



Discrete Water Quality Monitoring: Water Year 2021

Background

Streams and rivers along the Blue Ridge Parkway (BLRI) are important water resources for the park, as well as Southern Appalachia. Approximately 150 headwater streams in the park feed major rivers that provide much of the drinking water for the Southeast (Catlin 1984). The BLRI park boundary also encompasses four state- and nationally-designated Outstanding Resource Waters, 400 streams, five major rivers, and numerous wetlands and lakes.

Blue Ridge Parkway extends 469 miles (754.8 kilometers), connecting Shenandoah and Great Smoky Mountains National Parks and traversing 29 counties, four national forests, one Indian reservation, two state parks, and a dozen municipal watersheds (Emmott et al. 2005). The BLRI streams are driven by heavy precipitation along an elevational gradient ranging from 649 to 6,047 feet (197.8 to 1,843.1 meters). High ridges intercept rain-bearing winds and increase moisture at high-elevation sites, while temperatures drop by approximately 3°F (-16.1°F) for every 1,000 feet (304.8 meters) of elevation gain (Catlin 1984).



Monitoring stream along the parkway. NPS photo / APHN staff.

Issues of Management Concern

Local concerns about park waters include issues related to wastewater treatment systems, facilities development, and campgrounds. However, most threats to park water quality originate outside its approximately 1,000-mile (1,609.3 kilometers) long boundary, including urban and residential development adjacent to Blue Ridge Parkway, agricultural activity, atmospheric deposition, and forest insect/disease infestations. Soils at high-elevation sites typically have low buffering capacity, and streams are highly susceptible to acidification related to atmospheric pollutant deposition. Water resources on the parkway are affected by or affect 149 industrial/municipal discharges, 40 drinking water intakes, and 78 impoundments.

Highlights

- All measures of dissolved oxygen, temperature, and pH met state standards.
- ANC values indicated more than half of all sites were highly sensitive to acidification.
- Chloride and sodium levels were elevated at BLRI_H02 (Bass Lake Creek).
- 28% of samples had elevated levels of *E. coli*.

Monitoring and Objectives

The Appalachian Highlands Inventory and Monitoring Network (APHN) monitors water quality at 21 strategic management and elevational sites to identify water resource conditions. The network monitors core water quality parameters including:

- Streamflow
- Water Temperature
- Dissolved Oxygen
- pH
- Specific Conductance
- ANC
- *Escherichia coli* (*E. coli*)
- Turbidity
- Metals
- Nutrients
- Major Ions

For detailed methods, see Hughes et al. 2018.



Multi-sensor sonde measuring water quality in a stream. NPS photo / APHN staff.

National Park Service
U.S. Department of the Interior



ID	Name
H05	Soco Creek
15	Yellowface Overlook
H04	Wesner Bald Overlook
14	Redbank Branch
13	Flat Laurel Gap Bog
13A	Pisgah Creek WT Plant
12	Graybeard Mtn Overlook
11	Linville River
10	Simms Creek
H02	Bass Lake
L02	Grassy Gap Fire Rd

September 2022

Water Year 2021

During water year 2021 (WY21), the Appalachian Highlands Network conducted two water-quality sampling trips on the Blue Ridge Parkway (April and September 2021). Along the parkway, 21 sites were sampled resulting in more than 1,060 measurements. Sampling in WY21 was impacted by various factors, including the hiring of a new hydrologist (beginning February 2021), access to sites, and COVID-19 limitations and restrictions.

Prior APHN water quality data from Blue Ridge Parkway were compiled from three sampling trips in 2012, one in 2013, and one in 2019 to compare current and past conditions of field measured parameters. Prior data from December 2019 and January 2020 was compiled to compare lab analyzed parameters. Data were compared to state standards and reference conditions (Webb et al. 2001; Hughes et al. 2018).



Hydrology Assistant Isabel Ahlstrom collects a water sample. NPS photo / APHN staff.

Streamflow (Q)

Measured using a Sontek Flowmeter, streamflow in WY21 ranged from nearly 0.0 cubic feet per second (cfs) at BLRI_12 to 67.4 cfs at BLRI_11 (Figure 1, Q). Mean streamflow was 4.23 cfs for all sites. For smaller headwater streams, submersing the Flowmeter to obtain an accurate measurement was challenging and often only one measurement of depth and velocity was possible.

Water Temperature

Temperature ranged from 4.7°C to 20.6°C (40.5°F to 69.1°F) with a mean of 12.5°C (54.5°F). All measurements were below state temperature standards of 29°C (84.2°F). Reference conditions for Blue Ridge Parkway range from 0 to 20°C (32°F to 68°F). All but one site, BLRI_01 (20.6°C [69.1°F]), were within this range (Figure 1, Temp). Water temperature was negatively correlated with elevation ($r=-0.74$, $p\text{-value}<0.01$). Using linear regression, for every 1,000 feet (304.8 meters) increase in elevation water temperature decreased 1.8°C (35.2°F; $R^2=0.76$).

Dissolved Oxygen (DO)

All measurements of dissolved oxygen (DO) met state dissolved oxygen standards (> 5.0 mg/L). Reference levels for Blue Ridge Parkway are greater than 6.0 mg/L and all measurements were well above this criteria. Mean DO was 9.5 mg/L and ranged from 8.0 to 11.8 mg/L across all sites.

pH

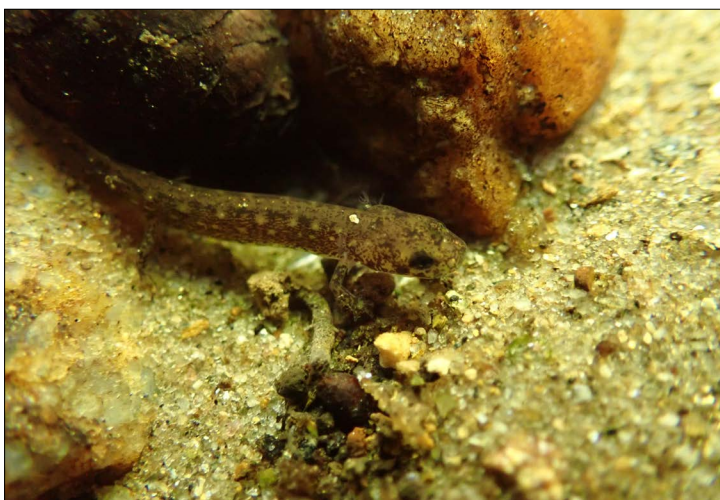
All pH measurements in WY21 were within state standards, ranging from 5.26 standard units (SU) to 7.61 SU. Mean pH was 6.54 SU across all measurements. pH reference conditions in BLRI streams range from 5 to 7 SU. Although most measurements were within this range, 22% of measurements exceeded 7 SU. Visually evident in the graphs (Figure 1, pH), pH increases south to north, where generally more acidic conditions are found at sites in the northern part of the Parkway. This is likely attributed in part to elevational gradients, as pH and elevation are negatively correlated ($r = -0.63$, $p\text{-value} < 0.01$), and site elevation is generally higher further south along the Parkway.

Specific Conductance (SpC)

In WY21, SpC ranged from 8.2 to 329.1 $\mu\text{S}/\text{cm}$, with a mean of 37.5 $\mu\text{S}/\text{cm}$. There are no numerical state standards in North Carolina or Virginia for SpC but reference conditions in BLRI streams are less than or equal to 50.0 $\mu\text{S}/\text{cm}$. Seventeen percent of measurements were above reference conditions; however, all measurements were below 100 $\mu\text{S}/\text{cm}$, except at BLRI_H02 (Bass Lake). The SpC levels at BLRI_H02 are elevated compared to reference conditions, where high levels of SpC have the potential to detrimentally impact aquatic life (EPA 2018). Elevated SpC at BLRI_H02 likely indicates additional inputs into the system.

Turbidity

Turbidity levels ranged from 0 to 10.7 FNU (Formazin Nephelometric Unit) with a mean of 2.05 FNU. All measurements were below the BLRI reference condition criteria of 10 FNU, except for one measurement that was slightly elevated (10.7 FNU at BLRI_04).



Juvenile salamander in a BLRI stream. NPS photo / APHN staff.

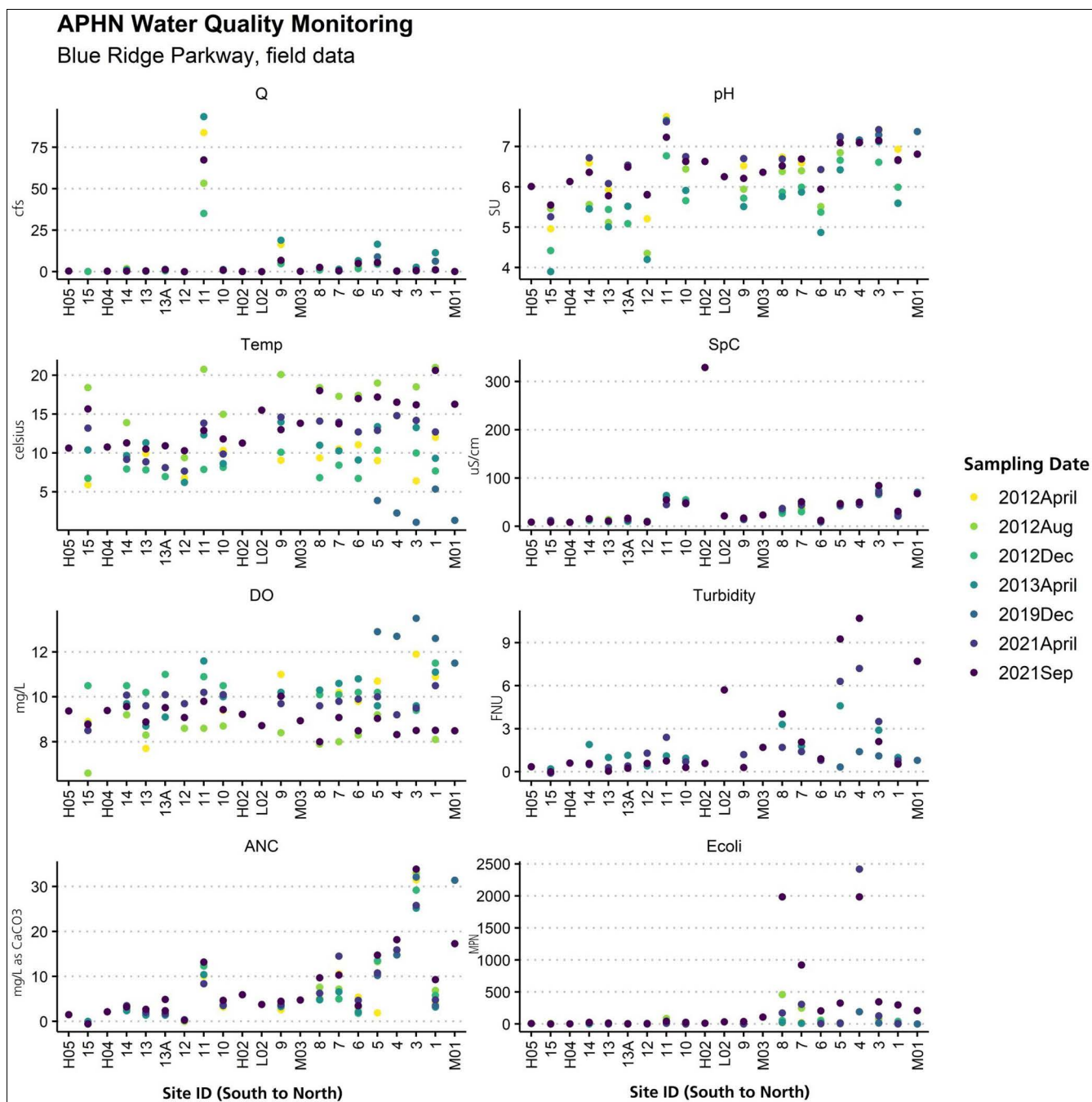


Figure 1. Water quality data measured in the field and APHN lab; Q (Streamflow), pH, temperature, SpC (Specific conductivity), DO (Dissolved oxygen), Turbidity, ANC (acid neutralizing capacity), and *E.Coli*. Sites are ordered from south to north along the parkway.

Water Year 2021 (Continued)

Acid Neutralizing Capacity (ANC)

Acid Neutralizing Capacity (ANC), the measure of a stream's ability to buffer acid inputs, ranged from -0.57 to 33.88 mg/L as CaCO_3 . Across all sites, mean ANC was 7.24 mg/L as CaCO_3 . The ANC values below 4.0 mg/L as CaCO_3 are considered highly sensitive to acidification (EPA 2003). Forty-three percent of ANC values from WY21 were below this value and considered highly sensitive. One site was below 0 mg/L as CaCO_3 and considered chronically acidic (BLRI_15). The ANC was highly correlated with magnesium (Mg, $r = 0.83$) and silicon (Si, $r = 0.78$), followed by calcium (Ca, $r = 0.65$).

E. Coli

Escherichia coli (*E. coli*) ranged from less than 0.01 to greater than 2419.6 MPN/100mL with a mean of 252 MPN/100mL. Most probable number, or MPN, is an estimate of organisms per sample and comparable to CFU, colony-forming units. State standards for *E. coli* are less than or equal to 200 cfu/mL for North Carolina and less than or equal to 126 cfu/mL for Virginia. However, these standards require a geometric mean based on five samples within 30 days, a sampling metric not achievable with the Appalachian Highlands Network's sampling design. Twenty-eight percent of samples in WY21 exceeded 200 MPN/mL, the NPS standard threshold value for *E. coli* (NPS 2018). Of note, BLRI_07 (Saddle Mountain Church), BLRI_08 (Big Pine Creek) and BLRI_04 (Coy Wade Bog) had especially elevated levels of *E. coli*, approaching or exceeding 1000 MPN/100mL (Figure 1, *E. coli*).

Nitrate (NO₃) + Nitrite (NO₂)

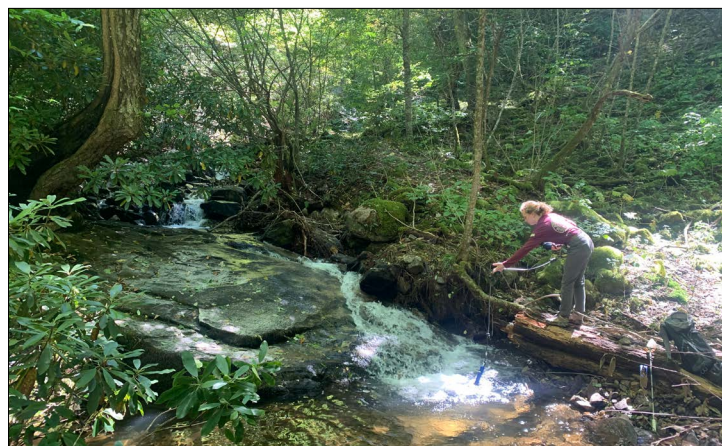
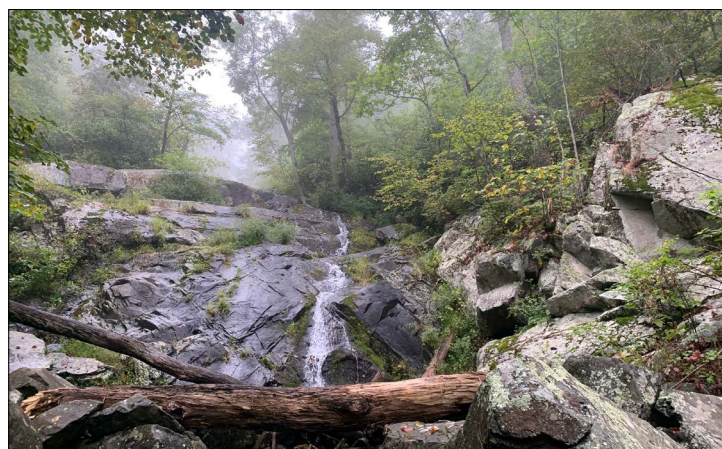
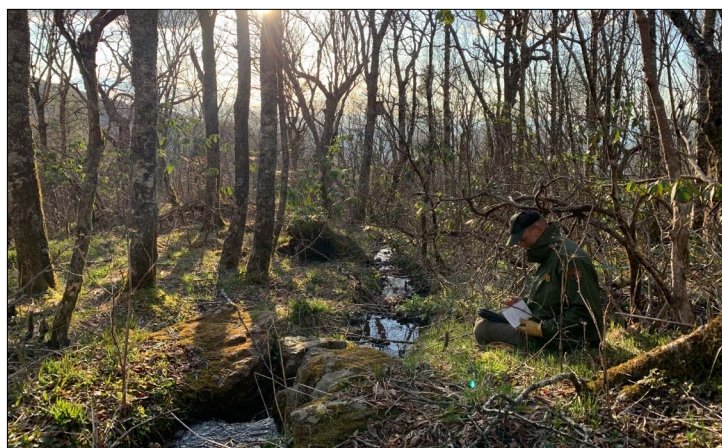
Across all sites mean $\text{NO}_3 + \text{NO}_2$ averaged 1.37mg/l and ranged from 0.04 to 5.5 mg/l. The EPA recommended reference standard for the ecoregion is 0.23 mg/l (EPA 2000). Eighty-six percent of $\text{NO}_3 + \text{NO}_2$ measurements exceeded the reference standard. Site BLRI_08 (Big Pine Creek) followed by BLRI_07 (Saddle Mountain Church) had the highest levels (Figure 2, $\text{NO}_3 + \text{NO}_2$).

Chloride (Cl)

Chloride ranged from 0.29 to 85.97mg/l with a mean of 4.6 mg/l. Site BLRI_H02 (Bass Lake Creek) had the highest levels of chloride, similar to measurements taken in January of 2020 (Figure 2, Cl). Of interest, the WY21 sample was collected in September when de-icing agents would not be in use. Whether chloride levels increase among all seasons due to de-icing (Corsi et al. 2015), or if de-icing is the cause of elevated chloride levels at BLRI_H02 is yet to be determined.

Sodium (Na)

Across all sites, average sodium levels were 3.0 mg/l. Measurements ranged from 0.44 to 46.0 mg/l. Site BLRI_H02 (Bass Lake Creek) had the highest levels of sodium, nearly eight times higher than the next highest measurement at BLRI_10 (Sims Creek; Figure 2, Na).



From top to bottom, APHN staff recording data, a stonefly in a BLRI stream, waterfall on the parkway, and measuring water quality with a data sonde. NPS photos / APHN staff.

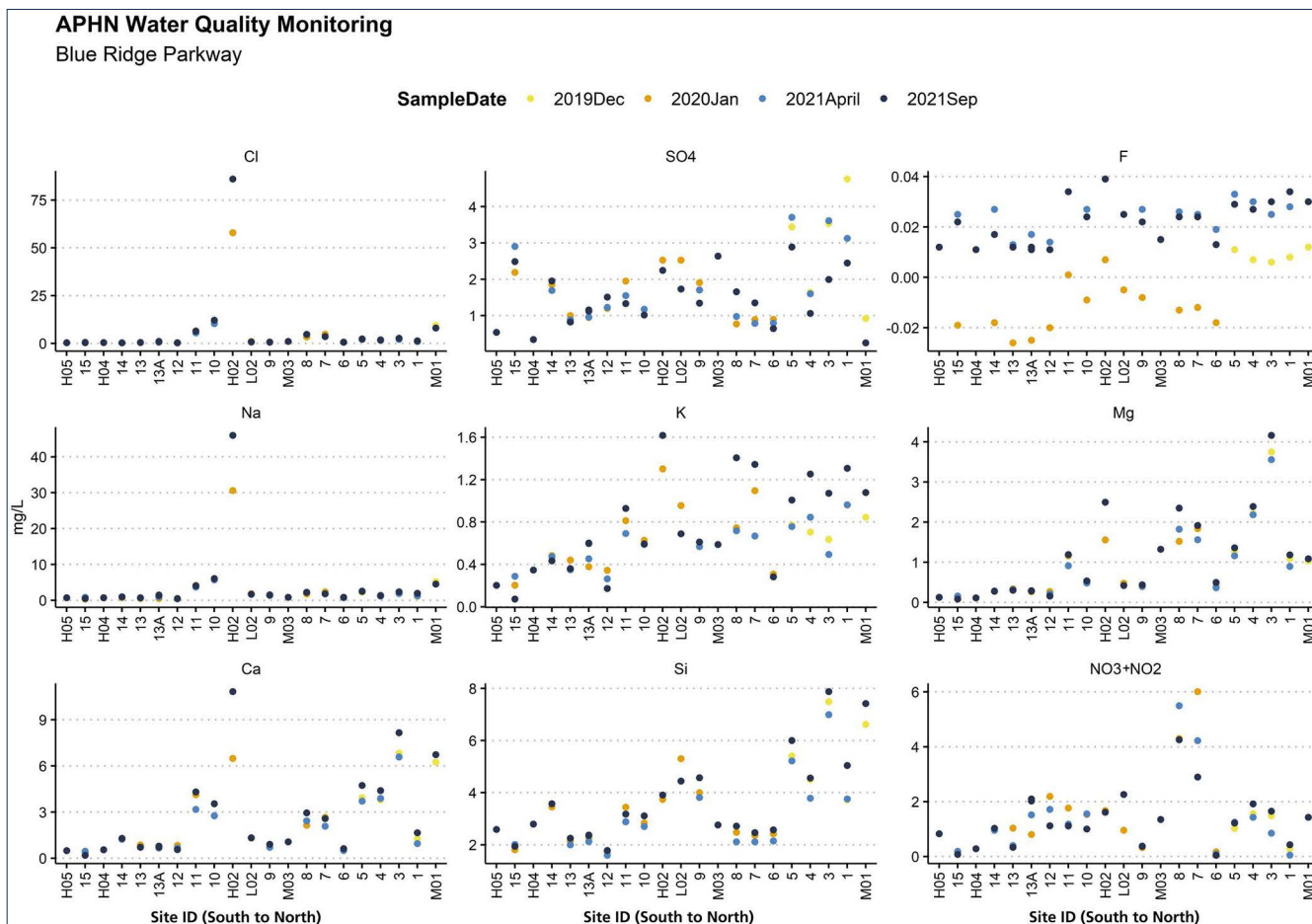


Figure 2. Water quality data from collected sample analyzed at the University of Tennessee at Knoxville lab; Cl (chloride), SO₄ (sulfate), F (fluoride; Of note, data from January 2020 is below lab detection limits and should be excluded), Na (sodium), K (potassium), Mg (magnesium), Ca (calcium), Si (silicon), and NO₃ (nitrate) + NO₂ (nitrite). Sites are ordered from south to north along the parkway.

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Protocol Citation

- Hughes, J., R. Emmott, E. Raskin, and B. Witcher. 2018. Long-term discrete water-quality monitoring at Big South Fork National River and Recreation Area, Blue Ridge Parkway, and Obed Wild and Scenic River: Protocol narrative. Natural Resource Report NPS/APHN/NRR—2018/1840. National Park Service, Fort Collins, Colorado. Available at: <https://irma.nps.gov/DataStore/Reference/Profile/2258269> (last accessed August 2022).

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