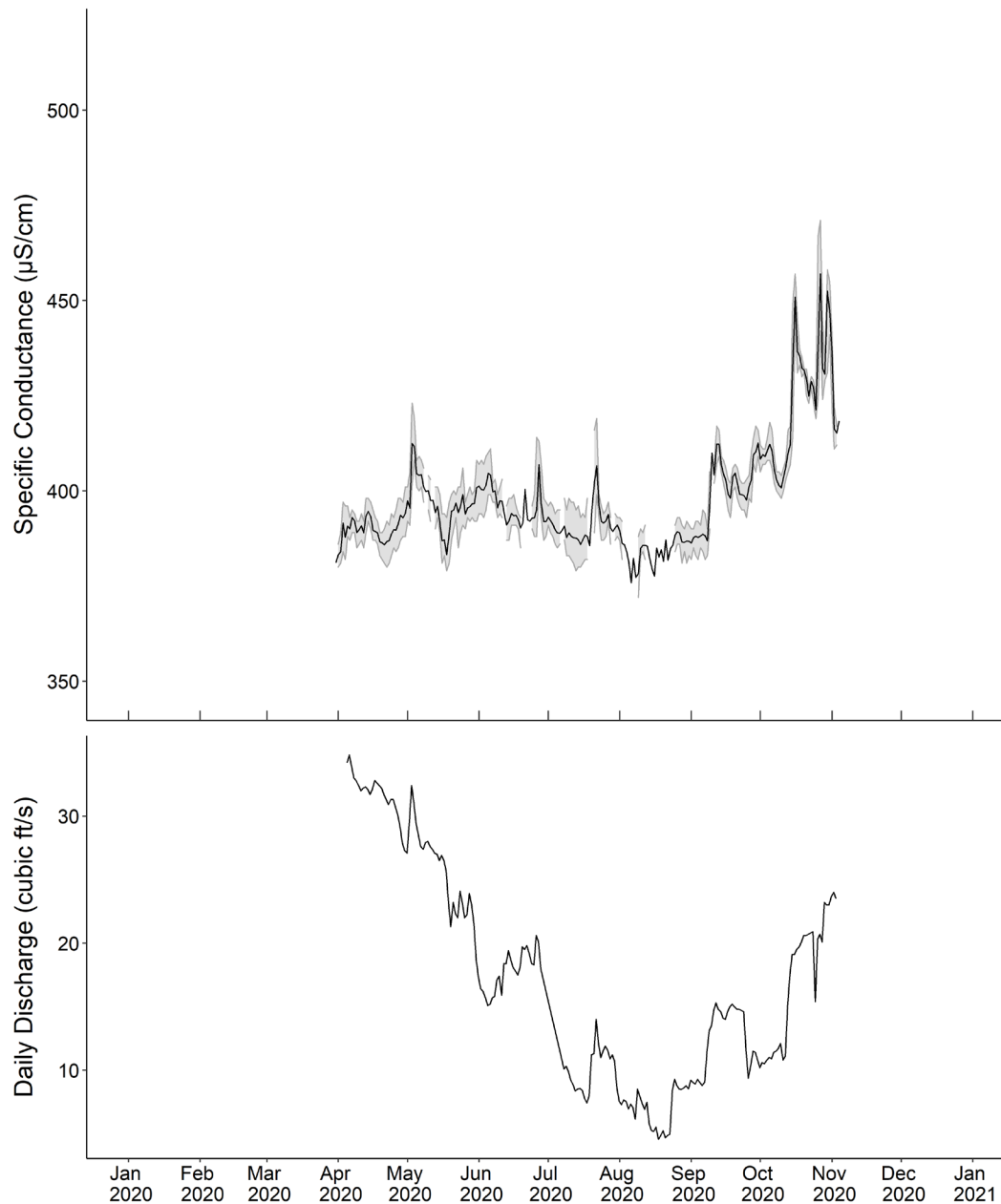


Figure 8. Daily mean specific conductance (top) and daily stage (bottom) of the Niobrara River at Agate Fossil Beds National Monument from March 31 to November 3, 2020, at USGS Gaging Station 06454100. The gray ribbon shows the daily maximum and minimum specific conductivity for the same period. The periods where the instrument did not collect data are indicated by gaps in the record.

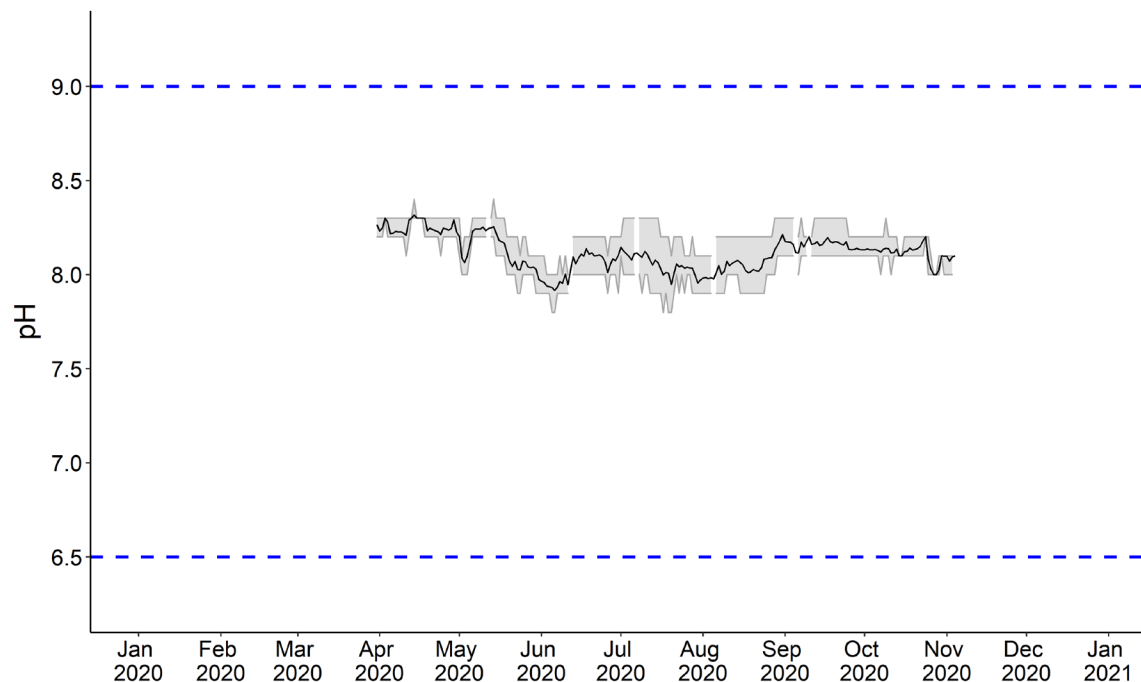


Figure 9. Daily mean pH (black line) of the Niobrara River at Agate Fossil Beds National Monument from March 31 to November 3, 2020, at USGS Gaging Station 06454100. The gray ribbon shows the daily maximum and minimum pH for the same period. The dashed blue lines indicate the Nebraska state water quality standards (see Table 1 for more details). The periods where the instrument did not collect data are indicated by gaps in the record.

Both dissolved oxygen and temperature are highly affected by climatic variables and directly influenced by streamflow (Dodds 2004). Low flow conditions can be highly stressful for organisms and may result in high stream temperatures. High primary production in warm stagnant conditions may lead to oxygen crashes as plants and algae respire and senesce. These conditions are common in prairie streams and excess plant growth may exacerbate conditions.

Despite relatively good data in 2020, the stretch of the Niobrara River running through Agate Fossil Beds NM was first listed by the state of Nebraska in 2016 as violating dissolved oxygen standards, impairing the aquatic life beneficial use. The 2014 report showed high levels of dissolved oxygen violation, up to 70% of samples in July 2014. The NE-WY border to Whistle Creek Segment is in EPA Category 5, meaning a TMDL will be required. Prairie streams are extremely precipitation-dependent and have high yearly and interannual variability in conditions (Dodds 2004). NGPN plans to continue monitoring this stretch of river and recommends the National Park Service work with the state of Nebraska to restore the beneficial uses of the river within the park.

Further Analysis

This Data Report is intended to provide a basic review of the data collected during the 2020 water quality monitoring season at Agate Fossil Beds National Monument. 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 06454100](#).

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Appendix A. USGS Water Data Quality and Station Reports for Niobrara River 06454100, 2020

06454100 NIOBRARA RIVER AT AGATE, NEBR.

LOCATION—Lat 42°25'25", long 103°47'32" referenced to North American Datum of 1983, in sec.06, T.28 N., R.55 W., Sioux County, NE, Hydrologic Unit 10150002, on the right bank, 19 miles southeast of Harrison, Nebraska.

[REVISIONS HISTORY](#)—Revisions: Daily discharge values for the period of April 11, 2014 to November 16, 2014 were removed on January 5, 2022, as these data were not quality assured and inadvertently approved.

SURFACE-WATER RECORDS

PERIOD OF RECORD—October 1958 to September 1991, February 18 to November 17, 2014 (discontinued).

GAGE—Water-stage recorder. Elevation of gage is 4,405 ft above sea level, from topographic map. U.S. Geological Survey data collection platform with satellite telemetry at station.

REMARKS—Records excellent.

EXTREMES FOR PERIOD OF RECORD—Maximum discharge, 181 ft³/s, June 23, 1959, gage height, 5.00 ft; maximum recorded gage height, 10.47 ft, March 7, 2014, discharge not determined.

WATER-QUALITY RECORDS

PERIOD OF DAILY RECORD—February 18, 2014 to November 17, 2014 (discontinued).

REMARKS—Specific conductance records are excellent except those for March 8–13, 18–30, and April 10–24, which are good; and March 31 to April 3, which are fair. pH records are excellent except those for July 6–15, which are good. Water temperature records are excellent. Water-temperature records represent water temperature at sensor within 0.2°C. Dissolved oxygen records are excellent except those for April 15–20, May 6–15, May 31 to June 6, July 9–15, July 31 to August 6, and October 12, 16–20, which are good; February 18, Mar. 8–13, April 21–24, which are fair; and February 19 to Mar. 7, which are poor. Maximum and minimum recorded values in the EXTREMES paragraphs may have occurred during days of partial record and may not appear in the daily values tables.

EXTREMES FOR PERIOD OF DAILY RECORD - SPECIFIC CONDUCTANCE: Maximum recorded, 512 uS/cm, August 29, November 14, 2014; minimum recorded, 149 uS/cm, March 8, 9, 2014. pH: Maximum recorded, 8.6 units, March 24, 2014; minimum recorded, 6.4 units, November 15, 16, 2014. WATER TEMPERATURE: Maximum recorded, 25.2°C, May 28, 2014; minimum recorded 0.0°C, March 7–10, 12, 2014. DISSOLVED OXYGEN: Maximum recorded, 13.0 mg/L, March 31, 2014; minimum recorded, 0.6 mg/L, March 2, 2014.

For this water year report and more information about specific water quality parameters, visit the archives found on the [USGS National Water Information System for site 06454100](#).

WATER QUALITY STATION ANALYSIS

06454100 NIOBRARA RIVER AT AGATE, NE

Dissolved Oxygen

Analysis Period: 03/31/2020 to 11/04/2020

Analysis:

Record: March 31 to Nov. 4, the DCP provided a complete and satisfactory record of Dissolved Oxygen. Backup DO data is provided by the DCP log. Sept. 8–10 the Optical-DO sensor malfunctioned, and data was deleted. Sept. 10 the DO sensor was replaced. On Nov. 4 instrumentation was removed.

Site characteristics: The site is located a straight reach of the channel, just above a culvert. The culvert acts as a controlling feature and contains most flows. The channel is well mixed both vertically and horizontally in the water column. The bed is composed of silt on the edges and grades into sand or gravel in the middle. It is fairly soft, however is stable. The sonde is most often fouled by fine silt that has been suspended in the flow. It can also be fouled by minor aquatic invertebrates and vegetation.

Instrumentation: Sutron Satlink HDR DCP, Sutron Acubar non-submersible pressure transducer, and YSI multi-parameter water-quality sensor are deployed to measure, log, and transmit the following data: stage, water temperature, specific conductance, pH, and dissolved oxygen (optical). The equipment is housed in a 36 CMP metal culvert at the right edge of the water. The pressure transducer orifice is attached near the staff on the gage house culvert. The sonde is encased in a 4 inch solid poly pipe that is 6 ft long, and located just downstream of the staff.

Sampling location: The sampling location has historically been located about 15–20 ft upstream of the staff. As stages rise above 4.30 ft., the best measuring section is located about 75 ft downstream of the gage. During this period of analysis, all sample cross sections were taken 75 downstream of the gage. The sonde pipe is located just downstream of the staff. It is well mixed and easy to access during all encountered stages during the period of analysis

Field Visits: During the period of analysis, the sonde was serviced on the following dates: March 31, May 12, June 12, July 7, Aug. 5, Sept. 10 and Nov. 4.

Deletions: During the period of analysis, erroneous values associated with servicing the sonde were deleted May 12, Aug. 5 and Sept. 10. Sept. 8–10 the Optical-DO sensor malfunctioned, and data was deleted.

Fouling Corrections: March 31 to Nov. 4, fouling corrections were minor, ranging from –4.47% (Nov. 4) to 1.33% (Aug. 5). Fouling corrections were applied in Set #1

May 12 a -3.47% (-0.36 mg/L) correction was indicated. This may have been due to fouling. However, the field meter was malfunctioning, and the corresponding fouling correction was considered unreliable. Therefore, the total correction was attributed to drift and not fouling.

May 12, after calibration, to Aug. 5 no fouling corrections were applied. June 12 a -2.28% (-0.19 mg/L) fouling correction was indicated. July 7 a 1.9% (0.1 mg/L), and Aug. 5 a 1.33% (0.1 mg/L) fouling corrections were indicated. These were all well within published criteria of correction and were not applied.

On Sept. 10 the DO sensor was found malfunctioning and reading 0.00. Data up to the start of the malfunction on Sept. 8 and 9, was assumed unaffected by fouling, and no correction was applied.

On Nov. 4 a -4.47% (-0.48 mg/L) fouling correction was indicated. This was applied as indicated and prorated between inspections on Sept. 10 and Nov. 4.

Calibration Drift Corrections: During the period of analysis drift corrections were minor, ranging from -3.47% (-0.36 mg/L) to 6.29% (0.44 mg).

March 31 to May 12: The sonde was installed and calibrated on March 31. As explained above, on May 12 a -3.47% (-0.36 mg/L) correction was indicated. This may have been due to fouling. However, the field meter was malfunctioning, and the corresponding fouling correction was considered unreliable. Therefore, the total correction was attributed to drift and not fouling.

May 12 to Aug. 5 no drift correction was applied. All indicated corrections during this period were well within published criteria of correction.

Sept. 10 the DO sensor was found malfunctioning. A new sensor was installed and calibrated during the inspection.

On Nov. 4 a 6.29% (0.44 mg/l) drift correction was applied as indicated. The drift correction was prorated between inspections on Sept. 10 and Nov. 4.

Other Corrections: No other corrections were applied during the period of analysis.

Cross-section surveys: Cross-sectional surveys were completed during each inspection. A cross-sectional survey was completed on: March 31, May 12, June 12, July 7, Aug. 5, Sept. 10 and Nov. 4. Most surveys indicated the flow was well mixed and the field meter was within reasonable limits during the period of analysis. On several visits the field meter do readings were higher than the sonde at the site. This could be attributed to different types of DO sensors on the meters, or the cross-section location. The sonde was not corrected to the field meter during the period of operation.

Vertical profiles: No vertical profiles were taken.

Remarks: DO record during the period of analysis is rated good.

Analysis for this period last updated 1/19/2021 2:49:05 PM by jswanson

Analyzed By: ejblajsz
Date: 01/04/2021
Approved By: jswanson
Date: 01/19/2021

06454100 NIOBRARA RIVER AT AGATE, NEBR.
Stage Only

Analysis Period: 09/10/2020 to 11/04/2020

Analysis:

Gage Height or Elevation Record: Sept. 10 to Nov. 4, the DCP provided a mostly complete and satisfactory record of stage. Equipment was removed after the inspection on Nov. 4, 2020.

Datum: Levels have not been run by USGS personnel at this gage location. The staff and datum are maintained by the Nebraska Department of Natural Resources.

Backup Data: Backup data were provided by the DCP's internal storage. No backup data were used during the period of analysis.

Ice Affected: No gage-height record was affected by ice during the period of analysis.

Edits: No other edits were made during the period of analysis.

Gage-Height Corrections: The DCP was referenced to a staff gage during the period of analysis. Corrections were minor and applied as indicated. On Sept. 10 and Nov., a -0.02 ft correction was applied as indicated.

Other Corrections: No other corrections were applied during the period of analysis.

Peak Stage: A peak stage of 3.91 ft was recorded on Oct. 29. This was not confirmed by a HWM, as no marks were evident. The peak stage for the 2020 Water Year was 4.39 ft, occurring March 31, 2020, the day the equipment was installed for the year. This peak is verified by staff gage readings during the site visit.

Estimates: No data was estimated.

Comments: Gage-height record for Sept. 10 to Nov. 4 is rated good.

Analysis for this period last updated 1/19/2021 1:36:27 PM by jswanson

Analyzed By: ejblajsz
Date: 01/04/2021
Approved By: jswanson
Date: 01/19/2021

06454100 NIOBRARA RIVER AT AGATE, NEBR.

pH Time Series

Analysis Period: 03/31/2020 to 11/04/2020

Analysis:

Record: March 31 to Nov. 4, the DCP provided a complete and satisfactory record of pH. An erroneous value, associated with servicing the sonde, was deleted May 12. Instrumentation was removed on Nov. 4 after the inspection.

Site characteristics: The site is located on a straight reach of the channel, just above a culvert. The culvert acts as a controlling feature and contains most flows. The channel is well mixed both vertically and horizontally in the water column. The bed is composed of silt on the edges and grades into sand or gravel in the middle. It is fairly soft, however is stable. The sonde is most often fouled by fine silt that has been suspended in the flow. It can also be fouled by minor aquatic invertebrates and vegetation.

Instrumentation: Sutron Satlink HDR DCP, Sutron Acubar non-submersible pressure transducer, and YSI multi-parameter water-quality sensor are deployed to measure, log, and transmit the following data: stage, water temperature, specific conductance, pH, and dissolved oxygen (optical). The equipment is housed in a 36 CMP metal culvert at the right edge of the water. The pressure transducer orifice line is attached to the gage house culvert near the staff gage. The sonde is encased in a 4 inch solid poly pipe that is 6 ft long and located just downstream of the staff.

Sampling location: The sampling location has historically been located about 15–20 ft upstream of the staff. During this period of analysis, all samples were collected 75 ft below the gage. The sonde pipe is located just downstream of the staff. It is well mixed and easy to access during all encountered stages during the period of analysis.

Field Visits: During the period of analysis, the sonde was serviced on the following dates: March 31, May 12, June 12, July 7, Aug. 5, Sept. 10 and Nov. 4.

Deletions: Erroneous values, associated with servicing the sonde, were deleted May 12 and Sept. 10. Amazingly, no other erroneous values required deletion during the period of analysis.

Fouling Corrections: March 31 to Nov. 4, fouling corrections to the pH record were minor, ranging from –0.33 to +0.02 units. Fouling was attributed to fine silt or minor aquatics during the period of analysis. Fouling corrections were applied in set #1.

May 12 and June 12, a –0.09- and –0.08-unit fouling correction were indicated respectively. Although they were within published criteria for correction, the fouling corrections were applied as indicated to maintain record continuity.

July 7 a +0.02-unit fouling correction was indicated. This was not applied as it was well within published criteria of correction.

Aug. 5 a -0.17-unit fouling correction was indicated and applied. This correction was prorated by time between inspections on July 7 and Aug. 5.

On Sept. 5 a distinct jump in pH record was noted. This was attributed to the onset of fouling. A -0.33-unit correction was calculated from the unit values after the jump. This was then prorated to a -0.26-unit correction, that was indicated by the unit values Sept. 10. On Sept. 10, a -0.16-unit correction was indicated from the inspection form. However, the sonde was considered slightly unstable and unit values were used to calculate the correction.

Nov. 4 a -0.04-unit fouling correction was indicated. While this was well within published criteria for criteria, it was applied to maintain record continuity.

Calibration Drift Corrections: The YSI calibration was checked during most visits, during the period of analysis. On May 12 and July 7 pH calibration was not checked, as the monitor was found reading within 0.1 units of the field meter after cleaning.

June 12 a -0.13-unit drift correction was applied as indicated. The sonde was considered slightly unstable and unit values were used to calculate the final correction value. This was prorated between inspections May 12 and June 12.

Aug. 5 a -0.07-unit drift correction was indicated. On Sept 10 a -0.01-unit correction was indicated. These were well within published criteria of correction and were not applied.

Nov. 4 a -0.07-unit correction was applied as indicated. Although this was well within published criteria of corrections, it was applied to maintain continuity of the record. This correction was prorated by time between inspections.

Other Corrections: No other corrections were applied

Cross-section surveys: Cross-sectional surveys were completed during each inspection. A cross-sectional survey was completed on: March 31, May 12, June 12, July 7, Aug. 5, Sept. 10 and Nov. 4. All surveys indicated the flow was well mixed and the field meter was within reasonable limits during the period of analysis.

Vertical profiles: No vertical profiles were taken.

Remarks: pH record during the period of analysis, March 31 to Nov. 4, is rated good.

Analysis for this period last updated 1/22/2021 12:54:49 PM by jswanson

Analyzed By: ejblajsz

Date: 01/04/2021

Approved By: jswanson

Date: 01/22/2021

06454100 NIOBRARA RIVER AT AGATE, NEBR.
Specific Conductance Time Series

Analysis Period: 09/10/2020 to 11/04/2020

Analysis:

Record: Sept. 10 to Nov. 4, the DCP provided a complete and satisfactory record of Specific Conductivity. Equipment was removed Nov. 4 for the season. Backup data were provided by the DCP's internal storage. Temporary periods of fouling or erroneous values associated with servicing the sonde were deleted as described below in the "Deletions" paragraph.

Site characteristics: The site is located a straight reach of the channel, just above a culvert. The culvert acts as a controlling feature and contains most flows. The channel is well mixed both vertically and horizontally in the water column. The bed is composed of silt on the edges and grades into sand or gravel in the middle. It is fairly soft, however is stable. The sonde is most often fouled by fine silt that has been suspended in the flow. It can also be fouled by minor aquatic invertebrates and vegetation.

Instrumentation: Sutron Satlink HDR DCP, Sutron Acubar non-submersible pressure transducer, and YSI multi-parameter water-quality sensor are deployed to measure, log, and transmit the following data: stage, water temperature, specific conductance, pH, and dissolved oxygen (optical). The equipment is housed in a 36 CMP metal culvert at the right edge of the water. The pressure transducer orifice is attached near the staff on the gage house culvert. The sonde is encased in a 4 inch solid poly pipe that is 6 ft long, and located just downstream of the staff.

Sampling location: The sampling location has historically been located about 15–20 ft upstream of the staff. As stages rise above 4.30 ft., the best measuring section is located about 75 ft downstream of the gage. During the period of analysis, all samples were collected 75 ft downstream of the gage. The sonde pipe is located just downstream of the staff. It is well mixed and easy to access during all encountered stages during the period of analysis.

Field Visits: During the period of analysis, the sonde was serviced on the Sept. 10 at Nov. 4.

Deletions: No erroneous values were deleted during the period of analysis.

Fouling Corrections: Indicated fouling corrections during the period of analysis were minor, ranging from –0.24 to –0.75%. Fouling was mainly attributed to aquatic invertebrates or silt. Both fouling corrections indicated during the period of analysis were well within published criteria of correction. Therefore, indicated corrections were not applied. Fouling corrections were applied in Set #1.

Calibration Drift Corrections: Drift corrections indicated during the period of analysis ranged from 2.65% (Sept. 10) to –0.20% (Nov. 4). Drift corrections were applied in "Set 2" of the USGS multipoint correction menu.

During the period of analysis, the sonde calibration was checked on Sept. 10 and Nov. 4.

September 10 a 2.65% drift correction was indicated. This was again within the published criteria of correction. However, to maintain continuity of record the correction was applied as indicated. The drift correction was prorated by time between inspections on Aug. 5 and Sept. 10.

Nov. 4 a -0.20% Drift correction was indicated. This was not applied as it was well within published criteria of correction.

Other Corrections: No other corrections were applied.

Cross-section surveys: Cross-sectional surveys were completed during both inspections, Sept. 10 and Nov. 4. Both surveys indicated the flow was well mixed and the field meter was within reasonable limits during the period of analysis.

Vertical profiles: No vertical profiles were taken during the period of analysis.

Remarks: Specific-conductivity record is rated good Sept. 10 to Nov. 4, 2020.

Analysis for this period last updated 1/19/2021 2:10:38 PM by jswanson

Analyzed By: ejblajsz

Date: 01/04/2021

Approved By: jswanson

Date: 01/19/2021

Analysis Period: 03/31/2020 to 09/10/2020

Analysis:

Record: March 31 to Sept. 10, the DCP provided a complete and satisfactory record of Specific Conductivity. Backup data were provided by the DCP's internal storage. Temporary periods of fouling or erroneous values associated with servicing the sonde were deleted as described below in the "Deletions" paragraph.

Site characteristics: The site is located a straight reach of the channel, just above a culvert. The culvert acts as a controlling feature and contains most flows. The channel is well mixed both vertically and horizontally in the water column. The bed is composed of silt on the edges and grades into sand or gravel in the middle. It is fairly soft, however is stable. The sonde is most often fouled by fine silt that has been suspended in the flow. It can also be fouled by minor aquatic invertebrates and vegetation.

Instrumentation: Sutron Satlink HDR DCP, Sutron Acubar non-submersible pressure transducer, and YSI multi-parameter water-quality sensor are deployed to measure, log, and transmit the following data: stage, water temperature, specific conductance, pH, and dissolved oxygen (optical). The equipment is housed in a 36 CMP metal culvert at the right edge of the water. The pressure transducer orifice is attached near the staff on the gage house culvert. The sonde is encased in a 4 inch solid poly pipe that is 6 ft long, and located just downstream of the staff.

Sampling location: The sampling location has historically been located about 15–20 ft upstream of the staff. As stages rise above 4.30 ft., the best measuring section is located about 75 ft downstream of the gage. During this period of analysis, all sample cross sections were taken 75 ft downstream of the gage. The sonde pipe is located just downstream of the staff. It is well mixed and easy to access during all encountered stages during the period of analysis.

Field Visits: During the period of analysis, the sonde was serviced on the following dates: March 31, May 12, June 12, July 7, Aug. 5 and Sept. 10.

Deletions: Erroneous data associated with servicing the sonde were deleted May 12 and Sept. 10. During the period of analysis, data was deleted due to temporary fouling, attributed to invertebrates or sediment, on the following days: May 9, June 20–23, July 19, 20, 29, Aug. 3–5, 7, 8, and Aug. 13–23.

Fouling Corrections: Indicated fouling corrections during the period of analysis were minor ranging from 5.33% to –2.26%. Fouling was mainly attributed to aquatic invertebrates or silt. Fouling corrections were applied in "Set 1" of the USGS multipoint correction menu.

May 12 a 5.33% fouling correction was indicated during servicing the sonde. No fouling event could be directly attributed to the onset of fouling. Therefore, the correction was prorated by time between the install March 31 and inspection May 12.

June 12 a -0.51% fouling correction and July 7 no fouling correction was indicated. During this period no fouling corrections were applied, as indicated corrections were well within published criteria of correction.

Aug. 5 a -2.26% fouling correction was indicated. While this correction was under the published criteria of 3% , the correction was applied as indicated to maintain continuity of record. No fouling event could be directly attributed to the onset of fouling and the correction was prorated by time, between inspections.

Sept. 10 a -0.75% fouling correction was indicated. No fouling corrections were applied, as the correction indicated was well within published criteria of correction.

Calibration Drift Corrections: Drift corrections indicated during the period of analysis ranged from -0.29% to 2.65% . Drift corrections were applied in “Set 2” of the USGS multipoint correction menu.

The sonde calibration was checked on March 31, June 12, Aug. 5 and Sept. 10. During two visits, May 12 and July 7, the sonde was found reading well within 3% of the field meter, and no calibration check was completed.

June 12, and Aug. 5 indicated drift corrections were minimal, -0.29 and 1.13% respectively. Indicated-drift corrections were well within published criteria of drift correction, and no correction was applied.

September 10 a 2.65% drift correction was indicated. This was again within the published criteria of correction. However, to maintain continuity of record the correction was applied as indicated. The drift correction was prorated by time between inspections on Aug. 5 and Sept. 10.

Other Corrections: No other corrections were applied.

Cross-section surveys: Cross-sectional surveys were completed during each inspection. A cross-sectional survey was completed on the following days: March 31, May 12, June 12, July 7, Aug. 5 and Sept. 10. All surveys indicated the flow was well mixed and the field meter was within reasonable limits during the period of analysis.

Vertical profiles: No vertical profiles were taken during the period of analysis.

Remarks: Specific-conductivity record is rated good, except for those Aug. 1 3–24 which are rated poor due to temporary fouling.

Analysis for this period last updated 1/19/2021 1:59:34 PM by jswanson

Analyzed By: ejblajsz

Date: 09/30/2020

Approved By: jswanson

Date: 01/19/2021

06454100 NIOBRARA RIVER AT AGATE, NEBR.

Water Temperature Time Series

Analysis Period: 09/10/2020 to 11/04/2020

Analysis:

Record: Sept. 10 to Nov. 4, the DCP provided a complete and satisfactory record of water temperature. An erroneous value, associated with servicing the sonde, was deleted Sept. 10. Instrumentation was removed on Nov. 4 after the inspection.

Site characteristics: The site is located on a straight reach of the channel, just above a culvert. The culvert acts as a controlling feature and contains most flows. The channel is well mixed both vertically and horizontally in the water column. The bed is composed of silt on the edges and grades into sand or gravel in the middle. It is fairly soft, however is stable. The sonde is most often fouled by fine silt that has been suspended in the flow. It can also be fouled by minor aquatic invertebrates and vegetation.

Instrumentation: Sutron Satlink HDR DCP, Sutron Acubar non-submersible pressure transducer, and YSI multi-parameter water-quality sensor are deployed to measure, log, and transmit the following data: stage, water temperature, specific conductance, pH, and dissolved oxygen (optical). The equipment is housed in a 36 CMP metal culvert at the right edge of the water. The pressure transducer orifice line is attached to the gage house culvert near the staff gage. The sonde is encased in a 4-inch solid poly pipe that is 6 ft long and located just downstream of the staff.

Sampling location: The sampling location has historically been located about 15–20 ft upstream of the staff. During this period of analysis, all samples were collected 75 ft below the gage. The sonde pipe is located just downstream of the staff. It is well mixed and easy to access during all encountered stages during the period of analysis.

Field Visits: During the period of analysis, the sonde was serviced on Sept. 10 and Nov. 4.

Deletions: An erroneous value, associated with servicing the sonde, was deleted Sept. 10. Aug. 18 and 21 erroneous values, most likely attributed to temporary fouling, were deleted.

Fouling Corrections: No fouling corrections were applied during the period of analysis. During all inspections, indicated fouling corrections were well within published criteria of correction and no corrections were applied.

Calibration Drift Corrections: The YSI 6920 was checked against a NIST traceable thermometer on Dec. 3, 2019. A five-point temperature check indicated the YSI 6920 temperature sensor was reading accurately and no drift correction for temperature is warranted.

Other Corrections: No other corrections were applied

Cross-section surveys: Cross-sectional surveys were completed during each inspection. A cross-sectional survey was completed on Sept. 10 and Nov. 4. All surveys indicated the flow was well mixed and the field meter was within reasonable limits during the period of analysis.

Vertical profiles: No vertical profiles were taken.

Remarks: Water-temperature record during the period of analysis, Sept. 10 to Nov. 4, is rated excellent.

Analysis for this period last updated 1/4/2021 1:15:25 PM by ejblajsz

Analyzed By: ejblajsz

Date: 01/04/2021

Approved By: jswanson

Date: 01/19/2021

Water Temperature

Analysis Period: 03/31/2020 to 09/10/2020

Analysis:

Record: March 31 to Sept. 10, the DCP provided a complete and satisfactory record of water temperature. An erroneous value, associated with servicing the sonde, was deleted Sept. 10. Aug. 18 and 21 erroneous values, most likely attributed to temporary fouling, were deleted.

Site characteristics: The site is located on a straight reach of the channel, just above a culvert. The culvert acts as a controlling feature and contains most flows. The channel is well mixed both vertically and horizontally in the water column. The bed is composed of silt on the edges and grades into sand or gravel in the middle. It is fairly soft, however is stable. The sonde is most often fouled by fine silt that has been suspended in the flow. It can also be fouled by minor aquatic invertebrates and vegetation.

Instrumentation: Sutron Satlink HDR DCP, Sutron Acubar non-submersible pressure transducer, and YSI multi-parameter water-quality sensor are deployed to measure, log, and transmit the following data: stage, water temperature, specific conductance, pH, and dissolved oxygen (optical). The equipment is housed in a 36 CMP metal culvert at the right edge of the water. The pressure transducer orifice line is attached to the gage house culvert near the staff gage. The sonde is encased in a 4-inch solid poly pipe that is 6 ft long and located just downstream of the staff.

Sampling location: The sampling location has historically been located about 15–20 ft upstream of the staff. During this period of analysis, all samples were collected 75 ft below the gage. The sonde pipe is located just downstream of the staff. It is well mixed and easy to access during all encountered stages during the period of analysis.

Field Visits: During the period of analysis, the sonde was serviced on the following dates: March 31, May 12, June 12, July 7, Aug. 5 and Sept. 10.

Deletions: An erroneous value, associated with servicing the sonde, was deleted Sept. 10. Aug. 18 and 21 erroneous values, most likely attributed to temporary fouling, were deleted.

Fouling Corrections: No fouling corrections were applied during the period of analysis. During all inspections, indicated fouling corrections were well within published criteria of correction and no corrections were applied.

Calibration Drift Corrections: The YSI 6920 was checked against a NIST traceable thermometer on Dec. 3, 2019. A five-point temperature check indicated the YSI 6920 temperature sensor was reading accurately and no drift correction for temperature is warranted.

Other Corrections: No other corrections were applied

Cross-section surveys: Cross-sectional surveys were completed during each inspection. A cross-sectional survey was completed on the following days: March 31, May 12, June 12, July 7, Aug. 5

and Sept. 10. All surveys indicated the flow was well mixed and the field meter was within reasonable limits during the period of analysis.

Vertical profiles: No vertical profiles were taken.

Remarks: Water-temperature record during the period of analysis, March 31 to Sept. 10, is rated excellent.

Analysis for this period last updated 1/4/2021 9:07:03 AM by jswanson

Analyzed By: ejblajsz

Date: 09/29/2020

Approved By: jswanson

Date: 01/04/2021

Appendix B. Nebraska Station Report for Niobrara River 06454100, 2020.

Niobrara River at Agate, Nebraska 06454100

LOCATION: Latitude and Longitude 42.42353, -103.7925

Road Log Located on right bank 10 feet upstream from 54-inch metal culvert under a farm access road. 300 feet upstream from bridge on State Highway 29, 0.2 mile northwest of post office at Agate, and 14.5 mile upstream from Whistle Creek.

Equipment Details Recording Gage SUTRON CBS bubbler gage with a Sutron Satlink DCP radio along with support equipment was installed on March 10, 2016. This gage provides one hour satellite transmissions with 15 minute data each hour. External Gage Base gage is enameled staff gage set to datum.

Bench Mark and Reference Marks R.M. No. 1, 2, 4, 5, and 6 have been Destroyed.

R.M. No.3 Standard bronze tablet in concrete post 14 feet west of shelter post. Elevation of 8.01 feet from levels and read 8.00 feet dated 06/21/2019 used as origin.

R.M. No. 7 Nebraska Department of Roads standard bronze tablet on left upstream wing wall of the highway bridge.

Elevation of 11.63 feet by levels dated 06/21/2019.

Staff Gage by levels dated 06/21/2019 held at 4.25 feet and reads 4.37 feet

Hydrology Drainage Area 840 square mile, approximately.

Channel and Control Low to high water control is approach to opening of the 54-inch CMP culvert and is stable. Minor shifts can be expected due to debris lodging near opening.

Practically all discharge measurements can be made by wading in the vicinity of the gage. In the event wading stages are exceeded measurements can be made from the State highway 29 bridge from downstream of gage.

Extremes for Period of Record 195 7–89 Maximum discharge 181 cubic feet per second June 23, 1959 (gage height, 5.00 feet from flood mark)

minimum daily 1.0 cubic feet per second March 29, 1975.

Point of Zero Flow Point of Zero Flow collected was 2.62 ft. on August 24, 2018.

Winter Flow Very little backwater from ice conditions. Extreme stage variation may be experienced from snow blowing into channel above gage and choking off flow.

Regulation and Diversions Diversions for irrigation of approximately 6,700 acres above station.

Accuracy Published records are rated good.

Cooperation Station maintained in cooperation with U.S. National Park Service.

Field work and data assembly are done by Nebraska Department of Natural Resources.

Establishment and History Established Dec. 12, 1957 by G. G. Jamison (USGS) and S.M. Christensen (Nebraska Dept. of Water Resources). Recording gage installed November 3, 1960 by J.G. Lathrop, M.D. Stevens (Nebraska Dept. of Water Resources) and L.L Hull (USGS).

Station discontinued and closed out with levels dated March 22, 1993.

Measurements were made quarterly. Station discontinued till September 29, 2004 at this time a cubical shelter mounted to a pipe pedestal was installed.

Present site location is 10 feet upstream and 5 feet south of USGS CMP station. An Isco 4230 bubble flow meter is used as recorder connected to stream with orifice line and sand point. On March 10, 2016 the ISCO 4230 bubbler was removed. SUTRON CBS bubbler gage with a Sutron Satlink DCP radio along with support equipment was installed on March 10, 2016. This gage provides one hour satellite transmissions with 15 minute data each hour. Base gage is enameled staff gage set to datum.

Revision History Original description prepared by: G.G.Jamison 12/16/1957 Revised by: L.L Hull 11/16/1960 Revised by: E.K. Steele 08/24/77 Revised by: J.W.Vassos 01/09/1991 Revised by: A. S. Leisy 08/01/2011 Revised by: J.A. Marburger 01/25/2017 Revised by: T. Stephens 10/24/2019

Manuscript 2020

NIOBRARA RIVER at Agate, NE. 06454100

LOCATION: 42.42353, -103.7925 Sioux County,

Hydrologic unit 10150002, on right bank 10 feet upstream from 54-inch metal culvert under a farm access road. 300 feet upstream from bridge on State Highway 29, 0.2 mile northwest of post office at Agate, NE, and 14.5 mile upstream from Whistle Creek.

DRAINAGE AREA: Approximately 840 square miles.

GAGE: Continuous stage recorder. Gage datum 4405.00 feet above sea level.

PERIOD OF RECORD: Established December 12, 1957. Recording gage November 3, 1960 to March 22, 1993, restarted September 29, 2004 to present.

REMARKS: Published by the USGS 10/01/1957 to 09/30/1991. Published by Department of Natural Resources 10/1/1991 to 12/31/1992. Records for 09/29/2004 to 09/30/2015 are available by request. Water Year 2016 to present published by Department of Natural Resources. Records are good, except estimated records are poor.

EXTREMES FOR PERIOD OF RECORD: not determined at this time.

EXTREMES FOR CURRENT YEAR: Peak discharge 37.3 cubic feet per second March 11, gage height 4.76 feet; minimum daily discharge 3.22 cubic feet per second August 18

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.

NPS 165/184006, August 2022

National Park Service
U.S. Department of the Interior



[Natural Resource Stewardship and Science](#)

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