



Long-Term Discrete Water Quality Monitoring at Big South Fork National River and Recreation Area, Blue Ridge Parkway, and Obed Wild and Scenic River

Data Quality Standards

Natural Resource Report NPS/APHN/NRR—2018/1847



ON THE COVER

Obed Wild and Scenic River at the Turnhole (photograph courtesy of Ann Froschauer, National Parks Conservation Association).

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Introduction and Summary

The purpose of this report is to document the standards used by the Appalachian Highlands Inventory and Monitoring Network (APHN) for activities related to the collection, processing, storage, analysis, and publication of monitoring data as described in the *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* (Hughes et al. 2018). The policies and procedures documented in this quality-assurance plan for activities complement the quality-assurance plans for other monitoring activities conducted by the network and supplement National Inventory & Monitoring Division Quality Management Plan (in prep). The plan also serves as a guide for all APHN personnel who are involved in protocol/program activities and as a resource for identifying memoranda, publications, and other literature that describe associated techniques and requirements in more detail.

Protocol Overview

The *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* (Hughes et al. 2018) describes the background, rationale, and sampling design for monitoring water quality using discrete sampling at three APHN parks: Big South Fork National River and Recreation Area (BISO), Blue Ridge Parkway (BLRI), and Obed Wild and Scenic River (OBRI; Hughes et al. 2018). The objective of this long-term monitoring project is to determine annual status and long-term trends for key indicators of water resource condition. Field analyses include pH, specific conductance, temperature, dissolved oxygen, and turbidity. Laboratory analyses are broadly grouped into the following analytical schedules: (1) In-house acid neutralization capacity (ANC) and turbidity, (2) (dissolved) solids, (3) routine anions/cations, (4) nutrients, (5) metals/metalloids, and (6) in-house bacteriology. To complement these field and laboratory analyses, the network will make stream discharge measurements in accordance with USGS methodologies at each sampling station.

Data collected using this protocol will be stored in NPSTORET and analyzed using a variety of analytical programs. A primary emphasis of the National Park Service (NPS) Inventory and Monitoring Program is to ensure that results and knowledge obtained from monitoring are communicated in a timely manner and to maximize information exchange in order to best meet park needs. Where appropriate to support the NPS mission, monitoring results will be shared as broadly as possible with park partners, NPS staff, and the public. Water quality status will be summarized in annual reports and resource briefs at the end of each calendar year. Longer term trends and/or synthesis reports will be written every five years, but trend analyses at individual stations may be conducted more frequently if warranted, depending on the needs of the parks. The synthesis reports will include information from a regional perspective in order to look at landscape-scale changes. Water-quality data collected using this protocol will provide a scientific foundation for evaluating water quality in the parks' major tributaries. This discrete water-quality monitoring protocol is intended to complement additional protocols that will be developed by the network to monitor aquatic, riparian, and terrestrial resources of APHN park units.

Sampling Design and Field Methods

To effectively monitor the diverse water resources of APHN parks, a two-tiered approach will be employed. Level I “core” monitoring stations represent the foundation or base level of the APHN water resource monitoring effort. Under the core monitoring effort, the Appalachian Highlands Network will monitor a static network of monitoring stations that will be sampled annually over the long-term. The core sampling network includes key stations within and adjacent to the individual APHN parks and consists largely of sampling stations identified in the initial draft of the APHN Water Quality Protocol (National Park Service 2005). However, some modification of the monitoring network has been made and the frequency of monitoring has been changed in response to personnel and laboratory budget considerations.

Level I: Fixed “Core” Sampling Stations

The core monitoring stations will be sampled on a fixed monthly or quarterly frequency, with sampling timed to characterize seasonal variability in water quality during seasonal baseflow conditions. Big South Fork NRRRA and Obed WSR stations that are also equipped with streamflow gages and continuous monitors will be sampled monthly while the remaining level I stations will be sampled quarterly. These core stations will be the primary monitoring locations for evaluation of long-term trends in APHN park waters and will be utilized to detect climatic or anthropogenic influence to park waters. By sampling seasonal baseflow conditions and avoiding runoff events, it is anticipated that short term temporal variability associated with changing streamflow conditions will be avoided, with a concomitant increase in precision and statistical power to detect trends.

Level II: Rotating Sampling Stations

To complement long-term monitoring of Level I stations, Level II water resource monitoring stations in APHN parks include a rotating bank of tributaries to main stem drainages at Big South Fork NRRRA and Obed WSR and high elevation watersheds at Blue Ridge Parkway. Level II monitoring sites are intended to enhance spatial distribution of water resource monitoring in each park within the limitations of budget and manpower. These manpower and budget limitations, in conjunction with geographic constraints such as the length of the BLRI corridor, the relatively large land base at Big South Fork NRRRA, and the influence of upstream land use on park waters of Big South Fork NRRRA and Obed WSR, prevent complete geographic coverage of water resource monitoring at the intensity of level I monitoring. Resource managers nevertheless need data to assess the general condition of water resources throughout individual parks to assist management decisions. Level II stations will typically be rotated on an annual basis, but individual stations may be sampled for two or more consecutive years in consultation with park resource management staff.

Level II monitoring stations at Obed WSR and Big South Fork NRRRA are intended to provide more comprehensive coverage of both NPS managed waters and of waters upstream of park boundaries that influence waters within the Obed River corridor and the Big South Fork NRRRA. Toward that end, a bank of important tributaries to main stem drainages has been developed, from which a subset of Level II monitoring stations will be sampled. Level II consists of three separate panels. Panel 1 is sampled for two consecutive years, then panel 2 is sampled for two consecutive years, and then panel 3 is sampled for two consecutive years. The total sampling period is six years. In this manner, over

time, a broader geographic coverage or water quality assessment will be provided. At Blue Ridge Parkway, Level II rotations (with the same six year sampling period) will involve more comprehensive sampling of high elevation headwater streams. Because Level II stations will be sampled less frequently, initial results may be less precise than results from Level I monitoring; but Level II efforts will provide useful synoptic characterization of a larger spatial distribution of waters in individual parks.

Equal Width Increment (EWI) sampling

In the majority of situations, Appalachian Highlands Network will utilize equal-width-increment sampling (EWI) methodologies to collect isokinetic, depth-integrated samples in accordance with procedures described in detail in *Standard Operating Procedure (SOP) DWQ11 Sample Collection Methods: Inorganic Chemistry and Bacteriology* (APHN 2018). EWI methodologies produce a discharge weighted sample that is representative of the entire water body and eliminates sampling bias that could occur due to incomplete mixing of a water body as a consequence of inflow from upstream tributaries or other factors. EWI samples are obtained by stretching an incrementally marked tagline or measuring tape across the stream cross section, then collecting subsamples at equally spaced intervals along the tagline. All equally spaced subsamples are collected by lowering and raising an isokinetic water sampler at a consistent rate through the water column at the center of each increment (each subsample location is referred to as a vertical). The combination of a constant transit rate used to sample at each vertical and the isokinetic property of the sampler results in a discharge-weighted total sample that proportionally subsamples each vertical based upon depth and streamflow velocity.

Collection of an isokinetic, depth integrated, discharge weighted sample is standard APHN procedure; however, site characteristics, sampling equipment limitations, or study objectives may constrain how a sample is collected and could necessitate use of other methods. EWI sampling during base flow conditions will typically utilize USGS approved wading samplers, while EWI samples collected during storm flows will utilize USGS approved samplers suspended from bridge cranes or bridge boards.

Measurable Objectives

All of the issues and monitoring questions identified during APHN scoping meetings were expressions of the need for better information to assist managers in protecting water quality. Therefore, the overarching goal of the APHN water-quality monitoring program is to obtain information that will aid the parks in making informed management decisions that will protect and improve water quality within the Network parks. With that goal in mind, and cognizant of our limitations in staffing and funding, we have established the following objectives for water quality monitoring using discrete sampling (see Table 3 in the accompanying protocol narrative [Hughes et al. 2018] for a more detailed explanation of the significance of the parameters to be sampled):

- Determine seasonal and annual water quality trends for four core parameters (pH, temperature, dissolved oxygen, conductivity) using discrete sampling during seasonal baseflow conditions at fixed stations in Big South Fork NRRA, Blue Ridge Parkway and Obed WSR.

- Determine seasonal and annual trends in concentrations of ANC, nutrients, major anions and cations, trace metals, turbidity, and *E. coli* bacteria using discrete sampling during seasonal baseflow conditions at fixed stations in Big South Fork NRRA, Blue Ridge Parkway and Obed WSR.
- Determine seasonal and annual trends in water quantity (streamflow) during seasonal baseflow conditions using discrete sampling at fixed stations in Big South Fork NRRA, Blue Ridge Parkway, and Obed WSR.

Monitoring data are obtained from field measurements of streamflow and field and laboratory measurements of water quality samples collected at monthly and quarterly intervals at permanent stations along streams and rivers within the parks. These stations are strategically positioned to capture the effects of known stressors on sensitive aquatic resources, which will allow us to determine compliance with state and regional water quality standards and ensure NPS has the data needed to detect long-term changes in these systems. Dissolved oxygen, conductivity, temperature, pH, streamflow and turbidity are measured in the field; ANC and *E.coli* are determined by field crews in the lab on the same day that sampling occurs. Water samples are sent to a contracted water quality lab for analyses of the remaining parameters.

Protocol Activities and Modules

Data are collected or derived as a part of the *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* (Hughes et al. 2018) in 21 separate activities or modules (Table 1).

Table 1. Protocol activity matrix for *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* (Hughes et al. 2018).

Category	Activity #	Activity	Description
Site Recon, Establishment, and Maintenance	1	Site recon and establishment	Cross-section surveys of field parameters must be made to determine the most representative location for monitor placement. Outside gages (OG) staff plates will be installed and leveled at all Level I discrete monitoring stations.
	2	Station maintenance	OG levels will be checked at 5 year intervals.
Field Observations	3	Hydrologic condition	Record hydrologic condition (rising/falling/steady) in pre-printed APHN Water Quality Program field book as indicated by available streamflow gage record for USGS streamflow gages in close proximity to sampling station. Record antecedent and current weather conditions in pre-printed field book. Note suitability of sample in relation to seasonal base flow conditions in comment section of pre-printed field book. Note water clarity, substrate embeddedness, and other appropriate field observations in pre-printed field book.
	4	Photographic documentation	Document item 3 information with photographs.
	5	Stage	Stage determination made from Outside Gage (OG) staff plates installed at Level I monthly and quarterly discrete sampling stations
	6	Stream Discharge	APHN staff conduct stream discharge measurements in accordance with SOP DWQ07 Stream Discharge Measurements (APHN 2018b) at Level I and Level II quarterly monitoring stations utilizing Sontek Flowtracker acoustic doppler velocity profiler (ADCP) or Aquacalc ProPlus handheld computer and USGS standard vertical axis AA or pygmy current meters.
Sensor Data	7	Core water quality parameters (pH, temperature, specific conductance, dissolved oxygen)	APHN staff will utilize handheld water quality meters to conduct field analyses of pH, specific conductance, dissolved oxygen, and temperature at each sampling station. Sensors will be placed in a well-mixed section of the water body, preferably at or near the thalweg if possible. Analyses of core parameters will be conducted with water quality meters calibrated in accordance with SOP DWQ08 Equipment and Calibration (APHN 2018c). Data are recorded in pre-printed APHN Water Quality Monitoring Program field books.

Table 1 (continued). Protocol activity matrix for *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* (Hughes et al. 2018).

Category	Activity #	Activity	Description
Field Sample & Specimen Collection and Processing	8	Water sample collection and processing	Equal-width depth-integrated sampling methods in accordance with SOP DWQ06 Field Sampling Sequence and Sample Handling (APHN 2018d) and SOP DWQ11 of 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 (Hughes et al. 2018). Samples retained for in-house processing of 9-11; sent to contract lab for activities 12-15.
Laboratory Data (In-House)	9	Acid Neutralization Capacity (ANC)	ANC determinations are made in accordance with SOP DWQ10 ANC Titrations for Low Alkalinity Waters (APHN 2018e)
	10	E. coli bacteriology	E. coli enumeration made utilizing IDEXX methodologies in accordance procedures described in SOP DWQ12 Bacteriological Sampling and Analyses (APHN 2018f)
	11	Turbidity	EWI samples will be analyzed for turbidity in accordance with ISO 7027 method utilizing a Hach 2100Q portable turbidimeter.
Laboratory Data (External Lab)	12	pH, ANC, specific conductance	Redundant (to in-house) analyses conducted as part of contract laboratory routine analytical schedule.
	13	Anions/Cations (Ca ²⁺ , Na ⁺ , Mg ²⁺ , K ⁺ , HCO ₃ ⁻ , SO ₄ ²⁻ , Cl ⁻)	Routine anions/cations analyses from filtered water sub-aliquot of EWI sample.
	14	Nutrients (TDN, NO ₂ , NO ₃ , NH ₄ , TDP)	Nutrient analyses conducted from filtered sub-aliquot of EWI sample. Nitrogen and phosphorus compounds that are essential for plant growth and occur in natural waters at varying concentrations as a result of runoff and biological activity in streams.
	15	Core Metals/Metalloids (Al, Cu, Fe, Mn, Zn, SiO ₂)	Metals/metalloids analyses conducted from filtered/acidified sub-aliquot of EWI sample. Elevated concentrations of aluminum, iron, manganese, copper, lead, and zinc have been documented in surface waters of the Cumberland Plateau and the Blue Ridge Provinces.

Table 1 (continued). Protocol activity matrix for *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* (Hughes et al. 2018).

Category	Activity #	Activity	Description
External Data	16	Stage	Data collected and available from USGS at monthly sampling stations coincident to APHN continuous monitoring stations/USGS streamflow gages.
	17	Streamflow Discharge	Data collected and available from USGS at monthly sampling stations coincident to APHN continuous monitoring stations/USGS streamflow gages.
Quality Control Data	18	Field Meter Calibration	Calibration records (item 7) maintained in APHN Water Quality Program pre-printed field book. Turbidity calibrations (item 11) stored electronically in Hach 2100Q meter.
	19	Laboratory AC balance	Calculated anion-cation balance as QA check from laboratory.
	20	Sample blanks	APHN will collect and analyze 4 sample blanks per year for all analytes.
	21	Sample replicates	APHN will collect and analyze 24 concurrent sample replicates per year distributed throughout APHN parks.

Sampling Design

Information regarding the sampling design is provided in Table 2.

Table 2. Activity-level sample design matrix for *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* (Hughes et al. 2018).

Category	Activity #	Metric	Sampling Design	Revisit Design
Field Observations	3–6	Hydrologic Condition, Photographic documentation, Stage, Stream discharge	<u>Level I:</u> Subjectively chosen sites based on significant threats to water resources distributed throughout parks and/or co-located with sites of concern for other resource management issues. <u>Level II:</u> BLRI – Probability. GRTS sample of headwater streams based on elevation zones. BISO, OBRI – Targeted based on land use and resource management concerns.	<u>Level I:</u> Revisit monthly (BISO/OBRI stations w/ continuous discharge and water quality sensors) or quarterly (all other core sites at BISO/OBRI/BLRI). <u>Level II:</u> 3-panel, 6-year design where sites in one panel are sampled quarterly for two consecutive years, then the next panel is sampled quarterly for two consecutive years, then the final panel is sampled quarterly for two consecutive years.
Sensor Data	7	Core Water Quality Parameters	Sampling location sampling design is the same as in activities 3-6. Data collected at well-mixed location.	Revisit design is the same as in activities 3-6.
Field Sample Collection and Processing	8	Water sample collection and processing	Sampling location sampling design is the same as in activities 3-6. EWI samples collected in accordance with SOP DWQ06 and DWQ11 of <i>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</i> (Hughes et al. 2018).	Revisit design is the same as in activities 3-6.
Laboratory Data (In-House)	9	Acid Neutralization Capacity (ANC)	Sampling design is the same as in activity 8.	Revisit design is the same as in activities 3-6.
	10	<i>E. coli</i> bacteriology	Sampling design is the same as in activity 8.	Revisit design is the same as in activities 3-6.
	11	Turbidity	Sampling design is the same as in activity 8.	Revisit design is the same as in activities 3-6.

Table 2 (continued). Activity-level sample design matrix for *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* (Hughes et al. 2018).

Category	Activity #	Metric	Sampling Design	Revisit Design
Laboratory Data	12	pH, ANC, specific conductance	Sampling design is the same as in activity 8.	Revisit design is the same as in activities 3-6.
	13	Anions/ Cations (Ca ²⁺ , Na ⁺ , Mg ²⁺ , K ⁺ , HCO ₃ ⁻ , SO ₄ ²⁻ , Cl ⁻)	Sampling design is the same as in activity 8.	Revisit design is the same as in activities 3-6.
	14	Nutrients (TDN, NO ₂ , NO ₃ , NH ₄ , TDP)	Sampling design is the same as in activity 8.	Revisit design is the same as in activities 3-6.
	15	Core Metals/Metalloids (Al, Cu, Fe, Mn, Zn, SiO ₂)	Sampling design is the same as in activity 8.	Revisit design is the same as in activities 3-6.

Data Quality Objectives

Data quality values and standards for implementation are provided in Table 3 through Table 7.

Table 3. Data Quality Values (DQVs) for *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* (Hughes et al. 2018).

Category	Data Quality Value	Definition	Protocol Considerations
Intrinsic Data Quality	Accuracy	Measurements reflect the true value of the parameter being observed. This applies to measures (length, width, position) or classes (species, types, or categories). Includes components of precision and bias.	Calibration of field meter water quality sensors are conducted in accordance with methods described in SOP DWQ08 in Hughes et al. (2018). Stream discharge measurements are conducted consistent with accepted USGS standards and in accordance with SOP DWQ07 in Hughes et al. (2018). ANC determined in accordance with methods described in SOP DWQ10 and Meiman (2005).
	Representativeness	Measurements represent conditions at the time of sampling. Combined with accuracy, leads to repeatable data collection.	Representativeness of water quality samples is assured by strict adherence to Equal Width Increment (EWI) sampling methodologies described in SOP DWQ11 Hughes et al. (2018). Collected samples are consistently handled and preserved in accordance with procedures described in SOP DWQ06.
Contextual Data Quality	Comparability	At all stations, data are collected using compatible (i.e., identical) field monitoring equipment and samples are collected using consistent methodologies. Laboratory water quality analytes are conducted for a consistent analytical schedule.	Instrumentation, standard operating procedures, calibration procedures, and sampling methods are identical for all discrete monitoring stations. Data management and editing is conducted in accordance with a standard operating procedures that are consistent between stations.
	Timeliness / Currency	Data at each station are collected in accordance with a fixed schedule (either monthly or quarterly) that is described in the <i>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</i> (Hughes et al. 2018).	Data management and editing in accordance with standardized procedures described in SOPs DWQ15 <i>Data Management</i> (APHN 2018g) and DWQ16 <i>Data Analyses and Reporting</i> (APHN 2018h) ensure that long term data trends and comparisons between stations are verifiable. Complete processing of data for individual water year completed on an annual basis at all stations. Certification of data completed on an annual basis with individual station reports. Where certified data cannot be provided for resource management decisions in a timely manner, requirements for provisional use of data are defined and documented prior to data dissemination and use.

Table 3 (continued). Data Quality Values (DQVs) for *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* (Hughes et al. 2018).

Category	Data Quality Value	Definition	Protocol Considerations
Contextual Data Quality (Continued)	Completeness	All data/ measures required to evaluate accuracy representativeness are present; incomplete data sets (either at a location, across sampling locations, or over time) lose utility or relevance. Data records contain values as planned across the period of record.	All sampling locations are monitored following the schedule described in Hughes et al. (2018). Field and laboratory water quality data are collected at all Level 1 stations each year and are collected at Level 2 panels on a rotating basis. There is a chance that, on an infrequent basis, one or more stations may not be sampled due to safety or other considerations. The design and analysis methods can accommodate occasional missing data.
Representational Data Quality	Consistent Representation	Use of standard definitions when describing data quality or resource quality based on data	Standard definitions of data quality are provided. Provisional data indicate data that have been reviewed but not certified. Provided data is defined as data provided by cooperating agency (i.e., USGS). Certified data are defined as those data that have been reviewed, QA/QC checked, and edited in accordance with procedures described in SOP DWQ13 <i>Quality Assurance/Quality Control</i> (APHNi). Data are reported and flagged in comparison to established management, ecological, or regulatory thresholds in accordance with procedures described in Hughes et al. (2018).
Data Accessibility	Secure	Access to data, products, and systems limited to appropriate audiences.	No protected data will be generated as part of the APHN Long-Term Discrete Water-Quality Monitoring Protocol.

Table 4. Measurement Quality Objectives for *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* (Hughes et al. 2018).

Category	Measure / Quality Indicator	Quality Objective
Site Establishment	Location Accuracy	Discrete monitoring stations are located at established locations. Geographic coordinates for all sampling stations are recorded in the <i>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</i> (Hughes et al. 2018). Deployment proximity varies by station depending upon site specific conditions, but does not vary by more than 30 meters from established coordinates.
	Location Description Detail	Maps, narrative directions, and site access descriptions are included in field folders for each continuous sampling location.
pH ¹	Units	standard pH units
	Accuracy	± 0.2 units
	Resolution	0.01 units
	Range	0 to 14 units
	Reporting	Report to one decimal place
ANC	Units	mg/L as CaCO ₃
	Accuracy	± 0.1mg/L
	Resolution	0.01 mg/L
	Range	0 to undefined
	Reporting	Report to one decimal place
Temperature ¹	Units	degrees Celsius (°C)
	Accuracy	± 0.15 °C
	Resolution	0.01 °C
	Range	- 5 to 50 °C
	Reporting	Report to one decimal place

¹ Accuracy, range, and resolution data taken from YSI, Inc. (2009).

Table 4 (continued). Measurement Quality Objectives for *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* (Hughes et al. 2018).

Category	Measure / Quality Indicator	Quality Objective
Dissolved Oxygen ¹	Units	milligrams per liter (mg/L)
	Accuracy	± 1%
	Resolution	± 1%
	Range	0 to 50 mg/L
	Reporting	Report to one decimal place
Specific Conductance ¹	Units	microsiemens per centimeter [µS/cm])
	Accuracy	0.5% within calibrated range
	Resolution	1 µS/cm
	Range	0 to 100,000 µS/cm
	Reporting	Report to whole number
Turbidity ¹	Units	nephelometric turbidity units (NTU)
	Accuracy	± 2% of reading or 0.3 NTU (whichever is greater)
	Resolution	0.1 NTU
	Range	0 to 1000 NTU
	Reporting	Report to whole number
Bacteriology	Units	MPN (most probable number) of colony forming units (cfu)/100 ml
	Accuracy	Greater of ± 1 cfu or ± 10%
	Resolution	1 cfu
	Range	< 1 cfu to 2,420 cfu MPN
	Reporting	Report to whole number
Stage	Units	Feet
	Accuracy	± 2% of measurement
	Resolution	0.01 feet
	Range	0 to undefined
	Reporting	Report to 0.01 feet

¹ Accuracy, range, and resolution data taken from YSI, Inc. (2009).

Table 4 (continued). Measurement Quality Objectives for *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* (Hughes et al. 2018).

Category	Measure / Quality Indicator	Quality Objective
Stream discharge	Units	Cubic feet per second (cfs)
	Accuracy	±5% of rating curve or check measurement
	Resolution	0.1 cfs
	Range	0 to undefined cfs
	Reporting	Report to 3 significant digits or whole number if greater than 3 significant digits.

¹ Accuracy, range, and resolution data taken from YSI, Inc. (2009).

Table 5. Laboratory method performance requirements and analysis methods to be used for inorganic chemistry analysis as part of the *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* (Hughes et al. 2018).

Category	Analyte	Units	MDL Objective	Precision Objective ¹	Accuracy Objective ¹	Potential Methods conforming to NELAC guidance
External lab pH, ANC, and specific conductance	pH	Standard pH units	NA	0.01 units	+/- 0.2 units	EPA method 150.1
	Specific conductance	[µS/cm])	1.0	+ 2 µS/cm or 5%	0.5% within calibrated range	EPA method 120.1
	ANC	mg/L as CaCO ₃	0.1	0.01 mg/L	+/- 0.1 mg/L	pH Titration Plus
Nutrients Ion Chromatograph (filtered aliquot)	Ammonia (NH ₄)	mg/L	0.01 (0.7 µeq/L)	± 0.01 or ±10%	± 0.01 or ±10%	EPA Method 350.2 (1979)
	Nitrate (NO ₃)	mg/L	0.01	± 0.01 or ±10%	± 0.01 or ±10%	-EPA Method 353.2 (1979) -Enzyme Catalyzed Reduction
	Nitrite (NO ₂)	mg/L	0.01	± 0.01 or ±10%	± 0.01 or ±10%	-EPA Method 353.2 (1979) -Enzyme Catalyzed Reduction
	Total dissolved Nitrogen (TDN)	mg/L	0.02	± 0.01 or ±10%	± 0.01 or ±10%	Standard Methods #4500-N C, 4500-NO ₃ F and EPA Method 353.2 (1979)
	Total dissolved Phosphorus (TDP)	mg/L	0.02	± 0.02 or ±10%	± 0.02 or ±10%	Standard Methods #4500-P.B.5, #4500 P.E, and EPA Method 365.1 (1979)\

¹ When both absolute and percentage values are listed for the precision or accuracy objective, the objective is the greater of the two. For example, if specific conductance is less than 40 µS/cm, the objective is +/- 2; if it is greater than 40 µS/cm, the objective is 5%.

Table 5 (continued). Laboratory method performance requirements and analysis methods to be used for inorganic chemistry analysis as part of the *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* (Hughes et al. 2018).

Category	Analyte	Units	MDL Objective	Precision Objective ¹	Accuracy Objective ¹	Potential Methods conforming to NELAC guidance
Anions/Cations Ion Chromatograph (filtered aliquot)	Calcium (Ca)	mg/L	0.03 mg/L	± 0.03 or ±10%	± 0.03 or ±10%	ICPE
	Magnesium (Mg)	mg/L	0.01 mg/L	± 0.01 or ±10%	± 0.01 or ±10%	ICPE
	Potassium (K)	mg/L	0.01 mg/L	± 0.01 or ±10%	± 0.01 or ±10%	ICPE
	Sodium (Na)	mg/L	0.01 mg/L	± 0.01 or ±10%	± 0.01 or ±10%	ICPE
	Chloride (Cl)	mg/L	0.01 mg/L	± 0.01 or ±10%	± 0.01 or ±10%	ICPE
	Sulfate (SO ₄)	mg/L	0.04 mg/L	± 0.04 or ±10%	± 0.04 or ±10%	Standard Methods 4110
	Bicarbonate (HCO ₃)	mg/L	0.10 mg/L	0.01	± 0.1	Calculated from ANC
Metals/Metalloids Inductively Coupled Plasma- Atomic Emission Spectroscopy (ICPE) (filtered and acidified aliquot)	Iron (Fe)	mg/L	0.041	± 0.04 or ±10%	± 0.04 or ±10%	ICPE
	Manganese (Mn)	mg/L	0.009	± 0.01 or ±10%	± 0.01 or ±10%	ICPE
	Aluminum (Al)	mg/L	0.030	± 0.03 or ±10%	± 0.03 or ±10%	ICPE
	Copper (Cu)	mg/L	0.036	± 0.04 or ±10%	± 0.04 or ±10%	ICPE
	Zinc (Zn)	mg/L	0.012	± 0.012 or ±10%	± 0.012 or ±10%	ICPE
	Silica (SiO ₂)	mg/L	0.017	± 0.02 or ±10%	± 0.02 or ±10%	ICPE
Bacteriology Idexx Colilert Defined Substrate (raw, untreated sample)	<i>E. coli</i>	cfu/100 mL	<1 cfu/100 ml	± 1cfu or ±10%	± 1cfu or ±10%	Idexx quantitray 2000

¹When both absolute and percentage values are listed for the precision or accuracy objective, the objective is the greater of the two. For example, if specific conductance is less than 40 µS/cm, the objective is +/- 2; if it is greater than 40 µS/cm, the objective is 5%.

Table 6. Laboratory accreditation requirements for *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* (Hughes et al. 2018).

Category	Activity Number	Parameter	Accreditation Requirement	Location of Certification Documentation ¹
Lab Accreditations	12-15	pH/ANC/specific conductance, anions/cations, nutrients, and core metals/metalloids	NELAC or equivalent	Copy of certification on file in Network office

¹ If training records and/or certificates are on file elsewhere, document their location in this column. If training records and/or certificates do not exist or are not available then this should be noted

Table 7. Data protection standards for *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* (Hughes et al. 2018). With the exceptions noted, all data collected are to be made publicly available in a timely fashion.

Category	Type of Data	Level of Protection	Rules for Dissemination
Discrete Water Quality Data and Information	Water Quality Data	Unprotected	Data available on-line as public information.
	Bacteriological Data	Unprotected	Data available on-line as public information.
Location Data and Information	Permanent Sampling Locations	Operationally protected	Provided upon request only. Shown in reports
Personally Identifiable Information	Non-NPS Staff Information	Legally Protected	All but first name and last initial redacted from public release

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