



Water Quality Monitoring for Theodore Roosevelt National Park

2019 Data Report

Natural Resource Data Series NPS/THRO/NRDS—2022/1375



**ON THIS PAGE**

Photograph of USGS Dakota Water Science Center water quality sonde location in the Little Missouri River near Medora, ND.
Photograph by USGS, station 06336000.

ON THE COVER

Photograph of Little Missouri River near Medora, ND, at Theodore Roosevelt National Park, July 2019.
Photograph by USGS, station 06336000.

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2019 Data Report

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Contents

	Page
Figures.....	iv
Tables.....	v
Abstract.....	vi
Introduction.....	1
Methods.....	5
Data Collection.....	5
Results.....	8
Further Analysis.....	18
Literature Cited.....	19
Appendix A.....	21
Appendix B.....	23

Figures

	Page
Figure 1. Map of Theodore Roosevelt National Park and the Little Missouri River in North Dakota.....	1
Figure 2. Map of Theodore Roosevelt National Park and water quality monitoring location (blue triangle) and nearby weather station (red flags).	3
Figure 3. A sonde device is used to measure water quality in the Little Missouri River at Theodore Roosevelt National Park and it is installed within a pipe for protection (left panel).....	5
Figure 4. Little Missouri River at USGS gaging station 06336000 March 26, 2019, just one day after peak recorded flow of 27,600 cfs.	8
Figure 5. Daily mean discharge on the Little Missouri River at Theodore Roosevelt National Park at USGS Gaging Station 06336000.	9
Figure 6. The top panel shows the total monthly precipitation (blue bars), average monthly minimum air temperature (dashed blue line) and average monthly maximum air temperature (solid red line) for the 2019 calendar year in Theodore Roosevelt National Park.	10
Figure 7. Daily mean water temperature (black line) collected on the Little Missouri River at Theodore Roosevelt National Park from April 17 to October 26, 2019, at USGS Gaging Station 06336000.	14
Figure 8. Daily mean dissolved oxygen concentrations (top) and daily discharge (bottom) of the Little Missouri River at Theodore Roosevelt National Park from April 17 to October 26, 2019, at USGS Gaging Station 06336000.....	15
Figure 9. Daily mean specific conductance (top) and daily discharge (bottom) of the Little Missouri River at Theodore Roosevelt National Park from April 17 to October 26, 2019, at USGS Gaging Station 06336000.	16
Figure 10. Daily mean pH (black line) of the Little Missouri River at Theodore Roosevelt National Park from April 17 to October 26, 2019, at USGS Gaging Station 06336000.....	17

Tables

	Page
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 2021).....	4
Table 2. Field journal for 2019 Water Quality Sampling at Theodore Roosevelt National Park.	7
Table 3. Summary of descriptive statistics for water temperature, dissolved oxygen, specific conductance, and pH measured for the ice-free sampling period on the Little Missouri River at Theodore Roosevelt National Park from April 17 to October 26, 2019, at USGS Gaging Station 06336000.	11
Table 4. Monthly summary of descriptive statistics and percent exceedances for core water quality parameters for the ice-free sampling period at Little Missouri River at Theodore Roosevelt National Park from April 17 to October 26, 2019, at USGS Gaging Station 06336000.	12
Table A-1. Recent ND Department of Environmental Quality (NDDEQ) <i>E. coli</i> counts from Water Quality Portal.	21
Table B-1. Fouling Corrections.....	25
Table B-2. Calibration Drift Corrections.	25
Table B-3. Calibration Drift Corrections.	26
Table B-4. Other Corrections: 4-11-19.	26
Table B-5. Other Corrections: 11-18-19.	26

Abstract

The Northern Great Plains Inventory and Monitoring Network (NGPN) began monitoring water quality in the Theodore Roosevelt National Park (THRO) in 2013, with the assistance of the U.S. Geological Survey (USGS). This report summarizes the data collected during the 2019 ice-free season (April 17 through November 4) for streamflow, water temperature, dissolved oxygen, specific conductance, and pH. This was the third season of continuous water quality monitoring.

Compared to earlier sampling periods in 2013 and 2016, 2019 was much wetter. Discharge on the Little Missouri River peaked at 27,600 cubic feet per second (cfs) prior to the ice-free season, and later peaked at 9,410 cfs during the ice-free season in May. For context, the highest flows in 2013 and 2016 were 8,400 and 1,650 cfs, respectively. 2019 had the highest recorded streamflow since 2011, which had a peak streamflow of 35,100 cfs. The 2019 peak was well under the highest peak ever recorded: 65,000 cfs in 1947. 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 entire ice-free season (Table 3) and for each month (Table 4). Notably, all measurements met the North Dakota water quality standards, with no exceedances during the ice-free season for the monitored parameters. *E. coli* bacteria, which is not monitored by NGPN, continues to be an issue for the north unit of THRO, as well as a small portion of the south unit south of Andrews Creek near the I-94 bridge.

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, [LITTLE MISSOURI RIVER AT MEDORA, ND - USGS Water Data for the Nation](#).

Introduction

Located in southwestern North Dakota, Theodore Roosevelt National Park (THRO) encompasses 70,477 acres of the Little Missouri Badlands. THRO is composed of three discrete management units, each of which is a patchwork of mixed-grass prairie, clay buttes, bottomland forest, and open shrublands. The three park units (North, Elkhorn Ranch, and South) are connected by the Little Missouri River, an undammed tributary of the Missouri River with headwaters located in northeastern Wyoming, making it the major hydrologic feature for THRO. The Little Missouri flows for approximately 560 miles from south to north through parts of Wyoming, Montana, South Dakota, and the badlands of North Dakota and is the only designated state scenic river in North Dakota. The river is listed as a fundamental resource of THRO and is an integral part of the landscape that inspired Theodore Roosevelt (NPS 2014). Approximately 28 miles run through the park (Figure 1). The 269 miles of intermittent streams within the park provide substantial flow to the Little Missouri River during spring snowmelt and summer rainfall events (Gitzen et al. 2010).

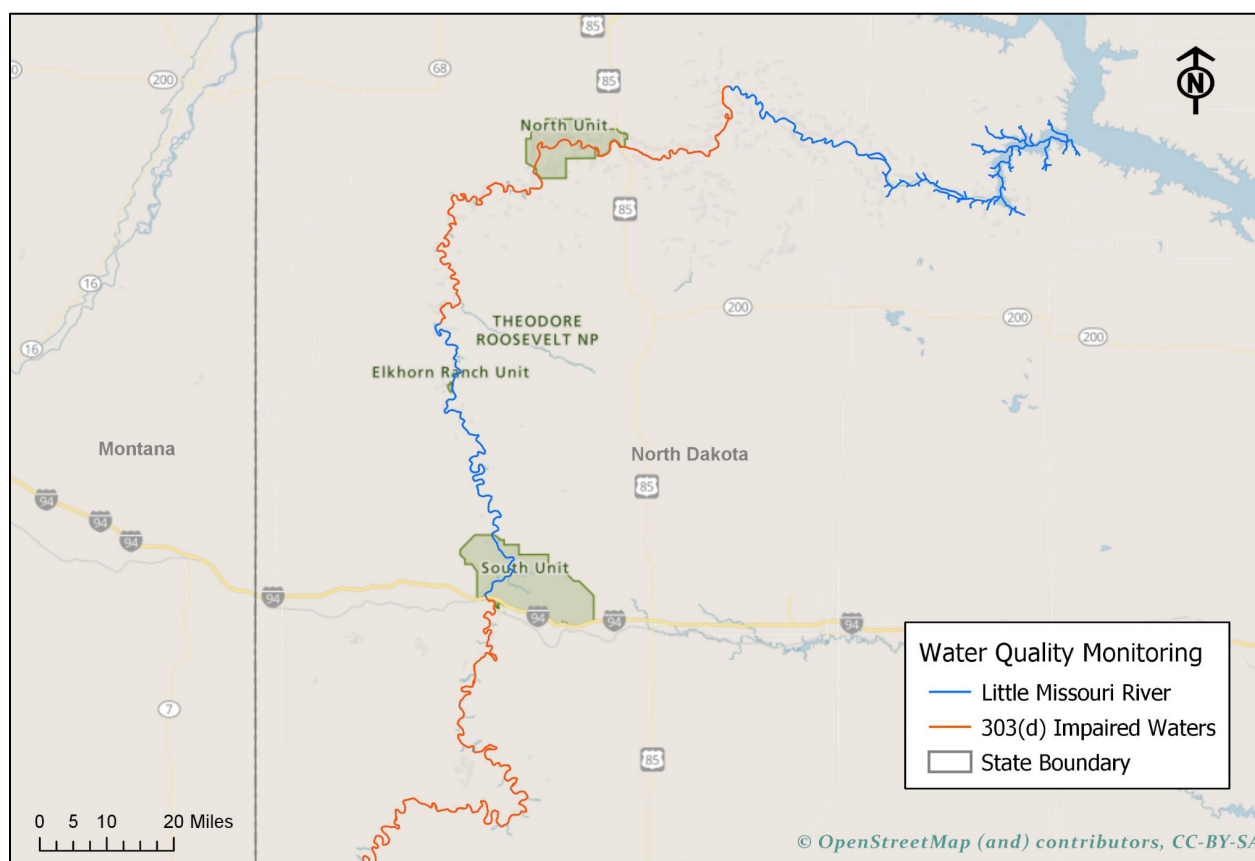


Figure 1. Map of Theodore Roosevelt National Park and the Little Missouri River in North Dakota. The stretch of the river running through the North Unit, is listed as impaired under 303(d) criteria (indicated in red) for *Escherichia coli*. [How's My Waterway - Community \(epa.gov\)](https://www.epa.gov/303d)

The Little Missouri River is designated as a Class II water in North Dakota. Class II waters are similar to Class I waters 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”. Class II waters may require additional treatment to meet drinking water requirements (NDDEQ 2021). The stretch of the Little Missouri that runs through the North Unit (ND-10110205-001-S_00) is listed as an impaired waterway under section 303(d) of the Clean Water Act for exceedances of *Escherichia coli* (ND Department of Health 2019). A small part of the Little Missouri River within the THRO South Unit boundary (Figure 1) is also listed as impaired for *E. coli* (ND-10110203-025-S_00 which is south of Andrews Creek near the I-94 bridge). No regular bacteria sampling occurs within the major south unit reach and it is likely the high *E. coli* counts found in ND-10110203-025-S_00 continue into the unassessed reach ND-10110203-057-S_00 which is the major reach in the South Unit of THRO.

The source of the *E. coli* and fecal coliform is unknown in the North Unit reach, but livestock feeding operations, agriculture, and failing septic systems are likely contributors to bacteria impairments in North Dakota (ND Department of Health 2019). The South Unit reach ND-10110203-025-S_00 has a total maximum daily load report (TMDL) in place (NDDEQ 2022). Significant sources of *E. coli* in that reach include largely nonpoint sources: unpermitted animal feeding operations and riparian grazing. Smaller point sources of bacteria including City of Medora and The Burning Hills Amphitheater WWTPs. For more details and current impairment information visit the [North Dakota Department of Environmental Quality website](#). Best management practices (BMPs) to reduce *E. coli* in ND-10110203-025-S_00 include livestock exclusion from riparian areas, water well and tank development, and prescribed grazing. Bacteria counts collected by NDDEQ are available from [Water Quality Data Home](#) and the past ten years of data are listed in Appendix A.

The Northern Great Plains Inventory & Monitoring Network (NGPN) began monitoring water quality at THRO in 2013 to better understand current conditions and changes over time in the Little Missouri River (Rockwood and Ashton 2020a and 2020b). The monitoring is conducted at the gaging station at Medora, ND (Monitoring Location 06336000, 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 THRO every three years, with the first cycle having been completed in 2013 (Wilson et al. 2014). NGPN will conduct an in-depth analysis of the status and trends of the Little Missouri River after three to five cycles of sampling.

NGPN’s core water quality parameters include streamflow, dissolved oxygen (DO), 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 [LITTLE MISSOURI RIVER AT MEDORA, ND - USGS Water Data for the Nation](#).

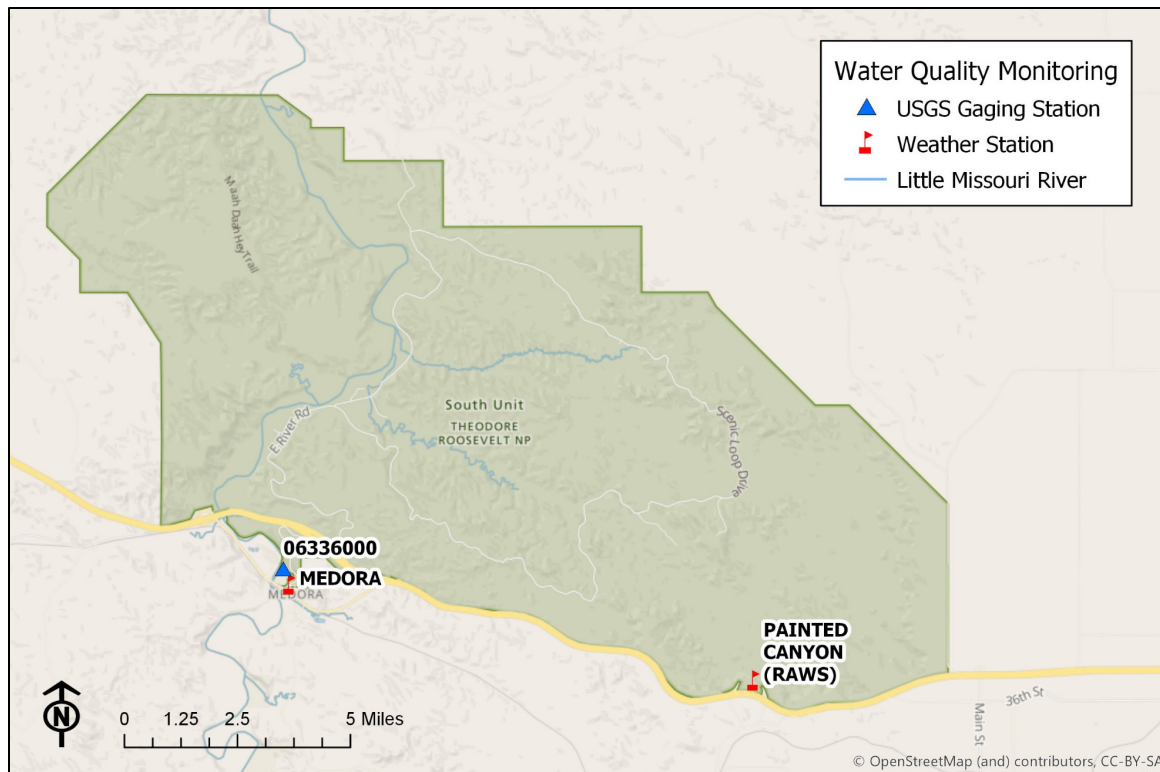


Figure 2. Map of Theodore Roosevelt National Park and water quality monitoring location (blue triangle) and nearby weather station (red flags). Climate data in this report is taken from the Painted Canyon RAWS weather station.

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 2021).

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 Fahrenheit (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 06336000) in Medora, ND at around 2,248 ft elevation. Water quality and streamflow are measured every 15 minutes throughout the ice-free season. Monitoring at THRO was conducted in 2013, 2016, and 2019; and will continue to be repeated every three years. Program funding currently limits monitoring efforts to a cycle of one year of monitoring, followed by two years without monitoring.

In 2019, NGPN continued to partner with the USGS North Dakota Water Science Center to have USGS staff collect water quality and streamflow data at THRO. The USGS deployed a continuous, multi-parameter sonde at the Little Missouri River Gaging Station (06336000) near Medora, ND, on April 17, 2019, (Figure 3) and visited the gaging station every three to four weeks for equipment maintenance (Table 2). The sonde instrument recorded dissolved oxygen (DO), pH, specific conductivity, and water temperature every 15 minutes, while the gage simultaneously measured stream stage (gage height; measured in feet) and discharge, a measure of streamflow.



Figure 3. A sonde device is used to measure water quality in the Little Missouri River at Theodore Roosevelt National Park and it is installed within a pipe for protection (left panel). The United States Geological Survey Little Missouri gaging station (06336000) is set up for real-time data transmission via satellite (right panel). Photographs courtesy of USGS, station 06336000.

Satellite telemetry transmitted the water data to the Water Science Center in near real-time (<https://waterdata.usgs.gov/monitoring-location/06336000/>). 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 to minimize the loss of data.

During each site visit, USGS staff conducted a site inspection and a side-by-side comparison between 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; this data is critical to the correction and grading of the final data. On November 4, 2019, the USGS removed the multi-parameter sonde from the Little Missouri River.

Quality assurance and quality control were conducted by USGS staff following established USGS guidelines (Wagner et al. 2006). NGPN received the final corrected (approved) data in January 2021 from the USGS, and used AQUARIUS Workstation by Aquatic Informatics (<http://aquaticinformatics.com/>) and R (R Core Team 2022) 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 data values were missing due to instrument error, the means were generated by excluding the missing values; the daily maximum and minimum were left blank for these days. 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 North Dakota environmental regulatory thresholds (Table 1).

Climate data were downloaded from the Painted Canyon RAWS climate station. The data were accessed and graphed using the web-based tool, [Climate Analyzer](#).

Table 2. Field journal for 2019 Water Quality Sampling at Theodore Roosevelt National Park.

Date	Notes
April 17, 2019	Installed YSI 6920 WQ monitor on right bank upstream, ~ 10 AM. Orifice was buried on arrival—pulled and reinstalled fence post. Reset bubbler. Parameters good.
May 7, 2019	Routine service of WQ monitor. DO drift correction applied. Gage is good.
June 18, 2019	DO drift correction after 5/7 visit. Serviced monitor—recalibrated DO and pH. Gage good, replaced N2 tank.
July 24, 2019	Serviced monitor, gage good, purged orifice lines, cross section collected from bridge.
August 20, 2019	Orifice cut on arrival—fixed and reset HG. Monitor cable cut on arrival—replaced and working. Serviced monitor—no fouling seen. One water temperature deletion.
September 19, 2019	Serviced monitor—very clean, cross section collected from bridge. Reinstalled orifice line, could not find any cuts. No HWM could be determined all bank was just mud. One specific conductance deletion for a spike. Drift correction for DO.
October 21, 2019	Fixed gage. Radar does not read into Satlink. Unplugged radar and all rest of sensors started working. Cleaned monitor. No reset of bubbler.
November 4, 2019	Pulled WQ probe and data logger was not working upon arrival, seems culprit was WQ cable. Reset HG to WWG at 1250. DO drift correction.

Results

The water quality monitoring season (ice-free) on the Little Missouri River at THRO lasted from April 17 to November 4, 2019. River discharge peaked in March before the monitoring season began. Subsequent smaller peaks occurred in May, July, and September. The maximum recorded daily discharge prior to the monitoring season was recorded on March 25, 2019 at 27,600 cubic feet per second (cfs). During the monitoring season, peak discharge was recorded at 9,410 cfs.

During the 2019 water year, 18.59 inches of precipitation were recorded. For context, the 2013 and 2016 water years experienced 16.89 and 16.74 inches of precipitation, respectively. September 2019 was exceptionally rainy with 6.65 inches of rainfall. Figure 4 shows the Little Missouri out of its banks in early 2019. March 2019 only had .07 inches of precipitation, so the high flows were due to rapid snowmelt in the upper watershed. Figure 5 shows a graph of discharge recorded during the ice-free season while Figure 6 shows some of the climate data collected at the nearby RAWS station during 2019.



Figure 4. Little Missouri River at USGS gaging station 06336000 March 26, 2019, just one day after peak recorded flow of 27,600 cfs.

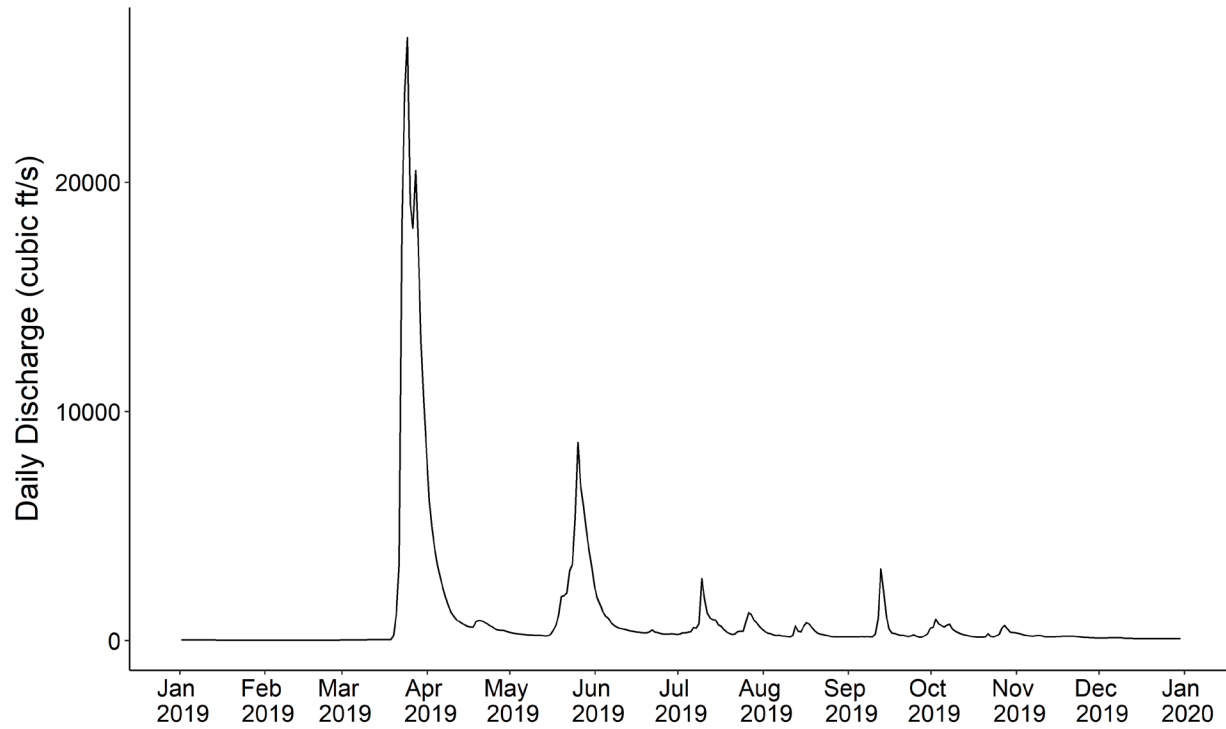


Figure 5. Daily mean discharge on the Little Missouri River at Theodore Roosevelt National Park at USGS Gaging Station 06336000.

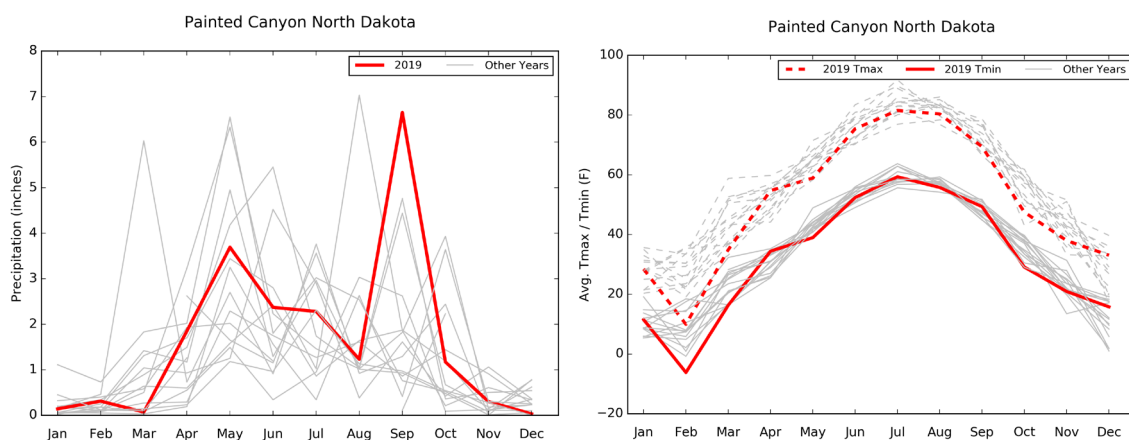
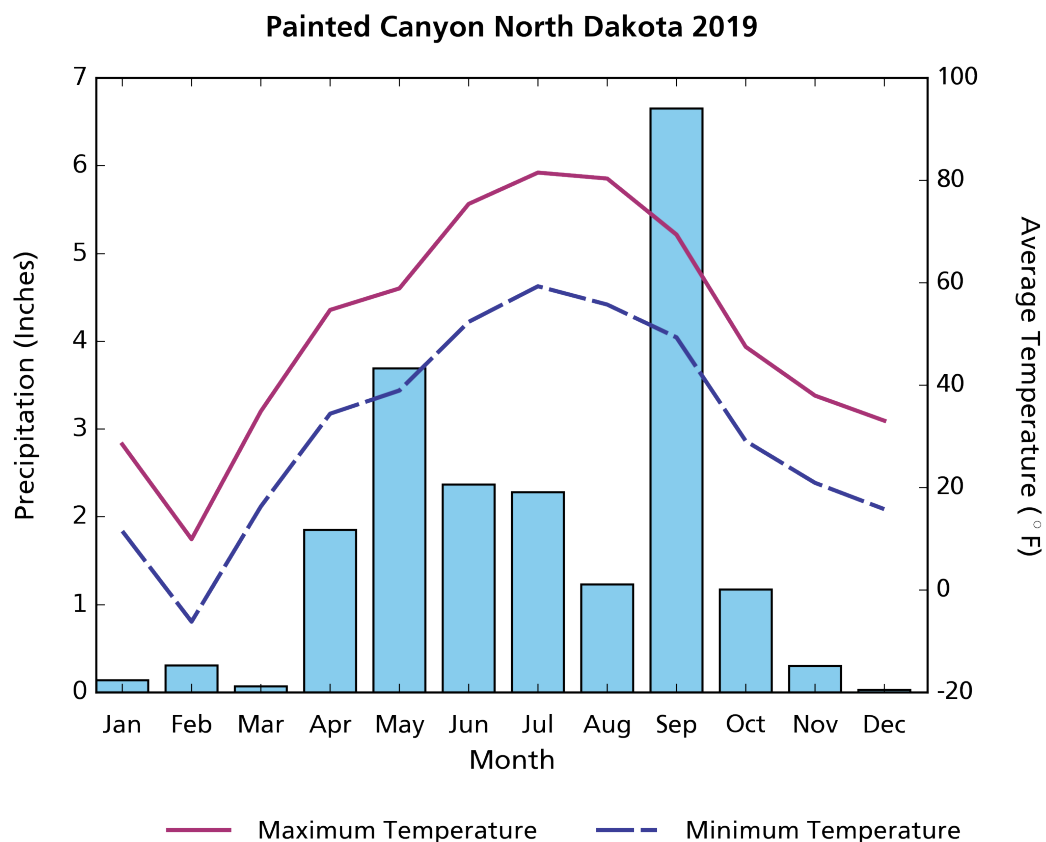


Figure 6. The top panel shows the total monthly precipitation (blue bars), average monthly minimum air temperature (dashed blue line) and average monthly maximum air temperature (solid red line) for the 2019 calendar year in Theodore Roosevelt National Park. The bottom left panel shows a comparison of 2019 precipitation data to the period of record, and the bottom right panel shows a comparison of 2019 temperature data to the period of record. Climate data are from Painted Canyon RAWs climate station. The data were accessed and graphed using the web-based tool Climate Analyzer.

During the ice-free season at THRO, approximately 16,500 water quality measurements were collected in the Little Missouri River (Table 3). Water monitor errors resulted in data loss from

August 8–20, October 12–21, and October 26–November 4. The remaining analysis will exclude November from the monitoring season since core water quality data were not recorded during that time.

This period had a mean water temperature of 16.64°C, a mean dissolved oxygen concentration of 8.87 mg/L, a mean specific conductance of 1,696 µS/cm, and a mean pH of 8.41 (Table 3). There was, however, variation across months in all parameters (Table 4). Monthly mean water temperature in April was 10.8°C and peaked to a mean of close to 23.8°C in July before declining back to 5.86°C in October (Table 4, Figure 7).

All observations met the North Dakota water quality standards, with no exceedances during the ice-free season for the monitored parameters.

Table 3. Summary of descriptive statistics for water temperature, dissolved oxygen, specific conductance, and pH measured for the ice-free sampling period on the Little Missouri River at Theodore Roosevelt National Park from April 17 to October 26, 2019, at USGS Gaging Station 06336000. 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 $\geq$ 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	16.64	8.87	1263.37	8.41
Standard Deviation	6.76	1.48	300.21	0.19
Median	17.5	8.5	1270	8.4
Minimum	−0.1	6.5	509	7.9
Maximum	29.2	13.6	1840	8.9
Number of Points	16582	16425	16580	16,583
Number of Points below or above standard	0 (above)	0 (below)	–	0 (above) 0 (below)
% Exceedance	0%	0%	–	0%

Table 4. Monthly summary of descriptive statistics and percent exceedances for core water quality parameters for the ice-free sampling period at Little Missouri River at Theodore Roosevelt National Park from April 17 to October 26, 2019, at USGS Gaging Station 06336000. 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 $\geq$ 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 (μ S/cm)	pH
April 17–30, 2019	Number of measurements	1,306	1,306	1,306	1,306
	Mean	10.83	10.13	1,107.23	8.38
	Standard Deviation	3.26	0.8	136.22	0.08
	Median	11.55	10	1,060	8.4
	Minimum	4.2	9.1	922	8.3
	Maximum	16.1	11.9	1,480	8.5
	% Exceedance	0%	0%	–	0%
May, 2019	Number of measurements	2,975	2,877	2,975	2,975
	Mean	11.58	9.86	1,302.68	8.37
	Standard Deviation	3.75	0.94	416.63	0.23
	Median	11	10	1,510	8.5
	Minimum	4.9	8	529	7.9
	Maximum	22	11.7	1,840	8.6
	% Exceedance	0%	0%	–	0%
June, 2019	Number of measurements	2878	2827	2878	2878
	Mean	20.74	7.88	1346.91	8.31
	Standard Deviation	2.87	0.47	269.76	0.15
	Median	20.6	7.8	1410	8.4
	Minimum	14.7	6.9	743	8
	Maximum	28.5	9	1700	8.5
	% Exceedance	0%	0%	–	0%
July, 2019	Number of measurements	2,974	2,967	2,974	2,974
	Mean	23.79	7.44	1,178.96	8.32
	Standard Deviation	2.13	0.42	326.14	0.15
	Median	23.8	7.4	1,170	8.4
	Minimum	19.2	6.5	509	7.9
	Maximum	29.2	8.9	1,730	8.5
	% Exceedance	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 at Little Missouri River at Theodore Roosevelt National Park from April 17 to October 26, 2019, at USGS Gaging Station 06336000. 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 $\geq$ 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, 2019	Number of measurements	1,782	1,781	1,782	1,783
	Mean	22.37	7.91	1,142.02	8.03
	Standard Deviation	3.61	0.63	187.05	0.56
	Median	23	7.8	1,140	7.9
	Minimum	13.9	6.9	799	7.1
	Maximum	28.7	9.4	1,590	9.1
	% Exceedance	0%	0%	–	0%
September, 2019	Number of measurements	2,878	2,878	2,876	2,878
	Mean	16.17	8.73	1,338.01	8.55
	Standard Deviation	3.64	0.76	254.01	0.15
	Median	16.3	8.6	1,450	8.6
	Minimum	8.1	7.6	653	8.2
	Maximum	23.8	10.7	1,790	8.9
	% Exceedance	0%	0%	–	0%
October 1–26, 2019	Number of measurements	1,789	1,789	1,789	1,789
	Mean	5.86	11.44	1,318.82	8.54
	Standard Deviation	2.98	0.95	175.14	0.11
	Median	6.2	11.4	1,250	8.5
	Minimum	–0.1	9.9	979	8.3
	Maximum	11.6	13.6	1,740	8.7
	% Exceedance	0%	0%	–	0%

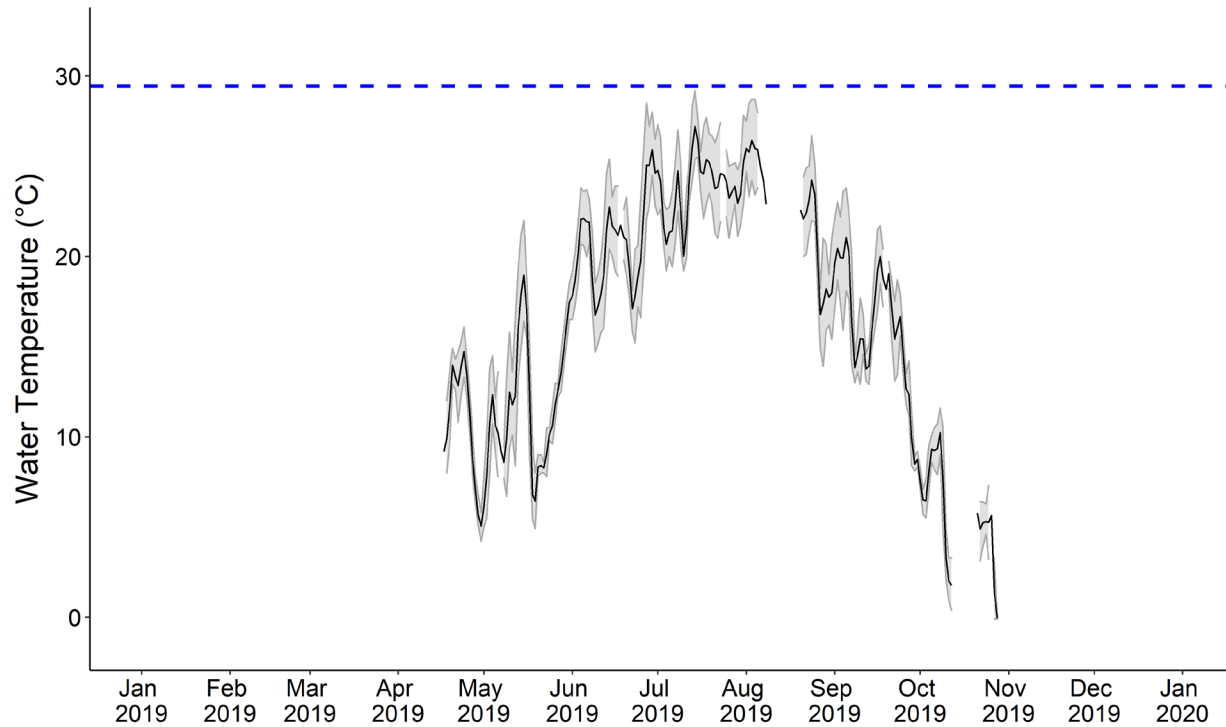


Figure 7. Daily mean water temperature (black line) collected on the Little Missouri River at Theodore Roosevelt National Park from April 17 to October 26, 2019, at USGS Gaging Station 06336000. The gray ribbon shows the daily maximum and minimum water temperature for the same period. The dashed blue 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 8). Higher mean dissolved oxygen concentrations occurred in the spring and fall, with a maximum monthly average of 11.4 mg/L in October 2019. Dissolved oxygen was lowest in July 2019. However, even the annual minimum of 6.5 mg/L remained in compliance with North Dakota water quality standards (Table 1).

Specific conductance of the Little Missouri River was highly variable throughout the year (Table 3, Figure 9), and showed a less predictable seasonal pattern than temperature or dissolved oxygen concentrations. The pH of the Little Missouri River ranged between 7.9 and 8.9 (Figure 10) and remained in compliance with North Dakota water quality standards all year.

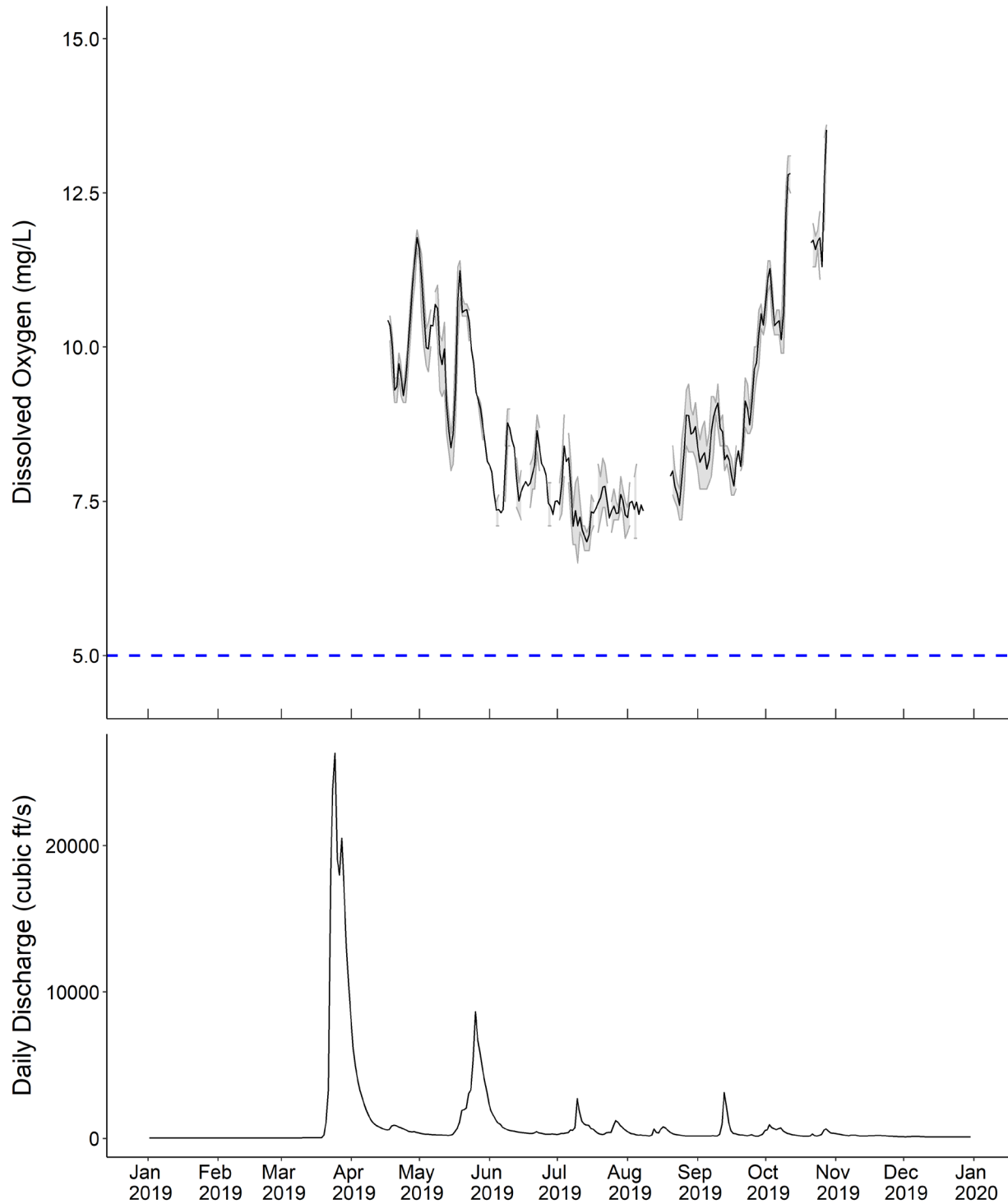


Figure 8. Daily mean dissolved oxygen concentrations (top) and daily discharge (bottom) of the Little Missouri River at Theodore Roosevelt National Park from April 17 to October 26, 2019, at USGS Gaging Station 06336000. The gray ribbon shows the daily maximum and minimum dissolved oxygen for the same 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.

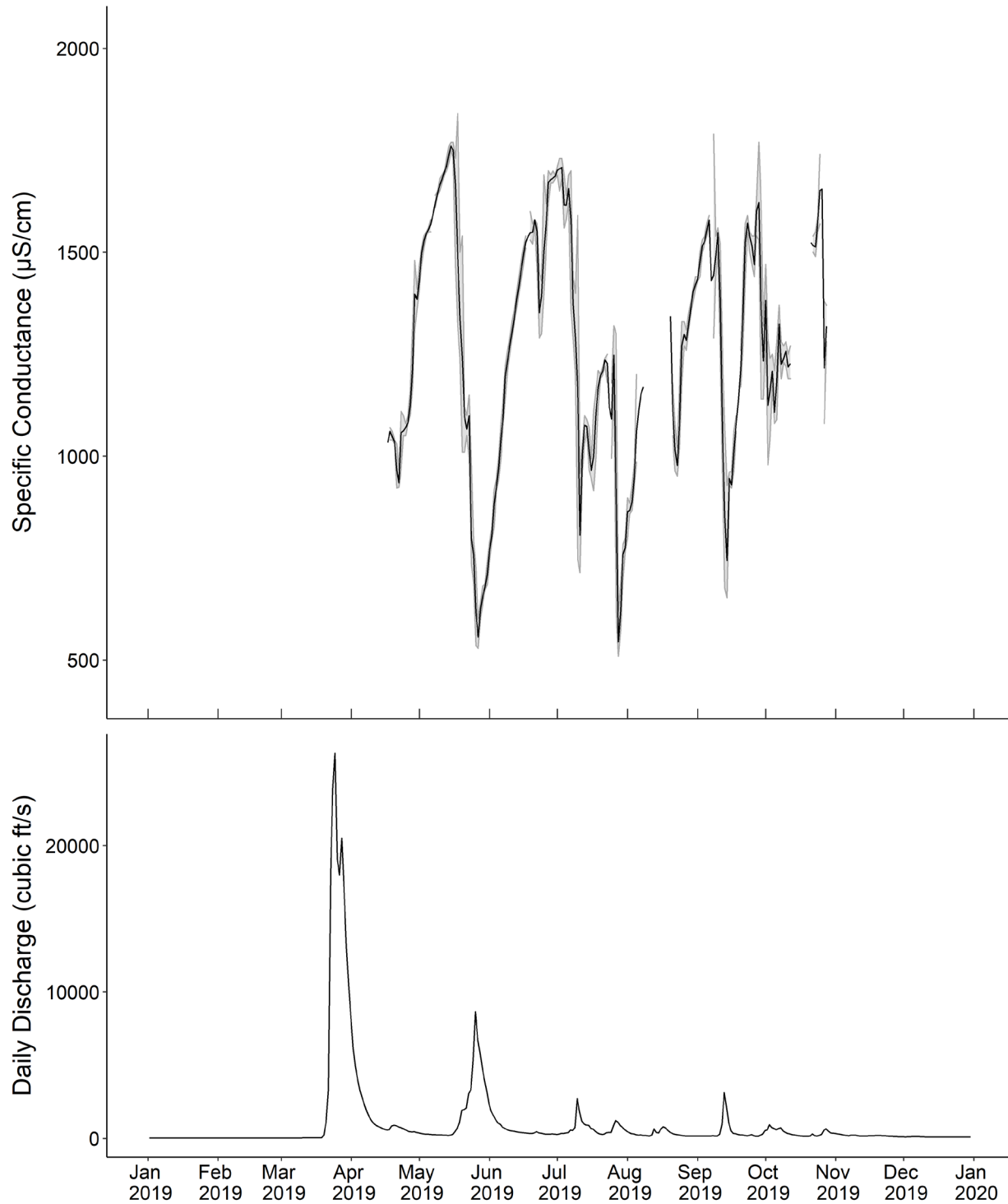


Figure 9. Daily mean specific conductance (top) and daily discharge (bottom) of the Little Missouri River at Theodore Roosevelt National Park from April 17 to October 26, 2019, at USGS Gaging Station 06336000. The gray ribbon shows the daily maximum and minimum specific conductivity for the same period. The periods where the instrument did not collect data are indicated by gaps in the record.

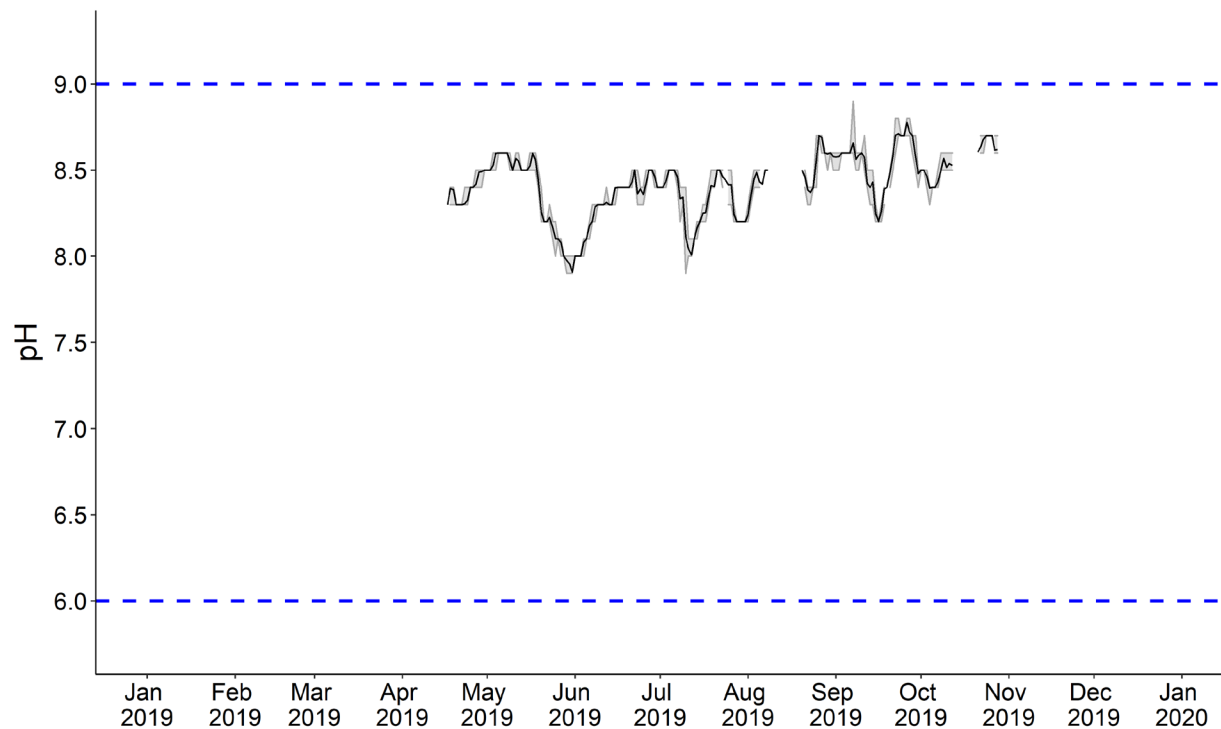


Figure 10. Daily mean pH (black line) of the Little Missouri River at Theodore Roosevelt National Park from April 17 to October 26, 2019, at USGS Gaging Station 06336000. The gray ribbon shows the daily maximum and minimum pH for the same period. The dashed blue lines indicate the North Dakota state 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 2019 water quality monitoring season at Theodore Roosevelt National Park. 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 06336000](#).

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Appendix A.

Table A-1. Recent ND Department of Environmental Quality (NDDEQ) *E. coli* counts from Water Quality Portal.

Date	Result (#/100ml)	
	South Unit 21NDHDWQ_WQX Little Missouri River Medora	North Unit 21NDHDWQ_WQX-380059 Little Missouri River Highway 85
5/7/2013	90	10
5/21/2013	>24000 *	>24000 *
6/11/2013	150 *	100
7/9/2013	390 *	80
8/13/2013	1300 *	>24000 *
5/13/2014	70	100
7/7/2014	920 *	940 *
8/12/2014	>24000 *	>24000 *
5/12/2015	40	10
6/9/2015	100	>24000 *
7/21/2015	10	100
8/25/2015	8000 *	200 *
5/17/2016	130 *	10
6/8/2016	700 *	2700 *
7/25/2016	80	1300 *
8/22/2016	50	70
5/15/2017	360 *	140 *
6/14/2017	110	80
7/19/2017	720 *	260 *
8/14/2017	>24000 *	16000 *
5/1/2018	52	41
5/22/2018	180 *	590 *
6/5/2018	430 *	3400 *
7/17/2018	41	31
8/21/2018	150	41
5/6/2019	20	20
5/20/2019	1600 *	2500 *
6/10/2019	52	200 *
7/22/2019	41	110

* *E. coli* count > 126/100ml, which exceed the ND water quality standard, also shown in bold. Counts marked >24000 were coded as 'too numerous to count.'

Table A-1 (continued). Recent ND Department of Environmental Quality (NDDEQ) E. coli counts from Water Quality Portal.

Date	Result (#/100ml)	
	South Unit 21NDHDWQ_WQX Little Missouri River Medora	North Unit 21NDHDWQ_WQX-380059 Little Missouri River Highway 85
9/3/2019	74	>24000 *
5/19/2020	330 *	830 *
6/4/2020	52	200 *
7/6/2020	1700 *	>24000 *
8/18/2020	2900 *	960 *
5/4/2021	75	63
6/28/2021	350 *	360 *
7/27/2021	540 *	1100 *
8/10/2021	110	1000 *
5/19/2022	400 *	1600 *
6/8/2022	6100 *	5200 *
7/13/2022	1600 *	9200 *
8/17/2022	20	84
9/6/2022	—	>24000 *
9/12/2022	—	31
9/21/2022	—	63
9/22/2022	—	41
9/27/2022	—	63

* E. coli count > 126/100ml, which exceeds the ND water quality standard, also shown in bold. Counts marked >24000 were coded as 'too numerous to count.'

Appendix B.

USGS Water Data Quality Report for Little Missouri River 06336000, 2019 and Station Analysis.

06336000 LITTLE MISSOURI RIVER AT MEDORA, ND

LOCATION—Lat 46°55'05.06", long 103°31'49.24" referenced to North American Datum of 1983, in T.140 N., R. 102 W., Billings County, ND, Hydrologic Unit 10110203, on left bank 50 ft above bridge on U.S. Highway 10, one quarter of a mi west of Medora, and 1 1/4 mi upstream from Andrews Creek.

DRAINAGE AREA—6,190 mi². approximately.

REVISIONS HISTORY—WSP 546: Drainage area, WSP 1279: 1903–7, 1923–24, 1930–31, 1934(M), When the gage was re-established in March 2001, the base gage was incorrectly set 0.84 ft too low. All gage heights since October 1, 2002, and the 2001 peak stage have been corrected, Unit values and daily values data for water years 2001-02 have not been adjusted, Discharge data for those years are unaffected by this correction.

SURFACE-WATER RECORDS

PERIOD OF RECORD—DAILY DISCHARGE—May 1903 to October 1908, October to November 1921, April, May, and December 1922, May 1923 to September 1924, October 1928 to September 1934, October 1945 to September 1975, March 2001 to current year, Monthly discharge only for some periods, published in WSP 1309.

PERIOD OF RECORD.·DAILY GAGE HEIGHT—August 2001 to current year.

GAGE—Water-stage recorder on upstream side of highway bridge, Datum of gage is 2248.44 ft above North American Vertical Datum of 1988 (NAVD88). National Geodetic Vertical Datum of 1929 (NGVD29) datum was converted to NAVD88 datum using the National Geodetic Surveys VDATUM transformation tool in November, 2017. Prior to October 1, 2017, datum was published as 2,246.75 ft above the NGVD29. September 1951 to September 1975, recording gage 600 feet downstream at current datum. October 9, 1945, to August 22, 1951, non-recording gage at current location at current datum. Prior to October 9, 1945, non- recording gages at several sites within 0.2 miles upstream from present site at various datums.

REMARKS—Accuracy of records for water years prior to 2014 are noted in the individual Annual Data Reports for those water years. For water years 2014 onward, records good except for estimated discharges, which are poor, unless otherwise noted.

U.S. Department of the Interior

U.S. Geological Survey

Suggested citation: U.S. Geological Survey, 2022, National Water Information System data available on the World Wide Web (USGS Water Data for the Nation), accessed [November 14, 2022], https://mvis.waterdata.usgs.gov/nwis/wysJpt?dv_ts_ids=&91565&adr_begin_date=2019-10-01&adr_end_date=2020-09-30&site_no=06336000&agency_cd=USGS

Record: The monitor was run at the station from 4/17/19 until 11/4/19 when the monitor was removed. This was part of NPS project that every three years we run a monitor for the open water period. The monitor recorded water temperature, specific conductance, pH, and dissolved oxygen. The monitor provided a good record for the period with only loss of data occurring from 8/8–8/20 due to the cable being cut; 10/12–10/21 and 10/26–11/4 due to DCP communication failures. All parameters are missing during these timeframes. DO is also missing on 5/25 due to high flows causing sediment buildup on sensor that obstructed the readings for a short period.

Site characteristics: The river is a muddy sand bottom channel that has numerous sand bars throughout the reach. The monitor is located upstream side of bridge where the river is around 200 ft wide. River is subject to very high flows that cause shifting sand across the channel redefining the channel bed.

Instrumentation: A YSI 6920 V2 with optical DO, SN: 03F1090AB, was used for the entire period. The monitor was strung through conduit and attached to a fence post near the right bank by the bridge.

Field Visits: The monitor was visited 8 times during the period on around a 4-week schedule. The monitor was cleaned during every visit and calibration checked every visit other than on 10/21/19. If the calibration check was outside of parameter criteria the monitor was recalibrated and this happened a few times during the period for pH and DO. These calibration corrections are noted in the calibration drift corrections.

Deletions:

WT: Only deletion was for bad data on 8/8 after backup data was uploaded. No additional edits were needed on the WT data. The unit values are in good condition for the period.

SC: One deletion for a spike on 9/7 was used during the period, otherwise, the unit values were in good condition for the period and no additional edits were needed for the period.

pH: No data needed to be edited during the period. The unit values are in good condition for the period.

DO: Numerous deletions and adjustable trims were used during the period to clean up spikes and painting data due to the sensor being affected by sediment load during higher flows. None of these edits caused any gaps in the data.

Fouling Corrections:

WT: No correction needed for the period.

SC: Two fouling corrections were used during the period.

Table B-1. Fouling Corrections.

Start Time	End Time	Correction Amount(s)	Comments
2019-05-07 09:00:00	2019-06-18 09:50:00	Start Shift Points: 0, 0; End Shift Points: 0, 0; 1e+05, 13724.036;	Moderate amount of fouling due to mud. Cleaned monitor.
2019-09-19 09:45:00	2019-10-21 13:30:00	Start Shift Points: 0, 0; End Shift Points: 0, 0; 10000, 160;	Very minor fouling found after monitor fixed. Cleaned monitor.

pH: No fouling corrections were needed for the period. All visits had correction within 0.1 units.

DO: No fouling corrections were needed for the period as the sensor stayed clean during the period. All visits had correction within 0.1 mg/l.

Calibration Drift Corrections:

WT: No correction needed for the period.

SC: After the initial monitor calibration at the start of the period, the monitor was within 3% for all calibration checks and no correction was used during the period.

pH: Once drift correction was used during the period from 5/7 until 6/18. The 6/18 visit showed that the calibration was off by around -0.17 units and a correction was applied with the monitor recalibrated before redeployment.

Table B-2. Calibration Drift Corrections.

Start Time	End Time	Correction Amount(s)	Comments
2019-05-07 09:00:00	2019-06-18 09:50:00	Start Shift Points: 0, 0; End Shift Points: 7.22, -0.19; 10.24, -0.15;	Calibration drift correction found at 7 and 10 pH units. Recalibrated monitor before redeployment.

DO: A few drift corrections were used during the period based on calibration checks done during field visits.

Table B-3. Calibration Drift Corrections.

Start Time	End Time	Correction Amount(s)	Comments
2019-04-17 08:40:00	2019-05-07 09:00:00	Start Shift Points: 0, 0; End Shift Points: 0, 0; 50, -3.291;	Drift correction found from 5/7 visit. Recalibrated monitor before redeployment.
2019-05-07 09:30:00	2019-06-18 09:50:00	Start Shift Points: 0, 0; End Shift Points: 0, 0; 50, -1.674;	Drift correction found on 6/18 visit. Recalibrated monitor before redeployment.
2019-07-24 09:15:00	2019-09-19 08:45:00	Start Shift Points: 0, 0; End Shift Points: 0, -0.13;	Drift correction found on 9/19 visit. Did not recalibrate monitor.
2019-09-19 09:30:00	2019-11-04 12:30:00	Start Shift Points: 0, -0.13; End Shift Points: 0, -0.09;	Continued drift correction found on 9/19 and prorated to drift correction found on 11/4 visit. No monitor recalibration during this time.

Other Corrections: 5 point WT corrections with NIST thermistor: 41516584

Table B-4. Other Corrections: 4-11-19.

NIST	Instrument	Correction
23.10	23.06	0.04
36.72	36.94	-0.22
6.37	6.48	-0.11
11.53	11.50	0.03
45.11	45.27	-0.16
Average Correction:		-0.08 OK

Table B-5. Other Corrections: 11-18-19.

NIST	Instrument	Correction
21.80	21.72	0.08
38.35	38.32	0.03
3.71	3.71	0.00
13.97	14.39	-0.42
28.93	28.58	0.35
Average Correction:		0.01 OK

Cross-section surveys: Cross sections were collected from the bridge on 7/24/19 and 9/19/19. Both of the cross sections showed that the channel was well mixed for all four parameters and that the cross sectional average is within criteria to the monitor readings. This shows that the monitor placement represents the average of the channel and no correction was needed for the period. The

data for the cross sections are located under the Field Visit folder for the visits and named as 06336000_20190724_Xsect and 06336000_20190919_Xsect.

Comparisons:

WT: The water temperature compares well with the other nearby stations at 06340590 and 06346500. Similar temperature trends are seen. The diurnal temperature pattern is seen throughout the period.

SC: The SC compares well with the discharge at the station. An inverse relationship is seen with the SC to the discharge with all runoff events seeing the corresponding decrease in SC concentrations. The SC graph compares well with other nearby station 06340590.

pH: The pH compared well with the one other nearby station that had pH 06340590. The pH was fairly steady for most of the period.

DO: DO compares well with the other nearby station 06340590. Similar trends are seen between the two. The common diurnal pattern with seen throughout the period and compares well with air temperature from NDAWN station at Hazen 06340500.

Remarks: Daily values for all the parameters look good with no additional remarks needed. Updated SIMS station description by added new water quality section and added information about the monitoring.

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 387/186908, November 2022

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