



Water Quality Monitoring for Devils Tower National Monument

2013 Data Report

Natural Resource Data Series NPS/DETO/NRDS—2020/1259





ON THIS PAGE

Photograph of USGS Wyoming-Montana Water Science Center installing the water quality equipment in the Belle Fourche River near Devils Tower, WY.

Photograph by M. Wilson

ON THE COVER

Photograph of Belle Fourche River at Devils Tower National Monument, WY

Photograph by M. Wilson

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2013 Data Report

Natural Resource Data Series NPS/DETO/NRDS—2020/1259

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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 Belle Fourche River at Devils Tower National Monument (DETO) in 2013, with the assistance of the U.S. Geological Survey (USGS). This report summarizes the data collected during the 2013 ice-free season (March 21 through November 20) for streamflow, water temperature, dissolved oxygen, specific conductance, and pH.

2013 was a wet year and stage height on the Belle Fourche River peaked at 7.13 feet in early June. There was considerable seasonal variation in all water quality measures. A summary of our results can be found in Descriptive Statistics Summary tables for the ice-free season (Table 3) and for each month (Table 4). Notably, dissolved oxygen concentrations dropped below 5 mg/ L, a Wyoming state water quality standard, 15 times during the night of August 12 and morning of August 13, 2013.

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.

Acknowledgments

Thank you to the staff of the USGS Wyoming-Montana Water Science Center, particularly R. Woodward, K. Miller, and S. Davidson for their attention to the details of data collection, reporting, and the transfer of data to NGPN.

Introduction

Devils Tower National Monument (DETO) was established in 1906 as the first National Monument in the United States, with a mission to preserve the Tower and the surrounding 1347 acres (545 ha) of ponderosa pine forests, mixed-grass prairies, and riparian corridor along the Belle Fourche River. Although there are several springs in the Monument, the Belle Fourche River is the major hydrologic feature of the park (NPS 1997). The Belle Fourche River is about 290 miles (470 km) long from the headwaters in northeastern Wyoming to its confluence with the Cheyenne River near Rapid City, South Dakota (Figure 1). Northeastern Wyoming is a dry region; on average receiving 17 inches of precipitation annually, with two-thirds occurring as rain in the spring and summer.

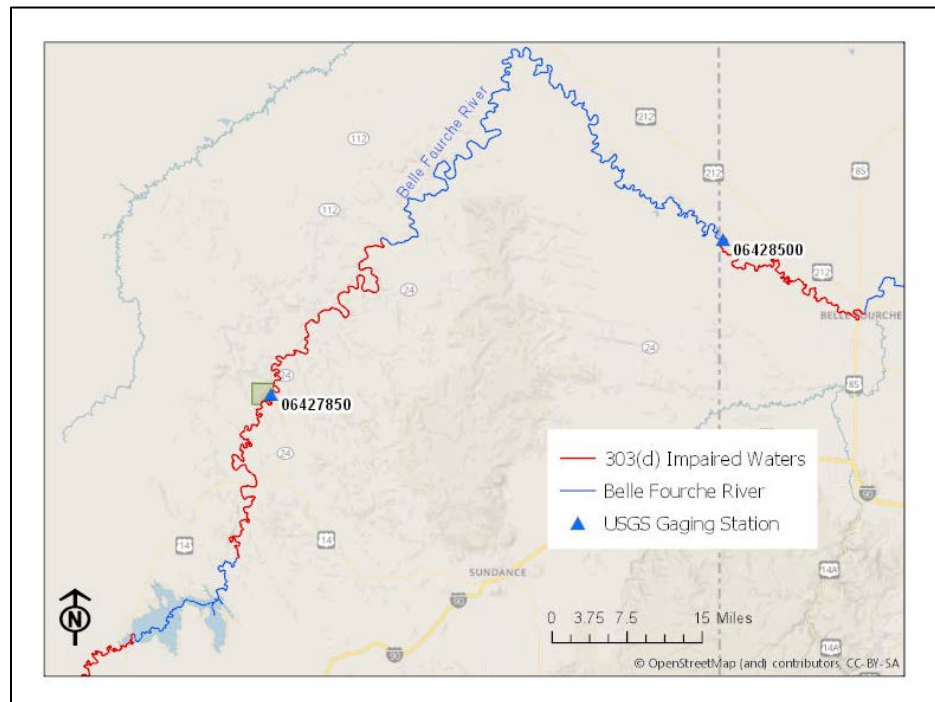


Figure 1. Map of the Devils Tower National Monument and the Belle Fourche River in Wyoming. The stretch of the river running through the monument, highlighted in red is listed as impaired under 303(d) criteria for fecal coliform bacteria. The two USGS stream gaging stations used in this report are indicated with blue triangles.

Approximately 2 miles (3.6 km) of the Belle Fourche River run through DETO as the river flows northeast toward South Dakota. In this area, river flow tends to peak between March and June, while annual low flows occur in November and December. River flow seasonality has been limited since 1952 by the construction of the Keyhole Reservoir and dam upstream of DETO. This reduced floods that cottonwood seedlings relied on for germination and establishment (Martin 1995). The river has become deeply incised, creating areas along the river where the water table is now 1.7-2.2 m deep and typical riparian vegetation, such as willows, are largely absent, having been replaced by grassland (Anderson 2013).

Primary land uses in the region and river basin include livestock grazing, hay production, mineral extraction, and oil and gas production (WYDEQ 2018b). The Belle Fourche River is designated as a Class 2AB warm 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 2018b). Several stretches of the river are listed as impaired waterways under section 303(d) of the Clean Water Act, including the 20-mile stretch running through DETO. This section is 303(d) listed for fecal coliform bacteria, high ammonia and high chloride levels (WYDEQ 2018b). Water quality monitoring at DETO in the 1970s found fecal coliform bacteria levels above state thresholds on several occasions in 1974 and 1975 (NPS 1997). Failing septic systems and livestock are likely contributing to the high bacteria loads (Tetra Tech Inc 2013). Crook County Natural Resource District developed a watershed plan to address these impairments, and has been conducting monitoring, and implementing septic, range, and water improvement projects (WYDEQ 2018b). For more details and current impairment information visit the Wyoming Department of Environmental Quality website.

The Northern Great Plains Inventory & Monitoring Network (NGPN) began monitoring water quality at DETO in 2013 to better understand current conditions and changes over time in the Belle Fourche River. The monitoring is conducted at the gaging station at Devils Tower National Monument, WY (Monitoring Location 06427850; 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 DETO every three years, starting in 2013 (Wilson et al. 2014), conducting in-depth analysis of status and trends after 3 to 5 cycles of sampling.

NGPN's core water quality parameters include streamflow, dissolved oxygen (DO), pH, specific conductivity, and water temperature (Table 1). These parameters were 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.

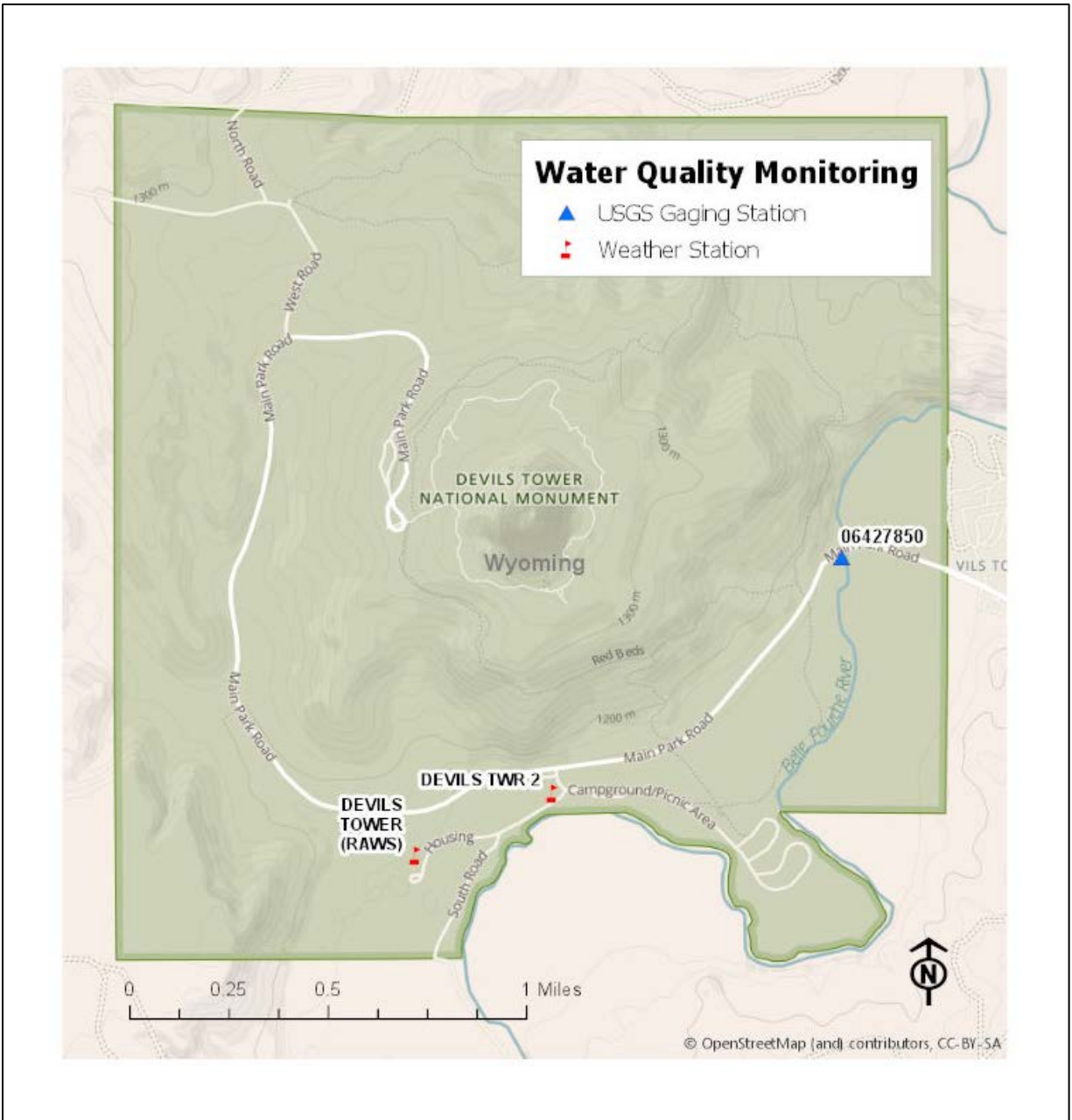


Figure 2. Map of Devils Tower National Monument and water quality monitoring location (blue triangle) and nearby weather stations (red flags). Climate data in this report are taken from the DEVILS TWR 2 weather station.

Table 1. Water quality parameters measured as part of the Northern Great Plains Inventory & Monitoring Water Quality Program and associated state standards (WYDEQ 2018a). 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 2018a).

Water Quality Parameter	Description	WY 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.	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 2.2°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 30°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 5.5 mg/L • 7-day mean of 6.0 mg/L • 7-day mean minimum of 4.0 mg/L • 1-day minimum of 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 06427850) inside the park, at 3840 ft. elevation. Water quality and stage height are measured every 15 minutes throughout the ice-free season. Monitoring at DETO began in 2013 and will be repeated in 2016, 2019, and every three years thereafter. Program funding currently limits monitoring to a cycle of one year of monitoring, followed by two years without.

In 2013, NGPN partnered with the USGS Wyoming-Montana Water Science Center to have USGS staff collect water quality and streamflow data at DETO. The USGS deployed a continuous, multi-parameter sonde at the gage on March 21, 2013 (Figure 3) and visited the gaging station every 3–4 weeks for equipment maintenance (Table 2). This instrument recorded dissolved oxygen, pH, specific conductivity, and water temperature every 15 minutes, while the gage simultaneously measured stream stage (or gage height).



Figure 3. A researcher deploys a sonde device in 2013 to measure water quality on the Belle Fourche River at Devils Tower, WY (right panel). The United States Geological Survey Belle Fourche River gaging station (06427850) is set up for real-time data transmission via satellite. Photographs courtesy of NPS.

Table 2. Field journal for 2013 Water Quality Sampling at Devils Tower National Monument.

Date	Notes
March 21, 2013	Instrument installed between 7:30 am and 9 am.
April 19, 2013	Instrument clean on arrival, only minor number of snails present.
April 30, 2013	A little silt and few slugs on instrument.
May 22, 2013	Some algae present.
May 28, 2013	Sonde moderate to heavy silt prior to cleaning. Pipe very silty
June 5, 2013	A lot of debris on sonde pipe and sand in sonde. Replaced DO sensor.
June 25, 2013	River is brown in color, some turbidity. Some silt and grass in sonde. Replaced DO sensor.
July 16, 2013	A lot of algae on the sonde pipe. Some stringy algae on rocks in stream
July 30, 2013	–
August 7, 2013	A lot of algae caught on sonde pipe. Ranger said the river was quite muddy two days ago.
August 16, 2013	–
September 9, 2013	Heavy algae on sonde pipe.
October 25, 2013	–
November 20, 2013	Very minor sediment. Instrument removed ~ 11 am.

Satellite telemetry transmitted the water data to the Water Science Center in near real-time (<https://waterdata.usgs.gov/monitoring-location/06427850/>). 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 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 20, 2013, the USGS removed the multi-parameter sonde from the Belle Fourche 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 2014 from the USGS, and used AQUARIUS Workstation by Aquatic Informatics (<http://aquaticinformatics.com/>) and R (R Core Team 2019) to store and analyze water data. Water year reports are provided by USGS and the text can be found in Appendix A. Figures were generated in R and daily mean values were calculated from 15-minute interval data. In the case where there were missing data due to instrument error, means were generated by excluding the missing values and the maximum and minimum were left blank. Means were not calculated for days where all time steps were missing (i.e. the instrument didn't collect any data that day). Discharge data were not

available for this site (only stage height), so a nearby stream gauge on the Belle Fourche River at the Wyoming and South Dakota border was used as a proxy (USGS ID number 06428500; Figure 1).

Climate data were downloaded from the Devils Tower 2 (482466) 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 Belle Fourche River at DETO lasted from March 21, 2013 to November 20, 2013. The discharge of the Belle Fourche River was low in the beginning of the monitoring period and then increased in May and June followed by a decline in fall (Figure 4). The maximum recorded gage height was recorded on June 2, 2013 at 7.13 ft and the minimum recorded gage height was recorded on October 3, 2013 at 1.07 ft (Appendix A). This seasonal pattern of increased flow in the spring is typical but in comparison to the 30-year period of 1981-2010, 2013 was much wetter than average (~165% of average). It rained and snowed 30.46 inches in 2013 with total monthly precipitation peaking in May (Figure 5).

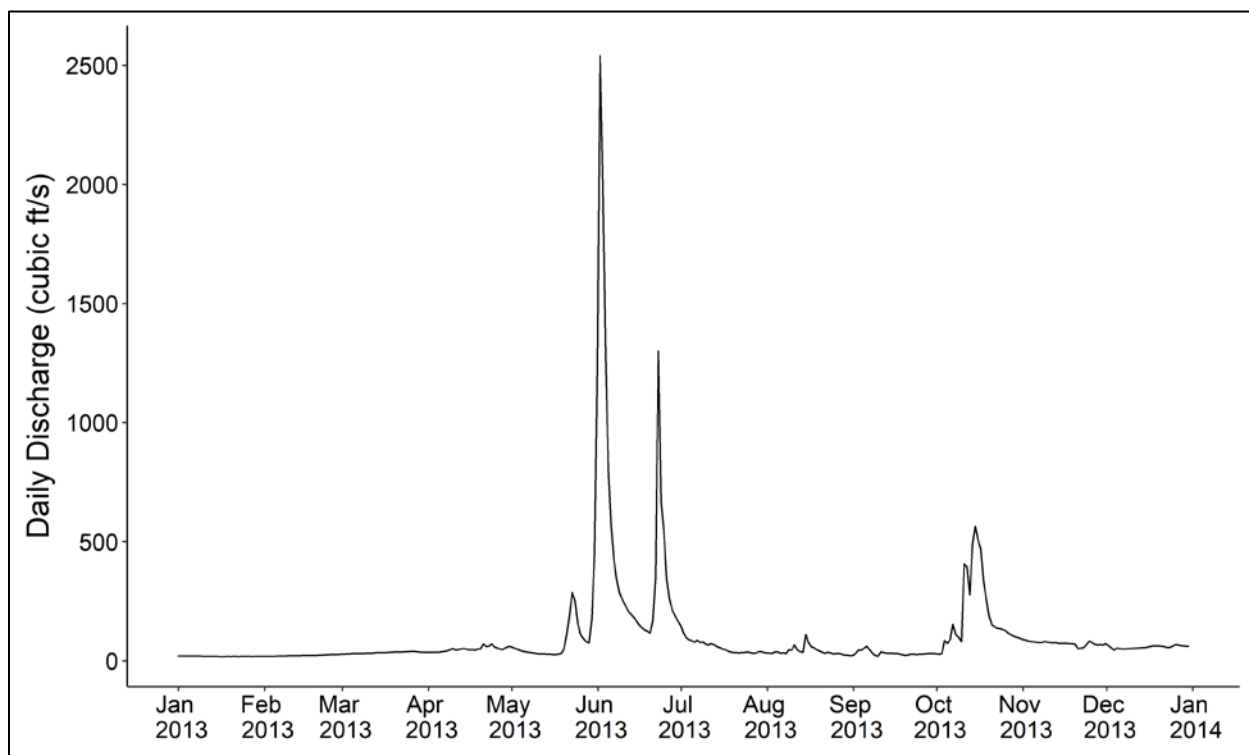


Figure 4. Daily mean discharge (black line) in 2013 on the Belle Fourche River at the Wyoming – South Dakota border, USGS Gaging Station 06428500.

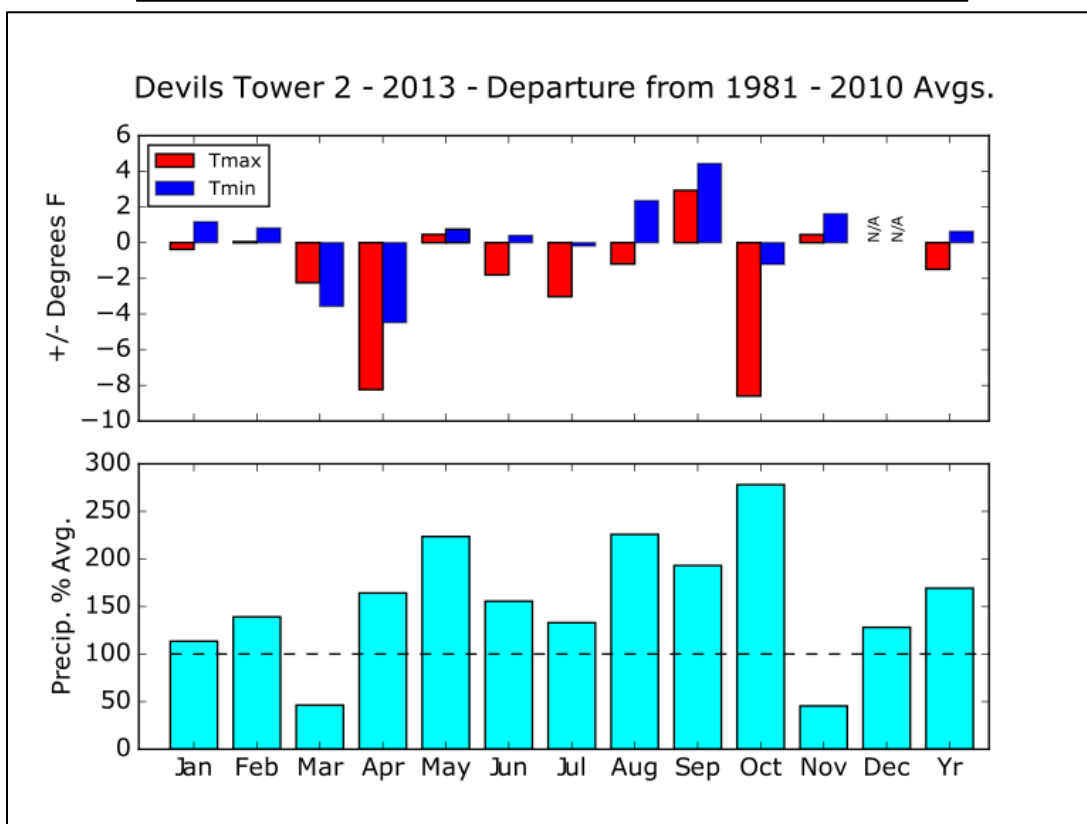
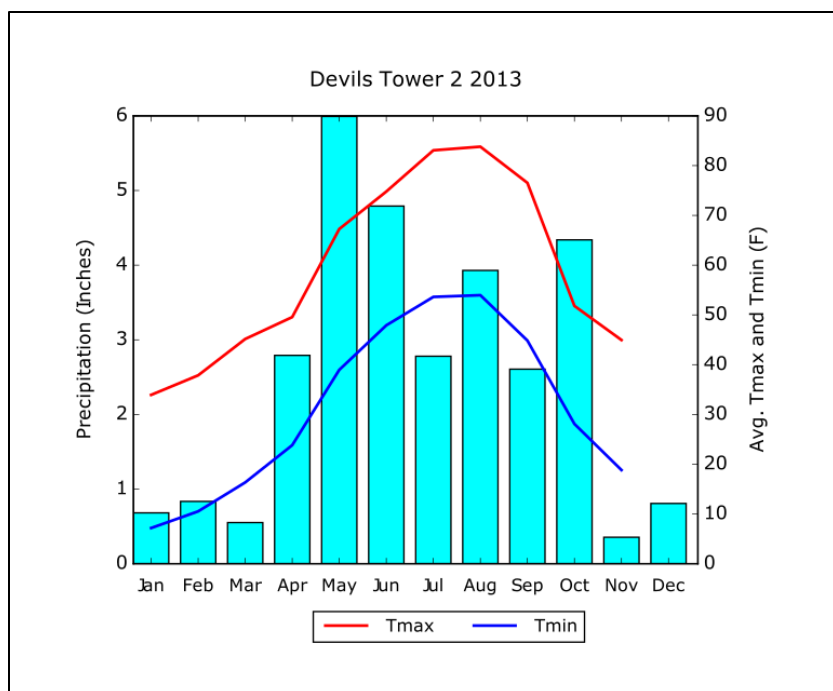


Figure 5. Total monthly precipitation (light blue) and average monthly minimum (blue) and maximum (red) temperature for 2013 in Devils Tower National Monument (top panel). Monthly departures from 1981-2010 average temperature and precipitation for 2013 in Devils Tower National Monument (bottom panel). Climate data are from Devils Tower 2 Station (482466). The data were accessed and graphed using the web-based tool [Climate Analyzer](#).

During the ice-free season at DETO, we collected over 20,000 water quality measurements in the Belle Fourche River (Table 3). We found mean water temperature of 15°C, dissolved oxygen concentrations of 9 mg/L, specific conductance of 1621, and pH of 8 (Table 3). There was, however, variation across months in all parameters (Table 4). Mean water temperature in March was 4°C and increased to a mean of close to 25°C in July before declining back to 3°C in November (Table 4, Figure 6). Maximum water temperature never exceeded the Wyoming water quality standard of 30°C (Table 1), but we did record temperatures as high as 29.6°C in July (Table 4).

Table 3. Summary of descriptive statistics for water temperature, dissolved oxygen, specific conductance, and pH measured for the ice-free sampling period on the Belle Fourche River at Devils Tower National Monument from March 22, 2013 through November 19, 2013. Percent exceedance is the proportion of samples that exceed the respective state regulatory threshold described in Table 1 (water temperature max. limit is 30.0°C; dissolved oxygen $\geq$ 5.0 mg/L and pH range is <6.5 or >9.0).

Descriptive Statistic	Water Temperature (°C)	Dissolved Oxygen (mg/L)	Specific Conductance (μ S/cm)	pH
Mean	15.14	9.01	1620.19	8.08
Standard Deviation	8.25	1.90	354.01	0.14
Median	16.30	8.60	1680	8.10
Minimum	-0.10	4.40	452	7.60
Maximum	29.60	13.80	2080	8.40
Number of Points	23524	20277	22192	23522
Number of Points below or above standard	0 (above)	15 (below)	NA	0 (above) 0 (below)
% Exceedance	0.00%	0.07%	NA	0.00%

Table 4. Monthly summary of descriptive statistics and percent exceedances for core water quality parameters for the ice-free sampling period at Devils Tower National Monument on the Belle Fourche River from March 21, 2013 through November 20, 2013. Percent exceedance is the proportion of samples that exceed the respective state regulatory threshold described in Table 1 (water temperature max. limit is 30.0°C; dissolved oxygen $\geq$ 5.0 mg/L and pH range is <6.5 or >9.0).

Dates	Descriptive Statistic	Water Temperature (°C)	Dissolved Oxygen (mg/L)	Specific Conductivity (μ S/cm)	pH
March 22–31, 2013	Number of measurements	1053	1052	1050	1053
	Mean	4.31	11.26	1933.50	8.22
	Standard Deviation	3.62	0.95	56.82	0.04
	Median	3.10	11.50	1950.00	8.20
	Minimum	-0.10	9.20	1800.00	8.20

Table 4 (continued). Monthly summary of descriptive statistics and percent exceedances for core water quality parameters for the ice-free sampling period at Devils Tower National Monument on the Belle Fourche River from March 21, 2013 through November 20, 2013. Percent exceedance is the proportion of samples that exceed the respective state regulatory threshold described in Table 1 (water temperature max. limit is 30.0°C; dissolved oxygen $\geq$ 5.0 mg/L and pH range is <6.5 or >9.0).

Dates	Descriptive Statistic	Water Temperature (°C)	Dissolved Oxygen (mg/L)	Specific Conductivity (μ S/cm)	pH
March 22–31, 2013 (continued)	Maximum	11.60	12.70	2030.00	8.30
	% Exceedance	0.00	0.00	–	0.00
April, 2013	Number of measurements	2875	2875	2338	2876
	Mean	7.97	10.21	1983.28	8.19
	Standard Deviation	4.14	1.16	80.96	0.07
	Median	8.00	10.30	2000.00	8.20
	Minimum	–0.10	7.70	1740.00	8.00
	Maximum	17.40	12.30	2080.00	8.30
	% Exceedance	0.00	0.00	–	0.00
May, 2013	Number of measurements	2972	2471	2780	2972
	Mean	16.38	8.09	1787.10	8.01
	Standard Deviation	3.94	0.93	358.51	0.13
	Median	16.80	8.20	1970.00	8.00
	Minimum	6.80	6.10	629.00	7.80
	Maximum	25.70	10.40	2080.00	8.30
	% Exceedance	0.00	0.00	–	0.00
June, 2013	Number of measurements	2875	2109	2493	2873
	Mean	19.71	7.57	1335.43	8.06
	Standard Deviation	4.28	0.53	198.17	0.11
	Median	20.20	7.50	1400.00	8.10
	Minimum	8.90	6.60	645.00	7.70
	Maximum	28.00	8.90	1580.00	8.20
	% Exceedance	0.00	0.00	–	0.00
July, 2013	Number of measurements	2972	2973	2967	2972
	Mean	24.65	7.21	1672.39	7.99
	Standard Deviation	2.36	0.93	143.50	0.13
	Median	24.50	7.10	1670.00	8.00
	Minimum	19.60	5.50	1250.00	7.70

Table 4 (continued). Monthly summary of descriptive statistics and percent exceedances for core water quality parameters for the ice-free sampling period at Devils Tower National Monument on the Belle Fourche River from March 22, 2013 through November 19, 2013. Percent exceedance is the proportion of samples that exceed the respective state regulatory threshold described in Table 1 (water temperature max. limit is 30.0°C; dissolved oxygen $\geq$ 5.0 mg/L and pH range is <6.5 or >9.0).

Dates	Descriptive Statistic	Water Temperature (°C)	Dissolved Oxygen (mg/L)	Specific Conductivity (μ S/cm)	pH
July, 2013 (continued)	Maximum	29.60	8.90	1880.00	8.30
	% Exceedance	0.00	0.00	–	0.00
August, 2013	Number of measurements	2974	2687	2971	2974
	Mean	23.34	7.45	1486.25	8.00
	Standard Deviation	2.59	1.01	331.32	0.12
	Median	23.50	7.20	1600.00	8.00
	Minimum	12.20	4.40	581.00	7.60
	Maximum	28.50	10.10	1930.00	8.30
	% Exceedance	0.00	0.56%	–	0.00
September, 2013	Number of measurements	2879	2387	2877	2879
	Mean	18.73	9.13	1760.57	7.99
	Standard Deviation	4.34	1.41	240.80	0.16
	Median	19.00	9.00	1780.00	8.00
	Minimum	8.00	6.40	892.00	7.60
	Maximum	28.70	12.00	2010.00	8.40
	% Exceedance	0.00	0.00	–	0.00
October, 2013	Number of measurements	2976	1775	2975	2976
	Mean	6.93	11.25	1235.16	8.15
	Standard Deviation	2.75	1.03	408.71	0.11
	Median	7.10	11.20	1360.00	8.20
	Minimum	0.40	9.10	452.00	7.90
	Maximum	16.70	13.80	1920.00	8.30
	% Exceedance	0.00	0.00	–	0.00
November 1–19, 2013	Number of measurements	1948	1948	1741	1947
	Mean	3.19	11.49	1650.47	8.20
	Standard Deviation	1.41	0.44	53.36	0.03
	Median	3.30	11.50	1650.00	8.20
	Minimum	–0.10	10.70	1540.00	8.10

Table 4 (continued). Monthly summary of descriptive statistics and percent exceedances for core water quality parameters for the ice-free sampling period at Devils Tower National Monument on the Belle Fourche River from March 22, 2013 through November 19, 2013. Percent exceedance is the proportion of samples that exceed the respective state regulatory threshold described in Table 1 (water temperature max. limit is 30.0°C; dissolved oxygen ≥ 5.0 mg/L and pH range is <6.5 or >9.0).

Dates	Descriptive Statistic	Water Temperature (°C)	Dissolved Oxygen (mg/L)	Specific Conductivity ($\mu\text{S}/\text{cm}$)	pH
November 1–19, 2013 (continued)	Maximum	5.90	12.50	1790.00	8.30
	% Exceedance	0.00	0.00	–	0.00

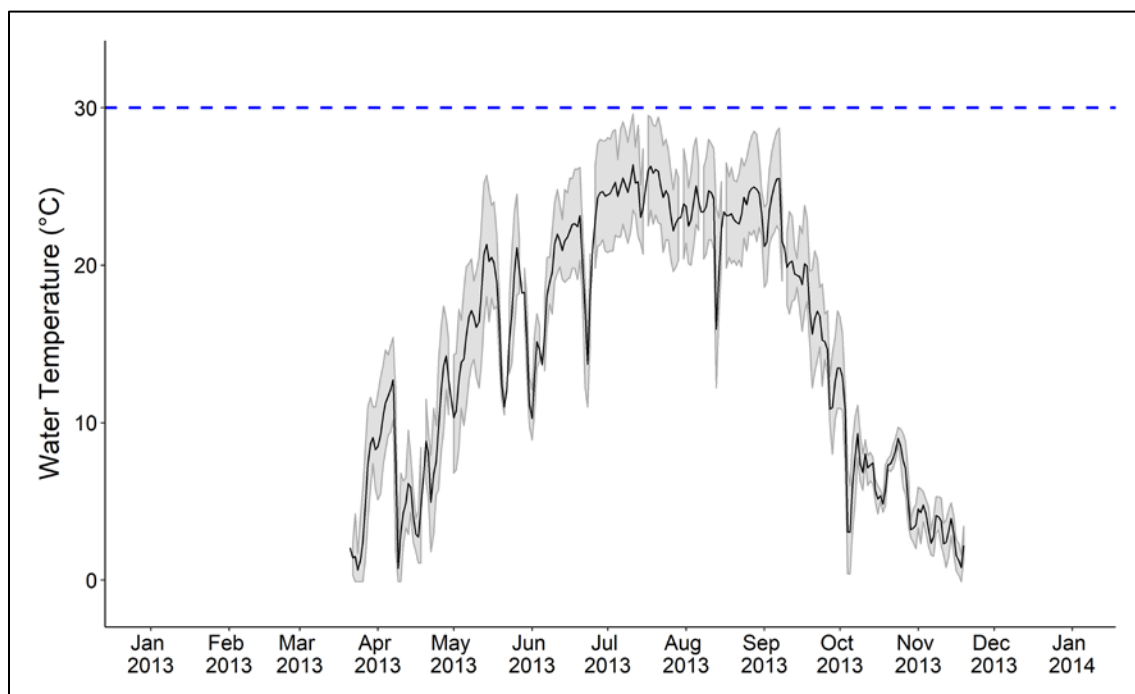


Figure 6. Daily mean water temperature (black line) collected on the Belle Fourche River at Devils Tower National Monument in 2013. The sonde was in the water from March 21, 2013 through November 20, 2013. The gray ribbon shows the daily maximum and minimum water temperature for the same period. The 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 also displayed seasonal variation (Table 3, Figure 7). The highest mean dissolved oxygen concentrations were in the spring and fall, averaging greater than 11 mg/ L in March, October, and November. Dissolved oxygen was the only water quality parameter that was below one of the Wyoming state water quality criteria (Table 1). Dissolved oxygen concentrations measured below 5 mg/ L in the Belle Fourche River 15 times during the night of August 12th and morning of August 13th, 2013 (Table 3, Figure 7).

Specific conductance of the Belle Fourche River was highly variable throughout the year (Table 3, Figure 8), but showed a less predictable seasonal pattern than temperature or dissolved oxygen

concentrations. The pH of the Belle Fourche River ranged between 7.6 and 8.4 (Figure 9) and was never outside the range of the Wyoming state standards of 6.5 -9.

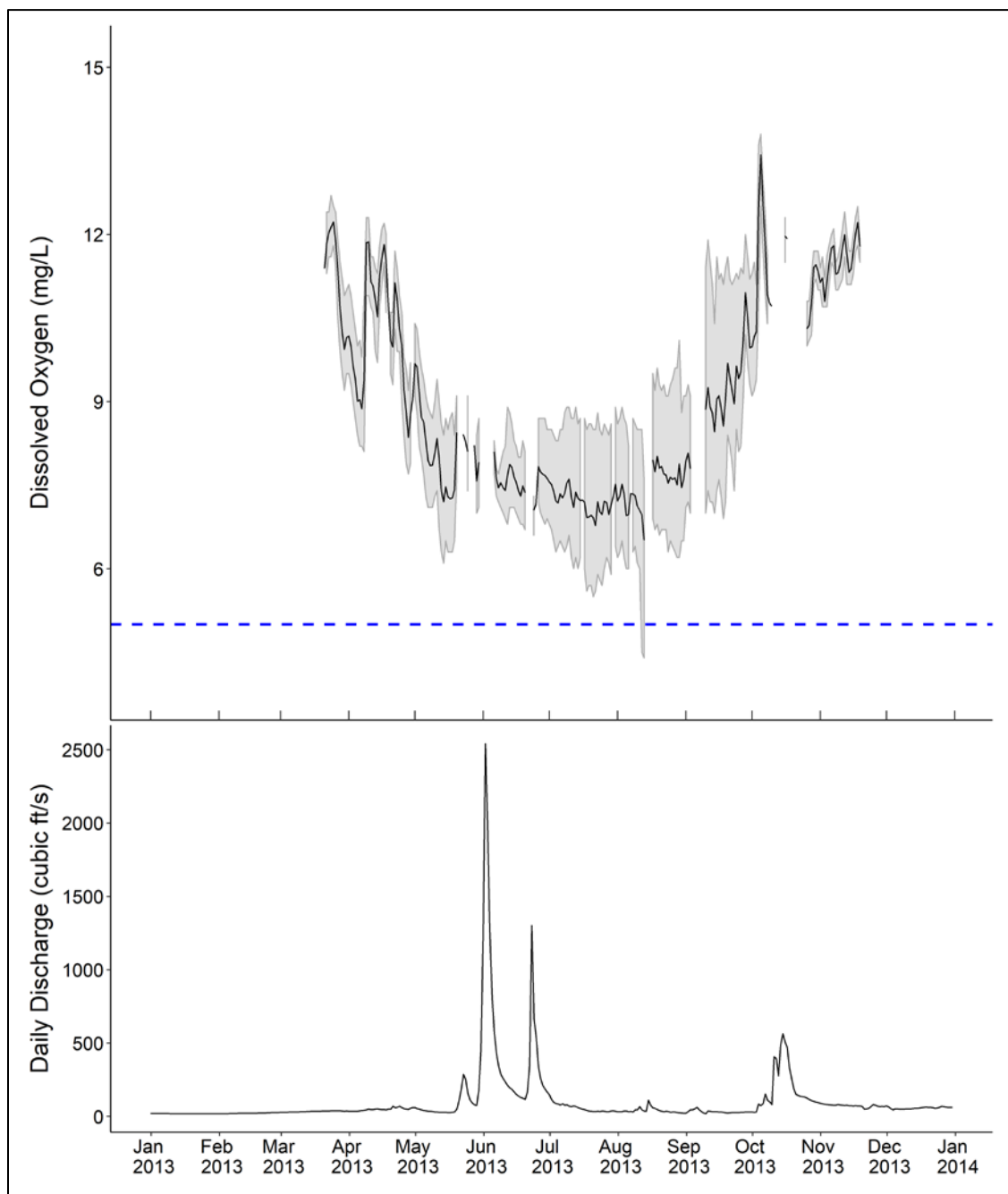


Figure 7. Daily mean dissolved oxygen concentrations (top) of the Belle Fourche River at Devils Tower National Monument in 2013 and daily discharge (bottom) of the Belle Fourche River at the Wyoming and South Dakota border. The gray ribbon shows the daily maximum and minimum dissolved oxygen for the 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.

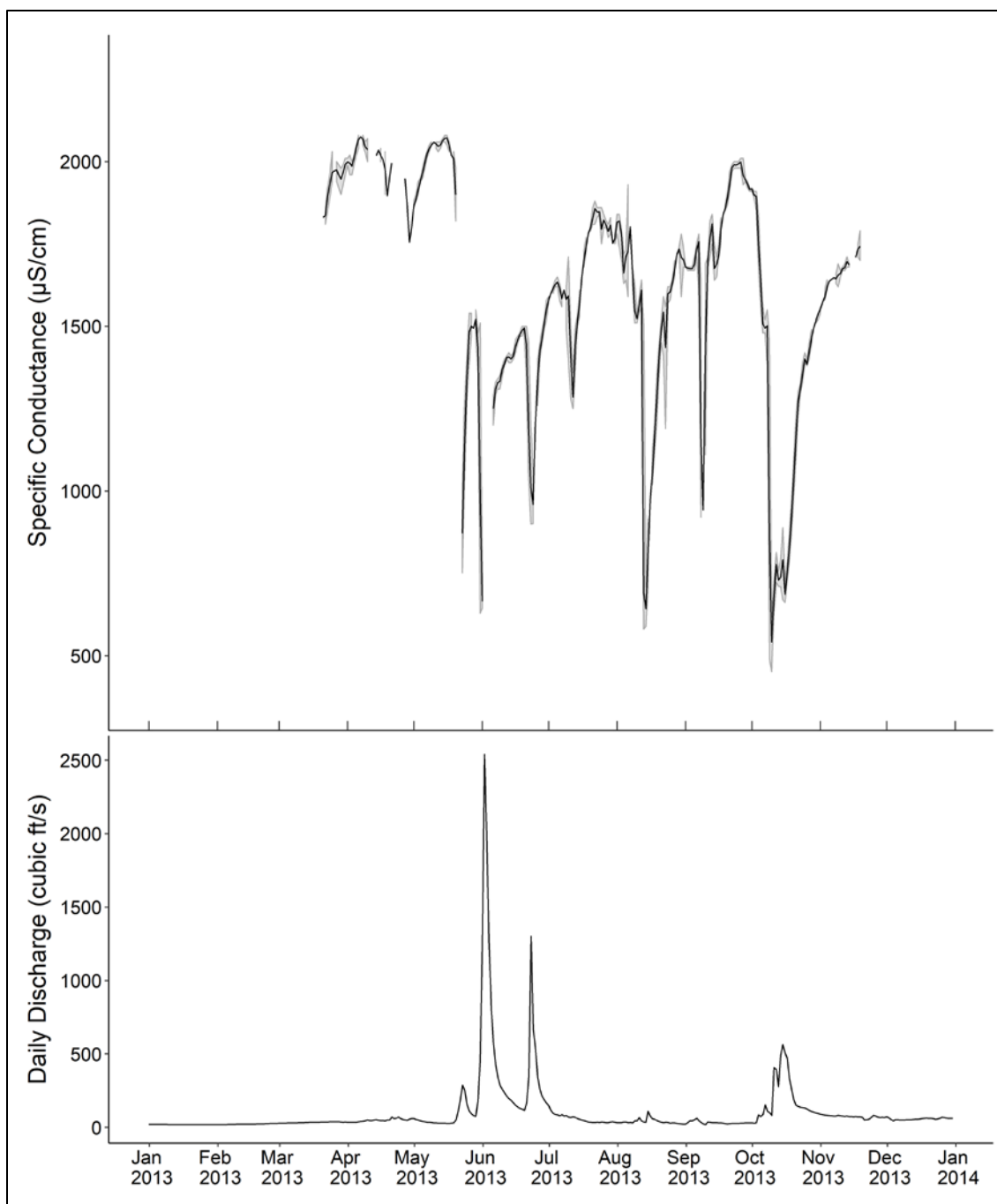


Figure 8. Daily mean specific conductance (top) of the Belle Fourche River at Devils Tower National Monument in 2013 and daily discharge (bottom) of the Belle Fourche River at the Wyoming and South Dakota border. The gray ribbon shows the daily maximum and minimum specific conductivity for the same period. The periods where the instrument did not collect data are indicated by gaps in the record.

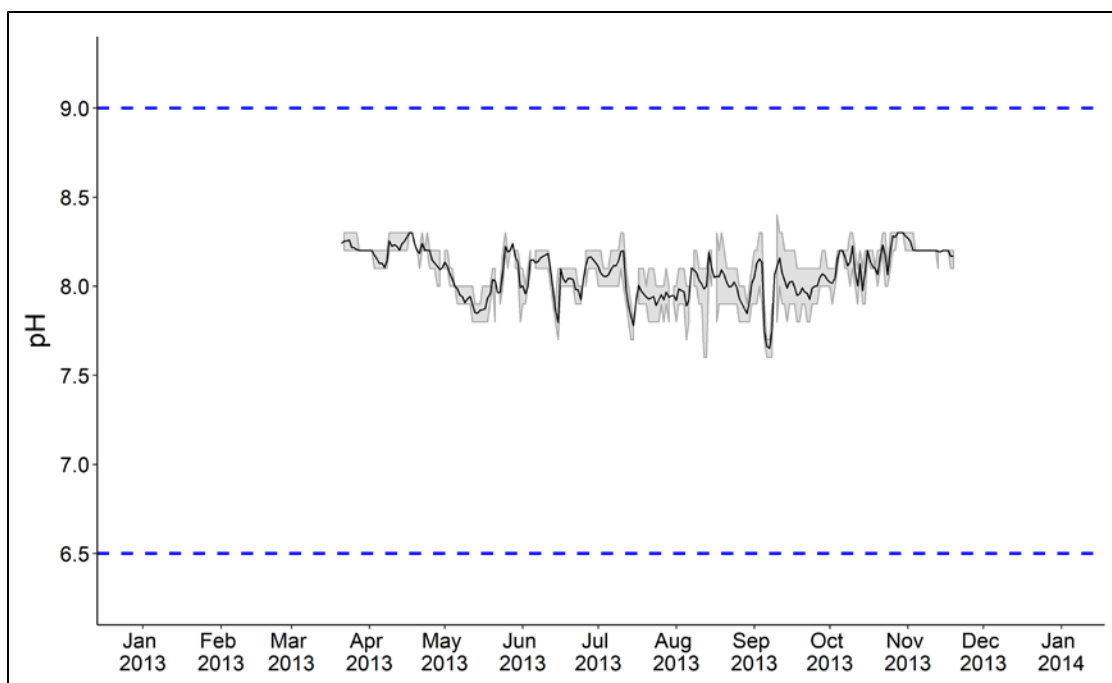


Figure 9. Daily mean pH (black line) of the Belle Fourche River at Devils Tower National Monument in 2013. Measurements were taken from March 22, 2013 through November 19, 2013. The gray ribbon shows the daily maximum and minimum pH for the same period. The dashed blue lines indicate the Wyoming state 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 data collected during the 2013 water quality monitoring season at Devils Tower National Monument. All data included in this report is available upon request from the Northern Great Plains Inventory and Monitoring Network, as well as in the archives found on the USGS National Water Information System for site 06427850

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Appendix A. USGS Water Data Quality Report for Belle Fourche River, 2013

06427850 BELLE FOURCHE RIVER AT DEVILS TOWER, WY

Belle Fourche Basin

Upper Belle Fourche Subbasin

LOCATION: Lat 44°35'22", long 104°42' 12" referenced to North American Datum of 1927. Crook County, WY, Hydrologic Unit 10120201 .

SURFACE-WATER RECORDS

PERIOD OF RECORD: March 2013 to November 2013.

GAGE—Water-stage recorder. Elevation of gage is 3,840 ft above sea level, from topographic map. U.S. Geological Survey data collection platform with satellite telemetry at station.

REMARKS—Records excellent.

EXTREMES FOR PERIOD OF RECORD: Maximum recorded gage height, 7.13 ft. June 2, 2013; minimum recorded gage height. 1.07 ft, October 3. 2013.

EXTREMES FOR CURRENT YEAR: Maximum recorded gage height, 7.13 ft, June 2; minimum recorded gage height, 1.07 ft. October 3.

WATER-QUALITY RECORDS

PERIOD OF RECORD: Water years 1968-1992.

PERIOD OF DAILY RECORD: March to November 2013.

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

REMARKS: Specific conductance records are excellent except those for April 15-19, May 31, June 21. 22. July 11 -16. August 7, 15. 16, and September 8, 9, which are good; June 23-25, which are fair; and June 1. 2. which are poor. pH records are excellent except those for May 23, June 2, and August 7. 15. 16. which are good; May 24 and June 3-5. which are fair; and May 25-28, which are poor. Water temperature records are excellent except those for May 24-26. and September 26-30, which are good; and May 27, 28, and August 13. which are fair; and August 14-16, which are poor. Water temperature records represent water temperature at sensor within O.ZOC. Dissolved oxygen records are excellent except those for March 20. 21. July 7-16, 24. 23, 28-30, and September 4. 5, 22-30. which are good; May 22-28 and September 6. 7. 22-30, which are fair. Maximum and minimum recorded values in the EXTREMES paragraphs may have occurred during days of partial record and may not appear in the daily values tables.

EXTREMES FOR PERIOD OF DAILY RECORD:

- SPECIFIC CONDUCTANCE: Maximum recorded, 2,080 $\mu\text{S}/\text{cm}$. April~. 13, May 15. 16. 2013; minimum recorded, 452 $\mu\text{S}/\text{cm}$. October 10. 2013.
- pH: Maximum recorded, 8.4 units, September 10. 2013; minimum recorded, 7.6 units, August 12 and September~2013.
- WATER TEMPERATURE: Maximum recorded, 29.6°C, July 11 . 2013; minimum recorded- 0.1°C. March 23-26. April 9, 10, and November 18, 2013.
- DISSOLVED OXYGEN: Maximum recorded, 13.8 mg/l , October 5, 2013; minimum recorded, 4.4 mg/l , August 13. 2013.

EXTREMES FOR CURRENT YEAR:

- SPECIFIC CONDUCTANCE: Maximum recorded, 2.080 $\mu\text{S}/\text{cm}$. April ~ . 13, May 15. 16; minimum recorded. 452 $\mu\text{S}/\text{an}$. October 10.
- pH: Maximum recorded, 8.4 units, September 10; minimum recorded. 7.6 units, August 12 and September ~ -
- WATER TEMPERATURE: Maximum recorded, 29.6°C, July 11; minimum recorded - 0.1°C, March 23-26, April 9. 10. and November 18.

DISSOLVED OXYGEN: Maximum recorded, 13.8 mg/l , October 5; minimum recorded, 4.4 mg/l , August 13.

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 109/166779, February 2020

National Park Service
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