



Water Quality Monitoring for Fort Laramie National Historic Site

2018 Data Report

Natural Resource Data Series NPS/FOLA/NRDS—2020/1279



ON THE COVER

Photograph of the Laramie River in 2018 at Fort Laramie National Historic Site, WY.
Photograph courtesy of the National Park Service.

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The Natural Resource Data Series is intended for the timely release of basic data sets and data summaries. Care has been taken to assure accuracy of raw data values, but a thorough analysis and interpretation of the data has not been completed. Consequently, the initial analyses of data in this report are provisional and subject to change.

All manuscripts in the series receive the appropriate level of peer review to ensure that the information is scientifically credible, technically accurate, appropriately written for the intended audience, and designed and published in a professional manner.

This report received informal peer review by subject-matter experts who were not directly involved in the collection, analysis, or reporting of the data. Data in this report were collected and analyzed using methods based on established, peer-reviewed protocols and were analyzed and interpreted within the guidelines of those protocols

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Abstract

The Northern Great Plains Inventory and Monitoring Network (NGPN) began monitoring water quality in the Laramie River at Fort Laramie National Historic Site (FOLA) in 2015 (Ashton and Rockwood 2020), with the assistance of the U.S. Geological Survey (USGS). This report summarizes the data collected during the 2018 ice-free season (March 27 through November 2) for streamflow, water temperature, dissolved oxygen, specific conductance, and pH.

Compared to the first sampling period in 2015, which was a record flood year, 2018 was significantly drier. Discharge on the Laramie River peaked at only 329 cubic feet per second in April of 2018, compared to a peak of over 4570 cubic feet per second in late May of 2015. A summary of our results can be found in Descriptive Statistics Summary tables for the ice-free season (Table 3) and for each month (Table 4). Notably, water temperatures were warm in the summer months and above the Wyoming state water quality standard for cold water fisheries from May through September.

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.

Introduction

Fort Laramie National Historic Site (FOLA) was established in 1938 with a purpose to preserve the historic scenes and resources at the confluence of the Laramie and North Platte Rivers, and to interpret the roles and significance of the diverse and vibrant cultures that interacted at this crossroads of the West (National Park Service 2017). The Laramie River is approximately 450 km long. It begins in the Roosevelt National Forest in Colorado (2800 m elevation) and flows north into Wyoming and then northeast where it joins the North Platte River at Fort Laramie, Wyoming (Figure 1). Approximately 6 km of the Laramie River flows through Fort Laramie National Historic Site.

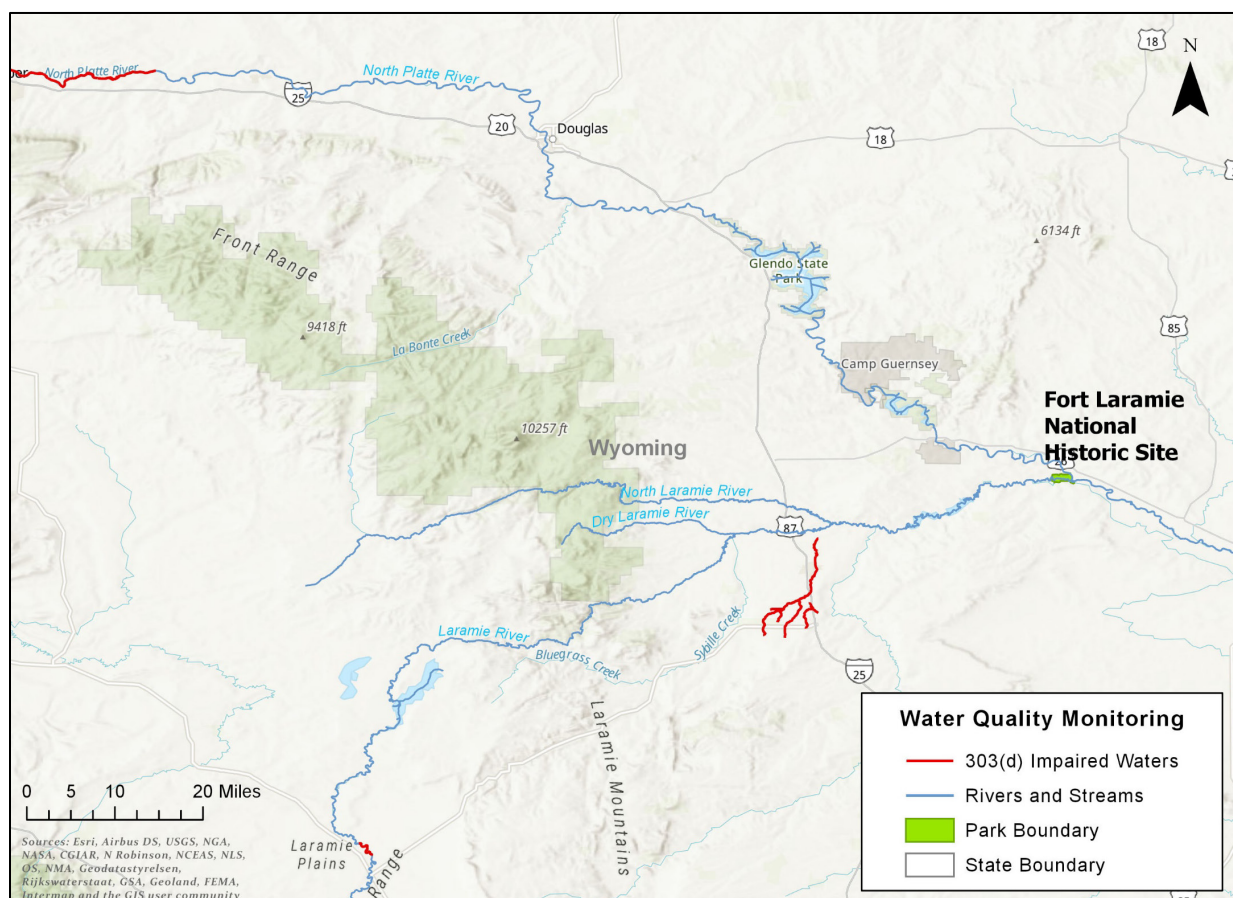


Figure 1. Map of Fort Laramie National Historic Site and the Laramie River and North Platte River in Wyoming. The stretches of the rivers highlighted in red are listed as impaired under 303(d) criteria for fecal coliform, *Escherichia coli*, or selenium.

The Laramie River is designated as a Class 2AB cold water fishery, defined as a water known to support game fish populations or spawning and nursery areas at least seasonally and where a game fishery and drinking water use is attainable (WYDEQ 2018). No impairments are reported for the stretch of river running through Fort Laramie National Historic Site (Figure 1). However, some stretches of the river are listed as impaired waterways under section 303(d) of the Clean Water Act for high fecal coliform and *Escherichia coli* concentrations. Restoration planning for fecal coliform

in Wheatland Creek and Rock Creek, the impaired area nearest to FOLA, have been delayed until 2020, and improvements are being made to sections of the North Platte River to the west. For more details and current impairment information visit the Wyoming Department of Environmental Quality [website](#).

The riparian area along the banks of the Laramie River is well established through FOLA, dominated by cottonwood, ash, willow trees, and an understory of grasses (Ashton and Davis 2016). Previous pH and dissolved oxygen data collected from the Laramie River met state criteria and the resource was described as in good condition (Dibner et al. 2018). Recent temperature sampling also met state criteria, and assessment of aquatic invertebrates indicated the Laramie River had good ecosystem quality (Tronstad 2013). The intact riparian vegetation is likely contributing to the maintenance of high ecosystem quality. However, a recent history of major flooding on the Laramie River, particularly in 2015 (Figure 2), has caused erosion of park lands as well as a loss of some archaeological resources (National Park Service 2017). Moreover, monitoring data in 2015 indicated periods in the summer where water temperature was warmer than state standards (Ashton and Rockwood 2020).



Figure 2. Photograph of the Laramie River on June 5, 2015, during a flooding event.

The Northern Great Plains Inventory & Monitoring Network (NGPN) began monitoring water quality at FOLA in 2015 (Ashton and Rockwood 2020) to better understand current conditions and

changes over time in the Laramie River. The monitoring is conducted at the gaging station at Fort Laramie National Historic Site, WY (Monitoring Location 06670500; Figure 3) 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 FOLA 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). These parameters are measured every 15 minutes throughout the ice-free season (typically March to November), and results were made available in real-time on the [USGS National Water Information System Website](https://nwis.waterdata.usgs.gov/nwis/realtime).

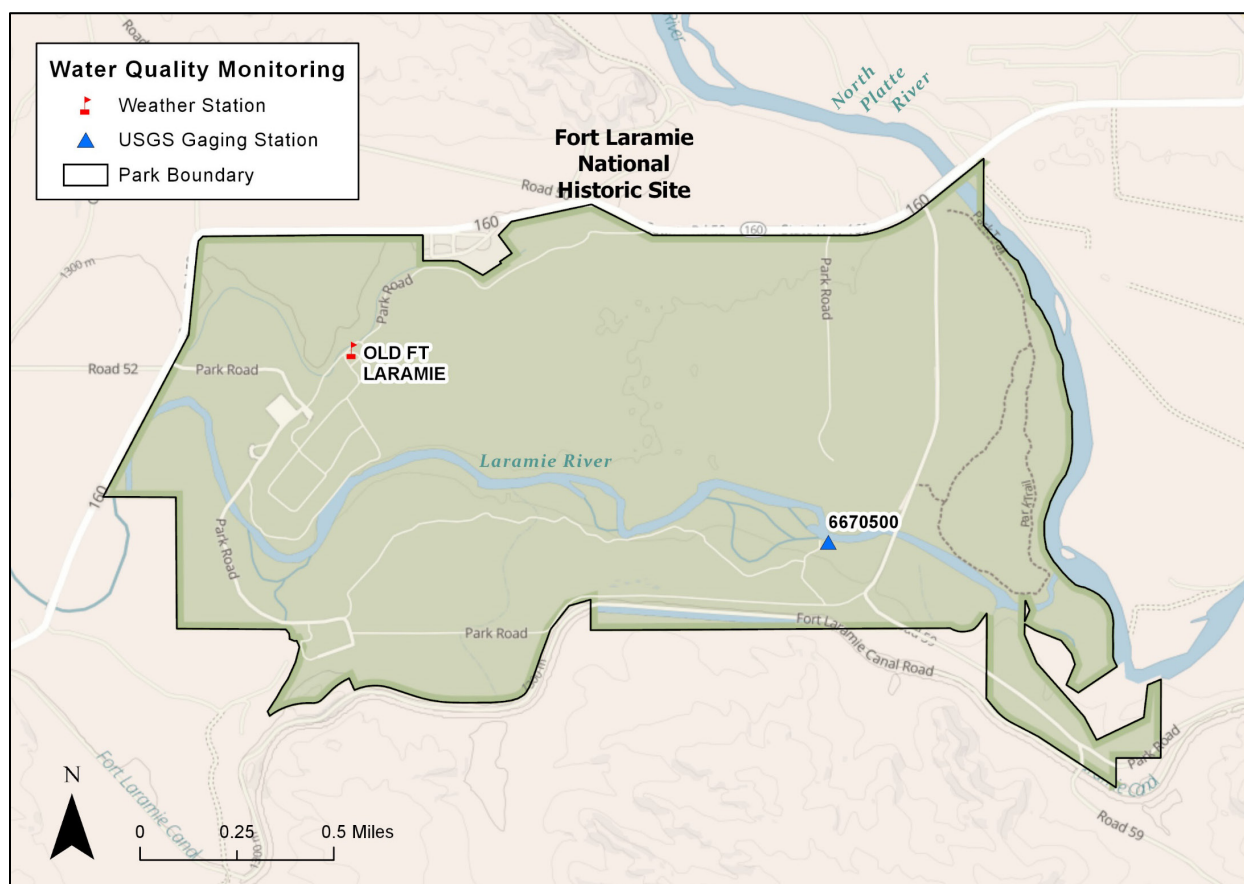


Figure 3. Map of Fort Laramie National Historic Site and water quality monitoring location (06670500, blue triangle) and nearby weather station (red flag). Climate data in this report is taken from the Old Fort Laramie weather station.

Table 1. Water quality parameters measured as part of the Northern Great Plains Inventory & Monitoring Water Quality Program and associated state standards (WYDEQ 2018). These standards are not enforceable in periods of low flow, as defined by the minimum seven consecutive day flow which has the probability of occurring once in ten years (WYDEQ 2018).

Water Quality Parameter	Description	WY state standards applicable to cold 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.	Pollution attributable to the activities of man shall not change ambient water temperatures to levels which result in harmful acute or chronic effects to aquatic life, or which would not fully support existing and designated uses. When ambient temperatures are above 15.6°C, pollution attributable to the activities of man shall not result in an increase of more than 1.1°C The maximum allowable stream temperature will be the maximum natural daily stream temperature plus the allowable change, provided that this temperature is not lethal to existing fish life and under no circumstance shall pollution attributable to the activities of man result in a temperature that exceeds 20°C
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.	Minimum criteria include • 30-day mean of 6.5 mg/L • 7-day mean of 9.5 / 6.5 mg/L • 7-day mean minimum of 5.0 mg/L • 1-day minimum of 8.0 / 5.0 mg/L
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.	Pollution attributable to the activities of man shall not be present in amounts which will cause the pH to be less than 6.5 or greater than 9.0 standard units. Pollution attributable to the activities of man shall not change the pH to levels which result in harmful acute or chronic effects to aquatic life, directly or in conjunction with other chemical constituents, or which would not fully support existing and designated uses.

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 06670500) inside the park, at around 4220 ft. elevation. Water quality and streamflow are measured every 15 minutes throughout the ice-free season. Monitoring at FOLA began in 2015, was repeated in 2018, 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 2018, NGPN partnered with the USGS Wyoming-Montana Water Science Center to have USGS staff collect water quality and streamflow data at FOLA. The USGS deployed a continuous, multi-parameter sonde at the gage on March 27, 2018, (Figure 4) 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, while the gage simultaneously measured stream stage (or gage height, measured in feet) and discharge, a measure of streamflow.



Figure 4. A sonde device is used to measure water quality in the Laramie River at Fort Laramie National Historic Site. The United States Geological Survey Laramie River gaging station (06670500) is set up for real-time data transmission via satellite. Photographs courtesy of NPS.

Satellite telemetry was used to transmit the water data to the Water Science Center in near real-time (<https://waterdata.usgs.gov/monitoring-location/06670500/>). 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, 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 (Table 2). Calibration included pre- and post-calibration checks to quantify fouling errors and equipment drift – data critical to correction and grading of the final data. On November 1, 2018, the USGS removed the multi-parameter sonde from the Laramie River.

Quality assurance and quality control was conducted by USGS staff following established USGS guidelines (Wagner et al. 2006). NGPN received the final corrected (approved) data in February of 2019 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 Wyoming environmental regulatory thresholds (Table 1).

Climate data were downloaded from the Old Fort Laramie (486852) 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 2018 Water Quality Sampling at Fort Laramie National Historic Site.

Date	Notes
February 15, 2018	Discharge measurement using Sontek Flowtracker, 100 ft downstream of gage site. Steady, uniform flow and section was clear. Gage pool 50% ice.
March 27, 2018	Installed sonde 06J1734 AD for the season, ~1:45 pm
April 12, 2018	Routine calibration visit, cleaned probe and monitor. No calibration on SC. Minor silt and invertebrates on sonde prior to cleaning. No cord for field meter, so unable to attain cross-section or field monitoring (DO) data.
May 1, 2018	Routine visit, cleaned probe and monitor. Field meter would not calibrate pH or DO. Used monitor sonde for cross-section because of field meter calibration problems. Specific conductance was only parameter that was working correctly. Discharge measurement, with Sontek Flowtracker, 200ft downstream of gage: uniform, steady flow; control in stream channel had minor debris.
May 23, 2018	Routine visit, cleaned probe and monitor. Conductance matched field meter, so no calibrations needed. DO on field meter would not calibrate, even after changing membrane twice. Discharge measurement, with Sontek Flowtracker, 200ft downstream of gage: uniform, steady flow; control in stream channel was clear. Serviced QW monitor; severe thunderstorm approaching.
June 13, 2018	Routine calibration visit, cleaned probe and monitor. Silt and plant life growing in sonde pipe; pipe partially full of silt. Cross-section survey completed.
June 18, 2018	Routine calibration visit, cleaned probe and monitor. Replaced DO sensor
July 13, 2018	Sonde had minor to moderate fine silt prior to cleaning; aquatic invertebrates and algae on and in sonde ports (algae on pH bulb)
July 31, 2018	Routine calibration visit, cleaned probe and monitor.
August 22, 2018	Routine calibration visit, cleaned probe and monitor. Discharge measurement, with Sontek Flowtracker, 200ft downstream of gage: uniform, steady flow; control channel had minor debris.
September 14, 2018	Routine calibration visit, cleaned probe and monitor.
October 3, 2018	Routine calibration visit, cleaned probe and monitor.
November 2, 2018	Removed sonde ~12:00 pm
December 6, 2018	Discharge measurement, with Sontek Flowtracker, 200ft downstream of gage: uniform, steady flow; gage pool 75% ice; minor debris in control channel.
February 1, 2019	Discharge measurement, with Sontek Flowtracker, 200ft downstream of gage: uniform, steady flow; control channel clear; gage pool 100% ice

Results

The water quality monitoring season (ice-free) on the Laramie River at FOLA lasted from March 28, 2018, to November 1, 2018. Discharge remained around 50 cubic feet per second, with little change throughout the ice-free season (Figure 5). In mid-April discharge peaked at 329 cubic feet per second on April 11, likely due to warm spring temperatures. The spikes in late May are in response to rainfall events of over one inch. Compared to the sampling year in 2015 where the peak discharge was over 4750 cubic feet per second and the gage height was over 8.5 feet, the 2018 sampling year had a much lower flow (Ashton and Rockwood 2020).

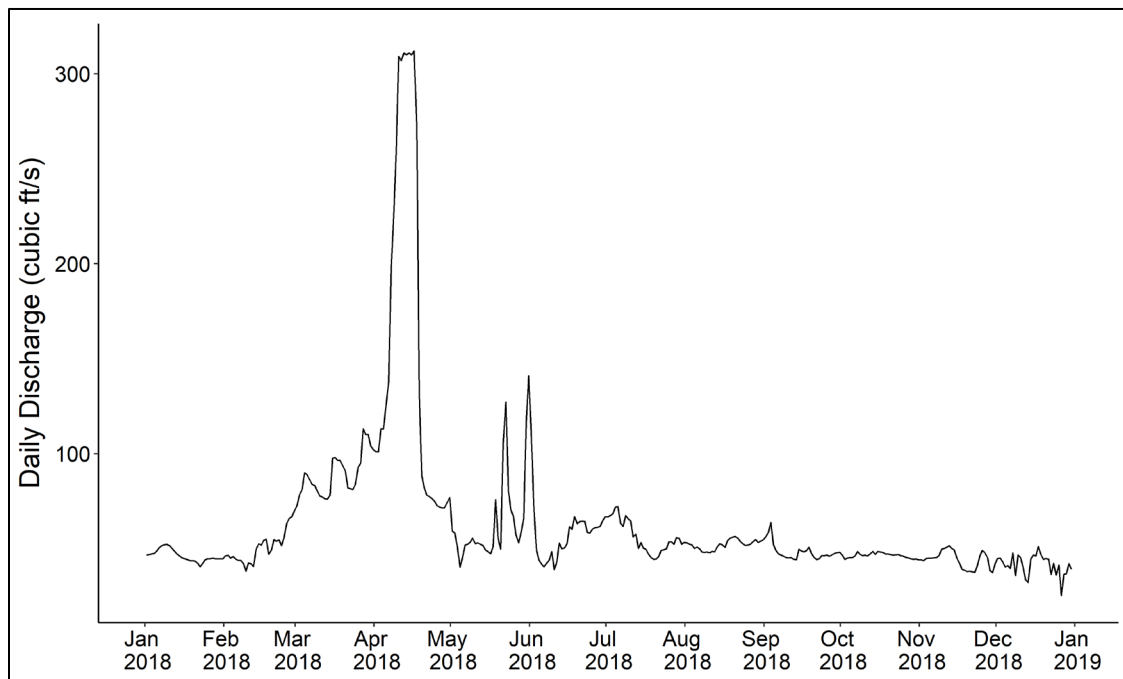


Figure 5. Daily mean gage height (black line) on the Laramie River at Fort Laramie National Historic Site from March 27, 2018, to November 1, 2018, at USGS Gaging Station 06670500.

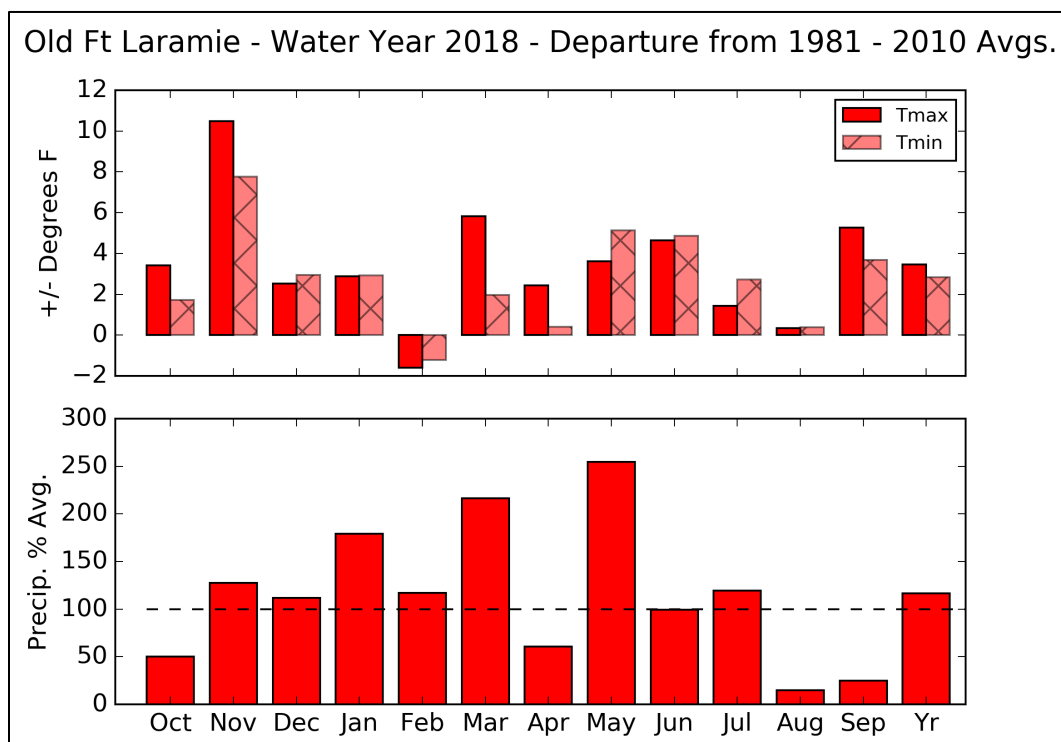
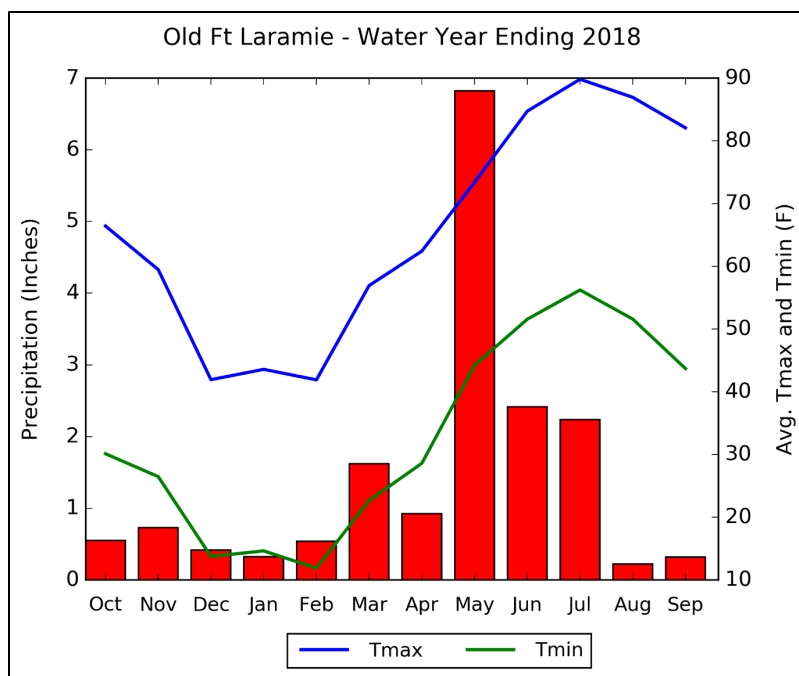


Figure 6. Total monthly precipitation (red bars) and average monthly minimum (green) and maximum (blue) temperature for the 2018 water year in Fort Laramie National Historic Site (top panel). Monthly departures from 1981-2010 average temperature and precipitation for the 2018 water year in Fort Laramie National Historic Site (bottom panel). Climate data are from Old Fort Laramie Station (486852). The data were accessed and graphed using the web-based tool [Climate Analyzer](#).

During the ice-free season at FOLA, we collected over 20,000 water quality measurements in the Laramie River (Table 2). We found mean water temperature of 15.96°C, dissolved oxygen concentrations of 8.57 mg/L, specific conductance of 669.4 µS/cm, and pH of 8.17 (Table 3). There was, however, variation across months in all parameters (Table 4). Mean water temperature in March was 7.12°C and quickly doubled by May to 16.37°C (Table 3, Figure 7). Mean water temperatures for the summer months of June, July, and August were around 20°C. Maximum temperature exceeded the Wyoming water quality standard of 20°C (Table 1), from May to September (Table 4). Overall, 31.8% of the recorded temperatures were above the state threshold for cold water fisheries (Table 3).

Dissolved oxygen displayed seasonal variation (Table 4, Figure 8). The highest mean dissolved oxygen concentrations were in the spring and fall, averaging greater than 9 mg/ L in March, April, May, October, and November. Dissolved oxygen measures exceeded Wyoming state water quality criteria (Table 1) in June and July.

Specific conductance of the Laramie River stayed roughly between 600 and 700 µS/cm (Table 3, Figure 9). The pH of the Laramie River ranged between 7.6 and 8.7 (Figure 10) and was never outside the range of the Wyoming state standards of 6.5 -9.

Table 3. Summary of descriptive statistics for water temperature, dissolved oxygen, specific conductance, and pH measured for the ice-free sampling period on the Laramie River at Fort Laramie National Historic Site from March 27, 2018, to November 1, 2018. Percent exceedance is the proportion of samples that exceed the respective state regulatory threshold described in Table 1 (water temperature max. limit is 20.0°C; dissolved oxygen ≥ 5.0 mg/L; pH range is 6.5–9.0; and specific conductance thresholds and exceedances are not reported).

Descriptive Statistic	Water Temperature (°C)	Dissolved Oxygen (mg/L)	Specific Conductance (µS/cm)	pH
Number of Measurements	21079	19685	21044	21075
Mean	15.96	8.57	669.4	8.17
Standard Deviation	5.32	1.68	19.88	0.23
Median	17.2	8.7	673	8.1
Minimum	2.2	4.6	588	7.6
Maximum	26.9	13.5	770	8.7
Number of Points below or above standard	5145 (above)	137 (below)	–	0 (above) 0 (below)
% Exceedance	31.8%	0%	–	0%

Table 4. Monthly summary of descriptive statistics and percent exceedances for core water quality parameters for the ice-free sampling period at Fort Laramie National Historic Site on the Laramie River from March 27, 2018, to November 1, 2018. Percent exceedance is the proportion of samples that exceed the respective state regulatory threshold described in Table 1 (water temperature max. limit is 20.0°C; dissolved oxygen $\geq$ 5.0 mg/L; and pH range is 6.5–9.0).

Dates	Descriptive Statistic	Water Temperature (°C)	Dissolved Oxygen (mg/L)	Specific Conductivity (μS/cm)	pH
March 27-31, 2018	Number of measurements	422	422	422	422
	Mean	7.12	10.17	656.27	8.47
	Standard Deviation	1.43	0.49	3.36	0.05
	Median	7	10.2	656	8.5
	Minimum	3.6	9.4	652	8.4
	Maximum	10	10.9	668	8.5
	% Exceedance	0	0	–	0
April 2018	Number of measurements	2878	2878	2878	2878
	Mean	8.88	10.05	652.7	8.53
	Standard Deviation	3.15	0.87	5.84	0.07
	Median	8.5	10.2	653	8.5
	Minimum	2.2	7.6	638	8.4
	Maximum	17.1	11.6	669	8.7
	% Exceedance	0	0	–	0
May 2018	Number of measurements	2968	2970	2970	2969
	Mean	16.37	9.19	644.4	8.17
	Standard Deviation	3.03	1.66	11.64	0.19
	Median	16.4	9	645	8.1
	Minimum	10.1	5.8	605	7.8
	Maximum	23.7	13.5	676	8.7
	% Exceedance	12.3	0	–	0
June 2018	Number of measurements	2867	1490	2844	2866
	Mean	20.25	7.97	679.2	8.16
	Standard Deviation	2.83	1.75	30.25	0.17
	Median	20	7.8	671	8.2
	Minimum	13.6	4.9	588	7.8
	Maximum	26.9	12.9	770	8.7
	% Exceedance	49.22	1.28	–	0

Table 4 (continued). Monthly summary of descriptive statistics and percent exceedances for core water quality parameters for the ice-free sampling period at Fort Laramie National Historic Site on the Laramie River from March 27, 2018, to November 1, 2018. Percent exceedance is the proportion of samples that exceed the respective state regulatory threshold described in Table 1 (water temperature max. limit is 20.0°C; dissolved oxygen $\geq$ 5.0 mg/L; and pH range is 6.5–9.0).

Dates	Descriptive Statistic	Water Temperature (°C)	Dissolved Oxygen (mg/L)	Specific Conductivity (μ S/cm)	pH
July 2018	Number of measurements	2973	2959	2958	2970
	Mean	21.1	7.38	675.9	7.98
	Standard Deviation	2.27	1.53	8.81	0.18
	Median	20.9	7.2	676	8
	Minimum	14.6	4.6	641	7.6
	Maximum	26.4	10.4	702	8.4
	% Exceedance	65.22	3.99	–	0
August 2018	Number of measurements	2972	2972	2973	2973
	Mean	19.28	7.49	685	7.99
	Standard Deviation	2.29	1.28	7.32	0.12
	Median	19.1	7.3	685	8
	Minimum	13.6	5.4	672	7.7
	Maximum	24.9	10.1	711	8.3
	% Exceedance	34.83	0	–	0
September 2018	Number of measurements	2880	2880	2880	2879
	Mean	17.17	7.82	672.7	8.06
	Standard Deviation	2.6	1.17	15.38	0.12
	Median	17.5	7.6	678	8.1
	Minimum	9.9	6	628	7.8
	Maximum	22	10.7	693	8.4
	% Exceedance	13.72	0	–	0
October 2018	Number of measurements	2975	2969	2975	2975
	Mean	10.3	9.54	676.8	8.24
	Standard Deviation	2.35	1.09	5.28	0.11
	Median	10.1	9.4	678	8.2
	Minimum	4.2	6.4	658	8
	Maximum	18	11.9	687	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 Fort Laramie National Historic Site on the Laramie River from March 27, 2018, to November 1, 2018. Percent exceedance is the proportion of samples that exceed the respective state regulatory threshold described in Table 1 (water temperature max. limit is 20.0°C; dissolved oxygen ≥ 5.0 mg/L; and pH range is 6.5–9.0).

Dates	Descriptive Statistic	Water Temperature (°C)	Dissolved Oxygen (mg/L)	Specific Conductivity ($\mu\text{S}/\text{cm}$)	pH
November 1-2, 2018	Number of measurements	144	145	144	143
	Mean	7.56	10.01	679.5	8.4
	Standard Deviation	0.51	0.64	1.15	0.06
	Median	7.4	9.7	680	8.4
	Minimum	6.9	9.3	677	8.3
	Maximum	8.6	11.4	681	8.5
	% Exceedance	0	0	–	0

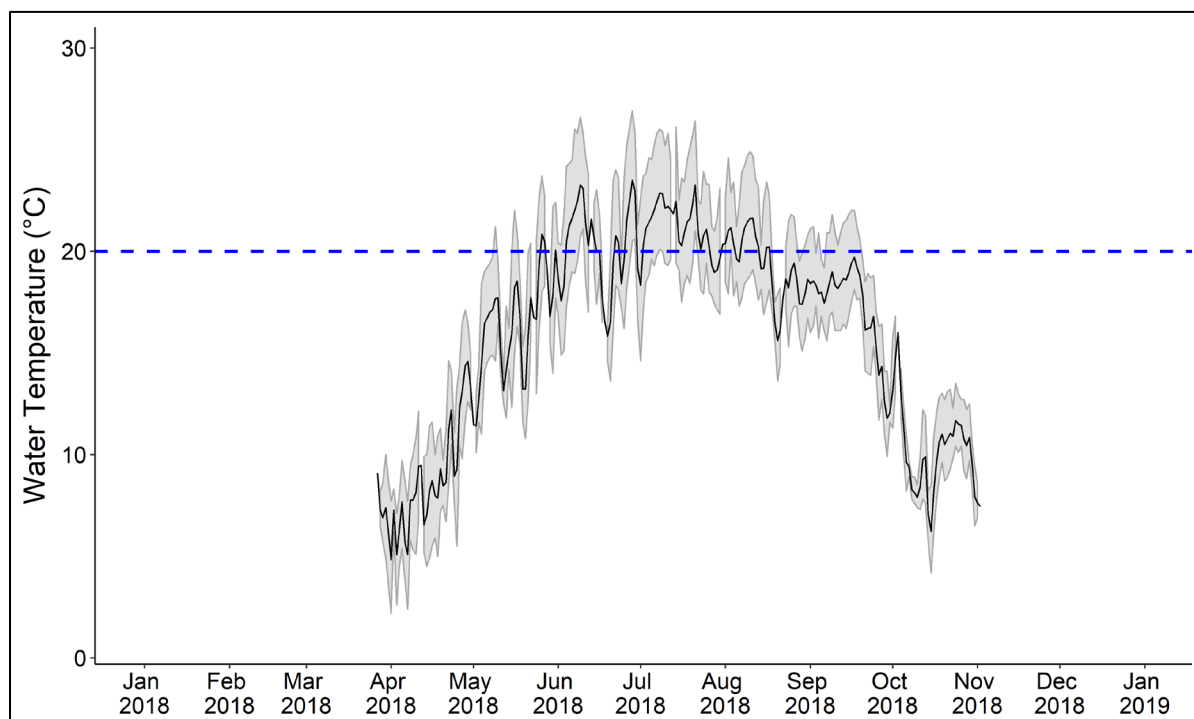


Figure 7. Daily mean water temperature (black line) collected on the Laramie River at Fort Laramie National Historic Site from March 27, 2018, to November 2, 2018. The gray ribbon shows the daily maximum and minimum water temperature for the same period. The dashed blue line indicates one of the Wyoming 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.

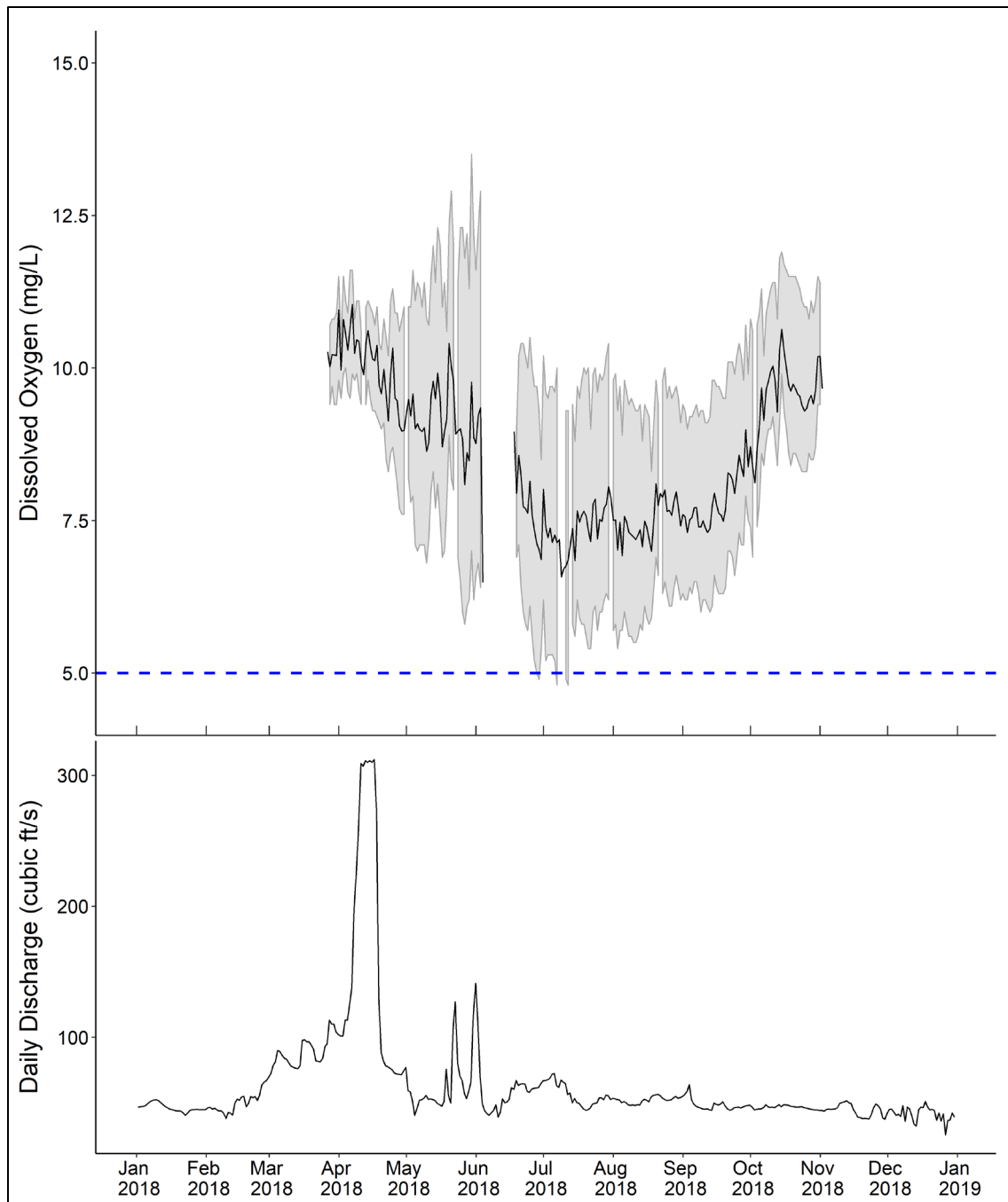


Figure 8. Daily mean dissolved oxygen concentrations (black line; top graph) and daily discharge (bottom) of the Laramie River at Fort Laramie National Historic Site from March 27, 2018, to November 1, 2018. The gray ribbon shows the daily maximum and minimum dissolved oxygen for the same period. The dashed blue line indicates one of the Wyoming 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.

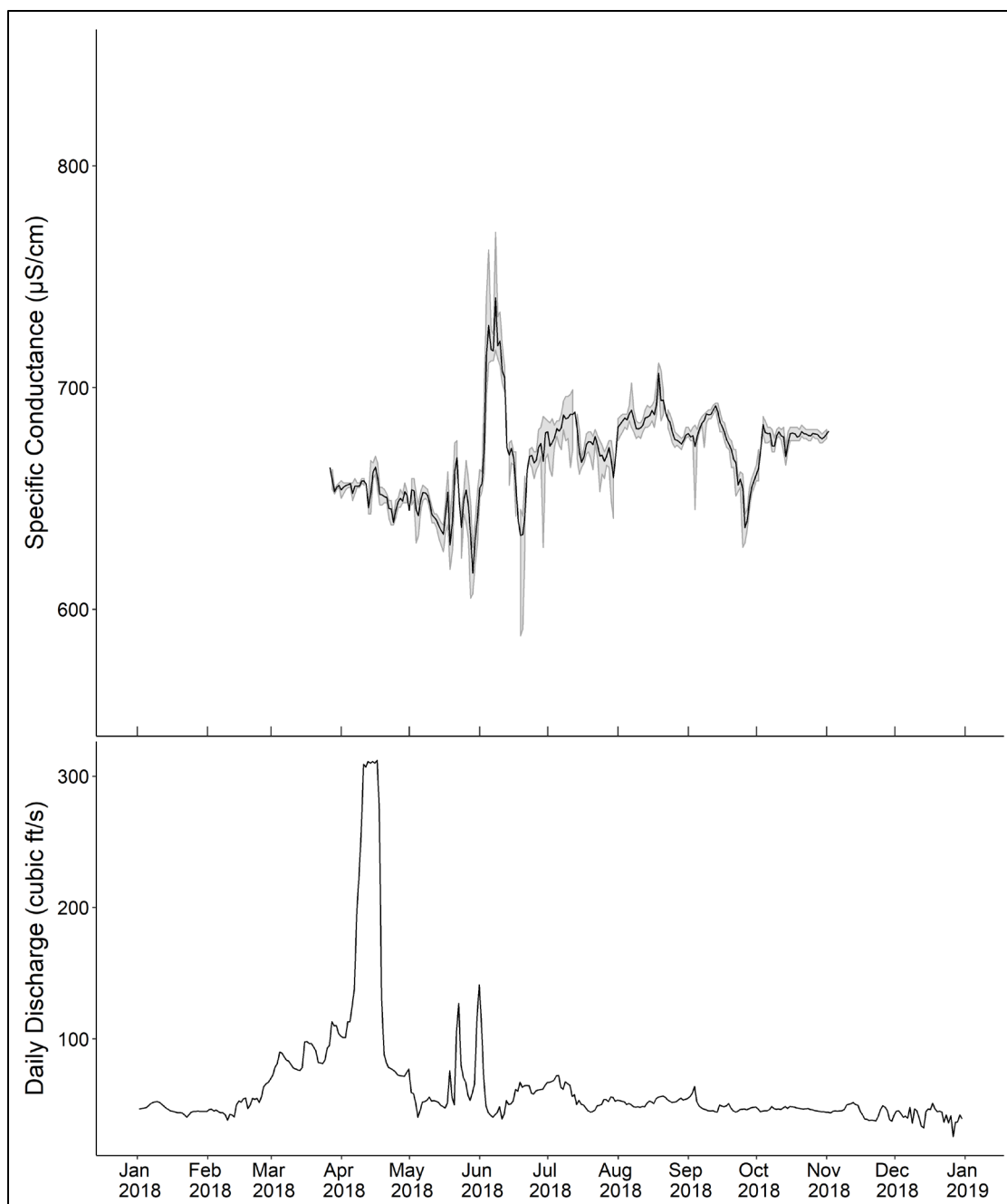


Figure 9. Daily mean specific conductance (top) and daily discharge (bottom) of the Laramie River at Fort Laramie National Historic Site from March 27, 2018, to November 1, 2018. The gray ribbon shows the daily maximum and minimum specific conductivity for the same period. The periods where the instrument did not collect data are indicated by gaps in the record.

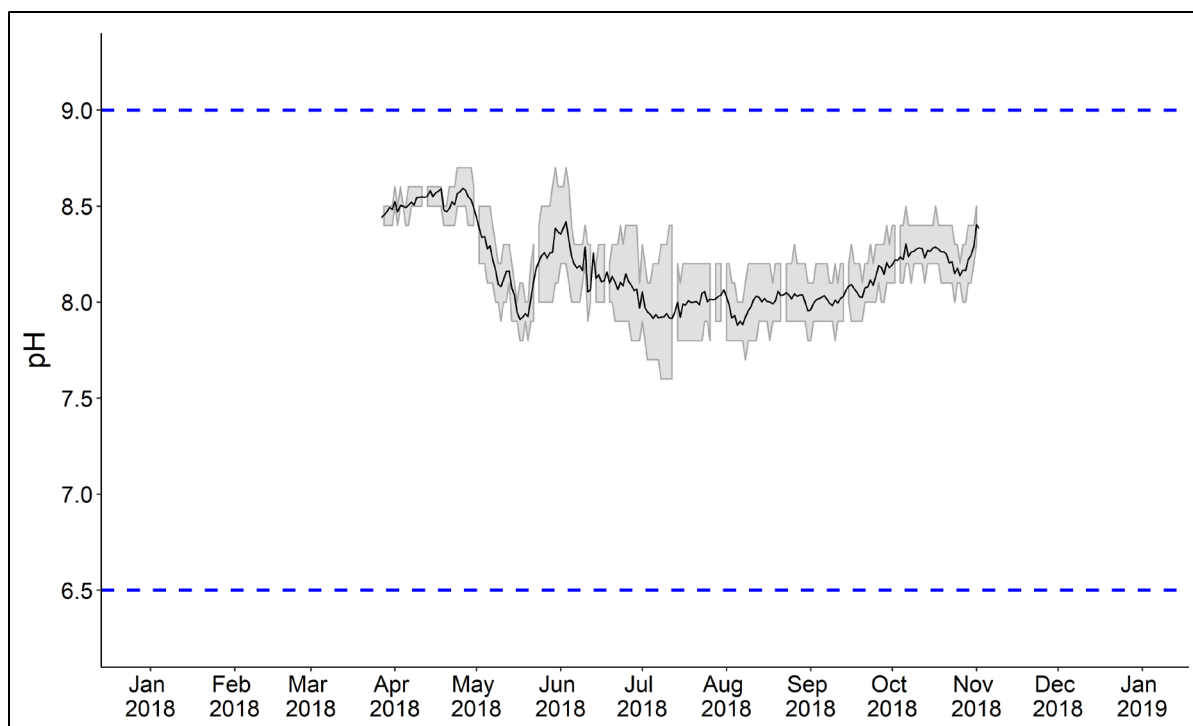


Figure 10. Daily mean pH (black line) of the Laramie River at Fort Laramie National Historic Site from March 27, 2018, to November 1, 2018. The gray ribbon shows the daily maximum and minimum pH for the same period. The dashed blue lines indicate the Wyoming state water quality standards (see Table 1 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 2018 water quality monitoring season at Fort Laramie National Historic Site. All data included in this report is available upon request from the [Northern Great Plains Inventory and Monitoring Network](#), as well as in the archives found on the [USGS National Water Information System for site 06670500](#).

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Appendix A. USGS Water Data Quality Report for Laramie River 06670500, 2018

The following report is from the USGS National Water Information System at https://nwis.waterdata.usgs.gov/wy/nwis/wys_rpt/?site_no=06670500&agency_cd=USGS.

06670500 LARAMIE RIVER NEAR FORT LARAMIE, WY

LOCATION - Lat 42°12'02", long 104°32'16" referenced to North American Datum of 1927, in NE 1/4 SE 1/4 NE 1/4 sec.28, T.26 N., R.64 W., Goshen County, WY, Hydrologic Unit 10180011, on right bank 600 ft upstream from bridge on county road, 0.6 mi upstream from mouth, and 1.1 mi southwest of Fort Laramie.

DRAINAGE AREA - 4,564 mi² of which 631 mi² probably is noncontributing.

REVISIONS HISTORY - WSP 1918: Drainage area.

SURFACE-WATER RECORDS

PERIOD OF RECORD: April 1915 to current year (no winter records prior to 1927). Monthly discharge only for some periods, published in WSP 1310. Records for water years 1926-39, previously published including diversions to Gering-Fort Laramie Canal, were adjusted to exclude flow in the canal in WSP 1310. Prior to October 1931, published as "at Fort Laramie". No diversion to Gering-Fort Laramie Canal since 1956.

GAGE: Water-stage recorder. Elevation of gage is 4,220 ft above NGVD of 1929, from topographic map. April 4, 1915 to March 31, 1925, nonrecording gage at site 0.1 mi downstream from station at different datum. April 1, 1925 to September 30, 1932, nonrecording gage and October 1, 1932 to August 20, 1935, water-stage recorder at site 4.3 mi upstream from station at different datum. August 21, 1935, to November 2, 1970, water-stage recorder at site 0.3 mi upstream from station at different datum. November 3, 1970 to May 9, 1973, water-stage recorder 0.1 mi downstream from station at different datum. May 10, 1973 to April 5, 1977, water-stage recorder 4.3 mi upstream from station at different datum. U.S. Army Corps of Engineers data collection platform with satellite telemetry at station.

COOPERATION: 10-15-2018 to 10-08-2019: Nine discharge measurements provided by the Wyoming State Engineer's Office. 11-03-2017 to 10-14-2018: Thirteen discharge measurements provided by the Wyoming State Engineer's Office. 10-01-2016 to 11-02-2017: Eleven discharge measurements provided by the Wyoming State Engineer's Office. 10-01-2015 to 09-30-2016: Fourteen discharge measurements provided by the Wyoming State Engineer's Office.

REMARKS: 10-15-2018 to 10-08-2019: records are fair, except estimated records are poor. 11-03-2017 to 10-14-2018: records are good, except estimated records are poor. 10-06-2016 to 11-02-2017: records are good, except estimated records are poor. 12-08-2015 to 10-05-2016: records are good, except estimated records are poor. 10-01-2014 to 12-07-2015: records are good, except estimated

records are poor. 10-01-2013 to 09-30-2014: records are good, except estimated records are poor. Major regulation began after completion of Grayrocks Reservoir in 1980. Diversion, at times, to Gering-Fort Laramie Canal, 5.4 mi upstream. Natural flow of stream affected by transbasin diversions, storage reservoirs, ground-water withdrawals and diversions for irrigation upstream from station, and return flow from irrigated areas.

EXTREMES FOR PERIOD OF RECORD: Minimum daily discharge, 2.0 ft³/s, Jan. 23, 1981, no flow Jan. 31 to Mar. 20, Oct. 24 to Dec. 17, 1926, Mar. 1-26, Apr. 14, 1938, all flows diverted to Gering-Fort Laramie Canal.

WATER-QUALITY RECORDS

PERIOD OF RECORD: October 1965 to June 1988, October 2003 to May 2014, October 2018.

PERIOD OF DAILY RECORD:

- SPECIFIC CONDUCTANCE: March to November 2015, March to November 2018.
- pH: March to November 2015, March to November 2018.
- WATER TEMPERATURE: March to November 2015, March to November 2018.
- DISSOLVED OXYGEN: March to November 2015, March to November 2018.

INSTRUMENTATION: Water-quality monitors for specific conductance, pH, water temperature, and dissolved oxygen.

REMARKS:

- SPECIFIC CONDUCTANCE 03-26-2015 to 11-02-2015: records are excellent, except records from Apr. 6-14, May 18, and Aug. 19-25 are good; records from May 19 and July 15-24 are fair; and records from June 3-5, and July 1-14 are poor.
- pH: 03-26-2015 to 11-02-2015: records are excellent, except records from July 19, Aug. 30 to Sept. 14, and Oct. 6 are good.
- WATER TEMPERATURE 03-26-2015 to 11-02-2015: records are excellent.
- DISSOLVED OXYGEN 03-26-2015 to 11-02-2015: records are excellent, except records from Apr. 10-14, Apr. 29 to May 1, and May 28 to June 2 are good. Maximum and minimum recorded values in the EXTREMES paragraph may have occurred during days of partial record and may not appear in the daily values tables.

EXTREMES FOR PERIOD OF RECORD:

- SPECIFIC CONDUCTANCE: Maximum recorded, 770 uS/cm, Jun. 8, 2018; minimum recorded, 369 uS/cm, May 29, 2015.

- pH: Maximum recorded, 8.7 units, Aug. 21-24 and Oct. 29 to Nov. 1, 2015; minimum recorded, 7.6 units, July 8 to 13, 2018.
- WATER TEMPERATURE: Maximum recorded, 27.5°C, July 1, 2015; minimum recorded, 2.2°C, Apr. 1, 2018.
- DISSOLVED OXYGEN: Maximum recorded, 13.5 mg/L, May 30, 2018; minimum recorded, 4.6 mg/L, July 8 and 10, 2018.

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NPS 375/170415, June 2020

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