

Obed Wild and Scenic River and Big South Fork National River and Recreation Area

National Park Service
U.S. Department of the Interior

Inventory and Monitoring Division
Appalachian Highlands Network



Continuous Water Quality Monitoring: Water Year 2021

Overview

Renowned for their rivers and aquatic species diversity, Big South Fork National River and Recreation Area (BISO) and Obed Wild and Scenic River (OBRI) are important park units protecting water resources. Water quality is an important indicator of ecosystem health and reflects the human activities, land use, and natural factors occurring throughout the Big South Fork and Obed watersheds. River and stream conditions influence aquatic and riparian habitats and the flora and fauna they support, as well as recreational activities and park visitation.

Big South Fork National River and Recreation Area and Obed Wild and Scenic River support the largest concentration and most pristine examples remaining of the globally imperiled Cumberlandian cobble bar. This habitat supports 27 rare plant species, including two threatened species, Cumberland rosemary (*Conradina verticillata*) and Virginia spirea (*Spiraea virginiana*), and depends on natural flood regimes and unpolluted water, as do the fish and mussels that inhabit the rivers. Big South Fork National River and Recreation Area is a global hotspot for freshwater mussel diversity with 42 species present, of which 11 are federally endangered. Of the two threatened fish species found at Big South Fork, one species, the tuxedo darter (*Etheostoma lemniscatum*) occurs nowhere else in the world. Obed Wild and Scenic River sustains several threatened aquatic species, including the Alabama lampmussel (*Lampsilis virescens*) and the purple bean (*Villosa perpurpurea*), as well as the spotfin chub (*Erimonax monachus*).



Left, APHN program manager installs a sonde at Clear Fork. Right, cobble bar prairie in Big South Fork NRRRA. NPS photos / APHN staff.

Summary

- In March 2021 a record flood event impacted BISO and OBRI watersheds.
- All measurements of water temperature and dissolved oxygen in WY21 were within state standards.
- At two sites, mean specific conductivity levels were above reference standards.
- All pH measurements were within the state standards range.
- However, pH exceeded state standards of greater than 1 unit fluctuations in 24 hours at three sites.

Objective

Water resources within Big South Fork National River and Recreation Area and Obed Wild and Scenic River are influenced by natural conditions and anthropogenic factors that occur upstream of park boundaries, including coal mining, oil and gas extraction, logging, agriculture, municipal development, wastewater discharge, and increased water demands.

Appalachian Highlands Network (APHN) monitors water-quality at five integrator sites, two at Big South Fork on the main tributaries (Clear Fork and New River; Figure 1) and three at Obed (Clear Creek, Daddys Creek, and Obed; Figure 2). Sondes are paired with USGS stations to monitor a suite of parameters, in addition to gage and streamflow, at 30-minute intervals. The objective is to determine annual status and long-term trends for five core parameters:

- Temperature
- Dissolved Oxygen
- Specific Conductivity
- Turbidity
- pH

For detailed methods, see Hughes et al. 2018.

Big South Fork National River & Recreation Area

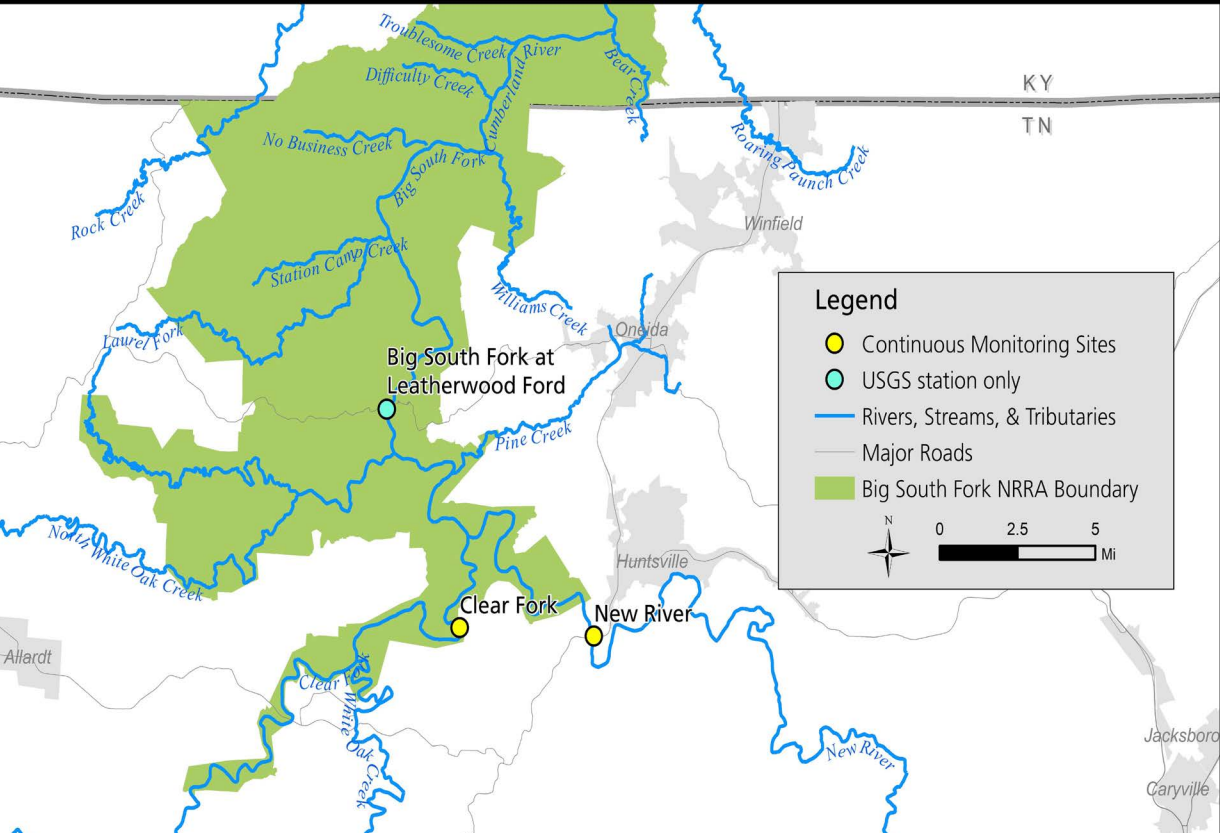


Figure 1. Map of the continuous monitoring sites and USGS stations at Big South Fork National River and Recreation Area.

Obed Wild & Scenic River

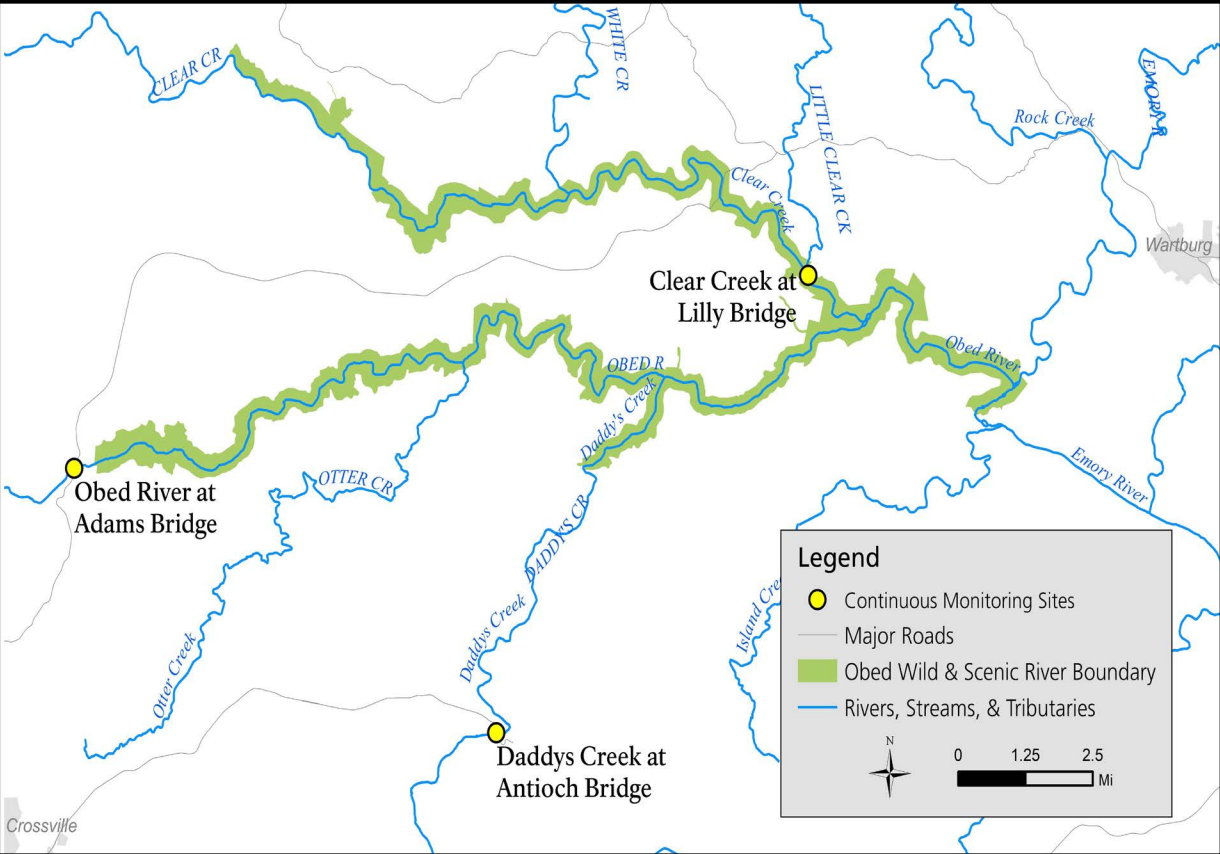


Figure 2. Map of the continuous monitoring sites at Obed Wild and Scenic River.

Water Year 2021

During water year 2021 (WY21), continuous water-quality sondes collected data at 30-minute intervals from October 1, 2020 to October 1, 2021 in the Big South Fork and Obed watersheds. This amounted to 369,700 data points included in this summation from all five water-quality parameters across five sites (Figures 3–7). Various factors impacted data collection during WY21, including COVID19 restrictions, equipment malfunction, flooding, station access, and sonde calibration. Unattributed data outliers, such as from potential sensor malfunction or uncorrected calibration drift, were removed from the dataset.

Streamflow

In late March of 2021, heavy precipitation caused record flooding throughout the Cumberland Plateau. Record high streamflow was documented on the Big South Fork of the Cumberland River at Leatherwood Ford (USGS 03410210 ‘Leatherwood Ford’) and Clear Creek at Lilly Bridge (USGS 03539778, ‘Clear Creek’), while the second and sixth highest recorded flows were documented at Clear Fork near Robbins, Tennessee (USGS 03409500, ‘Clear Fork’) and New River at New River, Tennessee (USGS 03408500, ‘New River’), respectively.

At Clear Fork, the flood destroyed the historic Burnt Mill Bridge and washed half of the bridge downstream, dislodging the metal structure that housed the water-quality sonde. Both the metal housing and sonde were lost in the flood. After river levels declined, a new sonde and metal support casing were installed approximately one week after the original sonde was lost.



March 2021 flooding on the Big South Fork at Leatherwood Ford. Streamflow peaked at >81,300cfs. NPS photo / APHN staff.



Burnt Mill Bridge on Clear Fork damaged from the March 2021 flooding. NPS photo / APHN staff.

Among the five monitoring sites, lowest average streamflow was observed at Obed River at Adams Bridge near Crossville, Tennessee (USGS 03538830, ‘Obed’) with a mean of 183 cubic feet per second (cfs) followed by Daddys Creek near Hebbertsburg, Tennessee at 302cfs (USGS 03539600, ‘Daddys Creek’). New River had the highest mean streamflow (813cfs), followed by Clear Fork (432cfs). In rank order, peak flows in WY21 were New River (45,600cfs), Clear Fork (35,400cfs), Clear Creek (22,800cfs), Daddys Creek (9,270cfs), and Obed (7,090cfs).

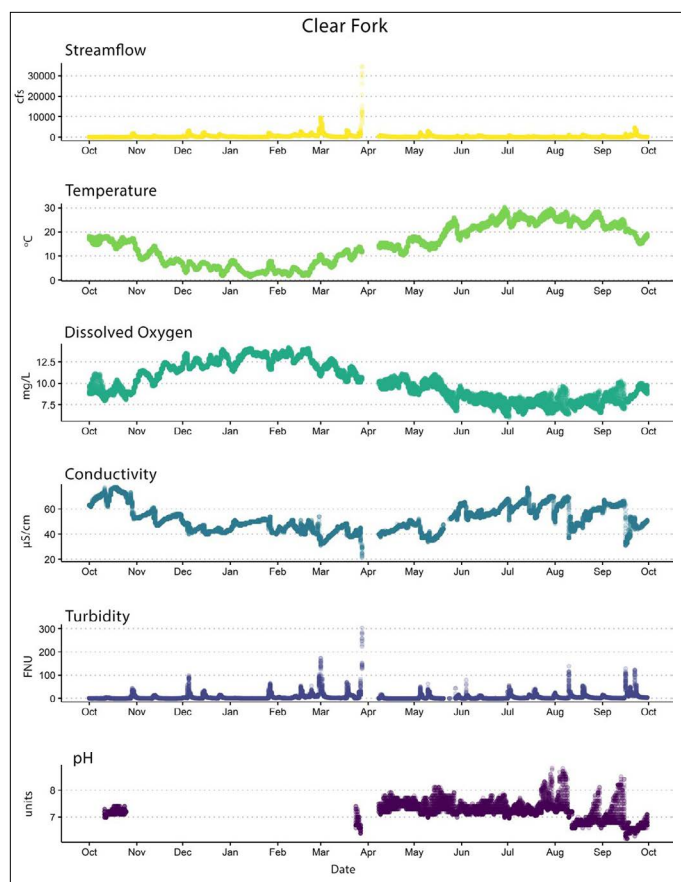


Figure 3. Big South Fork National River and Recreation Area continuous water quality data at Clear Fork.

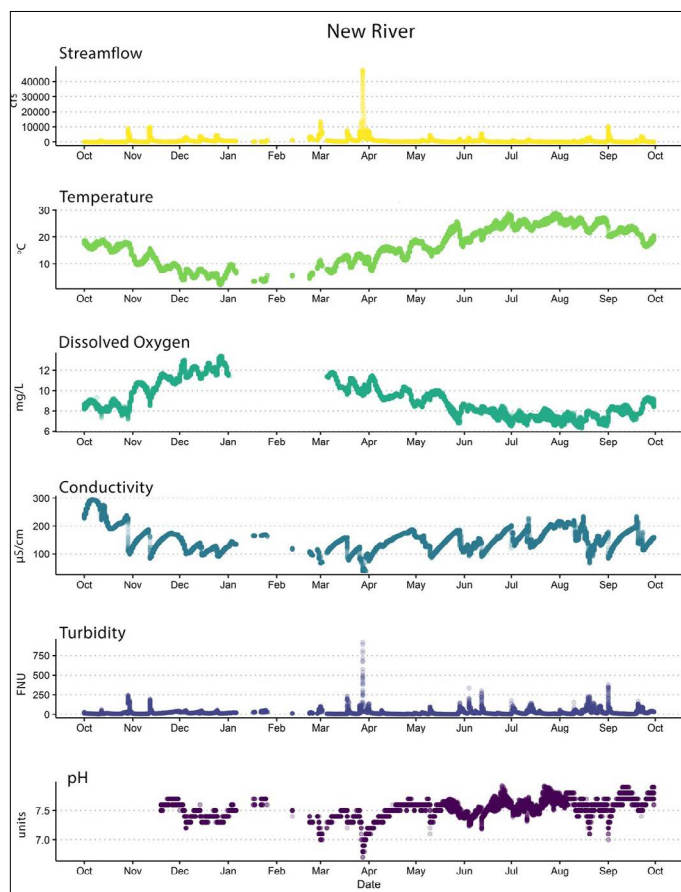


Figure 4. Big South Fork National River and Recreation Area continuous water quality data at New River.

Water Year 2021 (Continued)

Temperature

Water temperature ranged from a mean of 14.1°C (57.4°F) at Obed to 16.7°C (62.0°F) at New River. The highest maximum temperature and lowest minimum temperature was recorded at Clear Fork (Table 1). All stream temperatures during WY21 were below the Tennessee State Standards of 30.5°C (86.9°F).

Table 1. Minimum, Maximum, and Mean temperatures for water year 2021 at continuous monitoring sites.

Site	Minimum (C°)	Maximum (C°)	Mean (C°)
Clear Fork	1.1	30.4	14.7
New River	2.1	28.9	16.7
Clear Creek	1.8	28.8	14.7
Daddys Creek	2.0	29.0	14.5
Obed River	2.0	26.9	14.1

Dissolved Oxygen

In WY21, all measurements of dissolved oxygen (DO) were above the Tennessee State Standards of 5.0 mg/L (Table 2). Specific to the ecoregion, reference streams on the Cumberland Plateau generally have dissolved oxygen levels above 6.0mg/L (TDEC 2003). At all sites, average DO measurements were well above this, ranging from a mean of 9.1 mg/L at New River to 10.2 mg/L at Obed. The lowest DO levels (Table 2) were observed in late May at Obed and corresponded with a period of low steamflow (~12cfs) and increasing water temperature (23.3°C [73.9°F]).

Table 2. Minimum, Maximum, and Mean dissolved oxygen levels for water year 2021 at continuous monitoring sites.

Site	Minimum (mg/l)	Maximum (mg/l)	Mean (mg/l)
Clear Fork	6.0	14.2	10.1
New River	6.3	13.4	9.1
Clear Creek	6.1	13.8	10.1
Daddys Creek	6.2	13.7	10.0
Obed River	5.4	15.5	10.2

Dissolved oxygen exhibited seasonal and diel variations at all sites. As colder water retains more oxygen, DO was higher in winter months and lower in the summer. Dissolved oxygen fluctuations were observed at 24-hour cycles, with greater variation evident in the summer, attributed to the photosynthetic activity of aquatic plants and algae during the day. Obed exhibited the greatest diel fluctuations in DO, varying up to 3.6 mg/l in a 24-hour period, followed by Clear Fork varying up to 3.0 mg/l. New River varied the least in a 24-hour period, with diel shifts of up to 1.2 mg/l. Of note, diel cycles generally declined to minimal fluctuations during winter months at all sites except for Obed, which continued to exhibit fluctuations up to 2 mg/l. Further assessment of this year-round diel variation at Obed may be of additional interest.

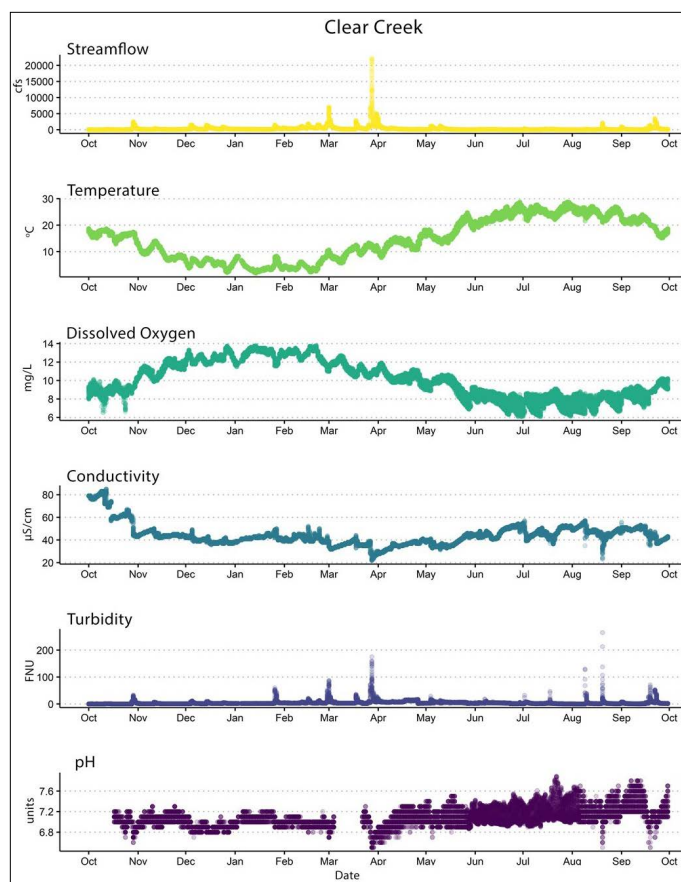


Figure 5. Obed Wild and Scenic River continuous water quality data at Clear Creek.

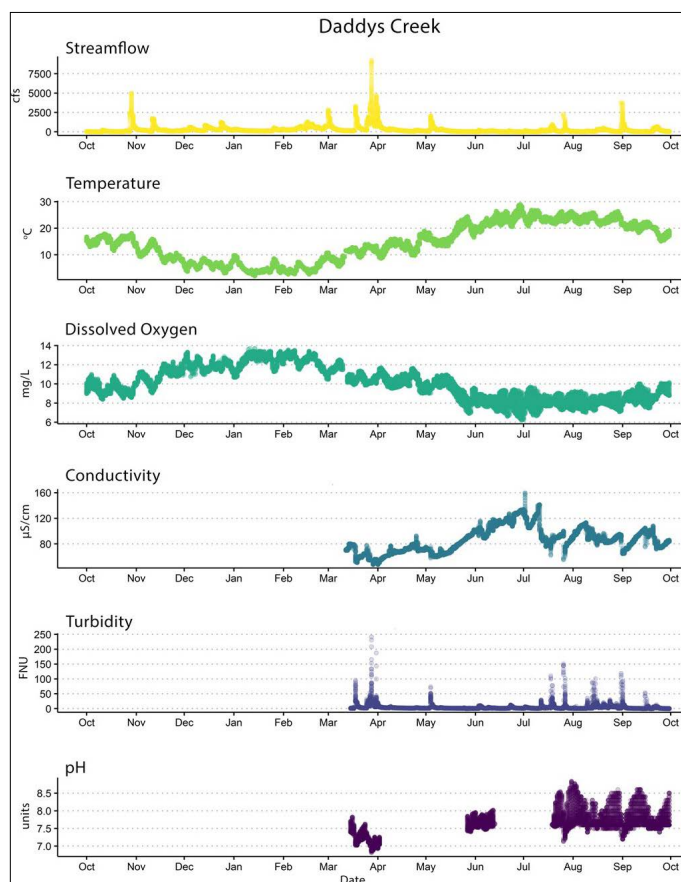


Figure 6. Obed Wild and Scenic River continuous water quality data at Daddys Creek.

Water Year 2021 (Continued)

Specific Conductivity

Although there is no numeric state standard in Tennessee for specific conductivity (SpC), streams and tributaries are generally below 100 $\mu\text{S}/\text{cm}$ on the Cumberland Plateau, with reference streams below 60 $\mu\text{S}/\text{cm}$ (Rikard et al. 1986). Of the five continuous monitoring sites, Clear Fork, Clear Creek, and Daddys Creek averaged below 100 $\mu\text{S}/\text{cm}$ for WY21 (Table 3). Mean SpC was 153.6 $\mu\text{S}/\text{cm}$ at New River and 120.1 $\mu\text{S}/\text{cm}$ at Obed. Specific conductivity at Clear Fork and Clear Creek did not exceed 100 $\mu\text{S}/\text{cm}$, while this was exceeded in 22% of measurements at Daddys Creek, 54% at Obed, and 82% at New River. However, maximum SpC levels were all below 300 $\mu\text{S}/\text{cm}$, a threshold thought to have potential detrimental impacts on aquatic organisms (see Hughes et al. 2018).

Table 3. Minimum, Maximum, and Mean specific conductivity levels for water year 2021 at continuous monitoring sites.

Site	Minimum ($\mu\text{S}/\text{cm}$)	Maximum ($\mu\text{S}/\text{cm}$)	Mean ($\mu\text{S}/\text{cm}$)
Clear Fork	21.0	77.0	52.1
New River	38.0	296.0	153.6
Clear Creek	22.0	85.0	44.2
Daddys Creek	48.0	160.0	86.2
Obed River	31.0	279.0	120.1

Turbidity

Overall, average turbidity measurements in WY21 were generally low, with mean turbidity in the single digits at all sites except for New River (Table 4). These findings aligned with Rikard et al. 1986, who identified turbidity reference conditions in BISO streams to be less than 10 NTU (Nephelometric Turbidity Unit). In addition, mean turbidity at New River and Clear Fork were above the EPA range of reference conditions for the ecoregion, recommended at 1.0-5.2 NTU (EPA 2000). Of note, WY21 turbidity data differs in units (FNU; Formazin Nephelometric Unit) from identified reference conditions (NTU), attributed to instrumentation and compliance differences. However, there is an approximate, albeit not 1:1, conversion.

Table 4. Minimum, Maximum, and Mean turbidity measurements for water year 2021 at continuous monitoring sites [FNU=Formazin Nephelometric Unit].

Site	Minimum (FNU)	Maximum (FNU)	Mean (FNU)
Clear Fork	0.0	304.0	6.5
New River	1.0	918.0	21.6
Clear Creek	0.0	265.0	4.4
Daddys Creek	0.0	241.4	4.8
Obed River	0.0	190.0	3.5

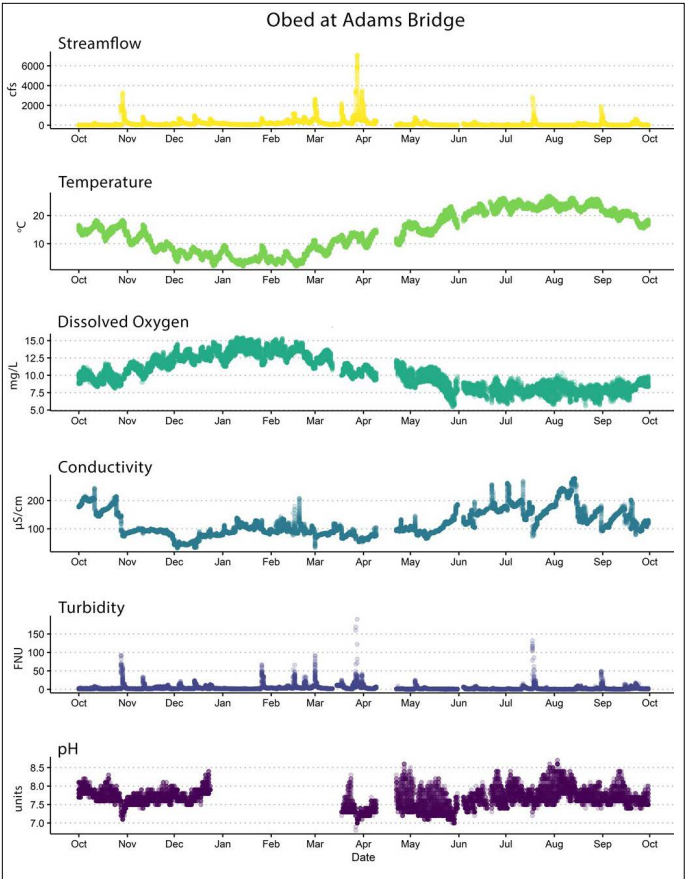


Figure 7. Obed Wild and Scenic River continuous water quality data at Obed River.

pH

All pH measurements in WY21 were within the state standards range for wadeable streams of 6.0–9.0SU, ranging from a mean of 7.07SU at Clear Creek to 7.68SU at Daddys Creek (Table 5). However, 24-hour fluctuations of pH exceeded state standards at three sites. Tennessee standards specify pH values shall not fluctuate more than 1.0 unit over a period of 24 hours (TDEC 2019). This metric was exceeded in 4% of pH measurements at Obed, 11% at Clear Fork, and 14% at Daddys Creek. Clear Creek and New River did not exceed this threshold.

Table 5. Minimum, Maximum, and Mean pH measurements in standard units (SU) for water year 2021 at continuous monitoring sites.

Site	Minimum (SU)	Maximum (SU)	Mean (SU)
Clear Fork	6.20	8.81	7.21
New River	6.70	7.93	7.52
Clear Creek	6.50	7.89	7.07
Daddys Creek	6.81	8.84	7.68
Obed River	6.80	8.70	7.66

Summary

Continuous water quality monitoring in Water Year 2021 indicated that overall water quality was mostly good but varied across parameters at the five monitoring sites. Clear Creek was demonstrative of near reference conditions and good water quality. Clear Fork generally exhibited good conditions, however pH variability within 24 hours did not meet Tennessee state standards. New River and Obed River also exceeded Tennessee state standards, varying greater than 1.0 SU in 24 hours. In addition, New River and Obed River had mean specific conductivity levels greater than reference conditions, with peak levels reaching a maximum of just below 300 $\mu\text{S}/\text{cm}$, a criterion suggested to have potential impacts on aquatic life. Although overall dissolved oxygen levels were well above state standards, Obed River fell below reference conditions for the Cumberland Plateau with a measure of 5.4 mg/L, just above the Tennessee state standard of 5.0 mg/L. Furthermore, dissolved oxygen at Obed River exhibited diel fluctuations throughout winter, a finding not observed at the other sites and which further investigation may be of interest.

Literature Cited

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Rikard, M., S. Kunkle, and J. Wilson. 1986. Big South Fork NRR Water Quality Report, 1982–1984. National Park Service Water Resources Division, Water Resources Report No. 86-7. 65pp.

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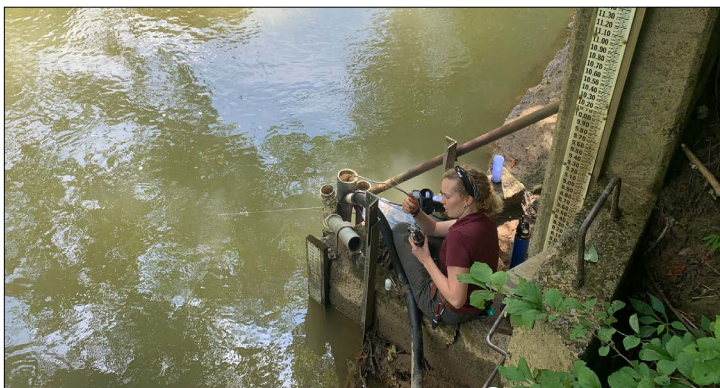
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Protocol Citation

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Sonde maintenance at Daddys Creek. NPS photo / APHN staff.



Sonde maintenance at New River. NPS photo / APHN staff.

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<https://www.nps.gov/im/aphn/water-quality.htm>

