



Water Quality Monitoring for Fort Laramie National Historic Site

2021 Data Report

Natural Resource Data Series NPS/FOLA/NRDS—2023/1388





ON THIS PAGE

Downstream from USGS Gaging Station 06670500 on the Laramie River in June 2021 at Fort Laramie National Historic Site.
Photograph by USGS, station 06670500

ON THE COVER

Upstream from USGS Gaging Station 06670500 on the Laramie River in June 2021 at Fort Laramie National Historic Site.
Photograph by NPS

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All manuscripts in the series receive the appropriate level of peer review to ensure that the information is scientifically credible and technically accurate.

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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 2021 ice-free season (April 5th through November 15th) for streamflow, water temperature, dissolved oxygen, specific conductance, and pH.

2021 was a dry year. Discharge on the Laramie River peaked at only 233 cubic feet per second (cfs) in May of 2021, less than the 2018 peak of 329 cfs in April and much less than the 4570 cubic feet per second peak in late May of 2015. A summary of our results can be found in Descriptive Statistics Summary tables for the ice-free season and for each month. Again, as in 2015 and 2018, water temperatures were consistently above the Wyoming state water quality standard for cold water fisheries from May through September. In 2021, 23.33% percent of samples were above the state standard of 20°C, July temperatures violated in 65.4% percent of samples.

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, of high priority to NGPN, is approximately 450 km long. The river 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 while the North Platte River forms its eastern border.

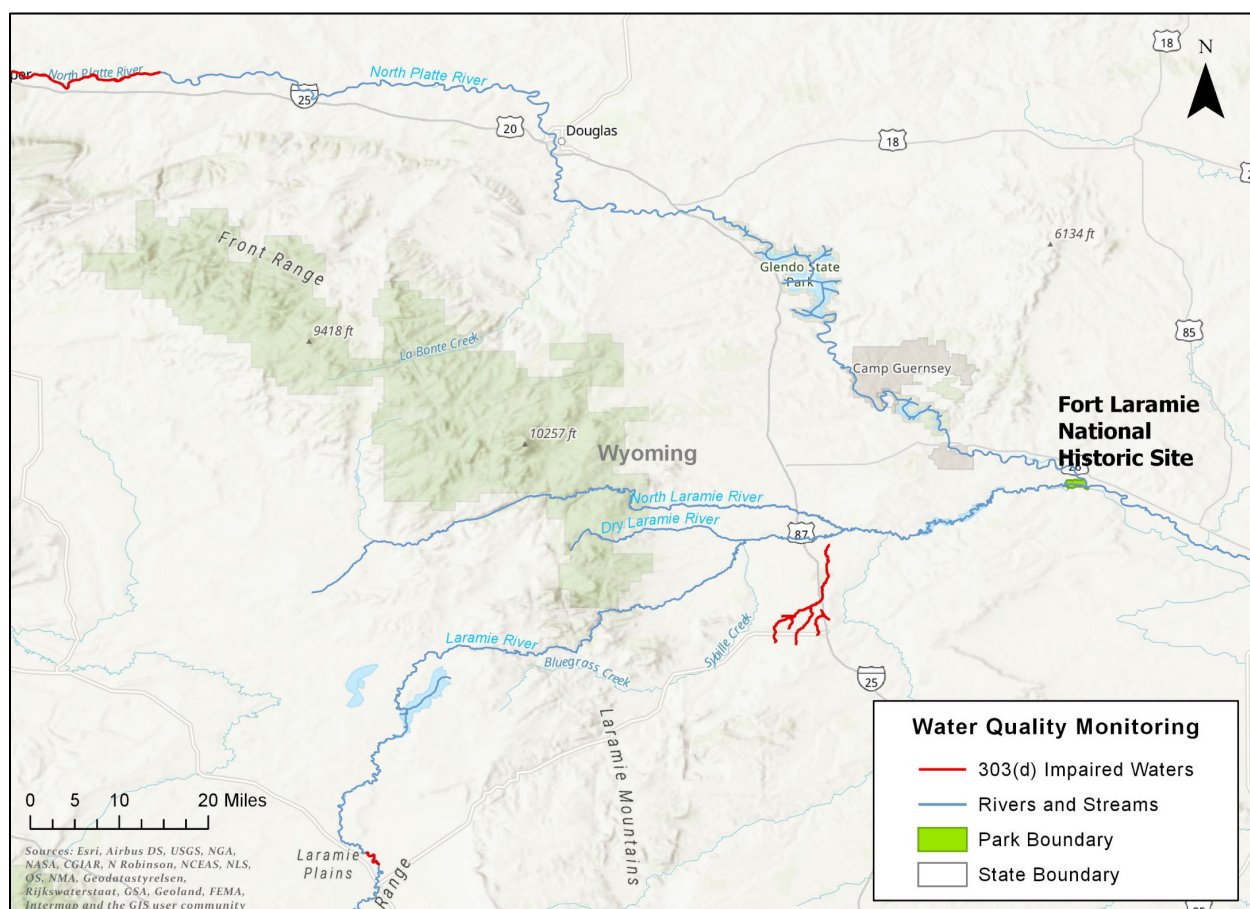


Figure 1. Map of Fort Laramie National Historic Site and the Laramie River and North Platte River in Wyoming. The stretches of the rivers highlighted in red are listed as impaired under 303(d) criteria for fecal coliform, *Escherichia coli*, or selenium. Both the North Platte River and the Laramie River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

The 6 km of the Laramie River running through Fort Laramie National Historic Site is considered a Class 1 water, as are all Wyoming waters flowing through National Parks (Figure 1). Class 1 waters have outstanding value. The Class 1 designation is based on the value of the water rather than on use attainment. No additional point sources other than dams are allowed to discharge to Class 1 waters.

The Laramie River at large 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). This portion of the Laramie River is unassessed by the state [How's My Waterway - Community \(epa.gov\)](#). However, some stretches of the river nearby are listed as impaired waterways under section 303(d) of the Clean Water Act for high fecal coliform and *Escherichia coli* concentrations. 26% of stream miles in the Laramie Basin and 69% of stream miles in the Lower North Platte/South Platte Basin are estimated to be impaired for *E. coli* (WYDEQ 2022). Nitrate and biological condition are other problems in the Laramie basin, though lack of local sampling impedes understanding of where the problems occur. Fort Laramie NHS lies 15 km downstream from Grayrocks Reservoir, which is privately operated to provide water for the Laramie River Power Plant. There are no large-scale restoration projects in the immediate vicinity of the park on the North Platte River [Nonpoint Source \(NPS\) Watershed Projects \(epa.gov\)](#) but resource conservation districts work to fund some watershed improvement activities elsewhere in the basin [Wyoming Watersheds Progress Report \(arcgis.com\)](#). For more details and current impairment information visit the Wyoming Department of Environmental Quality [website](#) or the EPA website, [How's My Waterway - Community \(epa.gov\)](#).

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, though continuous data was not used in this assessment (Dibner et al. 2018). Assessment of aquatic invertebrates indicated the Laramie River warranted moderate concern (Dibner 2018). The Laramie River was rated as having good ecosystem quality (Tronstad 2013) due to the community of aquatic invertebrates collected in the river and had high densities of sensitive taxa.

There are some water resource concerns though. Recent 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 and 2018 indicated periods in the summer where water temperature was much warmer than state standards for a significant portion of the season, 32% of samples in 2015 and 24% of samples in 2018. The Laramie River running through FOLA is functioning more as a warm water fishery than a cold water fishery (Ashton and Rockwood 2020 and Rockwood and Ashton 2020). The cold water fishery standard (20 °C) is much lower than the warm water fishery standard (30°C) and is the coldest temperature standard in NGPN (Wilson et al 2014). Even during warm summer months, the Laramie River has been able to maintain flows which lessens the impact of warm temperatures on the fish and other members of the aquatic community.



Figure 2. Photograph of the Laramie River, maintaining flow during the warm summer months.

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](#).

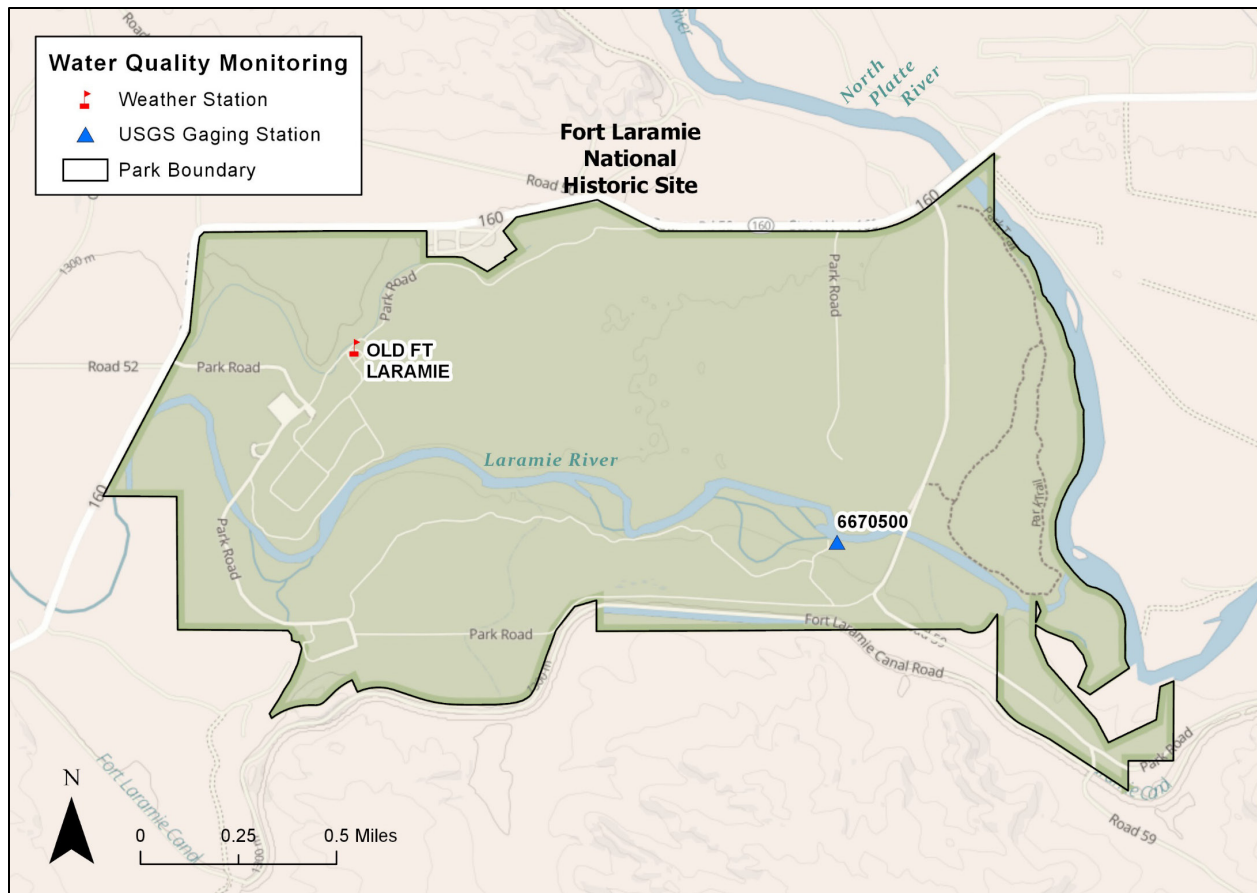


Figure 3. Map of Fort Laramie National Historic Site and water quality monitoring location (06670500, blue triangle) and nearby weather station (red flag). Climate data in this report is taken from USBR Whalen Dam weather station about 10 mi northwest of Old Ft. Laramie, as the Old Fort Laramie weather station had missing data during August–November.

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, 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.	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)	The dissolved oxygen (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.	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 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.	No criteria

Table 1 (continued). 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
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.	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 Water Quality Monitoring (U.S. National Park Service) (nps.gov)).

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 2021, 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 2021, 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 April 5, 2021, (Figure 4) and visited the gaging station every 3–4 weeks for equipment maintenance (Table 2). This instrument recorded dissolved oxygen, pH, specific conductivity, and water temperature every 15 minutes, while the gage simultaneously measured stream stage (or gage height, 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.

Table 2. Field journal for 2021 Water Quality Sampling at Fort Laramie National Historic Site.

Date	Notes
April 5, 2021	YSI 6920 multiparameter sonde installed for the season. Cross-section collected.
May 5, 2021	DCP downloaded. Sonde inspected. Cross-section collected.
June 3, 2021	Routine calibration visit, cleaned probe and monitor. Cross-section collected.
June 30, 2021	Routine calibration visit, cleaned probe and monitor. Cross-section collected. Some fouling June 10–24.
July 28, 2021	Routine calibration visit, cleaned probe and monitor. Sonde malfunctioned July 4–7, 12, 16, 17, 18, 20–22, 24–28. Cross-section collected. Some fouling July 18–28.
September 2, 2021	Routine calibration visit, cleaned probe and monitor. Peak streamflow calculated. Sonde malfunctioned Aug. 3, 4, 6–8. Cross-section collected.
October 21, 2021	Routine calibration visit, cleaned probe and monitor. Sonde malfunctioned Sept. 26 and Oct 5,6,8. Cross-section collected. Some fouling Sept. 9–15, Oct. 4–11,15,18,21.
November 16, 2021	Removed sonde from water. Cross-section collected. Some fouling October 23–27.

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. 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 15, 2021, 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 November of 2022 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 USBR Whalen Dam (489604) National Weather Service Cooperator Observer Program station. The data were accessed and graphed using the web-based tool [Climate Analyzer](#).

Results

The water quality monitoring season (ice-free) on the Laramie River at FOLA lasted from April 5, 2021 to November 15, 2021. The gage at Fort Laramie is permanent and flow is measured year-round. Except for the May- early June peak, discharge remained around 50 cubic feet per second (Figure 5). In mid-May discharge peaked at 233 cubic feet per second. 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 2021 sampling year had a much lower flow (Ashton and Rockwood 2020).

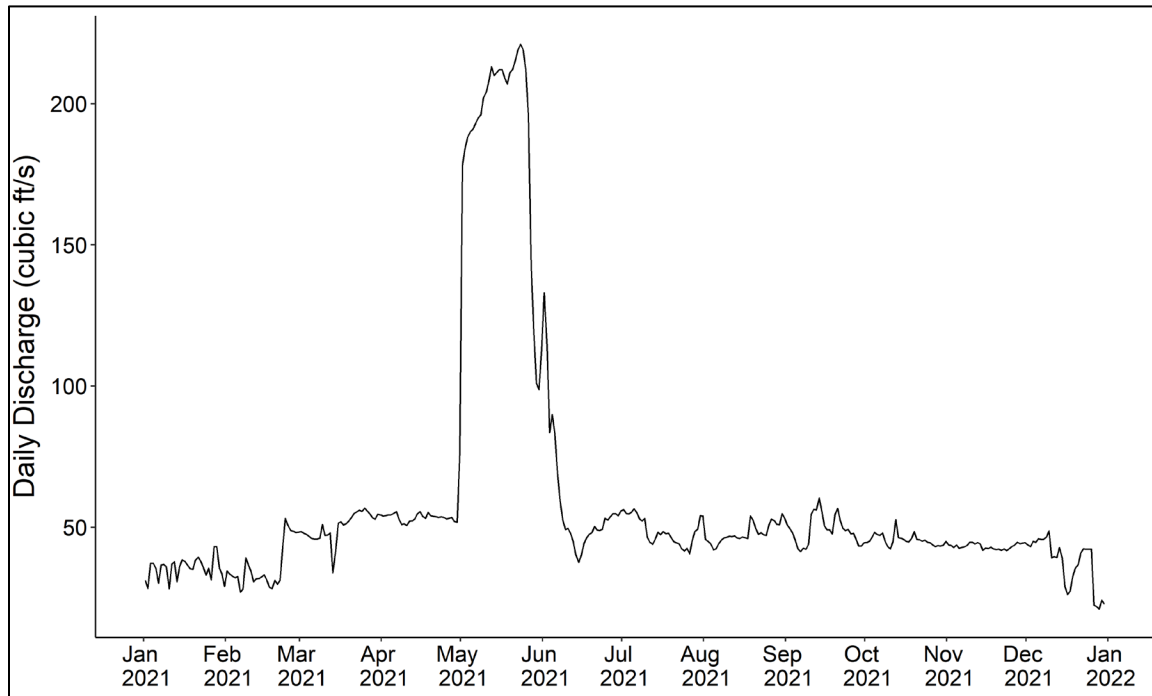


Figure 5. Daily mean gage height (black line) on the Laramie River at Fort Laramie National Historic Site 2021, at USGS Gaging Station 06670500.

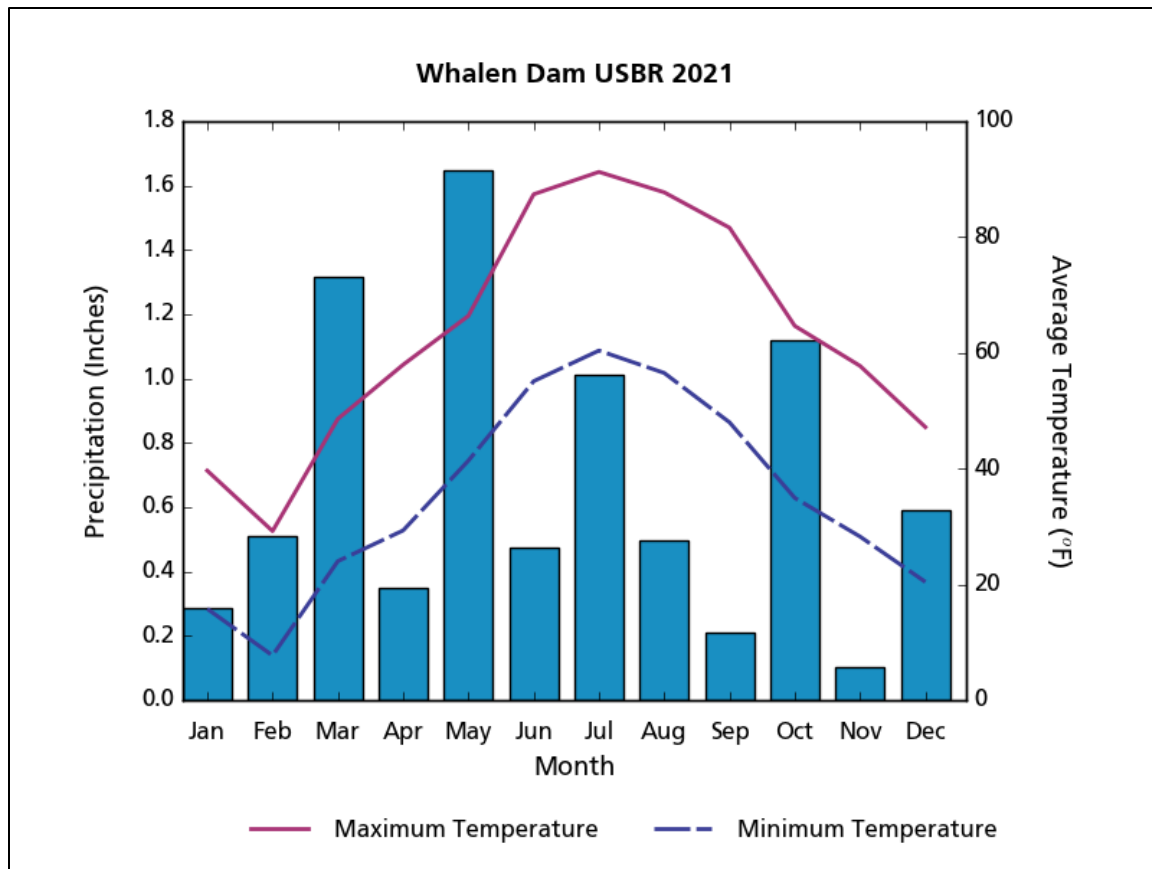


Figure 6. Total monthly precipitation (blue bars) and average monthly minimum (dashed blue) and maximum (red) temperature for the 2021 calendar year near Fort Laramie National Historic Site..

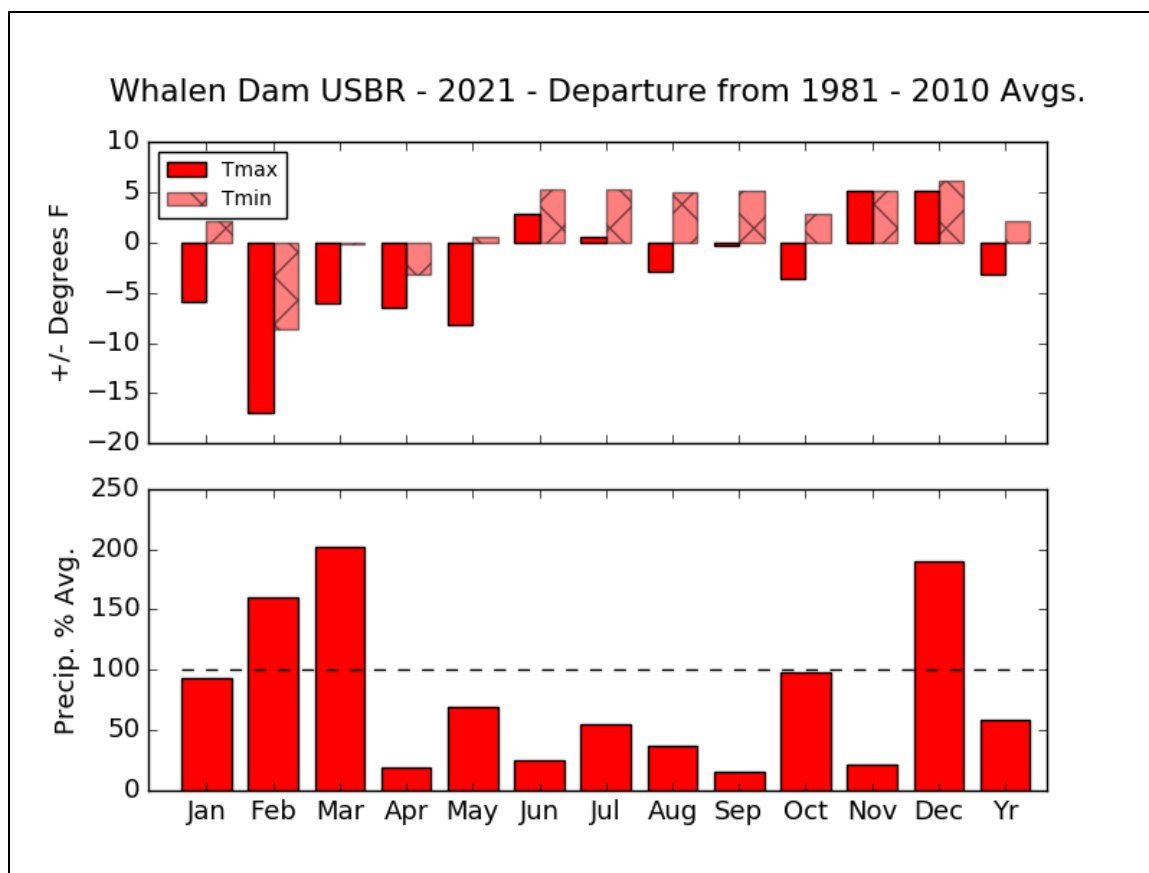


Figure 7. Monthly departures from 1981–2010 average temperature (top panel) and precipitation (bottom panel) for the 2021 water year near Fort Laramie National Historic Site. Climate data are from Whalen Dam USBR site (489604), as Old Fort Laramie Station (486852) had missing data in 2021. The data were 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 15.53°C, dissolved oxygen concentrations of 8.58 mg/L, specific conductance of 641.31 $\mu\text{S}/\text{cm}$, and pH of 8.24 (Table 3). There was, however, variation across months in all parameters (Table 4). Mean water temperature in April was 9.75°C and doubled by June to 20.79°C (Table 3, Figure 8). 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 June to September (Table 4). Overall, 23.3% of the recorded temperatures were above the state threshold for cold water fisheries (Table 3), a major violation of the temperature standard.

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 April 5, 2021, to November 15, 2021. 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 ($\mu\text{S}/\text{cm}$)	pH
Number of measurements	20600	20526	18386	20322
Mean	15.53	8.58	641.31	8.24
Standard Deviation	5.41	1.79	17.83	0.19
Median	16.4	8.7	639	8.2
Minimum	2.6	4.5	583	7.8
Maximum	28.2	12.5	696	8.8
Water Quality Standard	<20 (C°)	> 5 mg/L	Not reported	6.5–9.0
Number of Points violating water quality standard	4805	163	–	0
% Exceedance	23.33%	0.79%	–	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 April 5, 2021, to November 15, 2021. 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
April 5–30 2021	Number of measurements	2443	2443	2443	2443
	Mean	9.75	9.99	665.02	8.33
	Standard Deviation	3.17	1.3	8.82	0.15
	Median	9.7	10.1	663	8.3
	Minimum	2.6	6.9	652	8.1
	Maximum	19.3	12.3	693	8.7
	% Exceedance	0	0	–	0
May-21	Number of measurements	2973	2974	2973	2973
	Mean	13.1	9.24	632.87	8.41
	Standard Deviation	2.76	1.27	28.56	0.14
	Median	13	9.1	621	8.4

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 April 5, 2021, to November 15, 2021. 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
May-21 (continued)	Minimum	6.8	6.4	583	8
	Maximum	19.6	11.9	696	8.7
	% Exceedance	0	0	–	0
Jun-21	Number of measurements	2872	2870	2165	2672
	Mean	20.79	7.51	643.38	8.19
	Standard Deviation	2.82	1.58	8.74	0.18
	Median	20.6	7.4	645	8.2
	Minimum	14.7	4.8	624	7.8
	Maximum	28.2	10.9	665	8.6
	% Exceedance	56.82	0.94	–	0
Jul-21	Number of measurements	2393	2367	1821	2397
	Mean	21.21	7.29	636.47	8.09
	Standard Deviation	2.16	1.68	6.63	0.15
	Median	21.1	7.3	636	8.1
	Minimum	16.9	4.5	620	7.8
	Maximum	26	10.8	659	8.4
	% Exceedance	65.4	5.75	–	0
Aug-21	Number of measurements	2809	2809	2809	2809
	Mean	19.67	7.91	646.36	8.13
	Standard Deviation	2.11	1.92	11.69	0.19
	Median	19.6	7.6	648	8.1
	Minimum	14.3	5.2	604	7.8
	Maximum	24.6	12.5	668	8.5
	% Exceedance	42.54	0	–	0
Sept- 2021	Number of measurements	2839	2841	2627	2807
	Mean	17.4	7.98	639.89	8.2
	Standard Deviation	2.43	1.46	9.35	0.2
	Median	17.6	7.7	640	8.2
	Minimum	10.1	5.9	610	7.9

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 April 5, 2021, to November 15, 2021. 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
Sept- 2021 (continued)	Maximum	22.4	11.3	669	8.8
	% Exceedance	14.55	0	–	0
Oct-21	Number of measurements	2827	2826	2153	2824
	Mean	10.96	9.33	632.65	8.3
	Standard Deviation	2.98	1.2	9.09	0.13
	Median	10.5	9.1	631	8.3
	Minimum	2.8	6.9	606	8.1
	Maximum	18.5	11.8	651	8.7
	% Exceedance	0	0	–	0
November 1–15, 2021	Number of measurements	1444	1396	1395	1397
	Mean	7.61	10.23	626.72	8.31
	Standard Deviation	1.75	0.99	3.72	0.08
	Median	7.8	10.1	626	8.3
	Minimum	2.6	8.6	619	8.2
	Maximum	11.4	12.5	639	8.4
	% Exceedance	0	0	–	0

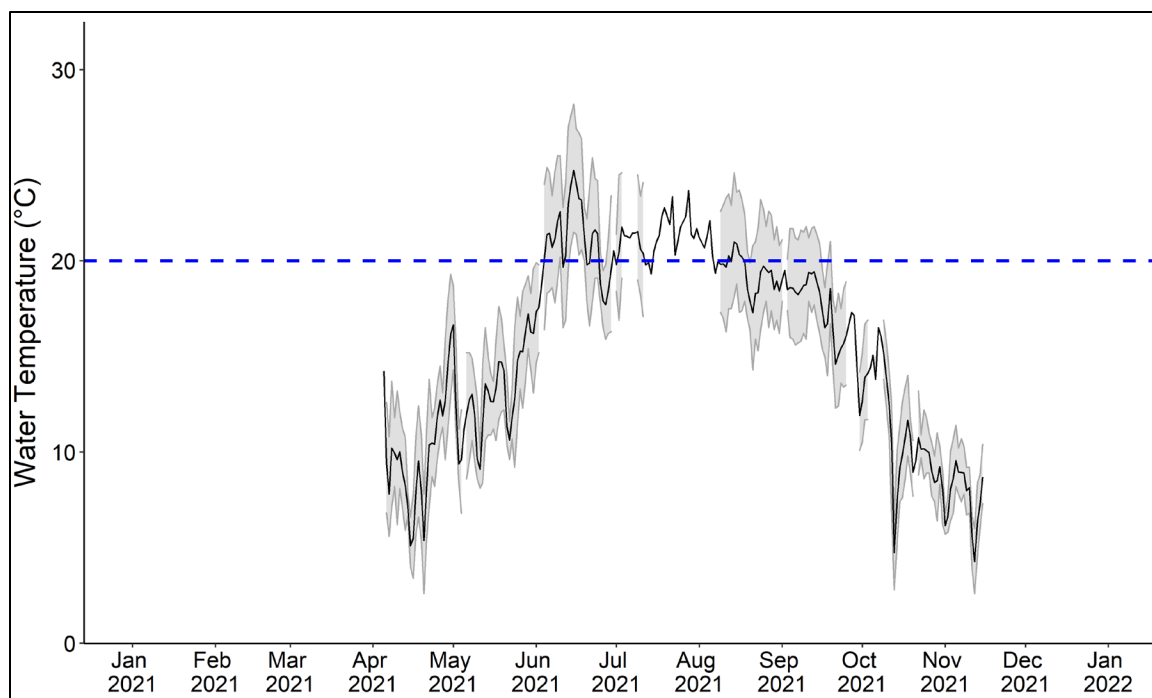


Figure 8. Daily mean water temperature (black line) collected on the Laramie River at Fort Laramie National Historic Site from April 5, 2021, to November 15, 2021. The gray ribbon shows the daily maximum and minimum water temperature for the same period. The dashed blue line indicates one of the Wyoming 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.

Dissolved oxygen displayed seasonal variation (Table 4, Figure 9). The highest mean dissolved oxygen concentrations were in the spring and fall, averaging greater than 9 mg/ L in April, May, October, and November. Dissolved oxygen minimums fell below Wyoming state water quality criteria (Table 1) in June and July, however the violations were minor with only .79% of samples violating standards.

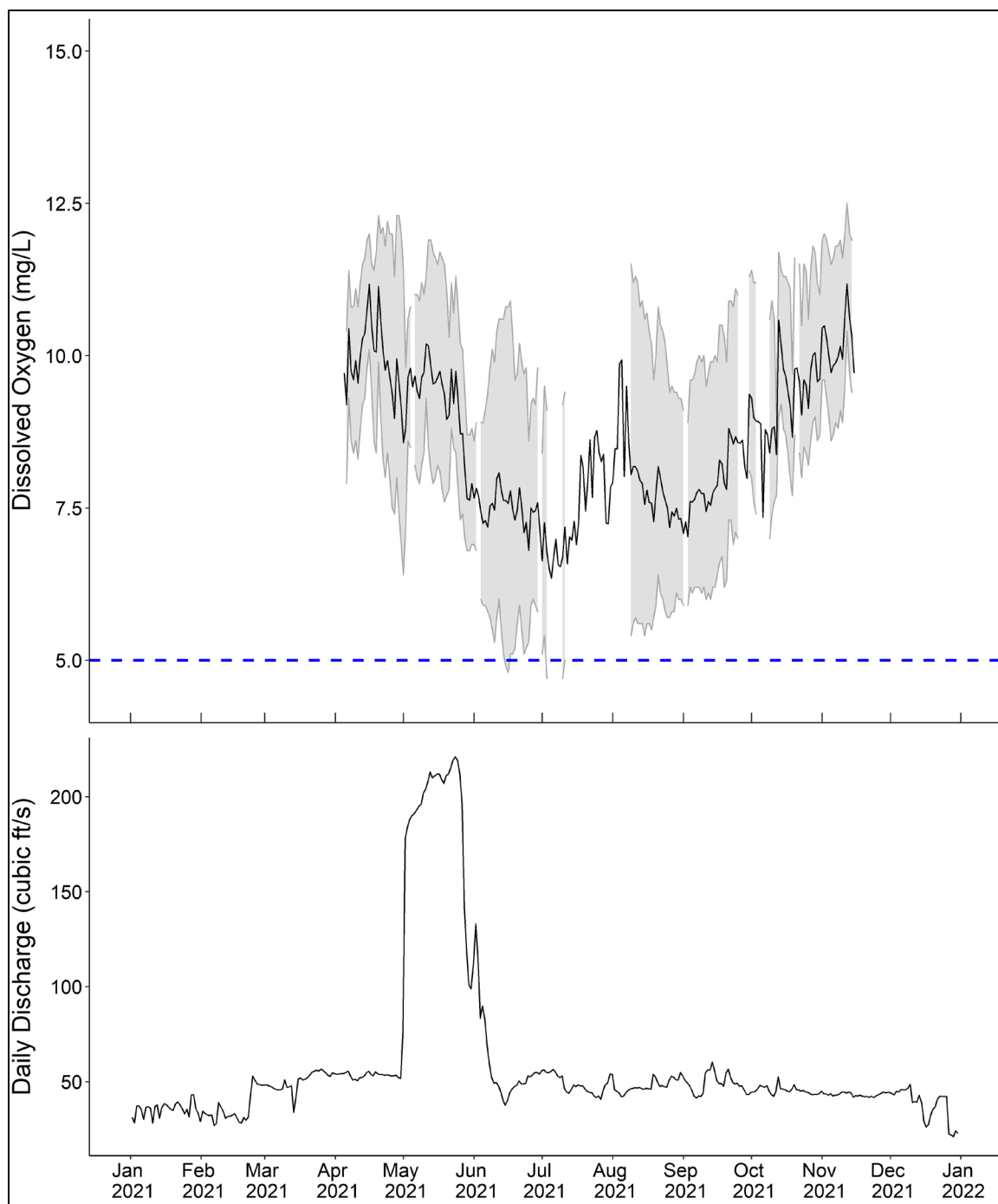


Figure 9. Daily mean dissolved oxygen concentrations (black line; top graph) and daily discharge (bottom) of the Laramie River at Fort Laramie National Historic Site from April 5, 2021, to November 15, 2021. The gray ribbon shows the daily maximum and minimum dissolved oxygen for the same period. The 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.

Specific conductance of the Laramie River stayed roughly between 580 and 700 $\mu\text{S}/\text{cm}$ (Table 3, Figure 10). The pH of the Laramie River ranged between 7.8 and 8.8 (Figure 11) and was never outside the range of the Wyoming state standards of 6.5–9.0.

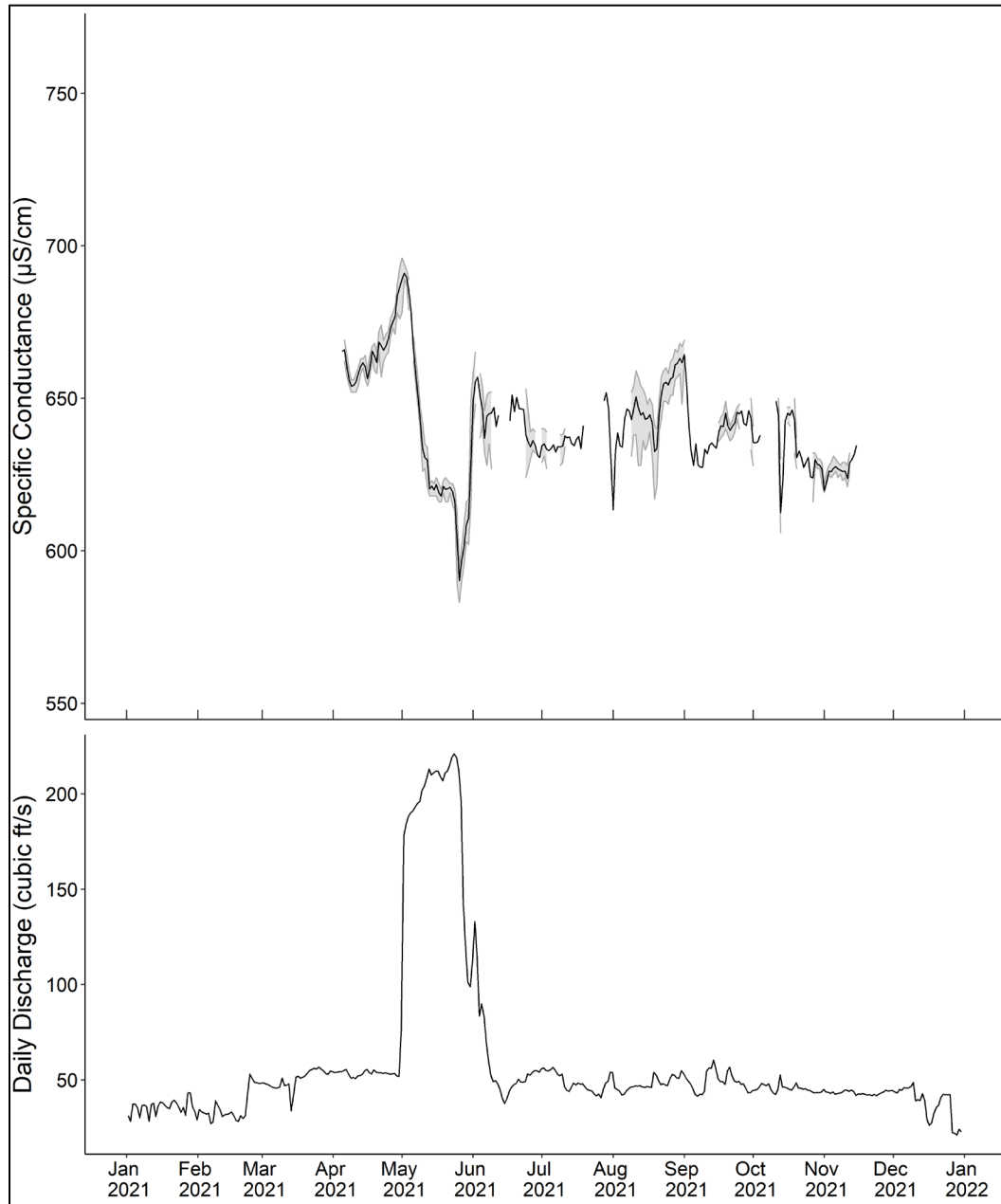


Figure 10. Daily mean specific conductance (top) and daily discharge (bottom) of the Laramie River at Fort Laramie National Historic Site from April 5, 2021, to November 15, 2021. The gray ribbon shows the daily maximum and minimum specific conductivity for the same period. The periods where the instrument did not collect data are indicated by gaps in the record.

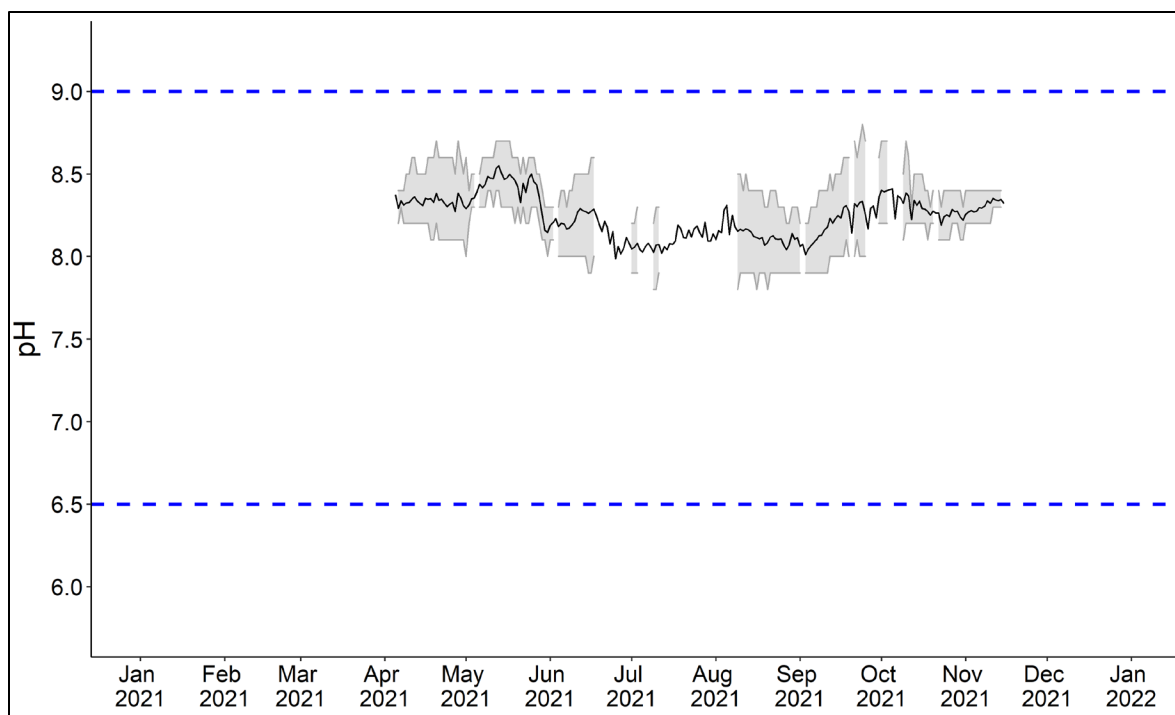


Figure 11. Daily mean pH (black line) of the Laramie River at Fort Laramie National Historic Site from April 5, 2021, to November 15, 2021. The gray ribbon shows the daily maximum and minimum pH for the same period. The dashed blue lines indicate the Wyoming state water quality standards (see Table 1 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 2021 water quality monitoring season at Fort Laramie National Historic Site. All data included in this report are 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. 06670500 Laramie River near Fort Laramie, WY Station Analyses, 2021

06670500 Laramie River near Fort Laramie, WY

Discharge Time Series

Analysis Period: 09/02/2021 to 12/08/2021

Analysis:

Gage-Height Record: The gage-height record for the period between Sept. 2 to Dec. 8 ranged from “fair” to “good” quality. Records were mostly complete during the period of analysis. Erroneous record was deleted on Nov. 17, 18, 25, and Dec. 6 due to cold/pressure leaks.

Datum: Levels were last completed on Dec. 22, 2020. The outside staff gage was reading +0.29 ft high, and a -0.29 ft datum correction was applied on Dec. 13, as it appears ice moved the outside gage around that time.

Backup Data: The DCP was downloaded on Oct. 21, but EDL data wasn’t used.

Ice Affected: Record was not affected backwater from ice for the period.

Edits: No edits

Gage-Height Corrections: The gage-height corrections applied during the period of analysis ranged from +0.10 to +0.12 ft and were prorated by time between site visits.

Outside gage chain was found to be off bolt on measurement no. 1148 (Dec 8). It is suspected that the OG reading for measurement no. 1147 (Nov 16) may have been incorrectly read due to the chain being off the bolt. Therefore, on Nov 16 a +0.10 ft correction was continued, as indicated on Sep 2. This correction was continued until Nov 17, when a cold leak occurred. After this cold leak, the correction indicated Dec 8 (0.11 ft) was applied.

It should be noted that a WSEO measurement was completed on Dec 1. The gage height for this measurement was also thought to be affected by chain and bolt conundrum.

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

Peak Stage: The peak computed stage (not verified as water level never reached CSG) during the period of analysis was 2.53 ft on Sept. 14. Stage-Discharge Relation: Rating 24.1 was continued during the period of analysis.

Discharge Measurements and Control Conditions: Six discharge measurements, Nos. 1145–1148 were completed during the period of analysis. Four measurements were completed by USGS personnel and two measurements were completed by WSEO personnel.

Measured discharge ranged from 42.6 to 51.0 cfs. All measurements were considered in the rating-shift analysis. No measurements were completed when the stage was affected by backwater from ice. Control conditions are only known for the USGS measurements. All measurements were completed during “clear” control conditions. The actual “control” is a little vague at the site, probably more influenced by the channel rather than any discrete feature.

Shift Curves: The indicated shifts ranged from +0.32 to +0.36 ft.

Indicated shifts during the period of analysis described a stable control condition.

One “half-house” shift curve was applied during the period of analysis. Shifts were applied up to a gage height of 2.9 ft, then the curves were merged back to the rating at 12.0 ft.

Application of Shift Curves: Shifts ranged from +0.32 to +0.36 ft and were prorated by time between inspections. The control remained in a stable, scoured state for the period.

In general, while the control remains in a scoured state, shifts trend to be more positive at lower flows and more negative at medium flows. The reason could be at medium flows the control is more influenced by the channel with brush and grass along the banks. All measurements during the period were made in low flow conditions.

Computed Discharge: Computed discharge ranged from 39.1 to 64.2 cfs during the period of analysis.

Estimates: Discharge records were not estimated for the period.

Hydrographic Comparison: North Platte River at WY/NE State Line (06674500)

Peak Streamflow: A peak of 64.2 cfs was computed on Sept 14 during the period of analysis.

Extremes For 2021 Water Year:

Gage height: 3.42 ft on May 24. Discharge: 233 cfs on May 24.

Comments: Records fair, expect those for estimated discharges, which are poor.

Gage-Height Record: The gage-height record for the period between Oct. 29, 2020 to Sept. 02, 2021 ranged from “poor” to “good” quality. Records were mostly complete during the period of analysis. Ice affected/obstructed record was deleted for many days from Dec. 3, 2020 to Mar. 15, 2021. Record was also deleted on Mar. 31, 2021 and Apr.01, 2021.

Datum: Levels were completed on Dec. 22, 2020. The outside staff gage was reading +0.29 ft high, and a -0.29 ft datum correction was applied on Dec. 13, as it appears ice moved the outside gage around that time.

Backup Data: The DCP was downloaded on May 5, 2021, but EDL data wasn’t used.

Ice Affected: Record was considered affected by backwater from ice on Dec. 18–21, 24–26, Dec. 30 to Jan. 1, Jan. 2, 3, 7, 9, 11–13, 14–16, 20, 21, 27–29, Feb. 7–9, 11–19, and Mar. 13–16. According

to the variable nature of the record it is difficult to discern areas of true backwater from ice, but record was estimated based off mean values/weather trends to maintain continuity.

Edits: No edits were completed during the period of analysis.

Gage-Height Corrections: The gage-height corrections applied during the period of analysis ranged from -0.29 to $+0.16$. Corrections were varied during the period of analysis due to erratic orifice movement/possible electronic drift and possible outside gage movement over time. Levels need to be ran again to determine the diverse nature of corrections as the conditions of the site should not warrant the wide range of corrections indicated.

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

Peak Stage: The peak computed stage (not verified as water level never reached CSG) during the period of analysis was 3.42 ft on May 24.

Stage-Discharge Relation: Rating 24.1 was continued during the period of analysis.

Discharge Measurements and Control Conditions: Eighteen discharge measurements, Nos. 1137–1145 were completed during the period of analysis. Nine measurement was completed by WSEO personnel.

Measured discharge ranged from 43.7 to 190 cfs. All measurements were considered in the rating-shift analysis.

No measurements were completed when the stage was affected by backwater from ice. Control conditions are only known for the USGS measurements. All measurements were completed during “clear” control conditions, except for Measurement No. 1139, which had shore ice. The actual “control” is a little vague at the site, probably more influenced by the channel rather than any discrete feature.

Shift Curves: The indicated shifts ranged from $+0.11$ to $+0.37$ ft.

Indicated shifts during the period of analysis described a changeable control condition, most likely attributable to variation over time.

Two shift curves were applied during the period of analysis. They were both “half house” type. The indicated shifts were applied up to a gage height of 3.5 ft, then the curves were merged back to the rating at 12.0 ft.

Application of Shift Curves: As shifts were a bit erratic during the period of analysis, shift curves were basically applied at points when discharge changed, then held static until the next change in flow.

For more in-depth descriptions of times applied see Aquarius.

The +0.11 ft shift from Oct. 29 was continued until Dec. 13 before the datum correction was applied. Measurement No. 1140 on Dec. 22 indicated a +0.37 ft shift after the datum correction. The +0.37 ft shift on Dec. 22 was prorated to the +0.31 ft shift on Feb. 23. The +0.31 ft correction on Feb. 23 was prorated to the +0.36 ft correction on Apr. 4.

The +0.36 ft shift from Apr. 4 was continued to May 1, before and increase in discharge. Measurement No. 1141 on May 5 indicated a +0.24 ft shift. The +0.24 ft shift was applied on May 2, after the increase in discharge. The +0.24 ft shift on May 5 was prorated to the +0.26 ft shift indicated on June. 3. Shifts from Jun. 30 to Sept. 2 ranged from +0.32 to +0.36 ft and were prorated by time between inspections.

In summary, while the control remains in a scoured state, shifts trend to be more positive at lower flows and more negative at medium flows. The reason could be at medium flows the control is more influenced by the channel with brush and grass along the banks.

Computed Discharge: Computed discharge ranged from 7.6 to 233 cfs during the period of analysis.

Estimates: Discharge records were estimated on Dec. 3, 8, 18–21, 24–26, Dec. 30 to Jan. 1, Jan. 2, 3, 7, 9 11–13, 14–16, 20, 21, 27–29, Feb. 7–9, 11–19, Mar. 13–16, and July 21–22.

Hydrographic Comparison: North Platte River at WY/NE State Line (06674500).

Peak Streamflow: A peak of 233 cfs was computed on May 24 during the period of analysis.

Extremes For 2021 Water Year: TBD

Comments: Records fair, expect those for estimated discharges, which are poor.

Dissolved Oxygen Time Series

Analysis Period: 11/02/2018 to 11/16/2021 Analysis:

Record: April 5 to November 1, 2021 (discontinued for the season). Data were collected Nov. 1 to 16. However, data were not published after Nov. 1 per agreement.

The sonde malfunctioned for short periods and no data were received the following days: July 4–7, 12, 16, 17, 18, 20–22, 24–28, 31, Aug. 3, 4, 6–8, Sept. 26, Oct. 5, 6, 8

Site characteristics: Sand, gravel, and rock banks and bottom. Channel curves upstream of the gage and is straight in the reach of the sonde. Banks are sparsely covered with grass, cactus on the right bank with a few dead trees. The left bank has more trees and grass.

Instrumentation YSI 6920 multi-parameter Sonde with water temperature, specific conductance, dissolved oxygen, and pH. A Sutron Satlink DCP provided data for the period of analysis.

Sampling location: 180 ft downstream from gage house.

Field Visits: During the period of analysis, the sonde was serviced 8 times. The sonde was installed April 5, removed Nov. 16, and inspections were completed on the following days: May 5, June 3, 30, July 28, Sept. 2, and Oct. 21.

Deletions: Erroneous values recorded during monitor maintenance on June 30, July 28, Oct. 21 and Nov. 16 (Although data were only published until Nov. 1).

Data were deleted using the adjustable trim tool, due to temporary fouling on July 8, 9, and 15–20.

Fouling Corrections: April 5 to May 5: The sonde was installed on April 5. During the inspection on May 5 a -4.93% (-0.55mg/L) fouling correction was indicated and applied.

June 3 a 0.58% fouling correction was indicated. This correction was well below published criteria of correction, and no fouling correction was applied.

June 30 a -2.42% fouling correction was indicated. Unit values were used for the before and after cleaning readings, as readings made during the inspection were considered slightly unstable.

July 28 a 4.68% fouling correction was applied as indicated. As no specific period of fouling could be determined, fouling was prorated between inspections June 30 to July 28.

July 28 to Nov. 16 four inspections were completed. Sept. 2 a -0.81% fouling correction was indicated. Oct. 21 a 0.19% fouling correction was indicated. Nov. 16 a 0.09% fouling correction was indicated. Indicated fouling corrections were well within published criteria of correction, and no fouling correction were applied.

Calibration Drift Corrections: During the period of analysis, drift corrections were minor. During each inspection, the DO probe was cleaned and calibrated. However, not all indicated drift corrections were applied, as drift corrections were not always indicated by unit values. This was mostly attributed to the sonde not being quite stable during calibration.

May 5 a -4.05% drift correction was indicated. This was not applied to maintain continuity of record. When the correction was applied a distinct jump in computed data was evident. Readings during calibration were assumed to be slightly unstable.

June 3 a 1.28% drift correction was indicated. Although this was within published criteria, the correction was applied as indicated to maintain continuity of record. In addition, the DO probe was recalibrated during this inspection.

June 30 a 5.8% drift correction was applied as indicated. The probe was cleaned and calibrated during the inspection

July 28 a 3.53% drift correction was applied as indicated. The probe was cleaned and calibrated during the inspection.

Sept. 2 a -1.46% fouling correction was indicated. This was well within published criteria, and no drift correction was applied.

Water Temperature Time Series

Analysis Period: 11/02/2018 to 11/16/2021 Analysis:

Record: April 5 to November 1, 2021 (discontinued for the season). Data were collected Nov. 1 to 16. However, data were not published after Nov. 1 per agreement.

The sonde malfunctioned for short periods and no data were received the following days: July 4–7, 12, 16, 17, 18, 20–22, 24–28, 31, Aug. 3, 4, 6–8, Sept. 26, Oct. 5, 6, 8

Site characteristics: Sand, gravel, and rock banks and bottom. Channel curves upstream of the gage and is straight in the reach of the sonde. Banks are sparsely covered with grass, cactus on the right bank with a few dead trees. The left bank has more trees and grass.

Instrumentation: YSI 6920 multi-parameter sonde with water temperature, specific conductance, dissolved oxygen, and pH. A Sutron Satlink DCP provided data for the period of analysis.

Sampling location: 180 ft downstream from gage house.

Field Visits: During the period of analysis, the sonde was serviced 8 times. The sonde was installed April 5, removed Nov. 16, and inspections were completed on the following days: May 5, June 3, 30, July 28, Sept. 2, and Oct. 2.

Deletions: Erroneous values were deleted July 28 during servicing of the sonde.

Fouling Corrections: None. Well with 0.2 degrees C.

Calibration Drift Corrections: None.

Other Corrections: None.

Cross-section surveys: Completed with each site visit.

Vertical profiles: None. River too shallow for vertical profiles.

Remarks: Records are excellent.

Specific Conductance Time Series

Analysis Period: 11/02/2018 to 11/16/2021 Analysis:

Record: April 5 to November 1, 2021 (discontinued for the season). Data were collected Nov. 1 to 16. However, data were not published after Nov. 1 per agreement.

The sonde malfunctioned for short periods and no data were received the following days: July 4–7, 12, 16, 17, 18, 20–22, 24–28, 31, Aug. 3, 4, 6–8, Sept. 26, Oct. 5, 6, 8.

Site characteristics: Sand, gravel, and rock banks and bottom. Channel curves upstream of the gage and is straight in the reach of the sonde. Banks are sparsely covered with grass, cactus on the right bank with a few dead trees. The left bank has more trees and grass.

Instrumentation: YSI 6920 multi-parameter sonde with water temperature, specific conductance, dissolved oxygen, and pH. A Sutron Satlink DCP provided data for the period of analysis.

Sampling location: 180 ft downstream from gage house.

Field Visits: During the period of analysis, the sonde was serviced 8 times. The sonde was installed April 5, removed Nov. 16, and inspections were completed on the following days: May 5, June 3, 30, July 28, Sept. 2, and Oct. 2.

Deletions: Data were deleted due to temporary fouling on the following days: June 10, 11, 12–24, July 18–28, Sept. 9–15, Oct. 4–11, 15, 18, 21, 23–27.

Fouling Corrections: Fouling was mainly attributed to silt or algae during the period of analysis. Indicated fouling corrections ranged from 7.58 to –20.29%. Minimum published criteria for correction is $\pm 3\%$. However, to maintain continuity of record corrections were mostly applied as indicated.

April 5 to June 30: The sonde was installed April 5, and three subsequent inspections were completed. During this period, fouling corrections were applied as indicated and prorated mostly by time between inspections. Fouling indicated June 30 was initiated in

Calibration Drift Corrections: The published criteria for drift correction is $\pm 3\%$. No drift corrections were applied during the period of analysis, as indicated-drift corrections ranged from –0.66 to +0.85%. The sonde calibration was checked during each inspection for the period of analysis.

Other Corrections: None.

Cross-section surveys: Cross sectional surveys were done about 180ft downstream from the sonde and readings are compatible with the readings at the sonde. Cross-sectional surveys were completed during each visit.

Vertical profiles: None completed, as the depth of stream does not warrant a vertical profile.

Remarks: Records are good except for several periods when temporary fouling necessitated the downgrade of the record to fair. The record is rated fair June 10, 11, 12–24, July 18–28, Sept. 9–15, Oct. 4–11, 15, 18, 21, 23–27.

pH Time Series

Analysis Period: 11/02/2018 to 11/16/2021 Analysis:

Record: April 5 to November 1, 2021 (discontinued for the season). Data were collected Nov. 1 to 16. However, data were not published after Nov. 1 per agreement.

The sonde malfunctioned for short periods and no data were received the following days: July 4–7, 12, 16, 17, 18, 20–22, 24–28, 31, Aug. 3, 4, 6–8, Sept. 26, Oct. 5, 6, 8.

Site characteristics: Sand, gravel, and rock banks and bottom. Channel curves upstream of the gage and is straight in the reach of the sonde. Banks are sparsely covered with grass, cactus on the right bank with a few dead trees. The left bank has more trees and grass.

Instrumentation YSI 6920 multi-parameter Sonde with water temperature, specific conductance, dissolved oxygen, and pH. A Sutron Satlink DCP provided data for the period of analysis.

Sampling location: 180 ft downstream from gage house.

Field Visits: During the period of analysis, the sonde was serviced 8 times. The sonde was installed April 5, removed Nov. 16, and inspections were completed on the following days: May 5, June 3, 30, July 28, Sept. 2, and Oct. 21.

Deletions: Erroneous values recorded during monitor maintenance on June 30, July 28, Oct. 21 and Nov. 16 (Although data were only published until Nov. 1). June 19 to 29 several erroneous values were deleted due to temporary fouling.

Fouling Corrections: April 5 to May 5: The sonde was installed on April 5. During the inspection on May 5 a -0.18 -unit fouling correction was indicated. However, a -0.24 correction was indicated with respect to the unit values and was applied. This discrepancy may be partially due to a small drift correction -0.12 which was not applied separately, as it was within published criteria of correction.

June 3 a -0.05 -unit fouling correction was indicated. This correction was well below published criteria of correction. However, the correction was applied to maintain continuity of record.

June 30 a -0.10 -unit fouling correction was indicated. Unit values were used for the before and after cleaning readings, as readings made during the inspection were considered unstable.

July 28 a 0.10 -unit fouling correction was indicated. This correction was initially applied, but corrected data did not fit surrounding trends well. The probe was thought slightly unstable during cleaning, and no correction was applied.

July 28 to Oct. 21 four inspections were completed. Sept. 2 a -0.25 unit fouling correction was indicated. However, when plotted corrected data did not line up well with after cleaning data. Assuming sonde not quite stable during calibration. Oct. 21 a 0.13 unit fouling correction was indicated and applied.

Nov. 16 the pH probe was damaged during cleaning. Therefore, no correction could be determined. Data were reasonable without correction when compared to the field meter alone. Therefore, no correction was applied.

Calibration Drift Corrections: During the period of record, the pH probe calibration was checked during each visit. Drift corrections were generally minor, ranging from -0.02 to -0.07 units. Although all indicated drift corrections were within published criteria of calibration, some drift corrections were applied to maintain continuity of record.

Drift corrections were applied on May 5 (-0.05) and June 30 (-0.06).

Other Corrections: None.

Cross-section surveys: Cross-section surveys were collected each field visit. Vertical profiles: None as the station does not meet criteria for vertical profiles. Remarks: Records are good.

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

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National Park Service
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